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Technical Memorandum

To: File	From: Elton Smith
Company: Tetra Tech	Date: September 10, 2009
Re: Rosemont Copper Project PMP Storm Estimation	Proj #: 114-320828-5.3
CC: David Krizek, P.E. (Tetra Tech)	

1.0 Introduction

This memo discusses the methodology behind the estimation of the Local and General Probable Maximum Precipitation (PMP) storm distributions for the Rosemont Copper Project.

2.0 Methodology

The methodology used for the Local PMP estimation is described in detail in the “Hydrometeorological Report No. 49 (HMR 49), Probable Maximum Precipitation Estimates, Colorado River and Great Basin Drainages”, from the National Oceanic and Atmospheric Administration (NOAA) in 1977. The HMR 49 method involves obtaining data from charts and tables, based on regional data and basin areas, until ultimately the storm distribution is obtained. Since the PMP distribution will be used to calculate run-off in basins as small as five (5) acres, this value was chosen in order to obtain a sufficiently conservative and universally applicable estimation of the PMP. The method behind the General PMP is documented in “PMF Studies for Evaluation of Spillway Adequacy, General Guidelines” from the Arizona Department of Water Resources (ADWR) in March 2004. This method includes the calculation of the 72-hour storm intensity using the HMR 49 method, but arrives at the ultimate rainfall distribution based on the steps described in the ADWR reference. Additionally, the wettest month, August, was chosen for the calculations of the rainfall distribution of the 72-hour General storm since it produces the highest rainstorm intensities. Calculations for the adjacent months, July and September, were also made to ensure August indeed produced the highest intensity rainfall distribution (see Attachment A for July and September General Storm distributions). On the other hand, the Local Storm does not vary in respect to the month in which it occurs (also see Attachment A for detailed procedures and rainfall distributions).



3.0 References

National Oceanic and Atmospheric Administration (NOAA). *Probable Maximum Precipitation Estimates, Colorado River and Great Basin Drainages*. Hydrometeorological Report No. 49 (HMR 49). 1977.

Arizona Department of Water Resources (ADWR). *PMF Studies for Evaluation of Spillway Adequacy, General Guidelines*. March 2004.

Attachment A

PMP Estimation



Subject	Rosemont Copper Company
	Site Water Management Plan
	Attachment A: PMP Estimation

Made by	E. Smith
Checked	J. Carrasco
Approved	D. Krizek

Job No.	114-320828
Date	12/5/2009
Sheet No.	1

OBJECTIVE:

Determine the probable maximum precipitation (PMP) hyetograph for the Rosemont Copper Company Mining Project

METHOD:

Use the methods described in Hydrometeorological Report No. 49 (NOAA, 1977) and "PMF Studies for evaluation of Spillway Adequacy" (ADWR, 2004).

ASSUMPTIONS:

- Site Location: (31.83 N, 110.75 W)
- Elevation: 4900.0 ft
- Watershed Area: 0.016 sq. miles (10 acres)

CALCULATIONS:

HMR 49 step 1:

(ref. HMR 49 Figures 2.5 - 2.16)

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
24-hr Convergence PMP (in)	9.1	9.1	9.1	8.9	8.8	9.4	14.6	16.0	15.8	14.0	10.4	9.4

Calculations for the 72-hour General Storm PMP for Jul, Aug, & Sep and the 6-hour Local Storm PMP are presented on the following pages.

RESULTS/CONCLUSIONS:

The 72-hour General Storm PMP events for July, August, and September (as computed on pages 2-4 of this attachment) are summarized below:

ADWR		<u>ELAPSED TIME (HRS)</u>								
Incremental Sequence:		0	24	30	36	42	48	72		
July	0.0	2.2	1.2	2.2	8.7	0.9	1.0	inches	↔ <u>Selected 72-hour General Storm</u>	
August	0.0	2.6	1.5	2.7	9.9	1.1	1.2	inches		
September	0.0	2.6	1.4	2.6	9.8	1.1	1.2	inches		

ADWR		<u>ELAPSED TIME (HRS)</u>								
Cumulative Sequence:		0	24	30	36	42	48	72		
July	0.0	2.2	3.4	5.6	14.4	15.3	16.2	inches	↔ <u>Selected 72-hour General Storm</u>	
August	0.0	2.6	4.1	6.7	16.6	17.7	18.9	inches		
September	0.0	2.6	4.0	6.7	16.5	17.5	18.7	inches		

The 6-hour Local Storm PMP (as computed on page 5 of this attachment) follows:

		<u>ELAPSED TIME (HRS)</u>									
HMR 49 Sequence:		0.00	0.25	0.50	0.75	1	2	3	4	5	6
Incremental:	0.0	8.5	1.7	0.7	0.6	1.6	0.8	0.5	0.3	0.2	inches
Cumulative:	0.0	8.5	10.2	10.9	11.5	13.1	13.9	14.4	14.7	15.0	inches



Subject **Rosemont Copper Company**
 Site Water Management Plan
 Attachment A: PMP Estimation

Made by **E. Smith**
 Checked **J. Carrasco**
 Approved **D. Krizek**

Job No. **114-320828**
 Date **12/5/2009**
 Sheet No. **2**

72-Hour General Storm Convergence PMP Calculations for July:

HMR 49 Step: (ref. Figures 2.5 - 2.16)

A. Convergence PMP

1. Drainage average value from Figure **2.11** equals **14.6** in.
2. Reduction for Barrier elev. [fig. 2.18] **63** %
3. Barrier-elevation reduced PMP [1 x 2]: **9.2** in.

4. Durational variation: [figs. 2.25-2.27] 79 % [table 2.7] in % of 24-hr event	<u>DURATION (HRS)</u>					
	6	12	18	24	48	72
	79	92	97	100	109	113
5. Convergence PMP for indicated durations [3 x 4]:	7.3	8.5	8.9	9.2	10.0	10.4
6. Incremental 10mi ² PMP [successive subtraction of 5]	7.3	1.2	0.5	0.3	0.8	0.4
7. Areal reduction [figs. 2.28 & 2.29]	100	100	100	100	100	100
8. Areal reduced PMP [6 x 7]	7.3	1.2	0.5	0.3	0.8	0.4
9. Drainage average PMP [accumulated values of 8]:	7.3	8.5	8.9	9.2	10.0	10.4

B. Orographic PMP

1. Drainage average orographic index [figs. 3.11a - 3.11d] **5.0** in. **[fig 3.11d]**
 2. Areal reduction [fig. 3.20] **100** %
 3. Adjustment of month [figs. 3.12 - 3.17] **78** %
 4. Areal and seasonally adjusted PMP [1 x 2 x 3] **3.9** in.
 5. Durational variation [table 3.9]
 6. Orographic PMP for given durations [4 x 5]
- | | | | | | | |
|------------|------------|------------|------------|------------|------------|-----|
| 38 | 65 | 84 | 100 | 134 | 150 | % |
| 1.5 | 2.5 | 3.3 | 3.9 | 5.2 | 5.9 | in. |

C. Total PMP

1. Add steps A9 and B6 **8.7 11.0 12.2 13.1 15.3 16.2** in.
2. PMP for other durations from plot of Computed data
3. Compare with local storm:

D. Incremental PMP

(Note that HMR-49 does not provide directions on the time distribution of 72-hour General Storm PMP. In order to accomplish this, the distribution prescribed by the Arizona Department of Water Resources, Dam Safety Section will be used.)

1. Incremental PMP [successive subtraction of C1] **8.7 2.2 1.2 13.1 2.2 1.0** in
0.9 } 6-hr increments

2. Time sequence of incremental PMP according to:

a. ADWR daily increments

order: <u>2</u>	<u>1</u>	<u>3</u>	
2.2	13.1	1.0	in
1	2	3	days

b. Four largest 6-hr increments

order: <u>3</u>	<u>2</u>	<u>1</u>	<u>4</u>	
1.2	2.2	8.7	0.9	in
30	36	42	48	hrs



Subject **Rosemont Copper Company**
 Site Water Management Plan
 Attachment A: PMP Estimation

Made by **E. Smith**
 Checked **J. Carrasco**
 Approved **D. Krizek**

Job No. **114-320828**
 Date **12/5/2009**
 Sheet No. **3**

72-Hour General Storm Convergence PMP Calculations for August:

HMR 49 Step: (ref. Figures 2.5 - 2.16)

A. Convergence PMP

1. Drainage average value from Figure **2.12** equals **16** in.
2. Reduction for Barrier elev. [fig. 2.18] **63** %
3. Barrier-elevation reduced PMP [1 x 2]: **10.1** in.

	DURATION (HRS)					
	6	12	18	24	48	72
4. Durational variation: [figs. 2.25-2.27] 79 % [table 2.7] in % of 24-hr event	79	92	97	100	109	113
5. Convergence PMP for indicated durations [3 x 4]:	8.0	9.3	9.8	10.1	11.0	11.4
6. Incremental 10mi ² PMP [successive subtraction of 5]	8.0	1.3	0.5	0.3	0.9	0.4
7. Areal reduction [figs. 2.28 & 2.29]	100	100	100	100	100	100
8. Areal reduced PMP [6 x 7]	8.0	1.3	0.5	0.3	0.9	0.4
9. Drainage average PMP [accumulated values of 8]:	8.0	9.3	9.8	10.1	11.0	11.4

B. Orographic PMP

1. Drainage average orographic index [figs. 3.11a - 3.11d] **5.0** in. **[fig 3.11d]**
 2. Areal reduction [fig. 3.20] **100** %
 3. Adjustment of month [figs. 3.12 - 3.17] **100** %
 4. Areal and seasonally adjusted PMP [1 x 2 x 3] **5.0** in.
 5. Durational variation [table 3.9]
 6. Orographic PMP for given durations [4 x 5]
- | | 6 | 12 | 18 | 24 | 48 | 72 |
|--|------------|------------|------------|------------|------------|------------|
| | 38 | 65 | 84 | 100 | 134 | 150 |
| | 1.9 | 3.3 | 4.2 | 5.0 | 6.7 | 7.5 |

C. Total PMP

1. Add steps A9 and B6 **9.9 12.5 14.0 15.1 17.7 18.9** in.
2. PMP for other durations from plot of Computed data
3. Compare with local storm:

D. Incremental PMP

(Note that HMR-49 does not provide directions on the time distribution of 72-hour General Storm PMP. In order to accomplish this, the distribution prescribed by the Arizona Department of Water Resources, Dam Safety Section will be used.)

1. Incremental PMP [successive subtraction of C1] **9.9 2.7 1.5 15.1 2.6 1.2** in
1.1 } 6-hr increments

2. Time sequence of incremental PMP according to:

a. ADWR daily increments

order:	<u>2</u>	<u>1</u>	<u>3</u>	
	2.6	15.1	1.2	in
	1	2	3	days

b. Four largest 6-hr increments

order:	<u>3</u>	<u>2</u>	<u>1</u>	<u>4</u>	
	1.5	2.7	9.9	1.1	in
	30	36	42	48	hrs



Subject **Rosemont Copper Company**
 Site Water Management Plan
 Attachment A: PMP Estimation

Made by **E. Smith**
 Checked **J. Carrasco**
 Approved **D. Krizek**

Job No. **114-320828**
 Date **12/5/2009**
 Sheet No. **4**

72-Hour General Storm Convergence PMP Calculations for September:

HMR 49 Step: (ref. Figures 2.5 - 2.16)

A. Convergence PMP

1. Drainage average value from Figure **2.13** equals **15.8** in.
2. Reduction for Barrier elev. [fig. 2.18] **63** %
3. Barrier-elevation reduced PMP [1 x 2]: **10.0** in.
4. Durational variation: [figs. 2.25-2.27] **79** %
 [table 2.7] in % of 24-hr event
5. Convergence PMP for indicated durations [3 x 4]:
6. Incremental 10mi² PMP [successive subtraction of 5]
7. Areal reduction [figs. 2.28 & 2.29]
8. Areal reduced PMP [6 x 7]
9. Drainage average PMP [accumulated values of 8]:

DURATION (HRS)						
6	12	18	24	48	72	
79	92	97	100	109	113	%
7.9	9.2	9.7	10.0	10.8	11.2	in.
7.9	1.3	0.5	0.3	0.9	0.4	in.
100	100	100	100	100	100	%
7.9	1.3	0.5	0.3	0.9	0.4	in.
7.9	9.2	9.7	10.0	10.8	11.2	in.

B. Orographic PMP

1. Drainage average orographic index [figs. 3.11a - 3.11d] **5.0** in. [fig 3.11d]
2. Areal reduction [fig. 3.20] **100** %
3. Adjustment of month [figs. 3.12 - 3.17] **100** %
4. Areal and seasonally adjusted PMP [1 x 2 x 3] **5.0** in.
5. Durational variation [table 3.9]
6. Orographic PMP for given durations [4 x 5]

5.0	in.					
100	%					
100	%					
5.0	in.					
38	65	84	100	134	150	%
1.9	3.3	4.2	5.0	6.7	7.5	in.

C. Total PMP

1. Add steps A9 and B6 **9.8 12.4 13.9 15.0 17.5 18.7** in.
2. PMP for other durations from plot of Computed data
3. Compare with local storm:

D. Incremental PMP

(Note that HMR-49 does not provide directions on the time distribution of 72-hour General Storm PMP. In order to accomplish this, the distribution prescribed by the Arizona Department of Water Resources, Dam Safety Section will be used.)

1. Incremental PMP [successive subtraction of C1] **9.8 2.6 1.4 15.0 2.6 1.2** in
1.1 } 6-hr increments
2. Time sequence of incremental PMP according to:
 - a. ADWR daily increments

order:	<u>2</u>	<u>1</u>	<u>3</u>	
	2.6	15.0	1.2	in
	1	2	3	days
 - b. Four largest 6-hr increments

order:	<u>3</u>	<u>2</u>	<u>1</u>	<u>4</u>	
	1.4	2.6	9.8	1.1	in
	30	36	42	48	hrs



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Local Storm PMP Calculations:

HMR 49 Step:

6.3A Local storm PMP computation

1. Average 1-hr, 1-mi² PMP for drainage [fig. 4.5] 11.5 in.

2. a. Reduction for elevation [5% per 1000' above 5000'] 0.0 %
 b. step 1 x (100 - 2a). 11.5 in

3. Average 6/1-hr ratio for drainage [fig 4.7] 1.26

4. Durational variation for 6/1-hr ratio of step 3 [table 4.4]	DURATION (HRS)									%
	0.25	0.5	0.75	1	2	3	4	5	6	
	74	89	95	100	114	121	125	128	130	

5. 1-mi² PMP for indicated durations [2b x 4] 8.5 10.2 10.9 11.5 13.1 13.9 14.4 14.7 15.0 in

6. Areal reduction [fig. 4.9] 100 100 100 100 100 100 100 100 100 %

7. Areal reduced PMP 8.5 10.2 10.9 11.5 13.1 13.9 14.4 14.7 15.0 in

8. Incremental PMP [successive subtraction of 7] 8.5 1.7 0.7 11.5 1.6 0.8 0.5 0.3 0.2 in
0.6 } 15-min increments

9. Time sequence of incremental PMP according to:
 a. HMR 49 Hourly increments [table 4.7]

order:	<u>5</u>	<u>3</u>	<u>1</u>	<u>2</u>	<u>4</u>	<u>6</u>	
	0.3	0.8	11.5	1.6	0.5	0.2	in
	1	2	3	4	5	6	hrs

b. Four largest 15-min increments [table 4.8]

order:	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	
	8.5	1.7	0.7	0.6	in
	0.25	0.50	0.75	1.00	hrs