

TO: Chris Garrett  
SWCA Environmental Consultants

DATE: August 5, 2011

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CC: Dale Ortman, Consultant  
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SUBJECT: **Technical Review of Modeling Files for Rosemont Copper's Mine Supply Pumping**

At your request, MWH Americas, Inc. (MWH) has reviewed the input and output (I/O) files prepared by Montgomery and Associates (M&A) for the simulations of Rosemont Copper's mine supply pumping. The scope of the review was to perform an audit of the consistency of the I/O files with what M&A has reported in the following documents:

- *Groundwater Flow Modeling Conducted for Simulation of Rosemont Copper's Proposed Mine Supply Pumping* (M&A, April 30, 2009)
- *Second Update to ADWR Modeling in Sahuarita/Green Valley Area* (M&A, April 27, 2009)
- *Addendum to Groundwater Flow Modeling Conducted for Simulation of Rosemont Copper's Proposed Mine Supply Pumping* (M&A, November 11, 2010)
- *Additional Discussion of Rosemont Mine Supply Pumping and Analysis of Calibration* (M&A, January 6, 2011)

The audit was specific to the verification of the consistency between the modeling files and the documentation referenced above, and it did not evaluate the assumptions and methods used in the model construction. MWH has previously reviewed the methods and assumptions for the model construction, calibration, and simulations. This review is documented in technical memorandums addressed to SWCA Environmental Consultants (SWCA) and dated October 23, 2009; August 9, 2010; and January 18, 2011.

The audit was conducted on the I/O files that were sent by M&A to MWH on a set of compact discs (CDs) via postal mail. The modeling I/O files included the MODFLOW I/O files for the following simulations discussed in the M&A reports:

- Simulation of Rosemont pumping (SanritaEWregrid1)
- Simulation of no Rosemont pumping (SanritaEWregrid1NoRosemont)
- Simulation with original distribution of hydraulic conductivity from the ADWR Tucson Active Management Area (TAMA) model (SanritaEWregrid1OriginalK)

The MODFLOW 2000 (MF2K) files for these simulations were created by M&A in Groundwater Vistas (Environmental Simulations Inc.). MWH used Groundwater Modeling System (GMS) (Aquaveo, Inc.) to import and view these files. Modeling input, including discretization, hydraulic properties, pumping rates, recharge rates, and specified heads were viewed inside GMS and values were verified against the text and tables included in the M&A documents. To avoid discrepancies that could arise from incompatibilities between the two modeling platforms and to ensure that the model output files corresponded to the input files that were sent, each simulation was rerun using the MF2K executable activated

from a DOS prompt. The output was then viewed in GMS and the simulated groundwater levels were verified against the figures in the M&A documents. The model cell locations referenced in the document, "*Second Update to ADWR Modeling in Sahuarita/Green Valley Area*" were relative to the discretization in the original TAMA model. For the Rosemont mine supply pumping model, M&A refined the grid cell spacing in the area of the proposed Rosemont supply wells. Therefore, the cell references in this document were translated to the equivalent cell locations in the Rosemont mine supply pumping model in order to verify pumping and recharge specifications.

MWH's audit of the modeling I/O files has found the model inputs and outputs to be consistent with the text, tables, and figures in the above referenced documents. Therefore, it is MWH's opinion that the construction methods and simulation results for the Rosemont mine supply pumping model have been accurately reported by M&A. Itemized audit checklists are included as attachments to this memorandum.

**ATTACHMENTS**

**AUDIT CHECKLISTS**

AUDIT CHECKLIST

Groundwater Flow Modeling Conducted for Simulation of Rosemont Copper's Proposed Mine Supply Pumping (M&A, April 30, 2009)

Report Section Number	Report Section Title	Consistent?	Notes
Section 7.1	<b>Model Grid and Boundary Conditions</b>		
	The refined grid is constructed of 155 rows, 135 columns, 3 layers	Yes	The model has 135x155 total rows and columns (20925 total grid cells, including inactive cells)
	Grid cells are 330 ft x 330 ft in area of Rosemont Wells	Yes	Layer 3 has 9966 active cells, Layer 2 has 8791 active cells, Layer 1 has 5845 active cells
	Ratio of grid spacing between adjacent cells is approximately 1.5 or less	Yes	Area of min. grid spacing is as shown in Fig. 19
	Layer 1 bottom increased to 2552 at well E-1 (cell 98, 75)	Yes	Maximum grid change in grid spacing is 1.5043
	Layer 1 bottom increased to 2609 at well RC-2 (cell 113, 99)	Yes	Verified in Global Grid Package
	Model layer boundaries as shown in Figure 19	Yes	Verified in Global Grid Package
	Constant head boundary at southern end of upper Santa Cruz Basin	Yes	Verified on screen display
	Constant flux boundary at south end of Avra Valley	Yes	Range from 3023 to 3005 to 3030 ft; same specified heads in all layers
Section 7.2	<b>Model Stress Periods and Initial Conditions</b>		
	The model includes a total of 1 + 66 + 31 = 98 stress periods	Yes	Specified using well package, constant flux = 2387 to 2390 gpm across boundary
Section 7.3	<b>Aquifer Parameters</b>		
	Model Layer 1 is unconfined	Yes	Constant heads range from 5966 ft to 2693 ft in Layer 3
	The hydraulic conductivity of Layer 1 ranges from 2 to 250 ft/d in the study area and is as shown in Figure 21	Yes	Constant heads range from 1661 ft to 1642 ft in Layer 2
	The specific yield of Layer 1 ranges from 0.08 to 0.18 in the study area and is as shown in Figure 22	Yes	Differences in constant heads between layers imply upward gradient
	Model Layer 2 is confined/unconfined	Yes	Each stress period is 365 days
	The hydraulic conductivity of Layer 2 ranges from 1 to 81 ft/d in the study area and is as shown in Figure 23	Yes	
	The specific yield of Layer 2 ranges from 0.08 to 0.18 in the study area and is as shown in Figure 24	Yes	
	The storage coefficient for all of Layer 2 is 0.0001	Yes	
	The apparent transmissivity for Layer 2 is approximately 1,783 ft <sup>2</sup> /d at E-1 and 891 ft <sup>2</sup> /d at E-2	Yes	
	Model Layer 3 is confined/unconfined	Yes	
	In this vicinity of the Rosemont supply well area, the transmissivity ranges from 30 to 2440 ft <sup>2</sup> /d (see Figure 25)	Yes	
	Storage coefficient for Layer 3 is 0.0001 for entire model area	Yes	
	Specific yield for Layer 3 ranges from 0.05 to 0.09	Yes	
Section 7.4	<b>Comparison of Observed and Simulated Water Levels</b>		
	Figure 26 shows simulated 1940 water levels	Yes	Verified in BCF package
Section 7.5	<b>Simulation of Rosemont Pumping 2012 through 2031</b>		
	Figures 8 - 15 show simulated hydrographs at various wells	Yes	Verified in HK grid
Section 7.6	<b>Model Results</b>		
	Rosemont mine supply pumping was simulated from 2012 through 2019 at a rate of 5,400 ac-ft/yr	Yes	Verified in SY grid
	Rosemont mine supply pumping was simulated from 2020 through 2031 at a rate of 4700 ac-ft/yr	Yes	Verified in BCF package
Section 7.6.1	<b>Individual Rosemont well pumping rates and cell coordinates are as shown in Table 3</b>	Yes	Verified in BCF package
	Projected groundwater levels with Rosemont pumping at the end of Year 2021 are as shown in Figure 27	Yes	Verified in transmissivity grid
	Projected groundwater levels without Rosemont pumping at the end of Year 2021 are as shown in Figure 27	Yes	Verified in storage coeff grid
	Project groundwater levels with Rosemont pumping at the end of Year 2031 are as shown in Figure 29	Yes	Verified in SY grid

**AUDIT CHECKLIST**

**Groundwater Flow Modeling Conducted for Simulation of Rosemont Copper's Proposed Mine Supply Pumping (M&A, April 30, 2009)**

Report Section Number	Report Section Title	Consistent?	Notes
Section 7.6.2	Project groundwater levels without Rosemont pumping at the end of Year 2031 are as shown in Figure 29	Yes	Including simulated groundwater level contours near Rosemont wells
	Projected drawdowns with Rosemont pumping at the end of Year 2021 are as shown in Figure 31	Yes	Assume drawdown period is from 2009 to 2021. Verified for Rosemont well area
	Projected drawdowns without Rosemont pumping at the end of Year 2021 are as shown in Figure 32	Yes	Assume drawdown period is from 2009 to 2021. Verified for Rosemont well area
	Projected drawdowns with Rosemont pumping at the end of Year 2031 are as shown in Figure 33	Yes	Assume drawdown period is from 2009 to 2031. Verified for Rosemont well area
	Projected drawdowns without Rosemont pumping at the end of Year 2031 are as shown in Figure 34	Yes	Assume drawdown period is from 2009 to 2031. Verified for Rosemont well area
Section 7.6.3	Project drawdowns due to Rosemont pumping at the end of Year 2021 are shown in Figure 35	Yes	Spot checked at 1, 10, and 40 foot drawdown contours
	Project drawdowns due to Rosemont pumping at the end of Year 2031 are shown in Figure 36	Yes	Spot checked at 1, 10, and 60 foot drawdown contours

AUDIT CHECKLIST

Second Update to ADWR Model in Sahuarita/Green Valley Area (M&A, April 27, 2009)

Report Section Number	Report Section Title	Consistent?	Notes
<b>Changes to Transient Recharge Projects through 2006</b>			
	Pima Mine Road recharge was updated as shown in Table 1	Yes	Verified in recharge package
	San Arroyo recharge was updated as shown in Table 1	Yes	Verified in recharge package
	Sahuarita WWTP release recharge was updated as shown in Table 1	Yes	Computed 227 AF/y in 2007 (reported as 49 AF/yr) and 1074 AF/y for 2008-2027 (reported as 896). The difference appears to be because recharge was added to Santa Cruz River recharge in same cell as is done for RRQC
	Green Valley WWTP and Robson Ranch/Quail Creek recharge updated as shown in Table 2	Yes	Compute slightly greater recharge. The difference is likely because Santa Cruz River Recharge is in the same cell. The text notes that WWTP recharge was added to Santa Cruz River Recharge.
<b>Changes to Transient Pumping through 2006</b>			
	3 Phelps Dodge Wells added in TAMA model cell 106.55, pumping at 3921 AF in 2006	Yes	Found well in equivalent model cell 131,55 pumping at 3921 AF in 2006
	Pumping in AN-4 (TAMA model cell 99,62) extended to 2006	Yes	Found well in equivalent model cell 124,62 pumping at 525 AF in 2006
	Pumping moved to next active layer (see Table 3)	Yes	Found no wells in inactive or dry cells
	All wells going dry moved down to next active model layer	Yes	Found no wells in inactive or dry cells
<b>Changes to Transient Mine Tailing Seepage through 2006</b>			
	Seepage added for Esperanza Tailing Impoundment (Table 4)	Yes	Checked random wells for years in Table 4
	Seepage added for Sierrita Tailing Impoundment (Table 4)	Yes	Checked random wells for years in Table 4
	Seepage added for Twin Buttes Tailing Impoundment (Table 4)	Yes	Checked random wells for years in Table 4
<b>Changes to Santa Cruz River Recharge through 2006</b>			
	Pumping and injection wells added only Santa Cruz River between Rows 54 and 105 (118) to updated river recharge with Burkam (1970)	Yes	Verified that pumping and injections wells are in locations specified. Cannot verify individual pumping rates with available information.
<b>Model Calibration through 2006</b>			
	Simulated hydrographs at wells are as shown in Figures 4 through 11	Yes	Previously verified for Groundwater Modeling Report (M&A, 2009)
<b>Changes to Predictive Recharge Projects</b>			
	Changes made as shown in Table 1	Yes	See verification above
<b>General Changes to Predictive Pumping</b>			
	All pumping wells found to go dry during predictive period were moved down to next active layer	Yes	Found no wells in inactive or dry cells
	Certain wells left unchanged from TAMA model		Cannot be verified
	Pumping for 15 wells in inactive cells redistributed (Table 3)	Yes	Previously verified above
	Future pumping for Twin Buttes wells reduced as per Table on p11	Yes	Verified for 2006, 2007
	Added pumping for ESP1,ESP2 for 2007 = 37.7+79.5 =117.2 AF/y, zero thereafter	Yes	Verified for 2007, 2008
	Changes to future pumping at ASARCO Mission Wells as shown in Table on p12	Yes	Verified for 2007, 2008
	Extended 2006 pumping rates for wells shown in Table 8	Yes	Spot checked for about half of the wells for 2006-2007
	Model cells with large increases between 2006 and 2007 evaluated and updated as shown in Table 9	Yes	Verified in SY grid
	Model cells with large decreases between 2006 and 2007 evaluated and updated as shown in Table 10	Yes	Verified for all wells in Table for 2007
	Well locations updated so that predictive period locations consistent with transient period, as given in Table 11	Yes	Verified for wells selected at random
	Freeport-McMoRan interceptor well pumping updated as shown in Table 13	Yes	Verified for all wells in Table for 2007
<b>Committed Demand Additions to Predictive Pumping</b>			
	Committed demands pumping for GVVWD updated as shown in Table 15	Yes	Verified for all wells in Table for 2037
	Committed demands pumping for Swan Southlands updated as shown in Table 16	Yes	Verified for all wells in Table for 2037
	Committed demands pumping for Las Quintas Serenas updated as shown in Table 18	Yes	Verified for all wells in Table for 2037
	Committed demands pumping for Sahuarita Heights updated as shown in Table 19	Yes	Verified for 2037
	Committed demands pumping for CWC updated as shown in Table 21	Yes	Verified for all wells in Table for 2007
	Committed demands pumping for AZ State Trust Land as shown in Table 22	Yes	Verified for random wells in Table for 2030-2037
	Committed demands pumping for Quail Creek WC as shown in Table 24	Yes	Verified for all wells in Table for 2030-2037
	Committed demands pumping for Sahuarita WC as shown in Table 26	Yes	Verified for most wells in Table for 2012 and 2037
	Committed demands pumping for Farmers WC and Continental Farms as shown in Tables 28 and 29	Yes	Verified for random wells (included combined with Table 28 wells) for 2037

AUDIT CHECKLIST

Second Update to ADWR Model in Sahuarita/Green Valley Area (M&A, April 27, 2009)

Report Section Number	Report Section Title	Consistent?	Notes
	Updated for Ag wells converted to residential supply as shown in Table 30	Yes	Verified for random wells in Table for 2037
	Updated for AZ State Land Houghton Rd Corridor as shown in Table 31	Yes	Verified for random wells in Table for 2012 and 2037
<b>Changes to FICO Agricultural Return Flow for 2000 through End of Model</b>			
	FICO return flow updated as shown in Table 33	Yes	Difficult to verify because return flow and river recharge additive, but appears consistent from cells examined
<b>Changes to Predictive Mine Tailing Seepage</b>			
	Updated future mine tailing seepage as shown in Table 4	Yes	Previously verified
<b>Changes to Santa Cruz River Recharge through 2007</b>			
	Re-evaluated Santa Cruz River Recharge - no change from TAMA mode	N/A	

AUDIT CHECKLIST

Addendum to Groundwater Flow Modeling Conducted for Simulation of Rosemont Copper's Mine Supply Pumping (M&A, November, 2010)

Report Section Number	Report Section Title	Consistent?	Notes
<b>Model Calibration and Updates to the ADWR TAMA Model</b>			
	Simulated groundwater level contours for model run with original TAMA model K distribution is shown in Figure A-2	Yes	Verified in area around Rosemont wells (area of K revisions)
<b>Section of Projected Groundwater Levels</b>			
	The groundwater levels in northwest-southwest section through eastern and western Rosemont Properties with and without Rosemont Pumping is as shown in Figure A-3 (Years 2021, 2031)	Yes, by inference	Spatial resolution of figure too coarse to verify; however, previous verification made of simulated GW levels in M&A, 2009
<b>Influence of Southern Constant Head Model Boundary</b>			
	Location of 0.1 foot projected drawdown due to Rosemont pumping is about 7 miles north of southern constant head boundary (Figure A-4)	Yes	Verified by viewing simulated groundwater contours
<b>Sensitivity of Model Projections to Changes in Aquifer Properties</b>			
	Sensitivities of simulated GW levels (2005) to model updates to TAMA model are as shown in Figure A-5	Yes	Verified by evaluating simulated groundwater level contours in area around Rosemont wells



**AUDIT CHECKLIST**

**Additional Discussion of Rosemont Mine Water Supply Modeling and Analysis of Calibration**

Report Section Number	Report Section Title	Consistent?	Notes
		Yes	Items discussed in this report have been previously verified in audit of other documents. No additional verification required.