Safford Mine

2011 – 2012 Groundwater Monitoring Report

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Project 00010

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1.0 Introduction

This report summarizes and presents an evaluation of the Model, Monitor, and Mitigate (3M) Program for the Dos Pobres/San Juan Project (Safford Mine). This evaluation was done in accordance with the Dos Pobres/San Juan Project Clean Water Act Section 404 Mitigation and Monitoring Plan (MMP), described in the Dos Pobres/San Juan Project Final Environmental Impact Statement (FEIS) (Section 3 of Appendix F of the FEIS; BLM, 2003). This report was prepared for Freeport-McMoRan Safford Inc. (FMSI) by AquaGeo, Ltd., with technical assistance from Clear Creek Associates and Dr. Robert Mac Nish.

The 3M Program was devised to assist in evaluating effects of groundwater pumping at the Safford Mine and the adequacy of measures implemented to mitigate such effects. The 3M Program involves the use of statistical measures in a series of tests using water level data from specified groundwater monitoring locations. Each statistical measure (3M Statistic) is evaluated against a set of criteria (3M Criteria). The sets of 3M Criteria establish bounds for each statistical test, and depending on whether a statistic falls in or out of the range of specified bounds, a decision is identified regarding required actions based on the overall evaluation of the 3M Program.

A component of the 3M Program is a three-dimensional computer model of groundwater flow (URS Corporation 2002), known as the 2002 FEIS Model. The purpose of the model is to predict future impacts, if any, of the current and planned mining operations on groundwater flow to or from the Gila River, Bonita Creek and the San Carlos Apache Reservation. The model is calibrated in both steady-state and transient modes to observed conditions. Water level data obtained from numerous piezometers and monitor wells in and around the Safford Mine (**Figure 1**) are used in the modeling process to compare simulated results with measurements.

There are five groups of monitoring wells included in the 3M Program. The 47 wells, with Group numbers, are shown on **Figure 2**. The wells are grouped geographically and hydrogeologically based on their locations relative to the mining and production well pumping areas, or relative to the Gila River, which is located approximately eight miles to the south of the mine.

- <u>Group 1</u> wells are located between the mining operation and the Gila River and are a critical component of the 3M Program. Four wells (LBF-01, LBF-02, LBF-03 and LBF-04) are screened in the Lower Basin Fill, and two wells (LBF-01d and LBF-02d) are screened in bedrock beneath the Lower Basin Fill. Although LBF-01d and LBF-02d are in Group 1, they are not included in the tests of the 3M Program because they are not screened in the Lower Basin Fill (see Section 6).

- <u>Group 2</u> wells are located similar to Group 1 wells, but occupy a more extensive area. These wells monitor water levels in either Upper or Lower Basin Fill, or bedrock.

- <u>Group 3</u> wells are located northeast of the Butte Fault. These wells are included in the 3M Program for general information, but are not included in the 3M decision process because they are not required for evaluating whether or not to recalibrate the model (see the MMP). All wells in this group are screened in bedrock.

- <u>Group 4</u> wells are located northwest of the Graben structure formed by, and situated between, the Butte Fault and the Valley Fault. Wells in this group are screened in bedrock. The production wells that provide water for the mining operation are located in the Graben structure to the southeast of the Group 4 wells[1].

- Group 5 wells are located between the mining operation and the San Carlos Apache Reservation boundary to the northwest and Bonita Creek to the northeast. Wells in this group also are screened predominately in bedrock.

Table 1 provides a summary of the following for wells in the 3M Program: group number, well name, coordinates, altitude of land surface, depth of open intervals, corresponding model layer and water level measured prior to when mining commenced.

2.0 Purpose and Scope

The purpose of this 3M evaluation is to monitor the performance of the 3M Model in simulating the effects of actual pumpage on an annual basis. The 3M Model is a revised version of the 2002 FEIS Model (see Section 5.0 below). The 3M evaluation relies on water level measurements obtained from wells in the vicinity of the Safford Mine. The results of this evaluation are used to assess whether or not the current model requires recalibration to bring the model projections into closer agreement with the conditions observed in the field. The model is used to predict potential future effects on the regional groundwater system and to guide the implementation of mitigation measures to offset the effects of the mine pumping on the flow of the Gila River. The time immediately preceding August 2007 through June 2012 is called the "evaluation period" for the current 3M evaluation (see Section 4 below for additional detail). The scope of this report includes presentation of the available water level data for the 37 wells (Groups 1, 2, 4 and 5) for the evaluation period[2]. The compiled data have been used to calculate differences between model-projected water levels and gradients with those collected by, or estimated from, measurements obtained from the 3M monitoring program. Information developed from the four well groups and the 3M Model are used in a decision process illustrated in Figure 11 of the MMP (included as **Attachment 1** of this report), titled "Schematic Flow Chart of the Groundwater Model, Monitor, and Mitigate Process". Note the attached figure has been annotated in red to identify test numbers described in Section 6.0.

3.0 Background

The Safford Land Exchange between Phelps Dodge Corporation (now Freeport-McMoRan Corporation) and the Bureau of Land Management (BLM) was completed in September 2005. Following receipt of the remaining environmental permits, Phelps Dodge Safford, Inc., now FMSI, began construction of the Safford Mine in August 2006. Mining operations in the Dos Pobres pit began in August 2007.

During 2006, groundwater pumping for construction water was accomplished by installing relatively small horsepower (HP), temporary pumps in two of the production wells, GI-P1 and GI-P4 (Figure **2**). A

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[1] Shaft 1produces groundwater most of which comes from the Graben structure as discussed in Section 5

[2] Water level data are presented for LBF-01d and LBF-02d but not used in any 3M tests (see Section 6)

larger HP pump was also installed in existing Shaft 1 in the spring of 2007. By the fourth quarter of 2007, permanent pumps with greater HP were installed in production wells GI-P1, GI-P2, and GI-P4. Also during the fourth quarter of 2007, water was used to pre-wet the crushed/screened over-liner fill and run-of-mine rock layers on top of the leach pad liner in advance of leaching activities. Crushed ore agglomerated with water and acid was placed on the leach pad for the first time near the end of November 2007. Shortly thereafter, water and acid were applied to the material by drip lines. Prior to this time, most of the water produced at the mine was used for dust control and, to a lesser extent, other construction-related work, such as moisture conditioning of the leach pad under-liner materials. The first production of copper cathode from the electrowinning tank house occurred on December 26, 2007.

Implementation of the Alternate Year Fallowing Plan (see Section 3.3.3 of Appendix F of the FEIS) commenced in January 2008, with the fallowing of 200 acres of farmland near the Gila River in the Sanchez area. Fields fallowed during 2012 are listed in **Attachment 2** of this report.

4.0 Data Summary

This section provides a summary of the data available for the 2011-2012 3M evaluation. The evaluation includes groundwater production rates and groundwater levels from July 2011 through June 2012.

4.1 Groundwater Production Rates

Table 2 lists the estimated rate of pumping on a month-by-month basis for the mine in gallons per minute (gpm). Prior to December 2007, the average monthly rate was estimated based on periodic meter readings of pumped volumes. Starting December 2007, the values listed are average rates for each month based on automatically recorded pumping rates that were digitally saved at regular intervals by FMSI. The average pumping rates were derived from the pumping records by calculating the total volume pumped, in gallons, for each month and dividing the value by the total number of minutes in the corresponding month.

Figure 3 shows the monthly average pumping rate for each production well over time since March 2006, when site preparations began. Groundwater pumping through November 2007 was relatively small, typically ranging from 40 to 680 gpm. Mining commenced in August 2007 followed by leaching operations in December 2007 resulting in an increase in pumping. Since that time, average monthly pumping has ranged from a low of about 740 gpm in February 2010 to a peak of just over 3,370 gpm in October 2011. In general, fluctuations in pumping rates correlate with seasons, with larger pumping rates occurring during the summer months and smaller pumping occurring during winter months. This seasonal variation in rates is due to the amount of precipitation and evaporation at the site. The average pumping rate for the 2011-2012 evaluation period, the fifth year of mining, was approximately 2,750 gpm, which is only 74% of the anticipated rate simulated in the 2002 FEIS Model for the same year of mining. From the time when mining commenced in August of 2007 to the end of June 2012, the volume of water pumped was approximately 16,400 acre-ft, which is approximately 34% less than the anticipated volume of approximately 24,760 acre-ft simulated in the 2002 FEIS Model for the first five years of mining.

4.2 Water Levels

Water levels for the current evaluation period were obtained from the U. S. Geological Survey's (USGS) National Water Information System (NWIS) website:

http://nwis.waterdata.usgs.gov/nwis

The water level data can also be accessed from the USGS project website, http://az.water.usgs.gov/projects/9671-BGJ/samap-gmap.html, which is linked to NWIS. The instruments used to monitor water levels are owned and operated by FMSI[3]. Water level hydrographs for wells in each of the five groups of the 3M Program are shown in **Figures 4** to **14**.

From the hydrographs, it is apparent that the measured water levels fluctuate over time in every well of the 3M Program. These fluctuations typically occur over durations of less than a day to several months. For example, during the month of June 2007, water level fluctuations in LBF-01 (Group 1) ranged in magnitude from approximately 0.02 to 0.2 feet; whereas, longer term fluctuations at the same location in 2007 ranged in magnitude from approximately 0.2 to 0.4 feet. These natural fluctuations can hide or mask small changes in hydraulic gradients and drawdown caused by pumping.

There are 44 wells in the 3M Program with data on which to base a reasonable interpretation of long-duration trends. These water level trends over the last several years indicate two distinct patterns (**Table 3** summarizes the short and long-duration trends for each of the 47[4] wells in the five groups in the 3M Program, as well as the change for the evaluation period):

- Pattern 1- Characterized by a long-duration rise in water levels in many of the wells completed primarily in basin fill south and southeast of the mine. Exclusive of wells with unusual fluctuations, the magnitude of the net rise since 2002 varies from approximately 0.8 foot at AP-34 to approximately 2 feet at AP-27, DPW-10 and G5-02[5]. This pattern is observed in 21 of the 44 wells in the 3M Program, including all Group 1 wells, more than half of the Group 2 wells, and one deep Group 5 well, G5-02, which is completed in bedrock on the north side of Lone Star Mountain. This pattern of rise is well represented in LBF-01 (**Figure 4**).
- Pattern 2 – This distinct pattern is associated with a long-term trend of decreasing water levels that has been observed in 22 of the 44 wells. For the most part, this pattern of decline is observed in bedrock wells located near to or south of the Butte Fault and is well represented in AP-32 (**Figure 11**).

The water-level trend in one of the 44 wells (AP-09) exhibits a combination of rise and decline (**Figure 10**). For most, but not every well in the 3M Program, the general pattern of either water level decline or

[3] USGS provides periodic oversight and makes confirmatory measurements biannually.

[4] Three wells in the 3M Program, AP-01, AP-3A and AP-21 have unusual water-level fluctuations or have no data available for evaluating long-duration trends; thus 44 wells are evaluated with regard to long-duration trends.

[5] **Table 3**, values listed under "Long-Duration Water Level Fluctuation". A rise in water level is a positive value.

rise was clearly observed before pumping began for mining operations with the pattern generally continuing afterwards. These observed water level trends, therefore, likely represent ongoing natural fluctuations in the groundwater system (**Figures 4 to 14** and **Table 3**).

Water levels in many of the wells of Groups 1 and 2, which are mostly located outside the Graben, have been generally declining starting at various times in 2011 (all of the Group 1 wells and 18 of the 22 wells in Group 2). The current magnitudes of water-level declines are smaller than the overall rises described previously (**Figures 4 to 7**). Although pumping related to the mine is a candidate as a causative factor, the start of declining water levels occurs approximately the same time in many wells and the overall frequency and amplitude of water-level fluctuations among wells is very similar. These observations suggest that:

- The relation of these declines to drawdown in the mine's well field is complex.
- Another factor may also be contributing to the observed declines recently observed in the groups 1 and 2 wells[6].

An example of such similar behavior is seen between DPW-07 (near to the Graben where pumping occurs) and DPW-13 (far from the Graben in the direction of the Gila River; see **Figure 2**). The hydrographs of these two wells (**Figures 5 and 6**) show strong similarities. However, water levels in other wells do not show such strong similarities. For example, water levels in DPW-11 (approximately one mile north of DPW-13) started declining in June 2011, while those in AP-28 (approximately three miles east of DPW-13) began declining six months later in January, 2012 even though both wells are about equidistant from production wells. Another year's worth of water-level data may clarify both the causes of the declines and the nature of the hydraulic connections between the Groups 1 and 2 monitoring wells and the Graben production wells. The situation will then be reviewed during the next 3M evaluation.

Between November 3, 2011 and November 12, 2011, pumping tests were performed at well WW-2. This well is located approximately 1,450 feet south and slightly east of LBF-01 and 3,130 feet northeast of LBF-02, and it was pumped at a rate of up to approximately 1,100 gpm. Water levels in LBF-01, LBF-01d, LBF-02 and LBF-02d responded to the pumping stress and these responses are apparent in the hydrographs for these four wells (**Figure 4**). Water levels in other wells may also have been influenced by WW-2 pumping. Data from the pumping tests will be used in future efforts to improve the model.

For each well in the 3M Program, an estimate of the net change in water level between July 2007 and June 2012 has been calculated as shown in **Table 3**. The estimated net changes in water levels from July 2007 to June 2012 are also shown on **Figure 15**.

[6] Anecdotal evidence suggests that there have been regional water-level declines throughout the Gila and San Simon valleys perhaps related to severe to extreme drought conditions, and that this trend is presently continuing. See http://www.azwater.gov/AzDWR/StatewidePlanning/Drought/DroughtStatus2.htm

Water level measurements at the Group 1 wells indicate that natural water-level fluctuations and trends occur at the same time and approximately the same magnitude in Lower Basin Fill (LBF-01 and LBF-02) and in the deeper bedrock (LBF-01d and LBF-02d) (**Figure 4**). This suggests good hydraulic connection between bedrock and Lower Basin Fill in the zones these wells monitor.

Inspection of the hydrographs of wells in Group 4 reveals behavior in two of the wells (GI-T25 and GI-T18) that is unusual (**Figure 13**). GI-T25 shows a water-level rise of nearly 14 feet that occurred between the end of June 2007 and the end of September 2007. GI-T25 is located a few tens of feet to the north of a storm-water diversion ditch constructed for the mine. The cumulative precipitation recorded at Safford Airport for June, July and August of 2007 was 4.3 inches (based on data obtained from the National Climate Data Center), whereas the typical amount for June to August is approximately 3.5 inches. The 2007 rise in water levels in GI-T25 was likely related to infiltration of focused runoff along the newly constructed diversion ditch when precipitation levels were above normal. Smaller water-level rises also were recorded in 2008 and 2010 (the lack of rise in 2009 is probably due to much reduced precipitation that year of approximately 2.2 inches for June-August). The approximately annual pulses of recharge from the ditch mask, but do not overwhelm, the longer-term trend of declining water level in the well. This longer-term trend is probably the result of pumping related to the mine.

Since mid-2007 the water level in GI-T18, which is located near to, but south of, the Butte Fault, has dropped nearly 80 feet. This well is surrounded by several wells in Groups 4 and 5 (**Figure 2**). The magnitude of the water-level decline in GI-T18 is much larger than it is in surrounding wells (GI-T20, GI-T25, GI-T34, GI-T38, and G5-01B). Declines in the surrounding wells indicate small to no influence from pumping related to the mine (**Figures 13 and 14**). It appears that GI-T18 is more directly connected to the pumping center or mine dewatering than the surrounding wells, perhaps through fracture zones associated with the nearby Butte Fault.

Because the water-level trend in GI-T25 remains reasonably consistent with nearby wells, it will be included in the current 3M evaluation until the water-level data for this well indicate that it is being dominated by the nearby diversion ditch. GI-T18 is not included in the current 3M evaluation because a routine statistical screening of the Group 4 water-level data led to the conclusion that the GI-T18 water level data was an outlier whose inclusion would introduce bias in the 3M evaluation[7]. Recalibration of the model will be triggered by measurements that clearly indicate the influence of pumping over an area larger than suggested by a single well. If the recalibrated model can reasonably match the water-level decline in GI-T18 without cell-by-cell or localized revisions, or if at least one other nearby well provides confirmatory observations, the well will be restored as a Group 4 well for the 3M Program. Monitoring of GI-T18 will continue.

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[7] The Dixon Extreme Value Test (Singh, Maichle and Armbya, 2010) was used to identify outliers in the calculated change in water levels of Group 4 (water-level changes were computed using the methods of Test 2A, Section 6.3). The water-level change computed for GI-T18, 79.8 feet, was identified as an outlier at a significance level of between 5% and 10%.

5.0 Groundwater Model for 3M Program

The 3M plan requires that predictions of the effects from actual mine pumping on the groundwater system be made using a groundwater model. For the 2007-2008 3M evaluation, the groundwater model developed for the FEIS (URS Corporation 2002), known as the 2002 FEIS Model, was slightly modified in order to perform the appropriate simulations for the 2007-2008 evaluation period. Modifications to the 2002 model are described in detail in the 2007-2008 3M report by AquaGeo. The modified 2002 model is referred to as the 2008 3M Model. For the current 3M evaluation, a copy of the 2008 3M Model was further modified as described in this section. The model used in the current 3M evaluation is called the 2012 3M Model.

The 2002 FEIS Model and the current 2012 3M Model simulate long-term average recharge, which originates as infiltration of precipitation and runoff. The observed small rise in water levels in most areas in the vicinity of and to the south of the mine, except in close proximity to the pumping wells, is probably mostly due to climatic fluctuations (for example, changes in groundwater recharge along the foot of the Gila Mountains caused by long term variations in precipitation). In addition, several pumping tests were performed in the area in the mid 1990's which may account for a portion of the observed rise of water levels (the amount of groundwater pumped was very small compared to the amount currently extracted).

Although the model predicted very small water-level declines over the 3M evaluation period, actual water levels over the same time period were observed to be rising slightly in 21 of the 47 3M Program wells (trends in three wells, AP-01, AP-3A and AP-21, cannot be evaluated; see Section 4.2). Annual precipitation declined after 2007, with below normal amounts observed between 2008 and 2011 (**Figure 16**). Reduced recharge probably contributed to recent declines in water levels observed in several of the groups 1 and 2 wells. However, the relationship between water levels in wells and the timing and location of recharge to the Lower Basin Fill needs further study.

Flow in the Gila River is affected by the amount of precipitation. **Figure 16** shows the annual cumulative precipitation for three weather stations along with the annual mean flow at the Gila River stream gage located upstream of the City of Safford where the river enters Gila Valley. The Alpine and Buckhorn weather stations are located in the drainage basin of the Gila River upstream from this gage. The Safford weather station is located downstream of the gage at the City of Safford. As expected, the annual mean flow in the river at the gage changes with the amount of annual precipitation in the Gila River basin.

To prepare the model for the current 3M evaluation, the following modifications were made to the 2008 3M Model:

- Three simulations were prepared using the 2012 3M Model.

    1. The first is a steady-state simulation of pre-mining conditions. This simulation is essentially a re-run of the 2002 FEIS Model to obtain initial hydraulic-head conditions for subsequent transient simulations. Because the 2002 FEIS Model was calibrated to steady-state conditions characterized by water levels available through June 1996, all transient simulations start in June 1996.

2. The second simulation is a transient prediction for the period of time from June 1, 1996 to June 30, 2012. This period of time includes pre-mining groundwater pumping conducted for the purposes of large-scale testing or water supply.

3. The third simulation is a transient prediction for the same period of time as the second, except that no pumping for mining operations is included. This third simulation provides the hydraulic head data for the groundwater system without mine-related pumping stresses, which is needed for calculating the predicted drawdown due to mining. This was accomplished by subtracting predicted water levels with mine pumping from those without pumping[8]. The second and third predictive simulations are referred to as "pumping" and "non-pumping", respectively.

- The transient simulations are based on stress periods of one month in length. The total number of stress periods is 192. Each stress period is simulated using five time steps of varying length (shortest at the beginning of the month).

- For each stress period, the average rate of pumping was specified at each pumping well based on FMSI records. Section 4.1 provides a discussion of pumping rates and their estimation. **Table 4** provides a listing of pumping rates simulated in the 2012 3M Model at each location by month.

Except as noted above, no other changes were made to the 2008 3M Model to obtain the current 2012 3M Model used for this report. Revisions made to the 2002 FEIS Model that resulted in the 2008 3M Model are documented in in detail in the 2007-2008 3M report by AquaGeo. No recalibration of the model was performed to obtain the current 2012 3M Model. After running the transient pumping and non-pumping simulations, predicted drawdown was calculated for subsequent 3M calculations.

6.0 Implementation of the 2011-2012 3M Evaluation

Evaluation of the 3M Criteria requires comparisons of observed and modeled elevations of groundwater at specified monitoring wells. These wells, along with the 3M group numbers, are shown on **Figure 2**. Each 3M Statistic to be estimated from the water levels is described in Section 3.3.1.3, "Data Analysis" of the MMP. The evaluation of the program is achieved through a decision process that comprises a series of tests. The specific tests, along with numerical values of the 3M Criteria, are described in Figure 11 of the MMP (**Attachment 1**).

The influences on measured water levels from groundwater pumping for mining purposes and from natural background fluctuations are incorporated into both the measurement-based estimates of changes in water levels and in hydraulic gradients generated for each of the 3M tests. For monitoring locations where the natural water-level fluctuations and trends are significant, the influence of mine pumping may

[8] It is likely that if pumping from the pre-mining period were included in the model-predicted drawdown and subsequently used in 3M Tests, the conclusions of the overall 3M Program would not change. The method of computing predicted drawdown in a large three dimensional transient model with varying hydraulic conductivity and hydraulic stress by comparing two transient simulations is a commonly accepted method that improves the precision of the calculated drawdown.

be a slight to immeasurably small component of the measurement-based estimates of change. In fact, the component related to the pumping may not be discernible from direct measurements, especially in areas distant from where the pumping occurs. The difficulty in assessing these small groundwater pumping effects on the aquifer system is the primary purpose for utilizing the 3M Model.

It must be noted that the 3M Program (BLM, 2003) indicates that the focus of the Group 1 wells is the Lower Basin Fill, the most permeable aquifer between the mine and the Gila River. The program also indicates that the purpose of the deep wells LBF-01d and LBF-02d is to monitor conditions in the bedrock beneath the Lower Basin Fill for model calibration purposes (particularly the vertical gradient between the bedrock and overlying Lower Basin Fill). According to well logs and construction information, LBF-01d and LBF-02d are completed in and monitor bedrock just below the Lower Basin Fill. The monitoring intervals of the wells are sealed off from the Lower Basin Fill, so that water levels in these two wells are representative of the bedrock beneath the Lower Basin Fill. In addition, due to the smaller permeability of the bedrock relative to that of the Lower Basin Fill, any hydraulic influence from the mine pumping in the Lower Basin Fill would probably be transmitted to the deep Group 1 wells through the overlying Lower Basin Fill. Therefore, wells LBF-01d and LBF-02d are not included in the 3M calculations.

Each test of the 3M Program corresponds to a specific test in the flowchart shown in Figure 11 of Appendix F of the FEIS (**Attachment 1**). Boxes on the left side of the flow chart are numbered Test 1 and Test 2, whereas corresponding boxes on the right side are numbered 1A and 2A. Diamond shapes on the figure list the established 3M Criteria upon which each test is evaluated. Each of the applicable tests is discussed in detail in the following subsections.

6.1 Description and Results of 3M Test 1

Test 1, which only applies to Group 1 wells, focuses on water-level changes in the Lower Basin Fill between the mine and the Gila River. Test 1 is intended to evaluate the difference between two values for each Group 1 well, with each value representing an estimate of the influence of mine pumping on groundwater levels. The first value is calculated from measured groundwater levels, whereas the second value is a projection from the 2012 3M Model. Both values represent a change in water level between pre-mining conditions and conditions during mining at the end of the evaluation period. For each well, the difference between the two values is the statistical measure of Test 1. To meet the statistical requirements of Test 1, the difference between the modeled and measurement-based values must be 5 feet or less. The 3M Program allows for an adjustment of the measurement-based value that may account for natural variation in water levels, as discussed below.

An adjustment for natural fluctuation in water levels is critical to a proper statistical evaluation of Test 1. Depending on which period of time is used to calculate the amount of natural water-level variation from measured water levels, the resulting estimate of drawdown attributed to the mine may be either too large or too small. A one-year period of time, from August 1, 2006 to July 31, 2007, is used for calculations related to pre-mining conditions. For the current 3M evaluation, available water-level data for Group 1 wells were used for calculating the average pre-mining water level and the pre-mining range of natural water-level fluctuation for each well. The natural fluctuation range is calculated by subtracting the minimum measured pre-mining water level from the maximum measured pre-mining water level.

A one-month period of time, from June 1, 2012 to June 30, 2012 (the end of the evaluation period) is used for calculations related to mining conditions as called for in the 3M Program[9]. Therefore, available water levels for Group 1 wells for this one-month period were used for calculating the average water level during the time period associated with mine pumping.

Estimated water-level changes based on model predictions were calculated from the pumping and non-pumping simulations (Section 5.0). To calculate the model-projected magnitude of change due to mine-related pumping, the water level at the end of June 2012 for the pumping simulation was subtracted from the water level at the end of June 2012 for the non-pumping simulation.

Results of Test 1 (**Table 5**) indicate that, for each Group 1 well, the difference between the two values representing the estimated influence of mine-related pumping on the groundwater system is acceptable. According to the MMP, if the difference between these two values is less than the pre-mining range of natural water-level fluctuations, the criterion for the test is presumed satisfied. Based on the successful results of Test 1, the decision analysis of the 3M process proceeds to the next step, Test 1A.

6.2 Description and Results of 3M Test 1A

Test 1A is intended to evaluate the difference between two values representing changes in horizontal hydraulic gradients due to the influence of groundwater pumping for mining purposes. The first value is calculated from measured groundwater levels, whereas the second value is based on modeling results from the transient simulation. For this test, the change in hydraulic gradient over time is expressed as a percentage. For the model to pass the Test 1A criterion, the difference between the two percentages must be 25% or less. The 3M Program does not allow for an adjustment of the measurement-based value representing the magnitude of change in hydraulic gradient that could account for natural variations. Because the hydraulic gradients are a composite response to numerous factors, including fluctuations of the natural system and groundwater pumping for mining purposes, the computed gradients represent a composite measurement-based value for assessing the magnitude of overall change over the area of interest. Prior to installation of the Group 1 wells, there were no data available that provided information on the transient variability of water levels in the Group 1 area. In addition, actual hydraulic gradients in the area of the Group 1 wells were much smaller than anticipated. This resulted in a situation where small natural fluctuations can cause apparent gradient changes that can exceed the range of the gradient criterion specified in the FEIS.

Test 1A only applies to the following two pairs of wells in Group 1 (see Section 6.0 regarding the exclusion of wells LBF-01d and LBF-02d):

- LBF-01 and LBF-02
- LBF-03 and LBF-04

For each well pair, the measurement-based values of hydraulic gradients were calculated as follows. In accordance with the 3M Program, the pre-mining average water level from Test 1 for the southwestern

[9] See Section 3, Exhibit 3, Appendix F of the FEIS; BLM, 2003

well (LBF-02 or LBF-04) was subtracted from the pre-mining average water level from Test 1 for the northeastern well (LBF-01 or LBF-03). This water-level difference is then divided by the distance in feet between the two wells in the well-pair under evaluation. A positive hydraulic gradient indicates an overall groundwater flow direction to the southwest. The hydraulic gradient value for the mining period is calculated similar to the pre-mining value except the average water levels for the mining period are used. Estimated hydraulic gradients based on model predictions were calculated similar to the measurement-based estimates using model-based average water levels at the model cells corresponding to each well location.

The percent change in hydraulic gradient over time is computed for each well pair from the estimates of hydraulic gradient for the pre-mining and mining periods[10]. This calculation is done for measurement-based values and model-based estimates of hydraulic gradient. The difference between the measurement-based and model-based change in hydraulic gradient, expressed in percent, is then computed and compared to the criterion of Test 1A.

The results of Test 1A indicate that the difference between the model- and measurement-based values of hydraulic gradient change over time are apparently unacceptable according to the 3M Program for LBF-03/LBF-04 (**Table 6)**. Based on the results of Test 1A, the decision analysis of the 3M process should proceed to Test 2. The consistent trend of rising water levels in all of the Group 1 wells that began before mining commenced has generally discontinued or reversed at various times starting in 2011. Another year's worth of water-level data may clarify both the causes of the declines and the nature of the hydraulic connections between the wells and the Graben. Therefore, the decision analysis of the 3M process proceeds to Test 2A which focuses on the Group 4 and 5 wells which are closer to the mine pumping.

6.3 Description and Results of 3M Test 2A

The intent of Test 2A is similar to that of Test 1, except Test 2A applies to wells in Groups 4 and 5. The numerical criterion for Test 2A is 10 feet of water elevation difference for the current 3M evaluation. Unlike Test 1, the 3M Program does not allow for an adjustment of the measurement-based values of water-level change that may account for natural transient variation in water levels.

For Test 2A, the water level measured immediately before mining commenced is used to represent pre-mining conditions. Similarly, conditions during mining operations are represented by the water level measured nearest the end of the evaluation period. For comparison to model prediction results, the simulated water level closest in time to the measured water level is used to represent pre-mining (i.e. non-pumping) and mining (i.e., pumping) conditions for each well and time period. To calculate the water-level change, the selected water levels during the mining period are subtracted from the selected pre-mining water levels.

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[10] Percent change in gradient is computed by subtracting the June 2012 gradient from the June 2007 gradient, then dividing that difference by the June 2007 gradient, and then multiplying the result by 100 (Section 3, Exhibit 3, Appendix F of the FEIS; BLM, 2003). A positive percentage indicates a decrease in the gradient toward the southeast.

Results of Test 2A indicate an acceptable difference between the modeled estimates of water-level change and the change in water level based on measurements for Group 4 and Group 5. **Table 7** provides a summary of results for Test 2A, which indicates that the statistical measures comply with the criterion of 10 feet. This outcome for Test 2A is reasonable considering the measured water levels for all wells of Groups 4 and 5. Therefore, the decision analysis of the 3M process terminates at the conclusion of Test 2A. According to the 3M Program, monitoring will continue for one year before a re-evaluation is conducted to assess possible further actions.

6.4 Summary of 3M Evaluation

An evaluation of the 3M Program for the 2011-2012 period has been conducted utilizing the 2012 3M Model to represent groundwater conditions and responses to induced stresses. The results of the 3M evaluation for the 2011-2012 period, which are summarized in **Table 8**, indicates that the model does not require recalibration at this time.

7.0 Summary and Conclusions

The fifth annual evaluation of the 3M Program for the Safford Mine has been conducted and is presented in this report. The purpose of the 3M evaluation is to monitor the performance of improved versions of the 3M Model with regard to its ability to simulate the changes in water levels and hydraulic gradients over time as mining proceeds. The performance of the model is evaluated using a series of tests that compare differences between measurement-based values and model-based estimates of field conditions. The measurement-based values are calculated from data obtained from five groups of wells monitored for the 3M Program. The model-based estimates are obtained from a version of the 2002 FEIS Model that has been modified to more accurately simulate monthly average pumping based on actual pumping records for the mine. The 2002 FEIS Model represents the most recent calibration of the model.

The intent of the 3M Program is to provide a more reliable groundwater model from which predictions of the effects of the mine pumping on the groundwater system can be made. The available data indicate that there have not yet been enough stresses from pumping on the hydrogeologic system to allow a substantial improvement to the model at this time. Due to the anomalous water-level decline in well GI-T18, it will not be included in evaluations of the 3M Program, at least until such time that a recalibration of the model, which is triggered by measurements that clearly indicate the influence of pumping over an area larger than suggested by a single well, can simulate more precisely the effects of mine pumping on water levels in this well without resorting to highly localized revisions. The overall conclusion of the current evaluation of the 3M Program is that the model does not need to be updated and recalibrated for the purposes of the 3M Program for at least one more year.

Review of the water-level data from the five groups of 3M wells continues to indicate that the elevation of water levels have either been consistently increasing or decreasing based on spatial location, and that these two trends were established considerably prior to commencement of mining. The increasing and decreasing water-level trends suggest that the regional groundwater system is in a natural dynamic state, adjusting to changing recharge. Of particular interest, general increases in the elevation of water levels in all of the Group 1 wells, and many of the Group 2 wells, located closest to the Gila River have been recorded. The rise in water levels at these locations began more than two and a half years before groundwater pumping commenced at mine production wells GI-P1, GI-P2, GI-P4 and Shaft 1. The data analysis has revealed that natural water-level fluctuations are, except for wells in close proximity to the pumping wells, up to approximately 10 times larger than model predicted drawdown from mine-related pumping. This has masked effects on the groundwater system that may have been due to localized pumping related to the mine.

Considerable data has been collected since the inception of the 3M Program. Accounting for this new information in the model will probably lead to beneficial improvements in our understanding of groundwater conditions in the area of monitoring. Although the result of the current evaluation of the 3M Program is that the model does not need to be recalibrated at this time, discussions will be held with the USGS regarding update of the model using new software technology and recalibration based on monitoring data.

Actual pumping rates for the Safford Mine, both during the construction period and through the mining period included in this analysis (see **Table 2** of this report), have been substantially less than the estimated water demand rates shown in Section 2.1.2.2.1 of the FEIS, which were used in the 2002 FEIS Model for developing model simulated effects of mine development. Based on the actual water demand for the Safford Mine thus far, as well as current operating plans, the pumping rates for the foreseeable future are expected to be less than the rates previously used in the model to assess potential effects to the regional groundwater system, including potential effects to surface flows of the Gila River. See Sections 4.3.2.5.1 and 4.3.2.6.1 of the FEIS for additional background on the 2002 FEIS Model studies and results.

Water levels in many of the wells in groups 1 and 2 have been declining starting at various times in 2011. The magnitudes of water-level declines are currently smaller than the overall rises described previously. Preliminary review of the water-level data suggests that the relation of the water-level declines to drawdown in the mine's well field is complex, and that other natural processes may also be contributing to the observed declines. Another year's worth of water-level data may clarify both the causes of the declines and the nature of the hydraulic connections between the monitoring wells and the Graben production wells.

8.0 Selected References

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TABLES

Table 1. Summary of Information for Monitoring Wells in the 3M Program

3M Program Monitoring Well Group or Water-Chemistry Well	Well	Latitude[1] NAD 83 (degrees)	Longitude[1] NAD 83 (degrees)	3M Model Layer[2]	Altitude of Land Surface[3] (ft)	Open Intervals[1] (depth below land surface, ft)	Water Level[4]	Date of Water Level[5]
Group 1	LBF-01	32.93609	-109.71638	10	3,421.803	375-495	3,027.45	7/30/07
	LBF-01d	32.93614	-109.71632	13	3,422.756	915-1,015	3,027.88	7/30/07
	LBF-02	32.92716	-109.72342	10	3,297.256	250-370	3,027.12	7/30/07
	LBF-02d	32.92723	-109.72343	12	3,297.772	604-705	3,027.77	7/30/07
	LBF-03	32.92247	-109.6918	10	3,474.962	425-545	3,033.62	7/30/07
	LBF-04	32.91365	-109.69869	10	3,332.027	270-390	3,033.40	7/30/07
Group 2	AP-11	32.94751	-109.69914	11	3,681.041	790-1,200	3,123.59	6/25/07
	AP-12	32.95105	-109.68904	8	3,798.969	560-610	3,242.66	6/25/07
	AP-20	32.94291	-109.658	9	4,043.345	928-988	3,522.74	6/29/07
	AP-22	32.9363	-109.68451	9	3,670.456	652-752	3,043.46	6/25/07
	AP-23	32.93309	-109.66599	9	3,759.342	758-808	3,039.98	6/29/07
	AP-24	32.93244	-109.65722	8	3,836.358	640-740	3,155.15	6/29/07

	AP-26	32.92704	-109.67695	9	3,647.706	620-670	3,039.21	6/29/07
	AP-27	32.92097	-109.69728	9	3,415.721	430-480	3,037.33	6/28/07
	AP-28	32.91674	-109.68399	10	3,475.688	509-559	3,039.62	6/29/07
	AP-29	32.9172	-109.66906	9	3,504.295	518-568	3,039.49	6/29/07
	AP-30	32.92778	-109.64711	6	3,824.308	250-300	3,750.00	6/29/07
	AP-34	32.93141	-109.70094	13	3,489.43	1,150-1,200	3,036.62	6/29/07
	DPW-01	32.95543	-109.70943	9	3,696.617	565-605	3,175.38	6/26/07
	DPW-03	32.93642	-109.67442	9	3,839.96	800-910	3,041.77	6/29/07
	DPW-07	32.9408	-109.71151	10	3,509.548	685-735	3,033.81	6/26/07
	DPW-08	32.91893	-109.72562	10	3,217.952	310-345	3,031.17	6/26/07
	DPW-10	32.93931	-109.75478	11	3,246.617	535-565	3,028.00	6/26/07
	DPW-11	32.93364	-109.74049	10	3,274.092	340-370	3,029.01	6/26/07
	DPW-12	32.92461	-109.7557	12	3,093.238	610-650	3,025.43	6/26/07
	DPW-13	32.91929	-109.74129	12	3,144.463	510-540	3,027.76	6/26/07
	DPW-15	32.929	-109.68775	10	3,575.524	770-800	3,038.49	6/29/07

	DPW-16	32.93148	-109.70099	11	3,489.616	770-800	3,037.02	6/29/07
Group 3	AP-01	32.973	-109.68429	5	4,167.092	497-608	3,974.29	6/26/07
	AP-02	32.96882	-109.67673	4	4,166.612	280-330	4,094.90	6/29/07
	AP-3A	32.97078	-109.65844	4	4,498.23	585-635	No Data	No Data
	AP-09	32.96171	-109.65821	3	4,273.178	135-185	4,185.76	6/26/07
	AP-10	32.95506	-109.64884	7	4,188.046	747-797	3,892.89	6/29/07
	AP-21	32.94071	-109.64774	4	4,089.629	258-308	3,948.26	6/26/07
	AP-25	32.93774	-109.65431	5	3,919.524	255-315	3,907.23	6/25/07
	AP-32	32.95951	-109.66263	5	4,185.191	408-458	3,884.46	6/26/07
	DPW-05	32.96892	-109.66833	10	4,290.937	1,320-1,370	3,971.68	6/26/07
	DPW-06	32.95591	-109.65458	7	4,159.725	700-750	4,070.43	6/26/07
Group 4	GI-T18	32.98311	-109.71113	9	4,153.553	1,236-1,614 1,724-2,501	3,250.89	6/26/07
	GI-T20	32.98753	-109.70342	6	4,302.121	492-1,092	3,814.36	6/26/07
	GI-T25	32.98037	-109.69494	5	4,335.144	200-1,320	4,104.47	6/26/07
	GI-T34	32.97332	-109.72002	11	3,925.887	645-2,489	3,257.58	6/26/07

	GI-T38	32.99575	-109.71974	8	4,374.871	500-1,919	3,833.14	6/26/07
Group 5	G5-01A	33.03156	-109.70211	1	5,089.749	278-478	4,884.25	6/26/07
	G5-01B	33.00588	-109.69841	3	4,568.338	358-458	4,475.95	6/26/07
	G5-02	32.93966	-109.58834	6	4,418.456	770-870	3,841.20	6/29/07
	RB-1	33.04295	-109.70973	2	5,699.193	1,070-1,270	4,858.39	6/26/07

[1] Obtained from http://nwis.waterdata.usgs.gov. "NAD" = North American Datum.
[2] URS Corporation, 2002, Appendix B.
[3] Data for 3M wells obtained from http://nwis.waterdata.usgs.gov; data for water-chemistry wells obtained from URS Corporation, 2002, Table 2-1.
[4] Data for 3M wells obtained from http://nwis.waterdata.usgs.gov; data for water-chemistry wells obtained from URS Corporation, 2002, Table 2-2.
[5] Mining commenced August 2007.

Table 2. Monthly Average Pumping Rate from March 2006 to June 2012

Date	Monthly Average Pumping Rate (gpm)				
	GI-P1	GI-P2	GI-P4	Shaft 1	Total Rate
March, 2006	0.0	0.0	38.0	0.0	38.0
April, 2006	0.0	0.0	44.9	0.0	44.9
May, 2006	0.0	0.0	107.0	0.0	107.0
June, 2006	0.0	0.0	107.0	0.0	107.0
July, 2006	0.0	0.0	107.0	0.0	107.0
August, 2006	0.0	0.0	107.0	0.0	107.0
September, 2006	96.6	0.0	107.0	0.0	203.6
October, 2006	119.4	0.0	106.0	0.0	225.4
November, 2006	99.9	0.0	88.0	0.0	187.9
December, 2006	63.7	0.0	63.4	0.0	127.1
January, 2007	80.2	0.0	80.0	0.0	160.2
February, 2007	90.0	0.0	88.0	0.0	178.0
March, 2007	156.3	0.0	159.1	0.0	315.4
April, 2007	203.2	0.0	191.8	37.5	432.5
May, 2007	218.0	0.0	176.4	134.8	529.2
June, 2007	202.4	0.0	142.2	284.2	628.8
July, 2007	156.6	0.0	134.2	42.1	332.9
August, 2007[a]	56.7	0.0	50.4	575.2	682.2
September, 2007	0.0	2.3	0.0	510.5	512.8

October, 2007	10.1	13.0	149.7	193.1	365.8
November, 2007	87.5	131.0	49.0	67.0	334.5
December, 2007	130.3	365.9	465.7	0.0	961.9
January, 2008	145.8	532.1	736.9	0.0	1,414.9
February, 2008	178.5	448.9	1,127.7	132.3	1,887.3
March, 2008	311.0	324.8	1,066.7	365.7	2,068.2
April, 2008	554.5	551.8	509.5	530.8	2,146.7
May, 2008	622.6	373.0	438.4	541.6	1,975.6
June, 2008	556.9	277.6	1,411.2	290.2	2,535.9
July, 2008	533.9	45.6	1,020.7	0.0	1,600.2
August, 2008	401.5	627.9	1,315.3	9.9	2,354.7
September, 2008	408.6	1,161.8	145.5	219.8	1,935.7
October, 2008	542.5	1,328.0	842.2	50.2	2,762.8
November, 2008	465.6	1,439.9	475.6	0.0	2,381.0
December, 2008	402.2	1,432.2	115.4	0.0	1,949.9
January, 2009	576.6	519.5	573.3	0.0	1,669.4
February, 2009	476.3	515.1	117.2	65.0	1,173.5
March, 2009	505.7	863.6	129.3	178.9	1,677.5
April, 2009	392.2	964.9	161.4	281.6	1,800.1
May, 2009	609.8	774.7	323.1	271.8	1,979.4
June, 2009	427.3	888.8	814.8	283.6	2,414.6
July, 2009	511.5	985.3	198.7	412.6	2,108.2

August, 2009	484.2	911.2	214.7	416.1	2,026.2
September, 2009	546.3	1,095.6	367.2	357.4	2,366.5
October, 2009	507.9	1,059.7	647.1	396.9	2,611.7
November, 2009	531.9	1,036.3	373.7	324.7	2,266.6
December, 2009	566.5	790.2	210.7	146.4	1,713.9
January, 2010	369.9	479.2	143.3	120.1	1,112.5
February, 2010	174.3	378.6	77.2	110.5	740.6
March, 2010	345.7	541.7	133.5	212.3	1,233.1
April, 2010	434.7	1,139.8	843.1	416.1	2,833.6
May, 2010	487.9	588.9	793.3	600.7	2,470.8
June, 2010	71.5	914.5	701.2	790.9	2,478.1
July, 2010	0.2	736.1	602.1	534.6	1,873.1
August, 2010	329.0	1,135.9	680.4	8.7	2,154.1
September, 2010	674.0	734.9	561.5	102.4	2,072.8
October, 2010	604.7	415.6	818.0	481.5	2,319.8
November, 2010	206.7	1,090.4	291.7	508.0	2,096.7
December, 2010	378.8	277.3	31.1	521.1	1,208.4
January, 2011	238.0	661.5	203.2	679.7	1,782.4
February, 2011	249.0	767.5	193.5	722.3	1,932.3
March, 2011	456.8	1,005.9	338.4	222.2	2,023.3
April, 2011	638.6	1,393.2	671.7	8.1	2,711.6
May, 2011	646.7	1,399.5	755.2	247.0	3,048.4

June, 2011	675.9	1,208.2	415.2	499.0	2,798.3
July, 2011	651.7	1,030.5	724.2	546.1	2,952.5
August, 2011	780.9	857.5	1,140.5	532.0	3,310.9
September, 2011	782.4	641.7	1,299.5	8.6	2,732.2
October, 2011	866.3	1,050.9	1,334.9	119.8	3,371.9
November, 2011	761.6	546.1	954.4	556.3	2,818.3
December, 2011	592.5	500.0	789.9	195.1	2,077.5
January, 2012	785.4	636.4	472.4	222.2	2,116.5
February, 2012	619.0	767.7	841.0	279.5	2,507.2
March, 2012	266.1	884.2	1,164.9	379.5	2,694.7
April, 2012	513.0	638.2	1,207.2	542.4	2,900.7
May, 2012	636.0	842.3	1,114.9	557.3	3,150.5
June, 2012	530.6	589.6	713.0	494.4	2,327.5

[a] Mining commenced August 2007.

Table 3. Approximate Magnitude of Water Level Fluctuations and Water Level Change for the 3M Evaluation Period

3M Program Monitoring Well Group Number	Well	Short-Duration Water Level Fluctuation[a] (ft)	Long-Duration Water Level Fluctuation[b] (ft)	Estimated Change in Water Level For Evaluation Period[c] (ft)	Notes[d]
Group 1	LBF-01	0.4	1.7	0.6	1, 2
	LBF-01d	0.4	1.5	0.5	1, 2
	LBF-02	0.3	1.4	0.5	1, 2
	LBF-02d	0.3	1.8	0.5	1, 2
	LBF-03	0.3	1.1	0.4	1, 2
	LBF-04	0.6	1.0	0.5	1, 2
Group 2	AP-11	0.4	-28.0	-23.2	1, 2, 9
	AP-12	0.1	-55.0	-47.8	3, 10
	AP-20	0.2	-7.3	-2.1	1, 2
	AP-22	0.4	-2.9	-4.6	1, 2, 5, 9
	AP-23	0.2	1.0	0.3	1, 2
	AP-24	0.4	-35.0	-2.6	1, 2, 4
	AP-26	0.2	1.3	0.2	1, 2
	AP-27	0.4	2.0	0.4	1, 2
	AP-28	0.2	1.8	0.5	1, 2
	AP-29	0.4	1.7	0.5	1, 2
	AP-30	1.4	-10.9	-4.6	1, 2
	AP-34	0.4	0.8	-0.4	1, 2

	DPW-01	0.4	-29.0	-23.7	1, 2
	DPW-03	0.2	-5.0	-2.1	1, 2
	DPW-07	0.4	1.1	0.2	1, 2
	DPW-08	1.0	1.5	0.4	1, 2
	DPW-10	0.5	2.0	0.4	1, 2, 6
	DPW-11	0.5	1.8	0.4	1, 2
	DPW-12	0.7	1.7	0.3	1, 2
	DPW-13	0.8	1.6	0.4	1, 2
	DPW-15	0.4	1.3	0.1	1, 2
	DPW-16	0.4	1.3	-0.2	1, 2
Group 3	AP-01	0.4	---	---	5
	AP-02	1	-20.0	-7.7	6, 11
	AP-3A	---	---	---	7
	AP-09	6	-2.0	-0.9	2
	AP-10	0.4	-24.0	-11.3	1, 2
	AP-21	5	---	---	5
	AP-25	10	-17.0	-14.4	2, 8, 9
	AP-32	0.4	-23.0	-17.7	1
	DPW-05	0.3	-29.0	-30.1	5
	DPW-06	0.4	-6.5	-2.5	1, 2
Group 4	GI-T18	0.4	-84.0	-79.8	1,14
	GI-T20	0.6	-17.0	-6.8	1, 2

	GI-T25	0.5	-7.0	6.9	6, 12
	GI-T34	0.5	-26.0	-25.4	1, 2
	GI-T38	0.4	-5.0	-2.4	1, 2
Group 5	G5-01A	0.4	-12.0	-4.9	1, 2, 13
	G5-01B	3.5	-3.0	-4.6	1, 2
	G5-02	0.3	2.0	1.6	1, 2
	RB-1	0.5	0.0	-0.3	1, 2, 6

[a] Short duration fluctuations are representative of less than one day to several days. Fluctuations are approximate values based on data collected prior to August 2007 (pre-mining).

[b] Long duration fluctuations represent approximate net change based on data collected since monitoring for the 3M Program began. A negative value indicates a declining water-level trend.

[c] Water-level change equals the average or representative water level for the month preceding the start of mining (July 2007) subtracted from the water level for last month of the 3M evaluation period (June 2010). A negative value indicates that the June 10 water level is lower than the July 07 water level.

[d] Notes:

1. Water-level trend (rising or falling) established prior to start of mining
2. Natural fluctuation (a or b) is larger than estimated change (c).
3. Located near pumping wells GI-P1 and GI-P4.
4. Unusual water level trend and fluctuations.
5. Water level is strongly influenced by water chemistry sampling events; recovery takes 1 to 2 (or more) years.
6. Unusual water level fluctuations.
7. Insufficient data.
8. Water level influenced by sampling.
9. Well is used in the Aquifer Protection Permit program.
10. After 7/29/09, the water level at AP-12 fell below the bottom of the monitored interval.
11. The 20-foot rise before mine pumping started correlates with an 18-month wet period starting June 2006 (previous 16-months drier), and may be related to construction activities
12. Water level is likely influenced by construction of diversion channel at this location that may have created a zone through which infiltration of ponded water is enhanced. Sharp water level rise in June of 2007 correlates with precipitation events starting on June 11th, 2007.
13. The 12-foot drop (as of June 2010) started at well construction and may be an artifact of drilling.
14. The value for the “Estimated Change in Water Level for Evaluation Period” has been identified as an outlier among the Group 4 wells (see Section 4.2, Water Levels)

Table 4. Monthly Average Pumping Rate Simulated in 2012 3M Model

Month	Monthly Average Pumping Rate (gpm)					
	GI-P1	GI-P2	GI-P4	Shaft 1	GI-P3	Total Rate
June, 1996	0.0	533.3	0.0	0.0	0.0	533.3
July, 1996	0.0	45.7	0.0	0.0	0.0	45.7
August, 1996	0.0	1,981.9	0.0	0.0	0.0	1,981.9
September, 1996	0.0	2,290.6	2,717.1	0.0	1,138.9	6,146.6
October, 1996	348.4	2,000.0	3,200.0	0.0	1,000.8	6,549.2
November, 1996	0.0	1,029.6	3,200.0	0.0	0.0	4,229.6
December, 1996	0.0	0.0	1,423.9	0.0	0.0	1,423.9
January, 1997 To February, 2006	0.0	0.0	0.0	0.0	0.0	0.0
March, 2006	0.0	0.0	5.1	0.0	0.0	5.1
April, 2006	0.0	0.0	6.0	0.0	0.0	6.0
May, 2006	0.0	0.0	14.3	0.0	0.0	14.3
June, 2006	0.0	0.0	14.3	0.0	0.0	14.3
July, 2006	0.0	0.0	14.3	0.0	0.0	14.3
August, 2006	0.0	0.0	14.3	0.0	0.0	14.3
September, 2006	12.9	0.0	14.3	0.0	0.0	27.2
October, 2006	16.0	0.0	14.2	0.0	0.0	30.1
November, 2006	13.4	0.0	11.8	0.0	0.0	25.1
December, 2006	8.5	0.0	8.5	0.0	0.0	17.0

January, 2007	10.7	0.0	10.7	0.0	0.0	21.4
February, 2007	12.0	0.0	11.8	0.0	0.0	23.8
March, 2007	20.9	0.0	21.3	0.0	0.0	42.2
April, 2007	27.2	0.0	25.6	5.0	0.0	57.8
May, 2007	29.1	0.0	23.6	18.0	0.0	70.7
June, 2007	27.1	0.0	19.0	38.0	0.0	84.1
July, 2007	20.9	0.0	17.9	5.6	0.0	44.5
August, 2007	7.6	0.0	6.7	76.9	0.0	91.2
September, 2007	0.0	0.3	0.0	68.2	0.0	68.6
October, 2007	1.3	1.7	20.0	25.8	0.0	48.9
November, 2007	11.7	17.5	6.6	9.0	0.0	44.7
December, 2007	130.3	365.9	465.7	0.0	0.0	961.9
January, 2008	145.8	532.1	736.9	0.0	0.0	1,414.9
February, 2008	178.5	448.9	1,127.7	132.3	0.0	1,887.3
March, 2008	311.0	324.8	1,066.7	365.7	0.0	2,068.2
April, 2008	554.5	551.8	509.5	530.8	0.0	2,146.7
May, 2008	622.6	373.0	438.4	541.6	0.0	1,975.6
June, 2008	556.9	277.6	1,411.2	290.2	0.0	2,535.9
July, 2008	533.9	45.6	1,020.7	0.0	0.0	1,600.2
August, 2008	401.5	627.9	1,315.3	9.9	0.0	2,354.7
September, 2008	408.6	1,161.8	145.5	219.8	0.0	1,935.7
October, 2008	542.5	1,328.0	842.2	50.2	0.0	2,762.8

November, 2008	465.6	1,439.9	475.6	0.0	0.0	2,381.0
December, 2008	402.2	1,432.2	115.4	0.0	0.0	1,949.9
January, 2009	576.6	519.5	573.3	0.0	0.0	1,669.4
February, 2009	476.3	515.1	117.2	65.0	0.0	1,173.5
March, 2009	505.7	863.6	129.3	178.9	0.0	1,677.5
April, 2009	392.2	964.9	161.4	281.6	0.0	1,800.1
May, 2009	609.8	774.7	323.1	271.8	0.0	1,979.4
June, 2009	427.3	888.8	814.8	283.6	0.0	2,414.6
July, 2009	511.5	985.3	198.7	412.6	0.0	2,108.2
August, 2009	484.2	911.2	214.7	416.1	0.0	2,026.2
September, 2009	546.3	1,095.7	367.3	357.4	0.0	2,366.5
October, 2009	507.9	1,059.7	647.1	396.9	0.0	2,611.7
November, 2009	531.9	1,036.3	373.7	324.7	0.0	2,266.6
December, 2009	566.5	790.2	210.7	146.5	0.0	1,713.9
January, 2010	369.9	479.2	143.3	120.2	0.0	1,112.5
February, 2010	174.3	378.6	77.2	110.5	0.0	740.6
March, 2010	345.7	541.7	133.5	212.3	0.0	1,233.1
April, 2010	434.7	1,139.8	843.1	416.1	0.0	2,833.6
May, 2010	487.9	588.9	793.3	600.7	0.0	2,470.8
June, 2010	71.5	914.5	701.2	790.9	0.0	2,478.1
July, 2010	0.2	736.1	602.1	534.6	0.0	1,873.1
August, 2010	329.0	1,135.9	680.4	8.7	0.0	2,154.1

September, 2010	674.0	734.9	561.5	102.4	0.0	2,072.8
October, 2010	604.7	415.6	818.0	481.5	0.0	2,319.8
November, 2010	206.7	1,090.4	291.7	508.0	0.0	2,096.7
December, 2010	378.8	277.3	31.1	521.1	0.0	1,208.4
January, 2011	238.0	661.5	203.2	679.7	0.0	1,782.4
February, 2011	249.0	767.5	193.5	722.3	0.0	1,932.3
March, 2011	456.8	1,005.9	338.4	222.2	0.0	2,023.3
April, 2011	638.6	1,393.2	671.7	8.1	0.0	2,711.6
May, 2011	646.7	1,399.5	755.2	247.0	0.0	3,048.4
June, 2011	675.9	1,208.2	415.2	499.0	0.0	2,798.3
July, 2011	651.7	1,030.5	724.2	546.1	0.0	2,952.5
August, 2011	780.9	857.5	1,140.5	532.0	0.0	3,310.9
September, 2011	782.4	641.7	1,299.5	8.6	0.0	2,732.2
October, 2011	866.3	1,050.9	1,334.9	119.8	0.0	3,371.9
November, 2011	761.6	546.1	954.4	556.3	0.0	2,818.3
December, 2011	592.5	500.0	789.9	195.1	0.0	2,077.5
January, 2012	785.4	636.4	472.4	222.2	0.0	2,116.5
February, 2012	619.0	767.7	841.0	279.5	0.0	2,507.2
March, 2012	266.1	884.2	1,164.9	379.5	0.0	2,694.7
April, 2012	513.0	638.2	1,207.2	542.4	0.0	2,900.7
May, 2012	636.0	842.3	1,114.9	557.3	0.0	3,150.5
June, 2012	530.6	589.6	713.0	494.4	0.0	2,327.5

Table 5. Results for 3M Test 1

Well	Measurement-Based Water-Level Change, Less Pre-Mining Annual Water Level Fluctuation, for Each LBF Well Since the Last Model Calibration[1] (ft)	Model-Based Water-Level Change, for Each LBF Well Since the Last Model Calibration[1] (ft)	Difference Between Measurement-Based and Model-Based Water-Level Changes (ft)	3M Criteria[2] and Result If Any Values Are Greater Than 5 feet, Then Go To Test 2; Otherwise Go To Test 1A
LBF-01	0.00	0.00	0.00	Go To Test 1A
LBF-02	-0.11	0.00	-0.11	
LBF-03	0.00	0.00	0.00	
LBF-04	0.00	0.00	0.00	

[1] Evaluation is performed on Well Group 1 for the period from commencement of mining through June 2012 (Evaluation Period). If the pre-mining fluctuation is greater than the change between July 2007 and June 2012, the water-level change, if any, related to mining is not measureable, and assumed to be zero, for the evaluation period. Conclusions of the current 3M evaluation are summarized in Table 8.

[2] For the purposes of the 3M Program, mining is assumed to have commenced in August, 2007.

Table 6. Results for 3M Test 1A

Well-Pair	Measurement-Based Estimated Hydraulic Gradient Since the Last Model Recalibration[1] (-)	Modeled Hydraulic Gradient Since the Last Model Recalibration[1] (-)	Difference in Percent Change of Measurement-Based Estimated and Modeled Hydraulic Gradients for each LBF Well-Pair Since the Last Model Recalibration[1] (%)	3M Criteria[2] and Result If Any Values Are Greater Than 25%, Then Go To Test 2; Otherwise Go To Test 2A.
LBF-01 : LBF-02	1.03E-04[a]	2.43E-04[a]	-4	Go To Test 2[c]
LBF-03 : LBF-04	2.44E-05[b]	6.19E-04[b]	62	

[1] Evaluation is performed on Well Group 1 for the period from commencement of mining through June 2012 (Evaluation Period). Conclusions of the current 3M evaluation are summarized in Table 8.

[2] For the purposes of the 3M Program, mining is assumed to have commenced in August, 2007.

[a] For the pre-mining period (August 2006 to June 2007), the measurement-based estimated hydraulic gradient is 9.88E-05 for LBF-01:LBF-02, and the corresponding modeled hydraulic gradient is 2.43E-04 (the model predicts that the gradient does not change over time).

[b] For the pre-mining period (August 2006 to June 2007), the measurement-based estimated hydraulic gradient is 6.48E-05 for LBF-03:LBF-04, and the corresponding modeled hydraulic gradient is 6.20E-04 (the model predicts that the gradient does not change over time).

[c] See Section 6.2.

Table 7. Results for 3M Test 2A

Well Group	Well	Measurement-Based Water-Level Change[1] (ft)	Model-Based Water-Level Change[1] (ft)	Absolute Value Of The Difference Between Measurement-Based and Model-Based Water-Level Change[1] (ft)	Computed mean value of the difference for Group 4 and 5 wells	3M Criteria[2] and Result If Any Value Is More Than 10 Feet, Then Recalibrate The Model, Run The Mining Period Prediction, And Adjust The Mitigation As Necessary, And Wait One Year And Re-Evaluate; Otherwise Wait One Year And Re-Evaluate
4	GI-T20	6.84	0.00	6.84	**5.2**	Wait one year and re-evaluate.
4	GI-T25	-6.90	0.48	7.38		
4	GI-T34	25.42	19.48	5.94		
4	GI-T38	2.39	1.84	0.55		
5	G5-01A	4.92	0.00	4.92	**2.8**	
5	G5-01B	4.61	0.00	4.61		
5	G5-02	-1.56	0.00	1.56		
5	RB-1	0.29	0.00	0.29		

[1] Evaluation is performed on Well Groups 4 and 5 for the period from commencement of mining through June, 2012 (Evaluation Period). Measurement-based water-level changes do not account for natural fluctuations or trends that began before mining commenced. Conclusions of the current 3M evaluation are summarized in Table 8.

[2] For the purposes of the 3M Program, mining is assumed to have commenced in August, 2007.

Table 8. Summary of Results for the Preliminary 2011-2012 3M Evaluation

Test	Evaluation Period	Well Group	3M Statistic	3M Criteria[1]	Result
1	Pre-Mining and 5th Evaluation Period	1	Difference between the measurement-based and model-based estimates of transient water-level change, less the pre-mining annual water level fluctuation[2], for each LBF well since last model calibration.	If any values are greater than 5 feet, then go to Test 2; otherwise go to Test 1A.	All values, which range from 0.00 to -0.11, are much less than 5 feet (go to Test 1A).
1A	Pre-Mining and 5th Evaluation Period	1	Difference in percent change in transient measurement-based and model-based estimates of hydraulic gradients for each LBF well pair, less the pre-mining gradient fluctuation[2], since the last model recalibration.	If any values are greater than 25%, then go to Test 2; otherwise go to Test 2A.	Since the measurement based gradients are dominated by natural fluctuations this evaluation is not relevant to characterizing the effects of pumping. Go to Test 2A
2	Pre-Mining and 5th Evaluation Period	2	Mean value of percent difference between measurement-based and model-based estimated water-level change.	If the value is more than 15%, then recalibrate the model, run the mining period prediction, and adjust the mitigation as necessary. Also, wait one year and re-evaluate. Otherwise go to Test 2A.	Not Evaluated.
2A	Pre-Mining and 5th Evaluation Period	4 & 5	Average of absolute differences between measurement-based and model-based estimates of water-level changes.	If the value for either well group is more than 10 feet, then recalibrate the model, run the mining period prediction, and adjust the mitigation as necessary. Also, wait one year and re-evaluate. Otherwise wait one year and re-evaluate.	Values (5.0 for Group 4 and 2.8 for Group 5) are less than 10 feet: **Final Result: Wait one year and re-evaluate**

[1] For the purposes of the 3M Program, mining is assumed to have commenced in August, 2007.

[2] To account for and remove natural fluctuations not caused by mining.

FIGURES

ATTACHMENT 1

ATTACHMENT 2