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**PROPOSED CESSATION OF HYDRAULIC  
CONTROL AT THE FLORENCE PROJECT  
IN-SITU TEST FIELD**

**AQUIFER PROTECTION PERMIT (APP)  
NUMBER 101704**

**AND  
UNDERGROUND INJECTION CONTROL  
(UIC) PERMIT NUMBER AZ39600001**

**FLORENCE COPPER  
FLORENCE, ARIZONA**

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## EXECUTIVE SUMMARY

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In 1997, the Arizona Department of Environmental Quality (ADEQ) and the United States Environmental Protection Agency (USEPA) issued permits authorizing BHP Copper, Inc. (BHP Copper) to construct, operate, and close an in-situ copper mine approximately 2.5 miles northwest of Florence, Arizona. Both agencies required BHP Copper to demonstrate, prior to the commencement of operations, that the proposed method of mining would not detrimentally impact groundwater. More specifically, BHP Copper was required to demonstrate that its proposed arrangement of injection and recovery wells would result in an inward hydraulic gradient that could be maintained while acidic solutions were being injected into the ore body and thereby prevent leachate from migrating out of the leach zone into the surrounding groundwater.

Shortly after the permits were issued, BHP Copper installed a test field in order to conduct a 90-day test to demonstrate hydraulic control. The 90-day test required by the permits was successfully completed in February 1998. Although the test was successful, BHP Copper decided to delay construction of the proposed mine and the associated solvent extraction plant in view of depressed copper prices. As required by the ADEQ and USEPA permits, hydraulic control has been maintained and monitored since the completion of the 90-day test in order to rinse leachate residues from the test field. In December of 2001, the mine site was sold to Florence Copper, Inc. (Florence Copper) which has continued pumping and monitoring water levels since it assumed ownership.

Groundwater samples from the test field were collected and analyzed in 2000, 2001, and 2003. The analytical results for the 2003 data indicate that the permit requirements for initiating closure of the test wells have been met. Florence Copper is therefore formally requesting ADEQ's and USEPA's concurrence that the permit requirements have been met so that it may begin the process of discontinuing hydraulic control. This report includes groundwater quality data that demonstrates compliance with the permit requirements. It also includes, for the approval of the ADEQ and USEPA, a proposed schedule for discontinuing hydraulic control.

## **1.0 INTRODUCTION**

### **1.1 PURPOSE**

Florence Copper Inc. (Florence Copper) proposes to discontinue hydraulic control at the test field located at the Florence Project Site in accordance with the Aquifer Protection Permit (APP) No. 101704 and the Underground Injection Control (UIC) Permit No. AZ39600001, issued in 1997 by the Arizona Department of Environmental Quality (ADEQ) and the United States Environmental Protection Agency (USEPA), respectively.

This report explains the purpose of the test field and demonstrates that hydraulic control can be discontinued in accordance with the permits without causing detrimental impacts to groundwater quality. This report also includes for the approval of the ADEQ and USEPA, a proposed schedule for discontinuing hydraulic control.

### **1.2 ORGANIZATION**

This report has been specifically designed to facilitate ADEQ's and USEPA's review, recognizing that matters discussed herein are part of the voluminous Florence Project permit files that span more than 9 years.

This section provides a brief history of the Florence Project Site, describes the facility as it is currently permitted to operate, describes the permit requirements for the hydraulic control test, and discusses the conditions that must be met before discontinuing hydraulic control.

Section 2 describes the construction and operation of the wells that comprise the test facility.

Section 3 includes a review of all groundwater quality data that have been obtained from samples collected from the test wells.

Section 4 includes a review of all data regarding the quality of water and sediments contained in the evaporation pond that was constructed as part of the test field.

Section 5 includes a brief overview of hydrogeologic and geochemical factors that are relevant to the evaluation of the data presented in Sections 3 and 4.

Section 6 includes Florence Copper's proposed schedule for discontinuing hydraulic control in accordance with applicable permit requirements.



### 1.3 SITE HISTORY

The ore body for which the Florence Project was developed is known as the Poston Butte or Florence porphyry copper deposit. Site records indicate that the deposit was discovered by geologists of the Continental Oil Company (CONOCO) in 1971. Following the discovery, CONOCO initiated a program to identify the dimensions and mineral composition of the ore body, which is located deep within a highly productive aquifer that is continuously replenished by sub-flow from the Gila River. That program was followed by the installation of a pilot underground mine and pilot-scale treatment processes. The Site was abandoned in 1977 after CONOCO concluded that the ore body could not be economically mined because of difficulties in dewatering the area around the ore-body to the depths needed for open pit or underground mining.

During the early 1990s, the Magma Copper Company (Magma) evaluated the ore body and decided to evaluate the feasibility of using in-situ mining methods as an alternative to open-pit and underground mining methods. In November 1994, Magma began the development of permit applications for the construction and operation of an in-situ copper mine and solution extraction/electrowinning (SX/EW) plant. The application for the USEPA permit included a request for an aquifer exemption for the mine area, the area in which all in-situ operations were proposed to be conducted.

The permit applications were submitted to ADEQ and USEPA on January 6, 1996. About the same time that the applications were submitted, ownership of the mine site was transferred from Magma to BHP Copper. To further support the permit applications, BHP Copper conducted additional studies and installed additional wells for use as point of compliance (POC) wells. The additional wells provided a total of 31 POC wells encircling the mine area. The POC wells have been sampled quarterly since early 1998 and quarterly reports have been submitted to ADEQ and USEPA since that time.

After notice and public hearing, USEPA issued a Class III UIC Permit No. AZ39600001 on May 1, 1997. ADEQ issued an APP No. 101704 on June 6, 1997. Both permits are discussed in Section 1.5 below.

The ADEQ and USEPA permits required BHP Copper to successfully complete a hydraulic control test before it could begin operating the permitted facilities. In response to the test requirements, BHP Copper constructed the test field that is described in Section 1.4.2 and in Section 2.

The hydraulic control test began November 8, 1997, and continued until February 10, 1998. Injection and recovery rates were monitored along with electrical conductivity and water levels throughout that period in order to demonstrate that hydraulic control could be established and maintained during the injection of sulfuric acid solutions into a portion of the ore body for which the aquifer exemption had been granted. The test was successful as described in a letter report dated April 6, 1998, from Ms. Corolla Hoag of BHP Copper to Ms. Julie Collins, ADEQ Compliance Officer.

Although the test was successful, BHP Copper elected to indefinitely delay construction due to depressed copper prices. The facility was maintained under a care and maintenance level of staffing until BHP sold all of its Florence holdings to Florence Copper in 2001. Florence Copper has continued the maintenance and care since that time.

Hydraulic control has been maintained and monitored in accordance with permit requirements since the test was completed in order to rinse leachate residues from the impacted ore body. All groundwater pumped from the recovery wells has been pumped to a double-lined evaporation pond where the recovered residues continue to concentrate via evaporation.

## **1.4 FACILITIES**

### **1.4.1 Mine and SX/EW Plant**

The site of the proposed Florence In-situ Copper Mine occupies approximately 700 acres and is located about 2.5 miles northwest of Florence, Arizona, as shown on Figure 1. Figure 2 shows the proposed facility components from the APP Application as well as the existing components.

The existing components include structures and wells left by CONOCO and wells that were installed by Magma during the site characterization process. Proposed components include a mine area of approximately 200 acres in which 2,000 injection and recovery wells are proposed to be installed during the anticipated 15-year mine life, a SX/EW plant, a double-lined pregnant leachate solution (PLS) pond, a double-lined raffinate pond, 9 13-acre double-lined evaporation ponds, and associated tanks and pipelines for transferring PLS from the recovery wells to the PLS surge pond and for transferring raffinate from the raffinate pond to the injection wells. If the components are installed, they will be operated in the manner described below.

PLS will be pumped from the recovery wells through a manifold and pipeline to a double-lined surge basin where it will then be piped to the SX/EW plant for removal of copper. As part of the process for re-using the acidic solution, approximately 10 percent of the barren PLS (also referred to as raffinate) will be bled to evaporation ponds for disposal.

Sulfuric acid will be added to the remaining raffinate as needed to maintain the sulfuric acid concentration at approximately 2 percent. The raffinate will then be piped to a double-lined impoundment and then piped to the mine field for injection. Raffinate injected into the ore body is referred to as injectate. PLS, formed as the injectate is drawn through the formation and pumped from the injection wells, will be pumped to the PLS surge basin where the process will be repeated until the concentration of copper becomes too low to warrant further injection. At that point, injection will be discontinued and the injection wells will be converted to recovery wells. Groundwater will continue to be pumped from the converted injection wells in order to maintain hydraulic control and to rinse the mine block of injectate and associated residues prior to the abandonment of the wells in accordance with permit requirements.

As shown in Figure 2, the mine area will be divided into 24 mine blocks with each block, on average, containing approximately 83 injection and recovery wells. The operating plan requires a sequenced construction and operation schedule so that one mine block would be ready to begin operations as copper is depleted in the previously constructed mine block. A primary benefit of the sequencing process is the capacity to rinse blocks as the mine progresses and thereby minimize the amount of rinsing required at the end of the mine life.

#### **1.4.2 Test Field**

BHP Copper installed an array of 4 injection wells, 9 recovery wells, 7 observation wells, and 1 evaporation pond so that hydraulic control could be fully demonstrated. All of the wells were installed within a small portion (approximately 1 acre) of the 200-acre mine area. Figure 2 shows the test field and evaporation pond in relation to existing facility components, while Figure 3 shows the layout of the wells in the test field. To ensure a valid test, the injection and recovery wells were constructed in accordance with the well designs approved by the ADEQ and USEPA for operation of the mine. To further ensure valid tests, the acidic solutions injected during the test were similar in composition to the solutions that were to be injected during normal mine operations. Information on wells used in the test field is provided in Section 2.

### **1.5 PERMIT REQUIREMENTS**

The following provides a review of APP and UIC permit requirements pertinent to the cessation of hydraulic control at the test field.

#### **1.5.1 APP No. 101704**

Part II.E.2.a of APP No.101704, provided as Appendix 1, sets forth procedures for conducting and evaluating the hydraulic control test. After the test had been successfully completed, Part II.E.2.a was deleted from the APP. That deletion is one of several minor revisions that have been made to the APP. The most recent revision was promulgated on December 5, 2001, to reflect the transfer of facility ownership from BHP Copper to Florence Copper.

Although Part II.E.2. included criteria for conducting and evaluating the hydraulic control test, it did not specify how the test wells were to be closed. However, the assumption is clear that the test wells would become part of an active mine block after the test was successfully completed and would be closed as part of the closure of the mine block. Procedures for closing mine blocks are set forth in Part II.H.2 of the APP, which is provided as Appendix 2.

The following steps are required to close a mine block in accordance with Part II.H.2.

1. Begin rinsing of the mine block at the time that injection is discontinued.
2. Monitor the rinsing process by monitoring sulfate concentrations in the headers for the injection and recovery wells.

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3. Once the sulfate concentration in the recovery well headers drops to approximately 750 parts per million (ppm), the injection well headers will be sampled for all Part IV, Table III.C constituents.
4. If the sampling for Part IV, Table III.C constituents shows exceedances of the numeric Arizona Water Quality Standards (AWQS), continue rinsing until the concentrations of all parameters are below the AWQS.
5. When the AWQS are met, sample all wells undergoing closure to determine sulfate concentrations.
7. If the sulfate concentrations are greater than the indicator sulfate concentration, continue rinsing until groundwater from each well meets the indicator concentration.
8. When the indicator sulfate concentrations are met at all wells undergoing closure, hydraulic control will be discontinued for 90 days.
9. At the end of the 90-day period, the headers will be re-sampled for sulfate.
10. If sulfate concentrations are greater than the indicator sulfate concentration, rinsing will continue.
11. If sulfate concentrations are less than the indicator sulfate concentration, all rinsing and monitoring in the mine block may cease.
12. A report will be submitted to ADEQ documenting the results of the closure tests.
13. Unless ADEQ or USEPA objects to the report within 30 days after it has been filed, the permittee will commence cementing the wells in accordance with the approved well abandonment plan.

#### **1.5.2 UIC Permit No. AZ39600001**

The UIC permit addresses federal underground injection control requirements found in Title 40 Code of Federal Regulations, Part 144 (40 CFR 144) and 40 CFR 146. The provisions of the UIC permit and APP are similar except that the UIC permit also addresses requirements that are unique to the UIC regulations, e.g. permit classification, aquifer exemption, and criteria for well construction and integrity testing.

The UIC regulations recognize two types of in-situ mining operations. Class V general permits are issued for mines where the extraction occurs within an ore body that is isolated from groundwater. Class III permits are issued for mines where the ore body can not be isolated from groundwater by traditional dewatering techniques. Class III permits require that hydraulic control be maintained during the injection and restoration phases of the individual mine blocks in order to prevent injectate and dissolved minerals from migrating into the surrounding

groundwater. An area-wide Class III permit was issued to BHP Copper in recognition that the proposed mining operation would involve the installation and operation of many wells over a large area.

The UIC regulations prohibit the issuance of a Class III permit unless an aquifer exemption is first issued, or issued as part of the permit. Before USEPA may issue an aquifer exemption, the applicant must demonstrate that the portion of the aquifer for which the exemption is requested (a) is not used as a source of drinking water and (b) contains minerals that can be economically mined using the proposed in-situ mining methods. The required demonstration was submitted as part of the UIC permit application.

The lateral and vertical boundaries of the exempted portion of the aquifer are described in Part II.B.1 of the UIC permit. The exempted portion extends from the base of the Middle Fine Grained Unit (MFGU) or 200 feet above the oxide zone, whichever is farther from ground surface, to the base of the interval that is amenable to extraction. In plan view, the lateral boundary extends 500 feet beyond the mine area, which is that portion of the ore body deemed to be economically mineable using the methods outlined in the UIC permit application.

Part II.B.2 of the UIC permit prohibits the migration of injection fluids or process by-products beyond the exempted zone. Part II.B.3 requires that, within 90 days after mining has been completed in a mine block, the permittee shall begin the process of restoring the mine block to primary maximum contaminant levels (MCLs) as described in Part II.I.1 of the UIC permit (Appendix 3). For sake of brevity and convenience, primary MCLs are considered in this report to be the same as numeric AWQS and are frequently referred to as numeric AWQS.

The provisions of Part II.I.1 of the UIC permit are similar to the provisions of Part II.H.2 of the APP except that the conditions required to initiate the 90-day test period are stated differently. APP Part II.H.2 specifies only one condition, the attainment of AWQS. In contrast, UIC Part II.I(a) requires groundwater to be restored to primary MCLs, or to pre-mine background conditions. In addition, UIC Part II.I.1(b) of Section I, requires the permittee to ensure that constituents which do not have a primary MCL will not affect the health of persons.

## **1.6 CLEANUP CRITERIA**

As discussed above, Part II.H.2 of the APP and Part II.I.1 of the UIC permit provide similar procedures for governing the closure of mine blocks except that the UIC specifically addresses pre-mining background conditions and constituents which do not have numerical standards and the APP does not. For reasons explained below, Florence Copper believes the differences are the result of oversight, not differences in agency requirements.

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There is no statutory or regulatory justification for ADEQ to require that Florence Copper attempt to restore the aquifer to AWQS when pre-mining conditions exceed the AWQS. In fact, that specific issue is addressed by Arizona Revised Statutes (A.R.S.) Section 49-243.B.3, which provides "That no pollutants discharged will further degrade at the applicable point of compliance the quality of groundwater that at the time of the issuance of the permit violates the aquifer water quality standards for that pollutant." In addition, the UIC requirement to consider public health for constituents which do not have numerical standards is similar to ADEQ's requirements described in the narrative AWQS.

Groundwater quality data presented in Section 3 of this report have been reviewed in context of the requirements discussed above. The review first focused on constituents which have numeric AWQS and then focused on constituents which do not have numeric AWQS.

## 2.0 IN-SITU TEST FIELD

In 1997, BHP Copper constructed a test field comprised of wells, pumps, pipelines, and an evaporation pond in order to satisfy a requirement of the APP and the UIC permit that BHP Copper demonstrate that the arrangement of injection and recovery wells proposed for the in-situ operations will provide sufficient hydraulic control to protect groundwater quality while acidic solutions are injected into the ore body. Figure 2 shows the test field in relation to principal components of the Florence Project Site and Figure 3 shows a more detailed view of the test field. Figure 4 provides a geologic block diagram which was presented in Volume 4 of the APP Application. The diagram shows the oxide zone in relation to other major geologic and hydrogeologic features beneath the proposed mine area. The oxide zone is the zone into which acidic solutions are proposed to be injected and recovered during commercial operations and into which acidic solutions were injected and recovered during the 90-day hydraulic control test. The test field is located in the southwest corner of the delineated mine area.

### 2.1 TEST WELLS

Figure 5 shows the general layout of the test wells. BHP-6, 7, 8 and 9, shown in green, were the injection wells through which the acidic solutions were introduced to the oxide zone. The 9 recovery wells, BHP-1, 2, 3, 4, 5, 10, 11, 12, and 13 are shown in red. They were used to pump leachate and groundwater from the leach zone to the evaporation pond during the 90-day hydraulic control test. The total depth of the wells is generally greater than 800 feet with the oxide zone containing copper ore beginning around 350 feet below the surface.

The injection and recovery wells are of the same design proposed for commercial operations. Just as would be the case during commercial operations, the injection wells were converted to pumping wells once the injection test was completed. The converted injection wells have been used to maintain hydraulic control and rinse the leach zone following completion of the test in 1998. The original recovery wells have not been used for recovery since the test was completed.

Observation wells OWB-1 through 5, shown in blue on Figure 5, surround the injection and recovery wells. The observation wells are approximately 800 feet in depth with the exception of OWB-2 installed to a depth of 225 feet. There are also two cluster wells, CH-1 and CH-2, also shown in blue, that are located between the 4 injection wells. Each of these wells has three screened intervals, G, B, and R with separate sampling tubes. The G zone is screened around 500 feet, the B zone around 600 feet, and the R zone is screened around 750 feet.

### 2.2 SUPPORTING FACILITIES

All groundwater and leachate pumped from the test wells is collected by pipes and directed to an evaporation pond. The pond occupies an area of approximately 13 acres. It is double-lined and is equipped with a leak detection and leachate collection system. The leak detection sump is

monitored weekly for signs of water leaking through the upper liner. BHP Copper and Florence Copper have provided records in each quarterly report to ADEQ and USEPA demonstrating that the sump has been monitored and that no leaks have been detected above the alert levels established in the APP. A small tank farm is located beside the pond which, during testing, contained sulfuric acid and sodium hydroxide which were used to maintain the proper acid content of the fluids that were injected into the oxide zone and to neutralize acidic solutions pumped into the evaporation pond from the recovery wells.

## **2.3 HYDRAULIC CONTROL**

Hydraulic control was maintained during the 90-day test by ensuring, on a daily basis, that the amount of acidic solutions injected into the oxide zone during any one day, was less than the combined amount of leachate and groundwater pumped from the recovery wells. As previously noted, the 4 injection wells were converted to pumping wells once the test was concluded. The 4 converted injection wells are operated on an alternating basis such that groundwater is pumped from two of the wells at all times in order to maintain hydraulic control, ensuring that the leach zone is being constantly rinsed. In order to demonstrate that hydraulic control is being maintained, groundwater levels in the four converted injection wells and four companion observation wells are measured daily. If a well pair fails to show an inward gradient, the pumping rates can be adjusted to maintain control. BHP Copper and Florence Copper have provided records in each quarterly report to ADEQ and USEPA demonstrating that hydraulic control has been maintained since the completion of the 90-day test.



### **3.0 ANALYTICAL RESULTS OF TEST WELL SAMPLES .**

Groundwater samples were collected from all wells in the test field in September 2000, June 2001, and December 2003. The samples were collected in accordance with the sampling and analysis plan set forth in the APP Application. Wells were purged for 3 well volumes and samples were then collected when the variability of field parameters stabilized, indicating that the samples were representative of aquifer conditions. The CH wells, which are cluster wells, have air pressure sampling tubes which do not allow for purging of 3 well volumes. Additionally, the sampling tubes to the top level, the G zone in both CH wells, have broken thereby preventing the collection of samples from that zone. .

All samples were analyzed for Part IV, Table III.C constituents in accordance with Part II.H.2 of the APP. The Part IV Table III.C constituents are the same constituents that are analyzed in samples collected biennially from the POC wells. The results of the analyses are discussed in this section by categories established in the APP for the biennial reports. The concentrations of the constituents in each category were evaluated to determine if they meet the criteria for initiating the 90-day suspension of hydraulic control at the test field. As discussed in Sections 1.5 and 1.6, the criteria require that (a) concentrations of constituents that have numeric AWQS must meet their numeric AWQS or pre-mining background conditions and (b) concentrations of constituents that do not have numeric AWQS must fall below levels that would present a threat to human health.

Constituents that do not have numeric AWQS have been evaluated in context of the National Secondary Drinking Water (NSDWS). Exceedances of NSDWS do not mean that the groundwater is a threat to human health. They are used in this report only as a benchmark.

#### **3.1 FIELD PARAMETERS**

Since the 90-day test was completed, the pH of groundwater pumped from the 4 converted injection wells (BHP-6, 7, 8, 9) has been measured weekly and, as shown in Figure 6, has increased slowly over time.

Field measurements of temperature, pH, and electroconductivity (EC) taken during the 3 sampling events are presented in Table 1. Figure 5 shows the pH value reported for each well during the December 2003 sampling event.

The pH measured at the 4 converted injection wells during each sampling event corresponds closely to the weekly values shown in Figure 6. Laboratory pH values of all samples collected during the 3 sampling events are generally higher than the field measurements and are discussed in Section 3.4 below.

While pH does not have an established AWQS, it can be compared to the NSDWS of 6.5 to 8.5. Samples obtained from the converted injection wells have depressed pH values; 3 of the wells have pH values less than 4.5. The pH values in samples from BHP-1, CH-1, and CH-2, all of which are located between the converted injection wells, are also low. However, the pH values for all other wells are above 6.5.

### 3.2 INDICATOR PARAMETERS

The four indicator parameters which were analyzed in samples from the 3 previous sampling events (magnesium, fluoride, sulfate, and total dissolved solids [TDS]), are the same indicator parameters sampled quarterly at the POC wells. Of the four indicator parameters, only fluoride has a numeric AWQS. Fluoride has a numeric AWQS of 4.0 milligrams per liter (mg/L) and a NSDWS of 2.0 mg/L. In all samples collected during the 3 sampling events, none exceeded the numeric AWQS. The highest fluoride reported was 2.0 mg/L.

Results for the indicator parameters are summarized in Table 2. All four indicator parameters have dramatically decreased in the test field from 2000 to 2003. In samples collected from the 4 converted injection wells, magnesium decreased by more than 60 percent, fluoride decreased by 30 percent, sulfate decreased by 70 percent, and TDS decreased by 50 percent. The decrease in sulfate in the injection wells can be seen over time in Figure 7. The highest sulfate concentration reported in samples collected from the converted injection well in 2003 is 160 mg/L, which is quite low in view of the 2 percent sulfuric acid that was injected into the leach zone. The TDS concentrations are also remarkably low. The average TDS concentration of the 2003 samples obtained from the converted injection wells is 503 mg/L, as compared to the NSDWS of 500 mg/L.

Concentrations of indicator parameters decreased in samples collected from the recovery wells between 2000 and 2003, but the decreases were not as great as observed in samples from the converted injection wells. The differences are logical, recognizing that samples from the converted injection wells are drawn from more heavily impacted zones than samples from the recovery wells. No decreases were observed in the observation wells OWB-1 through 5 because those wells were not impacted by the leaching process.

### 3.3 METALS

Metal results are summarized in Table 3. During the first sampling event in September 2000, 1 sample was reported to have exceeded the AWQS for beryllium and 7 samples were reported to have exceeded the AWQS for nickel. In the two subsequent events, there were no exceedances of AWQS and overall concentrations of metals declined. Decreases of 50 percent and greater were observed in the converted injection wells for several metals such as aluminum, copper, nickel, and zinc. With respect to the NSDWS, the 2003 NSDWS exceedances are found primarily, if not exclusively, in samples collected from the converted injection wells.

### 3.4 INORGANICS

Analytical results of the common inorganic constituents are summarized in Table 4. Nitrate is the only constituent that has an established AWQS. No nitrate exceedances were reported for any of the sampling events.

Concentrations of chloride, nitrate, sodium, and potassium have remained relatively constant across the test field through time. Calcium has decreased over 50 percent in the converted injection wells. The December 2003 samples indicate alkalinity, which has apparently been removed by the leaching process, is less than 10 mg/L in the converted injection wells. Samples from the same wells indicated elevated aluminum, copper, and silica concentrations and depressed pH values. On average, the laboratory pH values are about half a pH unit higher than the field measurements for the converted injector wells compared to all other wells where laboratory and field measurements are approximately equal.

### 3.5 ORGANICS

Benzene, ethylbenzene, toluene, and total xylene (BTEX) and diesel petroleum products were analyzed and none were detected in the test field for any of the sampling events. Organic results are shown in Table 5.

### 3.6 RADIOCHEMICALS

When radiochemicals are analyzed in groundwater, gross alpha is analyzed first. If gross alpha exceeds 5 picocuries per liter (pCi/L), radium-226 and radium-228 are measured and added together for total radium. The numeric AWQS for total radium is 5 pCi/L. If the gross alpha exceeds 15 pCi/L, uranium is analyzed and subtracted from the gross alpha value to obtain adjusted gross alpha. The numeric AWQS for adjusted gross alpha, the particle activity that includes radium-226 but not radon and uranium, is 15 pCi/L.

Table 6 summarizes the radiochemical results for the test wells. Note that radiochemicals were not analyzed during the September 2000 sampling event. For December 2003, there were 4 AWQS exceedances for adjusted alpha and 7 for total radium from the test field. Figure 7 shows the alpha activities (gross or adjusted) by well. In general, gross alpha or adjusted gross alpha and total radium have decreased throughout the test field since 2001.

Six of the alpha and radium exceedances occur in the two cluster wells CH-1 and CH-2. Uranium appears to be increasing in the two cluster wells inside the ring of injection wells, however, these wells cannot be purged completely and as such, may not represent accurate concentrations in the test field.

The remaining 5 exceedances occur in BHP-2, BHP-12, and OWB-4. It is important to note that none of the samples from these wells have indicated an acid-related impact. In fact, pH values from samples collected from BHP-2 and OWB-4 have remained above 7 standard units in samples collected in 2000, 2001, and 2003. Samples from BHP-12 equaled or exceeded a pH of 6.7 or more in 2000 and 2001. In the 2003 sample, the pH was 7.3. Additionally, sulfate values for the same wells show little variation over the same period. In contrast, sulfate values in wells impacted by leaching have decreased significantly over the same period. This indicates that the elevated alpha and radium values are not related to acid conditions and are likely background values.

### 3.7 DISCUSSION OF RESULTS

The analytical results presented above for the 2003 sampling event indicate that the concentrations of all constituents that have numeric AWQS are below AWQS, with the exception gross alpha and radium. However, those concentrations are consistent with background conditions as discussed below and in Section 5 of this report.

Concentrations of constituents which do not have numeric AWQS were also reviewed. The review indicated that samples from the converted injection wells and some immediately nearby wells contained metal concentrations in excess of the NSDWS, e.g., copper values exceeded the NSDWS of 1 mg/L. The same samples were also found to have pH values below the range of 6.5 to 8.5 established as a NSDWS.

High sulfate and TDS concentrations were in the injectate and PLS because the solution injected into the formation contained 2 percent sulfuric acid. Samples collected during the 3 sampling events indicate that virtually all of the acid has been removed. Samples collected from the converted injection wells in 2003 had concentrations equal to or below 160 mg/L, as compared to the NSDWS of 250 mg/L.

The significance of the conditions involving gross alpha, radium, metals, and pH are specifically addressed in Section 5.

## **4.0 ANALYTICAL RESULTS OF EVAPORATION POND**

All groundwater pumped from the test field, during the 90-day test and following the completion of the test has been pumped to the evaporation pond where concentration has occurred as a result of evaporation. Water from the pond was collected in November 1999, June 2001, and December 2003, while sediments from the pond were collected in November 1999 and December 2003. Results of pond water samples are included with the groundwater results in Tables 1 through 6.

### **4.1 FIELD PARAMETERS**

The pH in the pond water ranges from 6.7 to 7.7, which meets the NSDWS. The pond sediments were reported to have a pH of 7.6 (Table 8).

### **4.2 INDICATOR PARAMETERS**

The pond water has high concentrations of the indicator parameters as expected. All four analytes are significantly higher than concentrations reported in samples obtained from the test field (Table 1). Fluoride in the pond water exceeds the AWQS of 4 mg/L, with concentrations ranging from 6.2 to 13.0 mg/L.

### **4.3 METALS**

Concentrations of metals in the pond water are not significantly higher than those observed in the test field. This would suggest that the majority of the metals precipitate out into the sediments.

Metals concentrations in the sediments have been measured by two different methods, one to measure the total metals in the sediments and the other to measure the amount of leachable metals in the sediments. These results are shown in Table 7.

Leachable metal concentrations are compared to the AWQS. No metals exceed the standards. Therefore these sediments do not present a danger to the underlying aquifer if the material should be leached. Also the leachate is not a hazardous waste.

Total metals are compared to the residential and non-residential soil remediation standards and groundwater protection limits. Metal concentrations are substantially below all available limits. Therefore the sediments can be left in place without remediation.

#### **4.4 INORGANICS**

For pond water, alkalinity, nitrate, and silica have reported concentrations similar to concentrations reported in samples obtained from the test wells, while concentrations of calcium, chloride, and potassium are significantly higher. Analytical results of sediment samples are shown in Table 8.

#### **4.5 ORGANICS**

BTEX and diesel petroleum products were analyzed in samples from the pond water and sediments. No organic compounds were detected.

#### **4.6 RADIOCHEMICALS**

There were no exceedances of the AWQS for the pond water.

## **5.0 HYDROGEOLOGIC AND GEOCHEMICAL EVALUATION**

As discussed in Section 3, gross alpha and radium concentrations were detected above the numeric AWQS in samples from some of the test wells. Some constituents (primarily pH and metals such as aluminum and copper) which do not have AWQS were detected in concentrations which exceed the NSDWS. The samples were obtained from the converted injection wells and from wells that are located between the converted injection wells. The purpose of this section is to present information that will enable groundwater conditions which exceed either the AWQS or the NSDWS to be evaluated in context of the Florence ore body and the surrounding valley fill.

A large body of information regarding the ore body's features and hydrogeologic setting was developed by CONOCO during its exploration and feasibility studies. These data included data from approximately 700 exploratory coreholes (Magma, 1995). Magma included much of the data generated by CONOCO and data generated by its own studies in a detailed Site Characterization Report (APP Application Vol. 2) that was submitted to ADEQ and USEPA. That report included the results of geologic and hydrologic investigations of the Site and was designed to provide sufficient technical data and interpretations to support the environmental permitting of the mining facility. It included historical as well as recent (1995) site conditions. Summaries of information presented in the APP Application are provided below in order to provide an understanding of the current (2004) site conditions. The summaries are followed by a discussion of the groundwater quality impacts that resulted from the hydraulic control test and the subsequent leaching of the leach zone.

### **5.1 PHYSIOGRAPHIC SETTING**

The Florence Project is located within the Sonoran Desert section of the Basin and Range physiographic province of south-central Arizona. The last major tectonic event left a topography of deep basins surrounded by mountain ranges. The basins are now sediment-filled valleys, and the mountains are low and rugged. The Gila River traverses the region from east to west (Figure 1) and passes approximately 1 mile south of the Project Area. The braided riverbed meanders through a broad valley averaging 2 to 3 miles in width in the vicinity of the Town of Florence. Due to upstream control and diversions, the Gila River is generally dry, with the exception of brief flow following intense seasonal rainstorms or releases from upstream dams.

### **5.2 GEOLOGIC SETTING**

During the Precambrian and into the early Paleozoic time, regional stresses caused east-northeast trending structural lineaments. One such structure in southern Arizona is the Ray Lineament trending north 70 degrees east and extending approximately 50 miles from the Sacaton Mountains to the Pinal Mountains. At Florence, the lineament intersects a pre-existing Precambrian diabase dike swarm that strikes north 10 to 30 degrees west. Many east-northeast

trending Laramide age intrusive bodies were emplaced in central Arizona at the intersections of zones of weakness associated with the emplacement of the lineament (Figure 9). These intrusions consisted of granodiorite and quartz monzonite. Hydrothermal mineralization associated with these intrusions resulted in the formation of porphyry copper ore deposits. The Florence ore body was formed in this fashion. More recent Basin and Range faulting and tilting in the Florence Project Area resulted in north-northwest trending horst and graben structures bounded by normal faults with large displacement to the west.

The Florence ore body occurs on a complex horst block which is bounded on the east and west by grabens. The Party Line Fault defines the east side of the ore body with a vertical displacement of over 1,000 feet. The Sidewinder Fault is part of a series of en echelon normal faults which form a transition to the graben west of the test area. Post-Basin and Range basin-fill sediments were deposited over the bedrock surface (Figure 4). The sediments consist of unconsolidated to moderately well-consolidated interbedded clay, silt, sand, and gravel in variable proportions and thicknesses. Basalt flows are interbedded on the west and northwest portions of the in-situ mine area.

The basin-fill deposits in the region are divided into 3 units: (1) the Upper Basin-fill Unit (UBFU); (2) the Middle Fine-Grained Unit (MFGU); and (3) the Lower Basin-fill Unit (LBFU). Although perhaps not contiguous, these units likely correlate with similar units described by Laney and Hahn (United States Geologic Survey [USGS], 1986) in the eastern Salt River Valley to the north.

Figures 10 and 11 depict east-west subsurface cross sections that straddle the test field. The LBFU overlies bedrock, with the lower, more consolidated materials forming a conglomerate. In the Project Area, the thickness of the LBFU ranges from zero near the surface bedrock outcrops to approximately 1,000 feet in the grabens.

In the test area, the MFGU is composed of clays, silts, and sands which are consolidated to various degrees. The MFGU is generally discontinuous in the vicinity of the test area and varies in thickness up to approximately 50 feet.

The UBFU in the vicinity of the test area consists of unconsolidated to weakly bedded clays, silts, sands, and gravels. Recent floodplain alluvium occurs along the Gila River and numerous tributary washes in the Florence area. Together, the UBFU and alluvium have a fairly uniform thickness of approximately 250 feet.

### 5.3 HYDROLOGY

The Florence area is located along the northern edge of the Eloy sub-basin of the Pinal Active Management Area (AMA). It is also approximately 2.5 miles south of the southern edge of the Eastern Salt River Valley sub-basin of the Phoenix AMA. Locally, the UBFU is analogous to the Upper Alluvial Unit (UAU) discussed in Pinal AMA studies (Arizona Department of Water Resources [ADWR], 1991). This unit forms a significant aquifer throughout the area with well



Proposed Cessation of Hydraulic Control  
Florence Copper  
Florence, Arizona

yields of up to 3,000 gallons per minute (gpm). The middle unit is highly variable in thickness and is much less productive than the upper or lower units. While of lower permeability than the surrounding units, it does not serve to confine the LBFU except in small localized areas. The LBFU or Lower Alluvial Unit (LAU) also produces copious groundwater with yields of between 1,000 and 2,500 gpm.

Project-specific investigations characterized the vadose zone and the groundwater quality and level within the proposed in-situ mine area. The investigations were conducted by installing numerous monitoring wells, conducting aquifer tests on four of the wells, performing geophysical logging on the deeper wells, followed by gauging and sampling of the 14 new wells and 4 pre-existing irrigation wells in the immediate area. The following sections summarize the results of the above studies and compare the predicted geochemical changes with those observed during after the field test.

Groundwater elevations in the area circa 1900 represent pre-development conditions. At this time the elevations ranged from 1,380 to 1,420 feet above mean sea level (amsl), approximately 40 to 50 feet below ground surface (bgs). During the period 1923 to 1977, water levels declined an estimated 150 feet due to substantial groundwater withdrawals and partial elimination of flow in the Gila River. Between the mid 1970s to the mid 1980s, water level generally rose with elevations of approximately 1,250 to 1,300 feet amsl. During the 1980s and early 1990s, the water level elevations appear to have stabilized (Montgomery 1994). Water levels measured during the 1995 site investigation ranged from 100 to 150 bgs, or elevations of about 1,300 to 1,380 feet amsl.

Currently, both the UBFU and LBFU aquifers are recharged primarily through subsurface flow from the Gila River channel. Percolation of agricultural water and a small amount of rainfall and surface runoff from the mountains at the basin perimeter also contribute. A groundwater model for the area was developed in support of the APP Application (Vol. IV). The model incorporated results from 3 previous studies in the surrounding areas (ADWR, 1990, 1994, and Montgomery, 1994).

Flow enters the regional model domain along the eastern boundary, through and under the Gila River, then migrates westward toward the mine area. West of the mine area, the approximate center of a deep basin trending north to south marks the location where flow divides into three flow regimes moving north, south, and west and exiting the domain at these three boundaries. The presence of bedrock highs to the north and northeast of the mine area and on the western border restricts the flow in these regions and creates the distinctive pattern of groundwater flow shown in Figure 12.

The hydraulic conductivity for the UBFU in the model was set to 60 feet per day (ft/day) in the regional domain and 40 ft/day in the vicinity of the test area. The conductivity of the LBFU ranged from 20 ft/day in layers 2 and 3, to 0.5 ft/day in layer 8 (below 300 feet amsl elevation). For the oxide zone of the test area, the model calibrated hydraulic conductivity was 0.1 ft/day in the main area and 3 ft/day within the fault areas. Porosity was assumed to be 0.2, 0.1, 0.02, and 0.0002 for the UBFU, LBFU, oxide, and sulfide zones respectively. In several instances where the column and in-situ leaching experiments are discussed, a porosity of 10 percent was used. The "true" in-situ value within the leach test field is difficult to determine, however the larger

scale value of 2 percent used in the groundwater flow model, is directly correlated with the "calibrated" hydraulic conductivity of 0.1 ft/day. Therefore, the following calculation retains the values used in the groundwater flow model.

To calculate the rate of groundwater flow through a formation the Darcy equation is used:

$$v = \frac{K i}{n_e}$$

where:	v	=	Groundwater velocity (ft/day)
	K	=	Hydraulic conductivity (ft/day)
	i	=	Hydraulic gradient (ft/ft)
	n <sub>e</sub>	=	Effective porosity (dimensionless)

To the northwest of the test area, the gradient is approximately 10 feet elevation change over 2,000 linear feet or 0.005. Thus the range of calculated groundwater velocities is from 0.025 ft/day within the oxide zone of the ore body to 0.5 ft/day in the UBFU.

#### 5.4 FLORENCE ORE BODY

The Florence ore body deposit consists of highly fractured Precambrian quartz monzonite (71 percent) and Laramide granodiorite porphyry (26 percent). This distinction is important due to the differing concentrations of trace metals such as uranium in the minor minerals such as plagioclase and potassium-feldspar. Copper in the oxide zone is contained mainly in disseminated copper-enriched smectite formed from altered plagioclase, and in the fracture-filling chrysocolla, tenorite, and copper clays. The sulfide zone contains copper and other metallic sulfides that are not economic to recover. Intact drill samples of the ore body generally display a low porosity of approximately 2 percent. However, due to the intense fracturing, a value of 10 percent was used in modeling the column studies discussed below.

Prior studies of copper deposits in Arizona indicated that elevated levels of radioactivity, often in excess of federal MCLs, were frequently encountered (USEPA, 1999). Likely sources of the radionuclides are the Precambrian granite outcrops and Laramide intrusives (ADEQ, 1989). Detailed analyses of test samples from the Florence site by BHP indicate that leachate from the quartz monzonite and granodiorite is highly enriched in uranium and radium-226, and correspondingly, both display high counts of gross alpha. In addition, the leachate showed that the quartz monzonite displays gross alpha of approximately an order of magnitude higher (8,649 pCi/L vs. 897 pCi/L) than the granodiorite (APP Application, Vol. IV). As seen in the cross section D-D' through the ore body reproduced here as Figure 10, the test field wells penetrate ore consisting predominantly of granodiorite but there are also zones of quartz monzonite. Detailed examination of the drill logs shows that at some locations both quartz monzonite and granodiorite occur in thin alternating zones or may be mixed together. Another cross section drawn to the south of the test field shows the quartz monzonite thickening toward the south (Figure 11). It is therefore expected that the concentrations of gross alpha would be high and variable in the test wells.

The goal of the in-situ leaching test was to preferentially dissolve copper minerals. The general leaching reaction between sulfuric acid solution (raffinate) with a pH of approximately 2 and chrysocolla, yields free dissolved copper and hydrated silica. In the process, gangue minerals such as calcite ( $\text{CaCO}_3$ ) react with raffinate, neutralizing the acid and producing secondary minerals such as gypsum. During the leaching phase, this latter reaction wastes acid, therefore attempts are made to minimize the effect. However, during the recovery phase, any residual acid that might migrate from the test zone is neutralized via the same reaction.

Two independent laboratory column and bulk leaching experiments were performed. The first set of experiments was contracted to Core Laboratories. One of the studies involved the determination of the Acid Neutralization Potential (ANP) of the various rock types in the vicinity of the test area (APP Application, Vol. IV, Appendix A). A net positive ANP was indicated for all 21 samples submitted for analysis. ANP results are traditionally expressed in tons of calcium carbonate per kiloton of the material analyzed. The MFGU contains the highest ANP of the materials tested (197 tons per kiloton [T/kT]). However, even the samples from the sulfide zone showed appreciable ANP due to their low pyritic sulfur content. In fact, the lowest values were for the quartz monzonite oxide zone (average 4.3 T/kT), while the non-calcareous basin-fill material averaged 8.6 T/kT and the calcareous basin fill material averaged 71 T/kT. Thus, any acidic solutions that come in contact with the surrounding basin-fill materials would be quickly neutralized.

Additional tests were conducted by Controls for Environmental Pollution, Inc., to determine the radiochemical composition of the various ore-body materials. These results were reported in the APP Application as well as the USEPA survey "*Technologically Enhanced Naturally Occurring Radioactive Materials in the Southwestern Copper Belt of Arizona* (TENORM, USEPA, 1999)." The observed enrichment of radionuclides within quartz monzonite is discussed above and is shown to be characteristic of Arizona copper ore.

The second independent set of experiments consisted of two column tests and geochemical modeling that were conducted at the University of Arizona using material collected from the test field (Brewer, 1998). X-ray diffraction and electron-dispersive spectrometry were used to identify the predominant mineral phases. Laboratory column leaching experiments were conducted to determine the copper recovery and acid consumption of material. In these experiments, two 1.524-meter by 0.3048-meter columns were loaded with approximately 150 kilograms of fragments obtained from two separate diamond drill cores of the oxide zone. Both columns contained varying proportions of granodiorite porphyry and quartz monzonite. However, column B contained andesite with fractures coated with calcite. The leach solution was continuously adjusted to maintain a pH of approximately 1.4 while being circulated through the columns. The geochemical changes in the leachate, during the laboratory experiments, were modeled and found to be consistent with the above conceptual chemical model but could not completely account for the chemical changes in the leachate due to a much higher concentrations of calcite than expected and the inability to model gypsum dissolution and precipitation in the presence of sulfuric acid. For core B, it took over 21 days (approximately 3 pore volumes) before the pH of the effluent (PLS) decreased to less than 6. However, for core A, the pH was less than 3 within the first sampling round of 7 days. The ANP was determined to be 3.13 and 6.25 T/kT for columns A and B respectively, in excellent agreement with the Core Laboratories results discussed above.

After 84 days of leaching, tap water was injected into both the columns to simulate the reclamation phase of the in-situ leaching. In both cases, once acid injection ceased, pH recovered to approximately 4 in about 60 days (after the passage of approximately 8.5 pore volumes). Additional flushing at higher, but unreported, flow rates resulted in obtaining a final pH of 7 at day 180.

## **5.5 IMPACT OF HYDRAULIC CONTROL TEST ON GROUNDWATER**

The hydraulic control test involved the injection of 2 percent sulfuric acid via 4 injection wells into the test area of the oxide zone for 90 days. Since the test was completed in February 1998, ambient groundwater has been continuously pumped from the test area to maintain hydraulic control and to rinse leachate from the leach zone. Approximately 16.8 million gallons of acidic solutions were injected during the test through 4 injection wells. Approximately 123 million gallons of leachate and groundwater have since been extracted from the same 4 wells. The injection wells were converted to recovery wells once injection had been discontinued and were used to pump leachate and groundwater at rates which are significantly less than the injection rates but sufficient to maintain hydraulic control.

### **5.5.1 Current Groundwater Flow Conditions**

Regional groundwater flow in the area has not changed appreciably since the previous characterization was performed in November 1995 (Figure 12). At that time, the groundwater level at the divide just south of the mine area was approximately 1,350 feet amsl. More recent water level measurements obtained from the ADWR well database, supplemented by BHP measurements, indicate that by October to November 2001, the level has dropped across the region about 50 feet to approximately 1,300 feet amsl at the divide (Figure 13 and Table 9). The available data (Table 9) was contoured using the natural neighbor gridding algorithm and the computer program Surfer. The contours within the enlargement (Figure 14) show the successful achievement of hydraulic control for the test field. Groundwater levels are drawn down approximately 75 feet at the extraction well. The gridding procedure extends the contours to approximate the effectiveness of this capture zone outside the test field.

### **5.5.2 Evaluation of Test Results**

#### **5.5.2.1 pH Results**

As mentioned previously, several of the wells within the center of the test field continue to have pH concentrations of less than 6 (Wells BHP-6, 7, 8, 9, and CH-2). The first 4 wells are the converted injection wells and CH-2, which has 2 sampling ports, is located in the middle of the 4 converted injection wells. The groundwater from these wells is believed to contain little, if any, of the acid that was introduced during the hydraulic control test, given the long sampling duration and surprisingly low sulfate values. Samples of groundwater from these wells show negligible bicarbonate and carbonate ion concentrations and low calcium concentrations, thus suggesting intense leaching of the host rock.

The rock through which groundwater is currently being extracted was formerly in direct contact with the acid circulated through the injection wells and hence was subjected to the most intense leaching during the first phase of the test. During the laboratory column studies, the ANP was eventually overcome and a complete new mineral assemblage formed as new equilibrium conditions were established due to removal of magnesium (and copper) from the ore and the accompanying breakdown of the clay minerals.

The current low pH of the water extracted from this region is consistent with a geochemical model (PHREEQC) in which the buffering capacity of the rock in the center of the test field has been reduced leading to current values of low pH being controlled by equilibrium with goethite  $[\text{FeO}(\text{OH})]$ , jarosite  $[\text{KFe}_3(\text{SO}_4)_2(\text{OH})_6]$ , amorphous silica  $[\text{SiO}_2]$  and aluminum hydroxide  $[\text{Al}(\text{OH})_3]$ .

The reaction of dissolved oxygen in groundwater with sulfide-bearing minerals is another potential source of low pH. Because the groundwater obtained from the converted injection wells has little, if any, buffering capacity, it is not necessary that the reaction release large quantities of protons to create the low pH conditions observed. Therefore, only modest amounts of sulfide may be necessary to create the observed pH values. Sufficient amounts of sulfide may be present in lenses within the oxide zone. Higher concentrations are likely to exist in the transition between the oxide and sulfide zones and, of course, much higher sulfide concentrations exist in the sulfide zone. Several of the extraction wells are screened into the transition zone as shown on Figure 15. All the wells are projected onto a single line and the screen intervals for the injection, recovery, and observation wells indicated by the striped lines. Even a minor contribution of water from this zone, induced by the upward gradient caused by the current pumping, could be responsible for the low pH observed. If this is the case, the pH values in these wells should increase with the cessation of pumping.

#### 5.5.2.2 Radiochemical Results

Several of the test field wells currently display concentrations of gross alpha in excess of the Federal MCL of 15 pCi/L. Studies by USEPA and ADEQ indicate that within copper mining areas such as Florence, it is not at all unusual to find high uranium and radium concentrations and hence high gross alpha readings (USEPA 1999). Unfortunately, the test field wells were not tested prior to initiation of the leaching phase. Thus, pre-test background conditions specific to any of the test wells are not directly known. However, as discussed above in Section 5.4, laboratory experiments contracted by Magma (1996) have verified that the quartz monzonite rock, which comprises a significant part of the ore body, produces high counts of gross alpha when in contact with acidic groundwater. The survey of groundwater and surface water radioactivity prepared by USEPA in 1999 documents that throughout the Arizona copper belt high background values of gross alpha are frequently encountered.

It has also been observed that well OWB-4 and BHP-2, which have adjusted gross alpha concentrations above 15 pCi/L, have never had sulfate concentrations greater than 67 mg/L. Such a low sulfate concentration indicates that the well has not been influenced by the leaching process and hence the high radionuclide content most likely reflects background conditions.

### 5.5.3 Migration Potential

These next two sections discuss conditions that will limit the migration of test residues that may remain in the leach zone following the discontinuance of hydraulic control.

#### 5.5.3.1 Groundwater Flow

Previous discussions indicated groundwater flow rates ranging from between 0.025 ft/day within the oxide zone of the ore body to 0.1 ft/day in the LBFU and a groundwater flow to the northwest. As shown on Figure 13, the distance between the test field and the northwest boundary of the permitted in-situ mine area is approximately 2,500 feet. Using the higher flow velocity of 0.1 ft/day, it would take 25,000 days (approximately 68 years) for any fluid to migrate from the test field to the POC wells M6-GU, M7-GL, M8-O, M26-O, or M27-LBF located in the northwest corner of the mine area.

The estimated travel time described above can be confirmed using the Theis equation and drawdown information available at the test field. For example, the drawdown of OWB-3 is only about 5 feet as compared to the drawdown of 75 feet at the nearest converted injection well (Table 9). A brief analysis using the Theis equation confirms that a hydraulic conductivity of approximately 0.1 ft/day is consistent with the observed drawdown of 5 feet, using a porosity of 0.02 and a pumping rate of 20 gpm. This confirms the above estimate of 68 years for leachate to migrate to the POC wells. It is well known that most metals are retarded during transport through porous media by adsorption phenomena. Hence, the above migration time should be considered a minimum with actual times expected to be up to three times longer depending upon the constituent.

#### 5.5.3.2 Acid Neutralization Potential (ANP)

For the majority of the wells in the test field, the groundwater chemistry is similar to that observed in the POC wells and meets all regulatory standards. For the solutions with anomalously low pH, reactions with the surrounding host rock would ensue once hydraulic control ceased and would result in an increased pH. Additionally, the ANP for the surrounding host rock, which was discussed previously in Section 5.4, shows an average of 4.3 T/kT within the oxide zone and 8.6 T/kT for the non-calcareous basin-fill material.

The rate of groundwater circulation through the center of the test field is currently much higher than normal due to the hydraulic control system. This lowers the residence time of the water in the formation and may preclude complete re-equilibration. The combination of the non-pumping flow rate of less than 0.1 ft/day with the high ANP for the surrounding rock indicates that it is highly unlikely that the current disequilibrium with respect to pH would be maintained in the future.



## 5.6 SUMMARY AND CONCLUSIONS

A 90-day hydraulic control test, which ended on February 10, 1998, was conducted while acidic solutions were being injected into and recovered from a portion of the oxide zone which extends beneath the mine area of the Florence Project Site. The oxide zone consists of highly fractured Precambrian quartz monzonite (71 percent) and Laramide granodiorite porphyry (26 percent). The test wells were installed in an area that is composed predominately of granodiorite but which also includes zones of quartz monzonite. Detailed examination of the drill logs shows that at some locations both quartz monzonite and granodiorite occur in thin alternating zones or are sometimes even mixed together. The quartz monzonite and granodiorite have differing concentrations of trace metals such as uranium in the minor minerals such as plagioclase and potassium-feldspar. The quartz monzonite displays gross alpha activity of approximately an order of magnitude higher than the granodiorite.

The hydraulic control test involved the installation of 4 injection wells, 9 recovery wells, and 7 observation wells (two of which were cluster wells). After the test was completed, the injection wells were converted to recovery wells and have been pumping groundwater since February 1998. At the same time, pumping was discontinued at all wells previously used as recovery wells.

Pre-mine background conditions at each well are not known because samples were not collected before the hydraulic control tests were conducted. Groundwater sampling of the individual wells did not occur until June 2000. Samples were also collected in July 2001 and December 2003.

Although pre-test samples were not collected, the observation wells and some recovery wells appear not to have been impacted by the hydraulic control test. Three of the wells were reported to have exceedances of the numeric gross alpha and radium AWQS. Because the 3 wells appear not to have been impacted by the hydraulic control test, the exceedances are assumed to represent pre-mining background conditions. The distribution of quartz monzonite throughout the oxide zone, column tests conducted prior to the hydraulic control test, and samples collected at M12-0 during site characterization provide additional evidence that AWQS exceedances for gross alpha and radium may occur due to pre-mining background conditions.

Data from the 2000, 2001, and 2003 sampling events clearly show that groundwater impacts associated with the hydraulic control test have decreased significantly at all impacted wells, with the exception of pH. Table 10 has been prepared to summarize current conditions and includes data collected in 2003. Table 10 includes average concentrations of selected constituents that have no numeric AWQS and illustrates the remaining impacts associated with the hydraulic control test. The table clearly illustrates that evidence of impacts decreases away from the converted injection wells. The observation wells show no impact even though they are only 80 feet or so from the converted injection wells. The table shows average concentrations of selected parameters by well category and includes all wells in the test field (Figure 6).

The categories include:

1. Converted injection wells (BHP-6, 7, 8, and 9);
2. Central wells (BHP-1 and CH-1-B, R and CH-2-B, and R);
3. Original recovery wells (BHP-2 through 5 and 9 through 12); and
4. Observations wells (OBW-1 through 5).

Data in Table 10 indicate that the leaching removed virtually all alkalinity from the aquifer near the converted injection wells. The data also indicate that the leaching removed most of the alkalinity from the wells located at or near the center of the test field, a lesser amount from the recovery wells, and none from the observation wells. Laboratory pH measurements reflect the same pattern. The average pH of samples collected from the converted injected wells was 5.1. pH was 6.1 for samples from the central wells, 7.5 for samples from the recovery wells, and 7.8 for samples from the observation wells. Silica values reflect the same pattern; highest at the converted injection wells and lowest at the recovery and observation wells. Concentrations of aluminum and copper also reflect the same pattern; exceeding the NSDWS at and between the converted injection wells, and complying with the standards at the recovery and observation wells.

As discussed above, a small area, near and between the converted injection wells, still shows impacts resulting from the leachate process. However, there are no numeric AWQS exceedances except for gross alpha and radium, and both gross alpha and radium are believed to have existed in concentrations that exceed the numeric AWQS prior to the hydraulic control test.

Constituents that do not have numeric AWQS have been evaluated in context of the NSDWS. They are used in this report only as a benchmark and exceedances of NSDWS do not indicate that the groundwater is a threat to human health.

No NSDWS exceedance has been reported in any 2003 sample from any of the wells identified as recovery wells or observation wells in Table 10. Some exceedances have occurred in samples collected from the converted injection wells and the inner wells. For those wells, however, there have been significant decreases in all parameters except pH. For example, sulfate concentrations have dropped from about 500 mg/L in 2000, to less than 160 mg/L or less in 2003. Such low sulfate concentrations suggest that essentially all of the 2 percent sulfuric acid solution that was injected into the leach zone has been removed.

NSDWS exceedances in the 2003 samples are presently limited to the small area near and between the converted injection wells and involve metals and depressed pH. Because it is unlikely that injectate is causing the low pH values, the low pH must result from other causes. The low pH most likely results from oxygenated water passing through sulfide containing materials and/or areas in which there is little, if any, remaining alkalinity. The elevated metal concentrations are related to the low pH and will decrease as pH increases. The pH values can be expected to remain at the same level or possibly increase at some point following the cessation of pumping, as equilibriums are re-established. Once pumping has been discontinued, the impacted ground water will migrate slowly through materials known to have the potential to neutralize acids and, as that occurs, the pH will increase and the metals concentrations will decrease.



Proposed Cessation of Hydraulic Control  
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Florence, Arizona

For the reasons stated above, it is very unlikely that the existing pH and metals concentrations would present a threat to human health or migrate outside of the test zone. The more likely scenario is that conditions will improve with time, effectively reducing the size of the impacted area.

Therefore, Florence Copper believes the current groundwater quality qualifies for the 90-day suspension of hydraulic control as provided in Part II.H.2 of the APP and Part II.I.1 of the UIC permit.

## 6.0 SCHEDULE

The following describes the schedule that will be used to determine whether groundwater is of the quality required for the permanent cessation of hydraulic control at the test field. The schedule generally parallels the steps described in Section 1.5.1 for closing a mine block in accordance with Part II.H.2 of the APP and Part II.I.1 of the UIC permit. It differs from those steps in the way that sulfate is used as an indicator.

Part II.H.2 of the APP and Part II.I.1 of the UIC permit were written for the purpose of closing mine blocks at the end of their operating lives. They included the concept of using sulfate as AN indicator in an effort to avoid non-productive sampling and analysis as each well was being evaluated for closure. It was envisioned that data from the initial round of sampling of all wells within the mine block would provide enough data to statistically determine a sulfate value that would apply to all wells within the mine block.

The permits did not include specific procedures for the test field because it was assumed the test wells would become part of a mine block and closed accordingly. The concept of a universal sulfate indicator that would have been applicable to a mine block can not be fully applied to the test field because there are not enough injection wells in the test field to statistically develop a universal indicator. For that reason, the schedule presented below employs sulfate as an indicator on a well-specific basis.

The schedule uses, on a per sample basis, the sulfate value multiplied by a factor of 1.25. The factor takes into account normal sampling and analytical variability. The schedule is not intended to apply to gross or adjusted alpha, radium, or organics. Gross and adjusted alpha and radium are excluded because values in excess of AWQS existed in the test area before the test was conducted and are therefore exempt pursuant to Part II.H.2 of the APP and Part II.I.1 of the UIC permit. Organics are not included because the data presented in Table 5 satisfy the previously cited permit requirements. As shown in Table 5, organics have not been detected above detection limits in any sample collected during the 3 previous sampling events. Thus, there is no need to continue sampling for organics.

The schedule begins at a point equivalent to Step 8 shown in Section 1.5.1, i.e., samples collected at each well have been found to meet the numeric AWQS or pre-mining background conditions and have sulfate concentrations below 750 mg/L (ppm).

1. Hydraulic control will be suspended for 90 days beginning not later than 10 working days following notice that this schedule has been approved by the ADEQ and the USEPA.
2. Within 10 days following the 90th day of the suspension, samples will be collected and delivered to a licensed laboratory
3. Samples will be preserved for analysis of all Part IV, Table III.C constituents, but will be analyzed first for sulfate.

Proposed Cessation of Hydraulic Control  
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4. The sulfate values will be compared well-by-well to sulfate values reported from the December 2003 sampling event.
  - (a) If the sulfate value does not exceed the 2003 sulfate value by a factor of more than 1.25, the groundwater will be considered to have met the conditions of both the APP and UIC permit and no further analysis will be required.
  - (b) If the sulfate value exceeds the 2003 value by a factor of more than 1.25, but is less than either of the 2000 or 2001 sulfate values, any constituents, excluding gross alpha and radium, from preceding years which exceeded AWQS will be analyzed. If these constituents are found to meet AWQS or if the well has no history of AWQS exceedances other than gross alpha and radium, then groundwater will be considered to have met the conditions of both the APP and UIC permit and no further analysis will be required. If an AWQS exceedance is reported, rinsing will continue.
  - (c) If the sulfate value exceeds the 2003 sulfate value by more than a factor of 1.25 and also exceeds the values reported in 2000 and 2001, the sample will be analyzed for all Part IV, Table III.C constituents excluding organics. If the analysis indicates that all constituents other than gross alpha and radium meet the numeric AWQS, the groundwater will be considered to have met the conditions of both the APP and UIC permit and no further work will be required. If any of the constituents, other than gross alpha or radium, exceed the numeric AWQS, rinsing will continue.
5. A report detailing the results of the analysis will be submitted to ADEQ and USEPA within 20 working days following receipt of the final laboratory report.

Unless ADEQ or USEPA objects to the report within 30 days after it has been filed, Florence Copper may begin closing the wells in accordance with the approved well abandonment plan.

## 7.0 REFERENCES

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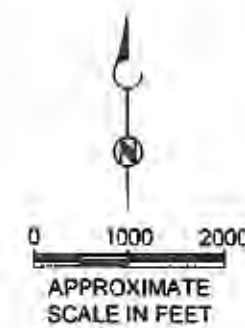
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SOURCE: AERIALS EXPRESS, OCTOBER 2003

**BROWN AND  
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**Figure 1**  
**VICINITY MAP**  
**MERRILL MINING, L.L.C.**  
**FLORENCE, ARIZONA**





## EXPLANATION

- APPROXIMATE PROPERTY BOUNDARY
- STATE LEASE LAND BOUNDARY
- PROPOSED IN-SITU MINE AREA
- POC MONITORING WELL
- TEST FIELD
- MINE BLOCKS
- PROPOSED EVAPORATION PONDS

Figure 2

**FACILITY PLAN**  
MERRILL MINING, L.L.C.  
FLORENCE, ARIZONA

BROWN AND  
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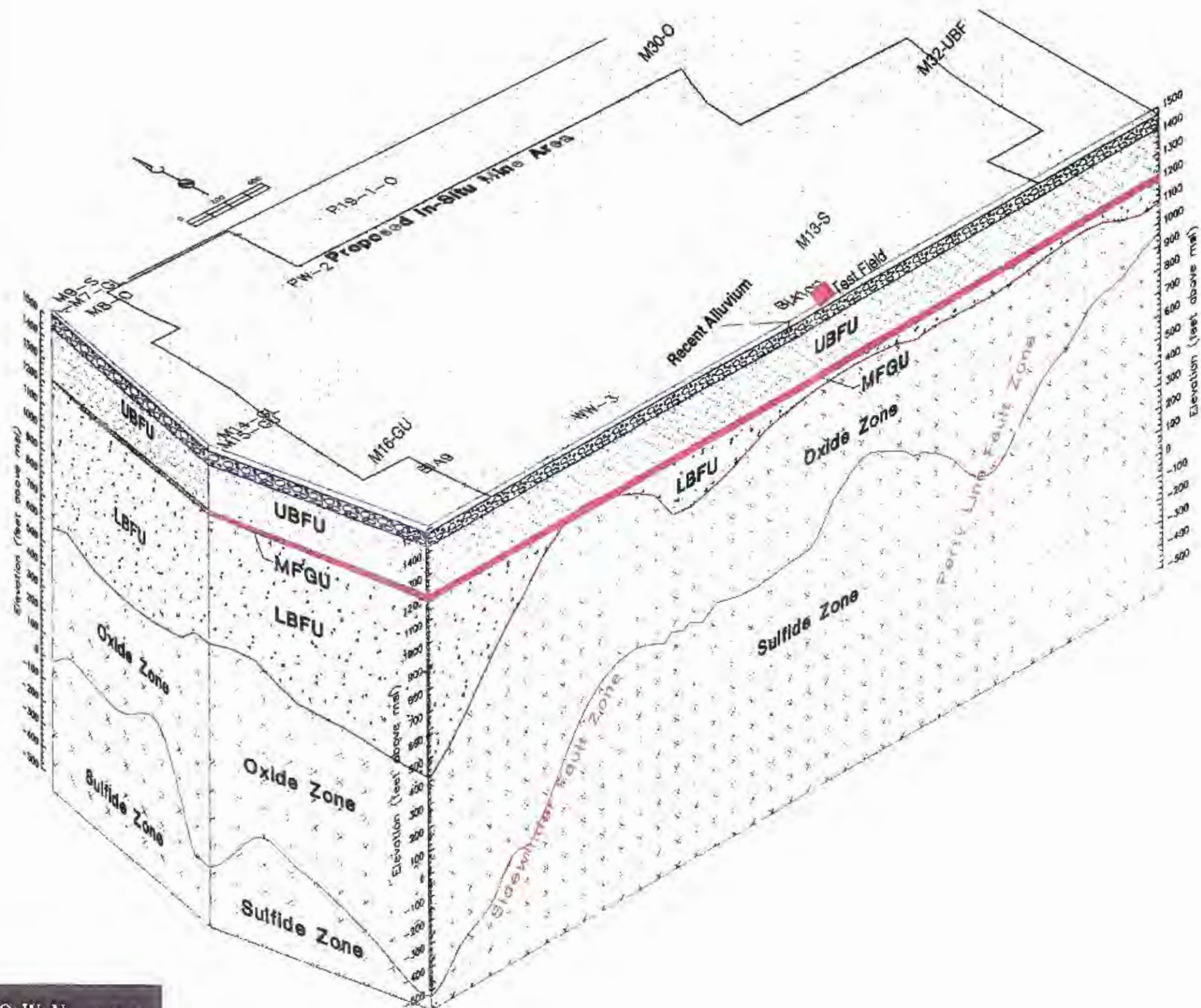
SOURCE: AERIALS EXPRESS, OCTOBER 2003

BROWN AND  
CALDWELL

- EXPLANATION**
- BHP-10 RECOVERING WELL (CURRENTLY INACTIVE)
  - OWB-2 OBSERVATION WELL
  - ▲ BHP-8 INJECTION / PUMPING WELL (RECOVERY MODE SINCE 1998)

Figure 3  
TEST FIELD LAYOUT  
MERRILL MINING, L.L.C.  
FLORENCE, ARIZONA





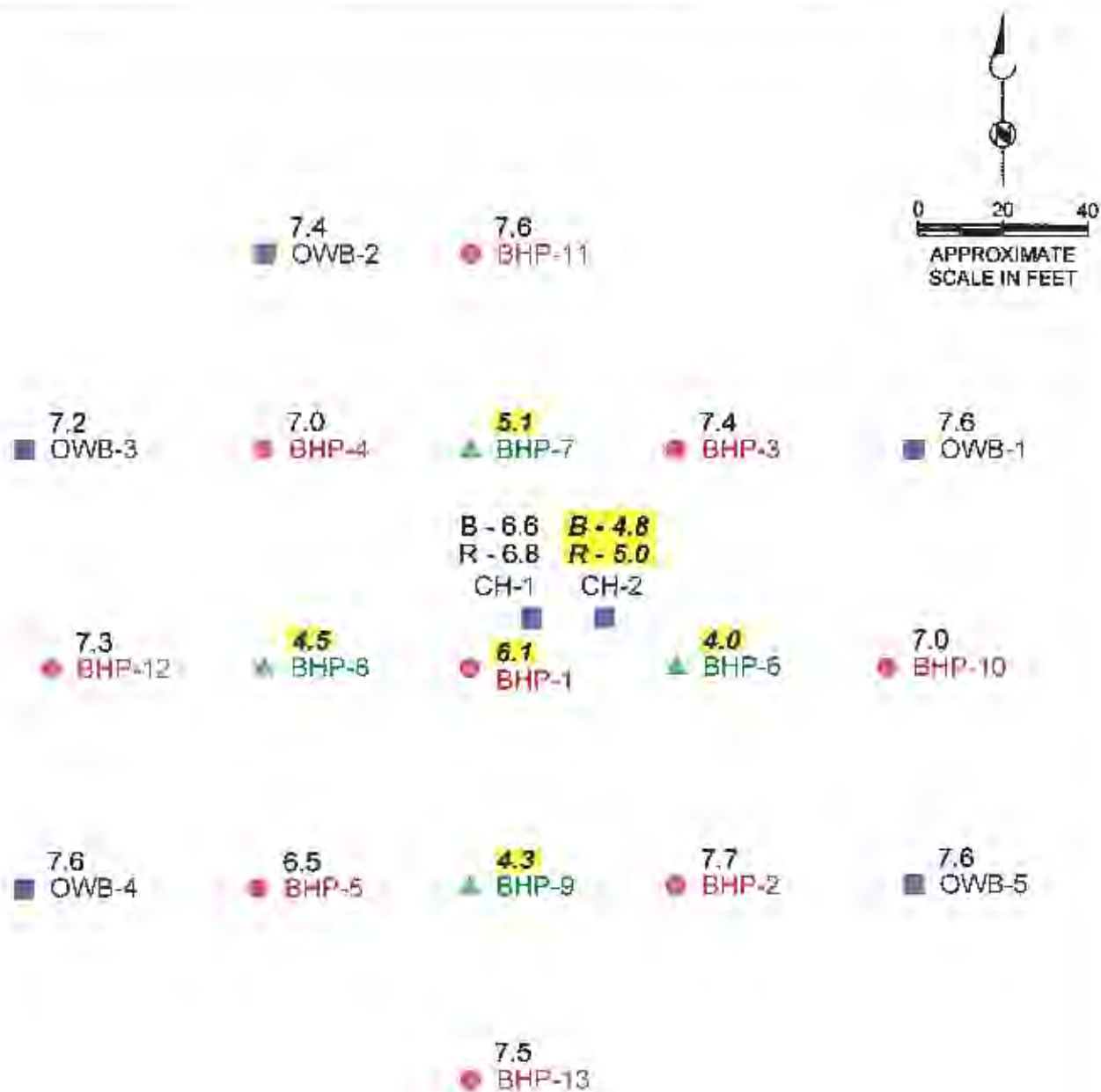
# EXPLANATION

- UBFU Upper Basin Fill Unit
- MFGU Middle Fine-Grained Unit
- LBFU Lower Basin Fill Unit
- M7-GL Locations of Selected Wells
- Location of Test Field

Figure 4  
**GEOLOGIC BLOCK DIAGRAM**  
MERRILL MINING, L.L.C.  
FLORENCE, ARIZONA

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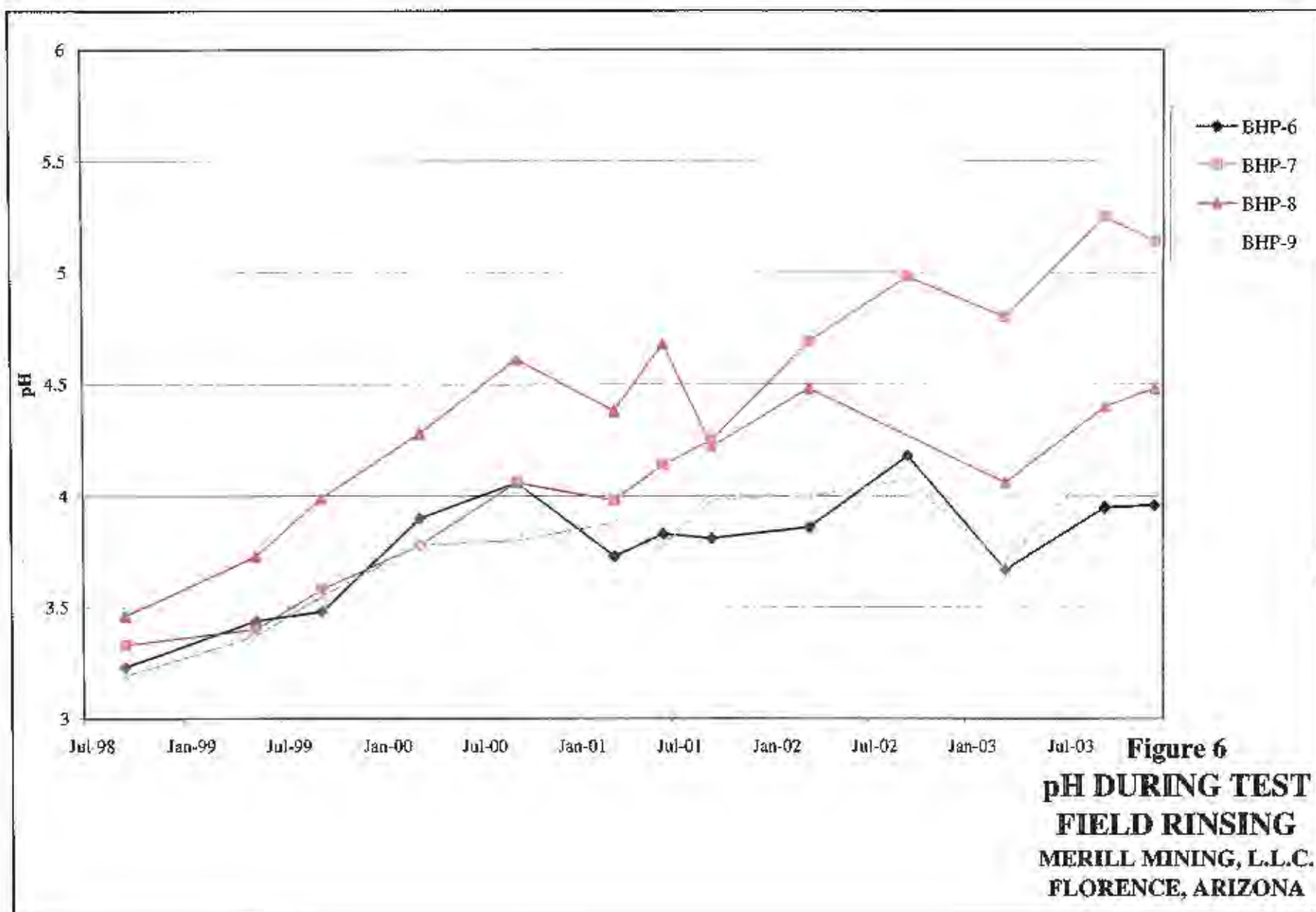


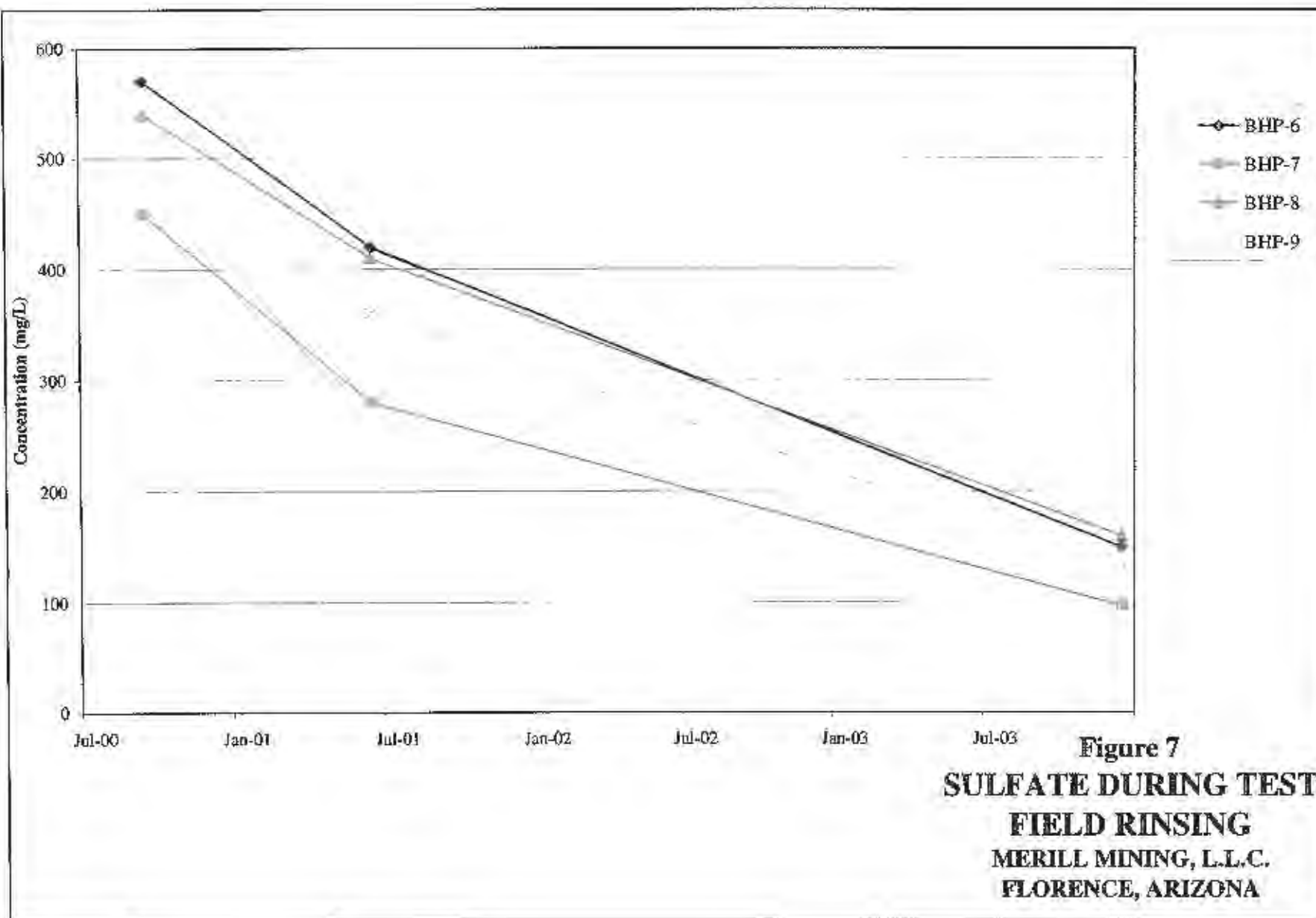
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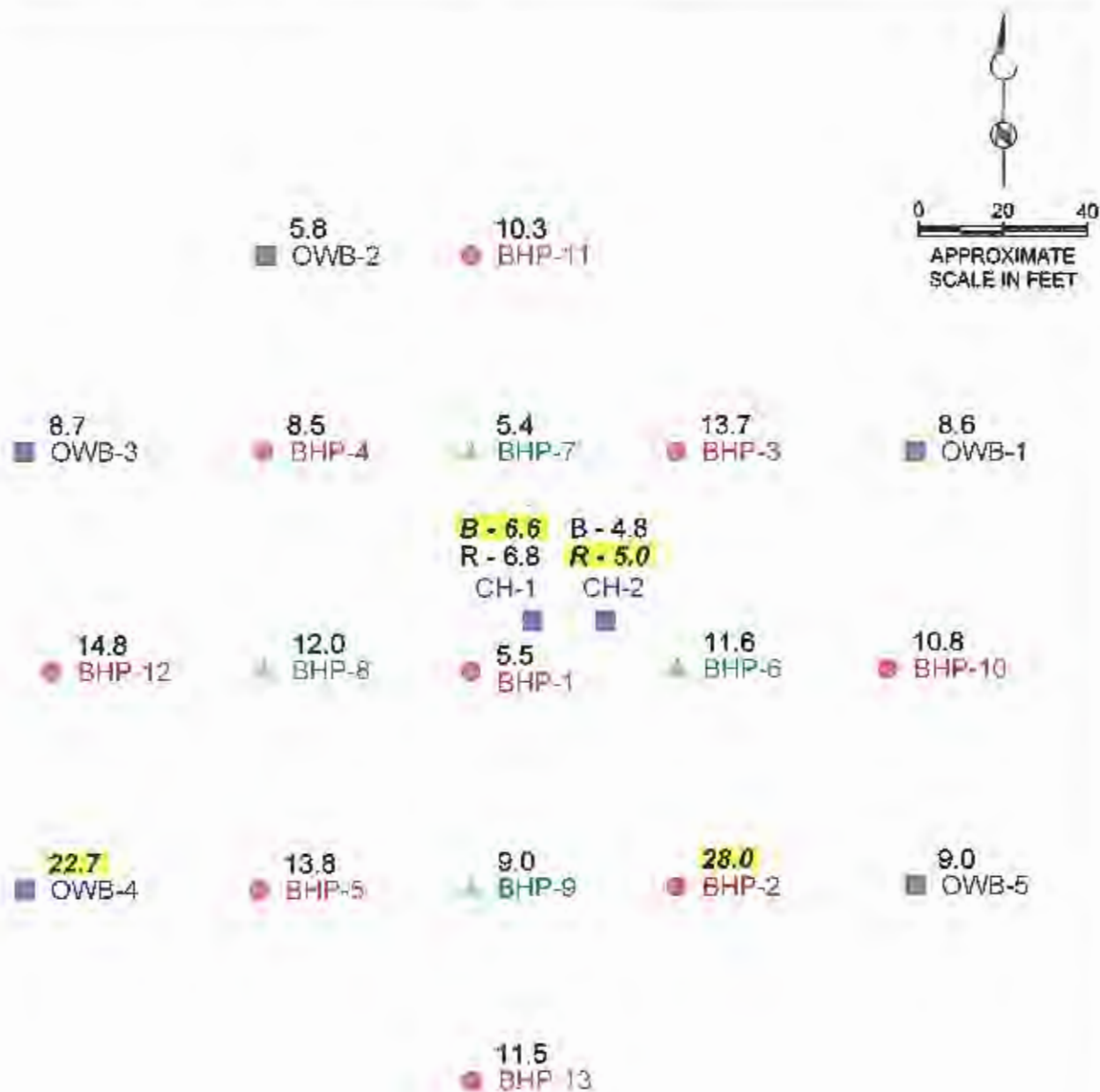
- BHP-10 RECOVERY WELL (CURRENTLY INACTIVE)
- OWB-2 OBSERVATION WELL
- ▲ BHP-8 INJECTION / PUMPING WELL (RECOVERY MODE SINCE 1998)

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Figure 5  
pH IN TEST FIELD  
(DECEMBER 2003)  
MERRILL MINING, L.L.C.  
FLORENCE, ARIZONA







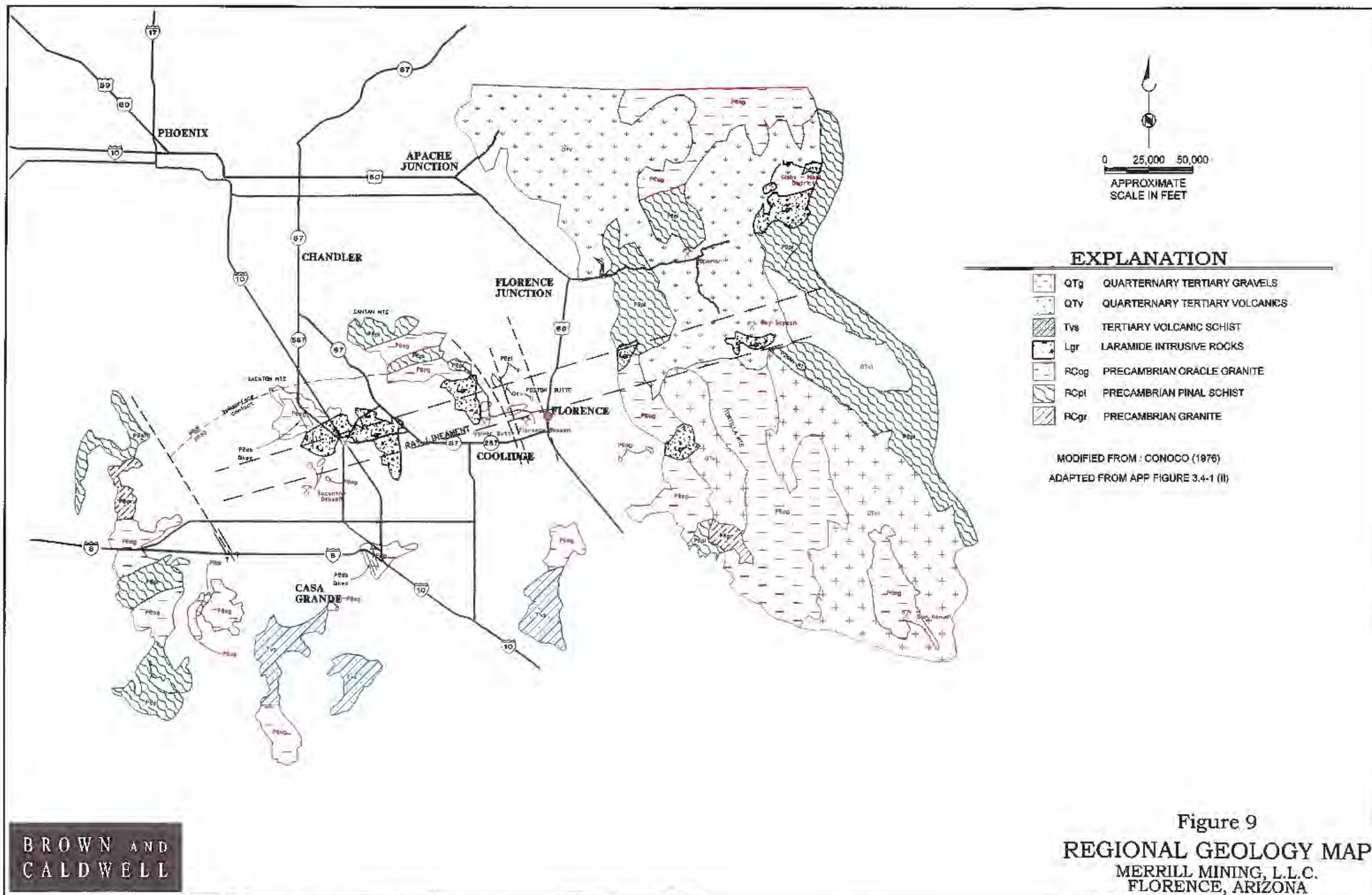
### EXPLANATION

- BHP-10 RECOVERY WELL (CURRENTLY INACTIVE)
- OWB-2 OBSERVATION WELL
- ▲ BHP-8 INJECTION / PUMPING WELL (RECOVERY MODE SINCE 1998)

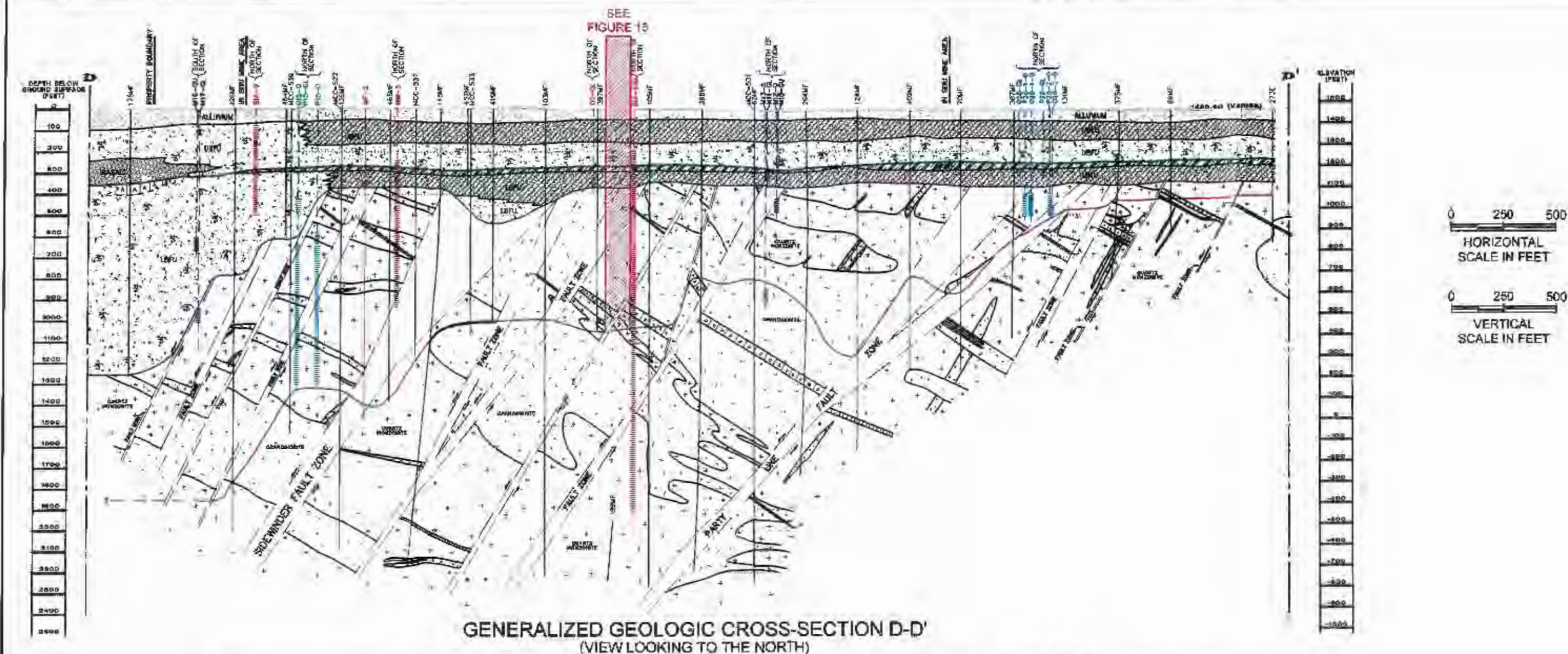
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Figure 8  
GROSS OR ADJUSTED  
ALPHA IN TEST FIELD  
(DECEMBER 2003)  
MERRILL MINING, L.L.C.  
FLORENCE, ARIZONA

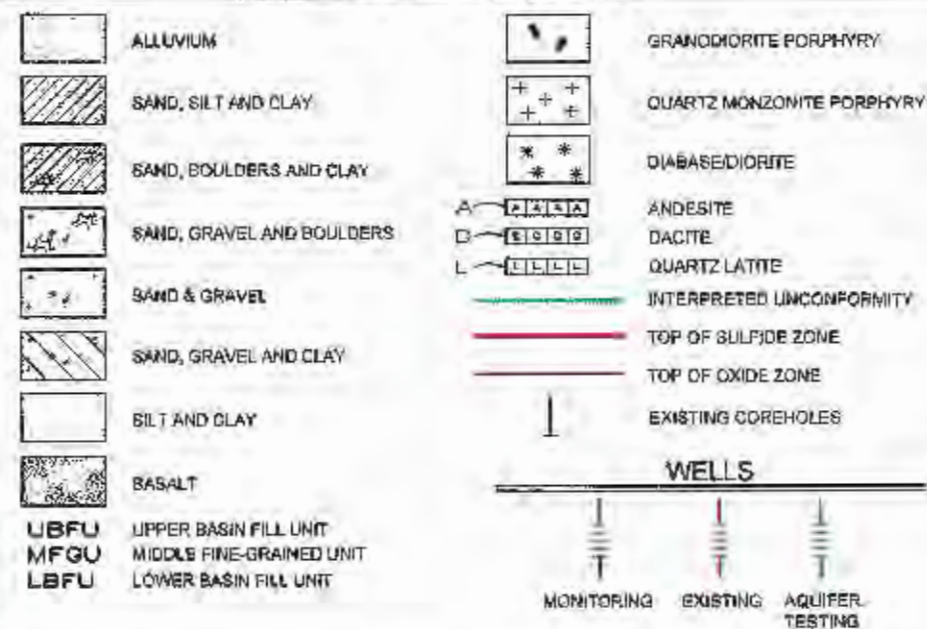








### EXPLANATION



### KEYMAP

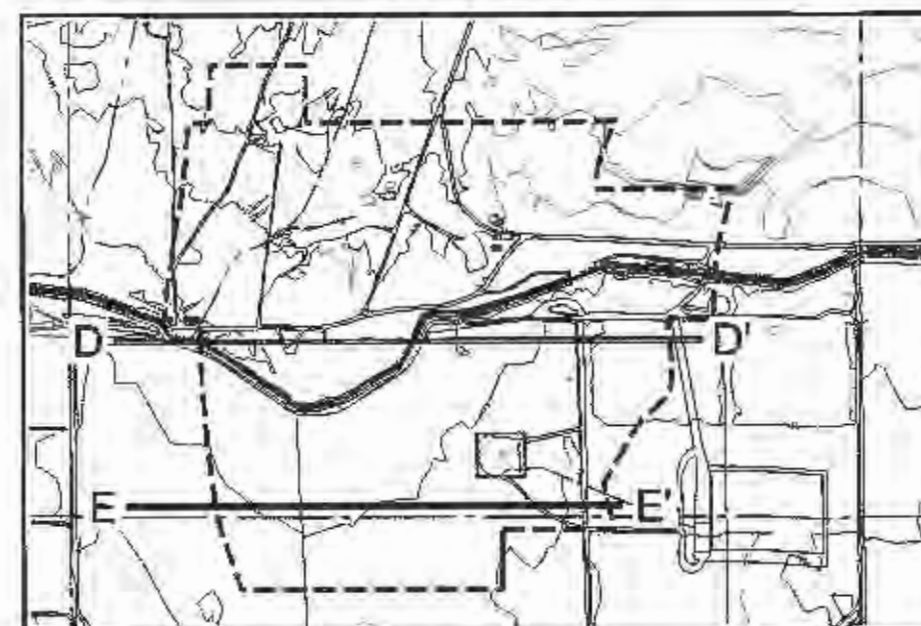
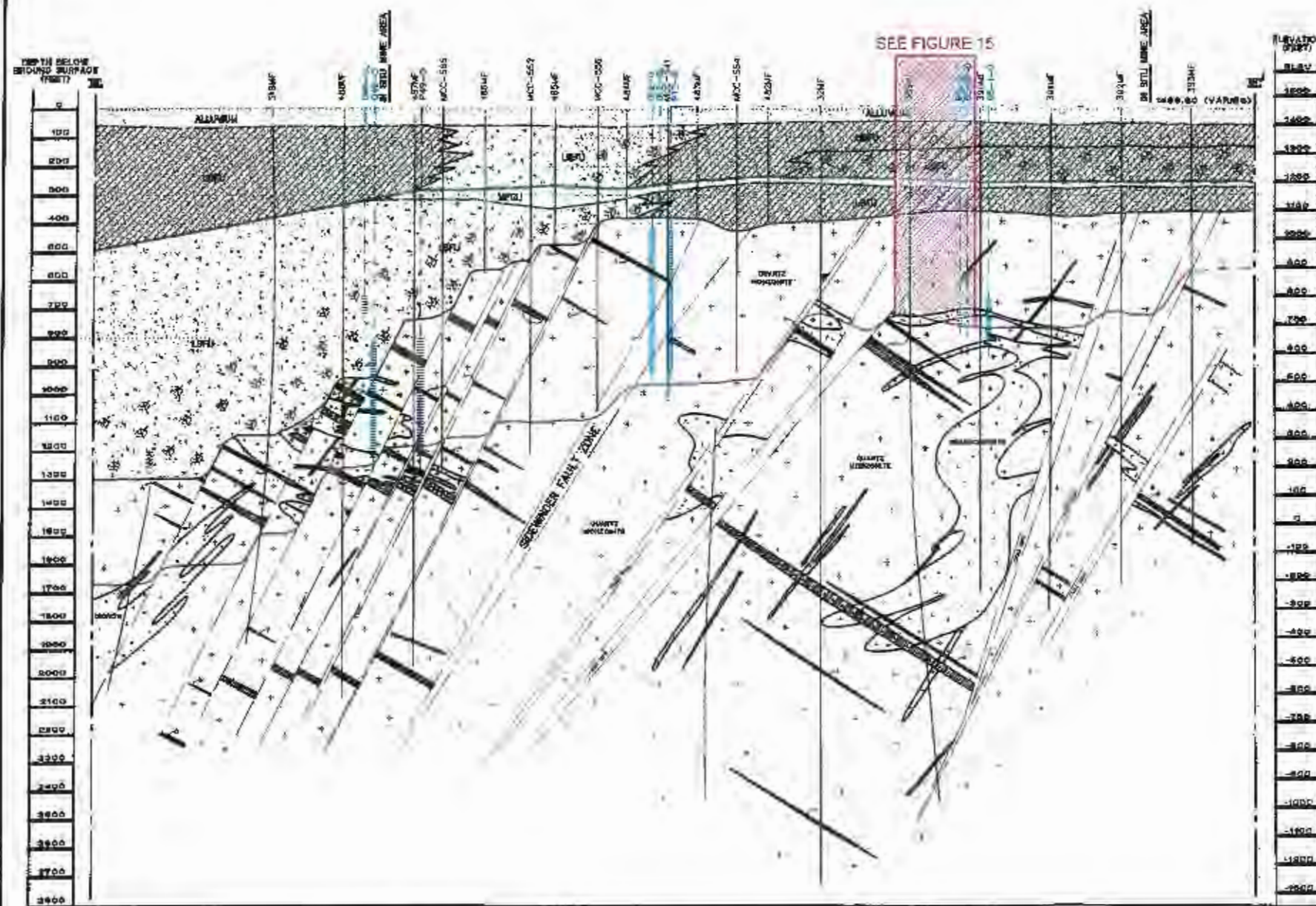


Figure 10  
GEOLOGIC  
CROSS-SECTION D-D'  
MERRILL MINING, L.L.C.  
FLORENCE, ARIZONA

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GENERALIZED GEOLOGIC CROSS-SECTION E-E'  
(VIEW LOOKING TO THE NORTH)

0 250 500

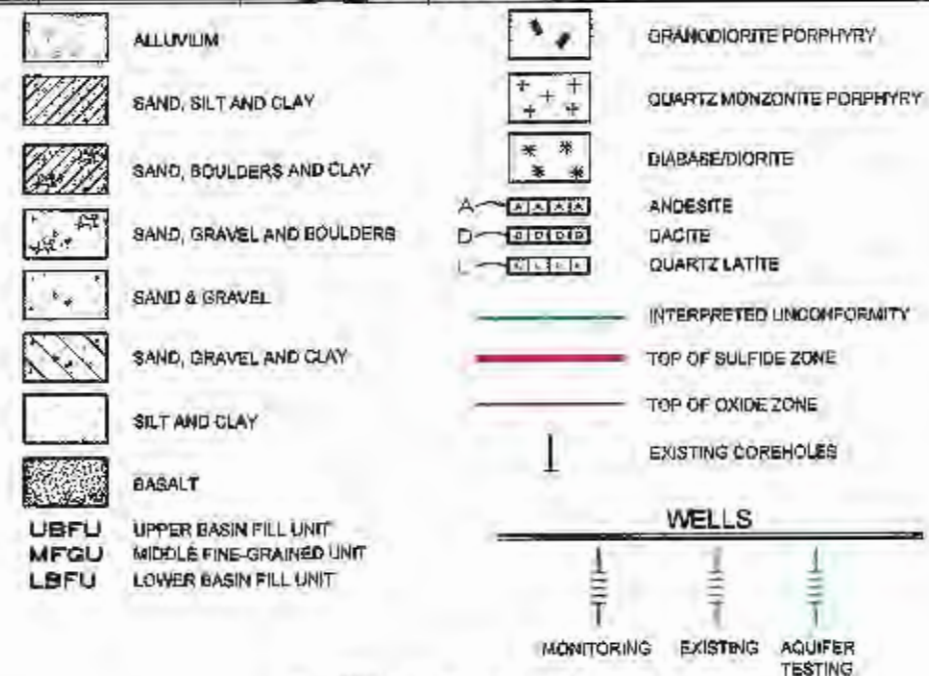
HORIZONTAL  
SCALE IN FEET

0 250 500

VERTICAL  
SCALE IN FEET

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## EXPLANATION



ADAPTED FROM APP FIGURE 4.3-3 (II)

## KEYMAP

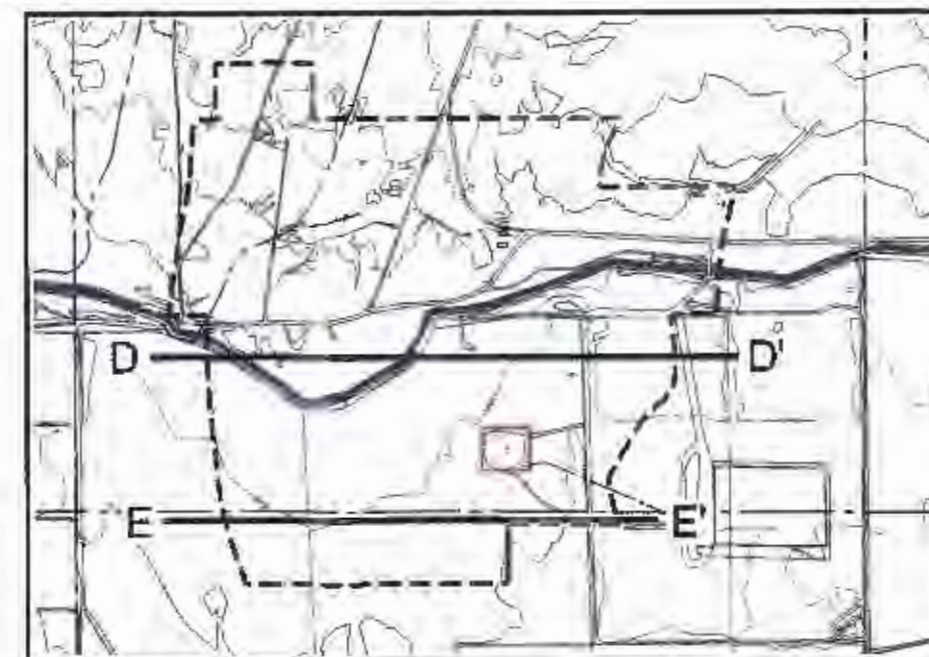
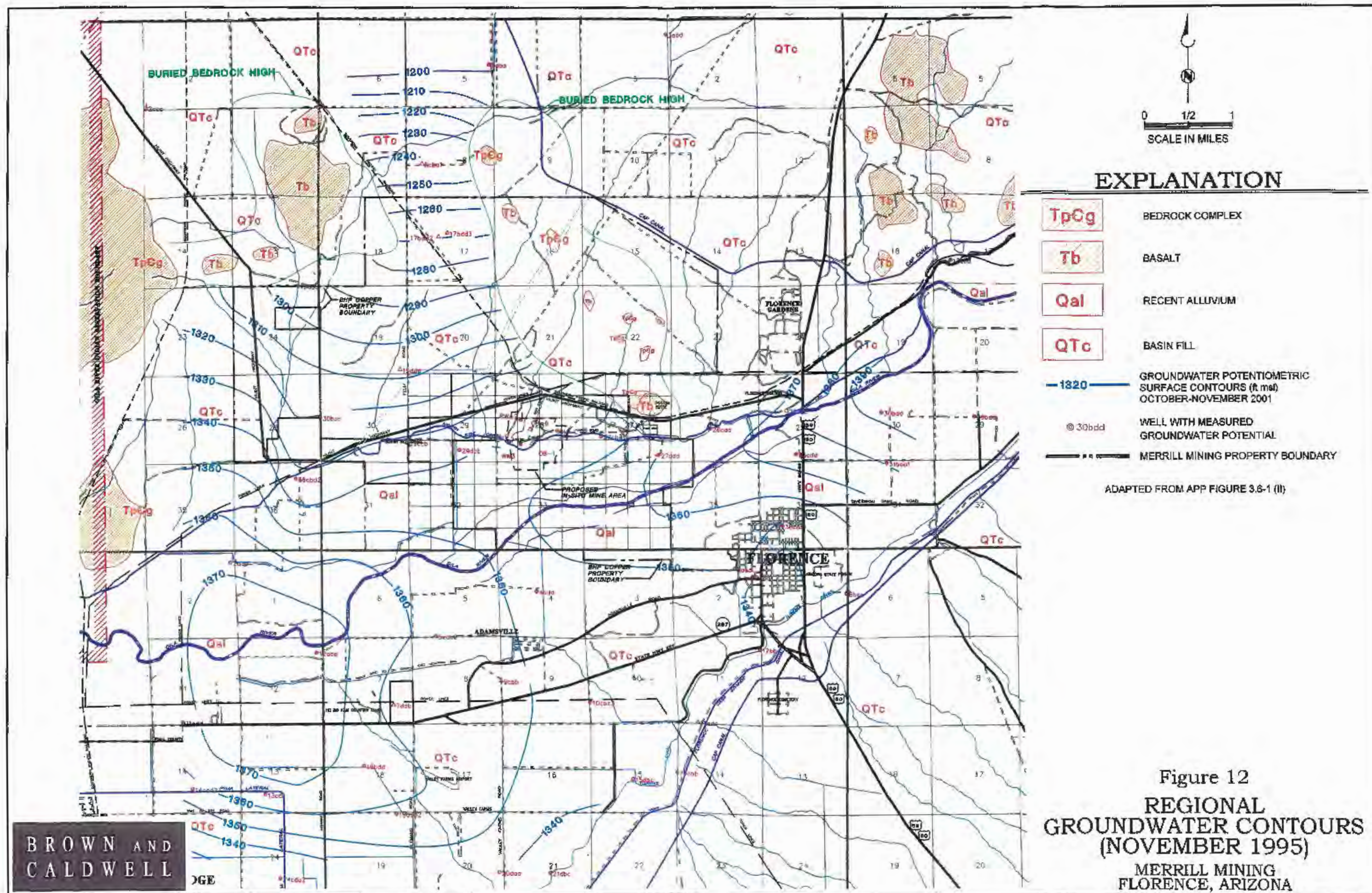
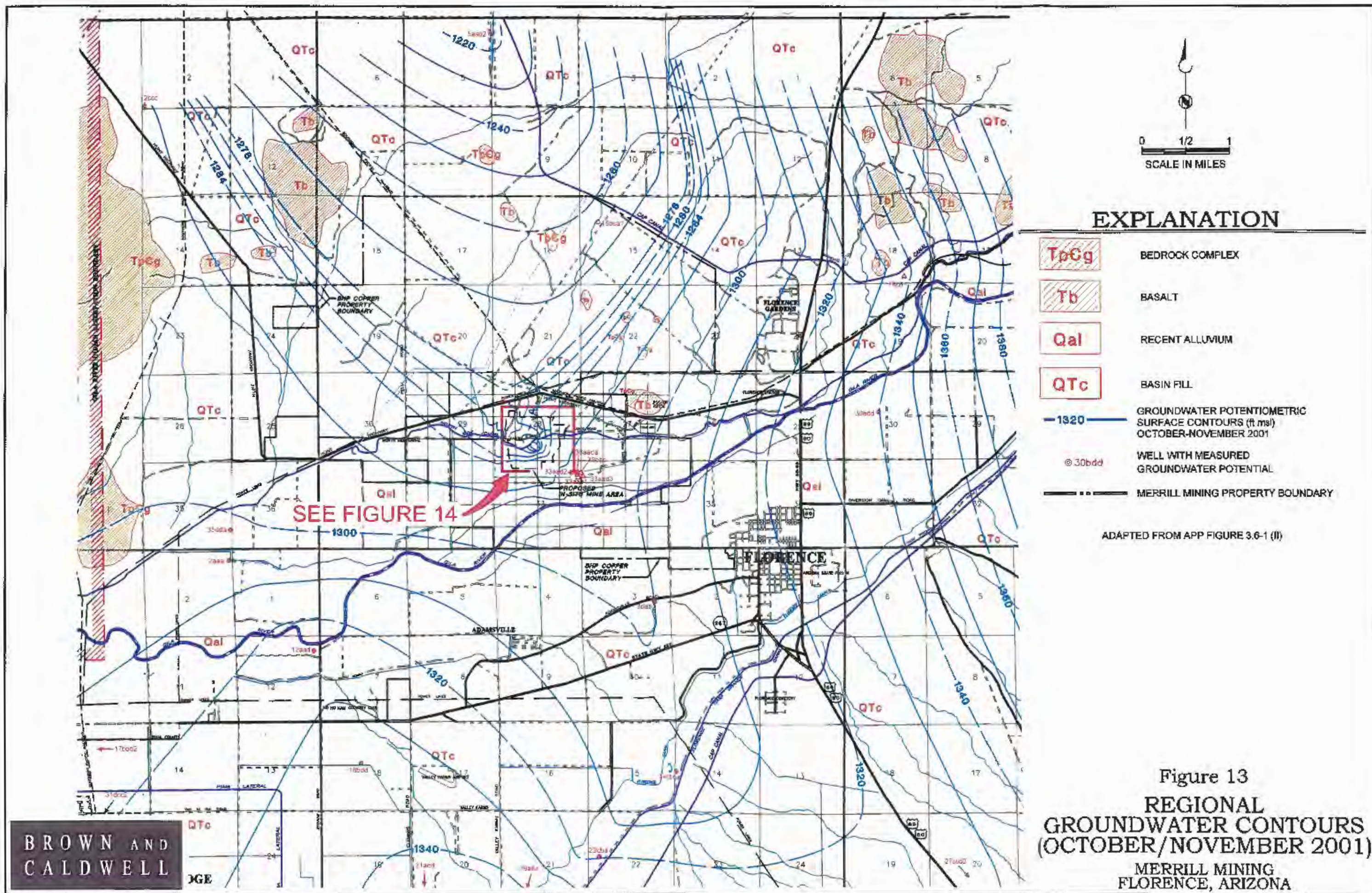


Figure 11  
GEOLOGIC  
CROSS-SECTION E-E'  
MERRILL MINING, L.L.C.  
FLORENCE, ARIZONA

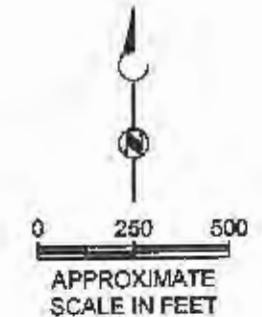
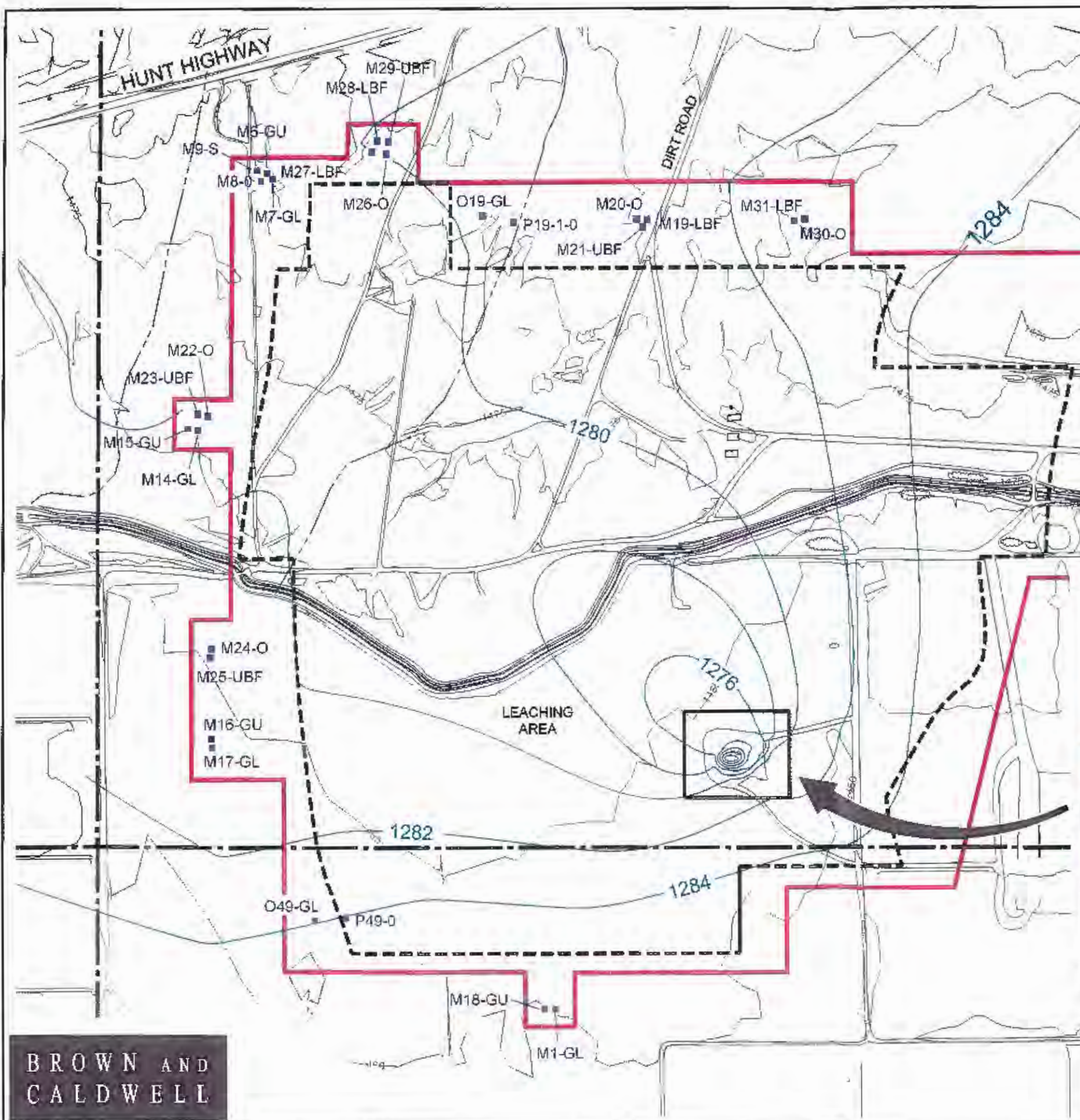












### EXPLANATION

- SUGGESTED MINE SITE BOUNDARY
- - - SECTION LINE
- - - PERMITTED IN-SITU AREA
- M19-LBF POC MONITORING WELL

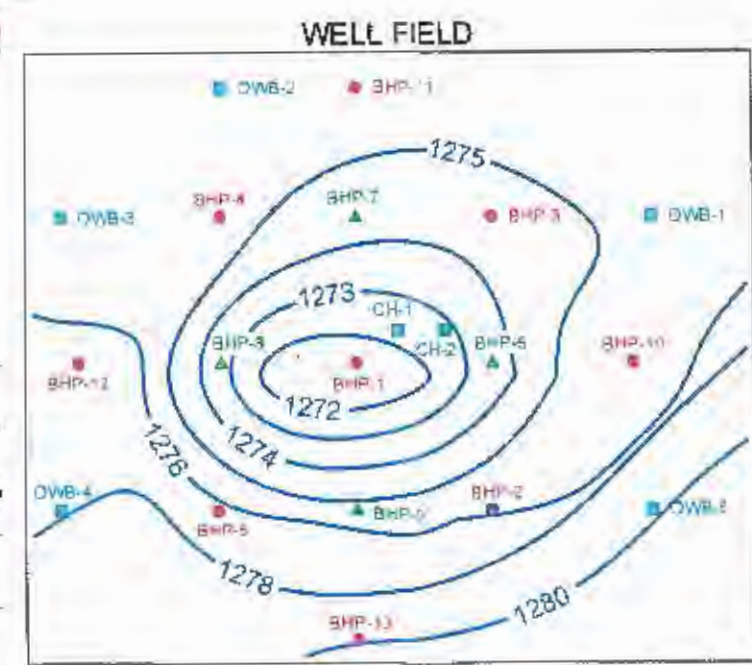


Figure 14  
**ENLARGED VIEW OF REGIONAL  
 GROUNDWATER CONTOURS  
 (FIGURE 13)**  
 MERRILL MINING, L.L.C.  
 FLORENCE, ARIZONA

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TABLE 1. TEST FIELD - FIELD PARAMETER RESULTS

Well ID	Sample Date	Temperature (°C)	Temperature (°F)	pH	Conductivity (µmhos/cm)
<b>Injection/Pumping Wells</b>					
BHP-6	Dec 29 2003	21.9	71.4	3.96	728
	Jun 04 2001	23.7	74.7	3.83	1171
	Sep 20 2000	23.9	75.0	4.06	1517
BHP-7	Dec 29 2003	21.9	71.4	5.14	636
	Jun 04 2001	24.2	75.6	4.14	1008
	Sep 20 2000	24.4	75.9	4.06	1326
BHP-8	Dec 29 2003	22.2	72.0	4.48	756
	Jun 04 2001	24.4	75.9	4.68	1150
	Sep 20 2000	24.3	75.7	4.61	1448
BHP-9	Dec 29 2003	21.4	70.5	4.34	701
	Jun 04 2001	23.9	75.0	3.78	1066
	Sep 20 2000	23.7	74.7	3.80	1398
<b>Recovery Wells</b>					
BHP-1	Dec 29 2003	22.5	72.5	6.12	808
	Jul 12 2001	23.3	73.9	6.34	1124
	Sep 21 2000	23.6	74.5	6.51	1338
BHP-2	Jan 12 2004	24.9	76.8	7.74	822
	Jun 04 2001	24.5	76.1	7.32	815
	Sep 21 2000	24.7	76.5	7.23	838
BHP-3	Dec 29 2003	23.2	73.8	7.37	798
	Jun 04 2001	24.8	76.6	7.17	854
	Sep 20 2000	24.9	76.8	6.58	981
BHP-4	Dec 29 2003	22.8	73.0	6.96	853
	Jun 04 2001	24.1	75.4	7.14	874
	Oct 19 2000	23.5	74.3	7.12	918
BHP-5	Dec 29 2003	23.1	73.6	6.46	687
	Jun 04 2001	24.5	76.1	5.81	762
	Sep 20 2000	24.3	75.7	5.81	873
BHP-10	Dec 29 2003	22.0	71.6	6.96	727
	Jun 04 2001	24.2	75.6	6.86	797
	Sep 20 2000	24.4	75.9	6.78	854
BHP-11	Dec 30 2003	23.6	74.5	7.57	838
	Jun 04 2001	24.6	76.3	7.40	840
	Sep 20 2000	25.0	77.0	6.78	877
BHP-12	Dec 30 2003	21.7	71.1	7.30	786
	Jun 04 2001	23.8	74.8	6.74	900
	Oct 19 2000	23.2	73.8	6.70	974

TABLE 1. TEST FIELD - FIELD PARAMETER RESULTS

Well ID	Sample Date	Temperature (°C)	Temperature (°F)	pH	Conductivity (µmhos/cm)
Recovery Wells					
BHP-13	Dec 29 2003	23.2	73.8	7.51	761
	Jun 05 2001	24.2	75.6	7.55	810
	Sep 20 2000	24.4	75.9	6.68	845
Observation Wells					
CH1-G	Dec 30 2003	NA	NA	NA	NA
	Jun 04 2001	NA	NA	NA	NA
	Sep 21 2000	22.6	72.7	6.11	1272
CH1-B	Dec 30 2003	NA	NA	6.60	712
	Jun 05 2001	22.9	73.2	6.53	1237
	Sep 21 2000	22.4	72.3	6.08	1523
CH1-R	Dec 30 2003	NA	NA	6.80	1026
	Jun 05 2001	22.7	72.9	6.43	1318
	Sep 21 2000	22.9	73.2	6.11	1525
CH2-G	Dec 30 2003	NA	NA	NA	NA
	Jun 05 2001	23.0	73.4	4.46	1141
	Sep 21 2000	21.8	71.2	4.23	1472
CH2-B	Dec 30 2003	NA	NA	4.82	630
	Jun 05 2001	22.9	73.2	4.31	1104
	Sep 21 2000	22.2	72.0	4.17	1513
CH2-R	Dec 30 2003	NA	NA	4.96	626
	Jun 05 2001	23.6	74.5	4.34	1271
	Sep 21 2000	22.2	72.0	4.33	1533
OWB-1	Dec 30 2003	22.0	71.6	7.62	782
	Jun 05 2001	23.7	74.7	7.70	812
	Sep 21 2000	23.8	74.8	7.16	835
OWB-2	Dec 30 2003	21.0	69.8	7.38	1135
	Jul 12 2001	21.1	70.0	7.25	1410
	Sep 20 2000	NA	NA	NA	NA
OWB-3	Dec 29 2003	22.2	72.0	7.23	775
	Jun 05 2001	23.7	74.7	7.53	805
	Sep 20 2000	23.6	74.5	6.98	822
OWB-4	Dec 30 2003	23.2	73.8	7.56	777
	Jun 05 2001	24.1	75.4	7.50	801
	Sep 21 2000	24.2	75.6	6.88	824
OWB-5	Dec 30 2003	23.2	73.8	7.61	780
	Jun 05 2001	24.2	75.6	7.74	808
	Sep 21 2000	24.5	76.1	7.24	845

**TABLE 1. TEST FIELD - FIELD PARAMETER RESULTS**

Well ID	Sample Date	Temperature (°C)	Temperature (°F)	pH	Conductivity (µmhos/cm)
<b>Evaporation Pond</b>					
Evap Pond	Dec 30 2003	NA	NA	7.69	7470
	Jun 05 2001	27.5	81.5	6.71	7850
	Sep 20 2000	NA	NA	NA	NA
NA = Not measured or not sampled					

TABLE 2. TEST FIELD - INDICATOR PARAMETER RESULTS

Well ID	Sample Date	Magnesium	Sulfate	Fluoride	Total Dissolved Solids
Observation Wells					
OWB-5	Dec 30 2003	13	60	0.46	470
	Dec 30 2003*	13	60	0.51	480
	Jun 05 2001	13	52	0.47	491
	Sep 21 2000	14	54	0.51	475
Evaporation Pond					
Evap Pond	Dec 30 2003	460	10000	6.2	8700
	Jun 05 2001	330	4100	13.0	6900
	Sep 21 2000	NA	NA	NA	NA
	Nov 09 1999	220	3000	8.8	4670
	Nov 09 1999*	230	3300	10.0	7820
	Nov 09 1999*	220	3300	7.9	4660
Arizona Aquifer Water Quality Standard		-	-	4	-
National Secondary Drinking Water Regs		-	250	2	500
All results in milligrams per liter (mg/L) < = less than detection limit * = Field duplicate sample NA = Not sampled or not analyzed					

TABLE 2. TEST FIELD - INDICATOR PARAMETER RESULTS

Well ID	Sample Date	Magnesium	Sulfate	Fluoride	Total Dissolved Solids
Injection/Pumping Wells					
BHP-6	Dec 29 2003	12	150	0.86	550
	Jun 04 2001	26	420	1.3	892
	Sep 20 2000	39	570	1.7	1140
BHP-7	Dec 29 2003	9	97	0.94	440
	Jun 04 2001	21	280	1.3	725
	Sep 20 2000	34	450	1.7	959
BHP-8	Dec 29 2003	13	160	0.92	530
	Jun 04 2001	27	410	1.3	871
	Sep 20 2000	39	540	1.6	1100
BHP-9	Dec 29 2003	12	130	0.96	490
	Jun 04 2001	25	360	1.5	785
	Sep 20 2000	36	490	2.0	1030
Recovery Wells					
BHP-1	Dec 29 2003	18	130	0.91	500
	Jul 12 2001	30	240	0.78	763
	Jul 12 2001*	28	260	0.78	767
	Sep 21 2000	34	390	0.68	904
BHP-2	Jan 12 2004	13	67	0.69	470
	Jun 04 2001	13	60	0.61	476
	Sep 21 2000	14	64	0.62	493
BHP-3	Dec 29 2003	13	69	0.55	470
	Jun 04 2001	14	73	0.78	488
	Sep 20 2000	18	130	0.94	549
BHP-4	Dec 29 2003	16	130	0.88	550
	Jun 04 2001	16	93	1.1	517
	Oct 19 2000	19	110	1.2	493
BHP-5	Dec 29 2003	12	67	1.7	420
	Dec 29 2003*	13	69	1.6	470
	Jun 04 2001	14	110	1.2	477
	Sep 20 2000	16	160	1.3	524
BHP-10	Dec 29 2003	14	60	1.0	440
	Jun 04 2001	15	59	1.2	451
	Sep 20 2000	17	66	1.3	436
BHP-11	Dec 30 2003	13	97	<0.4	520
	Jun 04 2001	14	64	0.42	489
	Sep 20 2000	15	66	0.5	446



TABLE 2. TEST FIELD - INDICATOR PARAMETER RESULTS

Well ID	Sample Date	Magnesium	Sulfate	Fluoride	Total Dissolved Solids
Recovery Wells					
BHP-12	Dec 30 2003	16	76	0.84	500
	Jun 04 2001	18	120	1.2	523
	Oct 19 2000	24	160	1.3	558
BHP-13	Dec 29 2003	13	57	<0.4	480
	Jun 05 2001	13	52	0.44	466
	Sep 20 2000	14	62	0.54	428
Observation Wells					
CH1-G	Dec 30 2003	NA	NA	NA	NA
	Jun 04 2001	NA	NA	NA	NA
	Sep 21 2000	37	430	0.96	953
CH1-B	Dec 30 2003	16	140	1.1	498
	Jun 05 2001	25	340	0.81	736
	Sep 21 2000	34	400	0.85	895
CH1-R	Dec 30 2003	26	300	0.93	740
	Jun 05 2001	26	340	0.9	753
	Sep 21 2000	37	420	0.85	904
CH2-G	Dec 30 2003	NA	NA	NA	NA
	Jun 05 2001	25	370	1.6	875
	Sep 21 2000	45	640	2.1	1210
CH2-B	Dec 30 2003	12	120	1.5	520
	Jun 05 2001	26	400	1.6	869
	Sep 21 2000	47	630	1.7	1250
CH2-R	Dec 30 2003	11	100	1.0	510
	Jun 05 2001	26	390	0.81	812
	Sep 21 2000	47	670	1.5	1320
OWB-1	Dec 30 2003	15	62	<0.4	480
	Jun 05 2001	14	53	0.49	484
	Sep 21 2000	15	96	0.46	479
OWB-2	Dec 30 2003	21	180	0.64	770
	Jul 12 2001	30	210	0.69	1010
	Sep 20 2000	NA	NA	NA	NA
OWB-3	Dec 29 2003	12	58	0.53	480
	Jun 05 2001	13	48	0.53	487
	Sep 20 2000	14	57	0.52	445
OWB-4	Dec 30 2003	13	59	<0.4	480
	Jun 05 2001	13	59	0.67	483
	Sep 21 2000	14	61	0.74	485

TABLE 3. TEST FIELD - TRACE METAL RESULTS

Well ID	Sample Date	Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Cobalt	Copper	Iron	Lead	Manganese	Mercury	Nickel	Selenium	Thallium	Zinc
Injection/Pumping Wells																		
BHP-6	Dec 29 2003	0.96	<0.001	0.01	0.011	0.0011	<0.001	<0.001	0.031	8.5	<0.05	0.004	0.45	<0.0002	0.036	0.002	<0.001	0.052
	Jun 04 2001	2.5	<0.001	0.009	0.014	<0.002	<0.002	<0.005	0.073	17.	0.064	<0.001	1.1	<0.0002	0.081	0.002	<0.001	0.12
	Sep 20 2000	4.4	<0.001	0.008	0.017	0.0034	<0.002	<0.005	0.11	24.	0.15	0.002	1.7	<0.0002	0.13	0.002	<0.001	0.22
BHP-7	Dec 29 2003	0.49	<0.001	0.009	0.023	<0.001	<0.001	<0.001	0.021	3.4	<0.05	0.001	0.26	<0.0002	0.026	0.002	<0.001	<0.05
	Jun 04 2001	2.3	<0.001	<0.001	0.02	<0.002	<0.002	<0.005	0.071	14.	<0.05	0.002	0.86	<0.0002	0.084	0.002	<0.001	0.096
	Sep 20 2000	4.1	<0.001	0.005	0.02	0.0034	<0.002	<0.005	0.11	24.	<0.05	0.003	1.5	<0.0002	0.14	0.003	<0.001	0.21
BHP-8	Dec 29 2003	0.91	<0.001	0.004	0.013	0.0011	<0.001	<0.001	0.037	9.6	<0.05	0.004	0.46	<0.0002	0.042	0.003	<0.001	0.067
	Jun 04 2001	2.	<0.001	0.004	0.015	<0.002	<0.002	<0.005	0.082	19.	0.09	<0.001	1.	<0.0002	0.093	0.004	<0.001	0.14
	Sep 20 2000	3.5	<0.001	0.004	0.016	0.0034	<0.002	<0.005	0.12	28.	0.17	0.001	1.6	<0.0002	0.14	0.004	<0.001	0.23
BHP-9	Dec 29 2003	1.1	<0.001	0.006	0.014	0.0011	<0.001	<0.001	0.032	8.9	<0.05	0.004	0.47	<0.0002	0.041	0.001	<0.001	0.073
	Jun 04 2001	2.8	<0.001	0.009	0.021	0.0028	<0.002	<0.005	0.076	19.	<0.05	0.002	1.1	<0.0002	0.093	0.002	<0.001	0.12
	Sep 20 2000	4.9	<0.001	0.009	0.021	0.0046	<0.002	<0.005	0.11	26.	0.055	0.002	1.7	<0.0002	0.15	0.003	<0.001	0.24
Recovery Wells																		
BHP-1	Dec 29 2003	<0.1	<0.001	0.002	0.029	<0.001	<0.001	<0.001	0.007	1.4	<0.05	<0.001	0.17	<0.0002	0.025	<0.001	<0.001	<0.05
	Jul 12 2001	0.053	<0.001	0.002	0.043	<0.002	<0.002	<0.005	0.007	1.	<0.05	<0.001	0.18	<0.0002	0.027	0.003	<0.001	<0.05
	Jul 12 2001*	0.044	<0.001	<0.001	0.041	<0.002	<0.002	<0.005	0.006	1.	<0.05	<0.001	0.17	<0.0002	0.026	0.002	<0.001	<0.05
	Sep 21 2000	<0.025	<0.001	0.001	0.053	<0.0025	<0.002	<0.005	<0.005	0.8	<0.05	<0.001	0.17	<0.0002	0.025	0.002	<0.001	0.1
BHP-2	Jan 12 2004	<0.1	<0.001	0.002	0.039	<0.001	<0.001	0.002	0.005	0.04	<0.05	<0.001	0.007	<0.0002	0.004	<0.001	<0.001	<0.05
	Jun 04 2001	<0.025	<0.001	<0.001	0.05	<0.002	<0.002	<0.005	<0.005	0.066	<0.05	<0.001	<0.003	<0.0002	<0.02	0.001	<0.001	<0.05
	Sep 21 2000	<0.025	<0.001	0.001	0.056	<0.0025	<0.002	<0.005	<0.005	0.074	<0.05	<0.001	<0.003	<0.0002	<0.02	0.001	<0.001	<0.05
BHP-3	Dec 29 2003	<0.1	<0.001	0.002	0.05	<0.001	<0.001	0.001	<0.001	0.081	<0.05	<0.001	0.004	<0.0002	0.003	<0.001	<0.001	<0.05
	Jun 04 2001	<0.025	<0.001	<0.001	0.053	<0.002	<0.002	<0.005	<0.005	0.14	<0.05	<0.001	0.011	<0.0002	<0.02	0.001	<0.001	<0.05
	Sep 20 2000	0.035	<0.001	0.002	0.042	<0.0025	<0.002	<0.005	0.013	1.1	<0.05	<0.001	0.2	<0.0002	0.022	0.001	<0.001	<0.05
BHP-4	Dec 29 2003	<0.1	<0.001	0.002	0.017	<0.001	<0.001	0.001	<0.001	0.22	<0.05	<0.001	0.014	<0.0002	0.006	0.001	<0.001	<0.05
	Jun 04 2001	<0.025	<0.001	<0.001	0.017	<0.002	<0.002	<0.005	<0.005	0.29	<0.05	<0.001	0.025	<0.0002	<0.02	0.002	<0.001	<0.05
	Oct 19 2000	0.043	<0.001	<0.001	0.022	<0.0025	<0.002	<0.005	<0.005	0.43	0.11	<0.001	0.053	<0.0002	<0.02	0.001	<0.001	<0.05
BHP-5	Dec 29 2003	<0.1	<0.001	0.005	0.0081	<0.001	<0.001	0.001	0.012	2.	<0.05	<0.001	0.18	<0.0002	0.016	<0.001	<0.001	<0.05
	Dec 29 2003*	<0.1	<0.001	0.004	0.0058	<0.001	<0.001	0.001	0.011	2.	<0.05	<0.001	0.17	<0.0002	0.016	<0.001	<0.001	<0.05
	Jun 04 2001	<0.025	<0.001	0.004	<0.0025	<0.002	<0.002	<0.005	0.026	5.4	<0.05	<0.001	0.37	<0.0002	0.029	0.002	<0.001	<0.05
	Sep 20 2000	0.4	<0.001	0.004	0.0098	<0.0025	<0.002	<0.005	0.033	7.5	<0.05	<0.001	0.51	<0.0002	0.04	0.003	<0.001	0.062
BHP-10	Dec 29 2003	<0.1	<0.001	0.004	0.011	<0.001	<0.001	0.001	<0.001	0.14	<0.05	<0.001	0.007	<0.0002	0.006	<0.001	<0.001	<0.05
	Jun 04 2001	<0.025	<0.001	0.003	0.009	<0.002	<0.002	<0.005	<0.005	0.18	<0.05	<0.001	0.01	<0.0002	<0.02	<0.001	<0.001	<0.05
	Sep 20 2000	0.034	<0.001	0.003	0.01	<0.0025	<0.002	<0.005	<0.005	0.27	0.063	<0.001	0.021	<0.0002	<0.02	<0.001	<0.001	<0.05
BHP-11	Dec 30 2003	<0.1	<0.001	0.002	0.017	<0.001	<0.001	0.001	<0.001	0.048	<0.05	<0.001	<0.003	<0.0002	0.002	<0.001	<0.001	<0.05
	Jun 04 2001	<0.025	<0.001	0.001	0.02	<0.002	<0.002	<0.005	<0.005	0.11	<0.05	<0.001	<0.003	<0.0002	<0.02	<0.001	<0.001	<0.05
	Sep 20 2000	<0.025	<0.001	0.001	0.022	<0.0025	<0.002	<0.005	<0.005	0.2	<0.05	0.002	<0.003	<0.0002	<0.02	0.001	<0.001	<0.05
BHP-12	Dec 30 2003	<0.1	<0.001	0.002	0.052	<0.001	<0.001	0.001	0.002	0.2	<0.05	<0.001	0.029	<0.0002	0.008	<0.001	<0.001	<0.05
	Jun 04 2001	<0.025	<0.001	0.003	0.049	<0.002	<0.002	<0.005	0.016	1.	<0.05	<0.001	0.19	<0.0002	<0.02	0.001	<0.001	<0.05
	Oct 19 2000	0.085	<0.001	0.003	0.05	<0.0025	<0.002	<0.005	0.023	1.7	0.14	0.002	0.33	<0.0002	0.031	0.002	<0.001	<0.05
BHP-13	Dec 29 2003	<0.1	<0.001	0.002	0.025	<0.001	<0.001	0.001	<0.001	0.017	<0.05	<0.001	<0.003	<0.0002	0.003	<0.001	<0.001	<0.05
	Jun 05 2001	<0.025	0.002	<0.001	0.03	<0.002	<0.002	<0.005	<0.005	0.021	<0.05	<0.001	<0.003	<0.0002	<0.02	<0.001	<0.001	<0.05
	Sep 20 2000	<0.025	<0.001	0.002	0.031	<0.0025	<0.002	<0.005	<0.005	0.031	<0.05	<0.001	<0.003	<0.0002	<0.02	0.001	<0.001	<0.05



TABLE 3. TEST FIELD - TRACE METAL RESULTS

Well ID	Sample Date	Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Cobalt	Copper	Iron	Lead	Manganese	Mercury	Nickel	Selenium	Thallium	Zinc
Observation Wells																		
CH1-G	Dec 30 2003	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Jun 04 2001	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Sep 21 2000	0.16	<0.001	0.003	0.04	<0.0025	<0.002	<0.005	0.033	1.7	0.3	<0.001	0.58	<0.0002	0.067	0.002	<0.001	0.097
CH1-B	Dec 30 2003	<0.1	<0.001	0.003	0.028	<0.001	<0.001	<0.001	0.016	0.99	<0.05	<0.001	0.25	<0.0002	0.029	0.002	<0.001	<0.05
	Jun 05 2001	0.053	<0.001	0.002	0.025	<0.002	<0.002	<0.005	0.014	0.5	<0.05	<0.001	0.28	<0.0002	0.033	0.002	<0.001	<0.05
	Sep 21 2000	<0.025	<0.001	0.003	0.032	<0.0025	<0.002	<0.005	0.021	0.69	<0.05	<0.001	0.38	<0.0002	0.044	0.002	<0.001	0.061
CH1-R	Dec 30 2003	<0.1	<0.001	0.002	0.021	<0.001	<0.001	<0.001	0.005	0.61	<0.05	<0.001	0.14	<0.0002	0.029	0.002	<0.001	<0.05
	Jun 05 2001	0.091	<0.001	0.002	0.027	<0.002	<0.002	<0.005	0.016	0.63	0.13	<0.001	0.32	<0.0002	0.04	0.002	<0.001	0.12
	Sep 21 2000	<0.025	<0.001	0.002	0.035	<0.0025	<0.002	<0.005	0.022	0.74	<0.05	0.001	0.43	<0.0002	0.047	0.002	<0.001	0.1
CH2-G	Dec 30 2003	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Jun 05 2001	2.5	<0.001	<0.001	0.012	<0.002	<0.002	<0.005	0.072	20.	<0.05	<0.001	1.1	<0.0002	0.094	<0.001	<0.001	0.17
	Sep 21 2000	4.9	<0.001	0.002	0.013	0.0031	<0.002	<0.005	0.13	31.	<0.05	0.002	2.1	<0.0002	0.17	0.002	<0.001	0.33
CH2-B	Dec 30 2003	1.2	<0.001	0.003	0.024	<0.001	<0.001	<0.001	0.031	8.3	<0.05	0.001	0.45	<0.0002	0.035	<0.001	<0.001	0.058
	Jun 05 2001	2.6	<0.001	<0.001	0.013	<0.002	<0.002	<0.005	0.074	20.	<0.05	<0.001	1.2	<0.0002	0.094	0.001	<0.001	0.15
	Sep 21 2000	5.3	<0.001	0.003	0.013	0.0031	<0.002	<0.005	0.14	32.	<0.05	0.002	2.2	<0.0002	0.18	0.002	<0.001	0.28
CH2-R	Dec 30 2003	0.78	<0.001	0.003	0.022	<0.001	<0.001	<0.001	0.03	7.2	<0.05	<0.001	0.44	<0.0002	0.034	<0.001	<0.001	0.11
	Jun 05 2001	2.7	<0.001	0.003	0.014	<0.002	<0.002	<0.005	0.075	19.	<0.05	<0.001	1.2	<0.0002	0.1	<0.001	<0.001	0.21
	Sep 21 2000	5.8	<0.001	0.003	0.015	0.0035	<0.002	<0.005	0.13	32.	0.064	0.001	2.1	<0.0002	0.17	0.001	<0.001	0.32
OWB-1	Dec 30 2003	<0.1	<0.001	0.002	0.021	<0.001	<0.001	0.001	0.005	0.039	<0.05	<0.001	0.006	<0.0002	0.002	0.001	<0.001	<0.05
	Jun 05 2001	<0.025	0.002	0.002	0.024	<0.002	<0.002	<0.005	<0.005	0.05	<0.05	<0.001	<0.003	<0.0002	<0.02	0.001	<0.001	<0.05
	Sep 21 2000	<0.025	<0.001	0.002	0.024	<0.0025	<0.002	<0.005	<0.005	0.063	<0.05	<0.001	<0.003	<0.0002	<0.02	<0.001	<0.001	<0.05
OWB-2	Dec 30 2003	<0.1	<0.001	0.003	0.042	<0.001	<0.001	<0.001	<0.001	<0.01	<0.05	<0.001	<0.003	<0.0002	0.003	<0.001	<0.001	<0.05
	Jul 12 2001	<0.025	<0.001	0.003	0.061	<0.002	<0.002	<0.005	<0.005	<0.003	<0.05	<0.001	<0.003	<0.0002	<0.02	0.003	<0.001	<0.05
	Sep 20 2000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
OWB-3	Dec 29 2003	<0.1	<0.001	0.002	0.014	<0.001	<0.001	0.001	<0.001	0.016	<0.05	<0.001	<0.003	<0.0002	0.002	<0.001	<0.001	<0.05
	Jun 05 2001	<0.025	<0.001	<0.001	0.018	<0.002	<0.002	<0.005	<0.005	0.011	<0.05	<0.001	<0.003	<0.0002	<0.02	<0.001	<0.001	<0.05
	Sep 20 2000	0.026	<0.001	0.001	0.017	<0.0025	<0.002	<0.005	<0.005	0.014	<0.05	<0.001	<0.003	<0.0002	<0.02	0.001	<0.001	<0.05
OWB-4	Dec 30 2003	<0.1	<0.001	0.002	0.026	<0.001	<0.001	0.001	<0.001	0.047	<0.05	<0.001	<0.003	<0.0002	0.002	<0.001	<0.001	<0.05
	Jun 05 2001	<0.025	<0.001	<0.001	0.035	<0.002	<0.002	<0.005	<0.005	0.063	<0.05	<0.001	<0.003	<0.0002	<0.02	<0.001	<0.001	<0.1
	Sep 21 2000	<0.025	<0.001	0.002	0.037	<0.0025	<0.002	<0.005	<0.005	0.08	<0.05	<0.001	<0.003	<0.0002	<0.02	0.001	<0.001	<0.05
OWB-5	Dec 30 2003	<0.1	<0.001	0.002	0.02	<0.001	<0.001	0.001	0.004	<0.01	<0.05	<0.001	0.006	<0.0002	0.002	<0.001	<0.001	<0.05
	Dec 30 2003*	<0.1	<0.001	0.002	0.02	<0.001	<0.001	0.001	0.005	<0.01	<0.05	<0.001	0.007	<0.0002	0.002	0.001	<0.001	<0.05
	Jun 05 2001	<0.025	<0.001	0.002	0.022	<0.002	<0.002	<0.005	<0.005	0.006	<0.05	<0.001	<0.003	<0.0002	<0.02	0.001	<0.001	<0.05
	Sep 21 2000	<0.025	<0.001	0.002	0.025	<0.0025	<0.002	<0.005	<0.005	0.009	<0.05	<0.001	<0.003	<0.0002	<0.02	0.001	<0.001	<0.05
Evaporation Pond																		
Evap Pond	Dec 30 2003	0.46	<0.001	0.006	0.067	<0.001	<0.001	<0.001	0.008	0.18	<0.05	<0.001	0.22	<0.0002	0.026	0.008	<0.001	<0.05
	Jun 05 2001	<0.025	<0.001	0.009	0.09	<0.002	<0.002	<0.005	0.082	0.44	<0.05	<0.001	4.	<0.0002	0.21	0.04	<0.001	0.087
	Sep 21 2000	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Nov 09 1999	0.7	<0.025	<0.005	NA	0.0079	0.005	<0.005	NA	15.	<0.05	<0.025	6.1	<0.0002	0.43	<0.025	<0.05	0.54
	Nov 09 1999*	0.62	<0.025	<0.005	NA	0.0076	0.006	<0.005	NA	15.	<0.05	<0.025	6.4	<0.0002	0.46	0.026	<0.05	0.57
	Nov 08 1999*	0.62	<0.025	<0.005	NA	0.0075	0.006	<0.005	NA	15.	<0.05	<0.025	6.3	<0.0002	0.45	0.03	<0.05	0.56

TABLE 1. TEST FIELD - TRACE METAL RESULTS

Well ID	Sample Date	Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Cobalt	Copper	Iron	Lead	Manganese	Mercury	Nickel	Selenium	Thallium	Zinc
Arizona Aquifer Water Quality Standard		-	0.006	0.05	2	0.004	0.005	0.1	-	-	-	0.05	-	0.002	0.1	0.05	0.002	-
National Secondary Drinking Water Reg		0.2	-	-	-	-	-	-	-	1	0.3	-	0.05	-	-	-	-	5

All results in milligrams per liter (mg/L)  
 <= less than detection limit  
 \* = Field duplicate sample  
 NA = Not sampled or not analyzed  
 Bold indicates result exceeds Aquifer Water Quality Standard



TABLE 4. TEST FIELD - COMMON INORGANIC RESULTS

Well ID	Sample Date	Total Alkalinity	Calcium	Chloride	Nitrate as N	Potassium	Sodium	Silica	pH (Lab)	Ion Balance
<b>Injection/Pumping Wells</b>										
BHP-6	Dec 29 2003	<6	51	140	0.53	5.8	75	120	4.38	1.38
	Jun 04 2001	<25	110	130	<0.5	6.5	66	38	4.05	8.
	Sep 20 2000	<25	170	140	0.48	6.7	81	NA	3.94	2.
BHP-7	Dec 29 2003	10	34	140	0.49	5.5	82	80	5.77	1.28
	Jun 04 2001	<25	30	140	<0.5	6.	62	22	4.88	7.
	Sep 20 2000	<25	130	130	0.43	7.3	84	NA	4.07	0
BHP-8	Dec 29 2003	<6	48	140	0.52	6.2	82	88	5.24	14
	Jun 04 2001	<25	100	130	<0.5	6.	74	36	4.78	7.
	Sep 20 2000	<25	150	130	0.47	7.3	91	NA	4.49	1.
BHP-9	Dec 29 2003	<6	46	140	0.5	5.7	78	84	4.95	2.88
	Jun 04 2001	<25	90	130	<0.5	6.2	62	40	4.07	9.
	Sep 20 2000	<25	140	140	0.45	7.6	75	NA	3.84	13.
<b>Recovery Wells</b>										
BHP-1	Dec 29 2003	64	64	150	0.94	6.4	81	45	6.71	2.19
	Jul 12 2001	80	110	140	0.54	5.9	100	NA	7.11	12.
	Jul 12 2001*	80	110	140	0.53	5.4	99	NA	6.91	9.
	Sep 21 2000	93	140	140	<1.	6.3	120	NA	6.65	8.
BHP-2	Jan 12 2004	140	61	140	0.65	7.4	92	36	7.58	3.88
	Jun 04 2001	130	63	130	0.35	5.3	76	29	7.54	10.
	Sep 21 2000	130	68	130	<1.	5.6	85	NA	7.52	14.
BHP-3	Dec 29 2003	150	62	140	0.47	7.1	89	36	7.79	2.11
	Jun 04 2001	130	68	150	0.36	4.4	74	25	7.28	5.
	Sep 20 2000	100	87	130	0.39	6.	84	NA	6.89	13.
BHP-4	Dec 29 2003	130	72	140	0.45	7.6	94	48	7.79	2.
	Jun 04 2001	120	71	140	<0.5	5.1	76	25	7.37	7.
	Oct 19 2000	120	85	150	<0.1	6.1	87	NA	7.34	11.
BHP-5	Dec 29 2003*	82	44	140	0.45	6.2	75	50	7.04	-0.44
	Dec 29 2003	84	44	140	0.49	6.2	85	49	6.93	2.08
	Jun 04 2001	44	51	130	0.34	5.	70	30	6.27	3.
	Sep 20 2000	34	65	130	0.38	5.3	77	NA	6.05	4.
BHP-10	Dec 29 2003	130	53	130	0.41	6.	89	36	7.43	4.82
	Jun 04 2001	120	57	130	0.44	4.	74	22	7.31	9.
	Sep 20 2000	110	65	140	0.48	4.8	85	NA	7.22	13.
BHP-11	Dec 30 2003	130	67	150	0.37	6.5	93	42	7.73	1.41
	Jun 04 2001	140	66	120	0.36	4.1	73	26	7.70	11.
	Sep 20 2000	130	73	140	0.38	7.3	86	NA	7.56	14.
BHP-12	Dec 30 2003	130	69	150	0.45	5.8	91	36	7.40	2.14
	Jun 04 2001	120	78	140	<0.5	4.9	71	22	7.23	5.
	Oct 19 2000	110	96	150	<0.1	5.1	75	NA	7.48	8.

TABLE 4. TEST FIELD - COMMON INORGANIC RESULTS

Well ID	Sample Date	Total Alkalinity	Calcium	Chloride	Nitrate as N	Potassium	Sodium	Silica	pH (Lab)	Ion Balance
Recovery Wells										
BHP-13	Dec 29 2003	150	62	140	0.48	6.3	90	37	8.06	4.04
	Jun 05 2001	130	62	140	<0.5	4.4	79	24	7.86	10.
	Sep 20 2000	130	67	140	0.4	4.8	84	NA	7.76	11.
Observation Wells										
CH1-G	Dec 30 2003	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Jun 04 2001	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Sep 21 2000	57	140	140	<1.	6.7	120	NA	6.27	7.
CH1-B	Dec 30 2003	52	62	150	0.38	6.1	74	63	6.53	-1.45
	Jun 05 2001	65	95	140	0.52	5.4	97	25	6.38	3.
	Sep 21 2000	65	130	140	<1.	7.	120	NA	6.44	6.
CH1-R	Dec 30 2003	70	110	140	0.4	8.4	95	52	6.87	2.56
	Jun 05 2001	65	100	150	<0.5	5.7	100	26	7.71	2.
	Sep 21 2000	69	150	140	<1.	6.4	120	NA	6.46	8.
CH2-G	Dec 30 2003	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Jun 05 2001	<25	100	160	0.66	5.6	60	36	4.49	12.
	Sep 21 2000	<25	180	140	<1.	7.9	73	NA	4.21	4.
CH2-B	Dec 30 2003	<6	46	160	0.5	5.3	66	100	4.95	-3.32
	Jun 05 2001	<25	100	150	0.66	5.7	61	80	4.60	12.
	Sep 21 2000	<25	190	140	<1.	7.7	73	NA	7.33	1.
CH2-R	Dec 30 2003	8	43	160	0.55	5.2	70	110	5.35	1.72
	Jun 05 2001	<25	110	150	0.65	5.8	62	37	6.35	9.
	Sep 21 2000	<25	190	140	<1.	7.1	77	NA	4.40	3.
OWB-1	Dec 30 2003	140	65	140	0.41	6.	94	38	7.88	5.51
	Jun 05 2001	130	65	140	<0.5	4.6	80	25	7.00	11.
	Sep 21 2000	140	69	140	<1.	5.2	87	NA	7.69	8.
OWB-2	Dec 30 2003	220	92	150	4.8	6.3	180	36	7.67	6.59
	Jul 12 2001	220	120	190	7.3	5.3	160	NA	7.71	11.
	Sep 20 2000	NA	NA	NA	NA	NA	NA	NA	NA	NA
OWB-3	Dec 29 2003	160	61	130	0.46	6.7	90	48	7.85	3.77
	Jun 05 2001	140	66	120	<0.5	5.2	82	28	7.68	16.
	Sep 20 2000	140	69	140	0.36	5.1	85	NA	7.56	12.
OWB-4	Dec 30 2003	140	59	150	0.38	6.2	88	43	7.75	1.52
	Jun 05 2001	120	63	140	<0.5	5.	83	28	7.88	11.
	Sep 21 2000	130	67	130	<1.	4.8	86	NA	7.41	14.
OWB-5	Dec 30 2003	140	60	150	0.38	6.3	89	46	7.81	1.82
	Dec 30 2003*	140	60	150	0.38	6.2	88	45	7.87	1.51
	Jun 05 2001	140	61	140	<0.5	4.5	76	28	7.82	8.
	Sep 21 2000	140	68	130	<1.	5.5	87	NA	7.67	15.

TABLE 4. TEST FIELD - COMMON INORGANIC RESULTS

Well ID	Sample Date	Total Alkalinity	Calcium	Chloride	Nitrate as N	Potassium	Sodium	Silica	pH (Lab)	Ion Balance
Evaporation Pond										
Evap Pond	Dec 30 2003	92	640	2400	<0.2	120.	1600	59	8.17	-32.2
	Jun 05 2001	<25	630	690	<2.5	45.	1000	33	6.75	1.
	Sep 21 2000	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Nov 09 1999*	NA	790	340	NA	27.	580	NA	6.42	NA
	Nov 09 1999	NA	730	350	NA	26.	620	NA	6.30	NA
	Nov 09 1999*	NA	750	370	NA	26.	530	NA	6.42	NA
AWQS		-	-	-	10	-	-	-	-	-
NSDWR		-	-	250	-	-	-	-	6.5-8.5	-
<p>All results in milligrams per liter (mg/L), except pH in pH units, and Ion Balance, a calculation</p> <p>&lt; = less than detection limit</p> <p>* = Field duplicate sample</p> <p>NA = Not sampled or not analyzed</p> <p>AWQS = Arizona Aquifer Water Quality Standard</p> <p>NSDWR = National Secondary Drinking Water Regulations</p>										

TABLE 5. TEST FIELD - ORGANIC RESULTS

Well ID	Sample Date	Benzene	Ethylbenzene	Toluene	Total Xylenes	Total Petroleum Hydrocarbons-Diesel
<b>Injection/Pumping Wells</b>						
BHP-6	Dec 29 2003	<0.0005	<0.0005	<0.0005	<0.001	<0.25
	Jun 04 2001	<0.002	<0.002	<0.002	<0.002	<0.5
	Sep 20 2000	<0.002	<0.002	<0.002	<0.002	<0.5
BHP-7	Dec 29 2003	<0.0005	<0.0005	<0.0005	<0.001	<0.25
	Jun 04 2001	<0.002	<0.002	<0.002	<0.002	<0.5
	Sep 20 2000	<0.002	<0.002	<0.002	<0.002	<0.5
BHP-8	Dec 29 2003	<0.0005	<0.0005	<0.0005	<0.001	<0.25
	Jun 04 2001	<0.002	<0.002	<0.002	<0.002	<0.5
	Sep 20 2000	<0.002	<0.002	<0.002	<0.002	<0.5
BHP-9	Dec 29 2003	<0.0005	<0.0005	<0.0005	<0.001	<0.25
	Jun 04 2001	<0.002	<0.002	<0.002	<0.002	<0.5
	Sep 20 2000	<0.002	<0.002	<0.002	<0.002	<0.5
<b>Recovery Wells</b>						
BHP-1	Dec 29 2003	<0.0005	<0.0005	<0.0005	<0.001	<0.25
	Jul 12 2001	<0.002	<0.002	<0.002	<0.002	<0.5
	Jul 12 2001*	<0.002	<0.002	<0.002	<0.002	<0.5
	Sep 21 2000	<0.002	<0.002	<0.002	<0.002	<0.5
BHP-2	Jan 12 2004	<0.0005	<0.0005	<0.0005	<0.001	<0.25
	Jun 04 2001	<0.002	<0.002	<0.002	<0.002	<0.5
	Sep 21 2000	<0.002	<0.002	<0.002	<0.002	<0.5
BHP-3	Dec 29 2003	<0.0005	<0.0005	<0.0005	<0.001	<0.25
	Jun 04 2001	<0.002	<0.002	<0.002	<0.002	<0.5
	Sep 20 2000	<0.002	<0.002	<0.002	<0.002	<0.5
BHP-4	Dec 29 2003	<0.0005	<0.0005	<0.0005	<0.001	<0.25
	Jun 04 2001	<0.002	<0.002	<0.002	<0.002	<0.5
	Oct 19 2000	<0.002	<0.002	<0.002	<0.002	<0.5
BHP-5	Dec 29 2003	<0.0005	<0.0005	<0.0005	<0.001	<0.25
	Dec 29 2003*	<0.0005	<0.0005	<0.0005	<0.001	<0.25
	Jun 04 2001	<0.002	<0.002	<0.002	<0.002	<0.5
	Sep 20 2000	<0.002	<0.002	<0.002	<0.002	<0.5
BHP-10	Dec 29 2003	<0.0005	<0.0005	<0.0005	<0.001	<0.25
	Jun 04 2001	<0.002	<0.002	<0.002	<0.002	<0.5
	Sep 20 2000	<0.002	<0.002	<0.002	<0.002	<0.5
BHP-11	Dec 30 2003	<0.0005	<0.0005	<0.0005	<0.001	<0.25
	Jun 04 2001	<0.002	<0.002	<0.002	<0.002	<0.5
	Sep 20 2000	<0.002	<0.002	<0.002	<0.002	<0.5
BHP-12	Dec 30 2003	<0.0005	<0.0005	<0.0005	<0.001	<0.25
	Jun 04 2001	<0.002	<0.002	<0.002	<0.002	<0.5
	Oct 19 2000	<0.002	<0.002	<0.002	<0.002	<0.5
BHP-13	Dec 29 2003	<0.0005	<0.0005	<0.0005	<0.001	<0.25
	Jun 05 2001	<0.002	<0.002	<0.002	<0.002	<0.5
	Sep 20 2000	<0.002	<0.002	<0.002	<0.002	<0.5



TABLE 5. TEST FIELD - ORGANIC RESULTS

Well ID	Sample Date	Benzene	Ethylbenzene	Toluene	Total Xylenes	Total Petroleum Hydrocarbons-Diesel
Observation Wells						
CH1-G	Dec 30 2003	NA	NA	NA	NA	NA
	Jun 04 2001	NA	NA	NA	NA	NA
	Sep 21 2000	<0.002	<0.002	<0.002	<0.002	<0.5
CH1-B	Dec 30 2003	<0.0005	<0.0005	<0.0005	<0.001	<0.25
	Jun 05 2001	<0.002	<0.002	<0.002	<0.002	<0.5
	Sep 21 2000	<0.002	<0.002	<0.002	<0.002	<0.5
CH1-R	Dec 30 2003	<0.0005	<0.0005	<0.0005	<0.001	<0.25
	Jun 05 2001	<0.002	<0.002	<0.002	<0.002	<0.5
	Sep 21 2000	<0.002	<0.002	<0.002	<0.002	<0.5
CH2-G	Dec 30 2003	NA	NA	NA	NA	NA
	Jun 05 2001	<0.002	<0.002	<0.002	<0.002	<0.5
	Sep 21 2000	<0.002	<0.002	<0.002	<0.002	<0.5
CH2-B	Dec 30 2003	<0.0005	<0.0005	<0.0005	<0.001	<0.25
	Jun 05 2001	<0.002	<0.002	<0.002	<0.002	0.53
	Sep 21 2000	<0.002	<0.002	<0.002	<0.002	<0.5
CH2-R	Dec 30 2003	<0.0005	<0.0005	<0.0005	<0.001	<0.25
	Jun 05 2001	<0.002	<0.002	<0.002	<0.002	<0.5
	Sep 21 2000	<0.002	<0.002	<0.002	<0.002	<0.5
OWB-1	Dec 30 2003	<0.0005	<0.0005	<0.0005	<0.001	<0.25
	Jun 05 2001	<0.002	<0.002	<0.002	<0.002	<0.5
	Sep 21 2000	<0.002	<0.002	<0.002	<0.002	<0.5
OWB-2	Dec 30 2003	<0.0005	<0.0005	0.0006	<0.001	<0.25
	Jul 12 2001	<0.002	<0.002	<0.002	<0.002	<0.5
	Sep 20 2000	NA	NA	NA	NA	NA
OWB-3	Dec 29 2003	<0.0005	<0.0005	<0.0005	<0.001	<0.25
	Jun 05 2001	<0.002	<0.002	<0.002	<0.002	<0.5
	Sep 20 2000	0.0043	<0.002	<0.002	<0.002	<0.5
OWB-4	Dec 30 2003	<0.0005	<0.0005	<0.0005	<0.001	<0.25
	Jun 05 2001	<0.002	<0.002	<0.002	<0.002	0.62
	Sep 21 2000	<0.002	<0.002	<0.002	<0.002	<0.5
OWB-5	Dec 30 2003	<0.0005	<0.0005	<0.0005	<0.001	<0.25
	Dec 30 2003*	<0.0005	<0.0005	<0.0005	<0.001	<0.25
	Jun 05 2001	<0.002	<0.002	<0.002	<0.002	<0.5
	Sep 21 2000	<0.002	<0.002	<0.002	<0.002	<0.5
Evaporation Pond						
Evap Pond	Dec 30 2003	<0.0005	<0.0005	<0.0005	<0.001	<0.25
	Jun 05 2001	<0.002	<0.002	<0.002	<0.002	<0.5
	Sep 21 2000	NA	NA	NA	NA	NA

TABLE 5. TEST FIELD - ORGANIC RESULTS

Well ID	Sample Date	Benzene	Ethylbenzene	Toluene	Total Xylenes	Total Petroleum Hydrocarbons-Diesel
AWQS		0.005	0.7	1	10	-
<p>All results are in milligrams per liter (mg/L)</p> <p>&lt; = less than detection limit</p> <p>* = Field duplicate sample</p> <p>NA = Not sampled or not analyzed</p> <p>AWQS = Arizona Aquifer Water Quality Standard</p>						

TABLE 6. TEST FIELD - RADIOCHEMICAL RESULTS

WELL ID	SAMPLE DATE	GROSS ALPHA	URANIUM	ADJ GROSS ALPHA	RADIUM 226	RADIUM 228	TOTAL RADIUM
Injection/Pumping Wells							
BHP-6	Dec 29 2003	11.6 ± 1.7	NA	NA	2.0 ± 0.2	0.6 ± 0.3	2.6 ± 0.4
	Jun 04 2001	36.9 ± 4.2	1.8 ± 0.4	35.1 ± 4.2	2.8 ± 0.5	2.3 ± 0.3	5.1 ± 0.6
BHP-7	Dec 29 2003	5.4 ± 1.1	NA	NA	1.0 ± 0.1	<0.4	1.0 ± 0.1
	Jun 04 2001	19.4 ± 2.7	5.4 ± 1.3	14 ± 2.7	1.9 ± 0.3	1.9 ± 0.3	3.8 ± 0.4
BHP-8	Dec 29 2003	12.0 ± 1.7	NA	NA	2.3 ± 0.2	<0.3	2.3 ± 0.2
	Jun 04 2001	25.3 ± 3.2	18.1 ± 2.1	7.2 ± 3.8	1.1 ± 0.3	2.9 ± 0.3	4 ± 0.4
BHP-9	Dec 29 2003	9.0 ± 1.5	NA	NA	1.7 ± 0.2	0.7 ± 0.3	2.4 ± 0.4
	Jun 04 2001	19.5 ± 1.4	5 ± 1.2	10.5 ± 1.8	0.8 ± 0.3	4 ± 0.4	4.8 ± 0.5
Recovery Wells							
BHP-1	Dec 29 2003	5.5 ± 1.1	NA	NA	1.2 ± 0.1	<0.3	1.2 ± 0.1
	Jul 12 2001	14.4 ± 2	NA	NA	0.9 ± 0.2	<0.4	0.9 ± 0.2
BHP-2	Dec 29 2003	36.6 ± 3.5	8.6 ± 1.5	28.0 ± 3.8	6.0 ± 0.6	2.5 ± 0.5	8.5 ± 0.8
	Jun 04 2001	64 ± 5.2	7 ± 1.4	57 ± 5.4	2.2 ± 0.5	8.3 ± 0.7	10.5 ± 0.9
BHP-3	Dec 29 2003	13.7 ± 1.9	NA	NA	0.4 ± 0.1	<0.3	0.4 ± 0.1
	Jun 04 2001	18.4 ± 2.2	6 ± 1.4	12.4 ± 2.6	1 ± 0.3	2 ± 0.3	3 ± 0.4
BHP-4	Dec 29 2003	16.0 ± 1.9	7.5 ± 1.0	8.5 ± 2.2	2.1 ± 0.2	0.3 ± 0.3	2.4 ± 0.4
	Jun 04 2001	19.3 ± 2.3	7.2 ± 1.4	12.1 ± 2.7	2.8 ± 0.5	2.3 ± 0.3	5.1 ± 0.6
BHP-5	Dec 29 2003	13.8 ± 1.8	NA	NA	1.9 ± 0.2	0.3 ± 0.3	2.2 ± 0.4
	Dec 29 2003*	14.1 ± 1.8	6.9 ± 1.0	7.2 ± 2.1	1.5 ± 0.2	<0.3	1.5 ± 0.2
	Jun 04 2001	30.4 ± 3.3	4.7 ± 0.5	25.7 ± 3.3	1.1 ± 0.3	2.5 ± 0.3	3.6 ± 0.4
BHP-10	Dec 29 2003	10.8 ± 1.5	NA	NA	0.6 ± 0.1	<0.3	0.6 ± 0.1
	Jun 04 2001	10.4 ± 1.6	NA	NA	0.7 ± 0.3	0.5 ± 0.1	1.2 ± 0.3
BHP-11	Dec 30 2003	16.0 ± 2.0	5.7 ± 0.9	10.3 ± 2.2	3.4 ± 0.3	1.4 ± 0.3	4.8 ± 0.4
	Jun 04 2001	23.6 ± 2.6	4.4 ± 0.5	19.2 ± 2.6	0.5 ± 0.3	1.6 ± 0.3	2.4 ± 0.4
BHP-12	Dec 30 2003	29.0 ± 3.0	14.2 ± 1.3	14.8 ± 3.3	6.4 ± 0.6	<0.4	6.4 ± 0.6
	Jun 04 2001	42.6 ± 3.9	10.9 ± 1.7	31.7 ± 4.2	2.2 ± 0.5	5.4 ± 0.5	7.6 ± 0.7
BHP-13	Dec 29 2003	18.0 ± 2.0	6.0 ± 0.9	11.5 ± 2.2	2.6 ± 0.3	1.8 ± 0.4	4.4 ± 0.5
	Jun 05 2001	28.1 ± 2.9	3.1 ± 0.4	25.2 ± 2.9	2.2 ± 0.2	2.9 ± 0.4	5.1 ± 0.6
Observation Wells							
CHI-B	Dec 30 2003	102.0 ± 8.0	68.4 ± 3.0	33.6 ± 8.5	21.0 ± 2.0	2.8 ± 0.4	23.8 ± 2.0
	Jun 05 2001	8.4 ± 1.4	NA	NA	0.8 ± 0.1	<0.4	0.8 ± 0.1

TABLE 6. TEST FIELD - RADIOCHEMICAL RESULTS

WELL ID	SAMPLE DATE	GROSS ALPHA	URANIUM	ADJ GROSS ALPHA	RADIUM 226	RADIUM 228	TOTAL RADIUM
CH1-R	Dec 30 2003	134.7 ± 10.7	126.6 ± 4.2	8.1 ± 11.5	1.4 ± 0.2	4.1 ± 0.5	5.5 ± 0.5
	Jun 05 2001	12.3 ± 1.8	NA	NA	2.0 ± 0.3	<0.5	2.0 ± 0.3
CH2-G	Jun 05 2001	15.3 ± 2.9	8.5 ± 0.7	6.8 ± 3.0	2.2 ± 0.3	1.4 ± 0.4	2.6 ± 0.5
CH2-B	Dec 30 2003	31.0 ± 5.4	18.1 ± 1.5	12.9 ± 5.6	4.7 ± 0.5	2.4 ± 0.4	7.1 ± 0.6
	Jun 05 2001	13.5 ± 1.1	2.9 ± 0.4	10.6 ± 1.2	2.5 ± 0.3	3.5 ± 0.5	5.0 ± 0.6
CH2-R	Dec 30 2003	65.0 ± 9.0	45.0 ± 3.4	20.0 ± 9.6	7.0 ± 0.7	3.2 ± 0.5	10.2 ± 0.9
	Jun 05 2001	11.3 ± 1.0	8.1 ± 0.7	3.2 ± 1.2	2.5 ± 0.3	2.3 ± 0.4	4.8 ± 0.5
OWB-1	Dec 30 2003	8.6 ± 1.4	NA	NA	0.6 ± 0.1	<0.4	0.6 ± 0.1
	Jun 05 2001	10.4 ± 1.6	NA	NA	0.8 ± 0.1	0.6 ± 0.3	1.4 ± 0.3
OWB-2	Dec 30 2003	5.8 ± 1.1	NA	NA	<0.3	<0.3	<0.3
	Jul 12 2001	6.5 ± 1.2	NA	NA	<0.3	<0.4	<0.4
OWB-3	Dec 29 2003	8.7 ± 1.3	NA	NA	1.7 ± 0.2	<0.3	1.7 ± 0.2
	Jun 05 2001	8.2 ± 1.4	NA	NA	1.3 ± 0.2	0.8 ± 0.3	2.1 ± 0.4
OWB-4	Dec 30 2003	29.0 ± 2.8	6.3 ± 0.9	22.7 ± 3.0	5.9 ± 0.6	<0.4	5.9 ± 0.6
	Jun 05 2001	39.0 ± 3.6	5.0 ± 0.6	34.0 ± 3.6	5.6 ± 0.5	1.3 ± 0.3	6.9 ± 0.6
OWB-5	Dec 30 2003	14.9 ± 1.8	5.9 ± 0.6	9.0 ± 1.9	2.1 ± 0.2	<0.4	2.1 ± 0.2
	Dec 30 2003*	14.0 ± 1.8	6.7 ± 0.6	7.3 ± 1.9	1.7 ± 0.2	1.2 ± 0.3	2.9 ± 0.4
	Jun 05 2001	16.4 ± 2.1	5.6 ± 0.6	9.9 ± 2.2	1.3 ± 0.2	1.5 ± 0.4	2.8 ± 0.4
Evaporation Pond							
Evap Pond	Dec 30 2003	11.3 ± 3.5	5.7 ± 0.8	5.6 ± 3.6	1.5 ± 0.2	<0.3	1.5 ± 0.2
AWQS		-	-	15.0	-	-	5.0
<p>All results in pico-curies per liter +/- a standard deviation of two (pCi/L +/- 2σ)</p> <p>Radium 226 and Radium 228 are analyzed when Gross Alpha exceeds 5.0</p> <p>Uranium is analyzed when Gross Alpha exceeds 15.0</p> <p>Total Radium = Radium 226 + Radium 228</p> <p>&lt; = less than detection limit</p> <p>* = Field duplicate sample</p> <p>NA = Not sampled or not analyzed</p> <p>AWQS = Arizona Aquifer Water Quality Standard</p> <p>Bold indicates result exceeds AWQS</p>							



TABLE 7. POND SEDIMENTS - TRACE METAL RESULTS

Sample ID	Sample Date	Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Cobalt	Copper	Iron	Lead	Magnesium	Manganese	Mercury	Nickel	Selenium	Silver	Thallium	Zinc
SPLP Leachable Metals (mg/L)																				
Pond Sediment	11/9/1999	<0.05	<0.05	<0.1	NA	<0.005	<0.01	<0.01	NA	<0.01	<0.1	<0.05	9.1	0.01	<0.002	<0.04	<0.1	<0.015	<0.1	<0.1
Pond Sediment	11/9/1999	0.081	<0.05	<0.1	NA	<0.005	<0.01	<0.01	NA	2.5	<0.1	<0.05	12	0.44	<0.002	<0.04	<0.1	<0.015	<0.1	<0.1
Pond Sediment	11/9/1999	0.12	<0.05	<0.1	NA	<0.005	<0.01	<0.01	NA	4.1	<0.1	<0.05	13	0.79	<0.002	0.052	<0.1	<0.015	<0.1	0.16
AWQS		-	0.006	0.05	2	0.004	0.005	0.1	-	-	-	0.05	-	-	0.002	0.1	0.05	-	0.002	-
NSDWR		0.2	-	-	-	-	-	-	-	1	0.3	-	-	0.05	-	-	-	0.1	-	5
Toxicity Standard		-	-	5	100	-	1	5	-	-	-	5	-	-	0.2	-	1	5	-	-
Total Metals (mg/kg)																				
Pond Sediment	1/5/2004	5,800	<5	<5	28	0.64	<0.5	3.4	15	5,400	NA	<5	NA	130	<0.099	23	<10	NA	<5	44
Residential SRL		77,000	31	10	5,300	1	38	2,100	4,600	2,800	-	400	-	3,200	7	1,500	380	380	-	23,000
Non-Residential SRL		1,000,000	680	10	110,000	11	850	4,500	97,000	63,000	-	2,000	-	43,000	180	34,000	8,500	8,500	-	510,000
Groundwater Protection Limit		-	35	290	12,000	23	29	590	-	NA	-	290	-	-	12	590	290	-	12	-
< = less than detection limit NA = Not analyzed AWQS = Arizona Aquifer Water Quality Standards NSDWR = National Secondary Drinking Water Regulations SRL = Soil Remediation Limit																				

Proposed Cessation of Hydraulic Control  
 Florence Copper  
 Florence, Arizona

TABLE 8. POND SEDIMENTS - COMMON INORGANIC RESULTS

Sample ID	Sample Date	Calcium	Chloride	Nitrate, as N	Potassium	Sodium	Sulfate	pH
<b>SPLP Leachable Inorganics (mg/L)</b>								
Pond Sediment	11/9/1999	41	NA	NA	<2	37	3000	NA
Pond Sediment	11/9/1999	140	NA	NA	<2	36	3000	NA
Pond Sediment	11/9/1999	550	NA	NA	<2	33	3000	NA
Aquifer Water Quality Standard		-	-	10	-	-	-	-
NSDWR		-	250	-	-	-	250	6.5-8.5
<b>Total Inorganics (mg/kg)</b>								
Pond Sediment	1/5/2004	NA	750	<2	NA	NA	16000	7.59
< = less than detection limit NA = Not analyzed NSDWR = National Secondary Drinking Water Regulations								

TABLE 9. AREA WATER LEVEL DATA FOR 2001

Well ID	Measure Date	Groundwater Elevation
<b>Local Wells</b>		
D-04-08 02CCC	10/30/2001	1,291.4
D-04-09 05AAB2	10/30/2001	1,210.9
D-04-09 15BCA2 PZ1	11/19/2001	1,263.6
D-04-09 33AAD	11/7/2001	1,291.4
D-04-10 12DDD	11/7/2001	1,518.3
D-04-10 18DCD PZ1	11/19/2001	1,331.4
D-04-10 18DCD PZ2	11/19/2001	1,331.4
D-04-10 30BDD	11/7/2001	1,339.2
D-05-08 02AAA	11/5/2001	1,302.1
D-05-08 12AAD	11/5/2001	1,327.8
D-05-08 17BBB2	11/5/2001	1,301.4
D-05-09 03DAB	11/7/2001	1,298.6
D-05-09 14CBB	11/6/2001	1,299.8
D-05-09 22CBA	11/6/2001	1,314.1
D-05-09 29ADA	11/6/2001	1,354.1
D-05-09 31ADD	11/6/2001	1,346.8
D-05-10 27CCD2	11/7/2001	1,335.5
<b>POC Wells</b>		
M1-GL	10/18/2001	1,286.8
M2-GU	10/18/2001	1,291.9
M3-GL	10/18/2001	1,294.1
M4-O	11/5/2001	1,294.8
M6-GU	10/15/2001	1,279.3
M7-GL	10/15/2001	1,277.4
M8-O	10/15/2001	1,277.8
M14-GL	10/16/2001	1,278.7
M15-GU	10/16/2001	1,278.4
M16-GU	10/16/2001	1,281.2
M17-GL	10/16/2001	1,279.5
M18-GU	10/18/2001	1,287.3
M19-LBF	10/15/2001	1,280.7
M20-O	10/15/2001	1,280.4
M21-UBF	10/15/2001	1,282.9
M22-O	10/15/2001	1,278.7
M23-UBF	10/16/2001	1,280.3
M24-O	10/17/2001	1,277.9
M25-UBF	10/17/2001	1,282.6
M26-O	10/15/2001	1,280.3
M27-LBF	10/15/2001	1,280.4
M28-LBF	10/15/2001	1,280.4
M29-UBF	10/15/2001	1,280.8
M30-O	10/16/2001	1,283.1
O19-GL	10/17/2001	1,281.4
P19-I-G	10/17/2001	1,280.4
<b>Test Field Wells</b>		
BHP-6	10/30/2001	1,276.9
BHP-7	10/30/2001	1,262.3
BHP-8	10/30/2001	1,204.9
BHP-9	10/30/2001	1,276.0
OWB-1	10/30/2001	1,279.4
OWB-3	10/30/2001	1,277.2
OWB-4	10/30/2001	1,279.4
OWB-5	10/30/2001	1,281.3

**TABLE 10. TEST FIELD - 2003 AVERAGE CONCENTRATIONS OF  
 SELECTED CONSTITUENTS BY WELL TYPE**

Well ID	Total Alkalinity	Calcium	Silica	Sulfate	TDS	Aluminum	Copper	pH (Lab)
Converted Injection Wells	10	45	93	134	503	0.9	7.6	5.1
Central Wells	49	65	74	158	552	1.0	3.7	6.1
Recovery Wells	131	61	40	78	481	<0.1	0.3	7.6
Observation Wells	160	67	42	84	536	<0.1	0.03	7.8
NSDWR	-	-	-	250	500	0.2	1	6.5-8.5

All results in milligrams per liter (mg/L) except pH in pH units

Non-detect values were not included in averages

Based on 2003 data presented in Table 4

NSDWR = National Secondary Drinking Water Regulations



**APPENDIX 1**

**PART ILE.2.a OF APP NO. 101704, DATED JUNE 6, 1997**

7. The maximum allowable hydraulic pressure for injection wells shall be established by a fracture gradient of 0.65 psi/ft depth measured from the ground surface to the top of the injection interval.

## **E. Monitoring Requirements**

All monitoring required in this permit shall continue for the duration of the permit unless otherwise designated in this permit or an approved contingency plan.

### **1. Pre-Operational Monitoring**

In addition to the Compliance Schedule requirements in Part II.K of this permit, the permittee shall complete items a and b prior to commencement of commercial operations.

#### **a. Pre-Operational Monitoring - *In-Situ* Mine**

The permittee shall demonstrate the effectiveness of the four-pair hydraulic control monitoring network by using all injection and recovery wells along the perimeter of the first mining block as observation wells for a period of 90 days. Observations of water level elevations shall be made and recorded daily for each well in the mining block during the 90-day period. In addition, the permittee will measure and record electrical conductivity of the groundwater on a daily basis in each of the designated observation wells. Hydraulic control for the mining block shall be demonstrated by data showing that an inward hydraulic gradient has been established. The permittee may not commence commercial operations until hydraulic control is demonstrated and the results of pre-operational monitoring submitted to the ADEQ Aquifer Protection Permit Program.

#### **b. Surface Facilities Background Monitoring**

Sixty days from the effective date of the permit, the permittee shall submit to the Department a workplan for characterizing the high background levels of nitrate and radiochemicals in the area of the surface facilities. When completed, the results of the background characterization shall be submitted to and reviewed by the ADEQ Aquifer Protection Permit Program. Changes to the monitoring program which act to increase the level of monitoring as a result of this characterization shall be considered a minor modification of the permit.

### **2. Operational Monitoring**

#### **a. Process Solution Monitoring**

The process solution monitoring points specified in Part IV, Table II.A for the PLS pond, raffinate pond and evaporation ponds shall be sampled according to the parameters and frequencies listed in Part IV, Table II.A. The results of process solution monitoring shall be documented on the Self-Monitoring Report Form and submitted with the quarterly report to the ADEQ address stated in Part II.L.2.

#### **b. Pre-existing Underground Workings - *In-Situ* Mine**

The pre-existing underground workings shall be monitored according to the monitoring and contingency plan to be submitted to the ADEQ Aquifer Protection Permit Program as required by Part II.K.d.

### **3. Groundwater Monitoring**

**APPENDIX 2**

**PART II.H.2 OF APP NO. 101704, DATED DECEMBER 5, 2001**



- f. any limitations on future land or water uses created as a result of the facility's operations or closure activities,
- g. the methods to be used to secure the facility,
- h. an estimate of the cost of closure, and
- i. a schedule for implementation of the closure plan and the submission of a post-closure plan.

#### 2. *In-Situ* Mine Block Closure

Permittee will commence mine block closure based on the economic recovery of copper from each *in-situ* mine block. During mine block closure operations, the permittee will cease the injection of raffinate, and will initiate a mine block rinsing program consisting of the injection of formation water and recovery. At all times during initial block rinsing, the permittee will maintain hydraulic control by sustaining an inward hydraulic gradient within the mine block. The permittee will monitor the rinsing progress by analyzing the water recovered from well-field headers for sulfate concentration. When levels of sulfate in the headers have reached approximately 750 parts per million, the permittee will sample the injection well header discharges for all Part IV, Table III.C constituents. If the results of the sampling described in Part IV, Table III.C, show concentrations of parameters in exceedance of any AWQS, then rinsing operations will continue until the concentrations of all parameters are below the AWQS. The sulfate concentration at or below which all AWQS are met will serve as an indication for acceptable closure of the mine block.

The permittee will sample all of the wells in the mine block undergoing closure to determine if the sulfate concentrations are less than or greater than the indicator sulfate concentration. The permittee will continue rinsing each well within the mine block until such time that the sulfate concentration in each well is less than the indicator concentration.

When all individual well concentrations are below the indicator sulfate concentration, hydraulic control will be discontinued for 90 days. At the end of the 90-day period, the headers will be re-sampled and if sulfate concentrations remain below the indicator sulfate concentration, then the permittee may cease all rinsing and monitoring activities within the mine block areas. (All POC wells will continue to be monitored in accordance with Part II.E.d).

The permittee will document the results of closure operations in the subsequent monitoring report. Permittee will commence cementing the wells per the well abandonment plan if no objection has been received from ADEQ within 30 days after filing of the report.

#### 3. Evaporation Pond Closure

The permittee shall submit a complete characterization of the evaporation pond precipitates and a detailed closure plan for the evaporation ponds no later than 180 days prior to the commencement date for facility closure.

#### 4. Closure Completion

Upon completion of closure activities, the permittee shall give written notice to the ADEQ Aquifer Protection Permit Program indicating that the approved closure plan has been fully implemented.

**APPENDIX 3**

**PART D.1.1 OF UIC NO. AZ239600001, DATED MAY 1, 1997**

5. Within thirty (30) days of receiving the laboratory results verifying that an AQL has been exceeded, the permittee shall do the following:

(a) Submit a written report to EPA providing an evaluation of the cause, impacts, or mitigation of the discharge responsible for the AQL exceedance, or

(b) Submit a written report to EPA which demonstrates that the AQL exceedance resulted from an error(s) in sampling, analysis, or statistical evaluation.

6. Upon review of the report documenting the AQL exceedance, the Director may require additional monitoring and/or action beyond those specified in this permit.

## **I. RESTORATION and PLUGGING & ABANDONMENT**

Pursuant to 40 CFR Parts 146.10 and 144.12, the permittee shall comply with the following aquifer cleanup, ground water monitoring, and plugging and abandonment activities to ensure adequate protection of USDWs:

### **1. Closure**

(a) **Constituents with primary MCLs:** Within 90 days after mining a zone, the permittee shall commence restoration activities for that zone. Each zone shall be restored to concentrations which are less than or equal to primary maximum contaminant levels (MCLs) defined at 40 CFR 141, or pre-mining background concentrations. The permittee shall follow the procedure detailed at (c), below.

(b) **Constituents without primary MCLs:** In addition to constituents with primary MCLs, the permittee shall ensure that constituents which do not have primary MCLs do not impact USDWs in a way that could adversely affect the health of persons.

(c) **Closure and Plugging & Abandonment Procedure:** The permittee will commence closure operations based on the economic recovery of copper from each in-situ zone. During closure operations, the permittee will cease injection of raffinate, and initiate a rinsing program consisting of injection/recovery and recovery. At all times during initial zone rinsing, the permittee shall maintain inward hydraulic gradients (hydraulic control) of the zone. The permittee will monitor the rinsing progress by analyzing water recovered from well-field headers for sulfate concentration. When levels of sulfate in the headers have reached approximately 750 parts per million, the permittee will sample header discharges for all Level 2 constituents defined at Part II, Section F



of this permit. If results of the Level 2 sampling show that one or more compounds are above primary MCLs and the pre-mining background concentrations, rinsing operations will continue until all compounds are below primary MCLs or the pre-mining background concentrations. The sulfate concentration at or below which all primary MCLs or pre-mining background concentrations are met will serve as an indication for acceptable closure for that zone.

The permittee will sample all wells in the zone undergoing closure to determine if the sulfate concentrations are less than or greater than the zone's indicator sulfate concentration. The permittee shall continue rinsing each well until such time that the sulfate concentration in the well is less than the indicator concentration for that zone.

When all individual well concentrations within the zone are below the zone's indicator sulfate concentration, hydraulic control for these wells will be discontinued for 90 days. At the end of the 90-day period, the headers will be re-sampled and if sulfate concentrations remain below the zone's indicator sulfate concentration, the permittee may cease all rinsing and monitoring activities for the wells in that zone. The permittee will document the results of the closure operation in the subsequent monitoring report. The permittee will commence cementing the wells per the Well and Corehole Abandonment Plan (Appendix C) if no objection has been received from EPA within 30 days after filing of the report.

2. Post-Closure: 30-year Monitoring at POC wells: To ensure that the restoration required at (1), above, accomplished the objective of returning all mining zones to primary MCLs (or pre-mining background concentrations) and thereby providing adequate protection to surrounding USDWs, the permittee shall comply with the 30-year Post-Closure monitoring program and the AQL exceedance contingency plan established at Part II, Section F and Section H.2.b of this permit.

## J. POST AUDITS

The permittee shall verify that the pollutant fate and transport are behaving as predicted. During the third (3), fifth (5), and fifteenth (15) years after the commencement of mining, the permittee shall conduct a post audit of the computer modeling which predicted the fate and transport of pollutants discharged by the Florence Project. For each audit, the permittee shall submit a report to EPA describing the post audit as well as any changes in the conceptual model, any model redesign, and any changes in predicted post-closure conditions.

#### **APPENDIX 4**

**TECHNICAL REPORT ON TECHNOLOGICALLY ENHANCED NATURALLY  
OCCURRING RADIOACTIVE MATERIALS IN THE SOUTHWESTERN  
COPPER BELT OF ARIZONA (EXCERPT)**

**TECHNICAL REPORT**

**ON**

**TECHNOLOGICALLY ENHANCED**  
**NATURALLY OCCURRING RADIOACTIVE MATERIALS**

**IN THE SOUTHWESTERN**  
**COPPER BELT OF ARIZONA**

U.S. Environmental Protection Agency,  
Office of Radiation and Indoor Air,  
Radiation Protection Division  
401 M St. SW,  
Washington, D.C. 20460

October 1999



wells were installed in the smelter/concentrator plant area. Water quality data have been collected at several monitoring points up- and downgradient of the tailings impoundments on San Pedro River. The ADEQ Mining Unit suggested that the Surface Water Section perform radiochemical analyses on future samples. New groundwater monitoring data from these wells is expected in 1999.

Based on the information above, radionuclide concentrations in some of the copper processing waste streams may be significantly above the natural crustal abundance.

## **B. In-Situ and Solvent Extraction Operations**

**S**everal Arizona copper ore bodies are either too deep or are too low-grade to be mined by conventional surface or underground methods. However, in-situ solution mining may be an economical option. There are several in-situ solution copper mines in the Arizona copper mining belt. High levels of TENORM have been found in the PLS of two in-situ leach operations in Arizona.

Typically, an in-situ copper mining company will be required to undergo a joint ADEQ-EPA permitting process. EPA issues a federally-administered Class III Underground Injection Control (UIC) permit and an aquifer exemption permit that focus on the subsurface injection and restoration activities. ADEQ initiates an APPA process that focuses on both subsurface activities and the surface facilities and impoundments.

A proposed operation must meet both of the following two criteria for an aquifer exemption: 1) the aquifer must not currently serve as a source of drinking water and 2) the permit applicant must demonstrate that the deposit contains minerals that are expected to be commercially producible. The permit covers the construction, operation, and eventual closure of the injection and recovery wells system and surface facilities and impoundments. The permit also defines the lateral and vertical boundaries of the proposed aquifer exemption.

A typical in-situ facility contains raffinate impoundments and processing facilities for the injectate (a lixiviant solution of sulfuric acid with a pH of 2), a PLS impoundment, a SX/EW plant, surface run-on/run-off facilities, an evaporation impoundment, a non-storm water containment impoundment, and ancillary facilities. The mining area is usually divided into discrete mining units. Injection mining proceeds on a unit-by-unit basis until the ore zone is depleted. Injection occurs within the screened interval throughout the ore zone. The recovery wells are constructed 50 feet to 200 feet from the injection wells, depending on the permeability of the formation, and are screened in the same zone. Once the ore zone has been depleted, it will be rinsed with fresh formation water until the aquifer meets Aquifer Water Quality Standards (AWQS) and Primary MCLs.

### **1. BHP Copper Florence In-Situ Project**

BHP Copper Florence (formerly Magma Florence) was granted a UIC permit (No. 396000001) and aquifer exemption to operate an in-situ copper mine located two miles northwest of Florence, Arizona. The Gila River flows southwest and its floodplain is about 1/4 mile south of the mine. The copper ore body is between 400 feet and 1600 feet deep in highly fractured Precambrian granite, gneiss, and schist. The ore zone is about 250 acres wide. The water table is 130 feet below the surface and the ore body is within the saturated zone. The local stratigraphy consists of four hydrogeologic units. The uppermost alluvial unit is an upper basin fill that consists of interbedded gravels,

sands, and silt lenses. The second unit is a middle silt and clay fine grained formation. A lower alluvial unit consists of conglomeratic gravel and sand. The basin fill are underlain by fractured igneous and metamorphic rocks that contain the ore body. ADEQ is currently in the process of reviewing BHP & APPA.

In January of 1996, BHP (Magma) conducted a column leach test to characterize the leachability of the mineralized zone and determine the chemical composition of the resultant PLS. Samples of ore-bearing quartz monzonite and granodiorite were leached for 58 days with 10 liters of sulfuric acid and maintained in a closed system at a pH of 1.5 to 1.7. The PLS was analyzed for common ions, metals and radiochemicals. The TDS and sulfate concentration at the end of the test was 26000 to 37000 mg/L for the quartz monzonite and 18000 to 23000 mg/L for the granodiorite. The gross alpha and beta activities for the quartz monzonite were 8649 and 3683 pCi/L, respectively. Similarly, the gross alpha and beta activities for the granodiorite were 897 and 612 pCi/L, respectively. The Ra-226 concentration of both samples was 33.6 pCi/L for the quartz monzonite and 19.5 pCi/L for the granodiorite. The total uranium, U-234, U-235, U-238 for the quartz monzonite were 4362, 1745, 598, and 1611 pCi/L and for the granodiorite 0.835, 254, 11.6, and 248 pCi/L, respectively (Table 18).

Subsequently, the raffinate from the PLS was recirculated into the leach system for another 19 days. Then the samples were drained and washed with groundwater for another 14 days in an open system. At the end of the wash test, the solution was tested for radiochemicals. The gross alpha and beta activities for the quartz monzonite and granodiorite were reduced to 11 and 3 (alpha) and <8 and <8 (beta) pCi/L for both the quartz monzonite and granodiorite. The Ra-226 and Ra-228 concentration was also reduced in both samples. The total uranium, U-234, and U-238 were 10, 27.3, 20.7 and 1.2, 6.8, and 4.82 pCi/L, respectively (Magma, 1/1996). The analytic results are shown in Table 18 (Magma, 1/1996). In all cases the quartz monzonite showed higher levels of radiochemicals than the granodiorite. The range of background levels alpha and beta activity and Ra-222 are shown at the bottom of the Table 18.

**Table 18**  
**Radiochemical Analysis of Leach Test Samples**  
**Magma Florence In-Situ Copper Project, January 1996 (pCi/L)**

Sample	Gross Alpha	Gross Beta	Total-U	U-234	U-235	U-238	Ra-226	Ra-228	Rn-222
<b>Leach Test</b>									
quartz monzonite	8649	3683	4362	1745	598	1611	33.6	<2	810
granodiorite	897	612	0.84	254	11.6	248	19.5	<2	243
<b>Wash Test</b>									
quartz monzonite	11	3	10	27.3	0.6	20.7	2.5	4	5.3
granodiorite	<8	<8	1.2	6.8	<0.6	4.82	<0.6	<3	7.9
<b>Bgd Florence<sup>1</sup></b>									
High	3.0	14.0	-	-	-	-	0.1	-	236
Low	1.0	4.0	-	-	-	-	-	-	197.8

Levels of radioactivity in excess of federal MCLs or Arizona guidelines are shown in bold

Reference: Magma, 1/1996

- No data

<sup>1</sup> Background data from Table 8, Florence, Arizona

These data indicate that the PLS produced from the Magma Florence in-situ projects contain very high levels of radionuclides and that they are leachable.

## 2. Santa Cruz In-Situ Copper Project

On October 30, 1994, ADEQ and EPA granted ASARCO Santa Cruz Inc. an EPA issued UIC permit (No 397000001) and an Aquifer Protection Permit (No P-101431) to operate an in-situ copper mining research facility. The site is seven miles west of Casa Grande and consists of a five spot well field containing four recovery wells and one injection well. The permit approved plans for down hole perforation of well casing and hydraulic fracturing of the aquifer test area, followed by injection testing using sulfuric acid for development and redevelopment and sodium bromide tracer testing during the mining phase. Surface treatment facilities included four evaporation ponds, one PLS pond, and one raffinate reservoir.

There are three geologic units beneath the Santa Cruz site. Six hundred feet of basin-fill deposits overlie 600 to 650 feet of Tertiary age conglomerate that lie upon the Precambrian granite. The basin-fill deposits comprise the principal aquifer in the mining area and the groundwater level in the basin-fill aquifer is about 490 feet below the surface. The copper mineralized zone begins at about 1100 feet. It includes a cap rock and an oxide and sulfide zone that extends to over 2360 feet.

The 4th Quarter 1996 monitoring report included radiochemical analyses of the raffinate and PLS. Total uranium of the raffinate and the PLS is 4.1 and 2.6 mg/L with 6800 and 4410 pCi/L gross alpha and 193 and 99 pCi/L Ra-226 (Table 19).

Table 19  
Radiochemical Water Sample Results, ASARCO Santa Cruz  
In-Situ Copper Project, January 1997 (pCi/L)

Sample	Gross Alpha	Total U	Ra-226	Rn-228	Rn-222
Raffinate	<b>6800</b>	2870	193	19	<b>2410</b>
Pregnant Leach Solution	<b>4410</b>	1823	99	8.3	<b>3760</b>
Bgd Casa Grande <sup>1</sup>	20	6.0	0.1	—	544.2

Levels of radioactivity in excess of federal MCLs or Arizona guidelines are shown in bold

Reference: ASARCO, 1997

— = No Data

<sup>1</sup> Background data from Table 8, Casa Grande

These results confirm that uranium occurs in the PLS and raffinate of the process streams at the Santa Cruz in-situ copper operation.



**APPENDIX 5**  
**LABORATORY ANALYTICAL DOCUMENTS**  
**(ON CD)**