phelps dodge Sierrita Inc.
A Freeport-McMoRan Company
6200 W. Duval Mine Road • P. O. Box 527 • Green Valley, AZ 85622-0527
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November 16, 2007

United Parcel Service #1Z 867 7E4 22 1000 2640
Return Receipt Requested

Mr. Robert Casey
Arizona Department of Environmental Quality
Water Quality Enforcement Unit
1110 West Washington Street
Phoenix, Arizona 85007-2935

Re: Revised Interceptor Wellfield Report
Phelps Dodge Sierrita, Inc. – Mitigation Order on Consent, Docket No. P-50-06

Dear Mr. Casey:

Phelps Dodge Sierrita, Inc. ("PDSI") submits three copies of the attached revised report titled *Evaluation of the Current Effectiveness of the Sierrita Interceptor Wellfield*. This document was prepared by Errol L. Montgomery and Associates as described in PDSI's letter to the Arizona Department of Environmental Quality (ADEQ) dated May 31, 2007. This revised report provides an estimate of current seepage rates from the Sierrita tailing impoundment based on an updated water balance and provides an associated estimate of sulfate mass flux as requested in ADEQ's April 17, 2007 comment letter.

Please do not hesitate to contact Mr. Stuart Brown at (503) 675-5252 or me at (520) 648-8857 if you have any question regarding this submittal.

Very truly yours,

Ned Hall

E. L. (Ned) Hall
Chief Environmental Engineer

ELH:ms
Attachments
20071116-001

xc: John Broderick, PDSI
Chad Fretz, PDSI
Ray Lazuk, Freeport McMoRan Copper and Gold Inc.
Stuart Brown, Bridgewater Group, Inc.

November 14, 2007

REVISED REPORT

Evaluation of the Current Effectiveness of the Sierrita Interceptor Wellfield Phelps Dodge Sierrita Mine Pima County, Arizona

Prepared for:

phelps dodge Sierrita Inc.

Errol L. Montgomery & Associates, Inc.

CONSULTANTS IN HYDROGEOLOGY

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November 14, 2007
REVISED REPORT

EVALUATION OF THE CURRENT EFFECTIVENESS OF THE SIERRITA INTERCEPTOR WELLFIELD PHELPS DODGE SIERRITA MINE PIMA COUNTY, ARIZONA

Prepared for
Phelps Dodge Sierrita, Incorporated

ERROL L. MONTGOMERY & ASSOCIATES, INC.
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ERROL L. MONTGOMERY & ASSOCIATES, INC.

November 14, 2007
REVISED REPORT

EVALUATION OF THE CURRENT EFFECTIVENESS OF THE SIERRITA INTERCEPTOR WELLFIELD PHELPS DODGE SIERRITA MINE PIMA COUNTY, ARIZONA

Prepared for
Phelps Dodge Sierrita, Incorporated

EXECUTIVE SUMMARY

This report has been prepared for Phelps Dodge Sierrita, Incorporated (PDSI), to summarize an evaluation of the current effectiveness of the Sierrita interceptor wellfield in controlling movement and capturing seepage containing sulfate from the Phelps Dodge Sierrita Tailing Impoundment (PDSTI). This report was originally submitted to the Arizona Department of Environmental Quality (ADEQ) on February 27, 2007 to satisfy the requirement of Section III.C.4 of the Mitigation Order on Consent Docket No. P-50-06 for an analysis of the effectiveness of PDSI's current groundwater sulfate source control system and in accordance with Task 3, Evaluation of PDSI Groundwater Sulfate Control System, in the October 31, 2006 *Work Plan to Characterize and Mitigate Sulfate with Respect to Drinking Water Supplies in the Vicinity of the Phelps Dodge Sierrita Tailing Impoundment, Pima County, Arizona* (Hydro Geo Chem, 2006). ADEQ provided written comments on the report to PDSI on April 17, 2007. PDSI submitted written responses to ADEQ's comments on May 31, 2007, wherein PDSI agreed to submit a revised report.

TAILING IMPOUNDMENT DEVELOPMENT

- Discharge of tailing slurry from the Sierrita concentrator to the PDSTI began in March 1970 and has continued through present day **(Figures 1 and 2)**.

- Tailing slurry is presently discharged to the PDSTI through spigots installed on pipelines positioned along the PDSTI dam. The slope of the PDSTI surface permits decanted water to flow towards the reclaim pond. Decanted water (reclaim water) is then pumped back to the Sierrita concentrator for reuse in mineral beneficiation.

INTERCEPTOR WELLFIELD DEVELOPMENT

- A line of interceptor wells was constructed along the east and south edge of the PDSTI to control and capture seepage from the PDSTI. The first seven interceptor wells began pumping in April 1979 and the wellfield was expanded and upgraded several times between 1979 and 2004; the interceptor wellfield currently consists of 23 active wells **(Figures 1 and 2)**.

- The Sierrita interceptor wellfield has been divided into South, Middle, and North Wellfields based on aquifer thickness and pumping rates:

    - South Wellfield: IW-1, IW-2, IW-3A, IW-4, IW-8, IW-9, and IW-24;

    - Middle Wellfield: IW-5, IW-6A, IW-10, IW-11, IW-22, and IW-23;

    - North Wellfield: IW-12 through IW-21.

- In the south wellfield, a large aquifer thickness accounts for large groundwater pumping rates. Interceptor wells in this area are capable of pumping 300 to 1,000 gallons per minute (gpm). A decrease in aquifer thickness of about 100 feet has occurred in the south wellfield since pre-wellfield conditions in 1977, primarily due to interceptor wellfield pumping **(Figure 3)**.

- In the middle wellfield, a moderate aquifer thickness results in pumping rates on the order of 150 to 400 gpm. A decrease in aquifer thickness of about 80 feet has occurred in the middle wellfield since pre-wellfield conditions in 1977, primarily due to interceptor wellfield pumping **(Figure 3)**.

- In the north wellfield, a small aquifer thickness results in small groundwater pumping rates. At the time of installation, interceptor wells in this area were capable of pumping on the order of 100 to 400 gpm. A decrease in aquifer thickness of about 60 feet has occurred in the north wellfield since pre-wellfield conditions in 1977, primarily due to groundwater pumping at the north wellfield **(Figure 3)**. As a result of the decrease in aquifer thickness, sustainable pumping rates have decreased to about 30 percent of the original pumping capacity. During 2006, average operational pumping rates in the north wellfield ranged from 10 to 180 gpm.

TAILING IMPOUNDMENT WATER BALANCE

- A water balance for the PDSTI, originally prepared in 1989, was recently updated through 2006. Estimates of the water balance components have been improved based on comprehensive research of historic data and processes, together with evaluation of evaporation rates and tailing physical and hydraulic properties **(Appendix B)**. Although uncertainties exist in the data sets and assumptions used to estimate the water balance components, the updated water balance is believed to provide a basis to estimate the current amount of seepage from the PDSTI that is as accurate as possible using reasonable methods or efforts. Estimates of historical seepage rates were also developed from the updated water balance, but are considered less accurate due to higher levels of uncertainty with most water balance components.

- The water balance consists of the following "input" components **(Table 2)**: 1) water in the tailing slurry delivered to the impoundment, 2) precipitation directly onto the impoundment, and 3) surface water discharge from upgradient areas (much of which is captured and delivered via Duval Canal). The water loss and storage components of the water balance consist of: 1) evaporation, 2) water recovered via pumping from the PDSTI reclaim pond, 3) water retained in the deposited tailing, and 4) seepage through the impoundment.

- The volume of seepage from the PDSTI is chiefly related to the amount of water delivered to the impoundment, which is a direct function of the amount of ore milled. In 2006, based on the measured mass of ore milled and measured ratio of tailing to water in the tailing slurry **(Appendix B)**, about 26,320 acre-feet of water was delivered to the PDSTI **(Table 2)**. Based on the water balance analysis, additional inputs of water include about 4,490 acre-feet from direct precipitation and 350 acre-feet from surface water discharges. Total water input to the PDSTI was estimated to be about 31,160 acre-feet, of which:

    - about 6,430 acre-feet was pumped from the PDSTI reclaim pond and returned to the mill;

    - about 11,980 acre-feet was evaporated from the PDSTI surface;

   - About 5,280 acre-feet was retained in the tailing deposited in the PDSTI;
   - about 7,470 acre-feet seeped from the PDSTI.

- Compared to the 1989 water balance, which only included the period from 1979 through 1987, the updated PDSTI water balance indicates smaller seepage estimates for most years. For the period from 1979 through 1987, the average annual seepage estimate based on the updated water balance is equal to about 70 percent of the seepage estimate from the 1989 water balance.

INTERCEPTOR WELLFIELD PUMPING

- Groundwater pumping from the interceptor wellfield has generally increased since 1979, when the first wells began pumping **(Figure 9)**; however, decreased saturated aquifer thickness in recent years **(Figure 4)** has resulted in reduced pumping capacity from some of the wells, particularly in the north wellfield **(Figure 12)**.

- In 2006, the operational run time for the wellfield was approximately 86 percent **(Figure 13)**. Total groundwater pumped from the interceptor wellfield in 2006 was about 7,900 acre-feet **(Figure 9)**.

- Of the 7,900 acre-feet of groundwater pumped in 2006, about 54 percent was from the south wellfield, 31 percent was from the middle wellfield, and 15 percent was from the north wellfield **(Figures 9 through 12)**.

- Based on the current configuration of interceptor wells and current aquifer thickness, and assuming an average run time of 90 percent, the estimated 2007 operational pumping capacity of the interceptor wellfield is about 5,000 gpm or about 8,100 acre-feet **(Table 3)**.

SULFATE MASS CAPTURE

- In general, the annual amount of sulfate mass captured by the interceptor wellfield has increased over time from about 5,000 tons in the early 1980s to about 15,000 tons in 2006 **(Figure 15)**.

- Of the 15,000 tons of sulfate captured in 2006, about 45 percent of the sulfate mass was captured from the south wellfield, 38 percent was captured by the middle wellfield, and about 17 percent was captured by the north wellfield **(Figure 15)**.

SULFATE MASS FLUX FROM PDSTI

- Measurements of sulfate concentration in water seeping from the PDSTI have not been obtained. However, sulfate concentrations would be expected to lie within the range of 1,700 to 2,000 milligrams per liter (mg/L), which corresponds to the gypsum-controlled solubility range for sulfate. Samples of water reclaimed from the PDSTI have been collected and analyzed for sulfate periodically from 1980 though 2006 **(Figure 8)**; average sulfate concentration in these samples was 1,956 mg/L. In addition, sulfate concentrations for the middle part of interceptor wellfield, where the highest concentrations have historically been detected, have consistently ranged from about 1,700 to 2,000 mg/L (typically close to 1,800 mg/L) since 1992 **(Figure 11)**.

- A current sulfate mass flux from the PDSTI of about 15,000 tons per year was computed based on average annual seepage estimates for the period 2004 through 2006 and a sulfate concentration of 1,850 mg/L, which is the average value of the potential sulfate concentration range of 1,700 to 2,000 mg/L.

- This estimate of sulfate mass flux should not be compared to sulfate mass captured to evaluate effectiveness of the interceptor wellfield due to uncertainties in seepage estimates (water balance), sulfate concentration in the seepage, and travel time through the PDSTI to the wellfield. Effectiveness of the wellfield is primarily a function of the containment or control of groundwater flow paths by the collective pumping regime rather than the quantity of sulfate mass removed during a given time period.

INTERCEPTOR WELLFIELD EFFECTIVENESS FOR CAPTURE OF PDSTI SEEPAGE

- Analysis of groundwater level gradients, sulfate concentrations in groundwater pumped from interceptor and monitor wells, and numerical simulation of groundwater movement indicates that the south wellfield and most of the middle wellfield can provide an effective hydraulic barrier to groundwater flow from the PDSTI when interceptor wells are consistently pumped **(Figures 16, 17, and 22).** However, limited aquifer thickness in the northernmost middle wellfield and north wellfield results in physical limitations that prevent sufficient pumping to develop an effective hydraulic barrier with the current wellfield configuration **(Figures 18 through 22)**.

ERROL L. MONTGOMERY & ASSOCIATES, INC.

November 14, 2007
REVISED REPORT

EVALUATION OF THE CURRENT EFFECTIVENESS OF THE SIERRITA INTERCEPTOR WELLFIELD PHELPS DODGE SIERRITA MINE PIMA COUNTY, ARIZONA

Prepared for
Phelps Dodge Sierrita, Incorporated

INTRODUCTION

On behalf of Phelps Dodge Sierrita, Incorporated (PDSI), Errol L. Montgomery & Associates, Inc. (Montgomery & Associates) has prepared this report summarizing results of an evaluation of the current effectiveness of the Sierrita interceptor wellfield in controlling movement and capturing seepage containing sulfate from the Phelps Dodge Sierrita Tailing Impoundment (PDSTI). The evaluation included a comprehensive review of current and historic tailing impoundment operations, interceptor wellfield operations and pumping history, hydrogeologic conditions in the vicinity of the wellfield, and groundwater quality data for the wellfield area.

This report was originally submitted to the Arizona Department of Environmental Quality (ADEQ) on February 27, 2007 to satisfy the requirement of Section III.C.4 of the Mitigation Order on Consent Docket No. P-50-06 for an analysis of the effectiveness of PDSI's current groundwater sulfate source control system and in accordance with Task 3, Evaluation of PDSI Groundwater Sulfate Control System, in the October 31, 2006 *Work*

Plan to Characterize and Mitigate Sulfate with Respect to Drinking Water Supplies in the Vicinity of the Phelps Dodge Sierrita Tailing Impoundment, Pima County, Arizona (Hydro Geo Chem, 2006). ADEQ provided written comments on the report to PDSI on April 17, 2007. PDSI submitted written responses to ADEQ's comments on May 31, 2007, wherein PDSI agreed to submit a revised report.

PDSI operates the PDSTI to receive discharge of tailing from mineral beneficiation at the Sierrita mill. The PDSTI is located about 2 miles southeast from the Sierrita mill, and about 1.5 miles west from the town of Green Valley. PDSI operates the Sierrita interceptor wellfield to control and capture seepage from the PDSTI. Locations for wells that comprise the interceptor wellfield are shown on **Figure 1.**

TAILING IMPOUNDMENT DEVELOPMENT AND OPERATION

Open-pit mining by Duval Corporation began at the Esperanza pit in October 1959 and at the Sierrita pit in March 1970. From 1959 through 1981, ore removed from the Esperanza pit was processed at the Esperanza concentrator, and tailing slurry from the Esperanza concentrator was discharged to the Esperanza tailing impoundment (ETI). From 1970 to present, ore removed from the Sierrita pit has been processed at the Sierrita concentrator, and tailing slurry has been discharged to the PDSTI. **Figure 2** shows six stages of development of the ETI and PDSTI from the early 1970s to present.

Discharge of mine tailing slurry from the Esperanza concentrator to the ETI was continuous from October 1959 through December 1971 and from January 1973 through December 1978, and was intermittent from January 1979 through December 1981, when the ETI was closed. The surface of the ETI was subsequently capped with a layer of alluvial material (Reed & Associates, 1986).

Discharge of mine tailing slurry from the Sierrita concentrator to the PDSTI began in March 1970 and has continued through present day **(Figure 2)**. Tailing slurry is presently discharged to the PDSTI through banks of spigots installed on pipelines positioned along the crest of the PDSTI dam. Slurry discharge is progressively moved around the perimeter of the PDSTI to ensure even distribution of tailings across the surface of the PDSTI. The slope of the PDSTI surface allows decanted water to flow to the west where the water collects at the reclaim pond. Water from the reclaim pond is then pumped back to the Sierrita concentrator for reuse in mineral beneficiation.

INTERCEPTOR WELLFIELD DEVELOPMENT AND OPERATION

In the mid-1970s, results of monitor well installation and groundwater sampling along the east edge of the PDSTI indicated that elevated concentrations of sulfate were present in the aquifer in these areas. In 1978, Duval Corporation initiated development of an interceptor wellfield to control eastward movement of seepage from the PDSTI. Operation and expansion of the interceptor wellfield have continued to date, with 23 interceptor wells currently being operated by PDSI **(Figure 1)**. Groundwater pumped from the interceptor wellfield is conveyed back to the Sierrita concentrator for use in mineral beneficiation operations.

Interceptor wells IW-1 through IW-11 were installed between 1978 and 1984 by Duval Corporation (Reed & Associates, 1986). Interceptor wells IW-6A, and IW-12 through IW-21 were installed in 1994 and 1995 by Cyprus Sierrita Corporation (Montgomery & Associates, 1995). Interceptor wells IW-22, IW-23, IW-24, and IW-3A were installed in 2003 and 2004 by PDSI (Montgomery & Associates, 2004a). The overall progression of monitor well installation and interceptor wellfield development is shown on **Figure 2**.

The numbers assigned to the interceptor wells reflect the chronological order in which they were drilled. Because of small pumping capacity at well IW-7 and poor well conditions at wells IW-6 and IW-3, these wells are presently unequipped and capped. Interceptor wells IW-3 and IW-6 were replaced by wells IW-3A and IW-6A. The interceptor wellfield study area is shown on **Figure 1** and schematic diagrams for each well are given in **Appendix A.** Records for interceptor wells and monitor wells shown on **Figure 1** are summarized in **Table 1.**

Hydrogeologic Conditions

Regional hydrogeologic conditions for the upper Santa Cruz basin are given in Davidson (1973), Pima Association of Governments (1979, 1983a, 1983b, and 1983c), Murphy and Hedley (1984), and Anderson (1987). Hydrogeologic conditions in the vicinity of the Sierrita Mine are summarized in Montgomery & Associates and Dames & Moore (1994), Montgomery & Associates (1987, 1989, 1991, 2001, and 2006) and Hydro Geo Chem (2006). The principal hydrogeologic units in the vicinity of the PDSTI and interceptor wellfield include recent alluvial deposits, basin-fill deposits, and a bedrock complex. The basin-fill deposits comprise the principal aquifer in the area, and are the principal source of water pumped from the interceptor wells. Detailed lithologic descriptions for hydrogeologic units in the interceptor wellfield area are provided in Montgomery & Associates and Dames & Moore (1994) and Montgomery & Associates (1991, 1995, 2004a, 2006).

A generalized hydrogeologic section of the interceptor wellfield area is shown on **Figure 3**. Based on aquifer thickness and interceptor well pumping rates, the interceptor wellfield has been divided into three parts:

- South Wellfield: IW-1, IW-2, IW-3A (replacement for IW-3), IW-4, IW-7 (inactive), IW-8, IW-9, and IW-24;
- Middle Wellfield: IW-5, IW-6A (replacement for IW-6), IW-10, IW-11, IW-22, and IW-23;
- North Wellfield: IW-12 through IW-21.

Saturated thickness of the basin-fill deposits aquifer is largest in the south wellfield, and decreases substantially to the north as the depth to bedrock decreases. Since installation of interceptor wells, the saturated thickness of the basin-fill deposits has decreased by about 100 feet in the south wellfield and about 60 feet in north wellfield. However, percent reduction in saturated thickness has been substantially larger in the north wellfield, with reduction in aquifer thickness approaching 80 percent in some areas.

Groundwater level hydrographs for the period 2003 through 2006 for monitor wells located in the south, middle, and north wellfields are shown on **Figure 4**. Inspection of the hydrographs indicates that groundwater levels declined in all three parts of the wellfield during this time period. In the south wellfield, decline was about 35 feet; in the middle wellfield, maximum decline was nearly 60 feet; in the north wellfield, decline was about 30 feet. Observed groundwater level declines at the wellfield area during the period 2003 through 2006 appear to be primarily due to increased pumping of groundwater from some parts of the wellfield during this period.

In the south wellfield, large saturated thickness of basin-fill deposits allows larger groundwater pumping rates. Wells in the south wellfield are capable of pumping 300 to 1,000 gallons per minute (gpm). In the middle wellfield, moderate aquifer thickness results in pumping rates on the order of 150 to 400 gpm. In the north wellfield, the relatively small saturated thickness of basin-fill deposits results in small groundwater yields. Wells in the north wellfield were originally capable of pumping on the order of 100 to 400 gpm. Because of decreasing aquifer thickness, the sustainable pumping rate for the north wellfield has decreased to about 30 percent of original design pumping capacity. During 2006, average operational pumping rates in the north part of the wellfield ranged from 10 to 180 gpm.

ANALYSIS AND RESULTS

The present evaluation of interceptor wellfield effectiveness is based on a comprehensive review of current and historic tailing impoundment operations, interceptor wellfield operations and pumping history, hydrogeologic conditions in the vicinity of the wellfield, and groundwater quality data for the wellfield area. Analysis and results are presented in the following progression:

- Description of the PDSTI water balance and use of the water balance for projecting current annual seepage and associated sulfate mass flux from the impoundment
- Analyses of annual volumes of groundwater and sulfate mass removal by the interceptor wellfield
- Results of groundwater monitoring
- Results of groundwater flow modeling capture analysis for the interceptor wellfield.

TAILING IMPOUNDMENT WATER BALANCE

Montgomery & Associates (1989) presented a water balance for the PDSTI for the time period from 1979 through 1987. The water balance was recently updated through 2006 by completing a comprehensive evaluation of historic data to provide more accurate estimates of the water balance components. In addition, data were recently obtained for characterization of the physical and hydraulic properties of the tailing impoundment by augmenting field investigations conducted by URS Corporation at the PDSTI during February through April 2007 (URS, 2007). URS's investigations were conducted for geotechnical characterization and slope stability evaluation of the tailing dam and included: 1) drilling, sampling, and installation of four piezometers along the outside toe of the PDSTI; 2) drilling, sampling, and installation of three piezometers along the crest of the PDSTI; 3) drilling and sampling of an exploration borehole in the interior of the PDSTI; and 4) conduct of cone-penetration tests in the interior and along the crest of the PDSTI. To more fully utilize URS's investigations for characterization of the PDSTI, Montgomery & Associates was retained to obtain tailing samples for additional physical and hydraulic analyses, and to design and conduct supplemental investigations for more accurately estimating evaporation loss from the PDSTI and improve estimates of other water balance components. A detailed description of the methods, data sources and assumptions of the water balance analysis is given in **Appendix B**. Results of the water balance analysis were used to estimate the amount of seepage from the PDSTI.

The water balance consists of the following "input" components: 1) water in the tailing slurry delivered to the impoundment, 2) precipitation directly onto the impoundment, and 3) surface water discharge from upgradient areas, much of which is captured and delivered via Duval Canal. The water loss and storage components of the water balance consist of: 1) evaporation, 2) water recovered via pumping from the PDSTI reclaim pond, 3) water retained in the deposited tailing, and 4) seepage through the impoundment. Annual values were determined based on measured and/or available data and appropriate assumptions for all the water balance components except seepage. Seepage was computed as the difference between the water "inputs" to the PDSTI and the water lost or stored. A summary of the updated water balance for the period 1971 through 2006 is given in **Table 2** and shown graphically on **Figure 5**. A schematic diagram of the 2006 water balance is shown on **Figure 6**, which demonstrates the relative magnitude of the water balance components (note that the size of the boxes representing the water balance components is roughly proportional to the magnitude of each component).

The largest water balance input or inflow component to the PDSTI is the water delivered in the tailing slurry, which is a function of the amount of ore milled. Substantial fluctuations in annual mill throughput have occurred in the past (for example: a 45 percent decrease from 2001 to 2002), resulting in substantial fluctuations in the amount of slurry (water) delivered to the PDSTI. For the period from 1988 through 2006, water delivery volumes were computed based on measured tonnage of ore milled and measured pulp density of the tailing slurry (dividing ore tonnage by pulp density gives mass of water in the slurry, which is then converted to volume of water). For the period from 1971 through 1987, data for water delivery volumes were directly available. For calculation of water delivery volumes for the period 1988 through 2006, measured values of annual tonnage of ore milled were available from PDSI, and pulp densities for the slurry were based on either anecdotal information (target densities used from 1988 through 1998) or recorded values measured with nuclear density meters (1999 through 2006). Prior to 1990, target pulp density for the slurry delivered to the PDSTI was about 55 percent solids. During the period 1990 through 2006, a lower pulp density of 52 percent solids or less was used for the slurry. Based on the compiled and/or computed volumes, annual water delivered to the PDSTI ranged from about 9,850 acre-feet in 1982 to 27,300 acre-feet in 1997 **(Table 2)** and averaged about 20,900 acre-feet.

The most significant water balance "output" component for the PDSTI is the loss of water through evaporation. Due to the potentially large effect of this component and the lack of direct measurements, present and historic evaporation rates from the PDSTI surface were evaluated using a multi-faceted analysis. Evaporation rates were computed using measured and correlated pan evaporation rates and associated evaporation coefficients for tailing surfaces of differing wetness. Historic and current pan evaporation measurements from weather stations located in the vicinity of the PDSTI and in Tucson were obtained and analyzed to estimate pan evaporation on the impoundment over time. Satellite images and digital aerial photographs were obtained and analyzed to estimate the areal extent and general moisture conditions of the tailing impoundment surface over time. Pan and tailing evaporation coefficients were based on measured pan evaporation at the PDSTI and on review of relevant published studies. Computed evaporation volumes from the PDSTI ranged from about 2,470 acre-feet in 1971 to 13,900 acre-feet in 1996 **(Table 2)** and averaged about 9,360 acre-feet.

The primary methods and assumptions for each of the other PDSTI water balance components are summarized as follows:

- Precipitation falling directly on the PDSTI surface was estimated using rainfall measurements from weather stations near the impoundment and in the Green Valley area. The volume of precipitation for each year was estimated by multiplying measured annual precipitation by the area of the impoundment in the given year. The historic area of the PDSTI was estimated using aerial photographs, digital orthophotography, and satellite images. The estimated volume of precipitation falling on the PDSTI ranged from about 730 acre-feet in 1971 to 5,330 acre-feet in 1983 **(Table 2)** and averaged about 3,070 acre-feet.
- Surface water discharges to the PDSTI occur as baseflow and stormwater runoff in Duval Canal, and as runoff from precipitation on land area directly upgradient from the tailing impoundment. Baseflow comprises process wash water from the mill. Stormwater runoff captured by Duval Canal is from the mill area watershed upgradient from the impoundment. Surface water modeling using precipitation data and the SCS Curve Number Method (SCS, 1986) was used to estimate annual volumes of runoff produced in the mill area watershed. Baseflow was assumed to be 100 gallons per minute (161 acre-feet per year). Estimated surface water discharges to the PDSTI ranged from about 240 acre-feet in 1996 to 870 acre-feet in 1983 **(Table 2)** and averaged about 420 acre-feet.
- The volume of water recovered from the PDSTI reclaim pond is measured by PDSI. Measured annual water reclaim volumes range from 0 acre-feet in 1971 (first full year of PDSTI operation) to about 6,430 acre-feet in 2006 **(Table 2)** and averaged about 3,550 acre-feet. Metered reclaim volumes are unavailable for the time periods 1992 through 1994 and 1999 through 2002; for these periods values are estimated using the average of reported values from 1979 through 2006.
- Water retained in the PDSTI was computed based on the average water content measured for more than 100 tailing samples obtained from the PDSTI during the

recent field investigations. Average (mass-based) water content was multiplied by the mass of ore milled in each year (adjusted for amount of copper and other metals removed) to compute the equivalent amount of water that (on average) will be retained in the tailing delivered to the impoundment after deposition. Annual volume of water retained ranged from about 2,220 acre-feet in 1982 to 5,600 acre-feet in 1997 **(Table 2)** and averaged about 4,460 acre-feet.

Although uncertainties exist in the data sets and assumptions used to determine the water balance components, the updated PDSTI water balance is believed to provide a basis for estimating the current amount of seepage from the PDSTI that is as accurate as possible using reasonable methods or efforts. Estimates of historical seepage rates were also developed from the updated water balance, but are considered generally less accurate due to higher levels of uncertainty with some water balance components. In particular, estimates of seepage for the 1970's and early 1980's are less certain and based on more assumptions for computing evaporation, surface water discharges, and retention, and for determining the size of the PDSTI, than for most subsequent years through 2006. Annual estimates of seepage from the impoundment are summarized in **Table 2** and are shown graphically on **Figure 7**. Computed seepage ranged from about 2,240 acre-feet in 1988 to 11,500 acre-feet in 1972 and averaged about 7,010 acre-feet. Compared to the 1989 water balance, which only included the period from 1979 through 1987, the updated water balance indicates substantially smaller seepage estimates for most years. For the period from 1979 through 1987, the average annual seepage estimate based on the updated water balance is equal to about 70 percent of the seepage estimate from the 1989 water balance.

The generally larger amounts of seepage computed for the periods from about 1990 through 1993 and 1999 through 2001 **(Table 2 and Figure 7)** appear to be due to a combination of factors, including increased delivery volumes of tailing and/or surface discharges concurrently with decreased volumes of reclaimed water pumping and slightly decreased volume of evaporation loss (relative to previous and subsequent years). Conversely, during the period from about 1995 through 1998, computed seepage rates decreased substantially despite consistently large slurry delivery volumes due to large evaporation loss, increased reclaimed water pumping, and reduced precipitation **(Table 2 and Figure 5)**.

Estimated annual seepage volumes for the period from 2003 through 2005 range from about 4,660 to 6,060 acre-feet **(Table 2 and Figure 7)**, which are on the same order of magnitude as the decreased seepage volumes computed for the period from 1995 through 1998. Annual delivery volumes increased during the period 2003 through 2005 due to increased ore milled, but were accompanied by increases in evaporation loss, reclaim pumping, and water retention **(Table 2 and Figure 5)**. Estimated seepage increased in 2006 (7,470 acre-feet) due to large water delivery volume and a substantial increase in precipitation volume. It is also notable that estimated seepage was very low in 2002 (2,860 acre-feet) due to a small water delivery volume resulting from substantially reduced ore production.

INTERCEPTOR WELLFIELD PUMPING

The interceptor wellfield has been operating from 1979 through present. Wellfield data for this operational period are summarized on the following illustrations:

- Annual groundwater pumped from the entire interceptor wellfield **(Figure 9)**
- Annual groundwater pumped from the south wellfield **(Figure 10)**
- Annual groundwater pumped from the middle wellfield **(Figure 11)**
- Annual groundwater pumped from the north wellfield **(Figure 12)**

Annual groundwater pumped for each interceptor well is shown on **Figures C-1 through C-24 (Appendix C)**.

Annual groundwater pumping generally increased from about 3,600 acre-feet in 1979 to a maximum of 8,640 acre-feet in 1994 **(Figure 9)**. Wellfield pumping decreased from 1995 through 1996 due to substantial pumping decreases in the south and middle wellfields **(Figures 10 and 11)**. Groundwater pumping generally increased from 1997 through 2000 as existing wells were pumped near operational capacity and as 10 additional wells in the north wellfield (IW-12 through IW-21) began operation in late 1996 **(Figure 12)**. Groundwater pumping decreased in 2001 primarily as a result of decreased pumping from the middle wellfield **(Figure 11)**. Groundwater pumping also decreased in 2003 due to decreased pumping in the south wellfield **(Figure 10)**. Annual groundwater pumped during 2004 through 2006 was relatively constant at about 8,000 acre-feet per year **(Figure 9)**.

Of the 7,900 acre-feet of groundwater pumped in 2006, about 54 percent was from the south wellfield, 31 percent was from the middle wellfield, and 15 percent was from the north wellfield **(Figures 9 through 12)**.

Wellfield percent run time data are available for years 2003 through 2006; average percent run time for the entire wellfield is shown on **Figure 13**. Average operational run time increased from about 36 percent in 2003 to 86 percent in 2006. **Figure 14** shows average percent run time and annual groundwater pumping volumes for the south, middle, and north wellfields for 2003 through 2006. In general, operational run time percentages for all three parts of the wellfield increased from 2003 through 2006 with the largest increase occurring in the north wellfield from about 24 percent in 2003 to about 90 percent in 2006. However, despite the increased operational run time percentage over the 4-year period, annual groundwater pumping volumes for the middle and north wellfields showed little to no increase. This was due to decreasing saturated aquifer thickness and the resulting reduction in pumping capacities for many of the wells in the middle and north wellfields.

Based on the current configuration of interceptor wells and current aquifer thickness, and assuming an average run time of 90 percent, the estimated 2007 operational pumping capacity of the interceptor wellfield is about 5,000 gpm or about 8,100 acre-feet **(Table 3)**.

Sulfate Mass Capture

Annual sulfate mass captured by the interceptor wellfield was computed using annual groundwater pumped and annual average sulfate concentrations for each individual well. Annual average sulfate concentrations for each interceptor well are shown on **Figures C-1 through C-24** (**Appendix C)**. Annual average sulfate concentrations for intercepted groundwater for the entire wellfield, and for the south, middle, and north wellfields were computed and are shown on **Figures 9 through 12**. Annual average sulfate concentrations for the wellfield were calculated using reported sulfate concentrations for individual wells for a given year and were weighted based on the annual average pumping volume for the wells. For example, for the entire wellfield calculation **(Figure 9)**, the average sulfate concentration for a single well for a given year was multiplied by the amount of groundwater pumped by that well for that year divided by the total groundwater pumped for all the wells for that year. The weighted values for all the wells were summed to give an average concentration for the entire wellfield, and similarly for the south, middle, and north wellfields. For years when sulfate concentrations are unavailable for individual wells, and when those wells pumped groundwater, the sulfate concentration for that year was computed using the average of the previous and subsequent years.

For the entire wellfield, the average sulfate concentration of intercepted water generally increased from about 900 milligrams per liter (mg/L) in the early 1980s to about 1,700 mg/L in 2002 and then decreased slightly to about 1,400 mg/L by 2006 **(Figure 9)**. Sulfate concentrations in the south wellfield showed a similar trend to the calculated concentrations for the entire wellfield with a more pronounced decrease in sulfate concentration occurring from about 1,500 mg/L in 2002 to less than 900 mg/L in 2006

(Figure 10). Sulfate concentrations in the middle wellfield increased from about 1,300 mg/L in 1980 to about 2,000 mg/L in 2002 and then decreased to about 1,700 mg/L in 2006 **(Figure 11)**. In the north wellfield, sulfate concentrations have generally increased from about 1,300 mg/L in 1997 to about 1,600 mg/L in 2006 **(Figure 12)**.

Cumulative sulfate mass capture for the south, middle, and north wellfields for the period 1980 through 2006 is shown on **Figure 15**. In general, sulfate mass capture increased from about 4,800 tons in 1982 to about 17,000 tons in 1999. Relatively low sulfate mass capture occurred in 1990, 1996, and 2001, corresponding to years of low groundwater pumping from the interceptor wellfield **(Figure 9).** During 2004 through 2006 the cumulative sulfate mass capture averaged about 15,000 tons per year with relatively consistent sulfate capture for each part of the wellfield.

Sulfate Mass Flux from PDSTI

Sulfate mass flux from the PDSTI refers to the rate of movement of dissolved sulfate mass in water that infiltrates through the impoundment and seeps into the underlying alluvial aquifer. Direct measurements of sulfate concentrations in water seeping from the PDSTI have not been made. However, samples of water reclaimed from the PDSTI have been collected and analyzed for sulfate concentration periodically from 1980 though 2006; results are shown on **Figure 8**. Average sulfate concentration in water samples obtained from the PDSTI reclaim pond over this timeframe was 1,956 mg/L. It is important to note that sulfate concentrations in the reclaim pond samples would be expected to be larger than in water that infiltrates through the impoundment due to large evaporation rates for the pond water. In addition, the average sulfate concentration of almost 2,000 mg/L is near the high end of the range of sulfate solubility for gypsum and therefore should represent essentially the maximum sulfate concentration that would be expected in seepage water. The lower end of sulfate solubility for gypsum is approximately 1,700 mg/L, which would be a reasonable estimate for the lower end of the range of sulfate concentrations that might occur in seepage water.

Sulfate concentrations in groundwater samples obtained from the interceptor wells also provide a basis for evaluating potential sulfate concentration in the seepage water from the PDSTI. Sulfate concentrations for the middle part of interceptor wellfield, where the highest concentrations have historically been detected, have consistently ranged from about 1,700 to 2,000 mg/L (typically close to 1,800 mg/L) since 1992 **(Figure 11)**. This range is consistent with range of sulfate solubility for gypsum.

Sulfate mass flux from the PDSTI (based on the PDSTI water balance analysis) was computed using seepage representative of current or recent conditions (between 2004 and 2006). Specifically, seepage flux (acre-feet per year) multiplied by sulfate concentration (mg/L converted to tons per acre-foot) equals sulfate mass flux in tons per year. Due to the uncertainty regarding sulfate concentrations in the seepage water, the average value (1,850 mg/L) of the potential sulfate concentration range described previously (1,700 to 2,000 mg/L) was used to estimate the current sulfate mass flux from the PDSTI. Based on the updated water balance, average annual seepage from the PDSTI was about 6,000 acre-feet per year during the period from 2004 through 2006. Based on this average seepage rate, sulfate mass flux was estimated to be about 15,000 tons per year for the 3-year period, which is equal to the computed sulfate mass captured by the interceptor wellfield during the same period (described in the previous section).

It is important to note that this estimate of sulfate mass flux should not be compared to sulfate mass captured to evaluate the effectiveness of the interceptor wellfield because the sulfate mass flux estimate (in particular) is only approximate due to uncertainties in seepage estimates (water balance), sulfate concentration in the seepage, and travel time through the PDSTI to the wellfield. The effectiveness of the wellfield is less a function of quantity of sulfate mass removed during a given time period than of containment or control of groundwater flow paths by the collective pumping regime, which is addressed in the following section.

INTERCEPTOR WELLFIELD EFFECTIVENESS FOR CAPTURE OF PDSTI SEEPAGE

Effectiveness of the interceptor wellfield in capturing groundwater seepage from the PDSTI was analyzed by two methods:

1. GROUNDWATER MONITORING: Groundwater levels and sulfate concentrations at interceptor wells and monitor well suites were used to determine the capture effectiveness at specific locations in the south, middle, and north wellfields; and

2. GROUNDWATER MODELING: A particle-tracking analysis using a numerical groundwater flow model was conducted to evaluate the effectiveness of the entire interceptor wellfield in capturing groundwater seepage from the PDSTI.

Groundwater Monitoring

The interceptor wellfield can provide an effective hydraulic barrier to groundwater flow when the water table is lowered sufficiently to create a hydraulic line-sink along the length of the wellfield. The groundwater depression along the line-sink should be sufficiently large that reversal of the hydraulic gradient occurs along the full distance between pumping wells. In 1990, the MH-15 and MH-16 paired monitor well suites were constructed between interceptor wells IW-10 and IW-11, and IW-3 and IW-8, respectively, to determine if the hydraulic line-sink was effective at these locations (Montgomery & Associates, 1991). In addition, monitor well MH-14 was constructed and paired with existing monitor well MH-3 to evaluate groundwater level gradients in what is now considered the north wellfield. The MH-14 monitor well suite is located between interceptor wells IW-18 and IW-19. Locations for the monitor well suites are shown in **Figure 1**.

For this evaluation, groundwater level and groundwater quality data for the MH-16, MH-15 and MH-14 monitor well suites were analyzed to determine if an effective hydraulic line-sink has been established between selected interceptor well pairs in the south, middle, and north wellfields. Although 13 new interceptor wells have been installed since the monitor well suites were established in 1990, the MH-16 and MH-14 monitor well suites are still located at a mid-point between operating pairs of interceptor wells.

SOUTH WELLFIELD: **Figure 16** shows groundwater level altitudes at the MH-16 monitor well suite, for the time period from July 2003 through 2006. Inspection of **Figure 16** indicates that from June 2003 through about August 2004 groundwater level altitude at well MH-16W was higher than well MH-16E, indicating the hydraulic gradient at this location was to the east, concordant with the regional gradient. During this time, well IW-3A was not pumping at operational capacity **(Figure C-3)**. Starting in September 2004 and continuing until the end of April 2006, wells IW-3A and IW-8 were pumping at or near operational capacity **(Figures C-3 and C-8)** which resulted in a reversal of the gradient (from east to west) for most of that 20-month period. At the end of April 2006, well IW-8 was shutdown for well rehabilitation which led to a groundwater level rise at the well MH-16 monitor well suite and a gradient change directed back to the east. These relations illustrate that the south wellfield at this location can be effective in capturing PDSTI seepage when interceptor wells are pumped at operational capacity.

Figure 17 shows annual groundwater pumping and average sulfate concentrations in groundwater for wells IW-3, IW-3A, and IW-8 along with sulfate concentrations in groundwater at well MH-16W for the period 1979 through 2006. From 1990 through 1995, average sulfate concentrations at interceptor wells IW-3 and IW-8 ranged from about 800 mg/L to larger than 1,600 mg/L. Conversely, sulfate concentrations measured at monitor well MH-16W during this time period had stabilized at about 50 mg/L, which is in the range of ambient concentrations for the regional aquifer. These relations indicate that, during this period, the interceptor wellfield at this location was effective in capturing PDSTI seepage. However, between 1996 and about 2000, combined pumping rates for wells IW-3 and IW-8 were smaller **(Figures C-3 and C-8)**. This resulted in an increase in sulfate concentrations at monitor well MH-16W to more than 1,500 mg/L by 1998, indicating less seepage capture at this location. Sulfate concentration in groundwater continued to increase at well MH-16W to more than 2,000 mg/L in 2001. By 2001, pumping from interceptor wells IW-3 and IW-8 began increasing once again to pre-1996 levels, and sulfate concentrations at monitor well MH-16W began to decrease. In 2006, observed sulfate concentration at monitor well MH-16W had decreased to about 1,000 mg/L.

MIDDLE WELLFIELD: **Figure 18** shows groundwater level altitudes at the MH-15 monitor well suite for the period from July 2003 through 2006. From July 2003 through June 2005, prior to commencement of pumping at well IW-22, comparison of measured water level altitudes at well MH-15W and MH-15E indicated that hydraulic gradient was to the east and concordant with the regional gradient, indicating that seepage capture was not complete at this location. During this time, wells IW-10 and IW-11 were not pumped at operational capacity **(Figures C-10 and C-11)**. However, during the period January through April 2005, wells IW-10 and IW-11 were pumped near operational capacity and the hydraulic gradient decreased but was not reversed.

In 2004, interceptor wells IW-22, IW-23, and IW-24 were installed in between existing interceptor wells to improve capture in this part of the wellfield. Well IW-22 was installed between wells IW-10 and IW-11 and began operation in July 2005, diminishing the effectiveness of this monitor well suite for monitoring development of a continuous hydraulic line-sink between interceptor wells IW-10 and IW-11. Inspection of **Figure 18** for the period July 2005 through 2006 shows that reversal of hydraulic gradient had occurred most of the time at the MH-15 monitor well suite, indicating improved effectiveness of the wellfield in this area.

Figure 19 shows annual groundwater pumping and average sulfate concentrations in groundwater for wells IW-10, IW-11, and IW-22 along with sulfate concentrations in groundwater at well MH-15W for the period 1986 through 2006. Average sulfate concentrations at wells IW-10, IW-11, and IW-22 generally ranged from about 1,500 mg/L to more than 2,000 mg/L and averaged about 1,750 mg/L. Sulfate concentrations at well MH-15W generally ranged from about 1,500 mg/L to about 2,300 mg/L and averaged about 1,750 mg/L. The generally larger concentrations at well MH-15W may indicate incomplete capture at this location. However, results of the flow path analysis indicate the interceptor wellfield line-sink would eventually capture sulfate seepage in this area, as described in a subsequent section of this report.

NORTH WELLFIELD: **Figure 20** shows groundwater level altitudes at the MH-14 monitor well suite for the time period from July 2003 through 2006. The hydraulic gradient at this location for the entire time period was to the east, concordant with the regional gradient, illustrating that this portion of the interceptor wellfield is less effective than the south and middle wellfields in capturing PDSTI seepage. Groundwater pumping did not occur at wells IW-18 and IW-19 during the time period from July 2003 through January 2004 **(Figures C-18 and C-19)**. From January 2004 through about February 2005, wells IW-18 and IW-19 were pumping near operational capacity, resulting in a decrease in the magnitude of the gradient at the monitor well suite and substantial groundwater level declines **(Figure 20)**. For most of 2005 and 2006, pumping decreased at well IW-18 **(Figure C-18)** and this resulted in an increase in the magnitude of the gradient between the MH-3 and MH-14 monitoring suite. Due to declining groundwater levels at this location, the pumping rate of IW-18 was reduced from about 85 gpm in 2004 to 10 gpm in 2006. The rate of water level decline at the monitoring suite decreased substantially in 2006, which suggests that at this location the system is approaching hydraulic equilibrium based on nearly continuous pumping at well IW-18 (90 percent run time in 2006) and well IW-19 (94 percent run time in 2006).

Figure 21 shows annual groundwater pumping and average sulfate concentrations in groundwater for wells IW-18 and IW-19 along with sulfate concentrations in groundwater at well MH-14. Average sulfate concentrations at wells IW-18 and IW-19 increased from about 1,300 mg/L in 1997 to about 1,600 mg/L in 2004. Sulfate concentrations at well MH-14 ranged from about 1,200 mg/L in 1997 to about 1,500 mg/L in 2004, indicating incomplete capture during this time period at this location. This conclusion is supported by results of the flow-path analysis described in the following section. Sulfate concentrations in groundwater from wells IW-18, IW-19, and MH-14 have remained relatively constant from 2004 through 2006.

Groundwater Modeling

Preliminary groundwater flow-path modeling has been conducted to evaluate the effectiveness of the interceptor wellfield based on the current wellfield configuration.

Groundwater flow paths from the PDSTI to the interceptor wellfield were simulated using a modified version of the numerical groundwater flow model constructed in support of the 1994 Aquifer Protection Permit application for the Sierrita Mine property (Montgomery and Associates, 1994). The model was updated in 2004 for evaluation of groundwater flow and sulfate transport in the vicinity of the PDSTI. The flow model was constructed using MODFLOW, a finite-difference groundwater flow model developed by the U.S. Geological Survey (USGS) (McDonald and Harbaugh, 1988). Flow paths are simulated with particles using the particle path model MODPATH, a code developed by USGS for use with the MODFLOW code (Pollock, 1994).

The model is constructed as one layer with grid cell spacing of 50 by 50 feet in the vicinity of the interceptor wellfield. The bottom of the model layer coincides with bedrock surface, as encountered during drilling of exploration boreholes and the interceptor wells. Rates for PDSTI seepage and interceptor well pumping were updated in the model through 2006; the model results reasonably reproduce groundwater level altitudes observed in the vicinity of the wellfield in 2006. The hydrogeologic section shown on **Figure 3** depicts the bedrock altitude and 2006 groundwater level altitude along the interceptor wellfield.

For the particle-tracking analysis, interceptor well pumping rates were updated based on current pumping capacity and assuming a 90 percent run time for each well. Estimated interceptor well pumping rates for 2007 are given in **Table 3**; total simulated rate was 8,107 acre-feet per year. Particles were released along the south, east, and northeast edge of the PDSTI. Projected capture zones as defined by simulated flow paths, and contours of simulated groundwater level altitude, are shown on **Figure 22**. Results of the analysis suggest the following:

<u>SOUTH WELLFIELD:</u> Particles along the southern part of the PDSTI are captured by the south wellfield, suggesting that pumping from the south wellfield effectively acts as a barrier to eastward movement of PDSTI seepage.

<u>MIDDLE WELLFIELD:</u> Particles from the middle part of the PDSTI are captured along most of the middle wellfield. Some particles pass by well IW-6A, which is the northernmost interceptor well in the middle wellfield, suggesting effective hydraulic capture exists south from interceptor well IW-11, but not north of it. From south to north, observed aquifer thickness decreases to less than 100 feet in this area, which limits pumping in well IW-6A and prevents development of an effective hydraulic line-sink between well IW-6A and adjacent wells IW-11 and IW-12.

NORTH WELLFIELD: The model further shows that particles from the north part of the PDSTI are only partially captured, indicating that effective hydraulic capture does not exist in the north wellfield. Observed aquifer thickness along the north wellfield ranges from about 30 feet at well IW-16 to about 300 feet at well IW-12, which limits pumping in the north wellfield and prevents hydraulic capture.

DISCUSSION AND RECOMMENDATION

TAILING IMPOUNDMENT WATER BALANCE

The updated PDSTI water balance **(Table 2 and Figure 5)** is based on: comprehensive evaluation and analysis of available historic data from PDSI; analysis of additional technical resources such as satellite images, digital orthophotography, and meteorological databases; and data obtained during recent field investigations for characterization of the physical and hydraulic properties of the tailing impoundment and evaporation rates. Although uncertainties exist in the data sets and assumptions used to determine the water balance components, the updated PDSTI water balance is believed to provide a basis for estimating the current amount of seepage **(Table 2 and Figure 7)** from the PDSTI that is as accurate as possible using reasonable methods or efforts. Estimates of historical seepage rates were also developed from the updated water balance, but are considered generally less accurate due to higher levels of uncertainty with some water balance components. Compared to the 1989 water balance (Montgomery & Associates, 1989), which only included the period from 1979 through 1987, the updated water balance indicates substantially smaller seepage estimates for most years. For the period from 1979 through 1987, the average annual seepage estimate based on the updated water balance is equal to about 70 percent of the seepage estimate from the 1989 water balance.

Based on the water balance analysis for 2006, about 26,320 acre-feet of water was delivered to the PDSTI **(Table 2)**. Additional inputs of water include about 4,490 acre-feet from direct precipitation and 350 acre-feet from surface water discharges. Total water input to the PDSTI was about 31,160 acre-feet, of which:

- about 6,430 acre-feet was pumped from the PDSTI reclaim pond and returned to the mill;

- about 11,980 acre-feet was evaporated from the PDSTI surface;
- about 5,280 acre-feet was retained in the tailing deposited in the PDSTI; and
- about 7,470 acre-feet seeped from the PDSTI.

INTERCEPTOR WELLFIELD OPERATION AND MAINTENANCE

Maximum effectiveness of the interceptor wellfield can be achieved with consistent operation and maintenance of wells and pipeline infrastructure. Routine monitoring and analysis of wellfield operational parameters, and implementation of a preventative maintenance program linked to the monitoring program, provides a basis for consistent wellfield operation. Since June 2003, PDSI has developed and implemented an Operation and Maintenance program to maintain consistent operation of the interceptor wellfield (Montgomery & Associates, 2004b, 2004c, and 2005). In 2006, the average percent run time for the wellfield was about 86 percent **(Figure 13),** with an annual pumpage volume of about 7,900 acre-feet. It is important to note that 100 percent run time is not possible to achieve given that routine maintenance (e.g. pump replacement and well rehabilitation) must occur on the wellfield infrastructure to keep it operational.

INTERCEPTOR WELLFIELD EFFECTIVENESS FOR CAPTURE OF PDSTI SEEPAGE

The effectiveness of the Sierrita interceptor wellfield in capturing seepage from the PDSTI has been evaluated by review and analysis of wellfield operational data and groundwater monitoring data, and by particle-tracking analysis using a numerical groundwater flow model. Results of this evaluation indicate that the interceptor wellfield can provide effective capture of seepage in the south and most of the middle wellfields.

However, as presently constructed, the northernmost portion of the middle wellfield and north wellfield are only partially effective.

South Wellfield

The south wellfield can provide an effective hydraulic barrier when interceptor wells are consistently pumped. Effective hydraulic control and seepage capture have been documented for the south wellfield in the past, and is presently occurring **(Figures 16, 17, and 22)**.

Middle Wellfield

Installation of wells IW-22, IW-23, and IW-24 in 2004 has improved the effectiveness of the middle wellfield. However, large well spacing and small saturated thickness in the vicinity of wells IW-6A and IW-11 prevents sufficient pumping to develop an effective hydraulic barrier in the north part of the middle wellfield **(Figures 18, 19, and 22)**.

North Wellfield

In the north wellfield, small aquifer thickness prevents sufficient pumping to develop an effective hydraulic barrier **(Figure 20, 21, and 22)**.

RECOMMENDATION

PDSI is committed to providing source control of seepage from the PDSTI, which is consistent with the overall objectives of Mitigation Order P-50-06. Given that the northern portion of the middle wellfield and the north wellfield have been determined to not provide effective hydraulic capture, PDSI proposed in the February 26, 2007 version of this report to conduct a focused feasibility study to evaluate potential options for improving the effectiveness of the interceptor wellfield. PDSI will be submitting the focused feasibility study during the 4th quarter of 2007. The focused feasibility study will provide a recommended alternative for consideration by ADEQ and discussion with the Community Advisory Group. PDSI will consider accelerated implementation of actions based upon the focused feasibility study.

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TABLE 1. RECORDS FOR INTERCEPTOR AND MONITOR WELLS IN VICINITY OF SIERRITA INTERCEPTOR WELLFIELD
PHELPS DODGE SIERRITA MINE, PIMA COUNTY, ARIZONA

WELL NAME	CADASTRAL	OWNER	ADWR REGISTRATION NUMBER	DATE COMPLETED	DEPTH DRILLED (feet below land surface)	CASING: DIAMETER (inches)	CASING: DEPTH (feet)	CASING: PERFORATED INTERVAL (feet below land surface)	REPORTED PUMPING RATE (gpm)[a]	ALTITUDE OF LAND SURFACE (feet, msl)[b]	NON-PUMPING WATER LEVEL: DEPTH (feet)[c]	NON-PUMPING WATER LEVEL: DATE MEASURED	NON-PUMPING WATER LEVEL: ALTITUDE (feet, msl)[b]	LOG[d]	USE[e]
INTERCEPTOR WELLS															
IW-1	(D-18-13)29dcd	PDSI	623129	7/31/1978	855	14	843	234-843	1,200	3,141	349.89	3/15/2005	2,758	D,L	I
IW-2	28ccc	PDSI	623130	5/18/1978	1,035	16	0-700	40-1,035	1,529	3,098	331.88	3/15/2005	2,704	D,L	I
						12.75	560-930								
						10.75	891-1,011								
						8.63	1,005-1,035								
IW-3	28cbc1	PDSI	623131	7/9/1978	1,047	14	1,041	232-1,041	1,001	3,118.44	331.17	12/2/2003	2,787.27	D,L	I,U
IW-3A	28cbc2	PDSI	201732	2/3/2004	1,052	14	1,050	400-1,030	1,000	3,117 ?	353	9/14/2006	2,785	D,L,GL	I
IW-4	28bbc	PDSI	623132	7/23/1978	946	14	946	334-946	1,300	3,134.07	385.75	3/14/2006	2,748.32	D,L	I
IW-5	21ccc	PDSI	623133	6/13/1979	956	14	956	301-956	---	3,134.66	372.55	12/17/2005	2,762.11	D,L	I
IW-6	21bcc2	PDSI	623134	6/21/1979	489	14	489	297-489	---	3,130	317.09	10/12/1993	2,812.91	D,L	I,U
IW-6A	21bcc3	PDSI	545565	11/29/1994	498	12	497	356-458	300	3,129.27	380.18	10/22/2005	2,749.09	D,L	I
IW-7	29cdd2	PDSI	623135	9/ /1979	1,050	14	1,045	321-1,045	---	3,161	342	3/18/1981	2,819	D,L	I,U
IW-8	28cbb2	PDSI	508236	8/ /1984	803	14	783	382-783	---	3,119.20	363.44	9/27/2005	2,755.76	D,L	I
IW-9	28bcc2	PDSI	508238	8/6/1984	853	14	853	412-853	725	3,099.98	340.55	11/18/2005	2,759.43	D,L	I
IW-10	21ccb1	PDSI	508237	8/15/1984	843	14	831	420-831	1,350	3,126.65	363.20	6/24/2005	2,763.45	D,L	I
IW-11	21cbb	PDSI	508235	8/24/1984	605	14	605	371-605	1,150	3,124.21	381.30	8/13/2006	2,742.91	D,L	I
IW-12	21bcb	PDSI	545555	12/6/1994	625	12	600	358-559	400	3,135.19	368.35	4/15/2006	2,766.84	D,L	I
IW-13	21bbc	PDSI	545556	12/12/1994	499	12	497	355-456	175	3,140.36	386.25	3/14/2006	2,754.11	D,L	I
IW-14	21bbb2	PDSI	545557	12/18/1994	553	12	549	357-507	200	3,143.43	379.95	3/14/2006	2,763.48	D,L	I
IW-15	16ccc	PDSI	545558	1/7/1995	550	12	547	355-506	175	3,149.03	387.55	3/14/2006	2,761.48	D,L	I
IW-16	16ccb	PDSI	545559	1/15/1995	473	12	469	357-427	100	3,159.86	399.6	1/14/2006	2,760.26	D,L	I
IW-17	16cbc	PDSI	545560	1/20/1995	502	12	499	357-457	200	3,157.77	426.35	8/13/2006	2,731.42	D,L	I
IW-18	16cbb	PDSI	545561	1/24/1995	508	12	503	381-461	150	3,168.16	441.60	1/14/2006	2,726.56	D,L	I
IW-19	16bcc3	PDSI	545562	1/30/1995	544	12	540	378-499	400	3,152.40	418.60	11/11/2006	2,733.80	D,L	I
IW-20	16bcb	PDSI	545563	2/5/1995	506	12	502	380-460	200	3,161.22	421.25	11/11/2006	2,739.97	D,L	I
IW-21	16bbc	PDSI	545564	2/12/1995	620	12	601	399-560	300	3,168.38	424.8	11/11/2006	2,743.58	D,L	I
IW-22	21cbc3	PDSI	200554	12/19/2003	592	14	590	359-560	600	3,119	390.5	3/14/2006	NA	D,L,GL	I
IW-23	21ccb2	PDSI	200555	1/18/2004	974	14	964	375-935	300	3,117	377.75	3/14/2006	NA	D,L,GL	I
IW-24	28bbb3	PDSI	200556	1/3/2004	884	14	880	348-860	350	3,101	353.9	3/14/2006	NA	D,L,GL	I
MONITOR WELLS															
MH-1	(D-18-13)16bbb	PDSI	803629	11/19/1975	524	3	480	420-480	---	3,176.28	443.9	11/21/2006	2,732.38	D,L	M
MH-2	28ccd2	PDSI	35-34590	11/26/1975	1,040	3	1,038	520-1,038	---	3,097	295	5/15/1979	2,802	D,L	M,Z
MH-3	16bcc1	PDSI	803630	2/ /1976	520	3	1	400-500	15	3,152.88	427.7	12/18/2006	2,725.18	D,L	M
MH-4	21bbb1	PDSI	803631	3/2/1976	550	3	520	420-520	---	3,136.63	368.8	5/24/1988	2,767.83	D,L	M
MH-5	21bcc1	PDSI	803632	3/ /1976	640	3	640	340-640	---	3,120.48	389.22	11/21/2006	2,731.26	D,L	M
MH-6	28bbb2	PDSI	803633	4/ /1976	960	3	960	320-960	---	3,130.98	381.65	11/14/2006	2,749.33	D,L	M
MH-7	28cbb1	PDSI	803634	4/1/1976	1,100	3	1,100	300-1,100	---	3,108.24	357.85	11/21/2006	2,750.39	D,L	M
MH-8	29ddc	PDSI	---	6/17/1976	1,065	3	1,060	300-1,060	100	3,125.00	293	12/14/1981	2,832.00	D,L	M,Z
MH-9	29cdd1	PDSI	803635	7/ /1976	1,400	3	1,365	350-1,365	---	3,159.58	380.58	11/8/2006	2,779.00	D,L	M
MH-10	30ddd	PDSI	803636	2/ /1977	600	3	600	280-600	---	3,184.85	346.7	11/8/2006	2,838.15	D,L	M
MH-11	16ddd	PDSI	803637	2/ /1977	820	3	820	300-820	---	3,040.30	369.9	11/9/2006	2,670.40	D,L	M
MH-12	16daa	PDSI	803638	2/ /1977	800	3	800	280-800	---	3,054.07	415.94	11/13/2006	2,638.13	D,L	M

TABLE 1. RECORDS FOR INTERCEPTOR AND MONITOR WELLS IN VICINITY OF SIERRITA INTERCEPTOR WELLFIELD
PHELPS DODGE SIERRITA MINE, PIMA COUNTY, ARIZONA

WELL NAME	CADASTRAL	OWNER	ADWR REGISTRATION NUMBER	DATE COMPLETED	DEPTH DRILLED (feet below land surface)	CASING DIAMETER (inches)	CASING DEPTH (feet)	CASING PERFORATED INTERVAL (feet below land surface)	REPORTED PUMPING RATE (gpm)[a]	ALTITUDE OF LAND SURFACE (feet, msl)[b]	NON-PUMPING WATER LEVEL DEPTH (feet)[c]	NON-PUMPING WATER LEVEL DATE MEASURED	NON-PUMPING WATER LEVEL ALTITUDE (feet, msl)[b]	LOG[d]	USE[e]
MH-13	21add1	PDSI	803639	2/ /1977	1,425	3	1,420	420-1,420	---	3,023.42	302.20	11/7/2003	2,721.22	D,L	M
MH-13A	21add2	PDSI	904071	3/17/2006	665	4	660	300-650	---	3,022.37	327.84	11/10/2006	2,694.53	D,L	M
MH-13B	21add3	PDSI	904072	4/2/2006	980	4	960	750-950	---	3,025.19	330.70	11/10/2006	2,694.49	D,L	M
MH-13C	21add4	PDSI	904073	3/6/2006	1,447	4	1,360	1,050-1,350	---	3,022.96	335.38	11/10/2006	2,687.58	D,L, GL	M
MH-14	16bcc2	PDSI	528098	6/12/1990	561	6	522	376-501	15	3,150.77	427.7	12/18/2006	2,723.07	D,L	M
MH-15E	21cbd2	PDSI	528094	6/22/1990	467	4	462	317-442	---	3,108.38	385.25	11/10/2006	2,723.13	D,L	M
MH-15W	21cbd1	PDSI	528093	6/15/1990	466	6	465	320-445	15	3,114.08	390.6	12/18/2006	2,723.48	D,L	M
MH-16E	28cba	PDSI	528100	7/1/1990	460	4	458	315-440	---	3,094.73	343.75	12/18/2006	2,750.98	D,L	M
MH-16W	28cbb3	PDSI	528099	6/29/1990	460	6	450	315-440	15	3,097.25	345.78	12/18/2006	2,751.47	D,L	M
MH-24	21bcc4	PDSI	563799	9/17/1997	468	6	468	358-468	---	3,128.17	397.50	11/21/2006	2,730.67	D	M
MH-25A	09dda1	PDSI	201528	12/17/2003	545	5	530	410-530	18	3,068.00	454.11	11/13/2006	2,613.89	D,L	M
MH-25B	09dda2	PDSI	208429	11/19/2005	690	4	680	580-680	---	3,068.80	455.36	11/13/2006	2,613.44	D,L	M
MH-25C	09dda3	PDSI	208426	11/10/2005	1,121	4	1101	731-901, 951-1081	---	3,069.28	454.65	11/13/2006	2,614.63	D,L, GL	M
MH-26A	09aaa1	PDSI	201527	12/18/2003	545	5	538	418-538	17	3,063	495.74	11/13/2006	2,567.26	D,L	M
MH-26B	09aaa2	PDSI	208427	12/4/2005	737	4	735	620-730	---	3,060.90	493	11/13/2006	2,567.90	D,L	M
MH-26C	09aaa3	PDSI	208428	11/23/2005	920	4	900	780-900	---	3,062.27	494.45	11/13/2006	2,567.82	D,L, GL	M
MH-28	21bbb3	PDSI	903648	12/15/2005	492	10	0-40	355-485	---	3,137.00	402.25	12/19/2006	2,734.75	D,L	M
						4	0-490								
MH-29	28bba	PDSI	903649	12/19/2005	480	10	0-40	340-470	---	3,100.00	377.01	12/19/2006	2,722.99	D,L	M
						4	0-475								
MH-30	17aba	PDSI	903884	1/21/2006	547	10	0-20	430-530		3,166.00	422.78	11/9/2006	2,743.22	D,L,GL	M
						5	0-535								

NOTE: Data queried where uncertain

[a] gpm = gallons per minute
[b] feet, msl = feet above mean sea level
[c] Depth in feet below land surface; P denotes pumping water level
[d] Logs available:
D = Drillers Log
L = Lithologic log
GL = Geophysical Log

--- = Not available

[e] Use:
I = Industrial
U = Unused
M = Monitor
Z = Destroyed or Abandoned

TABLE 2. SUMMARY OF WATER BALANCE COMPONENTS FOR SIERRITA TAILING IMPOUNDMENT
PHELPS DODGE SIERRITA MINE, PIMA COUNTY, ARIZONA

YEAR	WATER DELIVERED TO IMPOUNDMENT (acre-feet)	WATER RECLAIMED FROM IMPOUNDMENT (acre-feet)	SURFACE WATER DISCHARGE TO IMPOUNDMENT (acre-feet)	RAINFALL ON IMPOUNDMENT (acre-feet)	EVAPORATION FROM IMPOUNDMENT (acre-feet)	WATER RETAINED IN IMPOUNDMENT (acre-feet)	SEEPAGE FROM IMPOUNDMENT (acre-feet)
1971	13,756	0	547	731	2,467	3,178	9,389
1972	17,092	103	530	976	3,039	3,949	11,507
1973	16,741	335	512	1,221	3,802	3,868	10,470
1974	17,179	1190	402	1,530	4,565	3,969	9,388
1975	17,862	1933	289	1,007	5,225	4,127	7,873
1976	18,361	1,325	454	1,546	5,680	4,242	9,114
1977	16,754	1,205	707	2,472	6,034	3,871	8,823
1978	20,672	3,200	866	3,490	6,388	4,776	10,664
1979	19,242	4,400	406	1,791	6,742	4,446	5,852
1980	20,056	4,857	433	2,244	7,094	4,634	6,149
1981	18,292	3,914	736	3,662	7,456	4,226	7,095
1982	9,853	1,043	583	3,050	7,745	2,216	2,482
1983	13,008	1,755	872	5,332	7,941	2,917	6,599
1984	17,730	5,245	737	5,325	9,423	3,993	5,131
1985	21,847	3,930	514	4,136	11,436	5,079	6,051
1986	16,976	3,090	361	3,092	10,967	3,864	2,508
1987	16,012	4,325	458	3,602	9,458	3,790	2,498
1988	19,067	5,474	269	2,363	9,579	4,405	2,241
1989	19,091	3,435	316	2,196	10,416	4,411	3,341
1990	22,752	2,290	492	4,788	10,418	4,660	10,664
1991	23,251	1,958	332	3,680	10,036	4,762	10,507
1992	23,817	4,231	338	4,173	9,949	4,878	9,271
1993	24,166	4,231	423	5,071	10,494	4,949	9,987
1994	25,994	4,231	273	2,818	11,944	5,323	7,587
1995	27,248	4,839	255	2,827	13,309	5,580	6,601
1996	26,768	4,839	244	2,504	13,868	5,482	5,327
1997	27,342	5,646	247	2,493	13,717	5,600	5,119
1998	27,326	6,351	295	3,667	13,268	5,596	6,072
1999	26,527	4,231	321	3,382	12,936	5,171	7,893
2000	26,428	4,231	376	4,160	12,116	5,262	9,356
2001	26,776	4,231	294	3,446	11,025	5,236	10,024
2002	17,548	4,231	269	2,710	10,493	2,944	2,859
2003	19,695	3,458	283	4,131	10,926	3,660	6,065
2004	23,797	5,550	248	3,273	12,323	4,790	4,655
2005	26,344	6,015	281	3,322	12,772	5,383	5,777
2006	26,323	6,429	350	4,485	11,983	5,279	7,467

NOTE: a detailed description of the methods, data sources, and assumptions used to estimate annual volumes for the water balance components is given in **Appendix B**.

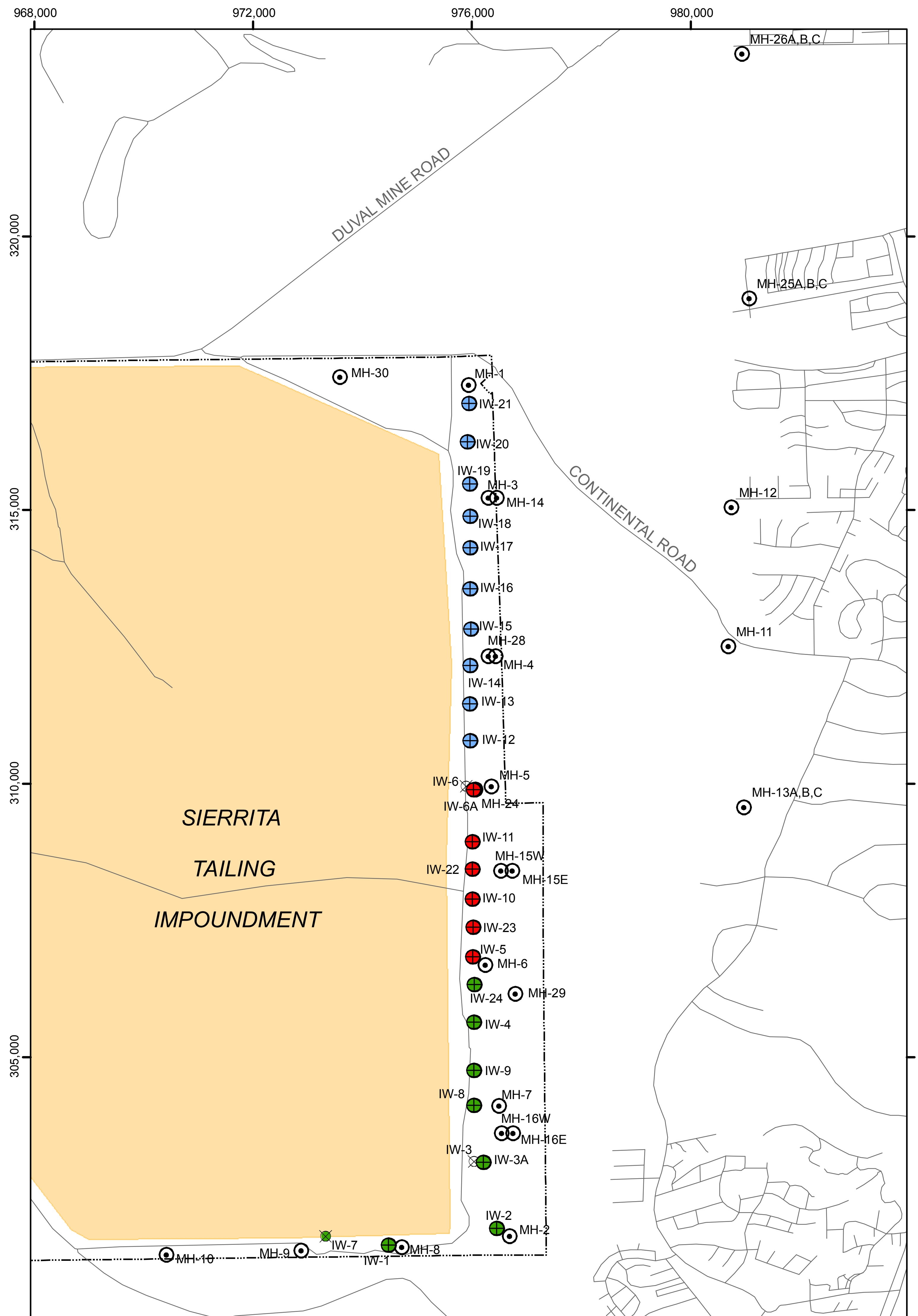
TABLE 3. ESTIMATED 2007 PUMPING CAPACITY OF INTERCEPTOR WELLFIELD PHELPS DODGE SIERRITA MINE, PIMA COUNTY, ARIZONA

INTERCEPTOR WELL	2007 OPERATIONAL PUMPING RATE	ADJUSTED 2007 PUMPING CAPACITY[a]	
	gpm[b]	gpm[b]	AF/yr[c]
IW-1	375	338	545
IW-2	700	630	1,017
IW-3A	850	765	1,235
IW-4	250	225	364
IW-5	150	135	218
IW-6A	125	113	182
IW-8	500	450	726
IW-9	275	248	399
IW-10	375	338	545
IW-11	400	360	581
IW-12	175	158	254
IW-13	25	23	36
IW-14	75	68	109
IW-15	50	45	73
IW-16	10	9	15
IW-17	10	9	15
IW-18	10	9	15
IW-19	150	135	218
IW-20	75	68	109
IW-21	150	135	218
IW-22	350	315	508
IW-23	200	180	291
IW-24	300	270	436
TOTAL:	5,580	5,022	8,107

[a] adjusted 2007 pumping capacity = based on 2007 operational pumping rate and assuming 90 percent run time

[b] gpm = gallons per minute

[c] AF/yr = acre-feet per year



EXPLANATION

IW-15	INTERCEPTOR WELL AND IDENTIFIER, NORTH WELLFIELD
IW-10	INTERCEPTOR WELL AND IDENTIFIER, MIDDLE WELLFIELD
IW-8	INTERCEPTOR WELL AND IDENTIFIER, SOUTH WELLFIELD
IW-7	INACTIVE INTERCEPTOR WELL AND IDENTIFIER, SOUTH WELLFIELD
IW-6	CAPPED INTERCEPTOR WELL AND IDENTIFIER
MH-6	MONITOR WELL AND IDENTIFIER
	TAILING IMPOUNDMENT
	SIERRITA PROPERTY BOUNDARY

Feet

0 2,000 4,000

N

phelps dodge Sierrita Inc.

LOCATION MAP

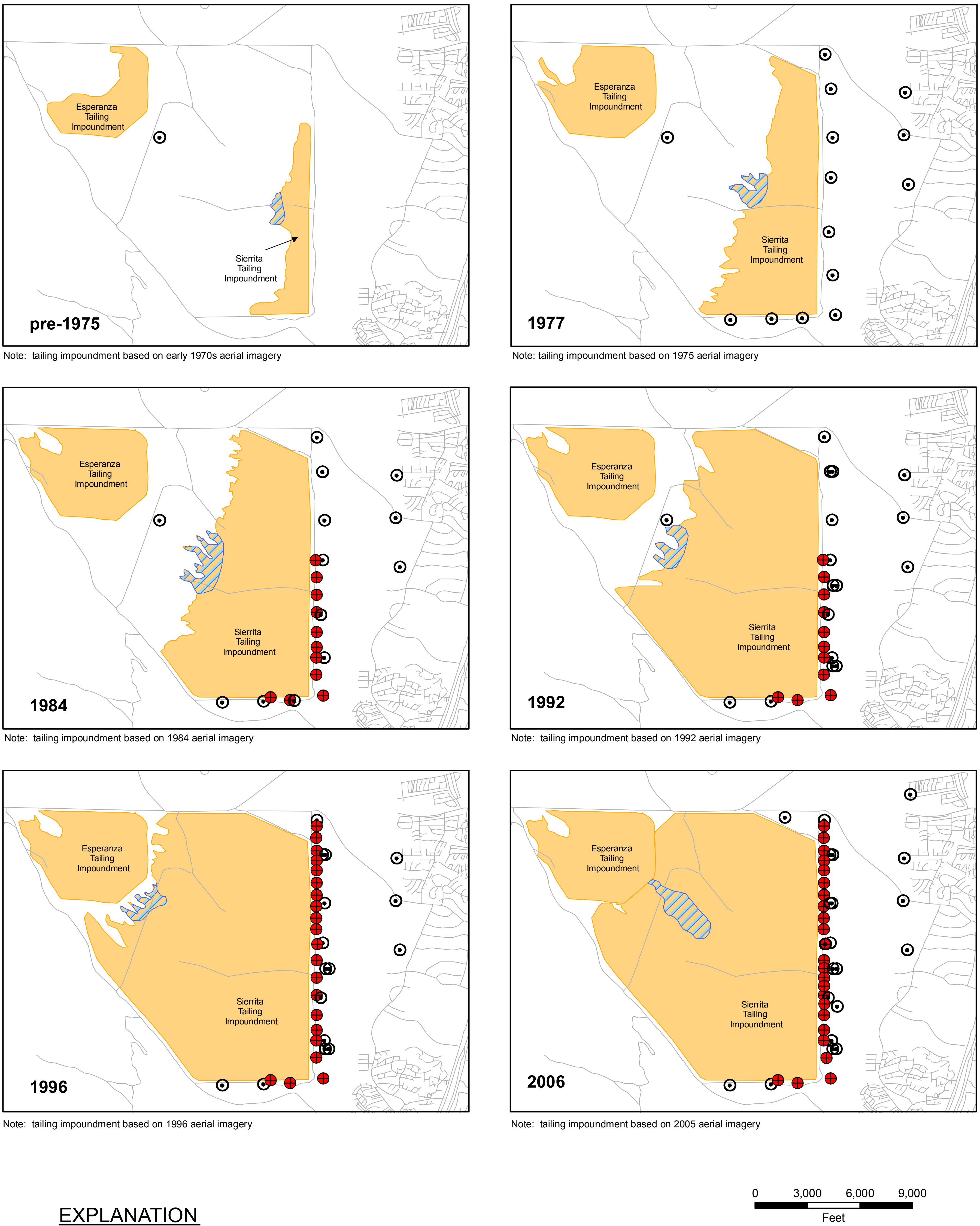
ERROL L. MONTGOMERY & ASSOCIATES, INC. 2007

CONSULTANTS IN HYDROGEOLOGY

TUCSON, ARIZONA

FIGURE 1

GIS-Tuc\546.39\LocationMap.mxd\13November2007 State Plane NAD83 Arizona Central, Feet



EXPLANATION

TAILING IMPOUNDMENT

RECLAIMED WATER POND

INTERCEPTOR WELL

MONITOR WELL

phelps dodge Sierrita Inc.

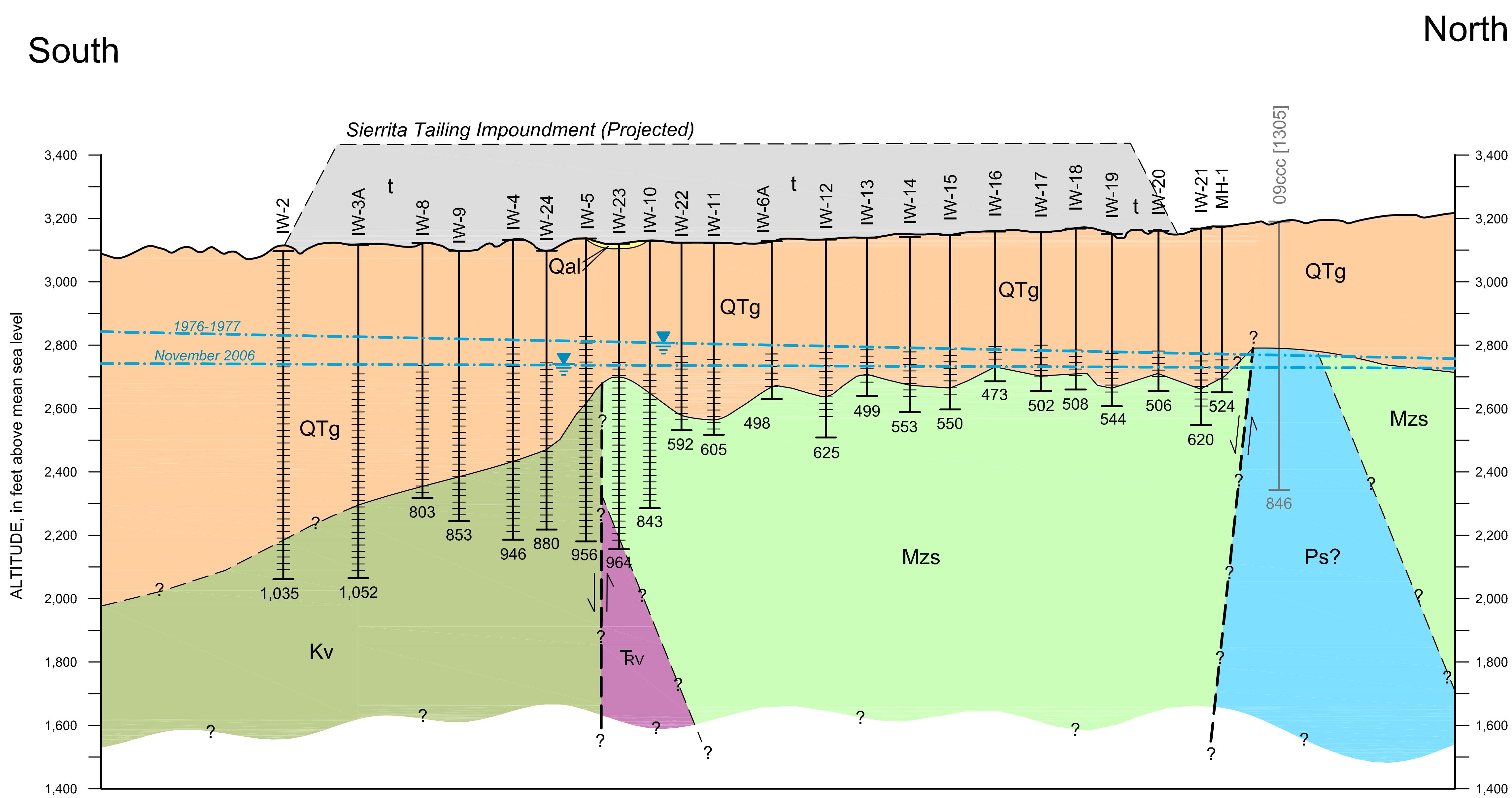
DEVELOPMENT OF TAILING IMPOUNDMENT AND INTERCEPTOR WELLFIELD

ERROL L. MONTGOMERY & ASSOCIATES, INC.
CONSULTANTS IN HYDROGEOLOGY
TUCSON, ARIZONA

2007

FIGURE 2

GIS-Tuc\546.39\TailingImpoundment_Wellfield.mxd\11November2007



EXPLANATION

t	TAILINGS
Qal	RECENT ALLUVIUM
QTg	BASIN-FILL DEPOSITS

Bedrock Complex

Kv	CRETACEOUS VOLCANIC ROCKS INCLUDING ANDESITES, DACITES, AND RHYOLITES OF THE DEMETRIE VOLCANICS
Mzs	MESOZOIC SEDIMENTARY AND METASEDIMENTARY ROCKS INCLUDING SANDSTONES, CONGLOMERATES, AND ARKOSES OF THE ANGELICA ARKOSE
T̄rv	TRIASSIC VOLCANICS INCLUDING RHYOLITIC FLOWS OF THE OXFRAME VOLCANICS
Ps	PALEOZOIC SEDIMENTARY ROCKS UNDIFFERENTIATED

IW-12 projected 30 feet east — INDICATES DIRECTION AND DISTANCE OF PROJECTION SECTION IF MORE THAN 10 FEET FROM SECTION LINE

WELL IDENTIFIER

GRAY INDICATES EXPLORATION BOREHOLE

PERFORATED INTERVAL

625 — TOTAL DEPTH, IN FEET

GEOLOGIC CONTACT, approximately located; dashed where uncertain

FAULT; arrows show relative direction of movement; dashed where uncertain

GROUNDWATER LEVEL

HORIZONTAL SCALE

0 2,000 4,000

FEET

VERTICAL EXAGGERATION 5:1

phelps dodge Sierrita Inc.

GENERALIZED HYDROGEOLOGIC SECTION

ERROL L. MONTGOMERY & ASSOCIATES, INC. 2007

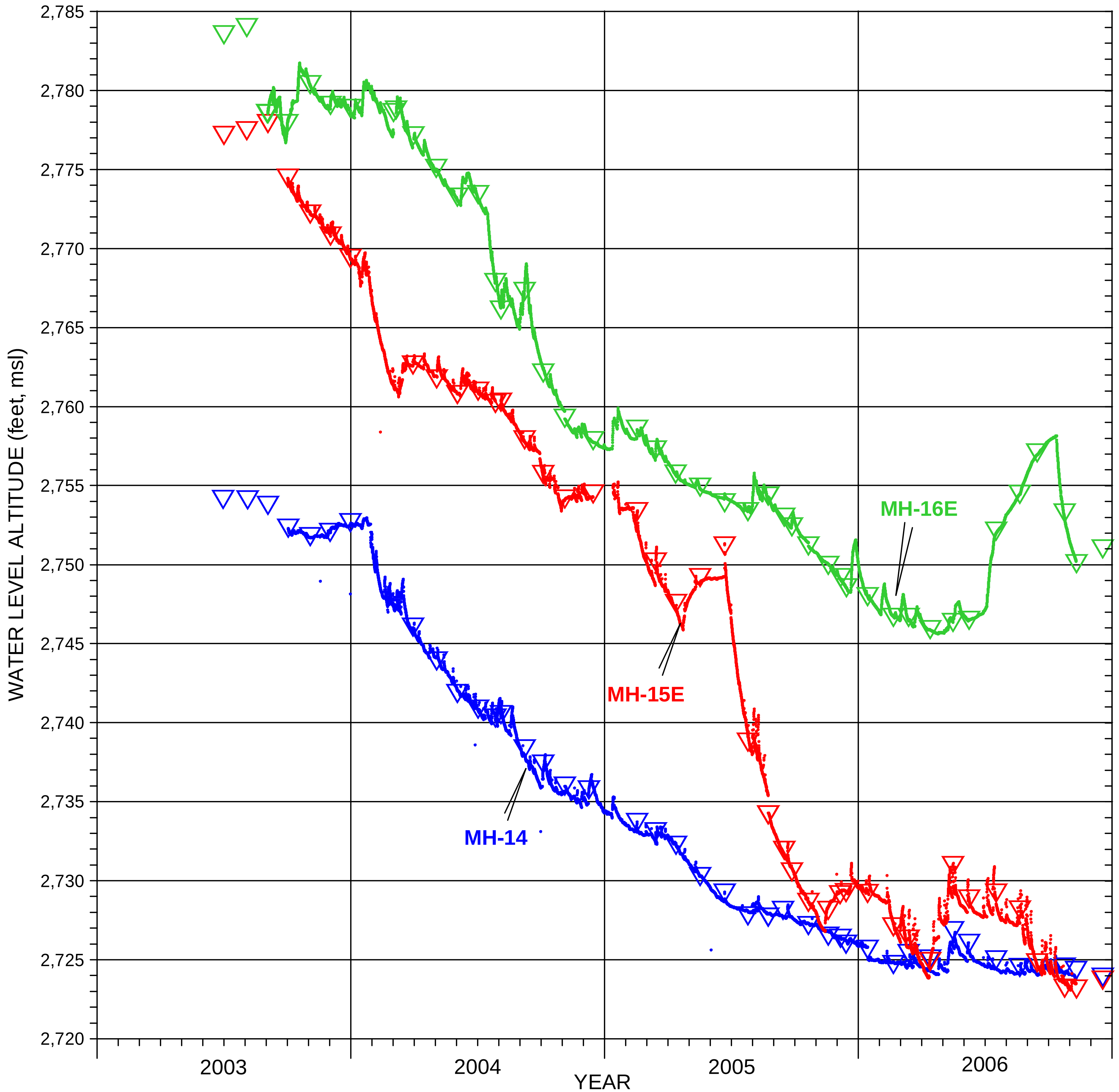
CONSULTANTS IN HYDROGEOLOGY

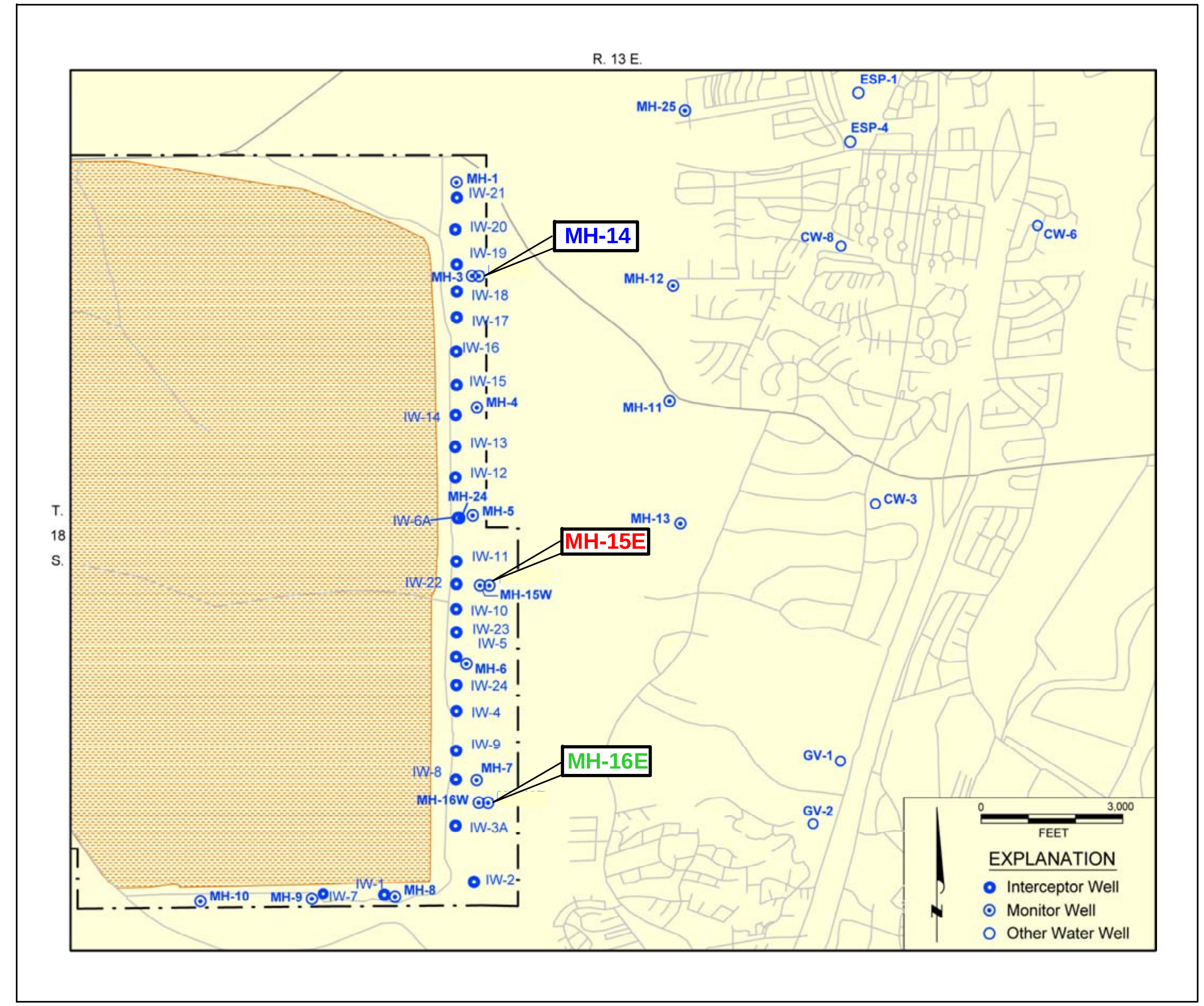
TUCSON, ARIZONA

FIGURE 3

546.39\xsec-revised\14Nov2007

546.21 - Interceptor Wellfield Optimization\05 - Monitoring\Water Levels & Pumping\Paired WellsWL_Hydrographs\MH_14_15E_16E.grf\11November2007





EXPLANATION

- Groundwater level measurement (datalogger and pressure transducer)
- ▽ Groundwater level measurement (electrical sounder)

FIGURE 4. HYDROGRAPH OF GROUNDWATER LEVELS FOR MONITOR WELLS MH-14, MH-15E, AND MH-16E

ERROL L. MONTGOMERY & ASSOCIATES, INC.

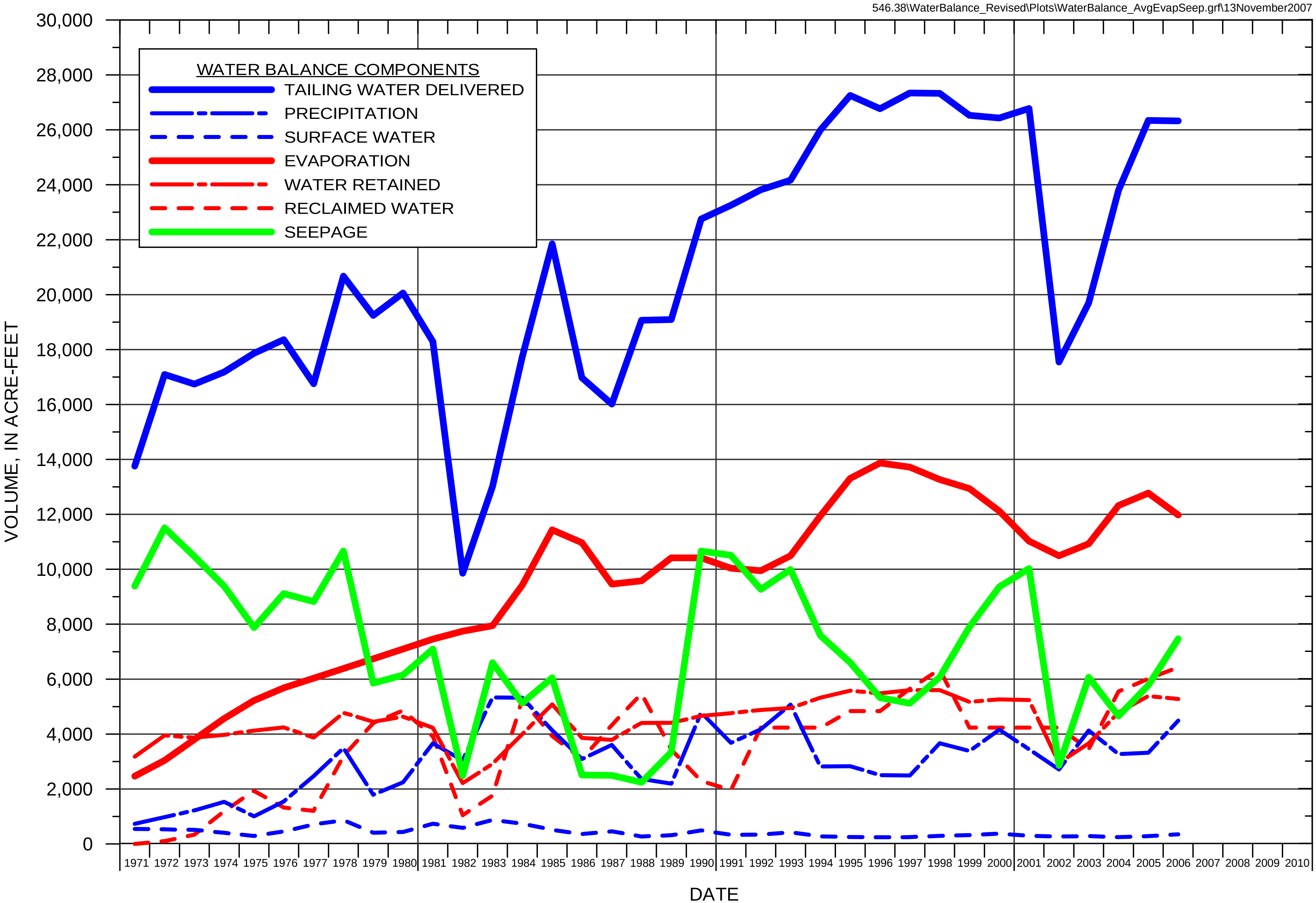
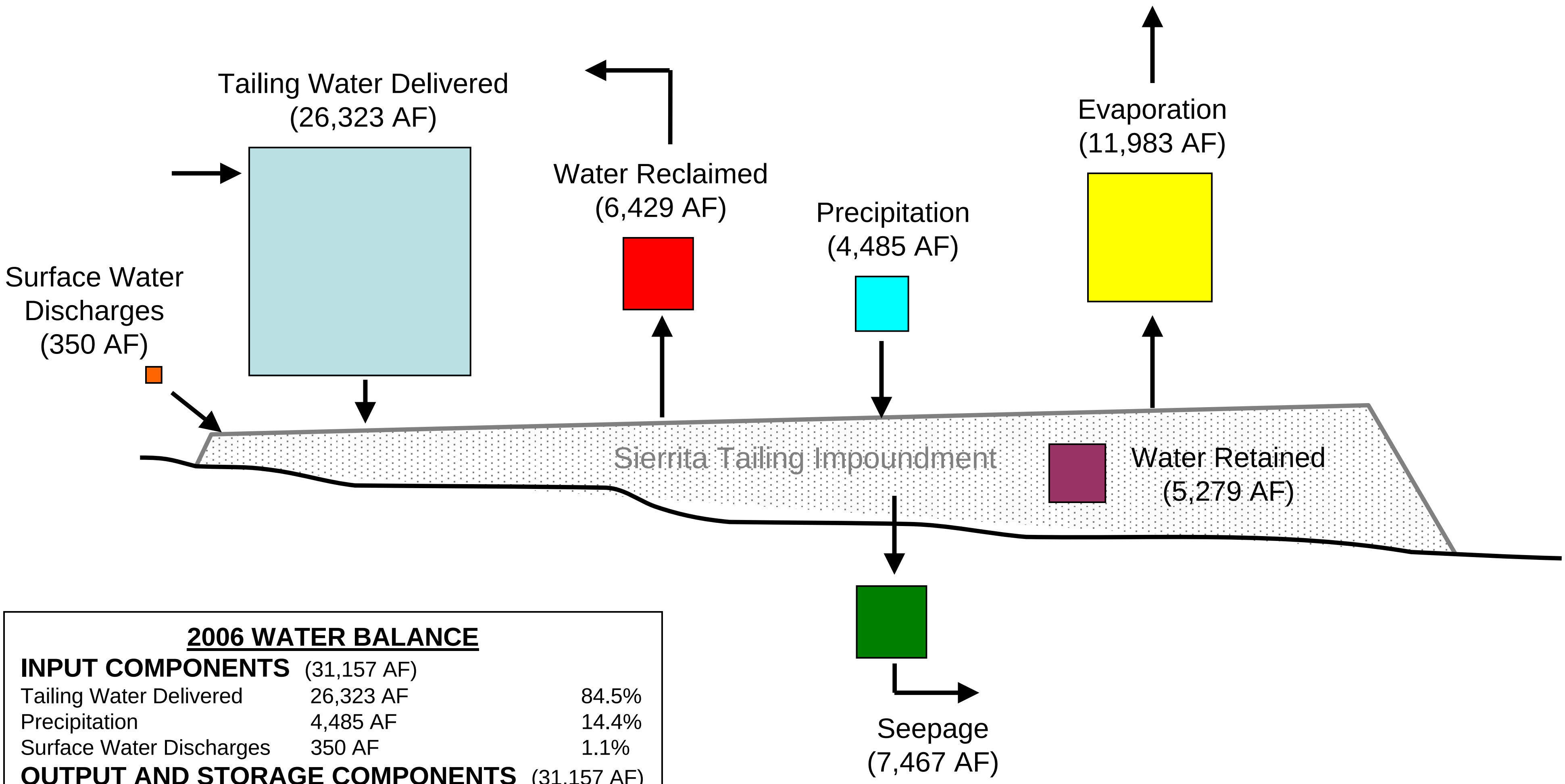


FIGURE 5. WATER BALANCE FOR SIERRITA TAILING IMPOUNDMENT

ERROL L. MONTGOMERY & ASSOCIATES, INC.



2006 WATER BALANCE

INPUT COMPONENTS (31,157 AF)		
Tailing Water Delivered	26,323 AF	84.5%
Precipitation	4,485 AF	14.4%
Surface Water Discharges	350 AF	1.1%
OUTPUT AND STORAGE COMPONENTS (31,157 AF)		
Water Reclaimed	6,429 AF	20.6%
Evaporation	11,983 AF	38.5%
Water Retained	5,279 AF	16.9%
Seepage	7,467 AF	24.0%

NOTE: AF = acre-feet

FIGURE 6. SCHEMATIC DIAGRAM OF 2006 WATER BALANCE FOR SIERRITA TAILING IMPOUNDMENT

ERROL L. MONTGOMERY & ASSOCIATES, INC.

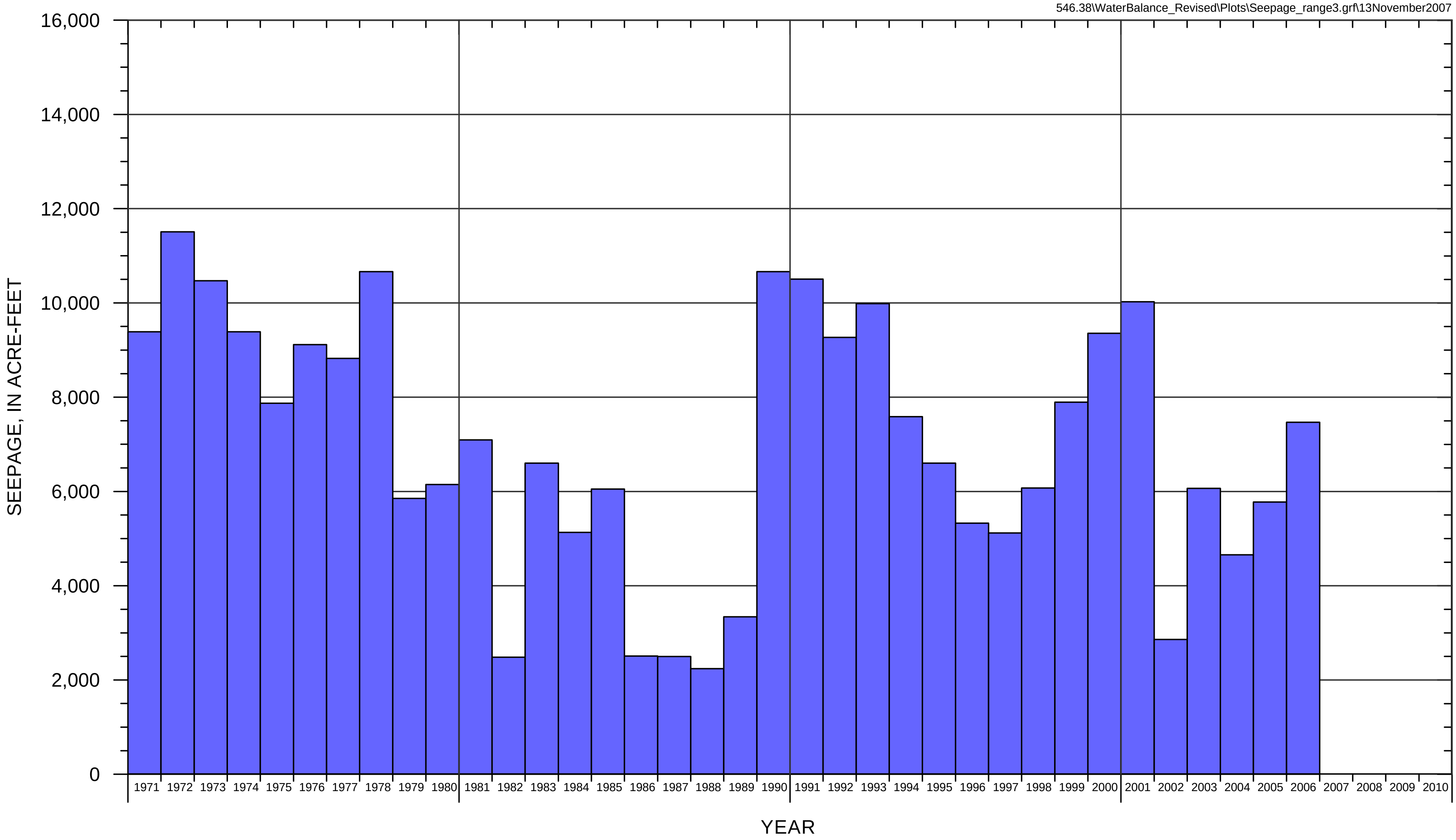


FIGURE 7. SEEPAGE COMPUTED FROM WATER BALANCE FOR SIERRITA TAILING IMPOUNDMENT

ERROL L. MONTGOMERY & ASSOCIATES, INC.

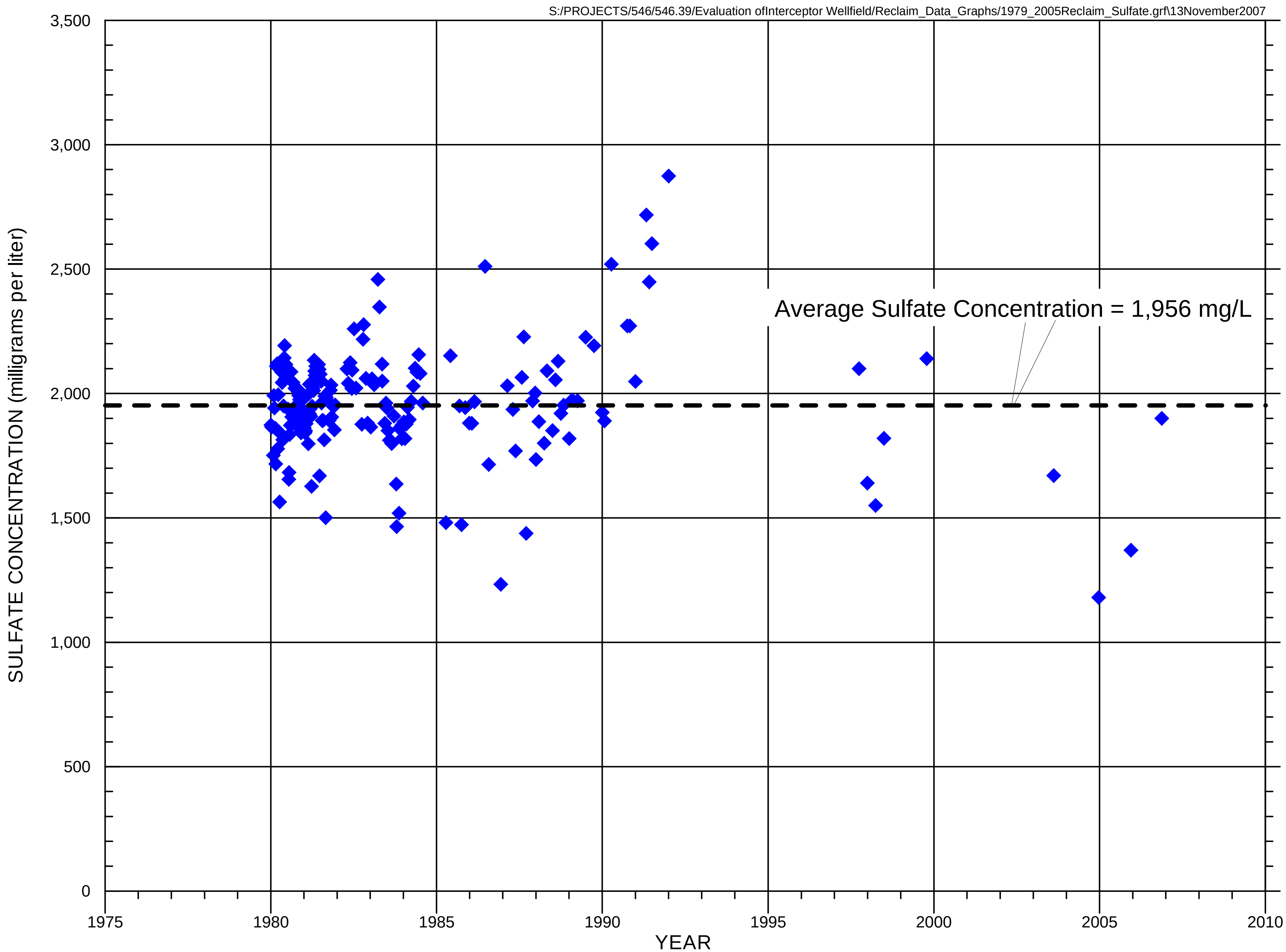


FIGURE 8. SULFATE CONCENTRATION OF RECLAIM WATER FROM SIERRITA TAILING IMPOUNDMENT

ERROL L. MONTGOMERY & ASSOCIATES, INC.

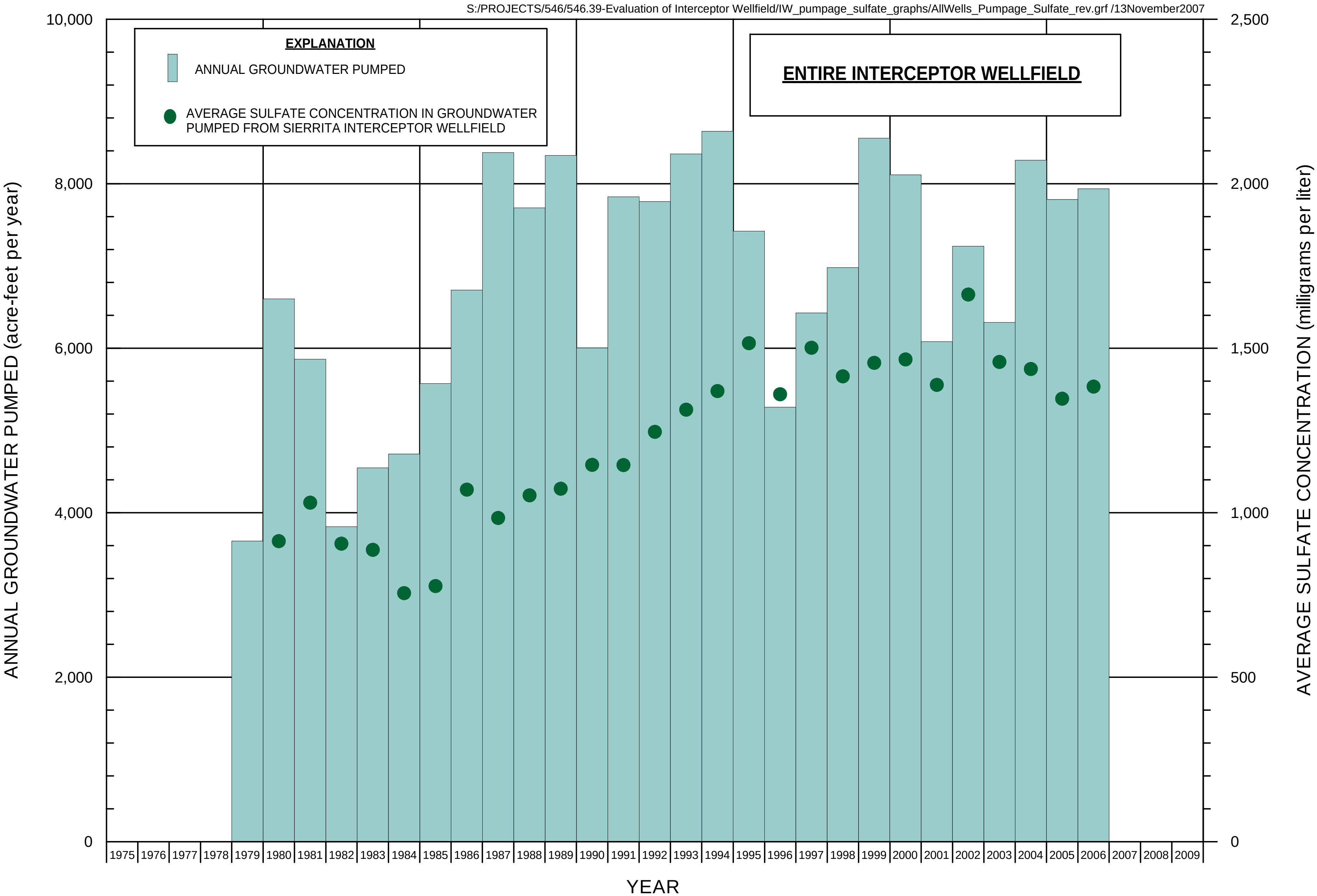


FIGURE 9. ANNUAL GROUNDWATER PUMPED AND AVERAGE SULFATE CONCENTRATION IN GROUNDWATER FOR SIERRITA INTERCEPTOR WELLFIELD

ERROL L. MONTGOMERY & ASSOCIATES, INC.

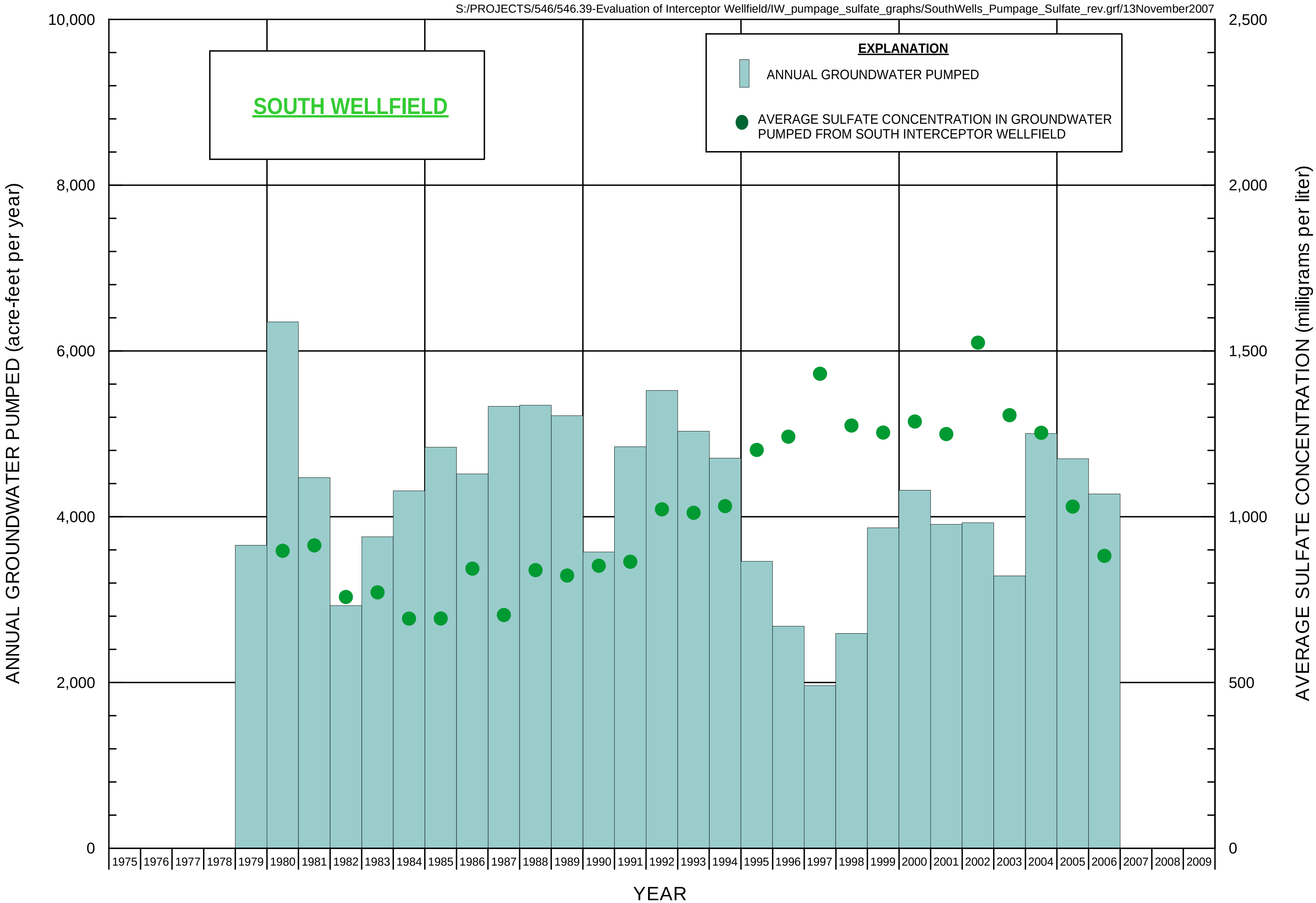


FIGURE 10. ANNUAL GROUNDWATER PUMPED AND AVERAGE SULFATE CONCENTRATION IN GROUNDWATER FOR SOUTH INTERCEPTOR WELLFIELD (WELLS IW-1, IW-2, IW-3, IW-3A, IW-4, IW-7, IW-8, IW-9, AND IW-24)

ERROL L. MONTGOMERY & ASSOCIATES, INC.

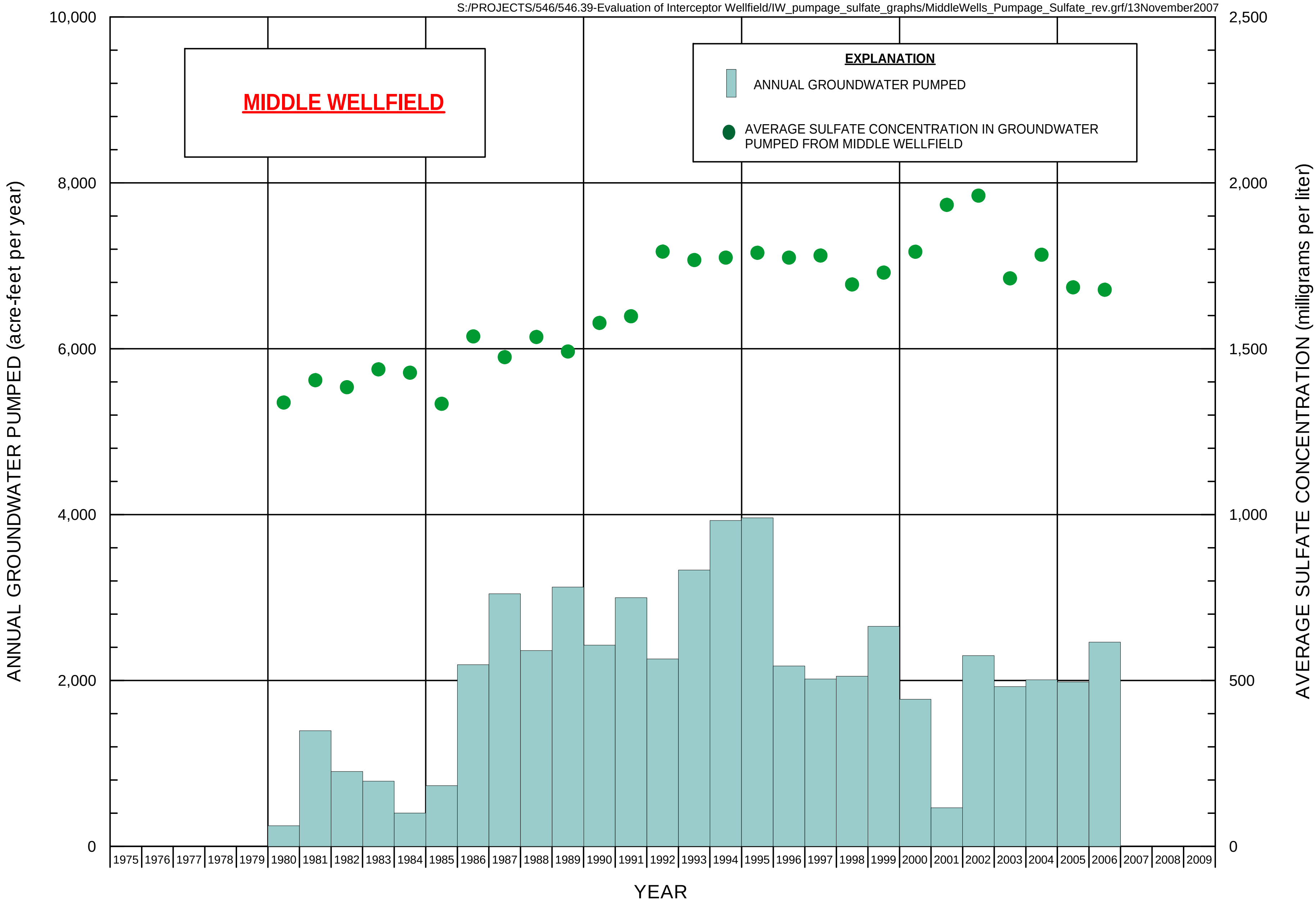


FIGURE 11. ANNUAL GROUNDWATER PUMPED AND AVERAGE SULFATE CONCENTRATION IN GROUNDWATER FOR MIDDLE INTERCEPTOR WELLFIELD (WELLS IW-5, IW-6, IW-6A, IW-10, IW-11, IW-22, AND IW-23)

ERROL L. MONTGOMERY & ASSOCIATES, INC.

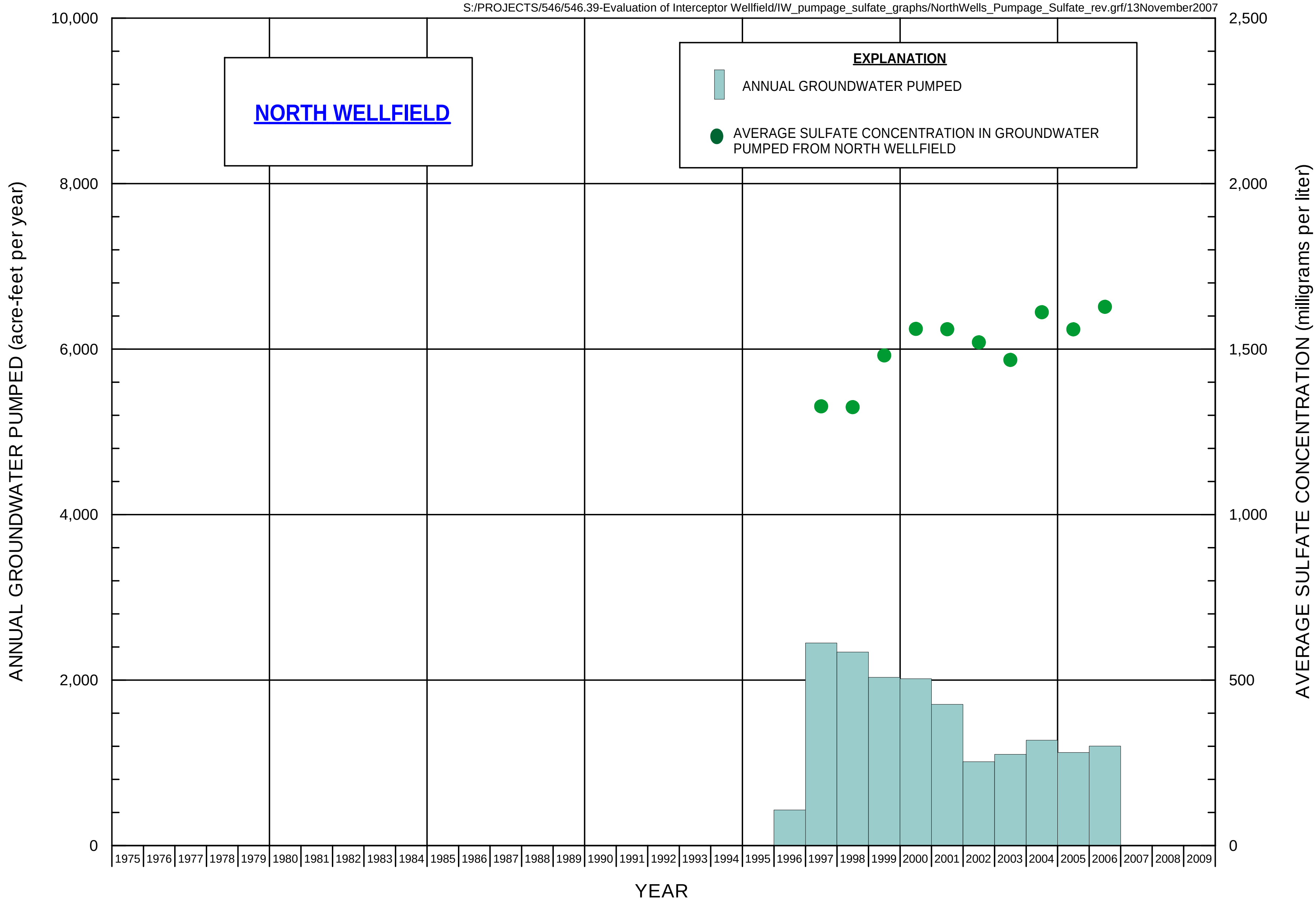


FIGURE 12. ANNUAL GROUNDWATER PUMPED AND AVERAGE SULFATE CONCENTRATION IN GROUNDWATER FOR NORTH INTERCEPTOR WELLFIELD (WELLS IW-12 THROUGH IW-21)

ERROL L. MONTGOMERY & ASSOCIATES, INC.

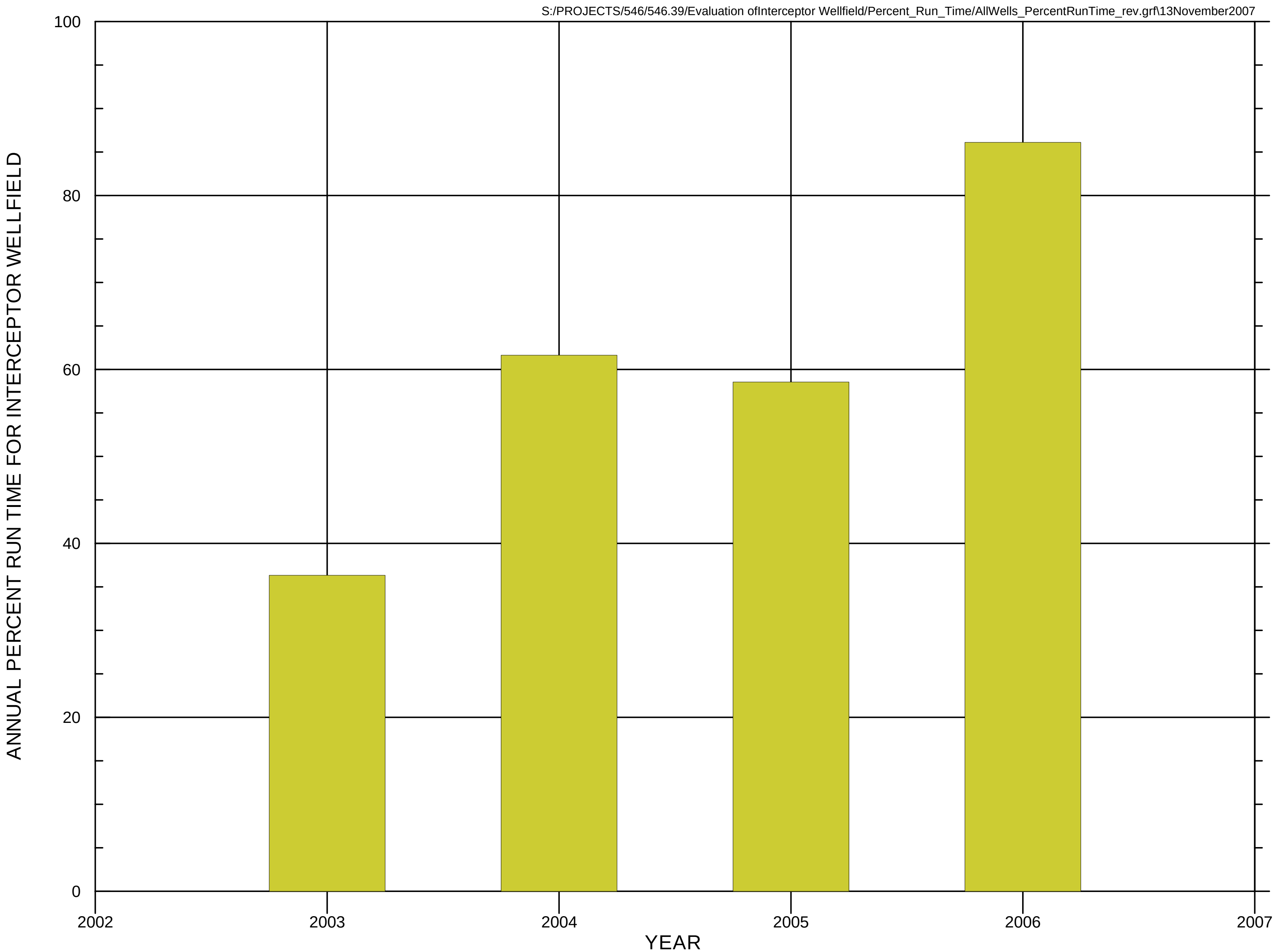


FIGURE 13. ANNUAL PERCENT RUN TIME FOR SIERRITA INTERCEPTOR WELLFIELD, 2003 THROUGH 2006

ERROL L. MONTGOMERY & ASSOCIATES, INC.

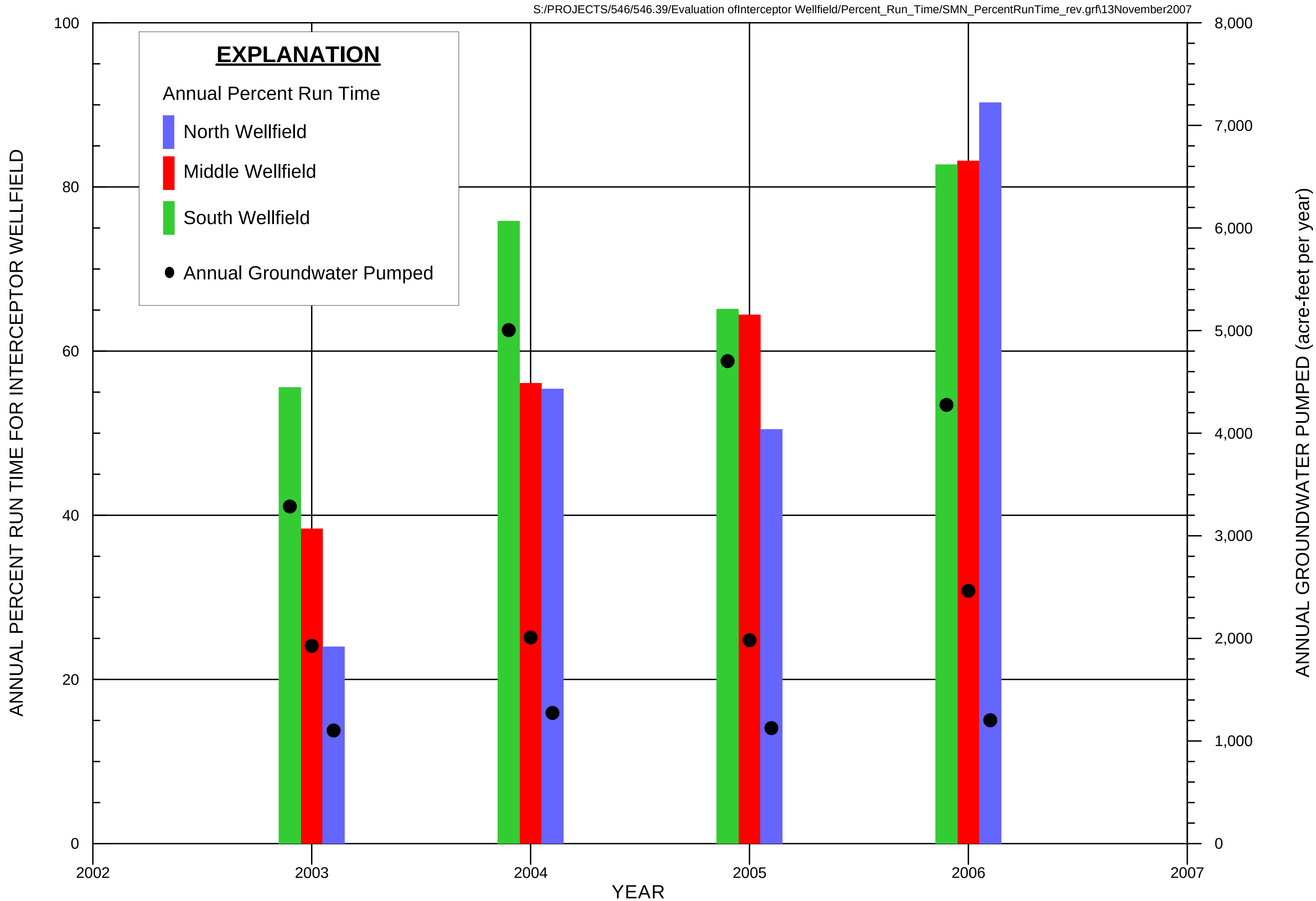


FIGURE 14. ANNUAL PERCENT RUN TIME AND GROUNDWATER PUMPED FOR SOUTH, MIDDLE, AND NORTH INTERCEPTOR WELLFIELDS, 2003 THROUGH 2006

ERROL L. MONTGOMERY & ASSOCIATES, INC.

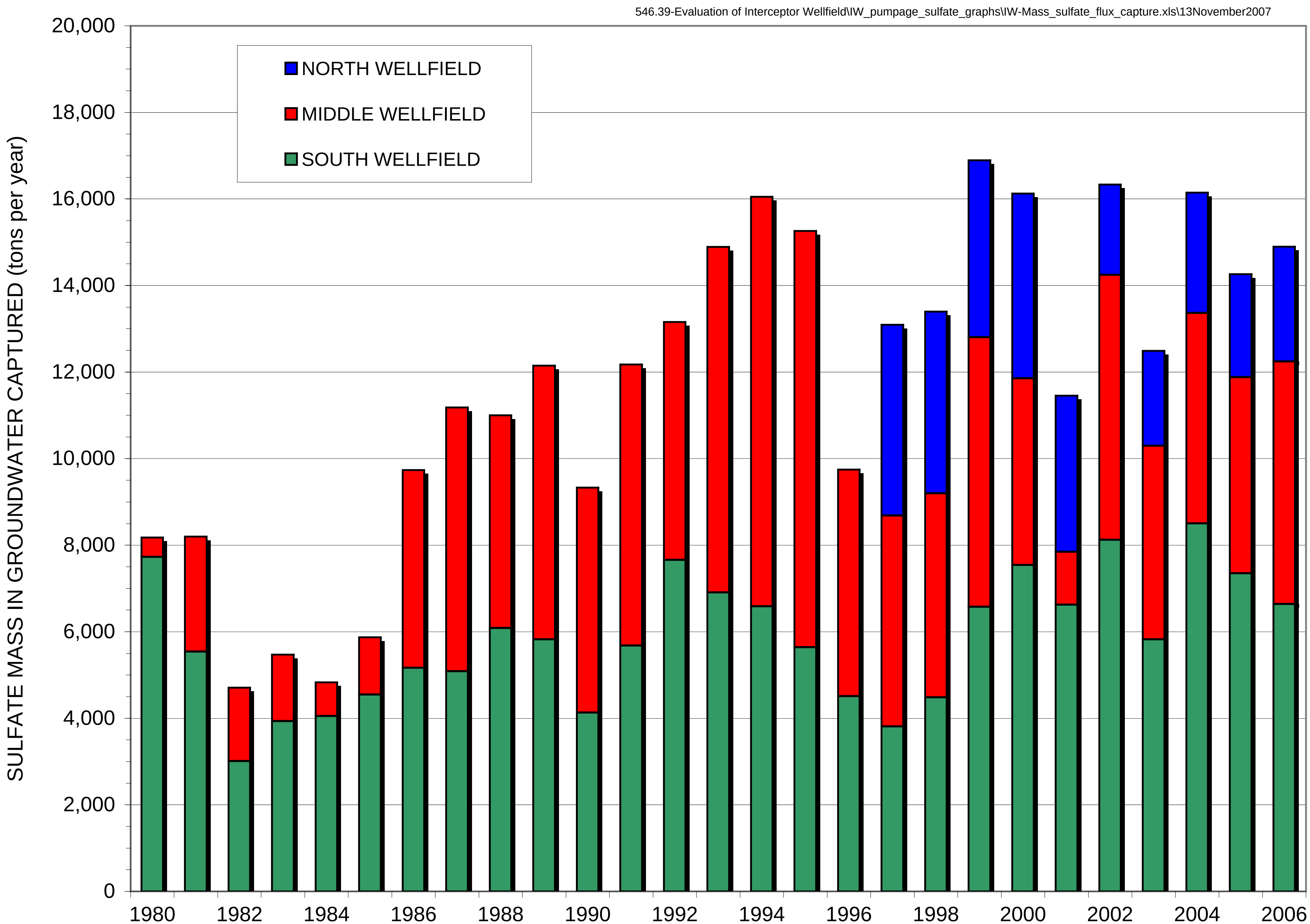
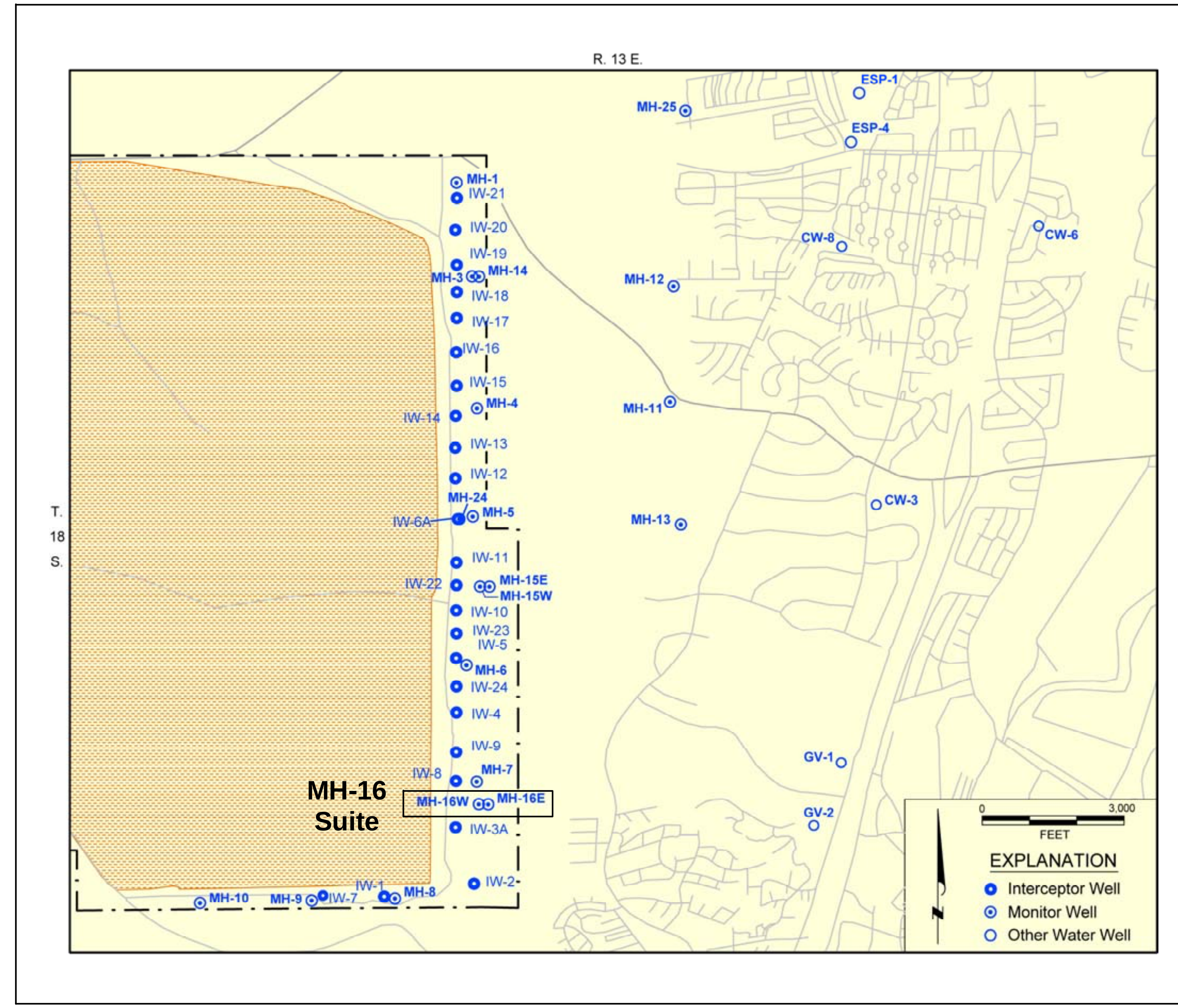


FIGURE 15. SULFATE MASS IN GROUNDWATER CAPTURED BY SOUTH, MIDDLE, AND NORTH INTERCEPTOR WELLFIELDS

ERROL L. MONTGOMERY & ASSOCIATES, INC.



EXPLANATION

- **Groundwater level measurement (datalogger and pressure transducer)**
- ▽ **Groundwater level measurement (electrical sounder)**

FIGURE 16. HYDROGRAPH OF GROUNDWATER LEVEL FOR MH-16 MONITOR WELL SUITE

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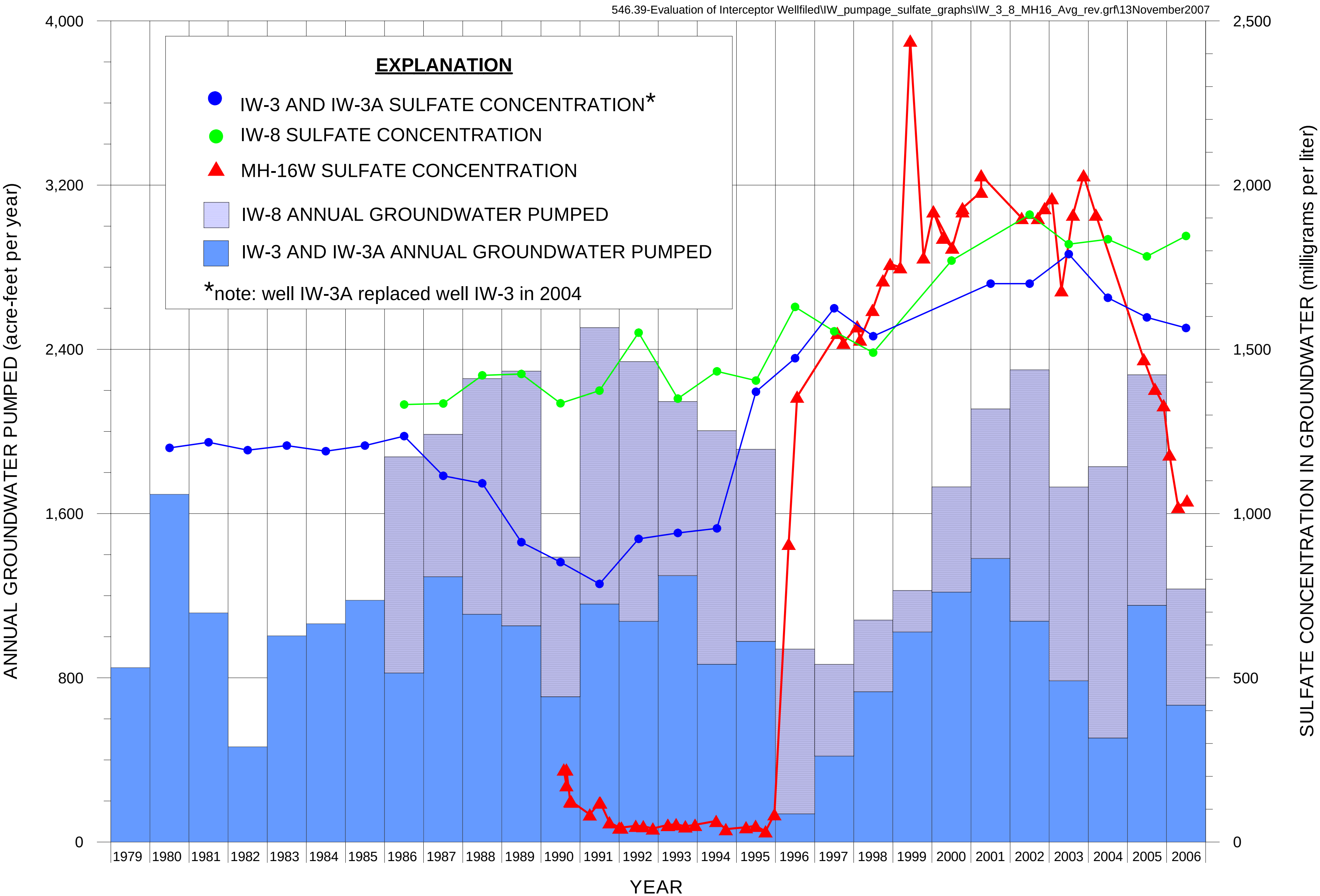
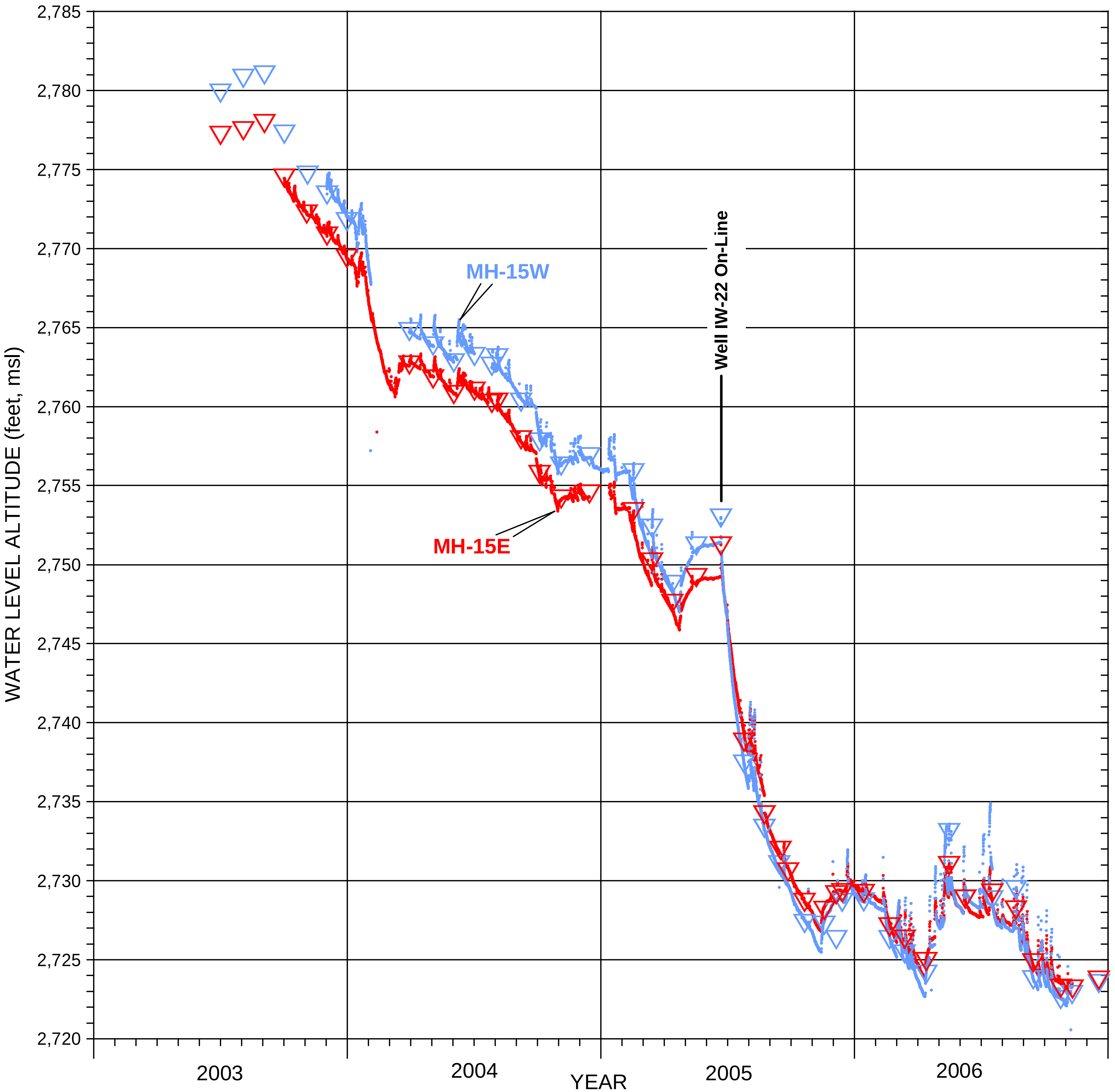
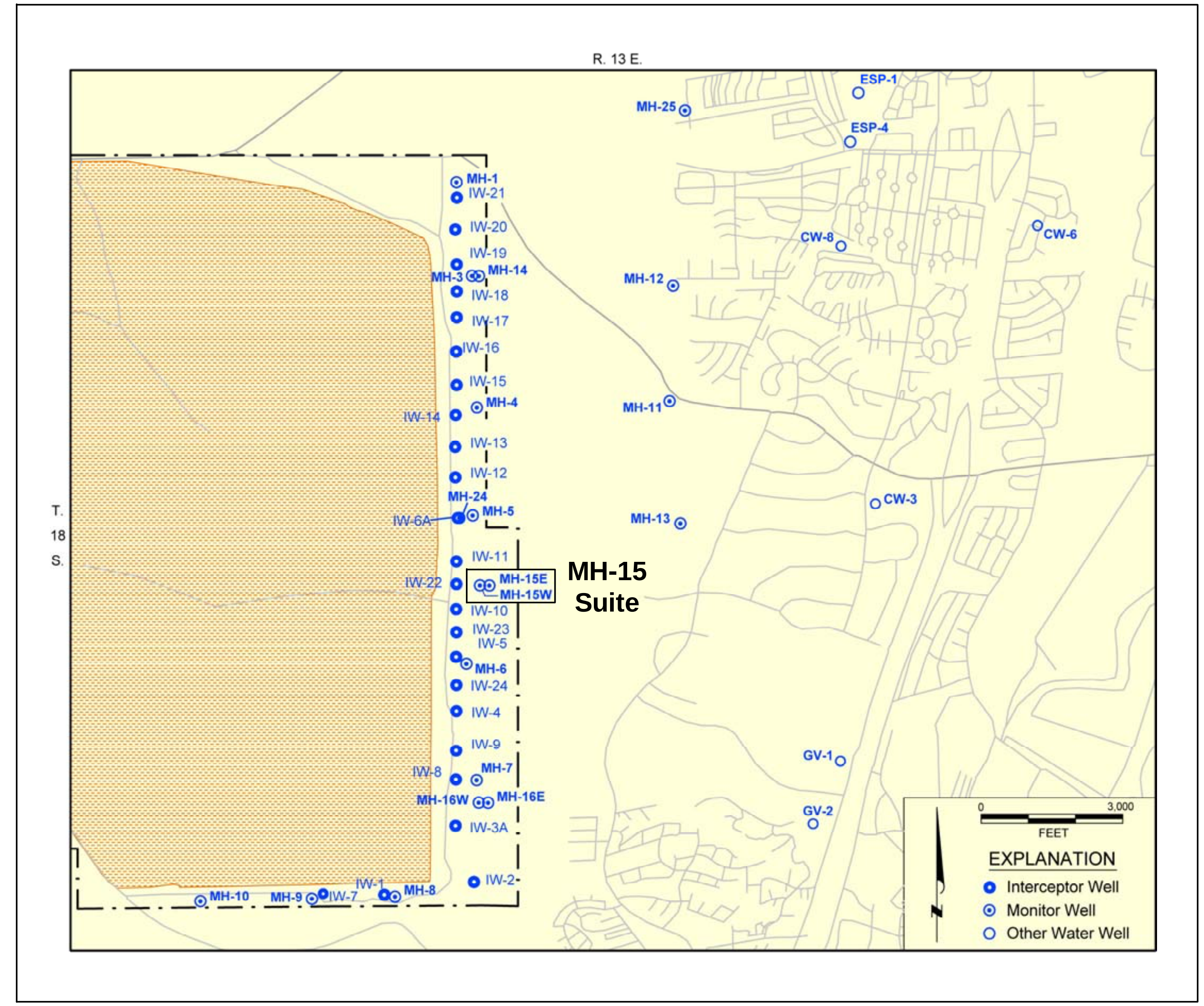


FIGURE 17. ANNUAL GROUNDWATER PUMPED AND AVERAGE SULFATE CONCENTRATIONS IN GROUNDWATER FOR INTERCEPTOR WELLS IW-3A, IW-3 AND IW-8 AND SULFATE CONCENTRATIONS IN GROUNDWATER AT MONITOR WELL MH-16W

ERROL L. MONTGOMERY & ASSOCIATES, INC.





EXPLANATION

- • Groundwater level measurement (datalogger and pressure transducer)
- ▽ Groundwater level measurement (electrical sounder)

FIGURE 18. HYDROGRAPH OF GROUNDWATER LEVEL FOR MH-15 MONITOR WELL SUITE

ERROL L. MONTGOMERY & ASSOCIATES, INC.

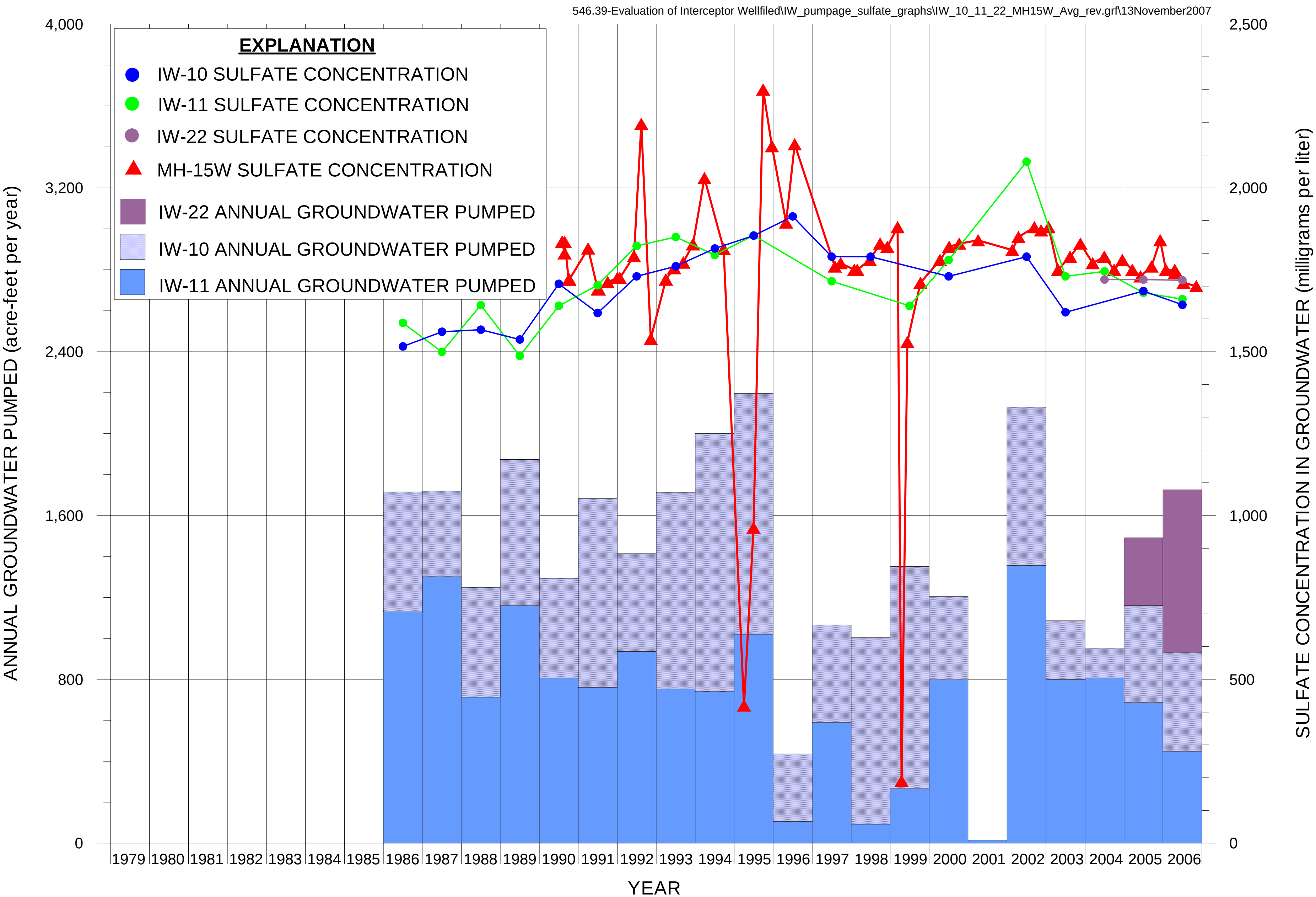
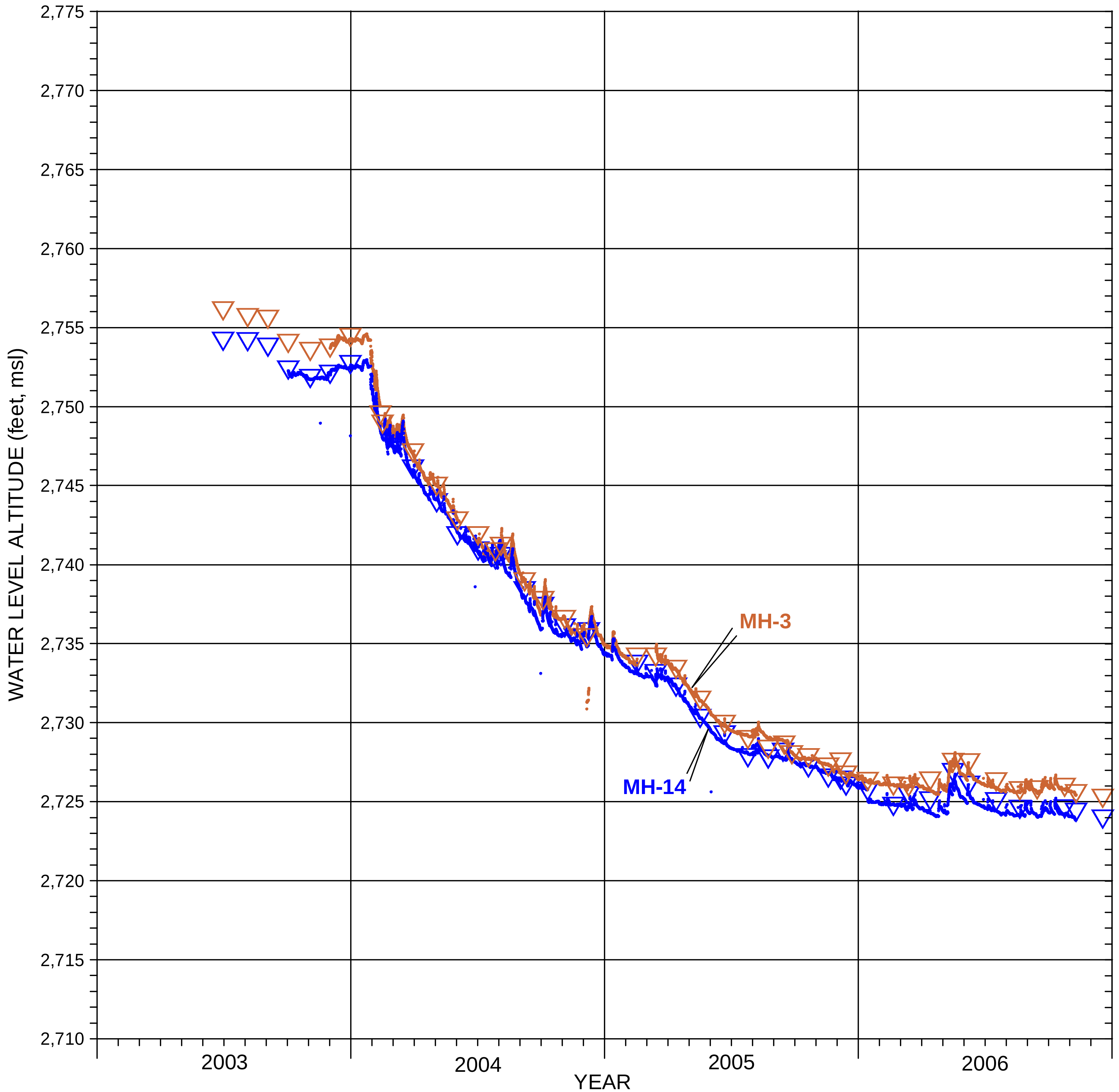
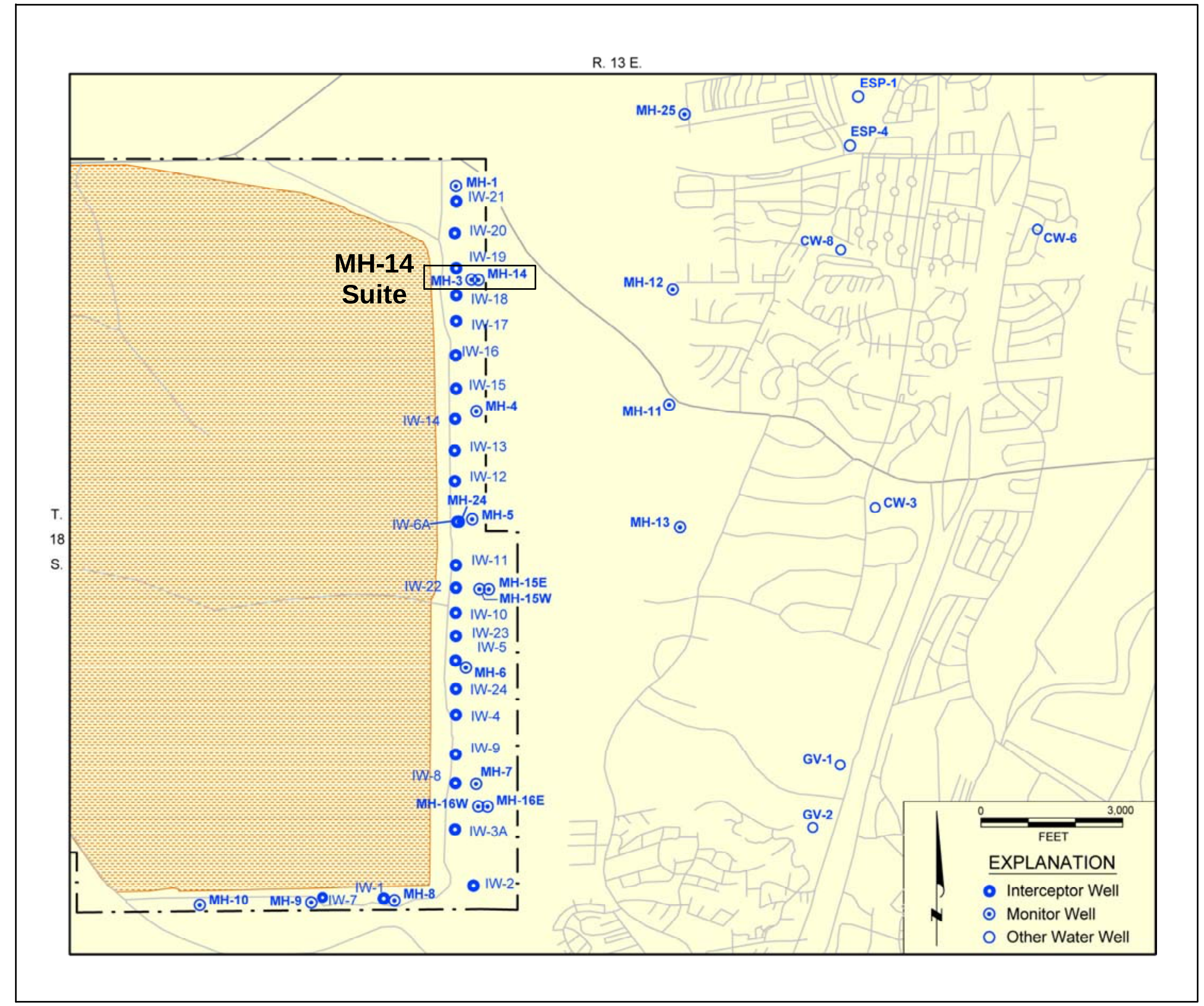


FIGURE 19. ANNUAL GROUNDWATER PUMPED AND AVERAGE SULFATE CONCENTRATIONS IN GROUNDWATER FOR INTERCEPTOR WELLS IW-10, IW-11 AND IW-22 AND SULFATE CONCENTRATIONS IN GROUNDWATER AT MONITOR WELL MH-15W

ERROL L. MONTGOMERY & ASSOCIATES, INC.





E X P L A N A T I O N

- Groundwater level measurement (datalogger and pressure transducer)
- ▽ Groundwater level measurement (electrical sounder)

FIGURE 20. HYDROGRAPH OF GROUNDWATER LEVEL FOR MH-14 MONITOR WELL SUITE

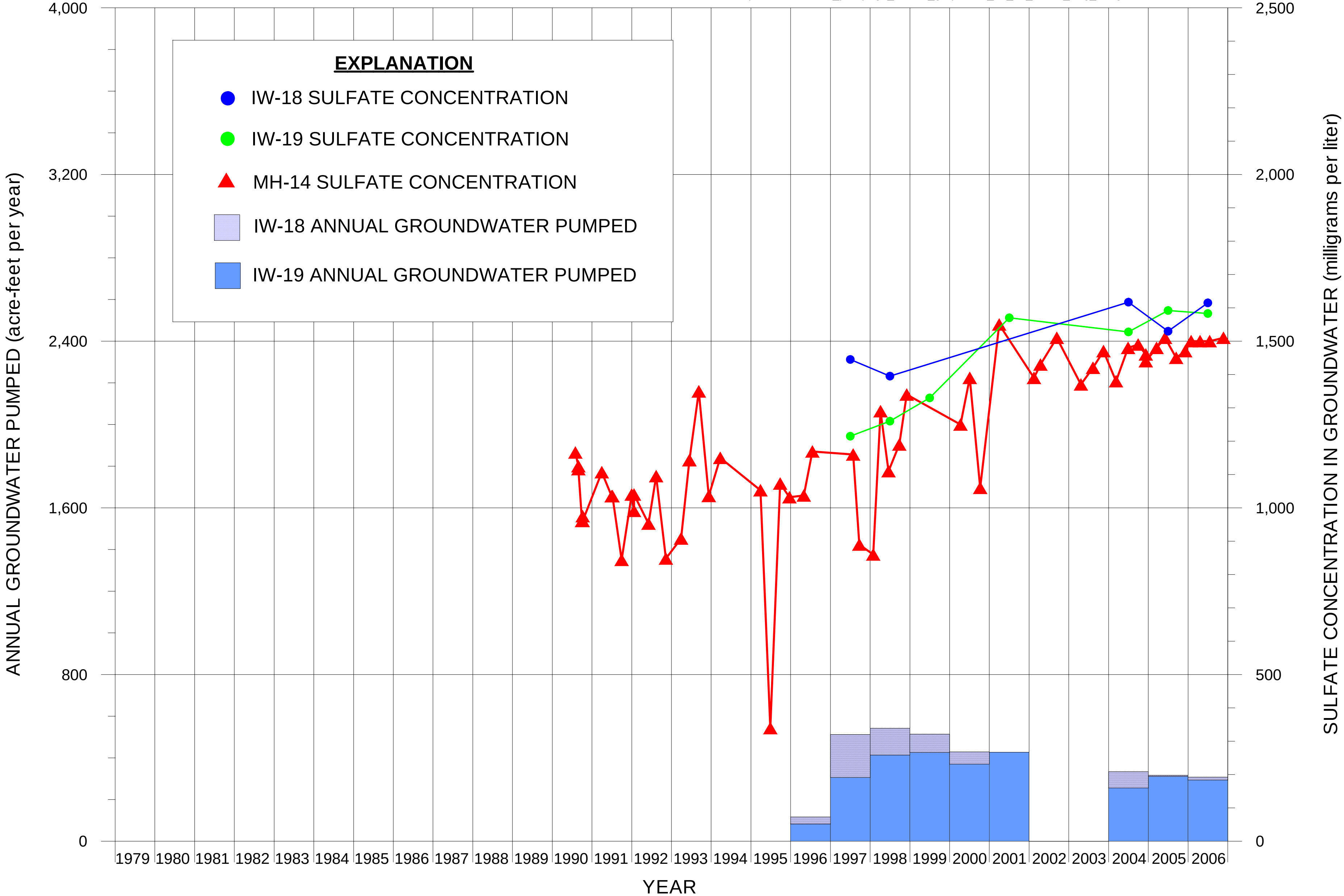
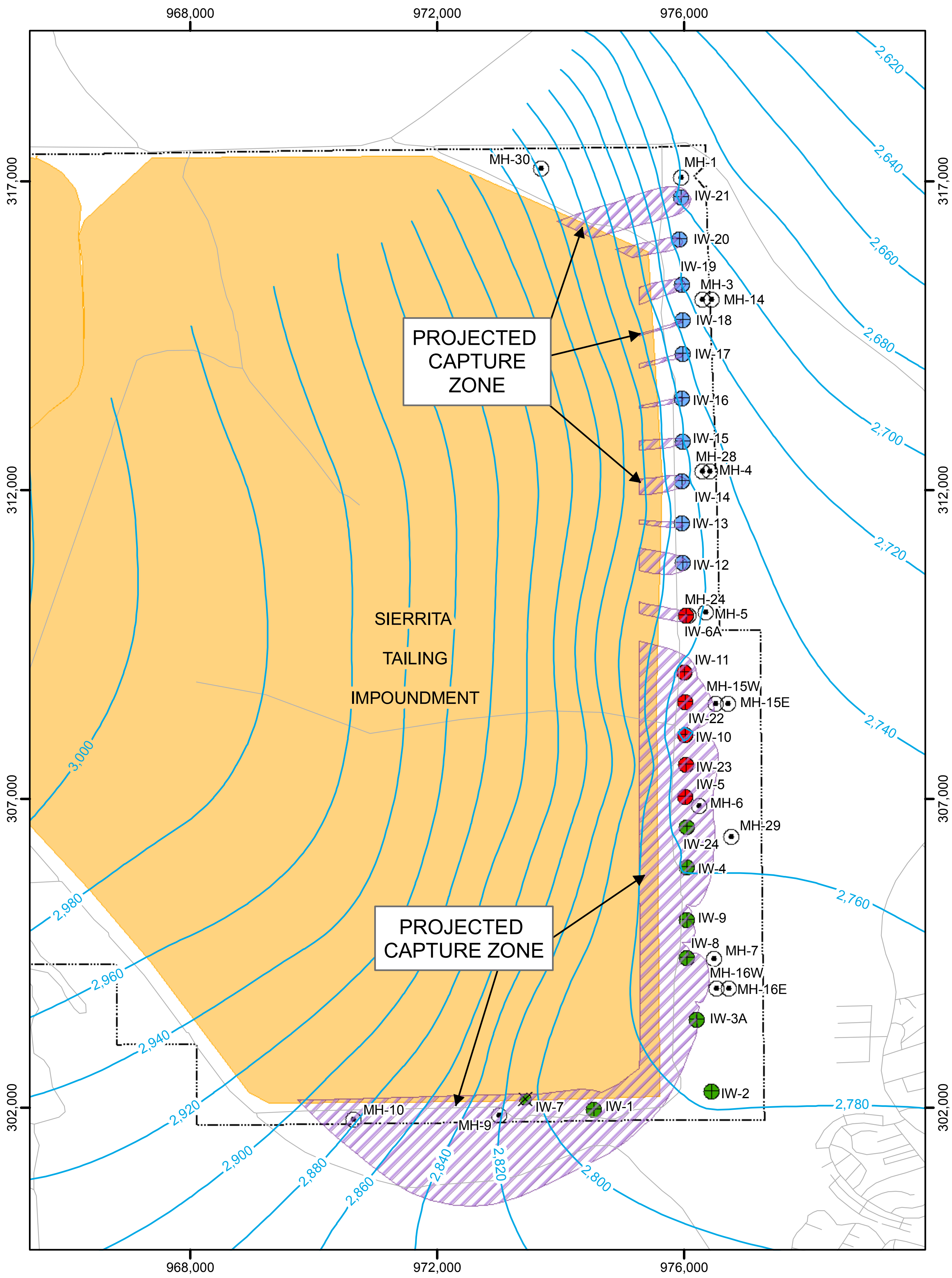


FIGURE 21. ANNUAL GROUNDWATER PUMPED AND AVERAGE SULFATE CONCENTRATIONS IN GROUNDWATER FOR INTERCEPTOR WELLS IW-18 AND IW-19 AND SULFATE CONCENTRATIONS IN GROUNDWATER AT MONITOR WELL MH-14



EXPLANATION

PROJECTED CAPTURE ZONE

IW-15 INTERCEPTOR WELL AND IDENTIFIER, NORTH WELLFIELD

IW-10 INTERCEPTOR WELL AND IDENTIFIER, MIDDLE WELLFIELD

IW-8 INTERCEPTOR WELL AND IDENTIFIER, SOUTH WELLFIELD

IW-7 INACTIVE INTERCEPTOR WELL AND IDENTIFIER, SOUTH WELLFIELD

MH-6 MONITOR WELL AND IDENTIFIER

2800 CONTOUR OF SIMULATED GROUNDWATER LEVEL ALTITUDE FOR 2007 WELLFIELD PUMPING REGIME, IN FEET ABOVE MEAN SEA LEVEL

TAILING IMPOUNDMENT

PHELPS DODGE SIERRITA PROPERTY

Feet
0 2,000 4,000

N

phelps dodge Sierrita Inc.

DELINEATION OF PROJECTED CAPTURE ZONES FOR SIMULATED WELLFIELD PUMPING

ERROL L. MONTGOMERY & ASSOCIATES, INC. 2007
CONSULTANTS IN HYDROGEOLOGY
TUCSON, ARIZONA

FIGURE 22

GIS-Tuc\546.39\CaptureZones.mxd\13November2007 State Plane NAD83, Feet