APPENDIX A

WELL SCHEMATIC DIAGRAMS FOR INTERCEPTOR WELLS
PHELPS DODGE SIERRITA MINE, PIMA COUNTY, ARIZONA

APPENDIX A

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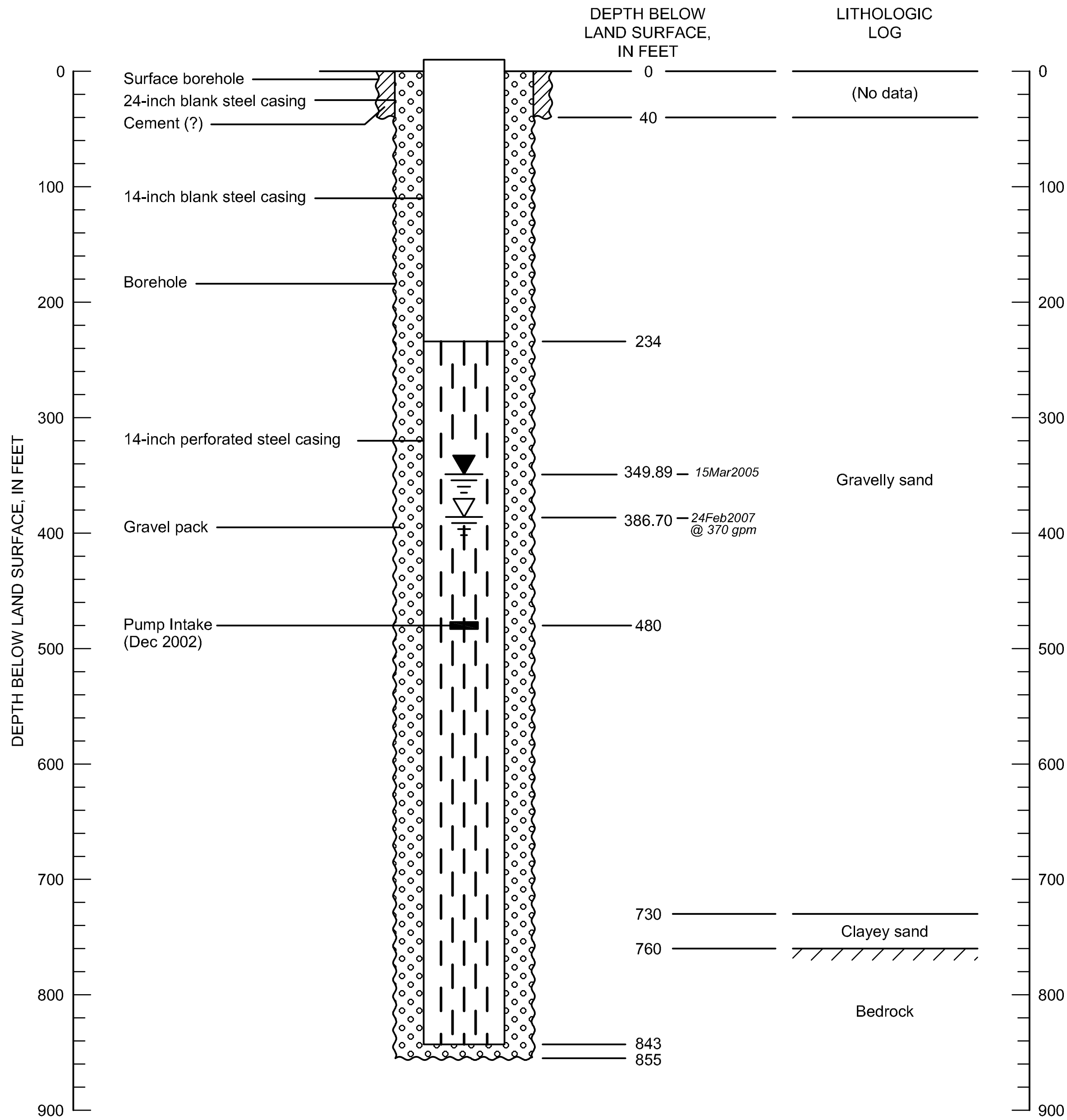
Figure



EXPLANATION

non-pumping water level

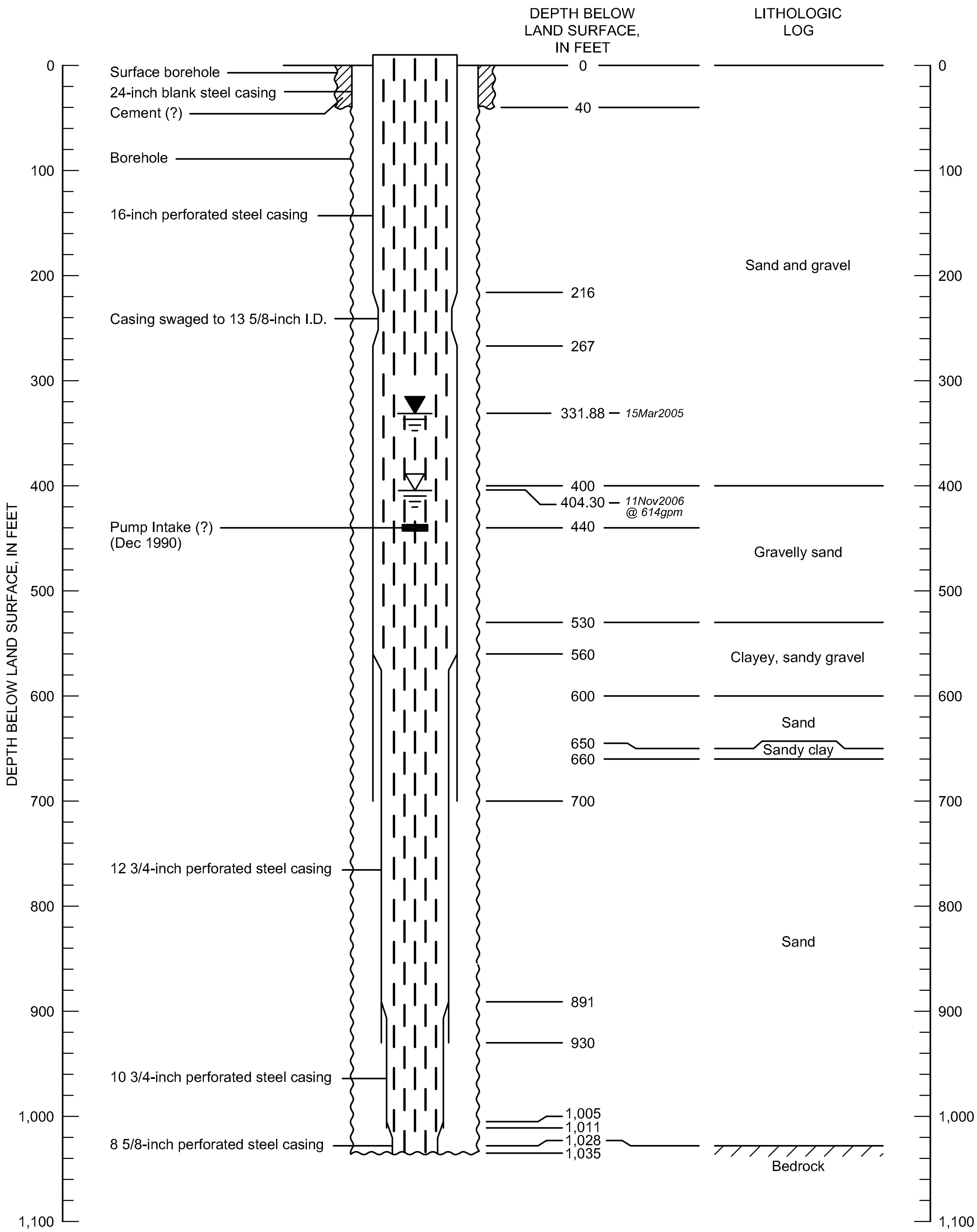
pumping water level

DRAWN BY: CEH	CHECKED BY: DSW	VERSION DATE: February 26, 2007

FIGURE A-1. SCHEMATIC DIAGRAM OF WELL CONSTRUCTION FOR INTERCEPTOR WELL IW-1

ERROL L. MONTGOMERY & ASSOCIATES, INC.

546.39\IW-1 WS_07



EXPLANATION

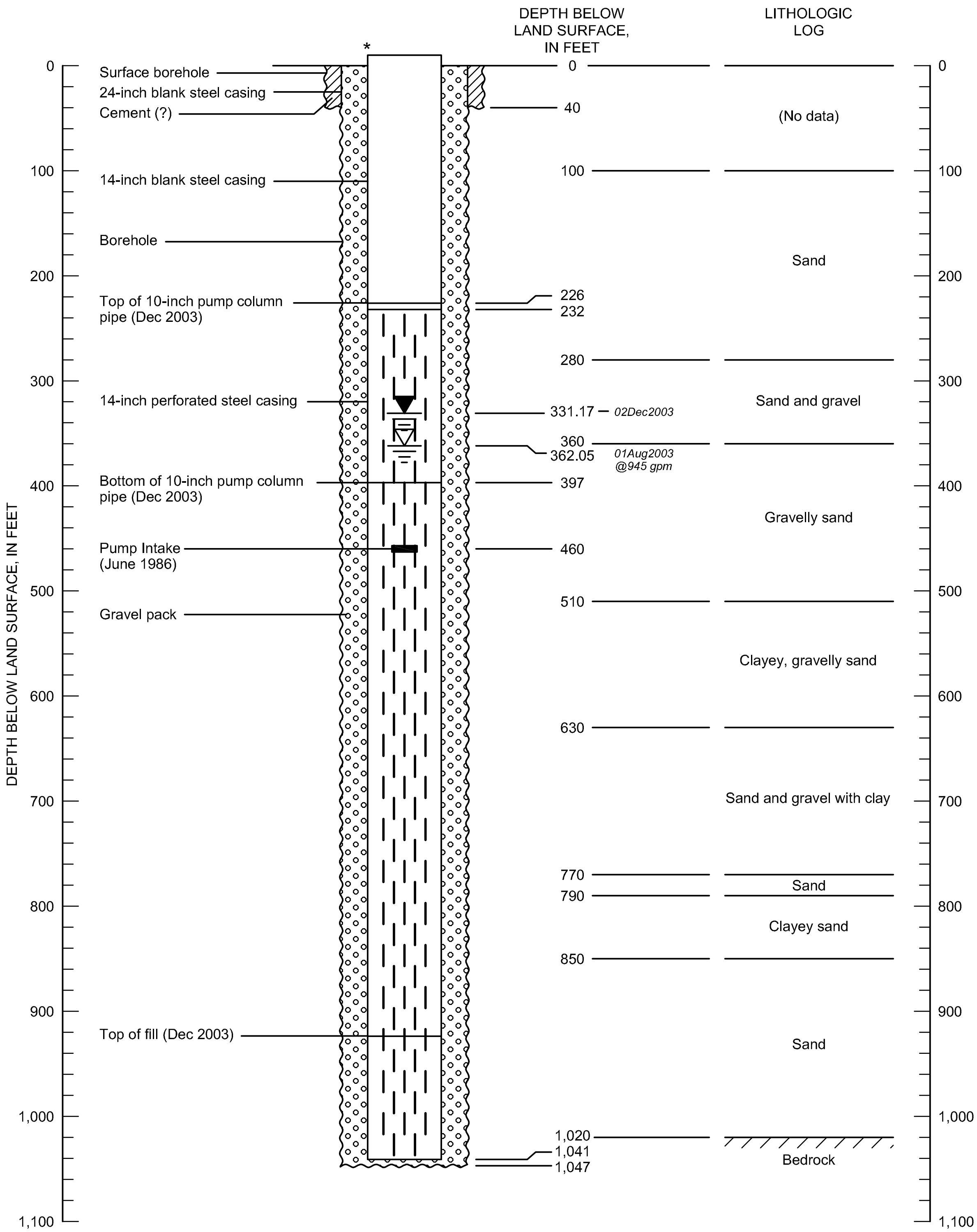
- non-pumping water level
- pumping water level

DRAWN BY: CEH	CHECKED BY: DSW	VERSION DATE: February 22, 2007

FIGURE A-2. SCHEMATIC DIAGRAM OF WELL CONSTRUCTION FOR INTERCEPTOR WELL IW-2

ERROL L. MONTGOMERY & ASSOCIATES, INC.

546.39\IW-2 WS_07



EXPLANATION

non-pumping water level

pumping water level

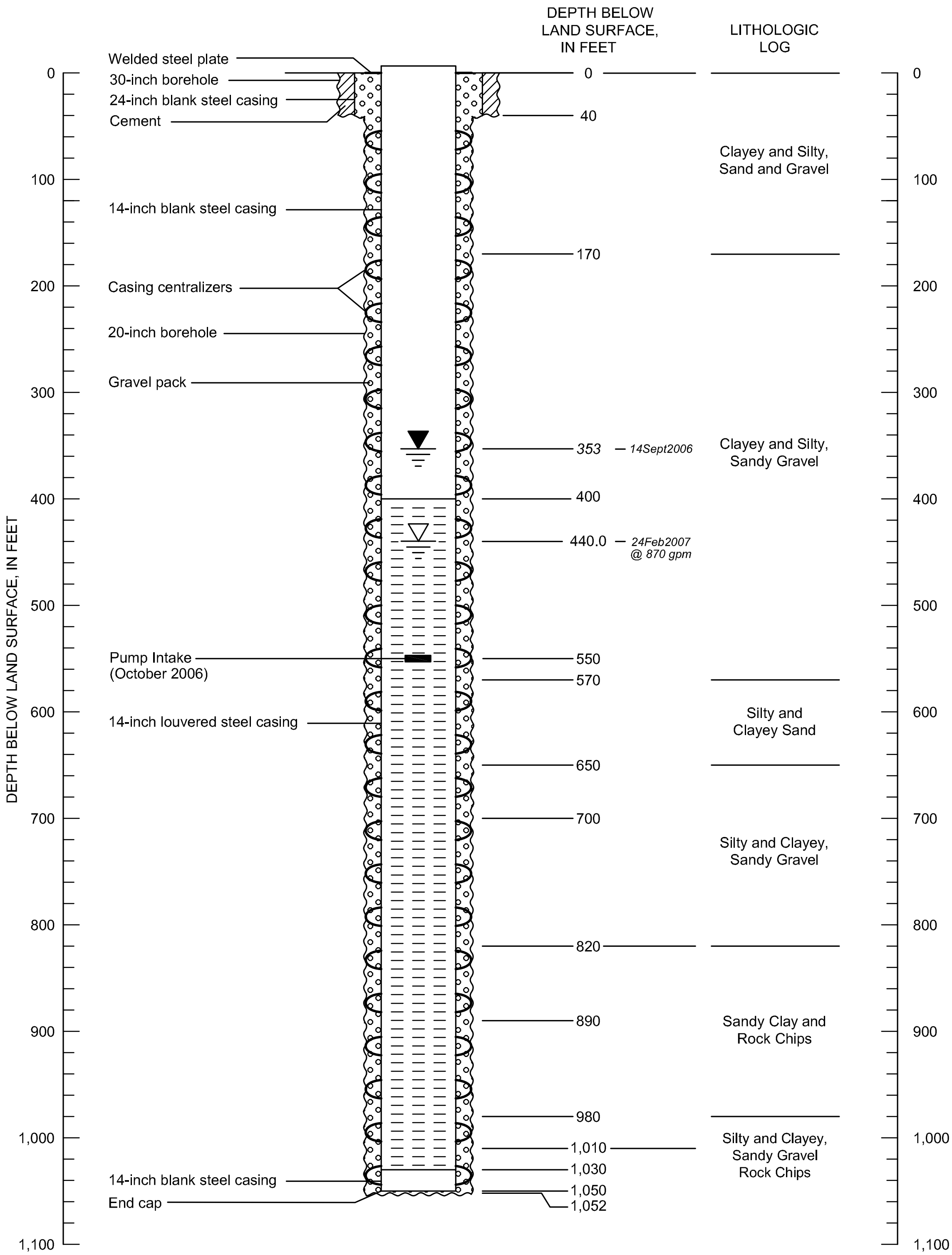
*Pump column pipe wedged in hole based on December 2003 video survey. Casing damaged. Well replacement recommended.

DRAWN BY: AMU	CHECKED BY: DSW	VERSION DATE: February 22, 2007

FIGURE A-3. SCHEMATIC DIAGRAM OF WELL CONSTRUCTION FOR INTERCEPTOR WELL IW-3

ERROL L. MONTGOMERY & ASSOCIATES, INC.

546.39|IW-3 WS_07



EXPLANATION

non-pumping water level

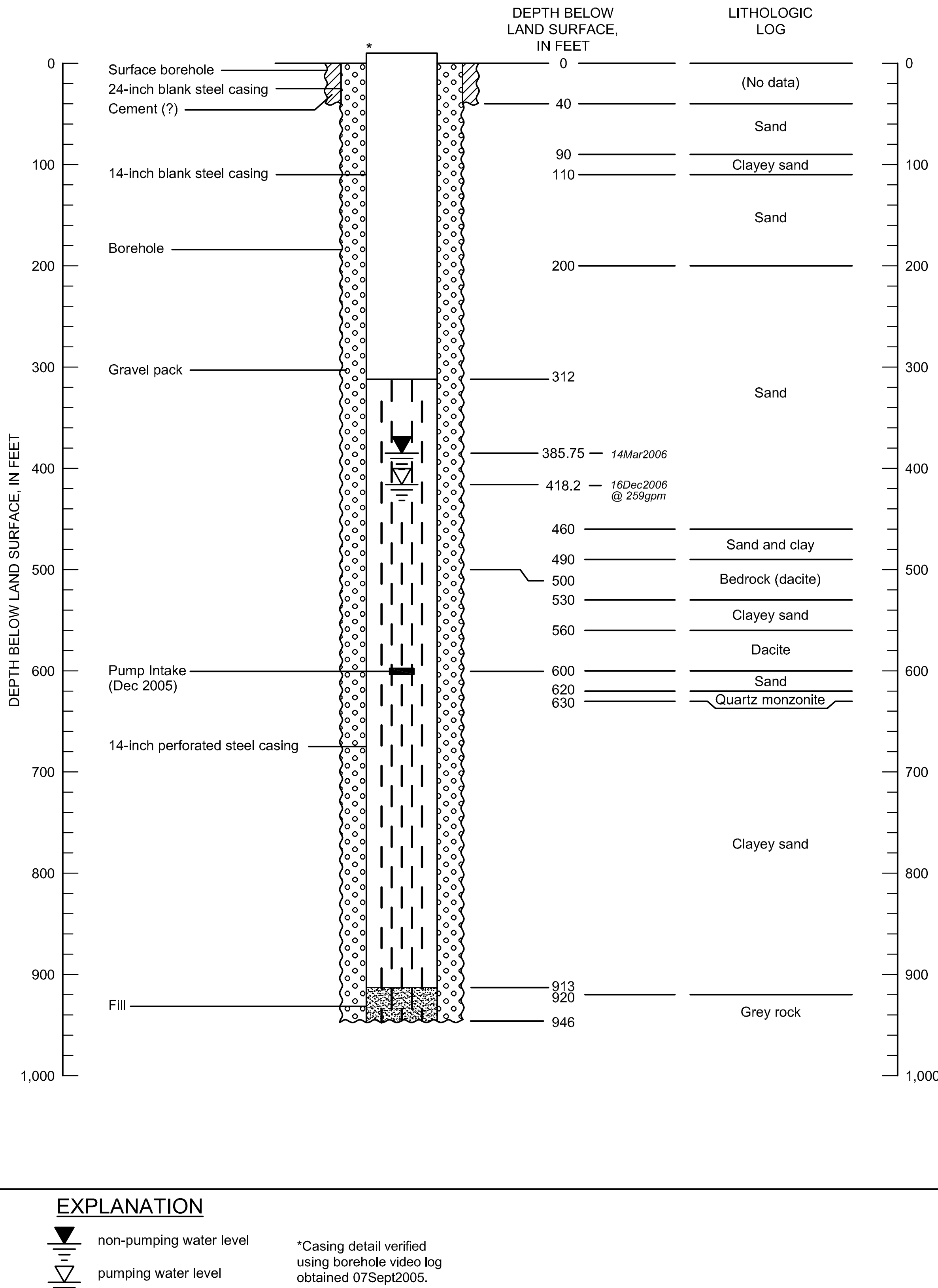
pumping water level

DRAWN BY: CEH	CHECKED BY: DSW	VERSION DATE: February 26, 2007

FIGURE A-4. SCHEMATIC DIAGRAM OF WELL CONSTRUCTION FOR INTERCEPTOR WELL IW-3A

ERROL L. MONTGOMERY & ASSOCIATES, INC.

546.39\IW-3A WS_07_Rev

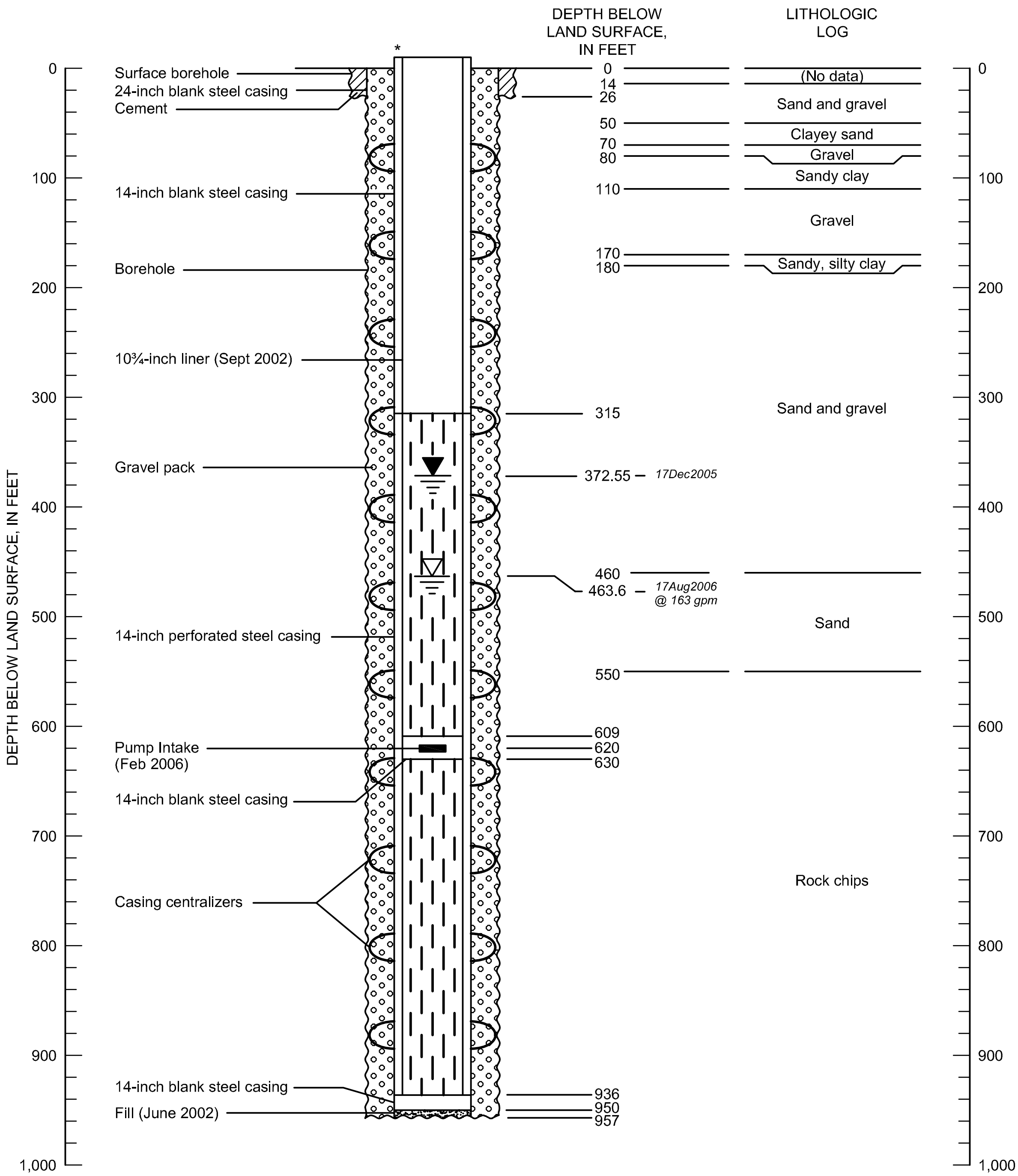


DRAWN BY: CEH | CHECKED BY: DSW | VERSION DATE: February 22, 2007

FIGURE A-5. SCHEMATIC DIAGRAM OF WELL CONSTRUCTION FOR INTERCEPTOR WELL IW-4

ERROL L. MONTGOMERY & ASSOCIATES, INC.

546.39\IW-4 WS_07



EXPLANATION

▼ non-pumping water level

▽ pumping water level

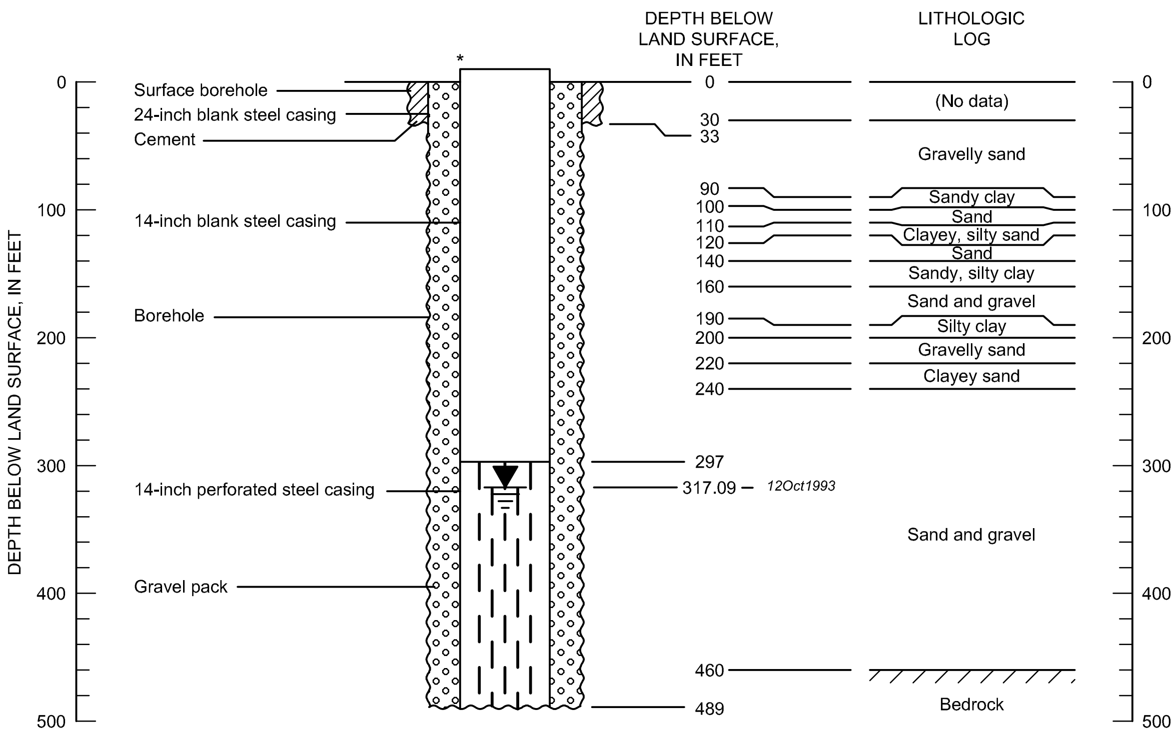
*Casing detail verified using Layne's invoice for well modifications (dated 22July2002)

DRAWN BY: CEH	CHECKED BY: DSW	VERSION DATE:February 22, 2007

FIGURE A-6. SCHEMATIC DIAGRAM OF WELL CONSTRUCTION FOR INTERCEPTOR WELL IW-5

ERROL L. MONTGOMERY & ASSOCIATES, INC.

546.39\IW-5 WS_07



EXPLANATION

* NOT EQUIPPED / CAPPED

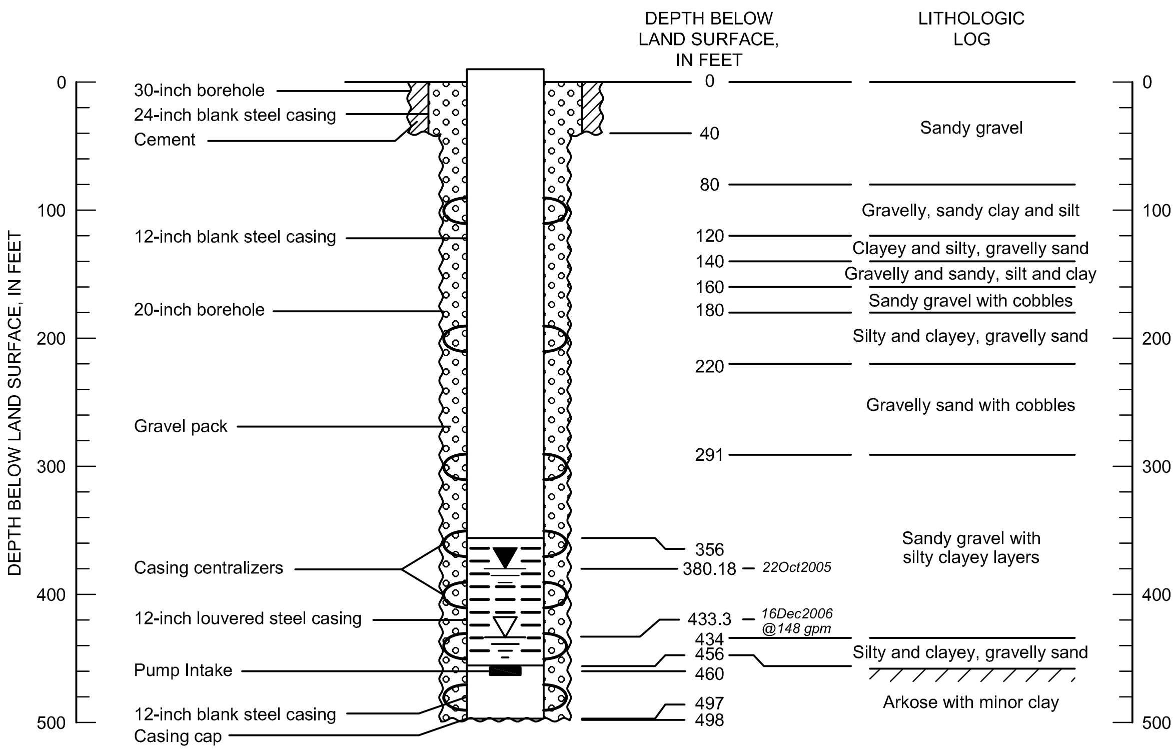
non-pumping water level

DRAWN BY: CEH	CHECKED BY: DSW	VERSION DATE: February 22, 2007

FIGURE A-7. SCHEMATIC DIAGRAM OF WELL CONSTRUCTION FOR INTERCEPTOR WELL IW-6

ERROL L. MONTGOMERY & ASSOCIATES, INC.

546.39\IW-6 WS_07



EXPLANATION

non-pumping water level

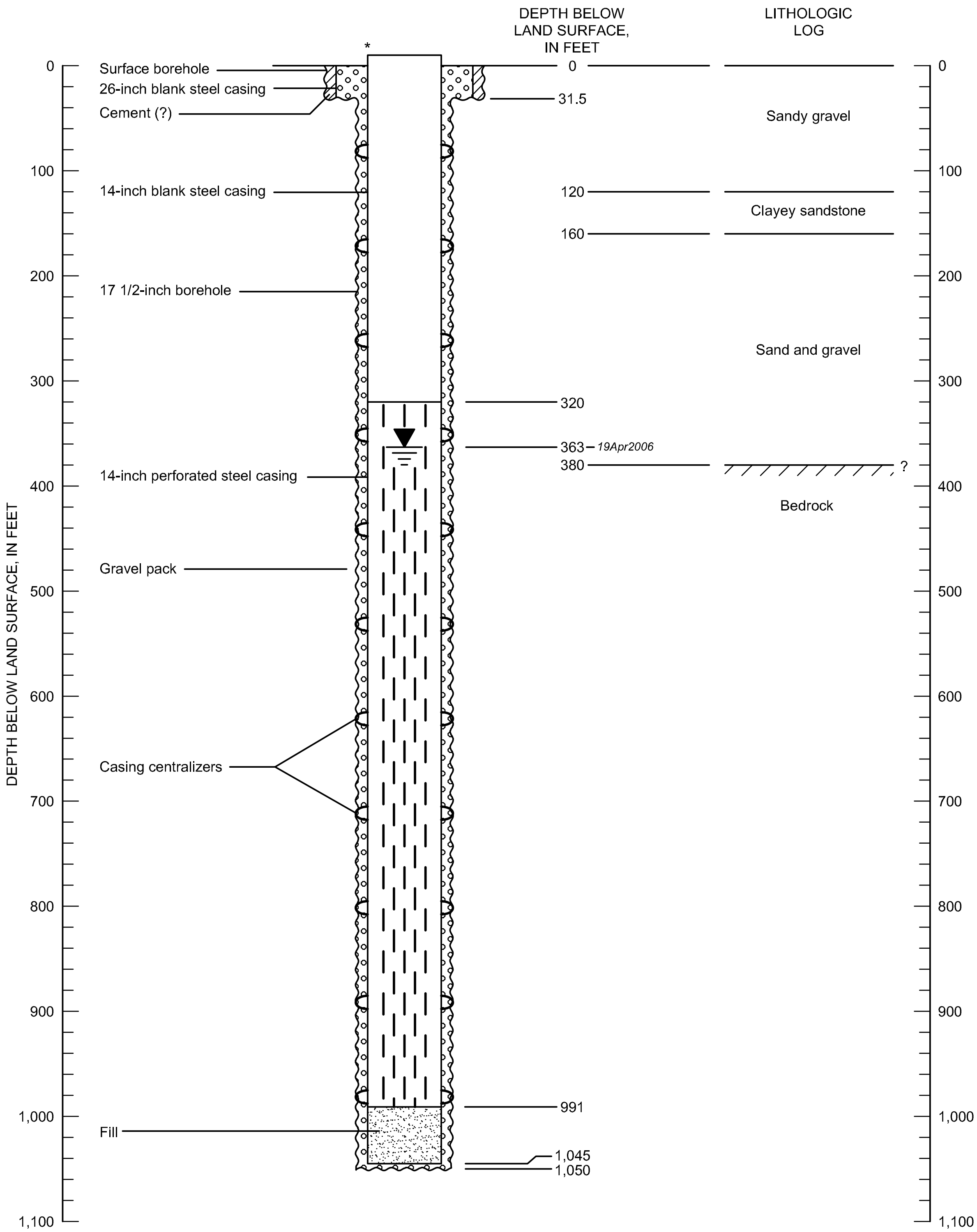
pumping water level

DRAWN BY: CEH	CHECKED BY: DSW	VERSION DATE: February 22, 2007

FIGURE A-8. SCHEMATIC DIAGRAM OF WELL CONSTRUCTION FOR INTERCEPTOR WELL IW-6A

ERROL L. MONTGOMERY & ASSOCIATES, INC.

546.39\IW-6A WS_07



EXPLANATION

* Not Equipped/Capped
Well video-logged 19Apr2006

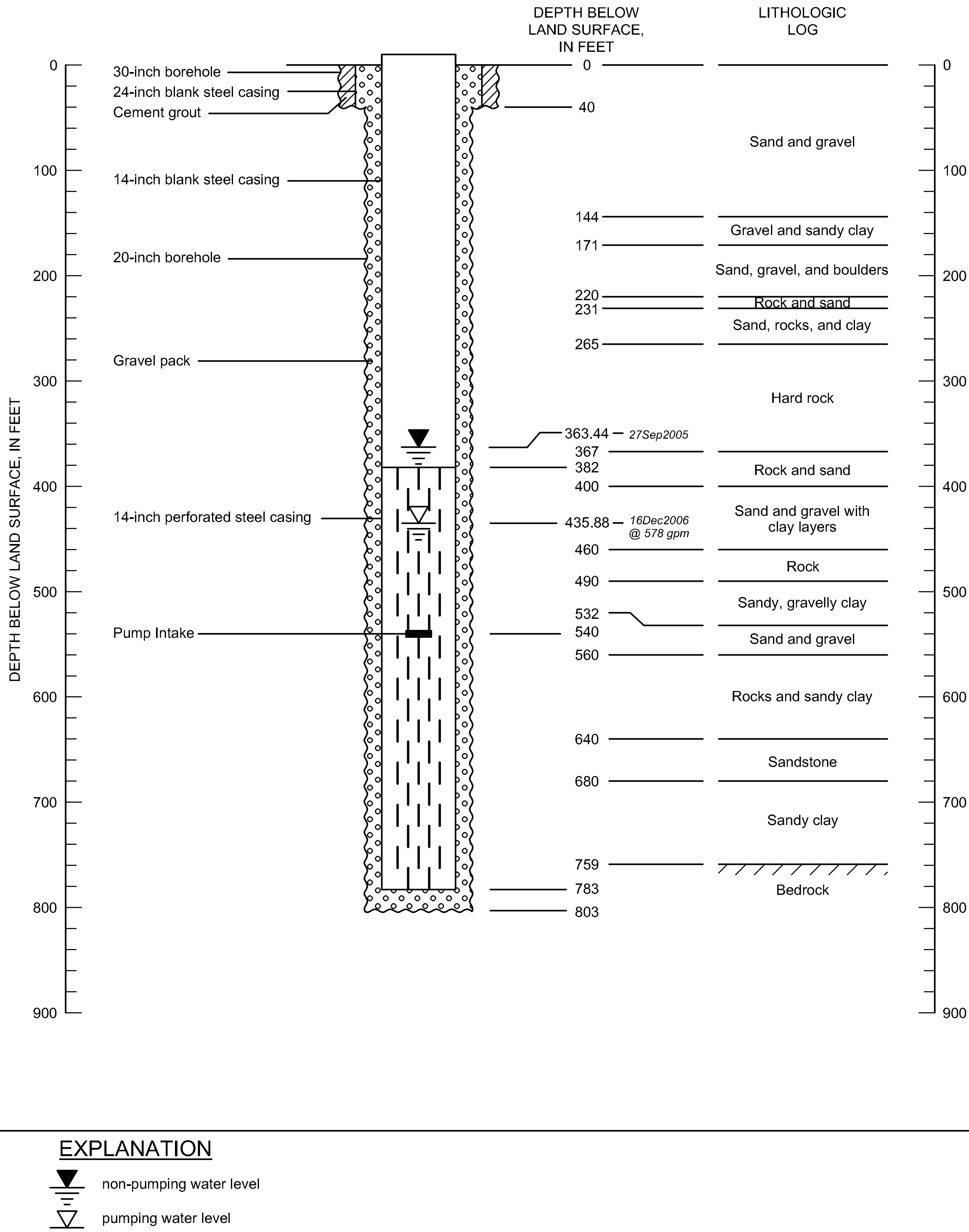
non-pumping water level

DRAWN BY: CEH	CHECKED BY: DSW	VERSION DATE: February 26, 2007

FIGURE A-9. SCHEMATIC DIAGRAM OF WELL CONSTRUCTION FOR INTERCEPTOR WELL IW-7

ERROL L. MONTGOMERY & ASSOCIATES, INC.

546.39\IW-7 WS_07

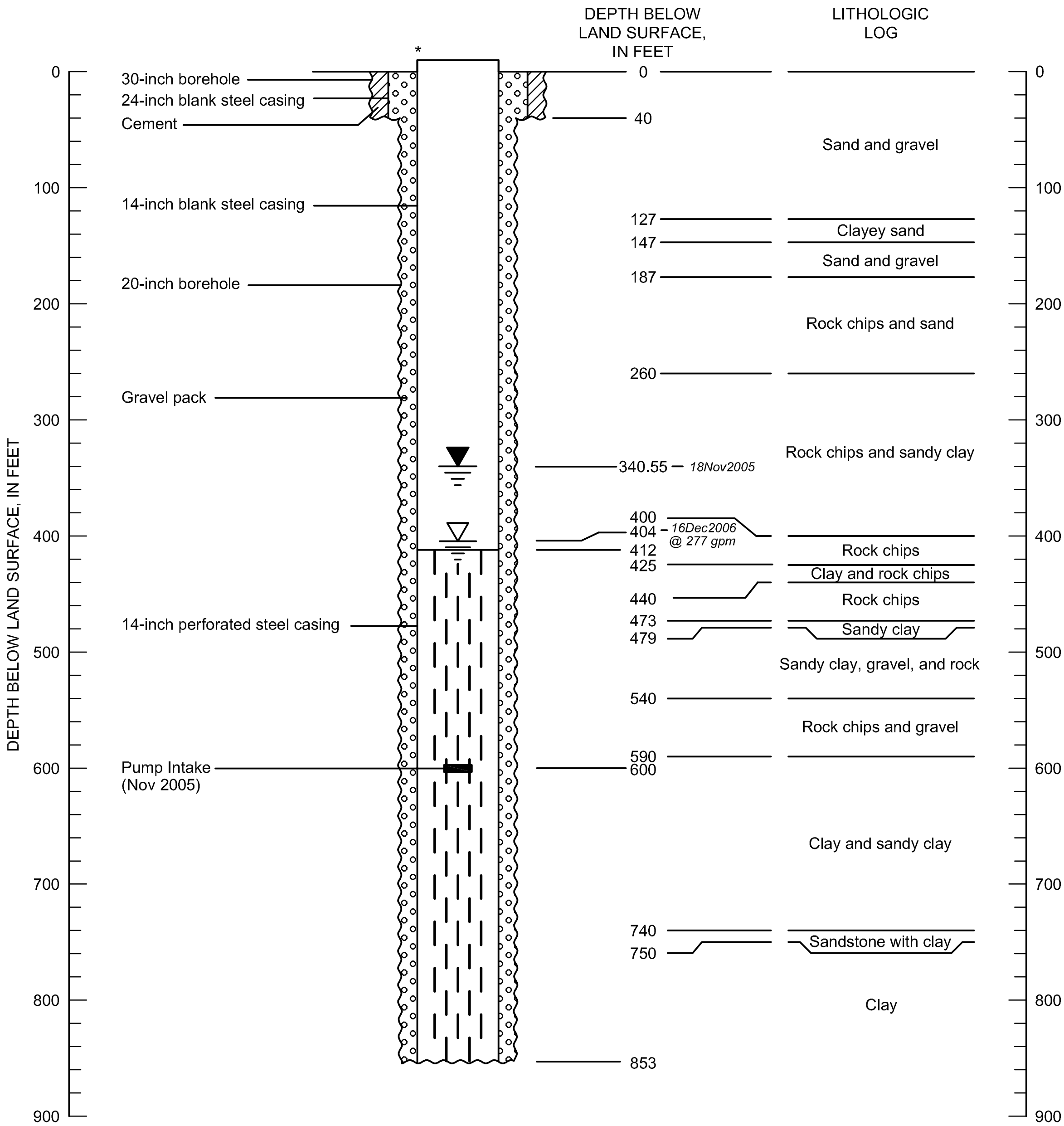


DRAWN BY: CEH	CHECKED BY: DSW	VERSION DATE: February 22, 2007

FIGURE A-10. SCHEMATIC DIAGRAM OF WELL CONSTRUCTION FOR INTERCEPTOR WELL IW-8

ERROL L. MONTGOMERY & ASSOCIATES, INC.

546.39\IW-8 WS_07



EXPLANATION

▼ non-pumping water level

▽ pumping water level

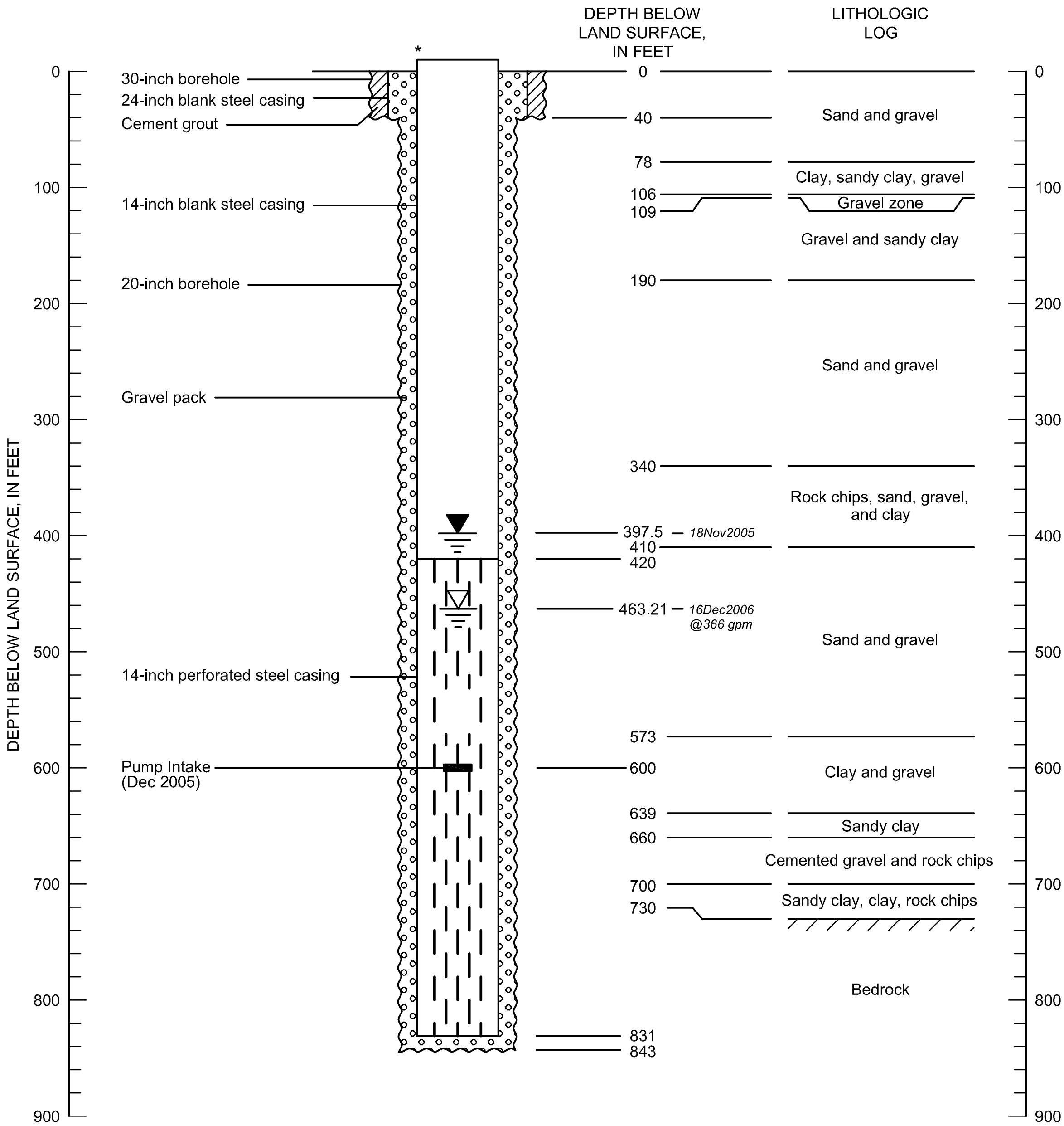
*Casing detail verified using borehole video log obtained 30April2003.

DRAWN BY: CEH	CHECKED BY: DSW	VERSION DATE: February 22, 2007

FIGURE A-11. SCHEMATIC DIAGRAM OF WELL CONSTRUCTION FOR INTERCEPTOR WELL IW-9

ERROL L. MONTGOMERY & ASSOCIATES, INC.

546.39\IW-9 WS_07



EXPLANATION

non-pumping water level

pumping water level

*Casing detail verified using borehole video log obtained 10Nov2003.

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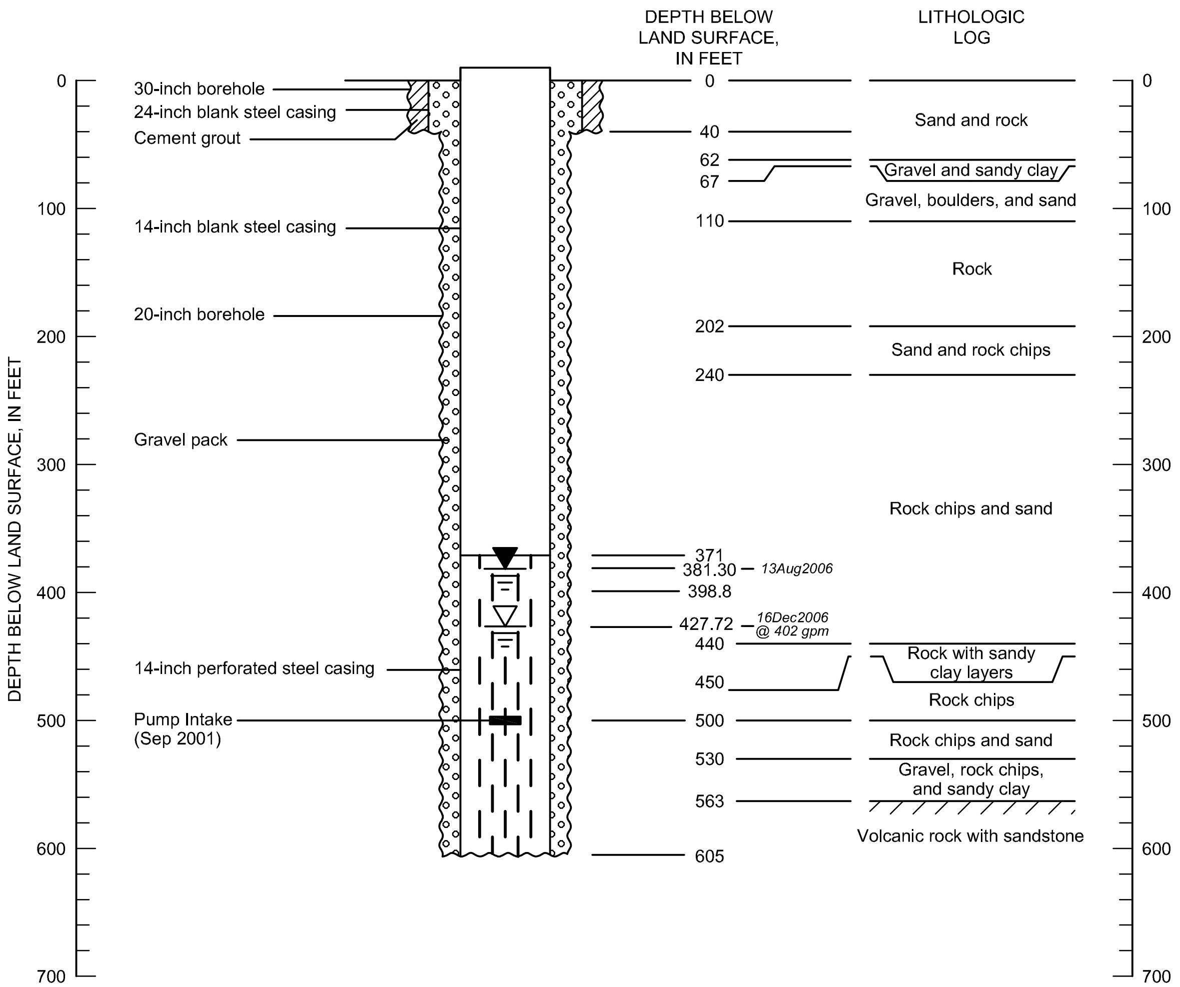
FIGURE A-12. SCHEMATIC DIAGRAM OF WELL CONSTRUCTION FOR INTERCEPTOR WELL IW-10

ERROL L. MONTGOMERY & ASSOCIATES, INC.

546.39\IW-10 WS_07



EXPLANATION

non-pumping water level

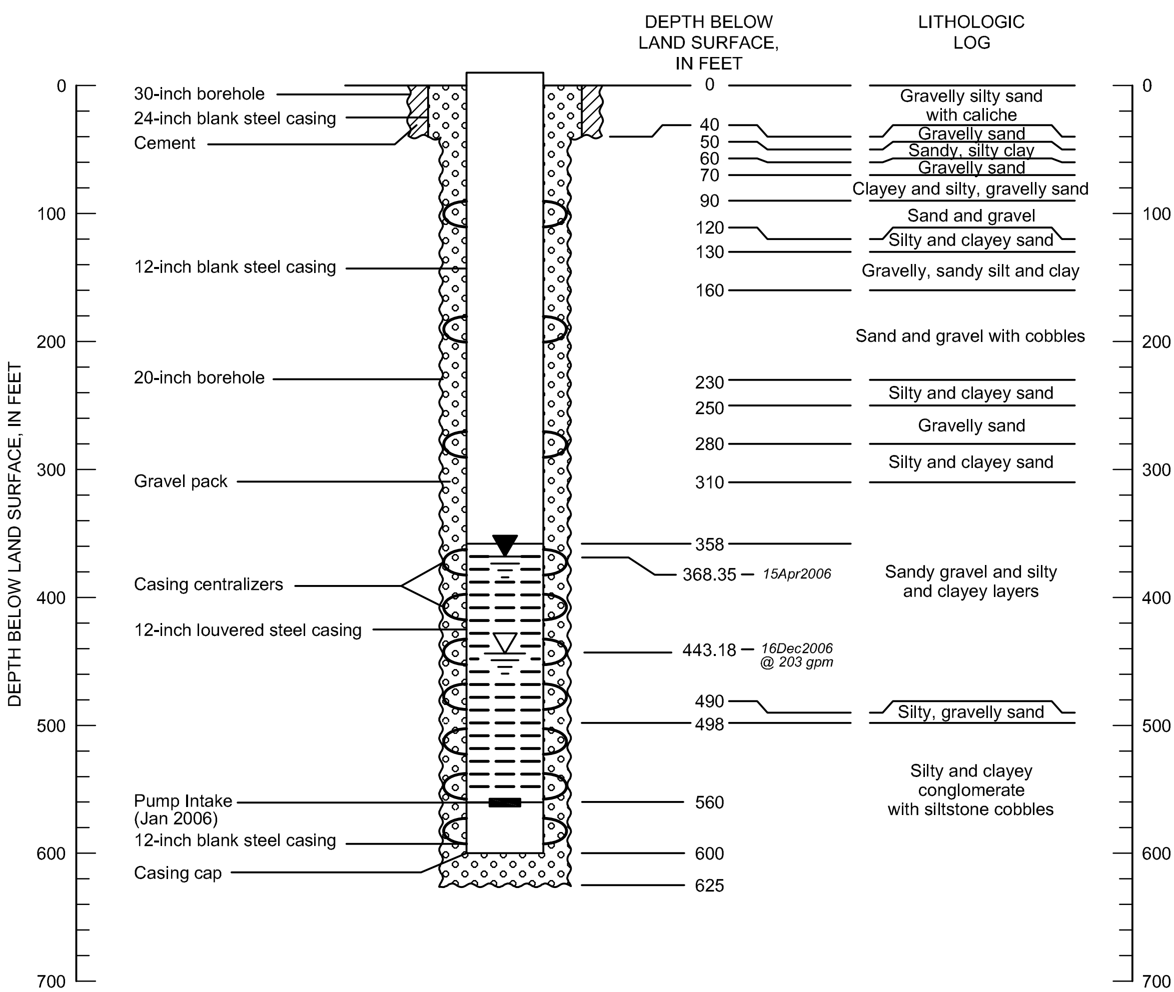
pumping water level

DRAWN BY: CEH	CHECKED BY: DSW	VERSION DATE: February 22, 2007

FIGURE A-13. SCHEMATIC DIAGRAM OF WELL CONSTRUCTION FOR INTERCEPTOR WELL IW-11

ERROL L. MONTGOMERY & ASSOCIATES, INC.

546.39\IW-11 WS_07



EXPLANATION

non-pumping water level

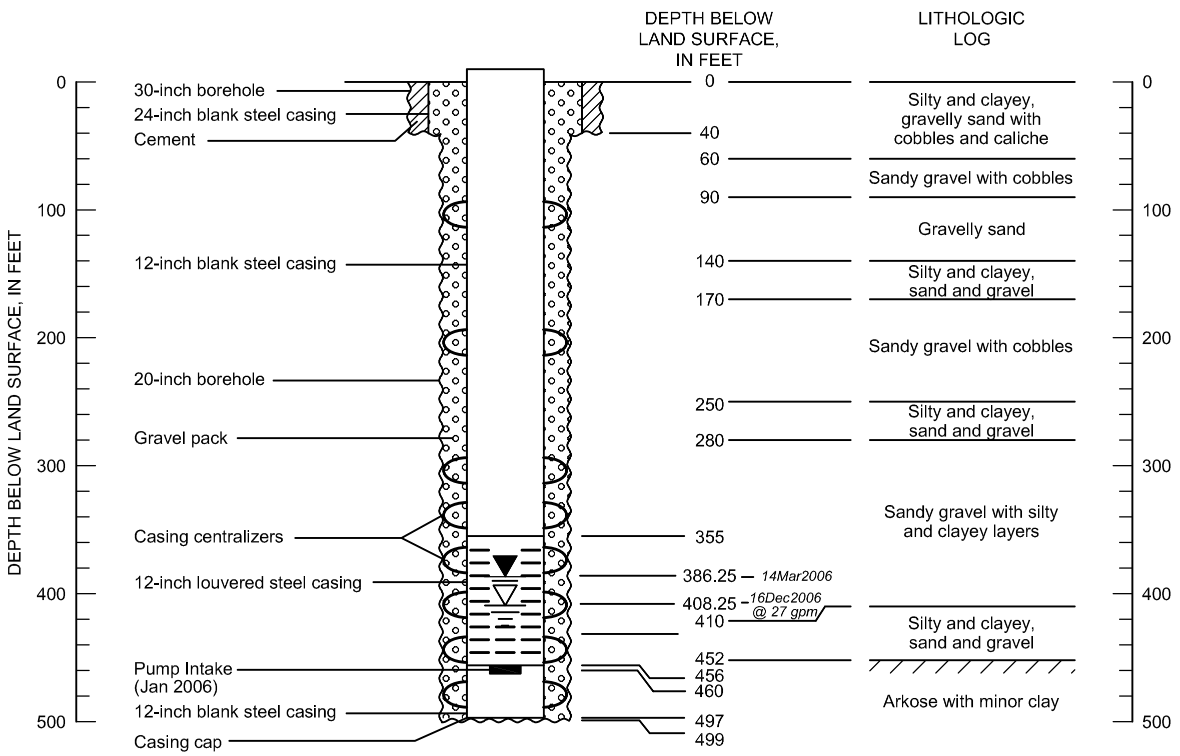
pumping water level

DRAWN BY: CEH	CHECKED BY: DSW	VERSION DATE: February 22, 2007

FIGURE A-14. SCHEMATIC DIAGRAM OF WELL CONSTRUCTION FOR INTERCEPTOR WELL IW-12

ERROL L. MONTGOMERY & ASSOCIATES, INC.

546.39\IW-12 WS_07



EXPLANATION

non-pumping water level

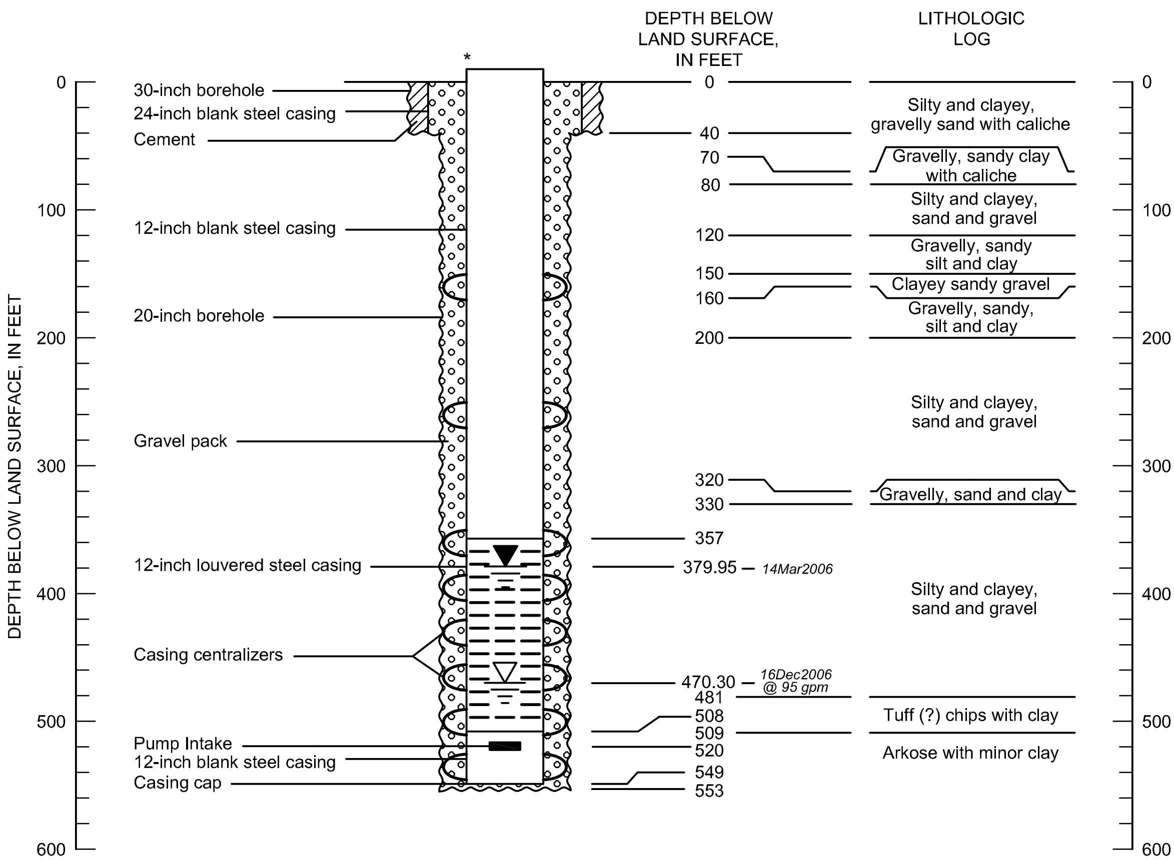
pumping water level

DRAWN BY: CEH	CHECKED BY: DSW	VERSION DATE: February 22, 2007

FIGURE A-15. SCHEMATIC DIAGRAM OF WELL CONSTRUCTION FOR INTERCEPTOR WELL IW-13

ERROL L. MONTGOMERY & ASSOCIATES, INC.

546.39\IW-13 WS_07



EXPLANATION

▼ non-pumping water level

▽ pumping water level

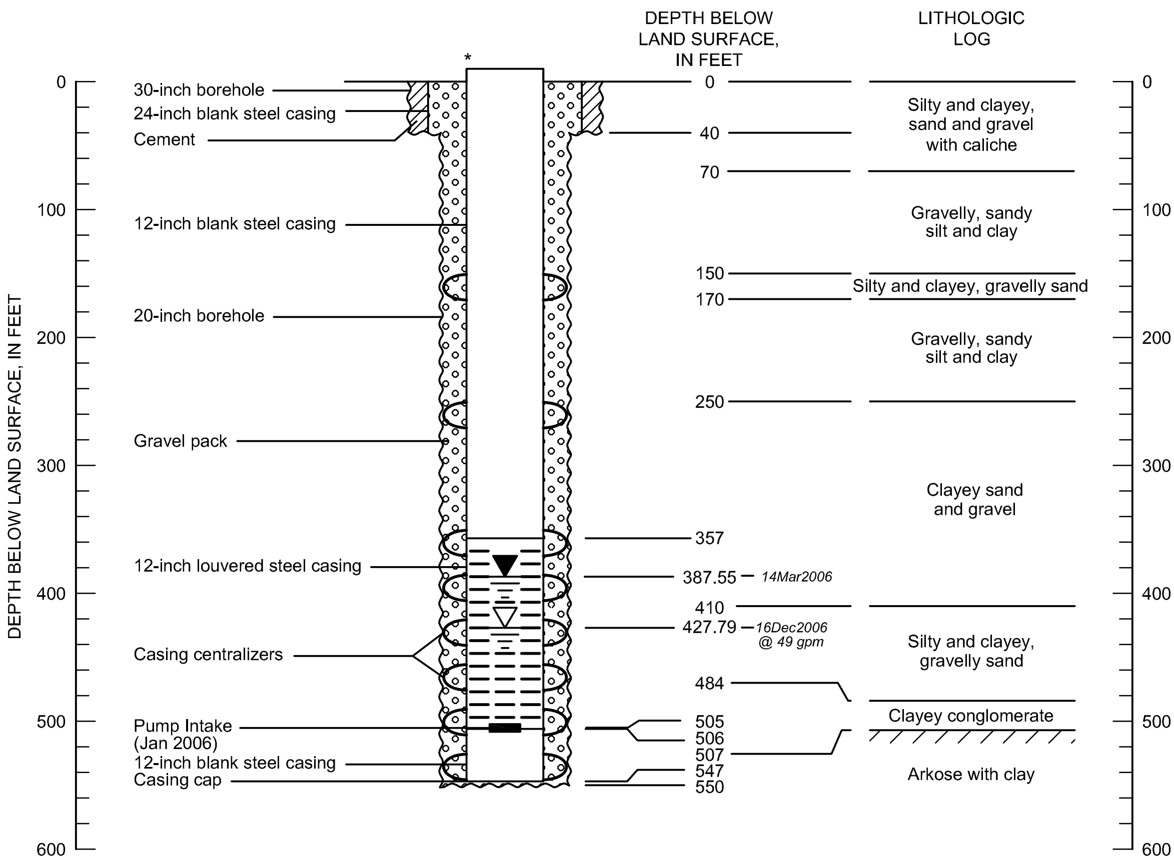
*Casing detail verified using borehole video log obtained 10Dec2003

DRAWN BY: CEH	CHECKED BY: DSW	VERSION DATE: February 22, 2007

FIGURE A-16. SCHEMATIC DIAGRAM OF WELL CONSTRUCTION FOR INTERCEPTOR WELL IW-14

ERROL L. MONTGOMERY & ASSOCIATES, INC.

546.39\IW-14 WS_07



EXPLANATION

non-pumping water level

pumping water level

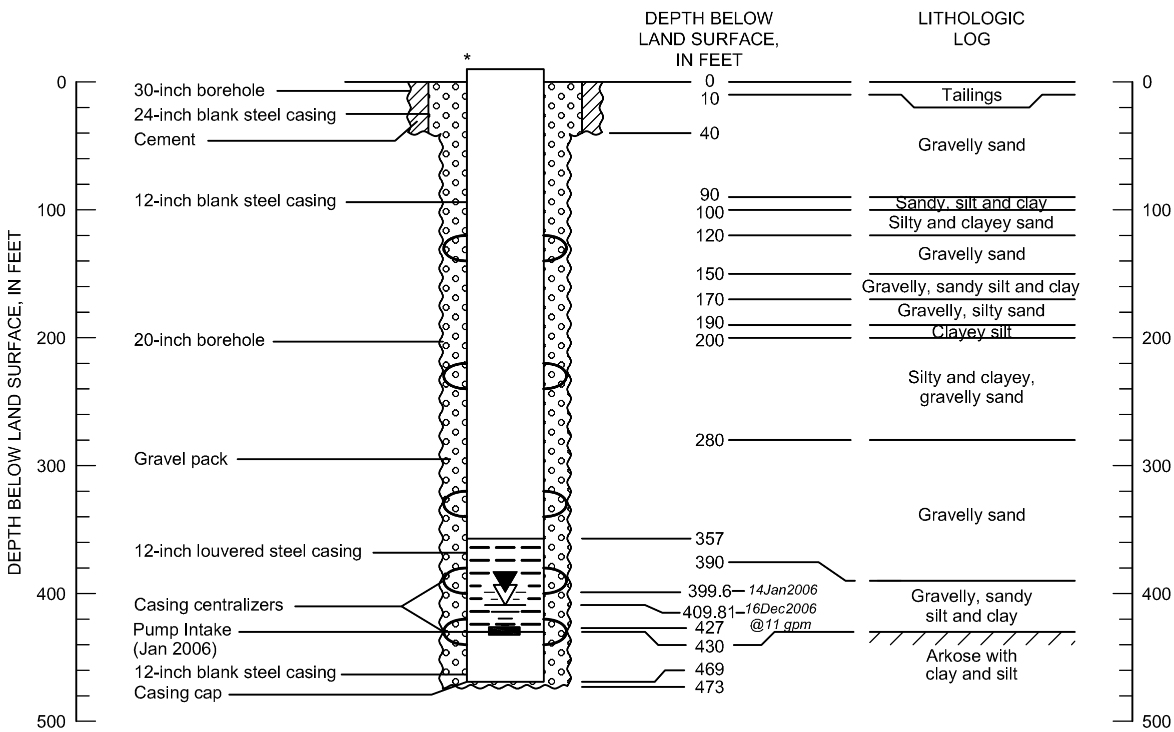
*Casing detail verified
using borehole video log
obtained 17Oct2003

DRAWN BY: CEH	CHECKED BY: DSW	VERSION DATE: February 22, 2007

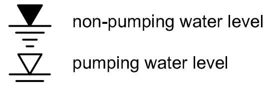
FIGURE A-17. SCHEMATIC DIAGRAM OF WELL CONSTRUCTION FOR INTERCEPTOR WELL IW-15

ERROL L. MONTGOMERY & ASSOCIATES, INC.

546.39\IW-15 WS_07



EXPLANATION



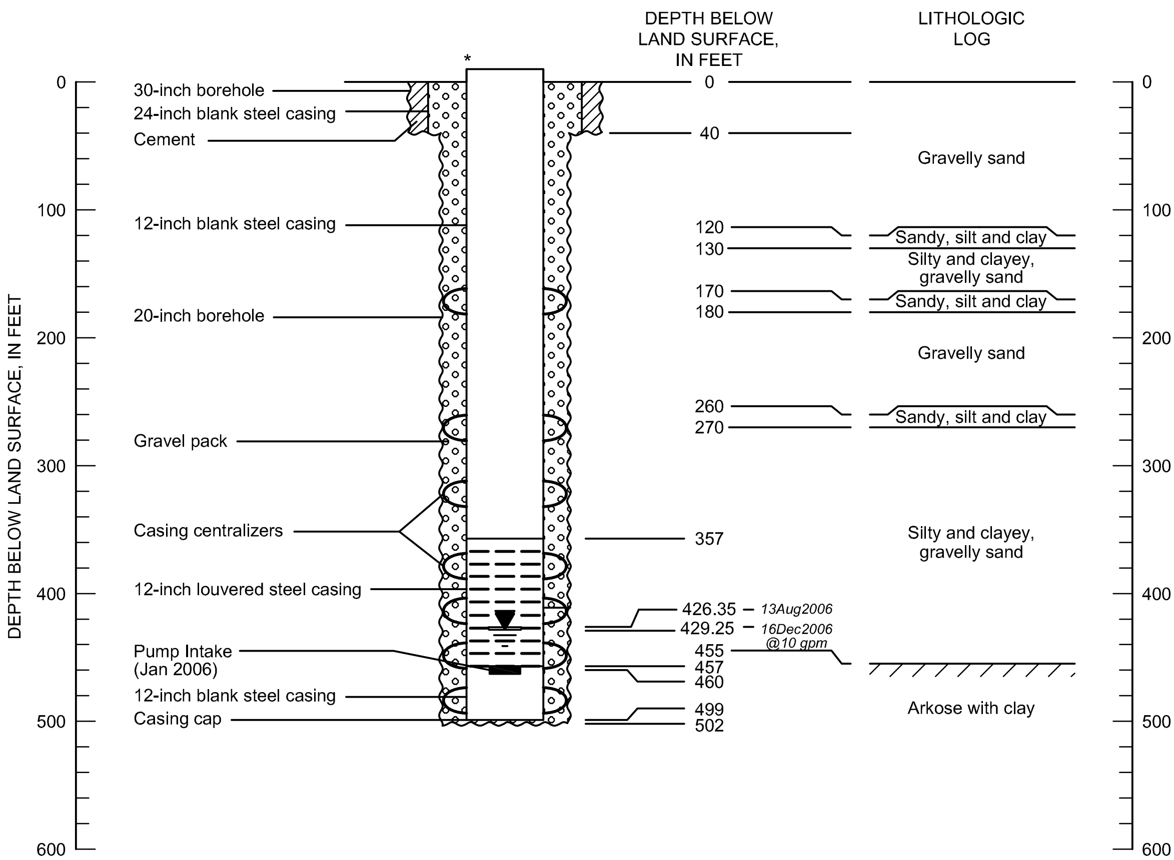
*Casing detail verified
using borehole video log
obtained 03Nov2005

DRAWN BY: CEH	CHECKED BY: DSW	VERSION DATE: February 22, 2007

FIGURE A-18. SCHEMATIC DIAGRAM OF WELL CONSTRUCTION FOR INTERCEPTOR WELL IW-16

ERROL L. MONTGOMERY & ASSOCIATES, INC.

546.39\IW-16 WS_07



EXPLANATION

non-pumping water level

pumping water level

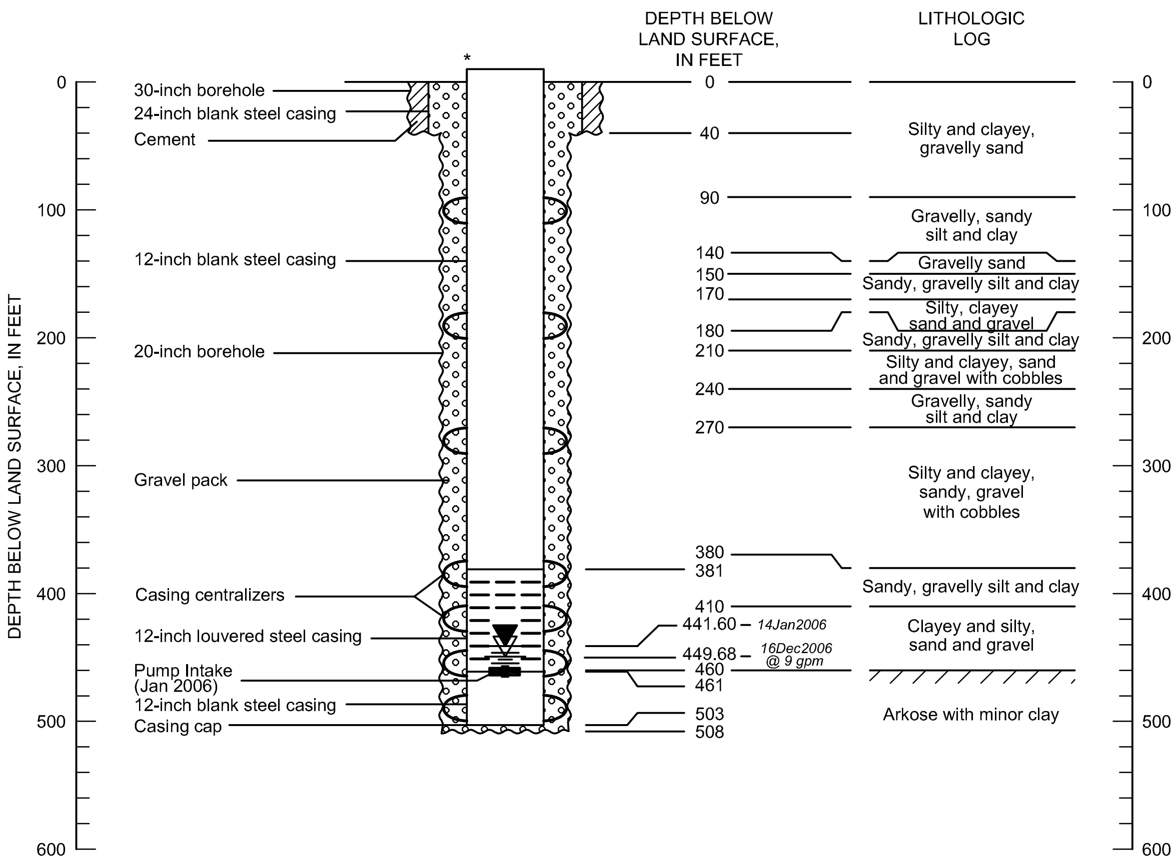
*Casing detail verified
using borehole video log
obtained 03Nov2005

DRAWN BY: CEH	CHECKED BY: DSW	VERSION DATE: February 22, 2007

FIGURE A-19. SCHEMATIC DIAGRAM OF WELL CONSTRUCTION FOR INTERCEPTOR WELL IW-17

ERROL L. MONTGOMERY & ASSOCIATES, INC.

546.39\IW-17 WS_07



EXPLANATION

non-pumping water level

pumping water level

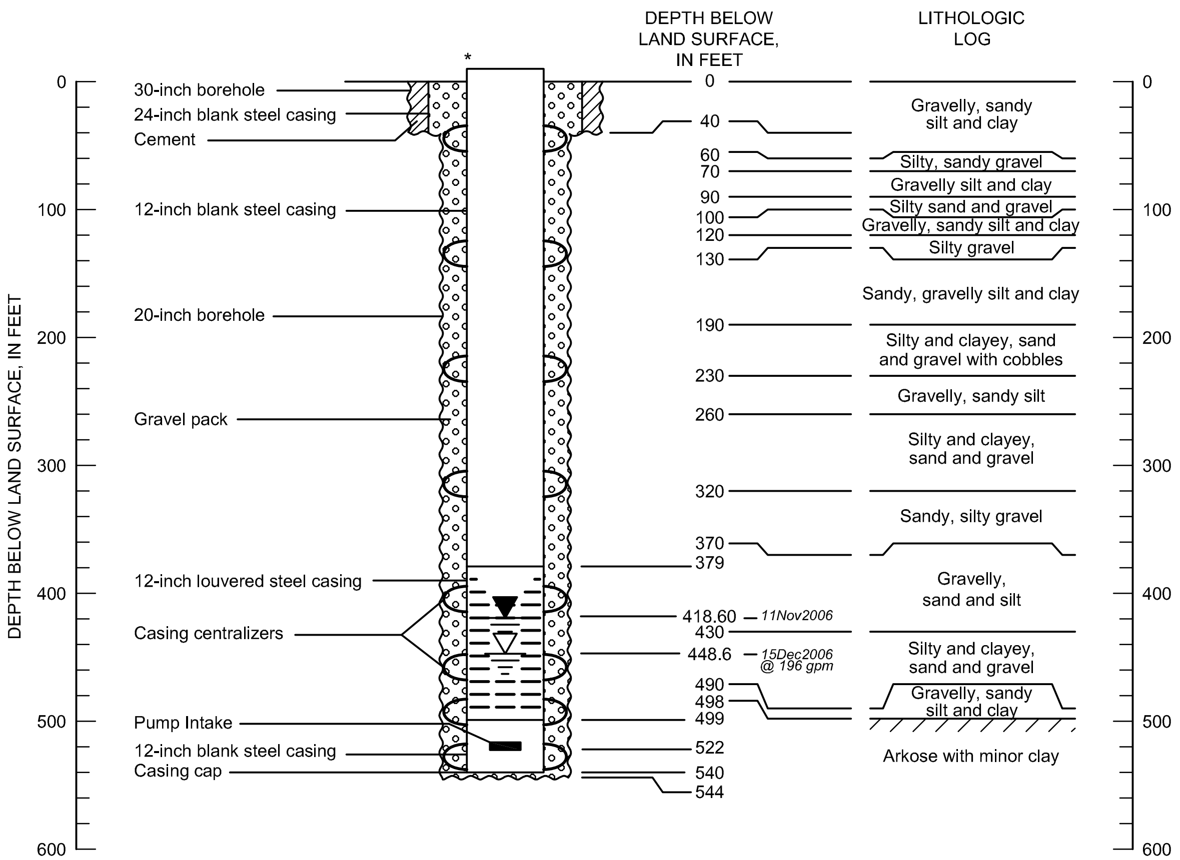
*Casing detail verified using borehole video log obtained 03Nov2005

DRAWN BY: CEH	CHECKED BY: DSW	VERSION DATE: February 22, 2007

FIGURE A-20. SCHEMATIC DIAGRAM OF WELL CONSTRUCTION FOR INTERCEPTOR WELL IW-18

ERROL L. MONTGOMERY & ASSOCIATES, INC.

546.39\IW-18 WS_07



EXPLANATION

non-pumping water level

pumping water level

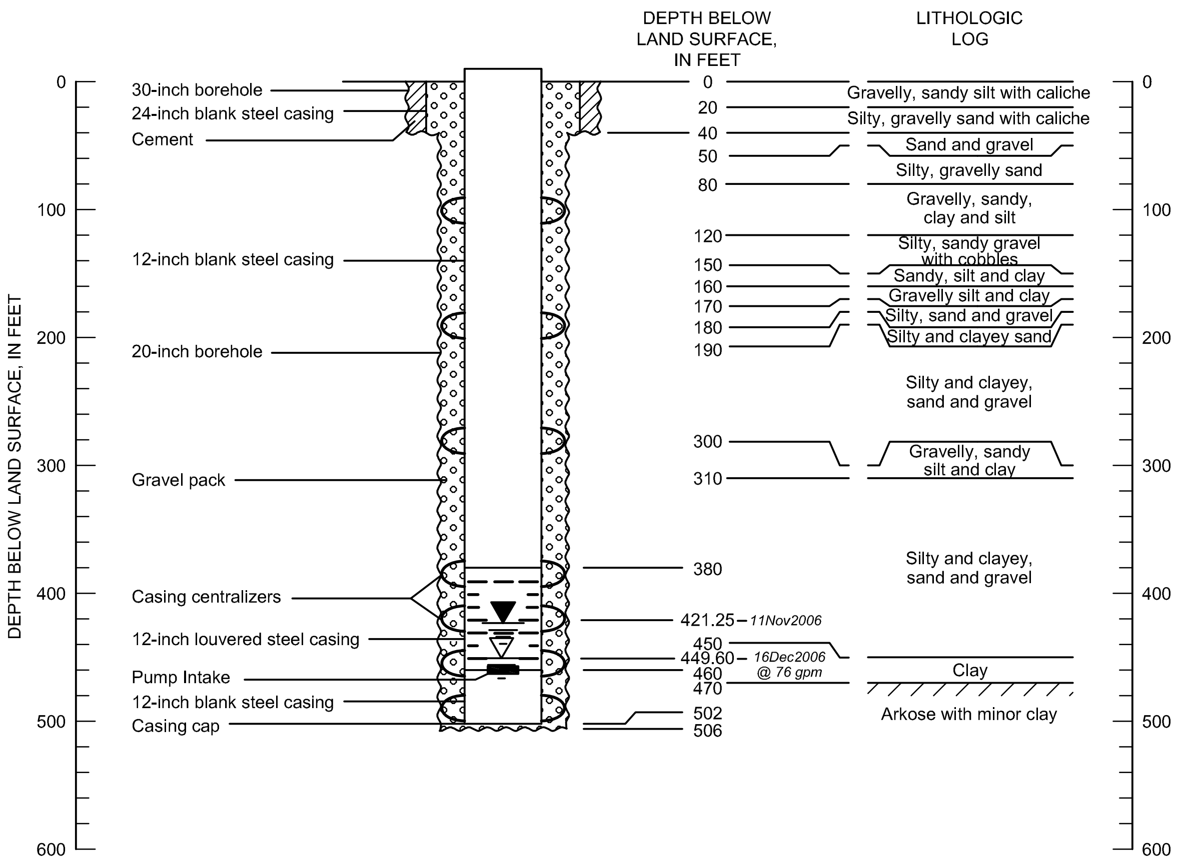
*Casing detail verified using borehole video log obtained 10Dec2005

DRAWN BY: CEH	CHECKED BY: DSW	VERSION DATE: February 22, 2007

FIGURE A-21. SCHEMATIC DIAGRAM OF WELL CONSTRUCTION FOR INTERCEPTOR WELL IW-19

ERROL L. MONTGOMERY & ASSOCIATES, INC.

546.39\IW-19 WS_07



EXPLANATION

non-pumping water level

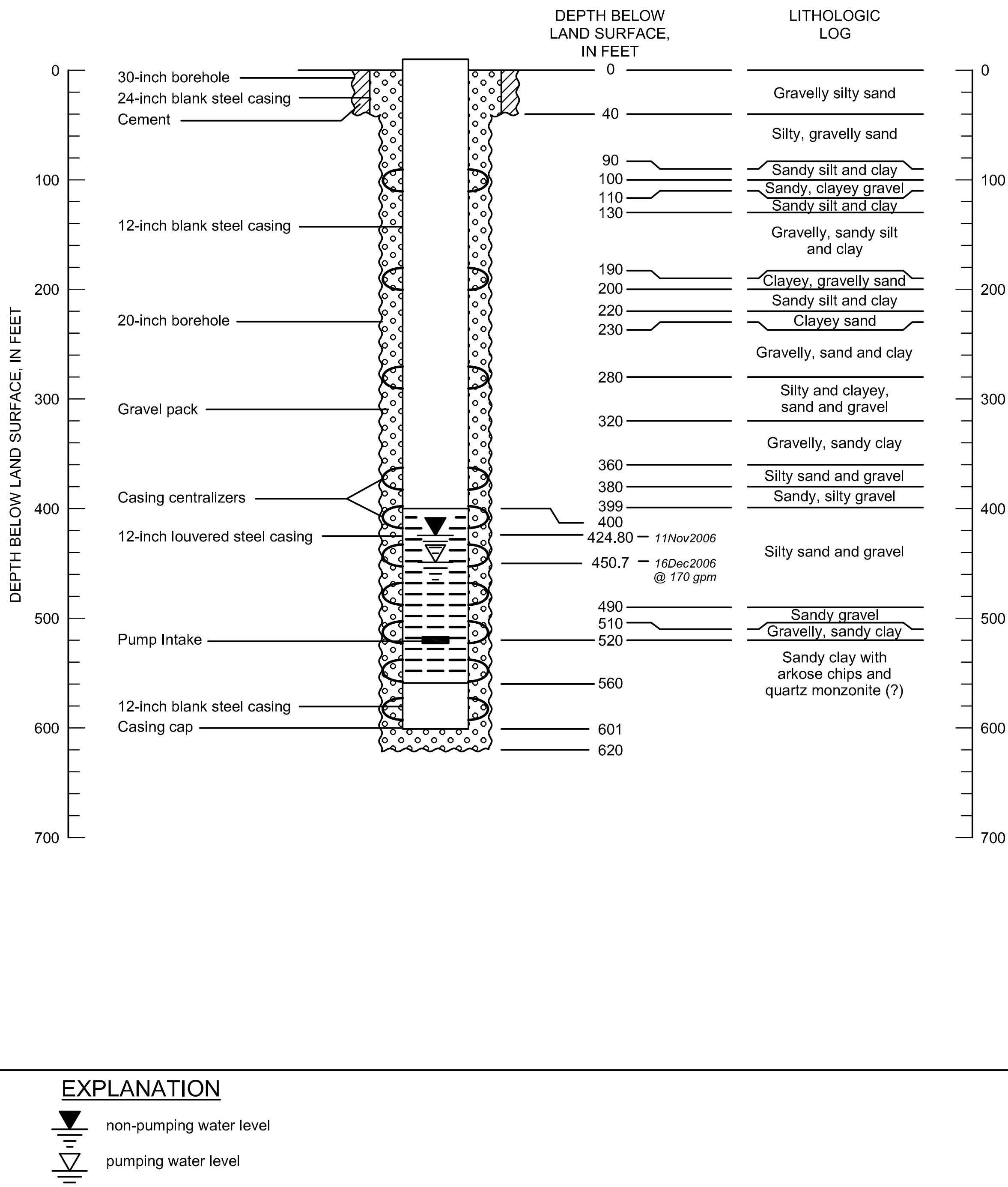
pumping water level

DRAWN BY: CEH	CHECKED BY: DSW	VERSION DATE: February 22, 2007

FIGURE A-22. SCHEMATIC DIAGRAM OF WELL CONSTRUCTION FOR INTERCEPTOR WELL IW-20

ERROL L. MONTGOMERY & ASSOCIATES, INC.

546.39\IW-20 WS_07

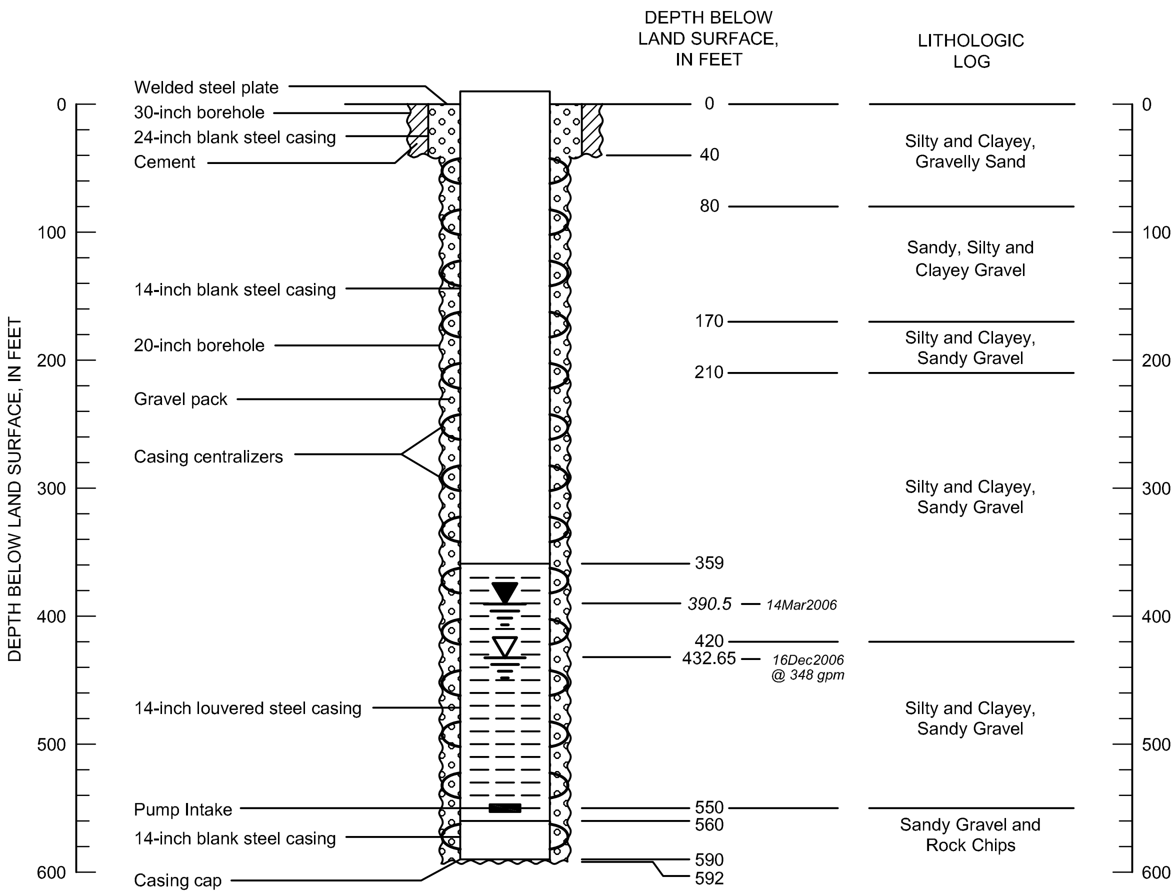


DRAWN BY: CEH	CHECKED BY: DSW	VERSION DATE: February 22, 2007

FIGURE A-23. SCHEMATIC DIAGRAM OF WELL CONSTRUCTION FOR INTERCEPTOR WELL IW-21

ERROL L. MONTGOMERY & ASSOCIATES, INC.

546.39\IW-21 WS_07



EXPLANATION

non-pumping water level

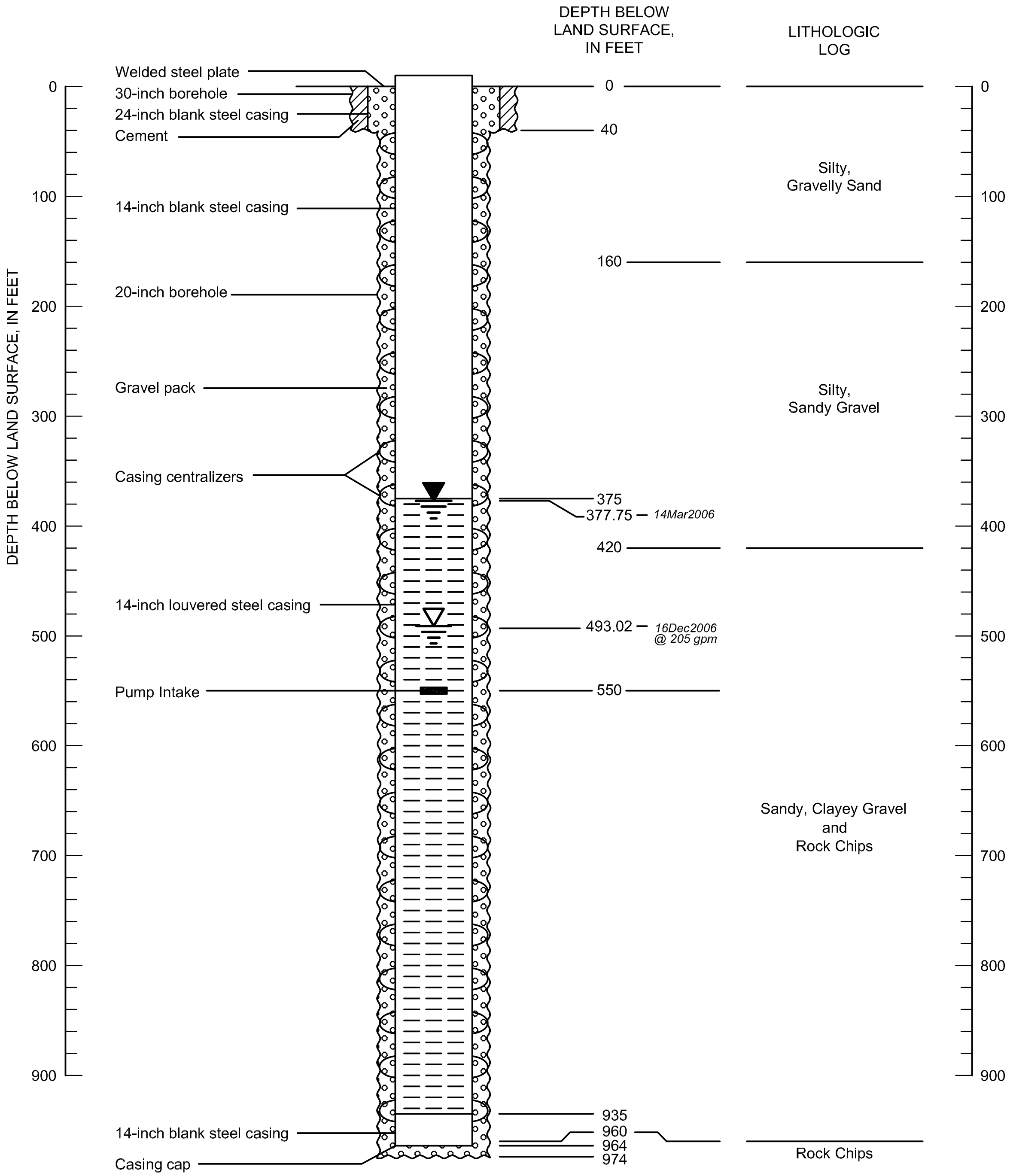
pumping water level

DRAWN BY: CEH	CHECKED BY: DSW	VERSION DATE: February 22, 2007

FIGURE A-24. SCHEMATIC DIAGRAM OF WELL CONSTRUCTION FOR INTERCEPTOR WELL IW-22

ERROL L. MONTGOMERY & ASSOCIATES, INC.

546.39\IW-22 WS_07



EXPLANATION

non-pumping water level

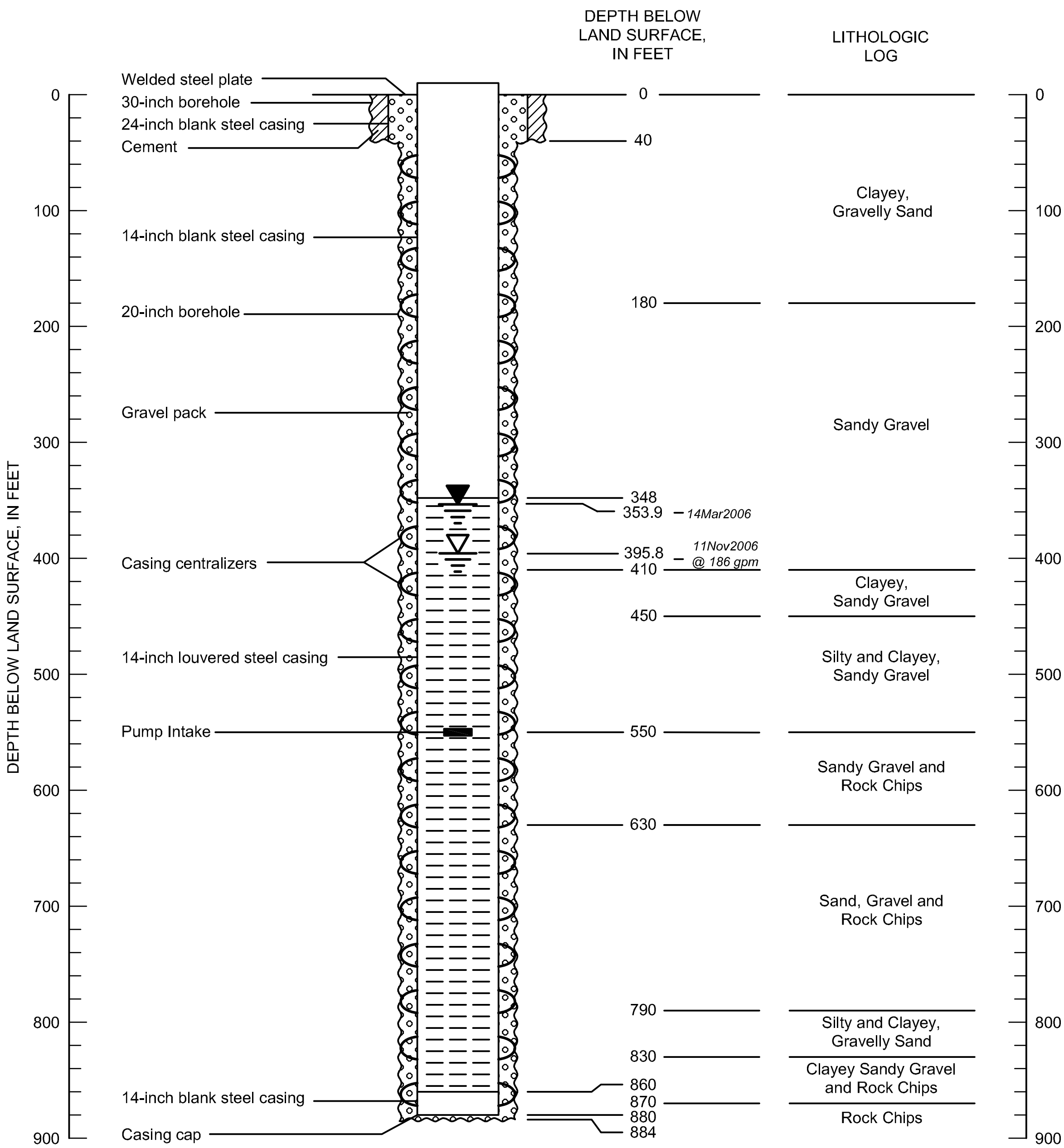
pumping water level

DRAWN BY: CEH	CHECKED BY: DSW	VERSION DATE: February 22, 2007

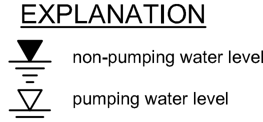
FIGURE A-25. SCHEMATIC DIAGRAM OF WELL CONSTRUCTION FOR INTERCEPTOR WELL IW-23

ERROL L. MONTGOMERY & ASSOCIATES, INC.

546.39\IW-23 WS_07



EXPLANATION



DRAWN BY: CEH	CHECKED BY: DSW	VERSION DATE: February 26, 2007

FIGURE A-26. SCHEMATIC DIAGRAM OF WELL CONSTRUCTION FOR INTERCEPTOR WELL IW-24

ERROL L. MONTGOMERY & ASSOCIATES, INC.

546.39\IW-24 WS_07

APPENDIX B

WATER BALANCE ANALYSIS FOR SIERRITA TAILING IMPOUNDMENT
PHELPS DODGE SIERRITA MINE, PIMA COUNTY, ARIZONA

APPENDIX B

WATER BALANCE ANALYSIS FOR SIERRITA TAILING IMPOUNDMENT
PHELPS DODGE SIERRITA MINE, PIMA COUNTY, ARIZONA

ERROL L. MONTGOMERY & ASSOCIATES, INC.
WATER RESOURCE CONSULTANTS

1550 EAST PRINCE ROAD
TUCSON, ARIZONA 85719 (520) 881-4912

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APPENDIX B

SIERRITA TAILING IMPOUNDMENT WATER BALANCE ANALYSIS

Montgomery & Associates (1989) presented a water balance for the Phelps Dodge Sierrita Tailing Impoundment (PDSTI) for the time period from 1979 through 1987, which was primarily based on information provided in a report by Reed and Associates (1986). The water balance was updated through 2006 based on a comprehensive evaluation of historic data to provide more accurate estimates for most water balance components. In addition, field data were obtained for characterization of the physical and hydraulic properties of the tailing material by augmenting a geotechnical characterization and slope stability study conducted by URS Corporation at the PDSTI during February through April 2007 (URS, 2007). A site map for the PDSTI is shown of **Figure B-1** and indicates locations for investigations conducted in 2007. A detailed description of the methods and assumptions for the water balance analysis is provided in this appendix. The primary purpose of the water balance analysis is to estimate the amount of seepage from the PDSTI.

The water balance consists of the "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 impoundment 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 then computed as the difference between the water "inputs" to the PDSTI and the water lost or stored. A summary of the 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).

Calculation of annual seepage from the tailing impoundment is based on the following equation:

$$\text{SEEPAGE} = \text{WATER DELIVERED} + \text{PRECIPITATION} + \text{SURFACE WATER DISCHARGES} - \text{WATER RECLAIMED} - \text{EVAPORATION} - \text{WATER RETAINED}$$

Descriptions of the methods, data sources, and assumptions used to estimate values for each of the water balance components are provided in the following sections.

Data and operations information for analysis and computation of the water balance components were compiled from: available reports, files, and databases of Phelps Dodge Sierrita Incorporated (PDSI); personal communication with PDSI staff; meteorological data available from PDSI and other nearby weather stations; available satellite images; and other sources as indicated in the subsequent description of methods.

URS's recent investigations at the PDSTI 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-penetrometer tests (CPTs) in the interior and along the crest of the PDSTI **(Figure B-1)**. 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 to improve estimates of other water balance components.

WATER DELIVERED

The water volume delivered to the PDSTI is a function of the amount of ore milled and the pulp density of the slurry (percent solids and water) discharged to the impoundment. The tonnage of ore milled is continuously measured at the Sierrita Mine using as many as 16 “weightometers”, which consist of loading cells underlying the conveyor belts transporting crushed ore into the mill. From 1999 to present, pulp density has been measured essentially continuously using nuclear density meters installed at the outflow of each of four pulp thickeners that feed slurry into the conveyance pipeline to the PDSTI. These pulp density data were provided by PDSI and were used to compute average annual pulp density values. Prior to installation of the nuclear density meters, pulp density was measured manually using a Marcy pulp density scale (Marcy balance), which is also currently used to provide confirmatory measurements for the nuclear density meters. Measurements of both ore tonnage and pulp density are considered accurate due to the direct methods of measurement and the critical importance to overall mining operations.

For the PDSTI water balance, the water delivered to the impoundment was determined based on two sources: 1) for the time period from 1971 to 1987, actual water delivery volumes were available from the mine records (Montgomery & Associates, 1989); and 2) for the time period from 1988 through 2006, water delivery volumes were not directly available but were computed based on available data for tonnage of ore milled and pulp density. Annual water delivery volumes for 1971 through 1987 and values of annual tonnage milled for 1982 through

2006 are given in **Table B-1**. The water delivery volumes for 1971 through 1987 are believed to be based on a pulp density of 55 percent solids, which is supported by the generally agreeable comparison with available data for tonnage milled that were also available for the period from 1982 through 1987. Based on information provided in Reed & Associates (1986) and on anecdotal information from PDSI personnel, a pulp density of 55 percent solids is believed to be representative of, if not a conservatively small estimate of, tailing pulp density for the period from 1971 through 1989. (Note that an underestimate of pulp density value results in an overestimate of water delivered and, therefore, overestimate of seepage through the impoundment.) Beginning in 1990, the pulp density was decreased to approximately 52 percent solids due to slight changes in the mineralogical characteristics of the ore being milled and associated flow properties of the resulting slurry. Based on anecdotal information from PDSI personnel (recorded data were not available), the pulp density of 52 percent solids essentially became the target density from 1990 to present. Therefore, for computing water delivery to the PDSTI for the period from 1988 through 2006, in conjunction with data provided for ore milled, the following pulp densities were used **(Table B-1)**:

- 1988 and 1989: 55 percent (0.55)
- 1990 through 1998: 52 percent (0.52)
- 1999 through 2006: average annual pulp densities (between 47 and 52 percent [0.47 and 0.52]) based on recorded nuclear density measurements

The PDSTI water balance prepared in 1989 (Montgomery & Associates, 1989) assumed a pulp density of 55 percent for all years.

For the water balance time period from 1988 through 2006, computation of water delivered to the impoundment based on data for tonnage of ore milled and pulp density uses the following equation:

$$\text{TOTAL WATER TO IMPOUNDMENT (acre-feet)} = \frac{T_m \times 0.98745}{Dp} \times \frac{V_w}{43{,}560 \text{ ft}^3/\text{acre-foot}}$$

Where, T_m = TONS ORE MILLED PER YEAR
V_w = VOLUME OF WATER PER TON OF PULP
Dp = PULP DENSITY

Inputs and assumptions used in this calculation include:

TONS OF SOLIDS IN TAILING SLURRY = $T_m \times 0.98745$ (assumes ore has 1.255 percent recoverable content of copper and other metals)

PULP DENSITY (Dp): 0.55 (55% solids, 45% water by weight) for 1988 and 1989
0.52 (52% solids, 48% water by weight) for 1990 through 1998
average annual pulp densities (between 0.47 and 0.52) for 1999 through 2006

$$V_w \ (\text{ft}^3) = \frac{(1 - Dp)}{Dw}$$ where Dw = Density of Water = 62.43 pounds/ft^3 or 0.0312 tons/ft^3

<u>Example: 1990 **(Table B-1)**</u>

Tonnage Ore Milled (Tm) = 33,931,999 tons/year

Pulp density (Dp) = 52% (0.52)

Vw is computed to be: (1 – 0.52) / 0.0312 tons/ft^3 = 15.385 ft^3/ton

$$\text{WATER DELIVERED} = \frac{33{,}931{,}999 \text{ tons} \times 0.98745}{0.52} \times \frac{15.385 \text{ ft}^3/\text{ton}}{43{,}560 \text{ ft}^3/\text{acre-foot}} = 22{,}752 \text{ acre-ft}$$

PRECIPITATION

The volume of precipitation falling directly on the PDSTI surface each year was estimated by multiplying measured annual precipitation by the surface area of the tailing impoundment for that year. Annual precipitation values and sizes of the impoundment surface area used in the water balance analysis are summarized in **Table B-2**. Note that precipitation falling on native land within the (eventual) PDSTI area prior to the area being covered by tailing is not included in this "direct precipitation" component of the water balance but is incorporated as stormwater runoff, as described in the following secton.

Precipitation data for the time period from 1974 through 2006 were provided by PDSI based on available measurements from weather stations near the PDSTI and in the Green Valley area. The available data included:

- Annual measurements for the period from 1974 through 1999 from the Western Regional Climate Center for the Green Valley weather station (COOP 023668) and other stations in the Green Valley area.
- Daily and/or monthly precipitation measurements for the time period from 2000 through 2006 from the meteorological station weather located adjacent to the PDSTI **(Figure B-1)**.
- An annual measurement for 1999 from a PDSI rain gauge located near the mine and mill areas

In addition, annual precipitation values for the Sierrita mine were measured during the period from 1960 through 1972; the average annual precipitation value of 15.98 inches per year for this time period was reported in Reed and Associates (1986). Because annual precipitation values were not available for years 1971, 1972, and 1973, the reported average annual precipitation of 15.98 inches per year was used for these years **(Table B-2)**.

The size of the PDSTI over time was estimated using available LANDSAT satellite images, digital aerial photographs, and digital orthophotography. Seven digital aerial images and 22 LANDSAT satellite images were obtained and analyzed to determine the total area of the tailing surface as the impoundment became larger with time. These images were also crucial for analysis of evaporation loss from the PDSTI, which is described in a subsequent section. The seven digital photographs were available for intermittent years ranging from the early-1970s to 2006; a LANDSAT image was obtained for every year from 1984 through 2005. The LANDSAT images are always for the month of May or June, which was chiefly a function of availability; images for other months were not consistently available for every year. Use of images taken during the same period each year provides a consistent basis for evaluating annual changes.

The historic total surface area of the PDSTI was estimated using yearly LANDSAT images for the time period from 1984 through 2005. Scanned aerial photographs and digital orthophotography were used to estimate the area of the impoundment in 1971, 1975, and 2006. For the remaining years when neither LANDSAT or aerial images were available (1972 through 1974 and 1976 through 1983), the area of the PDSTI was estimated by assuming a linear annual growth rate between the dates of available images. Annual growth rates were determined by dividing the change in area during a given time period by the number of years in the time period. The estimated areas of the PDSTI over time are shown on **Table B-2**.

SURFACE WATER DISCHARGES

Surface water discharges to the PDSTI occur as flows delivered in Duval Canal and stormwater runoff from areas upgradient from the impoundment. Flows in Duval Canal consist of baseflow and stormwater runoff. Baseflow is generated by daily discharges of wash water from the mill and is estimated to be 100 gallons per minute (161 acre-feet per year). Baseflow was assumed to be constant since 1971. Stormwater runoff from the mill area watershed is collected by Duval

Canal and delivered to the tailing impoundment. Duval Canal was extended and lined in the mid-1990s; however, for this analysis, it is conservatively assumed that all baseflow and runoff carried in the canal was discharged to the impoundment with no losses to infiltration through the unlined canal prior to the mid-1990s.

Annual volumes of stormwater runoff for the mill area watershed captured by Duval Canal were estimated based on results of runoff model simulations using measured precipitation amounts, estimated watershed surface properties, and measured surface areas. Input parameters required by the model include daily precipitation and soil and land surface properties within the watershed. In 1994, Dames and Moore conducted a detailed surface water runoff analysis for the mine site, including delineating watersheds and characterizing soil and land surface properties (Montgomery & Associates and Dames & Moore, 1994). The Dames and Moore analysis focused on evaluating 100-year storm events and, therefore, did not provide estimates of actual annual runoff. However, based on the soil and land surface properties used for the Dames and Moore analysis, the "SCS Curve Number Method" was used to estimate annual stormwater runoff. This method was developed by the U.S. Soil Conservation Service (1986) (now the National Resource Conservation Service). The Curve Number Method utilizes curve numbers (CNs) and associated empirical relationships to project runoff values from precipitation events. The CN is a function of surface properties such as land use, land cover, soil classification, hydrologic conditions, and antecedent runoff conditions (Hoggan, 1996). The Dames and Moore analysis determined a CN of 86 and an 8 percent impervious area for the mill area watershed. Empirical relationships between precipitation and runoff were readily available for CNs of 85 and 90 (SCS, 1986); therefore, a CN of 85 is used in the runoff model prepared for this discharge analysis because the CN of 85 is closest to the value of 86 determined by Dames and Moore. No water losses due to initial infiltration (initial abstractions) were used in the runoff model, which results in a conservatively large estimate of runoff to the PDSTI.

In addition to discharges from Duval Canal, until tailing covered the entire (current) PDSTI area in 2003, the impoundment received stormwater runoff from upgradient land area between the western margin of the tailing surface and the toe of the Esperanza tailing impoundment. This upgradient area was largest in 1971and decreased through time as the impoundment expanded to the west and covered the native alluvial surface. To estimate annual runoff for this upgradient area, the CN method was used with a CN of 80 and no impervious areas specified for the upgradient alluvial areas. The CN for this area is smaller than the CN for the mill area due to differences in land conditions, especially smaller average slope. An initial abstraction (infiltration) was allowed for this runoff model to account for actual infiltration, which would all likely become evapotranspiration losses eventually. Runoff from the upgradient area was assumed to be completely captured by the tailing impoundment. The size of the upgradient area for each year was determined based on results of the analysis conducted using satellite images and digital aerial photographs described in the previous section.

For both watersheds modeled using the CN method, daily precipitation values were required to project runoff volumes. Daily measurements were not available from PDSI rain gauges or meteorological station prior to 1999. However, daily measured values were available from a meteorological station in Green Valley (COOP 023668) for the period from 1988 through 2006. Incomplete data sets prevented the use of measurements obtained in 1995, 2005, and 2006. For years prior to 1988 and for years with incomplete data sets, annual runoff was assumed to be equal to runoff values modeled for years with similar total annual precipitation amounts measured at meteorological stations in the Green Valley area.

Estimated annual surface water discharges to the PDSTI are summarized in **Table 2** (water balance summary table). These total annual surface discharges were computed by summing the annual values for stormwater runoff projected using the runoff models and CN method for the mill area watershed and the area upgradient from the PDSTI plus the baseflow of 161 acre-feet per year estimated for Duval Canal.

RECLAIMED WATER

Decanted surface water that accumulates in the PDSTI surface pond (reclaim pond) has historically been pumped out of the PDSTI and recycled to the Sierrita mill for use in the mill circuit. Water pumped from the reclaim pond and from the interceptor wellfield is delivered to a reclaim water storage tank at the booster station **(Figure B-1)**. From this tank, reclaim water and interceptor wellfield water are pumped to the Sierrita mill. The combined water pumped from the reclaim water storage tank is metered, as is the water pumped from the interceptor wellfield. Total pumpage of reclaimed decant water is computed by PDSI personnel by subtracting water pumped from the interceptor wellfield from the total water pumped from reclaim water storage tank. Annual reclaim volumes, as provided by PDSI, are summarized in **Table 2**. Reclaim water volumes are available for most years from 1971 through 2006 but are unavailable for the time periods from 1992 through 1994 and from 1999 through 2002. For these time periods, reclaim volumes are assumed to be equal to the average of reported values for the period from 1979 through 2006. Reclaim volumes prior to 1979 were not used to compute this average volume because the values do not appear to be representative of the time periods when reclaim volumes are unavailable. Reported reclaim water volumes from 1979 through 2006 are consistently larger than volumes reported for the period prior to 1979. Furthermore, the ratio of reclaimed water to water delivered via the slurry discharge is typically equal to or less than 0.10 prior to 1979 and equal to or greater than 0.20 after 1979; the change in ratio implies a change in development and/or management of the impoundment or reclaim pumping.

EVAPORATION

Evaporation loss comprises the single largest “output” component of the PDSTI water balance. Due to the importance of evaporation loss in the water balance analysis, and therefore for estimating seepage through the impoundment, a comprehensive approach was used to obtain required data and determine or compute relevant parameters. For the 1989 water balance

(Montgomery & Associates, 1989), which was based on Reed & Associates (1986), evaporation volumes were computed based simply on an "evaporation factor" of 17.57 percent of total water delivered to the PDSTI.

Evaporation of water from the impoundment occurs at relatively large rates from free water surfaces such as the reclaim pond and the "streams" and/or sheet flow that emanate from the tailing discharge spigots as surface water flows toward the reclaim pond. Evaporation also occurs from the entire PDSTI surface at smaller rates that are a function of the relative wetness of the surface tailing. Therefore, determination of annual evaporation loss required investigation of two primary elements: 1) differing evaporation rates from PDSTI surfaces of differing wetness, and 2) quantification of the areas of differing wetness levels. Specific steps to conduct the evaporation analysis included:

- Determine evaporation rate for pond and other free water surfaces in the PDSTI
    - Evaporation pans installed in the PDSTI
- Obtain data for "standard pan" evaporation rates
    - PDSI meteorological station
    - Available data sets from other nearby meteorological stations
- Correlate current measured rates for pans installed in the PDSTI with standard pan rates to determine the "pan coefficient" for estimating pond evaporation rates from standard pan rates
- Use available historic data for standard pan rates, together with pan coefficient to compute historic pond evaporation rates for the PDSTI
- Estimate total surface area of PDSTI over time and delineate areas of differing relative surface wetness
    - Obtain annual satellite images for 1984 through 2005
    - Analyze near infrared signals from satellite images to delineate 10 categories of relative tailing wetness
    - Based on evaluation of digital aerial photography, further refine into 6 categories of relative tailing wetness, ranging from free water to dry tailing

- Determine "soil coefficient" for each relative wetness category to estimate evaporation rate for each category based on pond evaporation rates
    - Based on evaluation of pertinent studies and literature: Blight (2002), Maidment (1992), Sellers (1964), Wu and Wang (2005)
- Compute historic annual evaporation volumes
    - Compile standard pan evaporation rates
    - Multiply standard pan rates by pan coefficient to estimate evaporation rates for pond and other free water surfaces
    - For each soil wetness category determined from the satellite image analysis, multiply associated soil coefficient by pond evaporation rate to estimate evaporation rate from the PDSTI area associated with that wetness category
    - Multiply evaporation rate determined for each category by the associated PDSTI area and sum to compute total annual evaporation loss for the PDSTI

Additional explanation for the methods, sources, and assumptions outlined above are provided in the following sections.

Evaporation Rates

EVAPORATION PANS IN THE PDSTI: Evaporation pans were installed by Montgomery & Associates at three locations within and adjacent to the PDSTI. Locations of the pans, identified as EP-1, EP-2, and EP-3, are shown on **Figure B-1**. Pan EP-1 was installed on May 17, 2007, pan EP-2 was installed on May 25, and pan EP-3 was installed on June 21. Pan EP-1 was initially installed on April 25 within the PDSTI relatively close to the reclaim pond in an attempt to emulate the specific environment of the tailing impoundment and reclaim pond. However, due to the tailing slurry spigotting schedule and access limitations following spigotting, this initial location was abandoned and the pan was then installed at the mapped location on the edge of the PDSTI. Although the final locations were less ideal for simulating the reclaim pond "micro environment", they were still situated in the PDSTI. The three evaporation pans installed by Montgomery & Associates were not "standard pans" but were constructed of plastic with a diameter of 1.5 feet and depth of 2 feet. (A "U.S. Weather Bureau Class A standard pan" is constructed of steel with diameter of 4 feet and depth of 0.83 feet, and is raised 0.5 feet above land surface on a wooden platform.) The three plastic pans were installed within excavations in the impoundment or in an outer berm of the PDSTI so that the top lip of the pan was several inches above the level of the tailing surface and the pans were surrounded by moist tailing (same moisture content of surrounding tailing). However, pan EP-2 was installed on the "divider dike" near the east boundary (dam) of the PDSTI and the tailing surrounding the pan did not maintain the initially moist conditions. The pans were filled with water collected from the reclaim pond so that the high solute concentration of the tailing water would affect evaporation from the pans in a similar manner as the reclaim pond. Measurements of water loss from the three pans were obtained weekly to biweekly by Montgomery & Associates and PDSI personnel during the period from late April through September 2007 and were used to compute evaporation rates. A rain gauge was also installed at each pan location to provide data for correcting the measured evaporation rates for rainfall amounts.

Evaporation rates computed from the three pans are shown on **Figure B-2**. Inspection of the evaporation rate graphs on **Figure B-2** indicates that evaporation rates measured for pan EP-1 from late April through mid July were typically on the order of 0.4 to 0.5 inches per day, and decreased to less than 0.2 inches per day from late July through end of August during the summer rainy season. During September, evaporation rates measured at pan EP-1 were relatively steady at about 0.3 inches per day. Evaporation rates measured for pan EP-2, installed in late May, were larger than for pan EP-1 by about 0.1 to 0.2 inches per day (about 25 to 40 percent) until early July and then were in good agreement with pan EP-1 through the end of September. The larger rates measured for pan EP-2 from late May to early July were essentially equivalent to rates measured for the "AZMET" standard pan (described further below) **(Figure B-2)**. A likely cause for the larger measured rates for pan EP-2 during this time period was more windy conditions at the east side of the impoundment (which are common) and the drier tailing surrounding the pan due to its location at the top of the divider dike (no re-wetting from slurry). It is further likely that the measured rates for pan EP-2 decreased to similar levels as the other pans in early July due to increased humidity and rainfall at the onset of the summer rainy season. Evaporation rates measured for pan EP-3, installed in mid July, were similar to those measured for pans EP-1 and EP-2 through September. As described subsequently, evaporation rates measured for the pans installed in the PDSTI (EP-1, EP-2, and EP-3) were compared and correlated to available standard pan data from the PDSTI meteorological station and other stations; standard pan evaporation rates from the PDSTI station and "AZMET" are also shown on **Figure B-2**.

STANDARD PAN EVAPORATION DATA: Standard pan evaporation measurements from the meteorological station located near the PDSTI **(Figure B-1)** were available from 2003 to present. To obtain standard pan data for years prior to 2003, measurements from offsite (but nearby) weather stations were obtained for the evaporation analysis. Data sources used include the University of Arizona station (COOP ID #28117) of the National Weather Service's Cooperative Station Network (measurements available for 1982 through March 2000) and the Tucson station of the Arizona Meteorological Network (AZMET) (measurements available from 1987 through 2006). The pan evaporation rates obtained from AZMET are based on measured "reference evapotranspiration (ETo)". Evapotranspiration is the combined process of evaporation from the soil surface and transpiration from plant surfaces. ETo values were converted to pan evaporation rates based on a widely used empirical relationship (AZMET, 2007): divide ETo values by 0.7 for cool months (November through April) and divide ETo values by 0.6 for warm months (May through October). Correlation analysis of monthly pan evaporation measurements for 2003 through 2006 (the period of record for the PDSTI station) from the AZMET Tucson station and the PDSTI meteorological station indicate a correlation coefficient of 0.87. Correlation analysis of monthly pan evaporation measurements from the AZMET Tucson station and the University of Arizona station from 1987 through March 2000 indicate a correlation coefficient of 0.95. Measurements from the PDSTI meteorological station could only be correlated to measurements from the AZMET Tucson station because there was no overlap in time with the University of Arizona measurements. The strong correlations between the standard pan data sets allowed the longer-term data sets to be used for projecting / estimating historic pan evaporation rates at the PDSTI, which were then used to compute evaporation rates for free water surfaces (e.g. ponded areas), described subsequently.

Standard pan evaporation measurements from the meteorological station located near the PDSTI **(Figure B-1)** for the time period from April through September 2007 are shown on **Figure B-2**. These standard pan evaporation rates from the PDSTI station are essentially the same as the rates measured for pan EP-1 for the period April 28 through the end of June. The similarity of rates for these two pans is surprising because the rate for the standard pan (PDSTI station) would be expected to be larger than for pan EP-1, which was sunken in the impoundment and filled with reclaim water. The standard pan is filled with fresh water and exposed on all sides to solar radiation; both of these factors would be expected to result in larger evaporation. In addition, the PDSTI standard pan evaporation rates were substantially smaller than the AZMET standard pan rates during this same time period **(Figure B-2)**. For about 1 week in mid July, the standard pan evaporation rates from the PDSTI station were substantially smaller than the rates measured at pans EP-1, EP-2 and EP-3, followed by sporadic rates through mid September (which could be due in part to the higher humidity and precipitation during the summer rainy season). PDSTI standard pan evaporation rates were clearly erroneous for the last two weeks in September, during which the recorded rate was “0” for most days (these values are not shown on **Figure B-2**). Due to these suspect and/or missing intervals in the data set for the PDSTI standard pan (believed to be caused by equipment malfunctions), the PDSTI standard pan data set was not used to represent standard pan evaporation rates in the evaporation analysis.

Due to the data gaps in the available data sets, annual pan evaporation values used in the PDSTI water balance evaporation analysis for 1982 through 1986 are from the University of Arizona station and annual pan evaporation values for 1987 through 2006 are from the AZMET Tucson station. Pan evaporation measurements were not available from the selected data sources for the time period from 1971 through 1981. For this time period, average annual pan evaporation for the AZMET station data set for the period 1987 through 2006 was computed and used for the earlier time period. Annual standard pan evaporation rates used in the evaporation analysis for the PDSTI water balance are given in the second column of **Table B-2**; annual rates range from 9.46 to 11.31 feet per year.

EVAPORATION RATES FOR THE PDSTI: Following computation and/or compilation of the annual standard pan evaporation rates for all years of the water balance, the evaporation rates for "free water surfaces" on the impoundment (reclaim pond and surface flow areas) were computed by multiplying the standard pan evaporation rates by the "pan coefficient". The pan coefficient is equal to the average ratio between the evaporation rates measured with pans EP-1, EP-2, and EP-3 (only pan EP-1 prior to mid-July) to the standard pan evaporation rates (based on the AZMET Tucson station data set). The pan coefficient was determined to be 0.62. A pan coefficient of 0.62 is at the lower end of ranges commonly reported in references or studies of evapotranspiration for relating standard pan rates to lake evaporation rates. Therefore, use of this pan coefficient may result in a conservatively small estimate of evaporation from the PDSTI reclaim pond and surface flow areas.

The final step in determining evaporation rates for the PDSTI is estimating "soil coefficients" that adjust the evaporation rates determined for free water surfaces to rates that are representative of tailing materials with less than saturated water content. Appropriate values or ranges of values for soil coefficients for reasonably similar conditions are available in published studies and reference books, including Blight (2002), Maidment (1992), Sellers (1964), and Wu and Wang (2005). As described in the following section, satellite image analysis was used to divide the PDSTI surface into six sub-areas or categories based on relative water content (relative "wetness"). A soil coefficient was assigned to each category, with the largest coefficient representing the category with the highest water content and correspondingly smaller coefficients for smaller relative water contents. Due to uncertainty regarding the soil coefficients and delineated wetness categories, two sets or ranges of soil coefficients were considered. The larger set of coefficients ranged from 0.85 for "very moist" tailing (close to saturation) to 0.45 for dry tailing, and the smaller set of coefficients ranged from 0.70 for very moist tailing to 0.30 for dry tailing. To compute evaporation rates for each wetness category, the average value for the high and low soil coefficient for that category was computed and the annual evaporation rates determined for the free water surfaces were multiplied by the soil coefficient for that category. Additional description of the relative wetness categories is given in the following section.

Size and Water Content of Tailing Impoundment Surface

The size and moisture conditions (relative "wetness") of the PDSTI over time were estimated using available LANDSAT satellite images, digital aerial photographs, and digital orthophotography. This method is the same as described previously under the section "Precipitation", but is also used in the evaporation analysis for estimating relative wetness of the surface tailing. Seven digital aerial images and 22 LANDSAT satellite images were obtained and analyzed to determine the total area of the tailing surface as the impoundment became larger with time and to estimate the areas of tailing surfaces with differing wetness levels for each year. The seven digital photographs were available for intermittent years ranging from the early-1970s to 2006; a LANDSAT image was obtained for every year from 1984 through 2005. The LANDSAT images are always for the month of May or June, which was chiefly a function of availability; images for other months were not consistently available for every year. Use of images taken during the same period each year provides a consistent basis for evaluating annual changes. Seasonal variations were not considered for this analysis and it is acknowledged that use of one image per year may not accurately represent the relative portions of tailing surfaces with various wetness levels for any given year. However, within the constraints of available and reasonable means for estimating these historic areas and moisture conditions, the approach used for this analysis is believed to be as accurate or representative as possible for trying to quantify the changing conditions with time and their affect on evaporation rates.

The historic total surface area of the PDSTI was estimated using yearly LANDSAT images for the time period from 1984 through 2005. Scanned aerial photographs and digital orthophotography were used to estimate the area of the impoundment in 1971, 1975, and 2006. For the remaining years when neither LANDSAT or aerial images were available (1972 through 1974 and 1976 through 1983), the area of the PDSTI was estimated by assuming a linear annual growth rate between the dates of available images. Annual growth rates were determined by dividing the change in area during a given time period by the number of years in the time period. The estimated areas of the PDSTI surface over time are shown on **Table B-2**.

Spectral analysis of the satellite images was conducted to delineate and estimate areas of relative tailing wetness across the PDSTI surface. The images were analyzed for red (band 3) and near-infrared (band 4) portions of the electromagnetic spectrum. Near-infrared versions of the satellite images are compiled on **Figure B-3**. A linear relationship was produced by plotting red reflectance versus near infrared reflectance; the linear trend line of the plot is referred to as the "soil wetness line". The end values for the soil wetness line are ratios of red to near-infrared reflectance that correspond to ponded water and dry soil; the full range of water content is represented between the end values. The soil wetness line was divided into 10 equal sections, with each section representing an increased water content (starting from dry end value). The actual water content for each section is not known but the gradation from dry to ponded is clear from the spectral analysis and allows initial delineation of "relative wetness" groups or categories. Comparison of the initial 10 sections with available aerial photographs for similar time periods as the satellite images allowed combining of selected sections, which resulted in definition of six relative wetness categories. The six categories are qualitatively described as 1) ponded water, 2) shallow ponded water and stream flow or sheet flow of water produced by slurry spigotting, 3) "very moist" tailing, 4) "moist" tailing, 5) "slightly moist" tailing, and 6) dry tailing. Versions of the satellite images showing areas delineated based on the six relative wetness categories are compiled on **Figure B-4** (ponded water and surface flow are combined into one category). A summary of the PDSTI areas corresponding to the wetness categories for all years of the water balance are given in **Table B-4**. Based on the results of the satellite image spectral analysis and associated determination of the relative wetness categories, the average percentages of PDSTI total area comprising the wetness categories for the time period from 1984 through 2005 (years of available satellite images) are: 1.7 percent for the reclaim pond; 5.3 percent for the shallow ponded and surface flow areas; 36 percent for the "very moist" tailing; 31 percent for the "moist" tailing; 12 percent for the "slightly moist" tailing; and 14 percent for the "dry" tailing.

Because satellite images were not available for the spectral analysis for years prior to 1984 and for 2006, an appropriate average distribution (in percent) of the PDSTI areas into the six wetness categories was used to compute the corresponding areas for the categories for the years with no satellite image available. Therefore, the average wetness distribution determined for the PDSTI from 1984 through 1988 was used to estimate the wetness categories for 1971 through 1983, and the average wetness distribution determined for 2001 through 2005 was used to represent 2006.

As described in the previous section, a soil coefficient was assigned to each category, and the adjusted annual evaporation rate for a given tailing wetness category was computed by multiplying the annual evaporation rates determined for the free water surfaces by the soil coefficient for the respective category. Annual evaporation volumes for the PDSTI were computed by multiplying the adjusted evaporation rate for each category by the tailing impoundment area determined for that category, and summing the volumes for all categories **(Table B-3)**. To account for uncertainty regarding the soil coefficients and delineated wetness categories, two sets or ranges of soil coefficients were considered. The larger set of coefficients consisted of: 0.85 for "very moist" tailing (close to saturation); 0.65 for "moist" tailing; 0.55 for "slightly moist" tailing; and 0.45 for "dry" tailing. The smaller set of coefficients consisted of: 0.70 for very moist tailing; 0.50 for moist tailing; 0.40 for slightly moist tailing; and 0.30 for dry tailing. Both of these sets of soil coefficients are within ranges of (bare) soil coefficients reported in the literature and provide high and low estimates of evaporation rates for the PDSTI that are believed to bound or frame the actual evaporation rates. Therefore, for the PDSTI water balance, the average values of the two sets of soil coefficients were used to compute evaporation rates for the tailing impoundment. The average values for the soil coefficients consisted of: 0.78 for very moist tailing; 0.58 for moist tailing; 0.48 for slightly moist tailing; and 0.38 for dry tailing. A summary of the distribution of evaporation volumes corresponding to the tailing wetness categories for each year, together with the total computed PDSTI evaporation volume for each year, is shown on **Figure B-5** (ponded water and surface flow are combined into one category).

A final adjustment of the computed annual evaporation loss was conducted to help account for the use of one satellite image per year to represent the entire year. The conceptual basis for this adjustment is that the relative wetness conditions and areas indicated by a given year's satellite image, taken mid-year, are essentially evolving toward the conditions indicated by the subsequent year's satellite image, and similarly, evolved from conditions indicated by the previous year's satellite image. Therefore, the overall evaporation volume reported for a given year (final column of **Table B-3** and also reflected in the bar graphs shown on **Figure B-5**) was computed as the sum of one-half of the average for the given year with the previous year and one-half of the average for the given year with the subsequent year. For example, the adjusted 2004 evaporation volume is the sum of one-half the average of the 2003 and 2004 volumes plus one-half the average of the 2004 and 2005 volumes.

WATER RETAINED

Field investigations conducted at the PDSTI in 2007 by URS and Montgomery & Associates included collection of more than 100 tailing samples for laboratory analyses for physical and hydraulic parameters, including water content. Methods and results for these investigations are described in the following section. For the 1989 water balance, water retained in the PDSTI was computed based on results of a specific retention test and generally limited laboratory data for porosity and other parameters. Due to the present availability of substantial data that characterizes water content of the tailing impoundment at many locations and depths, the most appropriate estimate of water retention is the average (mass based) water content determined through the recent investigations because it represents the quantity of water actually being retained during dynamic conditions in the impoundment.

To account for differences in water content observed between samples obtained from the somewhat wetter PDSTI interior and somewhat drier exterior (crest) and the associated areas that might be represented by the interior versus exterior conditions, a weighted average water content was computed. The “exterior” was delineated as an “outer ring” of the PDSTI defined as the outer (approximately) 800 feet of the top of the impoundment plus the area of the tailing dam (this outer ring excluded the vicinity of the reclaim pond). Based on this general delineation, the exterior conditions represented about 20 percent of the total PDSTI area and the interior conditions represented about 80 percent. (Note that explanations for the interior and exterior sample locations and results are provided in the following section.) Therefore the weighted average water content for the PDSTI was computed as the average interior water content (19.5 percent) multiplied by 0.8 plus the average exterior water content (16.4 percent) multiplied by 0.2, which is equal to 18.9 percent.

To compute annual water retention volumes, the mass of solids being added to the impoundment during a given year was simply multiplied by the weighted average water content (18.9 percent) and appropriate conversion factors. It is important to note that mass-based water content is used for this analysis because it is being multiplied by the mass of solids to compute water mass, and ultimately, water volume. The mass of solids is equal to the reported annual tonnage of (dry) ore, reduced by the percent of recoverable copper and other metals (adjustment factor = 0.98745); this mass is equivalent to the mass of (dry) tailing delivered to the PDSTI. Annual volumes of water retained, computed based on tonnage of ore milled, are summarized in **Table 2**. For the time period from 1971 through 1981, data for tonnage of ore milled were not available. However, as previously described in the "Water Delivered" section, water delivery volumes were directly provided for this time period and are likely to be based on a pulp density of 55 percent solids. Therefore, the annual water delivery volumes were used to "back-calculate" the annual tonnages of ore milled for these years based on pulp density of 55 percent, and the ore tonnages were then used to compute annual volumes of water retained.

PHYSICAL AND HYDRAULIC CHARACTERIZATION OF THE PDSTI

As described at the beginning of this appendix, URS recently conducted investigations at the PDSTI for geotechnical characterization and slope stability evaluation of the tailing dam, which were augmented by Montgomery & Associates to provide additional data for characterization of the tailing impoundment. Investigations were conducted during February through April 2007, and included collection of more than 100 samples of tailing for laboratory physical and hydraulic analyses. Locations of the investigations conducted in 2007 are shown on **Figure B-1**. Samples were obtained during drilling of piezometers CD-07, DE-07, and H2-07, which are located along the crest of the PDSTI and completed to depths ranging from 145 to 200 feet. Samples were also obtained during drilling of exploration borehole CD2-07, located in the interior of the impoundment **(Figure B-1)**, to a depth of 150 feet. In addition, samples were obtained at many locations in the interior of the impoundment using the CPT rig's direct push capabilities (identifiers of "CS" and "MA" on **Figure B-1**). Montgomery & Associates personnel also obtained tailing samples from hand-augered borings at Stations 1, 2, and 4 in the impoundment interior **(Figure B-1)** at depths ranging from 1 to 22 feet. Tailing samples were obtained from the piezometers and borings using 2-inch and 2.5-inch diameter split-spoon samplers and a 3-inch diameter Shelby Tube sampler, and for the CPT holes, using a 1-inch diameter coring device that was hydraulically pushed by the CPT rig. Additional information and results for the borehole drilling and sampling, piezometer installation, and CPT investigations conducted by URS are provided in URS' draft Sierrita tailing dam stability evaluation report (URS, 2007).

Tailing samples obtained by Montgomery & Associates during the PDSTI field investigations were analyzed for physical and hydraulic properties by GeoSystems Analysis Inc., Tucson. Laboratory analyses included hydraulic conductivity/permeability, particle size distribution (sieve and hydrometer analyses), water content, bulk density, Atterberg limits, and particle density. Tailing samples obtained by URS were analyzed by URS' geotechnical laboratory (Totowa, New Jersey) for essentially the same physical and hydraulic properties as analyzed for the Montgomery & Associates' samples, plus additional engineering properties such as consolidation and shear strength (URS, 2007). Laboratory results for physical and hydraulic properties for both URS's and Montgomery & Associates' samples are summarized in **Table B-5**.

Results of the PDSTI sampling and laboratory analyses provide a substantial data set for characterizing physical and hydraulic properties of the tailing impoundment. The data were analyzed by evaluating possible relationships of physical and hydraulic properties with depth or location on the impoundment. Graphs and regressions prepared to evaluate possible depth relationships generally indicated slight trends that might be generally expected, such as increasing bulk density or decreasing permeability with depth. However, the large range or scatter of values indicated by the results **(Table B-5)** for most properties at the depths and locations investigated resulted in poor regression coefficients. The large range of results with depth or location is generally due to the highly stratified conditions within the impoundment, which are due to the fluvial deposition process of tailing from the slurry as it is discharged onto the impoundment. However, by separating results into large-scale groupings such as "shallow" versus "deep" samples and "interior" versus "exterior" samples, some general differences became more apparent and provided a basis for further use of the parameters in other analyses such as water retention.

Results of the laboratory analyses were grouped based on sample depth: "shallow" samples were defined as originating from depths less than or equal to 30 feet below the tailing surface, and "deep" samples were defined as originating from depths larger than 30 feet. Laboratory results were also grouped based on whether the borehole, piezometer, or CPT was located in the "interior" of the impoundment or the "exterior" (on the crest of the tailing dam). The sampling locations considered to be "exterior" comprised the crest piezometers CD-07, DE-07, and H2-07, and Station 4 **(Figure B-1)**. The sampling locations considered to be "interior" comprised borehole CD2-07, Stations 1 and 2, and CPT sites CS-1, CS-3, CS-5, MA-1, and MA-2. For each of these sample groups, average values were computed for the laboratory results for the physical and hydraulic properties analyzed. The average results are summarized in **Table B-6**. Based on overall evaluation of the laboratory results and on comparison of the average results for the sample groups, relevant results and possible relationships indicated by the data include:

Particle Size Distribution

- Particle size distribution for most of the tailing samples falls within a relatively narrow range: results for silt and clay content are predominantly within a range of 35 to 65 percent (of total sample mass). There were essentially no gravel-sized particles in the tailing samples.

- Overall, a majority of samples had a larger sand content than silt and clay content, and would be described as "silty sand" and "silty fine sand"; average silt and clay content for all samples is 43 percent.

- Clay content was measured for selected samples that generally appeared to have higher plasticity than other samples. Clay content for these samples was typically less than 10 percent (overall average was about 9 percent), with a maximum of 19 percent. These results indicate that the fine-grained portion of the tailing is predominantly silt but strata with larger clay content are present. Results for Atterbery Limits indicate that most samples analyzed were non-plastic or had a plasticity index of less than 5 percent. These results are consistent with the generally small clay content of the tailing samples.

- If results for each borehole, piezometer, and/or CPT site are evaluated as a whole and compared to the results for other boreholes, piezometers, or CPT sites, the interior sites do not appear substantially more fine-grained than the exterior sites (chiefly crest piezometers), with the exception of piezometer H2-07, which had generally larger sand content. Based on comparison of the average results for the sample groups, silt and clay content appears to be slightly larger in the interior samples (45 percent) than in the exterior samples (38 percent). The occurrence of only a slight difference in particle size distribution between the interior and exterior samples suggests that the amount of sorting that occurs during slurry discharge and flow at the PDSTI may not be very substantial over much of the impoundment. However, it is important to note that samples could not be obtained beneath or very close to the reclaim pond, where fine-grained tailing would likely be predominant.

- Based on comparison of the average results for the sample groups, silt and clay content appears to be slightly larger in the deeper samples (45 percent) than in the shallow samples (39 percent). The small difference indicated between these sample groups is not believed to have much significance; a relationship or trend in silt and clay content with depth would not generally be expected unless the ore composition and/or ore processing changed historically, which are not known to have occurred.

Water Content

- Overall, water content is generally large; average mass-based water content for all samples is 18.3 percent and average volumetric water content for all samples is 30.9 percent. Based on an average total porosity of 39.1 percent, average level of saturation for the samples is 80.2 percent.

- Based on comparison of the average results for the sample groups, volumetric water content appears to be notably larger in the interior samples (33.5 percent) than in the exterior samples (26.5 percent), and similarly larger in the deeper samples (34.5 percent) than in the shallow samples (24.1 percent).

- The general relationship of drier conditions near the PDSTI margins would be expected due to less opportunity for infiltration as the majority of water from spigotted slurry generally flows away from the higher elevation margins toward the PDSTI interior. This relationship is also consistent with the occurrence of slightly coarser-grained tailing near the impoundment margins.

Bulk Density

- Overall, bulk density values for the tailing samples are moderate and most results vary within a relatively small range of 1.5 to 1.8 grams per cubic centimeter (g/cm^3); average bulk density for all samples is 1.63 g/cm^3.

- Based on comparison of the average results for the sample groups, bulk density appears to be notably larger in the deeper samples (1.67 g/cm^3) than in the shallow samples

(1.55 g/cm^3). However, for samples obtained below the upper 20 to 40 feet of the impoundment, evaluation of results does not indicate a general relationship of increasing bulk density with depth.

- Based on comparison of the average results for the sample groups, bulk density appears to be slightly larger in the interior samples (1.64 g/cm^3) than in the exterior samples (1.60 g/cm^3); this difference is not likely significant.

Hydraulic Conductivity

- Laboratory results for saturated hydraulic conductivity varied substantially for the tailing samples analyzed, ranging from a maximum of 1.2 x 10^{-3} centimeters per second (cm/sec) to a minimum of 2.7 x 10^{-7} cm/sec; overall average (geometric mean) saturated hydraulic conductivity was 6.9 x 10^{-6} cm/sec.

- Most of the laboratory-measured values for hydraulic conductivity, as well as the overall average value, are relatively small, despite the results for particle size distribution indicating typically less than 50 percent silt and clay content. This is likely due to the sand fraction being predominantly very fine to fine sand, which when combined with the substantial silt fraction, results in smaller conductivity than might be expected based on sand content alone.

- Evaluation of results for all samples does not indicate an apparent or consistent relationship of hydraulic conductivity with depth. Saturated hydraulic conductivity appears to be only slightly larger in the shallow samples (1.1 x 10^{-5} cm/sec) than in the deeper samples (6.1 x 10^{-6} cm/sec).

- Based on comparison of the average results for the sample groups, saturated hydraulic conductivity appears to be notably larger in the <u>interior</u> samples (1.2 x 10^{-5} cm/sec) than in the exterior samples (2.4 x 10^{-6} cm/sec). The smaller average hydraulic conductivity for the exterior samples compared to the interior samples may not be an accurate representation of actual conditions, but it does support results for other physical properties indicating smaller differences between conditions at the interior and exterior parts of the tailing impoundment than might be expected based on typical depositional processes from discharge of tailing slurry at the impoundment margins.

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TABLE B-1. ANNUAL WATER DELIVERY VOLUMES TO SIERRITA TAILING IMPOUNDMENT PHELPS DODGE SIERRITA MINE, PIMA COUNTY, ARIZONA

YEAR	ORE MILLED (million tons)	PULP DENSITY[a]	WATER DELIVERED TO IMPOUNDMENT (acre-feet)
1971	23.14[b]	(0.55)[c]	13,756
1972	28.76[b]	(0.55)[c]	17,092
1973	28.17[b]	(0.55)[c]	16,741
1974	28.90[b]	(0.55)[c]	17,179
1975	30.05[b]	(0.55)[c]	17,862
1976	30.89[b]	(0.55)[c]	18,361
1977	28.19[b]	(0.55)[c]	16,754
1978	34.78[b]	(0.55)[c]	20,672
1979	32.37[b]	(0.55)[c]	19,242
1980	33.74[b]	(0.55)[c]	20,056
1981	30.78[b]	(0.55)[c]	18,292
1982	16.14	(0.55)[c]	9,853
1983	21.24	(0.55)[c]	13,008
1984	29.08	(0.55)[c]	17,730
1985	36.99	(0.55)[c]	21,847
1986	28.14	(0.55)[c]	16,976
1987	27.60	(0.55)[c]	16,012
1988	32.08	0.55	19,067
1989	32.12	0.55	19,091
1990	33.93	0.52	22,752
1991	34.68	0.52	23,251
1992	35.52	0.52	23,817
1993	36.04	0.52	24,166
1994	38.77	0.52	25,994
1995	40.64	0.52	27,248
1996	39.92	0.52	26,768
1997	40.78	0.52	27,342
1998	40.75	0.52	27,326
1999	37.66	0.508	26,527
2000	38.32	0.513	26,428
2001	38.13	0.508	26,776
2002	21.44	0.470	17,548
2003	26.65	0.496	19,695
2004	34.88	0.516	23,797
2005	39.20	0.519	26,344
2006	38.44	0.515	26,323

[a] Pulp density is the ratio of solids to water in the tailing slurry; measured values were only available for 1999 through 2006. Pulp densities of 52 and 55 percent solids were "target" values used for the years indicated above (based on anecdotal information from PDSI personnel).

[b] Measurements of ore tonnage milled were not available for 1971 through 1981; values shown for this period were "back-calculated" from reported water delivery volumes and a pulp density of 55 percent solids, which is believed to be the original basis for the reported water delivery volumes.

[c] Pulp density value of 55 percent solids was not used to compute water delivery volumes given in this table for 1971 through 1987. However, pulp density of 55 percent is believed to be the original basis for the reported delivery volumes, which is supported by the fact that use of this pulp density to compute annual water delivery volumes from the reported annual ore tonnage for the period 1982 through 1989 (when data for both ore tonnage and water delivery were available) results in similar values of water delivered to those provided separately.

TABLE B-2. ESTIMATED VOLUME OF DIRECT PRECIPITATION ONTO SIERRITA TAILING IMPOUNDMENT, PHELPS DODGE SIERRITA MINE, PIMA COUNTY, ARIZONA

YEAR	ANNUAL PRECIPITATION[a]		IMPOUNDMENT AREA[b]	PRECIPITATION VOLUME[c]
	(inches)	(feet)	(acres)	(acre-feet)
1971	15.98	1.33	549	731
1972	15.98	1.33	733	976
1973	15.98	1.33	917	1,221
1974	16.68	1.39	1,101	1,530
1975	9.40	0.78	1,285	1,007
1976	13.54	1.13	1,370	1,546
1977	20.39	1.70	1,455	2,472
1978	27.18	2.27	1,541	3,490
1979	13.22	1.10	1,626	1,791
1980	15.74	1.31	1,711	2,244
1981	24.47	2.04	1,796	3,662
1982	19.46	1.62	1,881	3,050
1983	32.53	2.71	1,967	5,332
1984	29.22	2.44	2,187	5,325
1985	20.36	1.70	2,438	4,136
1986	15.30	1.28	2,425	3,092
1987	17.74	1.48	2,436	3,602
1988	11.52	0.96	2,461	2,363
1989	10.10	0.84	2,609	2,196
1990	21.68	1.81	2,650	4,788
1991	15.76	1.31	2,802	3,680
1992	18.33	1.53	2,732	4,173
1993	22.00	1.83	2,766	5,071
1994	12.14	1.01	2,786	2,818
1995	11.75	0.98	2,887	2,827
1996	10.07	0.84	2,984	2,504
1997	10.26	0.86	2,916	2,493
1998	14.54	1.21	3,026	3,667
1999	13.69	1.14	2,964	3,382
2000	16.55	1.38	3,017	4,160
2001	13.34	1.11	3,100	3,446
2002	10.49	0.87	3,100	2,710
2003	15.99	1.33	3,100	4,131
2004	12.67	1.06	3,100	3,273
2005	12.86	1.07	3,100	3,322
2006	17.36	1.45	3,100	4,485

[a] Annual precipitation value used for 1971 through 1973 is the average of measured annual precipitation at the PDSI mine from 1960 through 1972, as reported in Reed & Associates (1986); values for 1974 through 1998 are average measurements from meteorological stations in the Green Valley area; values for 1999 through 2006 are average measurements from PDSI rain gauges near the mill, mine, and tailing impoundment areas.

[b] Historic tailing impoundment area was estimated using scanned aerial photographs, digital orthophotography, and LANDSAT images; tabulated values are for the surface area of the top of the impoundment (excludes the tailing dam).

[c] Annual volume of precipitation falling on the PDSTI, in acre-feet, is computed by multiplying annual precipitation amount, in feet, by the area of the impoundment for the given year, in acres.

TABLE B-3. SUMMARY OF EVAPORATION VOLUMES FOR SIERRITA TAILING IMPOUNDMENT WATER BALANCE
PHELPS DODGE SIERRITA MINE, PIMA COUNTY, ARIZONA

YEAR	STANDARD PAN EVAPORATION[a] (feet)	COMPUTED EVAPORATION VOLUMES[b] (acre-feet)							
		CATEGORIES OF RELATIVE SURFACE WETNESS[c]						TOTAL[f]	ADJUSTED TOTAL[g]
		FREE WATER SURFACE (pan coeff. = 0.62)		VERY MOIST TAILING (soil coeff. = 0.78)[e]	MOIST TAILING (soil coeff. = 0.58)[e]	SLIGHTLY MOIST TAILING (soil coeff. = 0.48)[e]	DRY TAILING (soil coeff. = 0.38)[e]		
		POND	SURFACE FLOW[d]						
1971	10.19	17	415	970	426	273	176	2,276	2,467
1972	10.19	22	555	1,295	569	364	235	3,039	3,039
1973	10.19	28	694	1,620	711	455	294	3,802	3,802
1974	10.19	33	833	1,944	854	547	353	4,564	4,565
1975	10.19	39	972	2,270	997	638	412	5,328	5,225
1976	10.19	42	1,037	2,420	1,063	680	439	5,680	5,680
1977	10.19	44	1,101	2,570	1,129	722	466	6,033	6,034
1978	10.19	47	1,166	2,722	1,196	765	494	6,389	6,388
1979	10.19	49	1,231	2,872	1,261	807	521	6,742	6,742
1980	10.19	52	1,295	3,022	1,327	849	548	7,094	7,094
1981	10.19	55	1,359	3,172	1,393	892	575	7,447	7,456
1982	10.23	57	1,430	3,338	1,466	938	605	7,836	7,745
1983	9.82	58	1,435	3,349	1,471	941	607	7,861	7,941
1984	10.08	24	457	3,731	1,828	1,039	1,128	8,207	9,423
1985	10.42	207	6,403	6,037	754	13	2	13,416	11,436
1986	10.73	64	2,265	4,810	821	2,061	686	10,705	10,967
1987	10.31	44	23	2,924	3,808	1,544	700	9,042	9,458
1988	10.11	38	265	3,954	2,119	1,379	1,289	9,044	9,579
1989	11.31	117	1,571	4,509	2,317	639	2,031	11,184	10,416
1990	10.03	39	129	5,825	2,370	637	1,252	10,251	10,418
1991	9.85	829	315	4,128	1,672	674	2,371	9,988	10,036
1992	9.46	337	65	4,363	3,186	1,398	569	9,918	9,949
1993	9.62	150	167	3,946	3,960	803	945	9,971	10,494
1994	10.37	257	825	7,389	2,203	689	753	12,116	11,944
1995	10.43	92	778	10,369	1,762	299	273	13,574	13,309
1996	10.88	292	1,890	6,906	3,906	656	321	13,971	13,868
1997	10.59	548	1,371	8,674	2,998	255	108	13,955	13,717
1998	9.99	215	2,514	5,432	3,706	748	373	12,988	13,268
1999	10.53	55	941	8,305	2,241	925	675	13,142	12,936
2000	10.12	486	216	6,234	4,306	1,043	186	12,470	12,116
2001	9.56	579	117	1,409	5,249	2,277	751	10,382	11,025
2002	10.35	244	40	2,220	5,126	2,079	1,155	10,865	10,493
2003	10.10	439	128	798	4,711	1,659	2,126	9,860	10,926
2004	10.07	779	955	7,325	2,618	793	648	13,119	12,323
2005	9.97	625	1,289	7,131	3,213	728	208	13,195	12,772
2006	9.95	539	511	3,803	4,221	1,521	983	11,579	11,983

[a] Annual "standard pan" evaporation rates are from University of Arizona weather station for 1982 through 1986, and from the Tucson weather station of the Arizona Meteorological Network (AZMET) for 1987 through 2006. Standard pan values were not available for 1971 through 1981; value used for this time period is the average of annual pan evaporation from the AZMET Tucson station for 1987 through 2006.

[b] Annual evaporation volumes were computed using the following equations:

FREE WATER EVAPORATION in acre-feet = (PAN EVAPORATION in feet) x (PAN COEFFICIENT) x (SURFACE AREA in acres) (Surface areas are given in **Table B-4**)

TAILING EVAPORATION in acre-feet = (PAN EVAPORATION in feet) x (PAN COEFFICIENT) x (SOIL COEFFICIENT) x (SURFACE AREA in acres)

[c] Categories of relative surface wetness were delineated by spectral analysis of satellite images.

[d] SURFACE FLOW refers to "streams" and sheet flow from spigot locations toward PDSTI interior and reclaim pond.

[e] Soil evaporation coefficients used to compute evaporation from the delineated areas of relative surface wetness are the average of values that represent the high and low ends of the potential range of coefficients.

[e] Total evaporation is equal to the sum of computed evaporation from all categories (tailing impoundment areas) of relative wetness.

[f] Adjusted total evaporation accounts for changes in the PDSTI area and surface wetness categories (areas) between years; adjusted value for a given year was computed as the average of total evaporation in the given year and total evaporation in the years before and after the given year.

TABLE B-4. SUMMARY OF ANNUAL AREAS OF RELATIVE WETNESS CATEGORIES FOR SIERRITA TAILING IMPOUNDMENT EVAPORATION ANALYSIS PHELPS DODGE SIERRITA MINE, PIMA COUNTY, ARIZONA

YEAR	TOTAL IMPOUNDMENT AREA[a] (acres)	CATEGORIES OF RELATIVE SURFACE WETNESS[b]					
		POND AREA (acres)	SURFACE FLOW AREA[c] (acres)	VERY MOIST TAILING AREA (acres)	MOIST TAILING AREA (acres)	SLIGHTLY MOIST TAILING AREA (acres)	DRY TAILING AREA (acres)
1971	549	3	66	198	117	91	74
1972	733	4	88	265	157	121	99
1973	917	4	110	331	196	152	124
1974	1,101	5	132	397	235	182	149
1975	1,285	6	154	464	275	213	174
1976	1,370	7	164	494	293	227	185
1977	1,455	7	174	525	311	241	197
1978	1,541	7	185	556	329	255	208
1979	1,626	8	195	587	347	269	220
1980	1,711	8	205	618	366	283	231
1981	1,796	9	215	648	384	297	243
1982	1,881	9	225	679	402	311	254
1983	1,967	9	236	710	420	326	266
1984	2,187	4	73	770	509	350	481
1985	2,438	32	991	1,206	203	4	1
1986	2,425	10	340	933	215	652	275
1987	2,436	7	4	590	1,036	508	292
1988	2,461	6	42	814	588	463	548
1989	2,609	17	224	830	574	192	772
1990	2,650	6	21	1,208	663	216	537
1991	2,802	136	52	872	476	232	1,035
1992	2,732	57	11	959	944	501	258
1993	2,766	25	28	853	1,154	283	422
1994	2,786	40	128	1,483	596	226	312
1995	2,887	14	120	2,069	474	97	113
1996	2,984	43	280	1,321	1,007	205	127
1997	2,916	83	209	1,704	794	82	44
1998	3,026	35	406	1,131	1,040	254	161
1999	2,964	8	144	1,641	597	298	276
2000	3,017	77	34	1,282	1,194	350	79
2001	3,100	98	20	307	1,540	809	338
2002	3,100	38	6	446	1,389	682	480
2003	3,100	70	20	164	1,308	558	905
2004	3,100	125	153	1,514	729	267	277
2005	3,100	101	209	1,489	904	248	90
2006	3,100	87	83	796	1,190	519	425

NOTE: Areas given for relative wetness categories are based on results of spectral analysis of satellite images from 1984 through 2005. Satellite images were not available for years prior to 1984 and for 2006; therefore, the average wetness distribution determined for 1984 through 1988 was used for 1971 through 1983, and the average wetness distribution determined for 2001 through 2005 was used for 2006.

[a] Historic tailing impoundment area estimated using scanned aerial photographs, digital orthophotography, and satellite images; tabulated values are for the top surface area of the impoundment only (excludes the tailing dam).

[b] Categories of relative surface wetness were delineated by spectral analysis of satellite images.

[c] SURFACE FLOW AREA consists of surface "streams" and sheet flow from spigot locations toward PDSTI interior and reclaim pond.

TABLE B-5. SUMMARY OF LABORATORY RESULTS FOR SOIL PHYSICAL AND HYDRAULIC ANALYSES FOR TAILING SAMPLES OBTAINED IN 2007 FROM SIERRITA TAILING IMPOUNDMENT, PHELPS DODGE SIERRITA MINE, PIMA COUNTY, ARIZONA

SAMPLE LOCATION	SAMPLE DEPTH (feet, bls)[a]	DRY BULK DENSITY[b] (g/cm3)[c]	WATER CONTENT Mass Based[d] (percent)	WATER CONTENT Volumetric[e] (percent)	PARTICLE DENSITY[f] (g/cm3)	TOTAL POROSITY[g] (percent)	SATURATION[h] (percent)	SATURATED HYDRAULIC CONDUCTIVITY[i] (cm/sec)[j]	PARTICLE SIZE DISTRIBUTION[k] SAND (percent, by mass)	PARTICLE SIZE DISTRIBUTION[k] SILT and CLAY (percent, by mass)	PARTICLE SIZE DISTRIBUTION[k] CLAY (percent, by mass)	ATTERBERG LIMITS[l] LIQUID LIMIT (percent, by mass)	ATTERBERG LIMITS[l] PLASTIC LIMIT (percent, by mass)	ATTERBERG LIMITS[l] PLASTICITY INDEX (percent, by mass)
CD-07	11.5 - 13.0	- - -	9.4	- - -	- - -	- - -	- - -	- - -	66.3	33.7	- - -	- - -	- - -	- - -
(piezometer)														
	21.0 - 21.5	1.44	11.3	16.2	- - -	46.97	34	- - -	60	40	- - -	- - -	- - -	- - -
	25.0 - 27.5													
	25.1	- - -	10.6	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
	25.7	- - -	12.7	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
	25.9	1.63	9.0	- - -	- - -	- - -	- - -	1.7E-06	- - -	- - -	- - -	- - -	- - -	- - -
	26.2	- - -	7.5	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
	26.45	1.59	16.8	26.7	2.657	40.13	67	1.6E-06	54.9	45.1	- - -	24	21	3
	26.8	- - -	25.0	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
	27	1.61	23.3	- - -	- - -	- - -	- - -	2.8E-07	34.2	65.8	14	- - -	- - -	- - -
	39.0 - 39.5	1.73	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
	40.5 - 41.0	- - -	15.0	25.9	2.64	34.47	75	- - -	62	38	7	- - -	- - -	NP
	41.0 - 41.5	- - -	- - -	- - -	- - -	- - -	- - -	1.5E-05	- - -	- - -	- - -	- - -	- - -	- - -
	60.75 - 61.0	1.26	17.3	21.7	- - -	53.67	40	- - -	- - -	- - -	- - -	- - -	- - -	- - -
	81.5 - 84													
	81.6	- - -	35.8	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
	82.15	- - -	18.2	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
	82.4	1.68	21.3	- - -	- - -	- - -	- - -	2.7E-06	- - -	- - -	- - -	- - -	- - -	- - -
	82.7	- - -	22.9	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
	82.95	1.61	21.1	34.0	2.679	39.91	85	3.0E-06	54.7	45.3	8	22	21	1
	90.25 - 90.5	1.81	23.3	42.1	2.81	35.59	100	- - -	48	52	- - -	- - -	- - -	- - -
	91.0 - 91.5	- - -	- - -	- - -	- - -	- - -	- - -	1.9E-06	- - -	- - -	- - -	22	20	2
	101.0 - 101.5	1.33	15.6	20.8	- - -	50.90	41	- - -	- - -	- - -	- - -	- - -	- - -	- - -
	162.0 - 162.5	- - -	24.1	- - -	2.77	- - -	- - -	- - -	54	46	- - -	- - -	- - -	NP
	180.0 - 181.0	1.61	21.1	34.0	2.679	39.91	85	3.0E-06	54.7	45.3	8	22	21	1
CD2-07	1.0	1.29	12.7	- - -	- - -	- - -	- - -	- - -	53	47	- - -	- - -	- - -	- - -
(deep														
borehole)	5.0 - 5.75													
	5.35	- - -	11.3	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
	5.9	- - -	12.4	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
	6.45	- - -	7.1	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
	6.7	1.63	16.1	26.2	- - -	40.15	65	- - -	- - -	33.7	- - -	- - -	- - -	- - -

ERROL L. MONTGOMERY & ASSOCIATES, INC.

TABLE B-5. SUMMARY OF LABORATORY RESULTS FOR SOIL PHYSICAL AND HYDRAULIC ANALYSES FOR TAILING SAMPLES OBTAINED IN 2007 FROM SIERRITA TAILING IMPOUNDMENT, PHELPS DODGE SIERRITA MINE, PIMA COUNTY, ARIZONA

SAMPLE LOCATION	SAMPLE DEPTH (feet, bls)[a]	DRY BULK DENSITY[b] (g/cm3)[c]	WATER CONTENT Mass Based[d] (percent)	WATER CONTENT Volumetric[e] (percent)	PARTICLE DENSITY[f] (g/cm3)	TOTAL POROSITY[g] (percent)	SATURATION[h] (percent)	SATURATED HYDRAULIC CONDUCTIVITY[i] (cm/sec)[j]	PARTICLE SIZE DISTRIBUTION[k] SAND (percent, by mass)	PARTICLE SIZE DISTRIBUTION[k] SILT and CLAY (percent, by mass)	PARTICLE SIZE DISTRIBUTION[k] CLAY (percent, by mass)	ATTERBERG LIMITS[l] LIQUID LIMIT (percent, by mass)	ATTERBERG LIMITS[l] PLASTIC LIMIT (percent, by mass)	ATTERBERG LIMITS[l] PLASTICITY INDEX (percent, by mass)
CD2-07	10.0	- - -	22.0	- - -	- - -	- - -	- - -	- - -	65	35	- - -	- - -	- - -	- - -
(continued)														
	10.0 - 12.5													
	10.5	- - -	20.0	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
	10.7	1.47	15.0	- - -	- - -	- - -	- - -	4.3E-05	- - -	- - -	- - -	- - -	- - -	- - -
	11	- - -	19.2	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
	11.3	1.55	21.2	32.8	2.675	42.10	78	5.1E-06	- - -	49.3	8	28	23	5
	11.6	- - -	22.6	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
	11.8	- - -	20.5	- - -	- - -	- - -	- - -	2.7E-06	- - -	- - -	- - -	- - -	- - -	- - -
	20.25 - 20.5	1.59	- - -	- - -	2.97	46.40	65	- - -	68	32	4	- - -	- - -	- - -
	21.5 - 22.0	- - -	18.9	30.1	- - -	- - -	- - -	7.7E-06	- - -	- - -	- - -	- - -	- - -	- - -
	25.25 - 25.5	- - -	- - -	- - -	2.74	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	NP
	26.5 - 27	1.18[m]	20.6	- - -	- - -	- - -	- - -	- - -	60	40	- - -	- - -	- - -	- - -
	35.0 - 37.5													
	35.5	- - -	14.4	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
	36.1	- - -	24.5	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
	36.2	- - -	24.7	- - -	- - -	- - -	- - -	1.4E-06	- - -	64.7	- - -	- - -	- - -	- - -
	36.4	1.60	23.5	37.6	- - -	41.16	91	- - -	- - -	- - -	- - -	- - -	- - -	- - -
	36.6	- - -	21.1	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
	50.0 - 52.5													
	50.6	- - -	23.0	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
	50.8	1.63	19.2	- - -	- - -	- - -	- - -	2.1E-06	- - -	- - -	- - -	- - -	- - -	- - -
	51.1	- - -	14.0	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
	51.4	1.64	14.3	23.4	2.665	38.58	61	3.8E-05	72.0	28.0	6	NP	NP	NP
	51.7	- - -	14.6	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
	51.9	1.69	11.7	- - -	- - -	- - -	- - -	6.9E-05	- - -	- - -	- - -	- - -	- - -	- - -
	60.25 - 60.5	1.73	- - -	- - -	2.71	36.08	100	- - -	56	44	6	- - -	- - -	- - -
	61.5 - 62.0	- - -	22.0	38.2	- - -	- - -	- - -	1.6E-05	- - -	- - -	- - -	- - -	- - -	- - -
	100.0 - 102.5													
	100.15	- - -	20.5	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
	100.7	- - -	26.1	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
	101.3	- - -	16.8	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
	101.5	- - -	24.7	- - -	- - -	- - -	- - -	- - -	38.5	61.5	- - -	- - -	- - -	- - -
	101.8	- - -	22.6	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
	102.75 - 103.0	1.65	- - -	- - -	- - -	- - -	- - -	- - -	62	38	- - -	- - -	- - -	- - -
	103.0 - 103.5	- - -	22.6	37.3	3.16[m]	- - -	- - -	2.5E-06	- - -	- - -	- - -	- - -	- - -	NP
	111.0 - 111.5	1.86	23.5	43.6	- - -	- - -	- - -	- - -	- - -	- - -	- - -	22	19	3
	111.5 - 112.0	- - -	- - -	- - -	2.74	32.12	100	2.1E-06	50	50	8	- - -	- - -	- - -

TABLE B-5. SUMMARY OF LABORATORY RESULTS FOR SOIL PHYSICAL AND HYDRAULIC ANALYSES FOR TAILING SAMPLES OBTAINED IN 2007 FROM SIERRITA TAILING IMPOUNDMENT, PHELPS DODGE SIERRITA MINE, PIMA COUNTY, ARIZONA

SAMPLE LOCATION	SAMPLE DEPTH	DRY BULK DENSITY[b]	WATER CONTENT		PARTICLE DENSITY[f]	TOTAL POROSITY[g]	SATURATION[h]	SATURATED HYDRAULIC CONDUCTIVITY[i]	PARTICLE SIZE DISTRIBUTION[k]			ATTERBERG LIMITS[l]		
			Mass Based[d]	Volumetric[e]					SAND	SILT and CLAY	CLAY	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
	(feet, bls)[a]	(g/cm3)[c]	(percent)	(percent)	(g/cm3)	(percent)	(percent)	(cm/sec)[j]	(percent, by mass)			(percent, by mass)		
CD2-07	120.25 - 120.5	- - -	- - -	- - -	2.76	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	NP
(continued)	121.5 - 122.0	1.06[m]	20.8	- - -	- - -	- - -	- - -	- - -	58	42	- - -	- - -	- - -	- - -
	140.5 - 141.0	- - -	23.0	40.9	- - -	- - -	- - -	2.5E-06	- - -	- - -	- - -	- - -	- - -	NP
	141.5 - 142.0	1.78	- - -	- - -	3.17[m]	- - -	- - -	- - -	57	43	7	- - -	- - -	- - -
	150.0 - 152.0													
	150.15	- - -	18.0	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
	150.7	- - -	14.8	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
	151.3	- - -	19.2	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
	151.5	1.63	22.5	36.7	- - -	39.96	92	8.7E-07	22.6	77.4	14	- - -	- - -	- - -
	151.8	- - -	24.8	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
	152.1	1.54	27.1	- - -	2.718	- - -	- - -	- - -	- - -	- - -	- - -	27	21	6
	153.0 - 153.5	- - -	- - -	- - -	2.77	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	NP
	154.0 - 154.5	1.17[m]	16.3	- - -	- - -	- - -	- - -	- - -	37	63	- - -	- - -	- - -	- - -
DE-07	20.0 - 21.5	- - -	11.6	- - -	- - -	- - -	- - -	- - -	59.5	40.5	- - -	- - -	- - -	- - -
(piezometer)														
	30.0 - 31.5	- - -	10.9	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
	50.5 - 51.0	- - -	15.5	27.2	2.75	36.36	75	- - -	87	13	- - -	- - -	- - -	NP
	51.0 - 51.5	1.75	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
	55.0 - 57.5													
	55.6	- - -	18.4	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
	55.8	- - -	18.6	- - -	2.712	- - -	- - -	- - -	71.0	29.0	- - -	- - -	- - -	- - -
	56.1	- - -	19.7	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
	80.25 - 80.5	- - -	22.6	38.4	- - -	- - -	100	- - -	- - -	- - -	- - -	- - -	- - -	- - -
	80.5 - 81.0	- - -	- - -	- - -	- - -	- - -	- - -	1.5E-06	- - -	- - -	- - -	- - -	- - -	NP
	81.0 - 81.5	1.70	- - -	- - -	2.68	36.57	- - -	- - -	43	57	11	- - -	- - -	- - -
	81.5 - 84.0													
	82.1	- - -	5.6	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
	82.3	- - -	4.6	- - -	- - -	- - -	- - -	- - -	94.3	5.7	- - -	- - -	- - -	- - -
	82.6	- - -	4.5	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
	83.2	- - -	18.1	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
	83.4	- - -	17.8	- - -	- - -	- - -	- - -	- - -	76.0	24.0	- - -	- - -	- - -	- - -
	100.25 - 100.5	1.71	24.7	42.2	- - -	37.04	100	- - -	- - -	- - -	- - -	- - -	- - -	- - -
	100.5 - 101.0	- - -	- - -	- - -	- - -	- - -	- - -	- - -	48	52	- - -	21	20	1
	141.0 - 141.5	1.83	19.9	36.5	2.74	33.23	100	6.6E-06	52	48	- - -	- - -	- - -	NP

TABLE B-5. SUMMARY OF LABORATORY RESULTS FOR SOIL PHYSICAL AND HYDRAULIC ANALYSES FOR TAILING SAMPLES OBTAINED IN 2007 FROM SIERRITA TAILING IMPOUNDMENT, PHELPS DODGE SIERRITA MINE, PIMA COUNTY, ARIZONA

SAMPLE LOCATION	SAMPLE DEPTH (feet, bls)[a]	DRY BULK DENSITY[b] (g/cm3)[c]	WATER CONTENT Mass Based[d] (percent)	WATER CONTENT Volumetric[e] (percent)	PARTICLE DENSITY[f] (g/cm3)	TOTAL POROSITY[g] (percent)	SATURATION[h] (percent)	SATURATED HYDRAULIC CONDUCTIVITY[i] (cm/sec)[j]	PARTICLE SIZE DISTRIBUTION[k] SAND (percent, by mass)	PARTICLE SIZE DISTRIBUTION[k] SILT and CLAY (percent, by mass)	PARTICLE SIZE DISTRIBUTION[k] CLAY (percent, by mass)	ATTERBERG LIMITS[l] LIQUID LIMIT (percent, by mass)	ATTERBERG LIMITS[l] PLASTIC LIMIT (percent, by mass)	ATTERBERG LIMITS[l] PLASTICITY INDEX (percent, by mass)
DE-07 (continued)	160.0 - 162.0													
	160.4	1.60	22.5	- - -	- - -	- - -	- - -	5.4E-06	- - -	- - -	- - -	- - -	- - -	- - -
	160.7	- - -	21.0	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
	160.9	1.66	20.6	34.1	- - -	38.83	88	1.0E-06	62.3	37.7	6	27	20	7
	161.2	- - -	22.5	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
	161.5	1.73	20.2	- - -	- - -	- - -	- - -	2.7E-07	- - -	- - -	- - -	- - -	- - -	- - -
	181.0 - 181.5	1.70	20.9	35.5	- - -	37.14	96	- - -	35	65	- - -	- - -	- - -	- - -
	181.5	- - -	26.5	- - -	- - -	- - -	- - -	- - -	48.2	51.8	- - -	28	23	5
H2-07 (piezometer)	20.5 - 21.0	1.15[m]	5.7	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
	30.0 - 30.5	- - -	- - -	- - -	- - -	- - -	- - -	1.4E-05	- - -	- - -	- - -	- - -	- - -	- - -
	30.5 - 30.75	- - -	8.7	15.9	2.70	32.22	- - -	- - -	85	15	- - -	- - -	- - -	- - -
	31.0 - 31.5	1.83	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	NP
	40.0 - 41.5	- - -	9.2	- - -	- - -	- - -	- - -	- - -	74.5	25.5	- - -	- - -	- - -	- - -
	51.0 - 51.5	1.78	15.0	26.6	- - -	34.41	77	- - -	67	33	- - -	- - -	- - -	NP
	75.0 - 76.5													
	75.3	- - -	18.2	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
	75.8	- - -	11.6	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
	76.1	- - -	14.9	- - -	- - -	- - -	- - -	- - -	69.6	30.4	5	- - -	- - -	NP
	80.5 - 81.0	- - -	- - -	- - -	2.73	38.42	81	- - -	60	40	6	- - -	- - -	NP
	81.0 - 81.25	1.68	18.5	31.1	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
	100.25 - 100.5	- - -	23.4	42.0	2.66	32.33	100	- - -	69	31	- - -	- - -	- - -	NP
	100.5 - 101.0	- - -	- - -	- - -	- - -	- - -	- - -	6.2E-06	- - -	- - -	- - -	- - -	- - -	- - -
	101.0 - 101.5	1.80	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
	112.0 - 112.5	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
	112.3	- - -	16.4	- - -	2.699	- - -	- - -	- - -	51.5	48.5	- - -	- - -	- - -	- - -
	140.0 - 141.0	- - -	9.3	- - -	- - -	- - -	- - -	- - -	62.2	12.5	- - -	25	12	13
CS-1 (CPT site)	30	1.63	20.4	33.3	- - -	40.03	83	- - -	49	51	- - -	- - -	- - -	NP
	35	- - -	23.4	38.1	2.67	- - -	- - -	4.6E-05	36	64	- - -	- - -	- - -	NP
CS-3 (CPT site)	43	1.53	22.5	34.5	3.18[m]	- - -	- - -	- - -	45	55	12	21	16	5
	60	1.83	21.6	39.5	2.96	38.12	100	- - -	63	37	- - -	19	15	4
	72	1.70	24.5	41.7	- - -	37.49	- - -	4.5E-05	46	54	13	22	18	4
	72B	- - -	15.1	25.7	2.66	36.08	71	8.5E-05	79	21	- - -	- - -	- - -	NP
	88	1.53	21.2	32.4	- - -	43.83	74	- - -	42	58	- - -	- - -	- - -	NP
	108	1.64	23.2	38.0	2.74	40.11	95	2.0E-06	32	68	- - -	23	19	4
	130	1.76	20.7	36.4	- - -	35.14	100	- - -	71	29	- - -	- - -	- - -	NP

TABLE B-5. SUMMARY OF LABORATORY RESULTS FOR SOIL PHYSICAL AND HYDRAULIC ANALYSES FOR TAILING SAMPLES OBTAINED IN 2007 FROM SIERRITA TAILING IMPOUNDMENT, PHELPS DODGE SIERRITA MINE, PIMA COUNTY, ARIZONA

SAMPLE LOCATION	SAMPLE DEPTH (feet, bls)[a]	DRY BULK DENSITY[b] (g/cm3)[c]	WATER CONTENT Mass Based[d] (percent)	WATER CONTENT Volumetric[e] (percent)	PARTICLE DENSITY[f] (g/cm3)	TOTAL POROSITY[g] (percent)	SATURATION[h] (percent)	SATURATED HYDRAULIC CONDUCTIVITY[i] (cm/sec)[j]	PARTICLE SIZE DISTRIBUTION[k] SAND (percent, by mass)	PARTICLE SIZE DISTRIBUTION[k] SILT and CLAY (percent, by mass)	PARTICLE SIZE DISTRIBUTION[k] CLAY (percent, by mass)	ATTERBERG LIMITS[l] LIQUID LIMIT (percent, by mass)	ATTERBERG LIMITS[l] PLASTIC LIMIT (percent, by mass)	ATTERBERG LIMITS[l] PLASTICITY INDEX (percent, by mass)
CS-5 (CPT site)	25	1.52	24.3	37.0	- - -	44.02	84	- - -	43	57	- - -	22	20	2
	36	1.60	23.1	36.8	- - -	41.33	89	- - -	42	58	19	22	18	4
	73	1.70	22.8	38.8	- - -	37.38	100	- - -	69	31	- - -	- - -	- - -	NP
	103	1.80	23.2	41.8	2.74	34.29	100	- - -	47	45	8	20	19	1
	132B	- - -	16.8	- - -	2.65	- - -	- - -	1.2E-05	51	49	13	21	17	4
	163	1.94	19.2	37.2	2.68	27.61	100	2.6E-05	69	31	- - -	17	14	3
MA-1 (CPT site)	20	1.51	22.8	34.4	- - -	44.59	77	- - -	72	28	- - -	- - -	- - -	NP
	50	1.79	22.7	40.7	2.73	34.36	100	- - -	55	45	11	22	17	5
	60	1.51	21.4	32.4	- - -	44.46	73	- - -	68	32	- - -	- - -	- - -	NP
	70	1.59	25.6	40.8	- - -	41.38	99	- - -	48	52	- - -	24	20	4
	80	1.87	19.3	36.1	2.68	30.22	100	5.6E-06	55	45	- - -	20	16	4
	90	1.65	20.1	33.2	- - -	39.39	84	- - -	39	61	- - -	25	18	7
	100	1.64	17.0	27.9	2.76	40.57	69	2.9E-06	38	62	8	21	18	3
	110	1.75	22.2	38.8	2.64	33.78	100	4.6E-06	42	58	8	22	19	3
	120	1.85	13.8	25.5	2.69	31.16	82	4.5E-06	50	50	- - -	- - -	- - -	NP
MA-2 (CPT site)	30	- - -	21.2	- - -	- - -	- - -	- - -	- - -	67	33	10	20	16	4
	40	1.63	18.1	29.5	- - -	40.00	74	- - -	28	72	- - -	27	22	5
	50	1.74	14.7	25.6	- - -	35.97	71	- - -	58	42	- - -	20	18	2
	60	1.41	10.5	14.7	- - -	48.25	30	- - -	57	43	- - -	21	18	3
	70	1.53	19.7	30.2	3.27[m]	- - -	- - -	5.8E-06	44	56	8	- - -	- - -	NP
	80	1.77	26.7	47.1	2.66	33.62	100	7.7E-05	57	43	10	18	17	1
Station 1 (shallow boring) (February)	1	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
	5	- - -	- - -	- - -	- - -	- - -	- - -	- - -	60	40	- - -	- - -	- - -	NP
	10	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
	20	- - -	- - -	- - -	- - -	- - -	- - -	- - -	50	50	7	- - -	- - -	NP
(April)	3	1.02[m]	12.9	- - -	- - -	- - -	- - -	- - -	65	35	- - -	- - -	- - -	- - -
	7	1.58	14.3	22.6	- - -	41.84	54	- - -	72	28	- - -	- - -	- - -	NP
	12	- - -	15.7	- - -	2.72	- - -	- - -	- - -	61	39	- - -	- - -	- - -	NP
	17	- - -	18.7	- - -	2.83	- - -	- - -	1.4E-05	64	36	- - -	19	17	2
	22	- - -	26.3	- - -	2.66	- - -	- - -	1.9E-05	57	43	11	19	17	2
(August)	1	1.59	17.1	27.2	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
	4	1.44	13.7	19.7	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
	8	- - -	28.3	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
	13	1.49	14.7	21.9	- - -	45.32	48	- - -	- - -	- - -	- - -	- - -	- - -	- - -
	18	1.28	36.8	47.0	- - -	53.08	89	- - -	- - -	- - -	- - -	- - -	- - -	- - -
Station 2 (shallow boring) (February)	1	- - -	12.6	- - -	- - -	- - -	- - -	- - -	74	26	- - -	- - -	- - -	- - -
	2	- - -	7.7	- - -	2.67	- - -	- - -	1.2E-03	73	27	3	- - -	- - -	NP
	5	- - -	- - -	- - -	- - -	- - -	- - -	- - -	60	40	- - -	- - -	- - -	NP
	20	- - -	- - -	- - -	2.69	- - -	- - -	- - -	71	29	- - -	- - -	- - -	NP

TABLE B-5. SUMMARY OF LABORATORY RESULTS FOR SOIL PHYSICAL AND HYDRAULIC ANALYSES FOR TAILING SAMPLES OBTAINED IN 2007 FROM SIERRITA TAILING IMPOUNDMENT, PHELPS DODGE SIERRITA MINE, PIMA COUNTY, ARIZONA

SAMPLE LOCATION	SAMPLE DEPTH (feet, bls)[a]	DRY BULK DENSITY[b] (g/cm3)[c]	WATER CONTENT		PARTICLE DENSITY[f] (g/cm3)	TOTAL POROSITY[g] (percent)	SATURATION[h] (percent)	SATURATED HYDRAULIC CONDUCTIVITY[i] (cm/sec)[j]	PARTICLE SIZE DISTRIBUTION[k] (percent, by mass)			ATTERBERG LIMITS[l] (percent, by mass)		
			Mass Based[d] (percent)	Volumetric[e] (percent)					SAND	SILT and CLAY	CLAY	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX
Station 2	1.5	1.05[m]	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
(continued)	3	- - -	16.2	- - -	- - -	- - -	- - -	- - -	61	39	- - -	- - -	- - -	NP
(April)	4	- - -	20.8	- - -	2.68	- - -	- - -	7.5E-05	61	39	6	- - -	- - -	NP
	7	- - -	22.3	- - -	2.67	- - -	- - -	- - -	56	44	- - -	- - -	- - -	NP
	12	1.71	21.1	36.1	2.69	36.43	99	3.1E-05	60	40	- - -	- - -	- - -	- - -
	17	1.09[m]	9.8	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
	22	1.67	18.8	31.5	2.68	37.61	- - -	- - -	63	37	- - -	- - -	- - -	- - -
(August)	1	- - -	16.2	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
	8	1.49	20.6	30.7	- - -	45.08	68	- - -	- - -	- - -	- - -	- - -	- - -	- - -
	13	1.84	16.9	26.6	- - -	32.30	82	- - -	- - -	- - -	- - -	- - -	- - -	- - -
	18	1.71	19.9	28.4	- - -	37.13	76	- - -	- - -	- - -	- - -	- - -	- - -	- - -
	23	1.91	22.1	34.7	- - -	29.64	100	- - -	- - -	- - -	- - -	- - -	- - -	- - -
Station 4	1.5 - 1.75	1.42	5.5	7.8	- - -	47.79	16	- - -	- - -	- - -	- - -	- - -	- - -	- - -
(shallow	2 - 2.5	- - -	22.2	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -	- - -
boring)	3.0 - 3.5	1.36	16.1	21.9	- - -	50.00	44	- - -	- - -	- - -	- - -	- - -	- - -	- - -
(July)	5.5 - 6.0	1.40	21.0	29.4	- - -	48.41	61	- - -	- - -	- - -	- - -	- - -	- - -	- - -
	10.75 - 11.25	1.57	19.6	30.7	- - -	42.10	73	- - -	- - -	- - -	- - -	- - -	- - -	- - -

NOTE: Most tailing samples were obtained by Montgomery & Associates or URS personnel during field investigations conducted during the period February through April 2007. Samples obtained at Stations 1, 2, and 4 were obtained in the months (of 2007) indicated in column 1. All samples obtained by URS were analyzed by the URS geotechnical laboratory, Totowa, New Jersey. Samples obtained by Montgomery & Associates were analyzed by GeoSystems Analysis, Inc., Tucson, Arizona.

--- = analysis not conducted

NP = Nonplastic

[a] feet, bls = feet below land surface

[b] Bulk Density was determined using ASTM method 2937 and Methods of Soil Analysis, Chapter 13

[c] g/cm^3 = grams per cubic centimeter

[d] Mass-based Water Content was determined using ASTM method D2216

[e] Volumetric Water Content (VWC) was computed based on laboratory results for Mass-based Water Content (MWC) and Bulk Density (BD): VWC = MWC x BD

[f] Particle Density (Specific Gravity) was determined using ASTM method D854

[g] Total Porosity was computed based on laboratory results for Bulk Density (BD) and Particle Density (PD): Porosity = (1 - BD/PD) x 100. If Particle Density was not analyzed for the given sample, the overall average Particle Density of 2.72 g/cm3 was used.

[h] Percent Saturation was computed based on laboratory results for computed Volumetric Water Content (VWC) and Total Porosity (see footnotes e and g): Saturation (percent) = (VWC / Porosity) x 100 If computed VWC > computed Total Porosity (which occurs due to different sub-samples being used for analysis of Bulk Density, Water Content, and/or Particle Density), Saturation was set to 100 percent.

[i] Saturated Hydraulic Conductivity was determined using constant-head methods ASTM 2434 and Methods of Soil Analysis, Part 4, Method 3.4.2.2

[j] cm/sec = centimeters per second

[k] Particle size distribution was determined by wet sieve analysis using ASTM method C136 for sand and combined silt and clay content; clay content was determined by the hydrometer method using ASTM method D422

[l] Atterberg Limits (plasticity indices) were determined using ASTM method D4318; if the Plasticity Index result is "NP", the sample was determined to be Non-Plastic and the associated plastic limit and liquid limit are undefined

[m] these results are believed to be laboratory "outliers" and were not used for computation of Volumetric Water Content, Total Porosity, and Percent Saturation, or for computation of parameter averages

TABLE B-6. SUMMARY OF AVERAGE RESULTS FOR SELECTED SOIL PHYSICAL AND HYDRAULIC ANALYSES AND SAMPLE GROUPINGS, SIERRITA TAILING IMPOUNDMENT PHELPS DODGE SIERRITA MINE, PIMA COUNTY, ARIZONA

SAMPLE GROUPING[a]	WATER CONTENT (percent)		BULK DENSITY (g/cm^3)	TOTAL POROSITY[c] (percent)	SATURATION[d] (percent)	SILT and CLAY CONTENT (percent)	SATURATED HYDRAULIC CONDUCTIVITY[e] (cm/sec)
	Mass-based	Volumetric[b]					
EXTERIOR	16.4	26.5	1.60	39.9	74.6	38	2.4×10^{-6}
INTERIOR	19.5	33.5	1.64	38.8	83.1	45	1.2×10^{-5}
DEEP	19.5	34.5	1.67	38.0	87.5	45	6.1×10^{-6}
SHALLOW	16.5	24.1	1.55	42.4	67.8	39	1.1×10^{-5}
OVERALL	18.3	30.9	1.63	39.1	80.2	43	6.9×10^{-6}

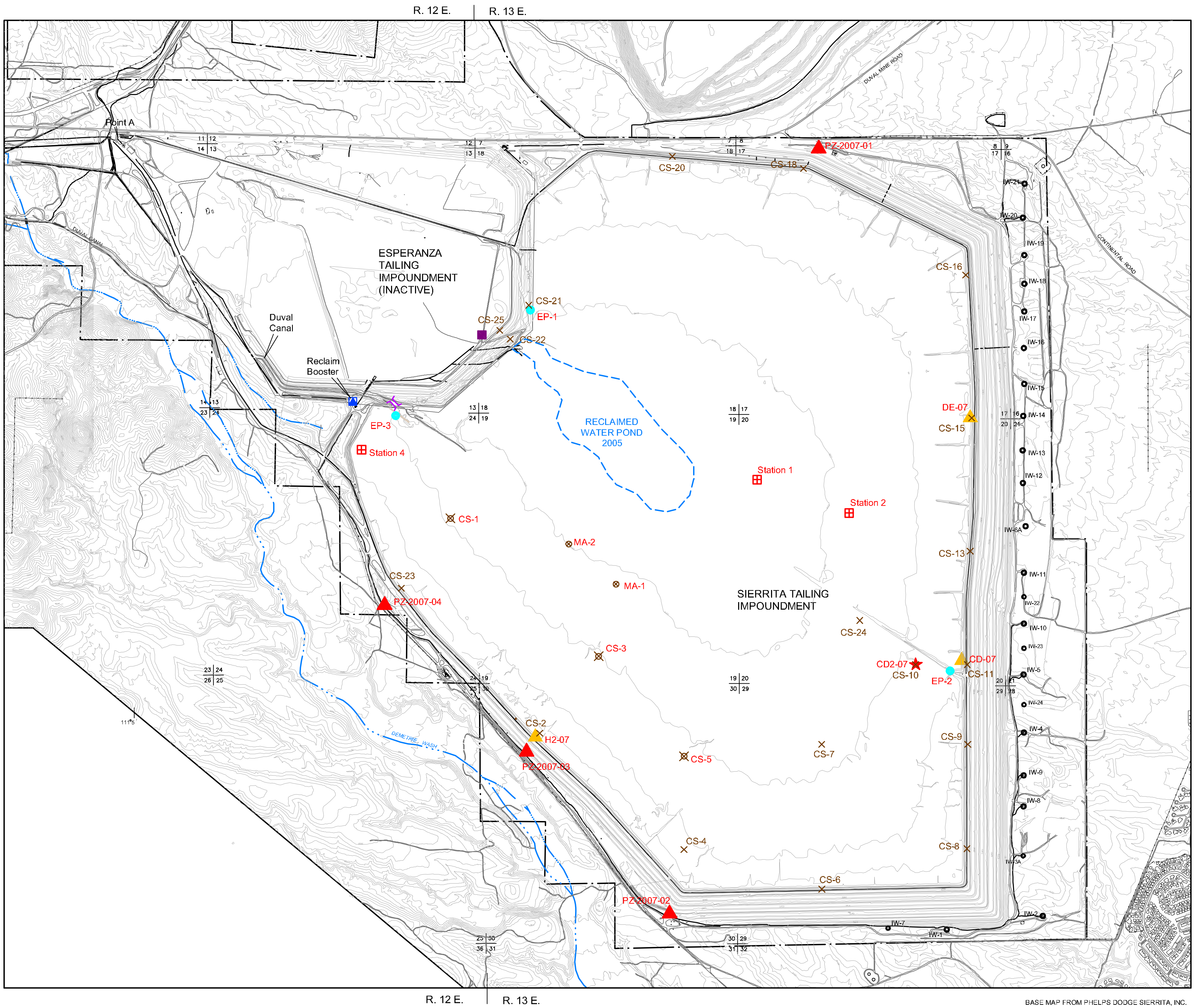
[a] EXTERIOR refers to sampling locations on or near the crest of the tailing impoundment (piezometers CD-07, DE-07, H2-07, and Station 4)
INTERIOR refers to sampling locations in the interior of the tailing impoundment (borehole CD2-07, Stations 1 and 2, and CPT sites CS-1, CS-3, CS-5, MA-1, and MA-2)
DEEP refers to samples collected at depths larger than 30 feet below the tailing impoundment surface
SHALLOW refers to samples collected at depths less than or equal to 30 feet below the tailing impoundment surface
OVERALL refers to the average of all sample analyses (for all locations and depths)

[b] Volumetric water content (VWC) was computed based on laboratory results for mass-based water content (MWC) and bulk density (BD): VWC = MWC x BD

[c] Total porosity was computed based on laboratory results for bulk density (BD) and particle density (PD): Porosity = (1 - BD/PD) x 100

[d] Percent saturation was computed based on laboratory results for water content and computed total porosity (see footnote c): Saturation (percent) = (VWC / Porosity) x 100

[e] Average values given for saturated hydraulic conductivity were computed as geometric means



EXPLANATION

IW-6 INTERCEPTOR WELL

PROPERTY BOUNDARY - PHELPS DODGE SIERRITA, INC.

18 | 17 / 19 | 20 SECTION CORNER

PHELPS DODGE METEOROLOGICAL STATION WITH STANDARD EVAPORATION PAN

RECLAIMED WATER BOOSTER STATION

DUVAL CANAL OUTLET

2007 INVESTIGATIONS

CD2-07 DEEP EXPLORATION BOREHOLE (URS and Montgomery & Associates)

PZ-2007-03 TOE PIEZOMETER (URS and Montgomery & Associates)

H2-07 CREST PIEZOMETER (URS)

Station 1 SHALLOW EXPLORATION BOREHOLE (Montgomery & Associates)

CS-24 CONE PENETROMETER TEST (URS)

MA-1 CONE PENETROMETER SAMPLING LOCATION (Montgomery & Associates)

CS-1 CONE PENETROMETER TEST (URS) AND SAMPLING (Montgomery & Associates) LOCATION

EP-2 EVAPORATION PAN (Montgomery & Associates)

phelps dodge Sierrita Inc.

SIERRITA TAILING IMPOUNDMENT SITE MAP

ERROL L. MONTGOMERY & ASSOCIATES, INC.
WATER RESOURCE CONSULTANTS
TUCSON, ARIZONA

2007

FIGURE B-1

546.39\LocationMap_wells\14Nov2007 UTM NAD27-meters

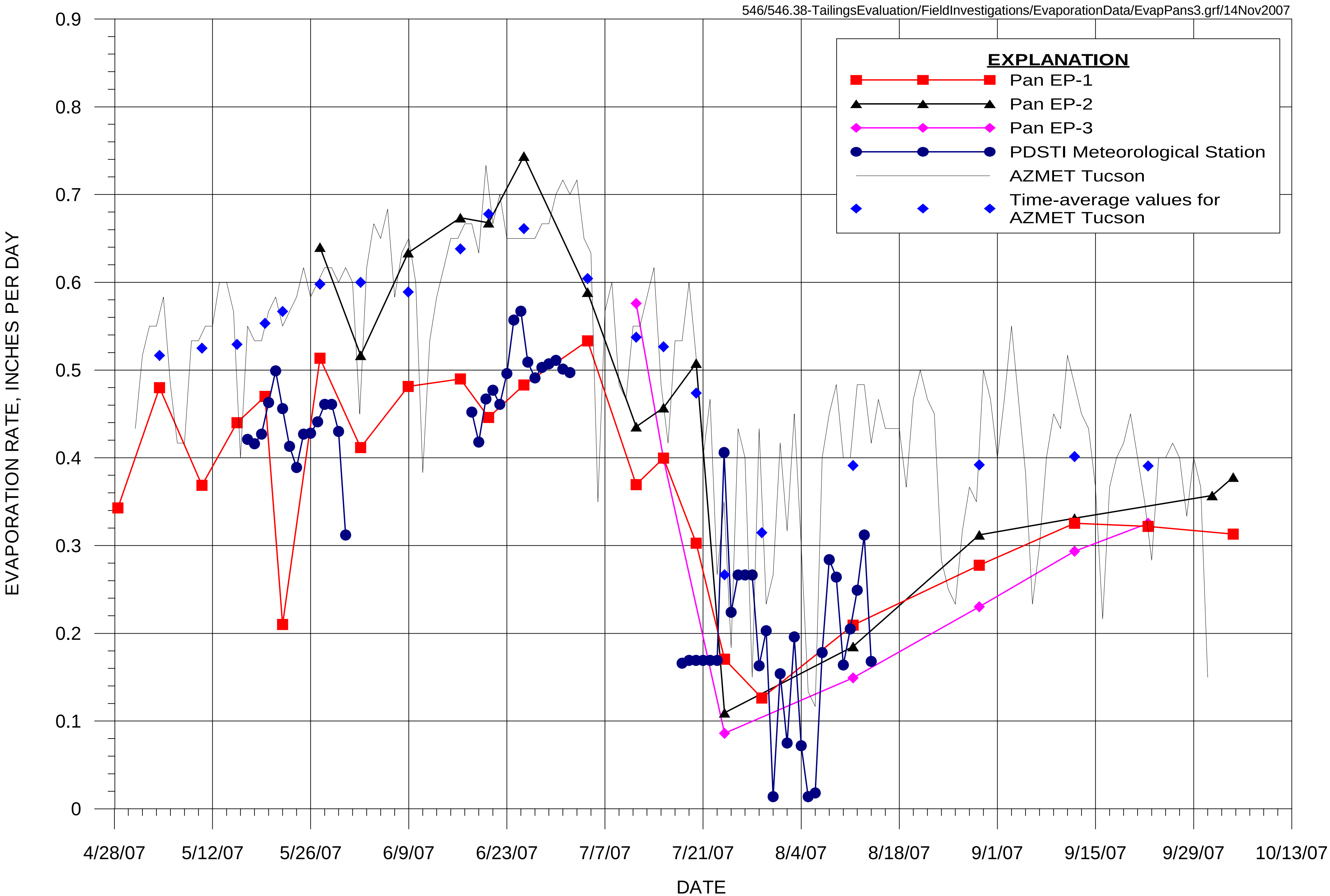
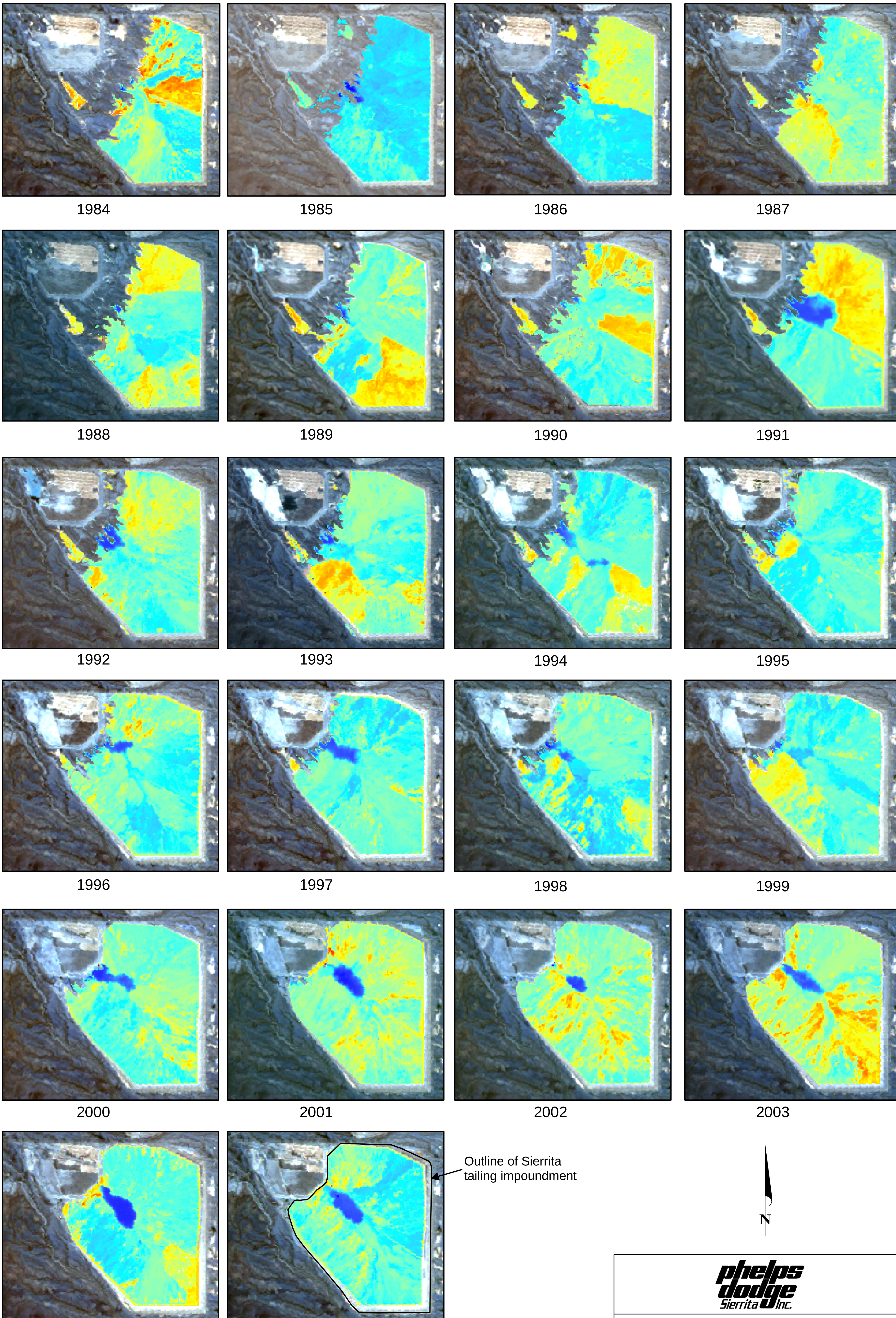


FIGURE B-2. MEASURED EVAPORATION RATES AND STANDARD PAN EVAPORATION RATES FOR SIERRITA TAILING IMPOUNDMENT

ERROL L. MONTGOMERY & ASSOCIATES, INC.



NOTE: In general, dark blue areas shown on the Sierrita tailing impoundment indicate ponded water; lighter blue areas indicate moist tailing; and yellow and red areas indicate dry tailing. LANDSAT images were taken in May or June of indicated year.

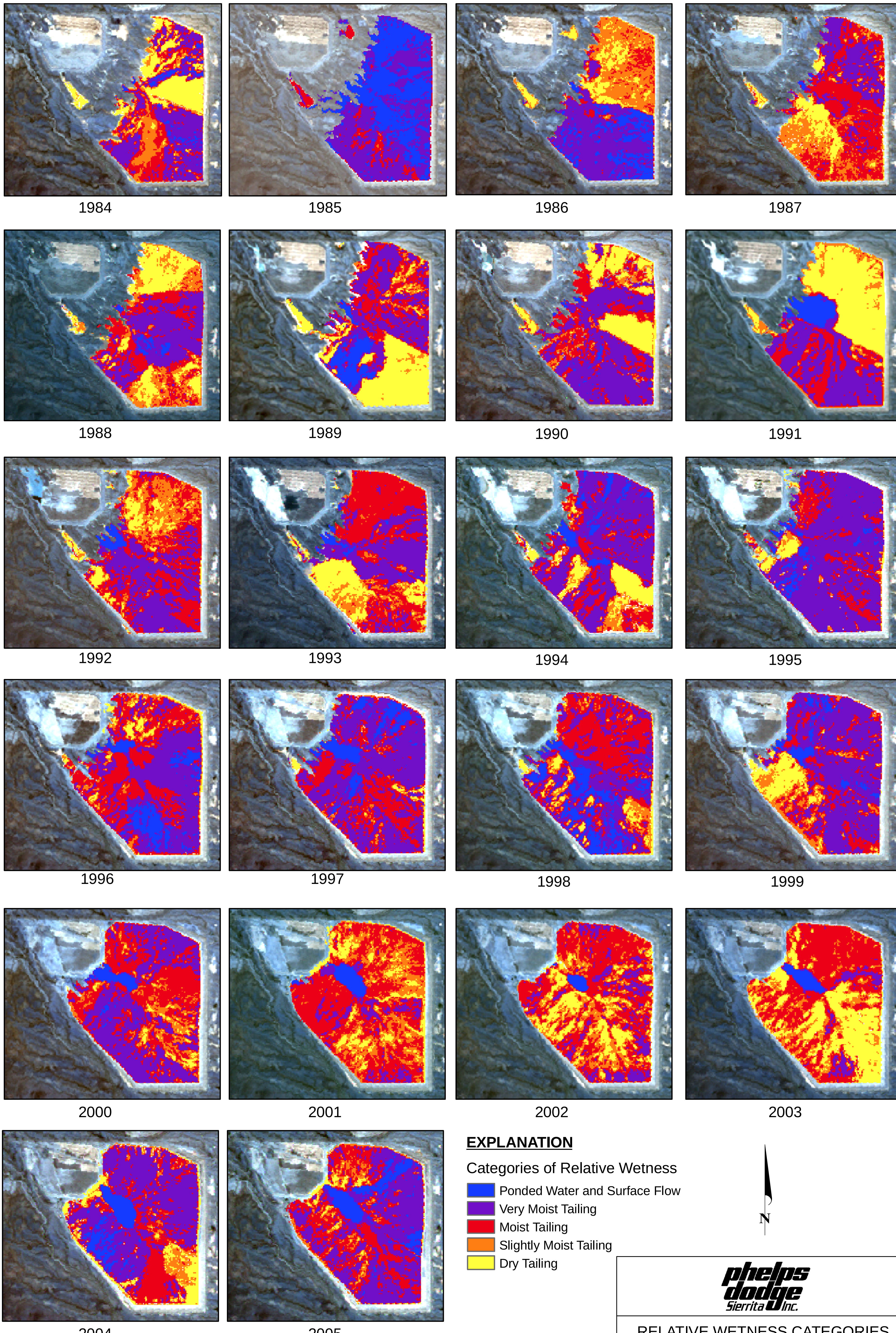
phelps dodge Sierrita Inc.

NEAR-INFRARED SATELLITE IMAGES OF SIERRITA TAILING IMPOUNDMENT 1984 THROUGH 2005

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

FIGURE B-3

GIS-Tuc\546\38\WetSoils_infrared.mxd\13November2007



EXPLANATION

Categories of Relative Wetness

- Ponded Water and Surface Flow
- Very Moist Tailing
- Moist Tailing
- Slightly Moist Tailing
- Dry Tailing

N

NOTE: Delineated areas for relative wetness categories are based on spectral analysis of LANDSAT images shown on Figure B-3.

phelps dodge Sierrita Inc.

RELATIVE WETNESS CATEGORIES
FOR SIERRITA TAILING IMPOUNDMENT
BASED ON SPECTRAL ANALYSIS

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

2007

FIGURE B-4

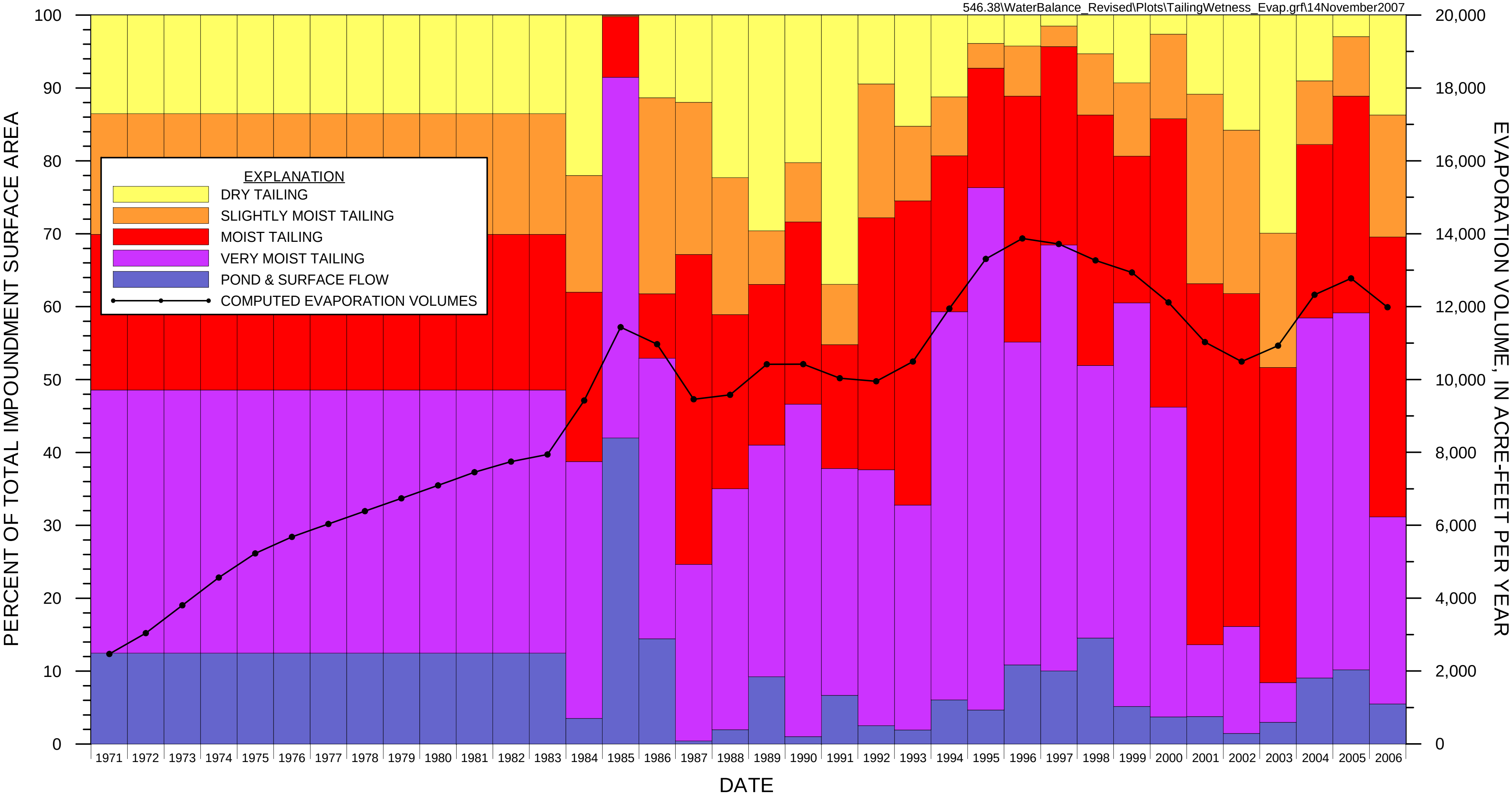


FIGURE B-5. DISTRIBUTION OF RELATIVE WETNESS CATEGORIES FOR SIERRITA TAILING IMPOUNDMENT AND COMPUTED EVAPORATION VOLUMES

ERROL L. MONTGOMERY & ASSOCIATES, INC.

APPENDIX C

ANNUAL GROUNDWATER PUMPED AND AVERAGE SULFATE CONCENTRATION IN GROUNDWATER FOR INTERCEPTOR WELLS PHELPS DODGE SIERRITA MINE, PIMA COUNTY, ARIZONA

APPENDIX C

CONTENTS

Figure

<u>CONTENTS</u> – continued

Figure

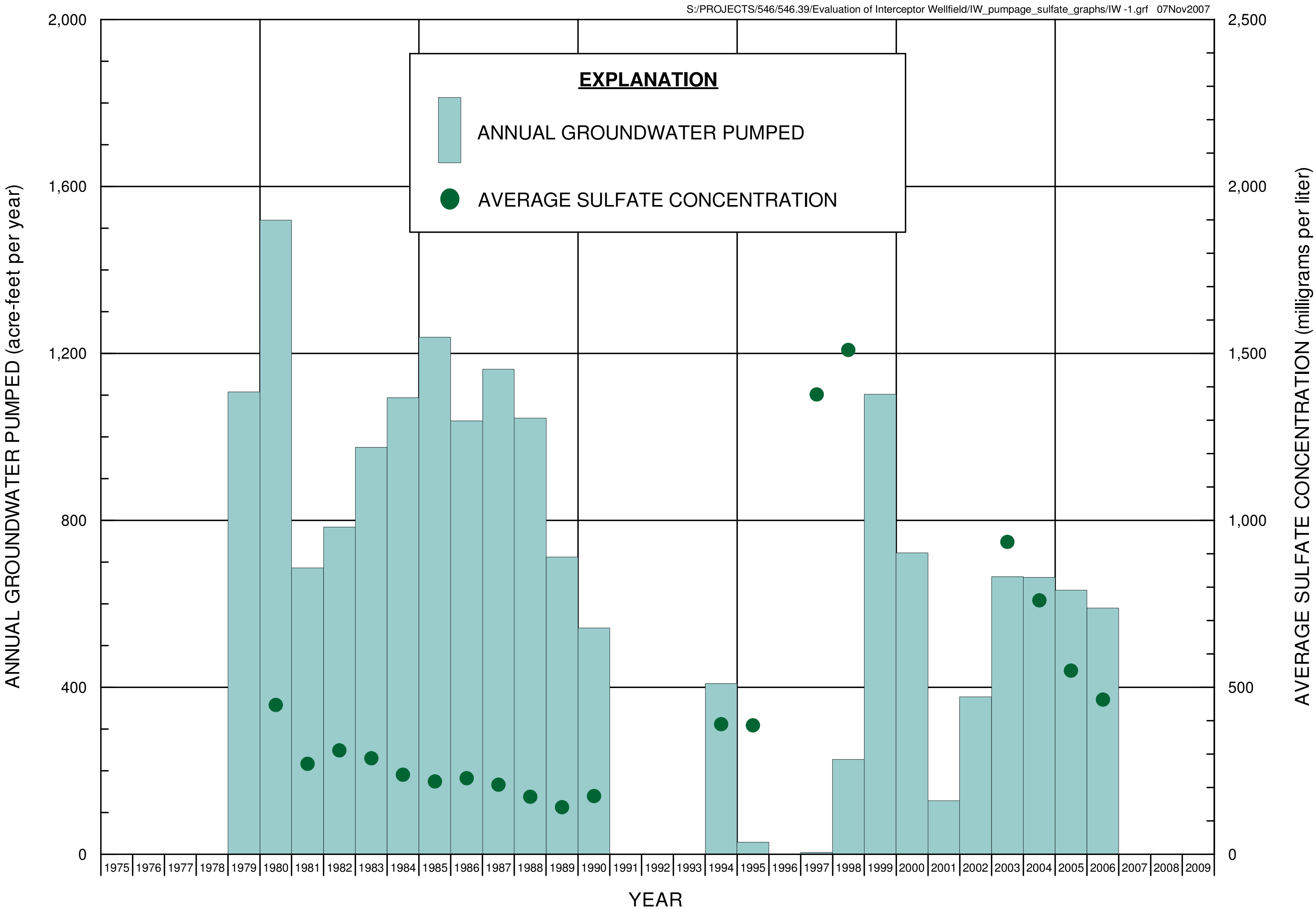


FIGURE C-1. ANNUAL GROUNDWATER PUMPED AND AVERAGE SULFATE CONCENTRATION IN GROUNDWATER FOR INTERCEPTOR WELL IW-1

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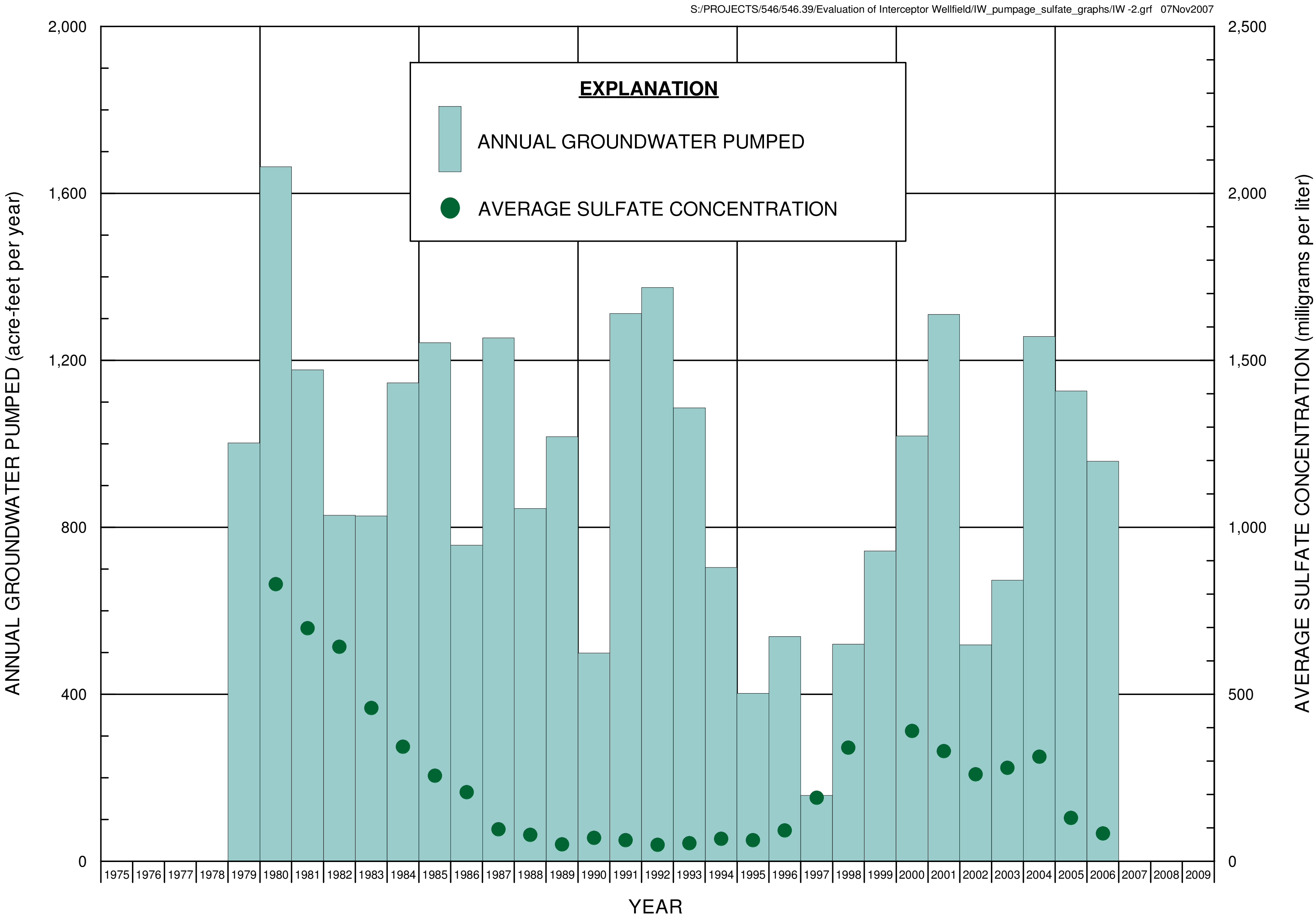

FIGURE C-2. ANNUAL GROUNDWATER PUMPED AND AVERAGE SULFATE CONCENTRATION IN GROUNDWATER FOR INTERCEPTOR WELL IW-2

ERROL L. MONTGOMERY & ASSOCIATES, INC.

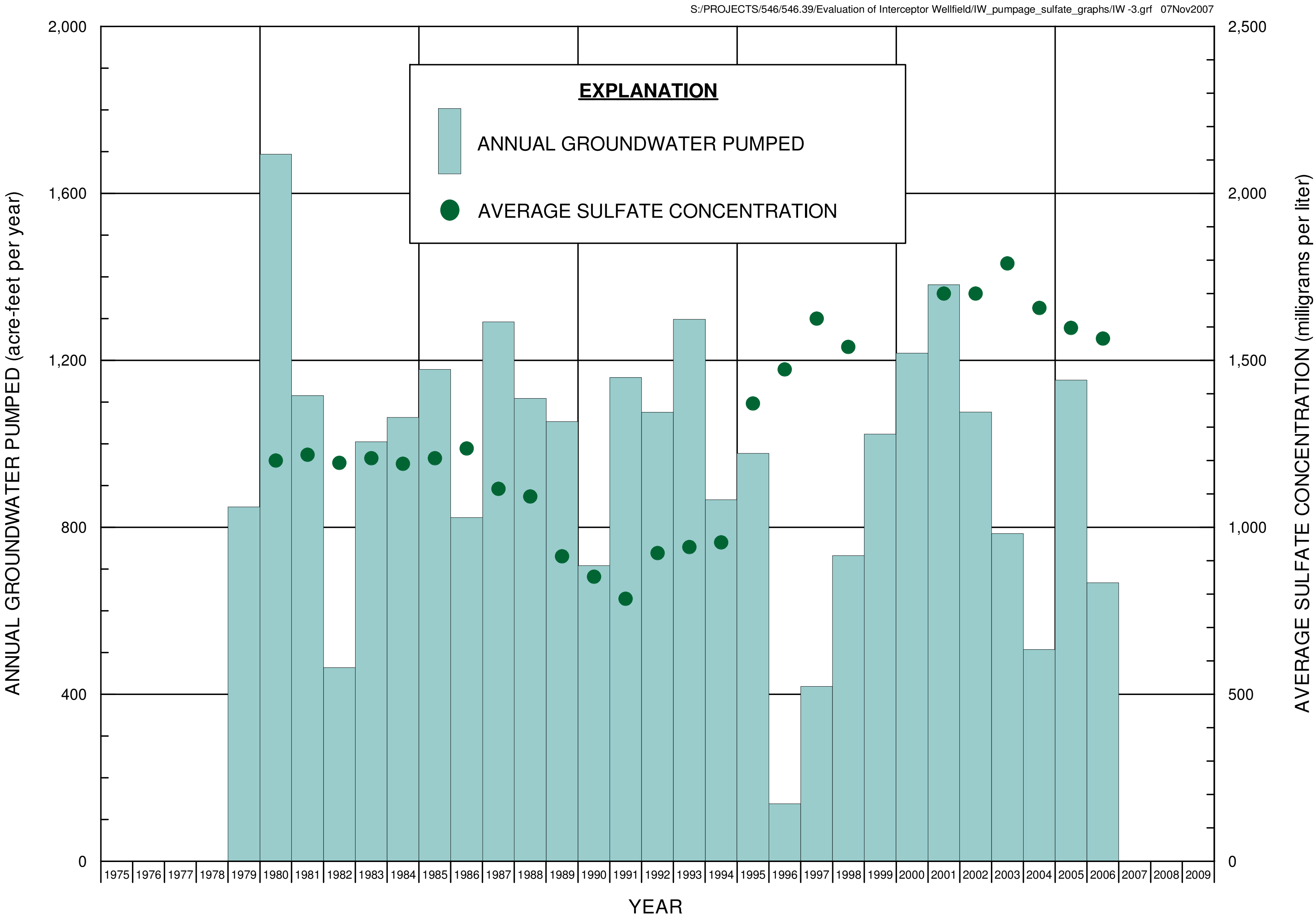

FIGURE C-3. ANNUAL GROUNDWATER PUMPED AND AVERAGE SULFATE CONCENTRATION IN GROUNDWATER FOR INTERCEPTOR WELLS IW-3 AND IW-3A

ERROL L. MONTGOMERY & ASSOCIATES, INC.

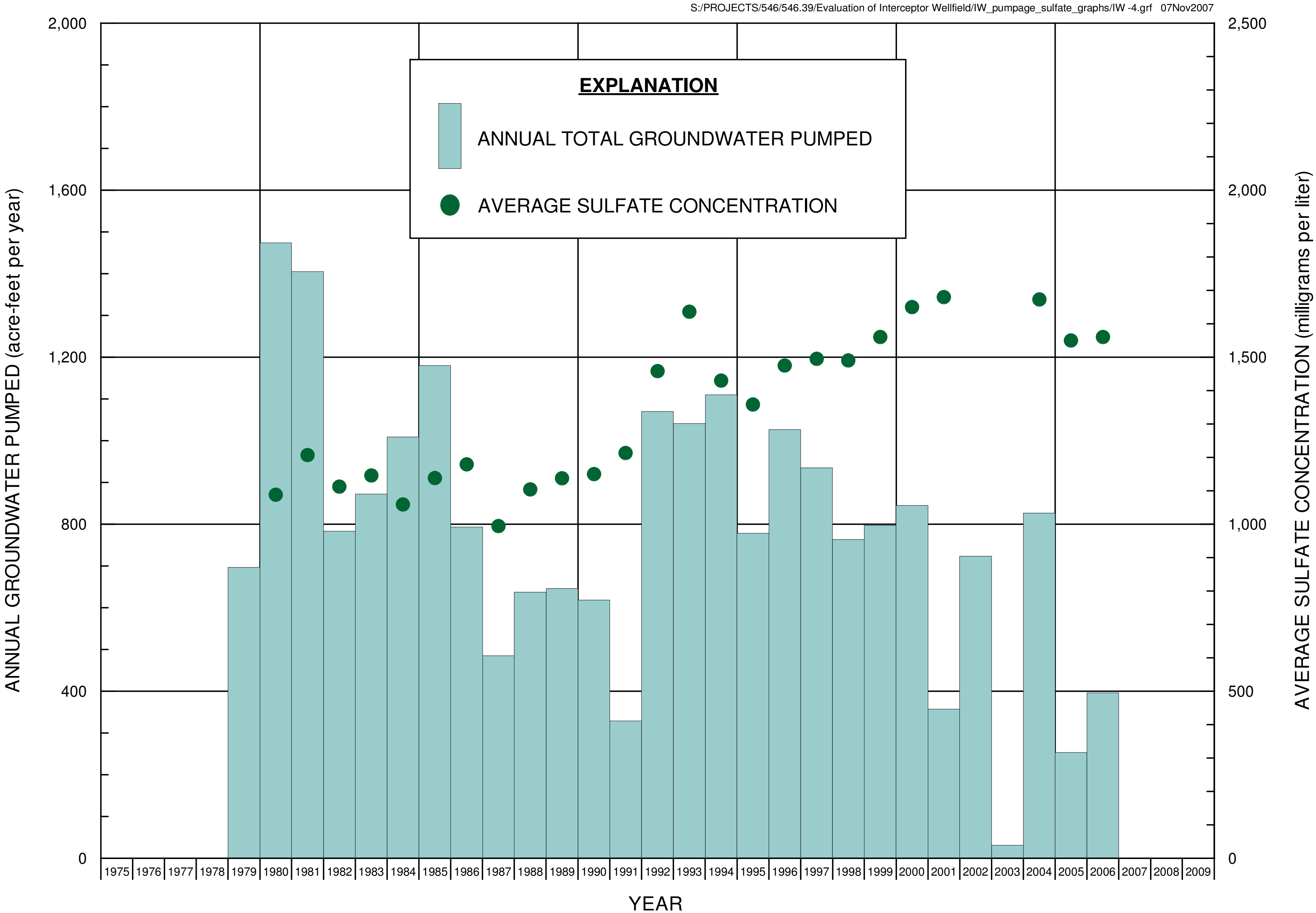

FIGURE C-4. ANNUAL GROUNDWATER PUMPED AND AVERAGE SULFATE CONCENTRATION IN GROUNDWATER FOR INTERCEPTOR WELL IW-4

ERROL L. MONTGOMERY & ASSOCIATES, INC.

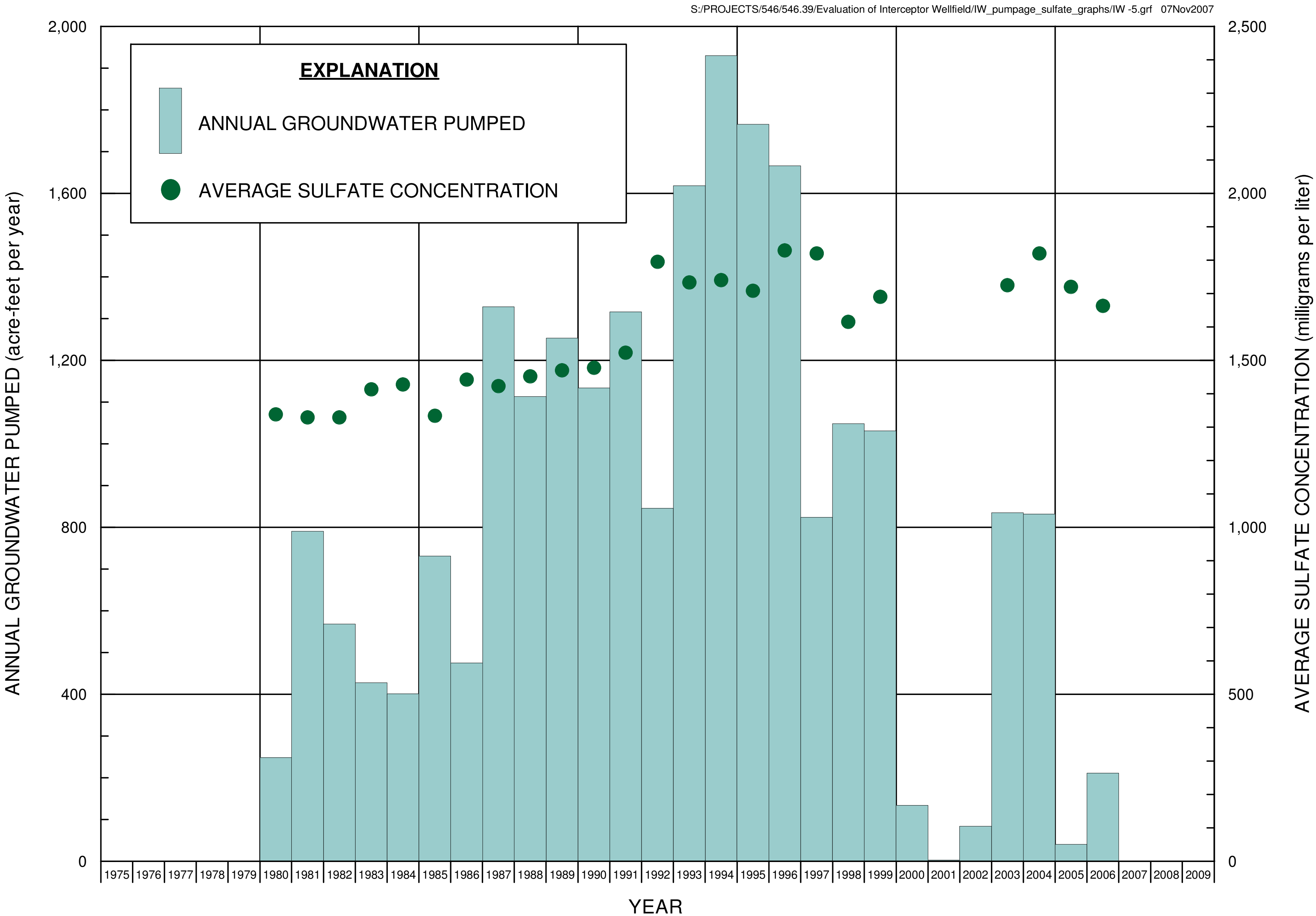

FIGURE C-5. ANNUAL GROUNDWATER PUMPED AND AVERAGE SULFATE CONCENTRATION IN GROUNDWATER FOR INTERCEPTOR WELL IW-5

ERROL L. MONTGOMERY & ASSOCIATES, INC.

S:/PROJECTS/546/546.39/Evaluation of Interceptor Wellfield/IW_pumpage_sulfate_graphs/IW -6A.grf 07Nov2007

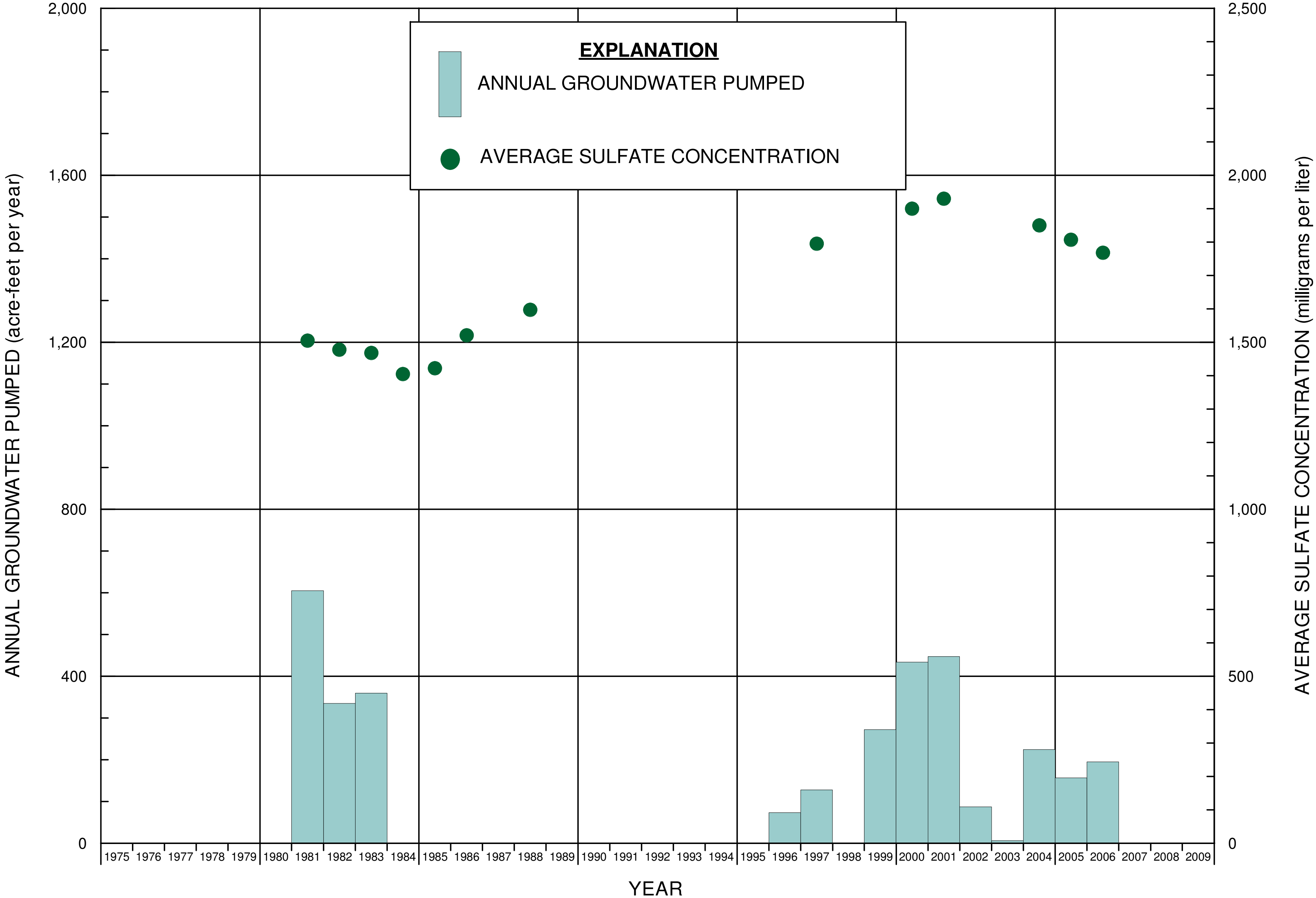

FIGURE C-6. ANNUAL GROUNDWATER PUMPED AND AVERAGE SULFATE CONCENTRATION IN GROUNDWATER FOR INTERCEPTOR WELLS IW-6 AND IW-6A

ERROL L. MONTGOMERY & ASSOCIATES, INC.

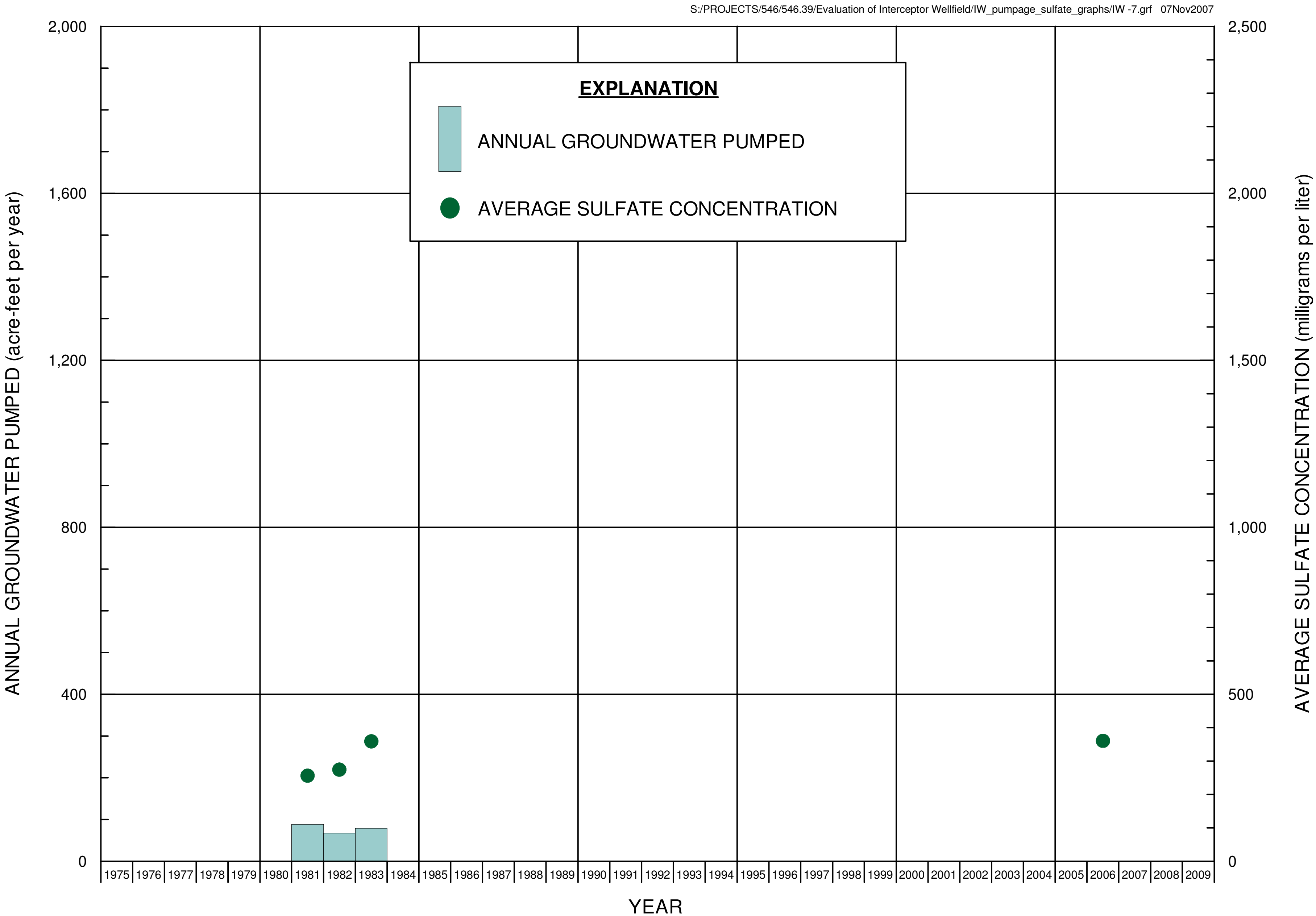

FIGURE C-7. ANNUAL GROUNDWATER PUMPED AND AVERAGE SULFATE CONCENTRATION IN GROUNDWATER FOR INTERCEPTOR WELL IW-7

ERROL L. MONTGOMERY & ASSOCIATES, INC.

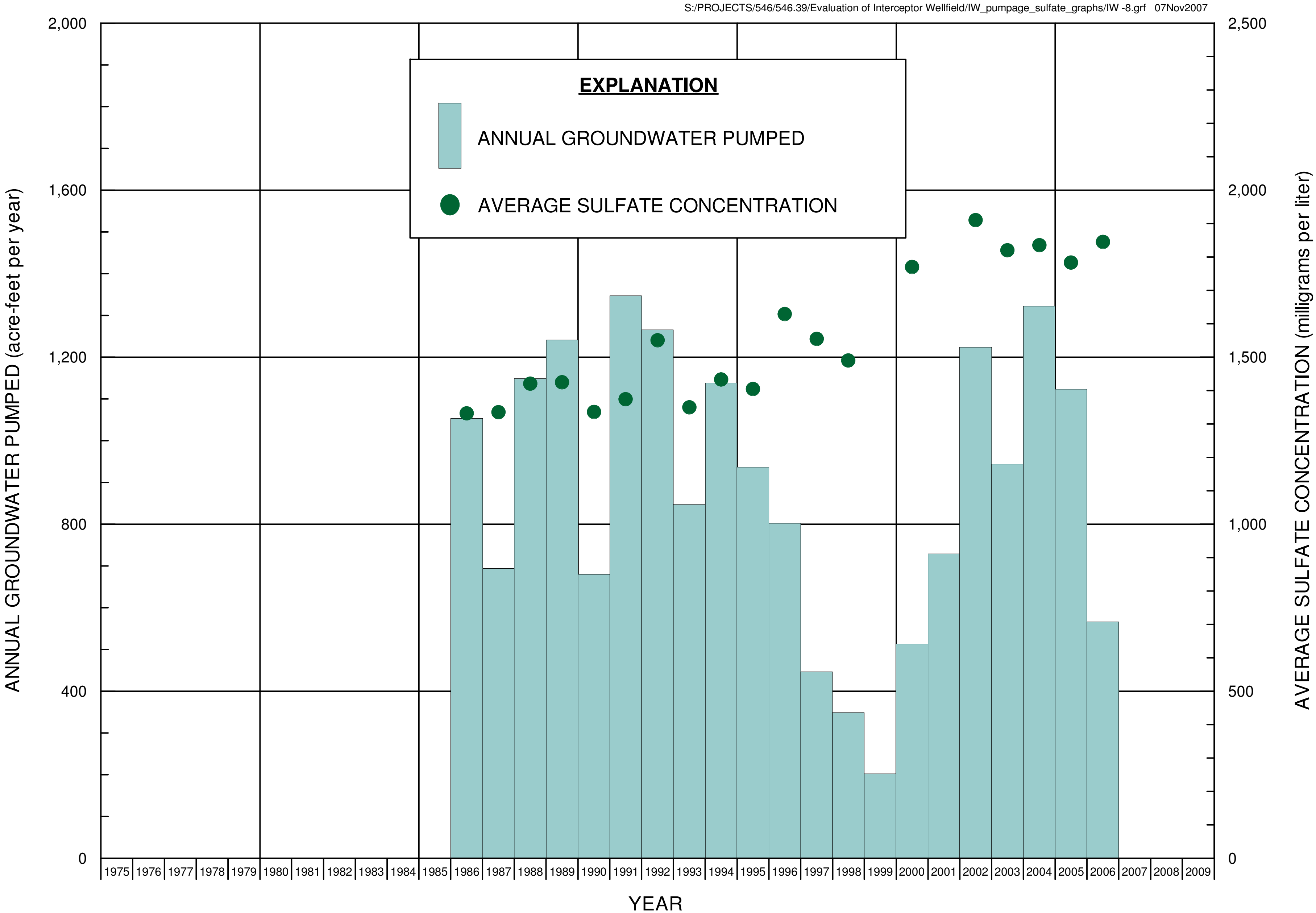

FIGURE C-8. ANNUAL GROUNDWATER PUMPED AND AVERAGE SULFATE CONCENTRATION IN GROUNDWATER FOR INTERCEPTOR WELL IW-8

ERROL L. MONTGOMERY & ASSOCIATES, INC.

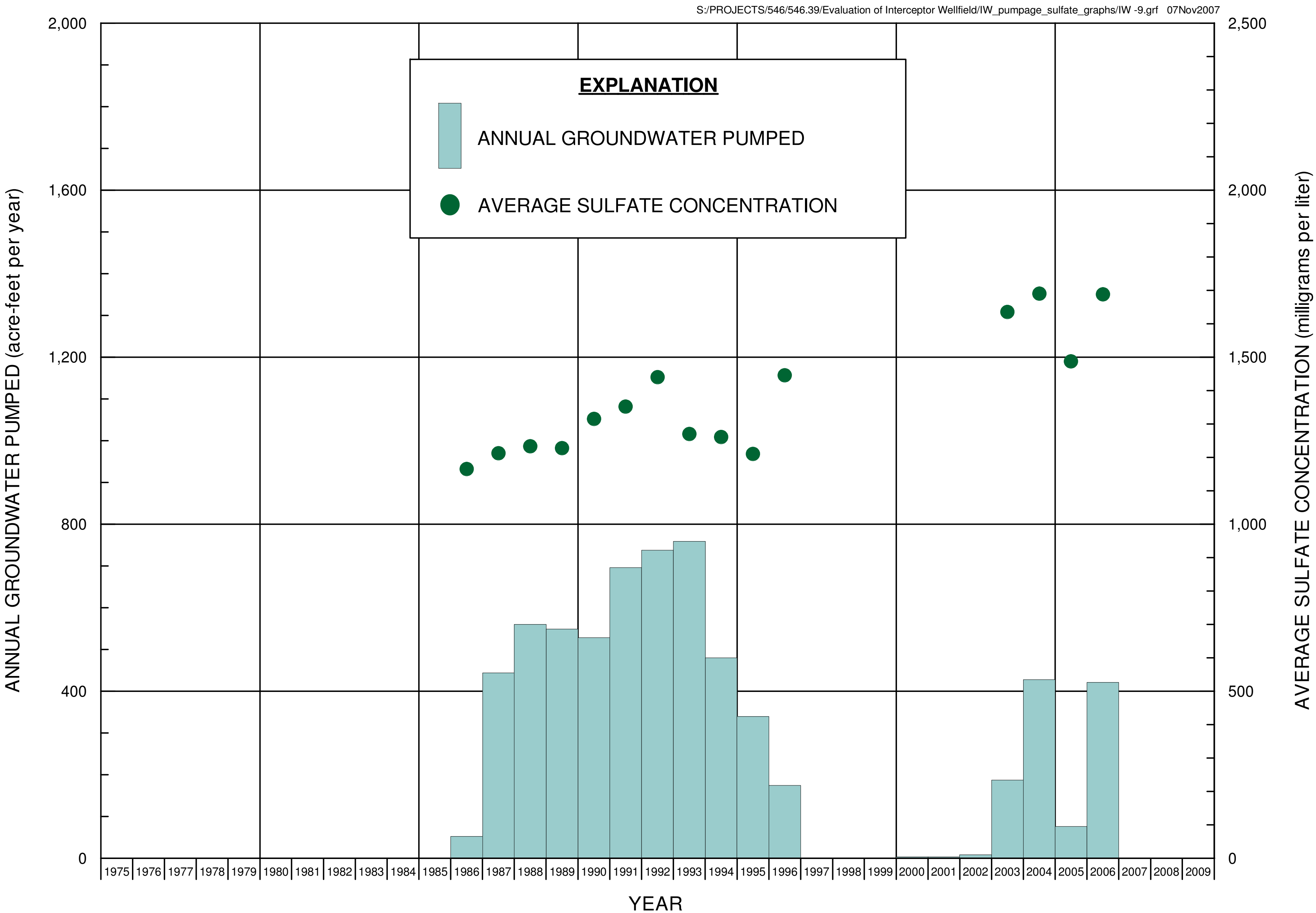

FIGURE C-9. ANNUAL GROUNDWATER PUMPED AND AVERAGE SULFATE CONCENTRATION IN GROUNDWATER FOR INTERCEPTOR WELL IW-9

ERROL L. MONTGOMERY & ASSOCIATES, INC.

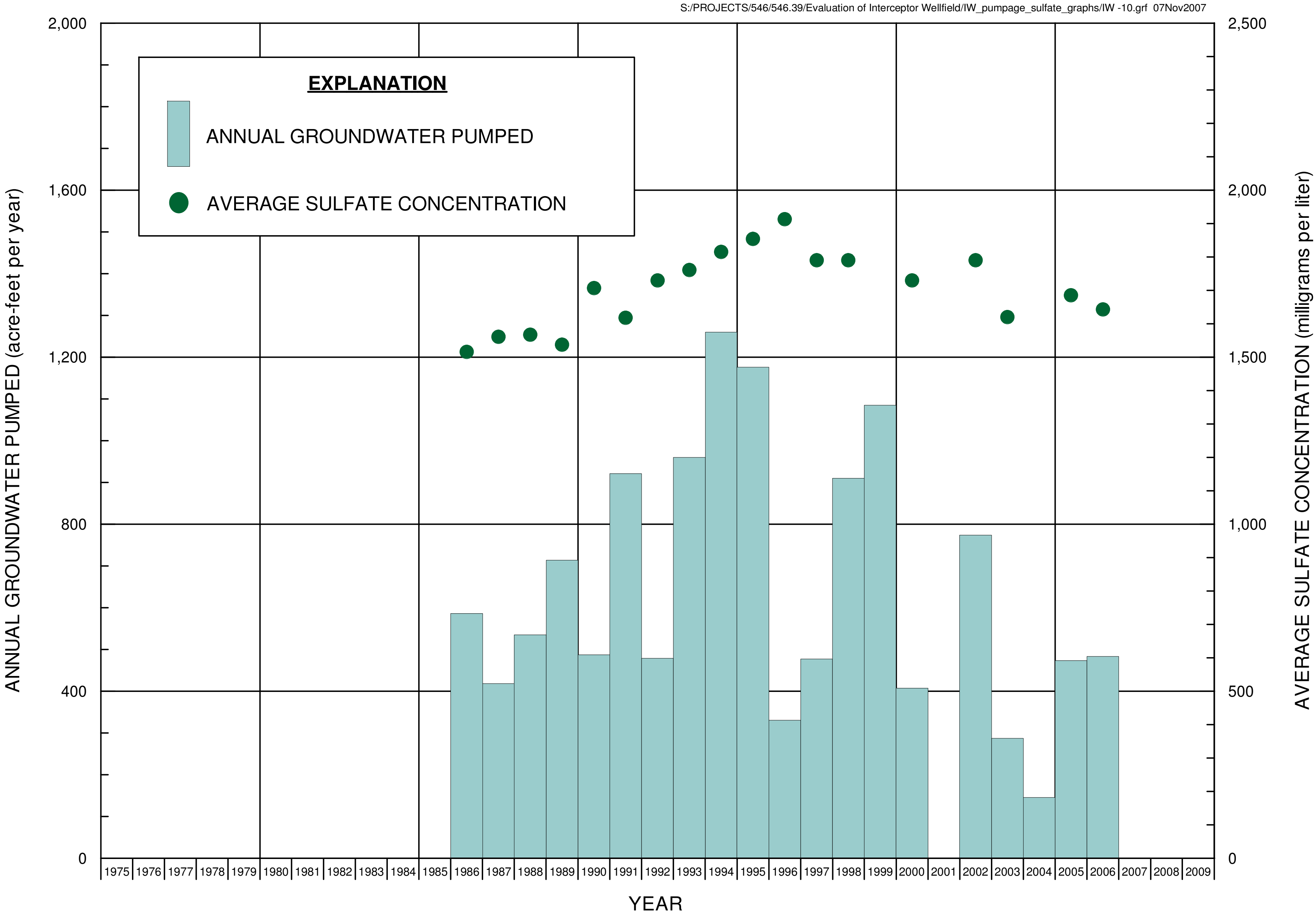

FIGURE C-10. ANNUAL GROUNDWATER PUMPED AND AVERAGE SULFATE CONCENTRATION IN GROUNDWATER FOR INTERCEPTOR WELL IW-10

ERROL L. MONTGOMERY & ASSOCIATES, INC.

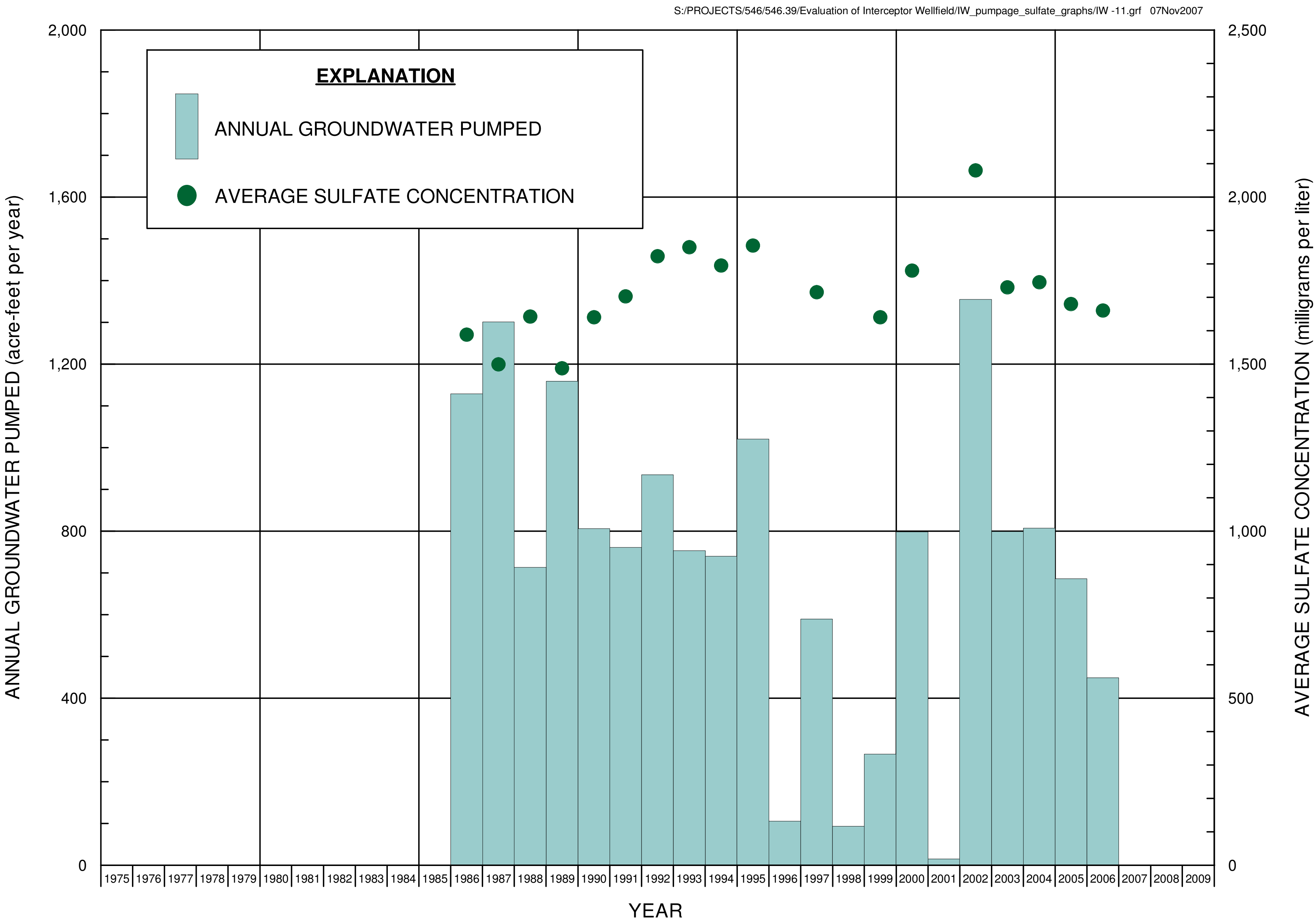

FIGURE C-11. ANNUAL GROUNDWATER PUMPED AND AVERAGE SULFATE CONCENTRATION IN GROUNDWATER FOR INTERCEPTOR WELL IW-11

ERROL L. MONTGOMERY & ASSOCIATES, INC.

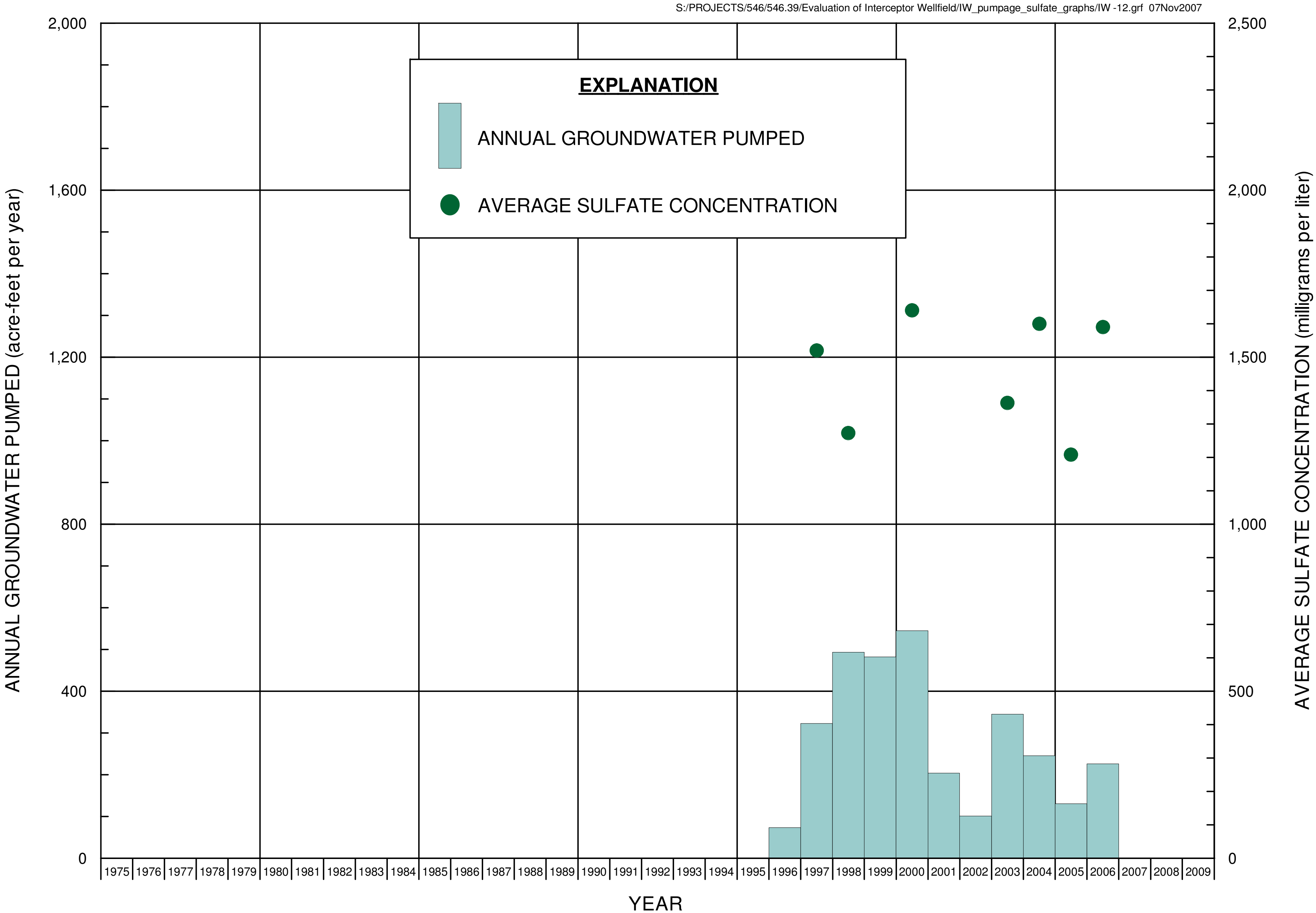

FIGURE C-12. ANNUAL GROUNDWATER PUMPED AND AVERAGE SULFATE CONCENTRATION IN GROUNDWATER FOR INTERCEPTOR WELL IW-12

ERROL L. MONTGOMERY & ASSOCIATES, INC.

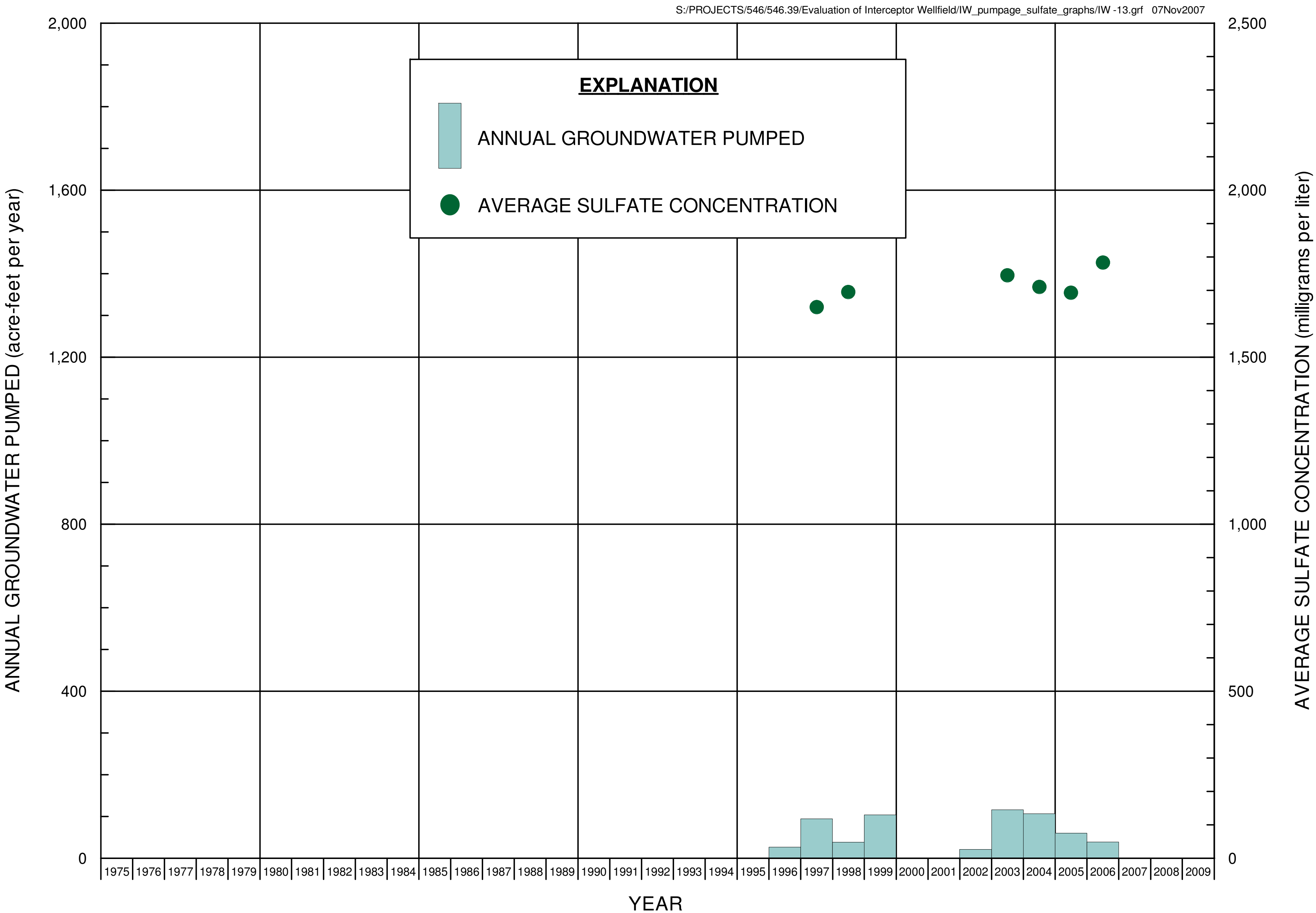

FIGURE C-13. ANNUAL GROUNDWATER PUMPED AND AVERAGE SULFATE CONCENTRATION IN GROUNDWATER FOR INTERCEPTOR WELL IW-13

ERROL L. MONTGOMERY & ASSOCIATES, INC.

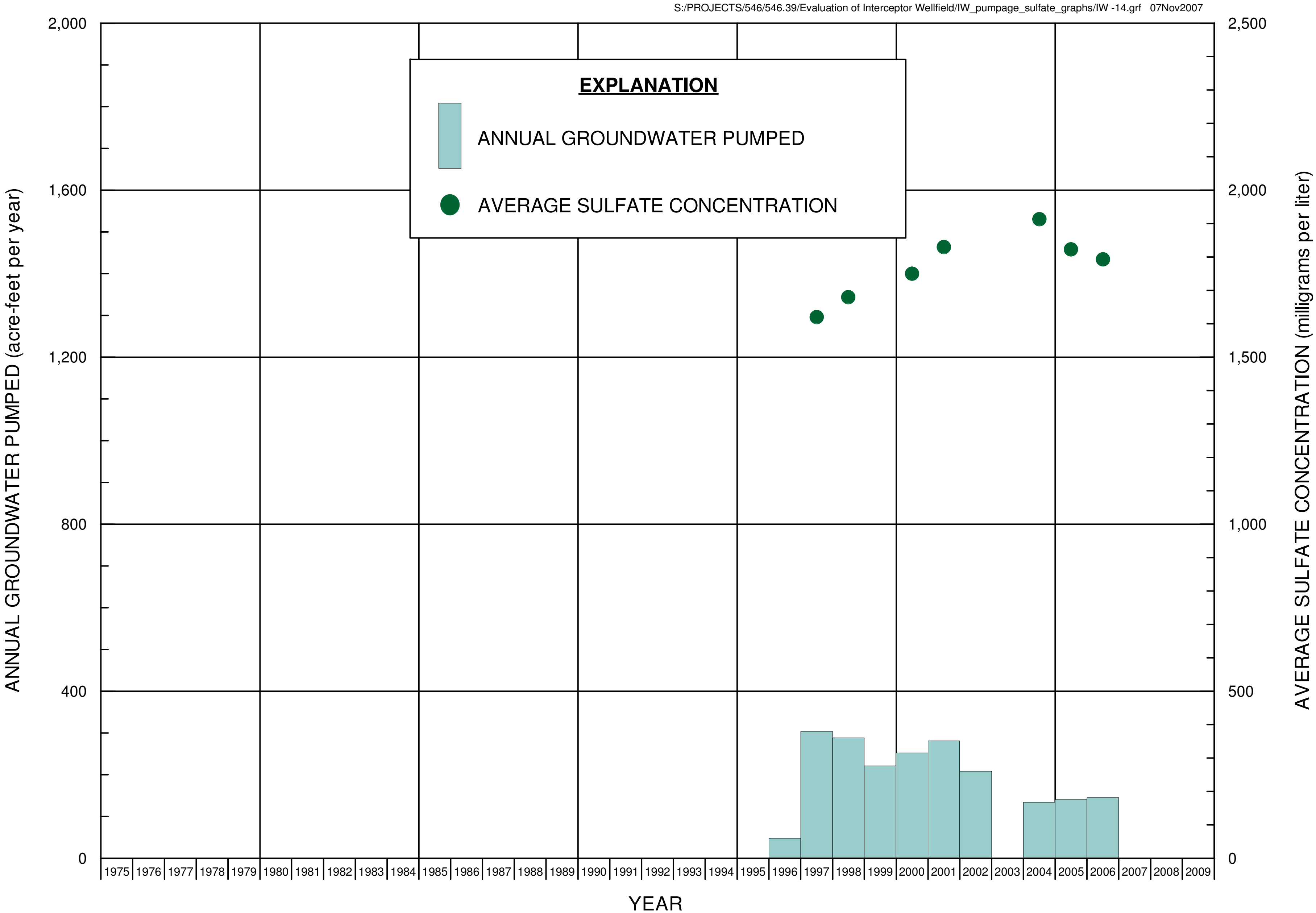

FIGURE C-14. ANNUAL GROUNDWATER PUMPED AND AVERAGE SULFATE CONCENTRATION IN GROUNDWATER FOR INTERCEPTOR WELL IW-14

ERROL L. MONTGOMERY & ASSOCIATES, INC.

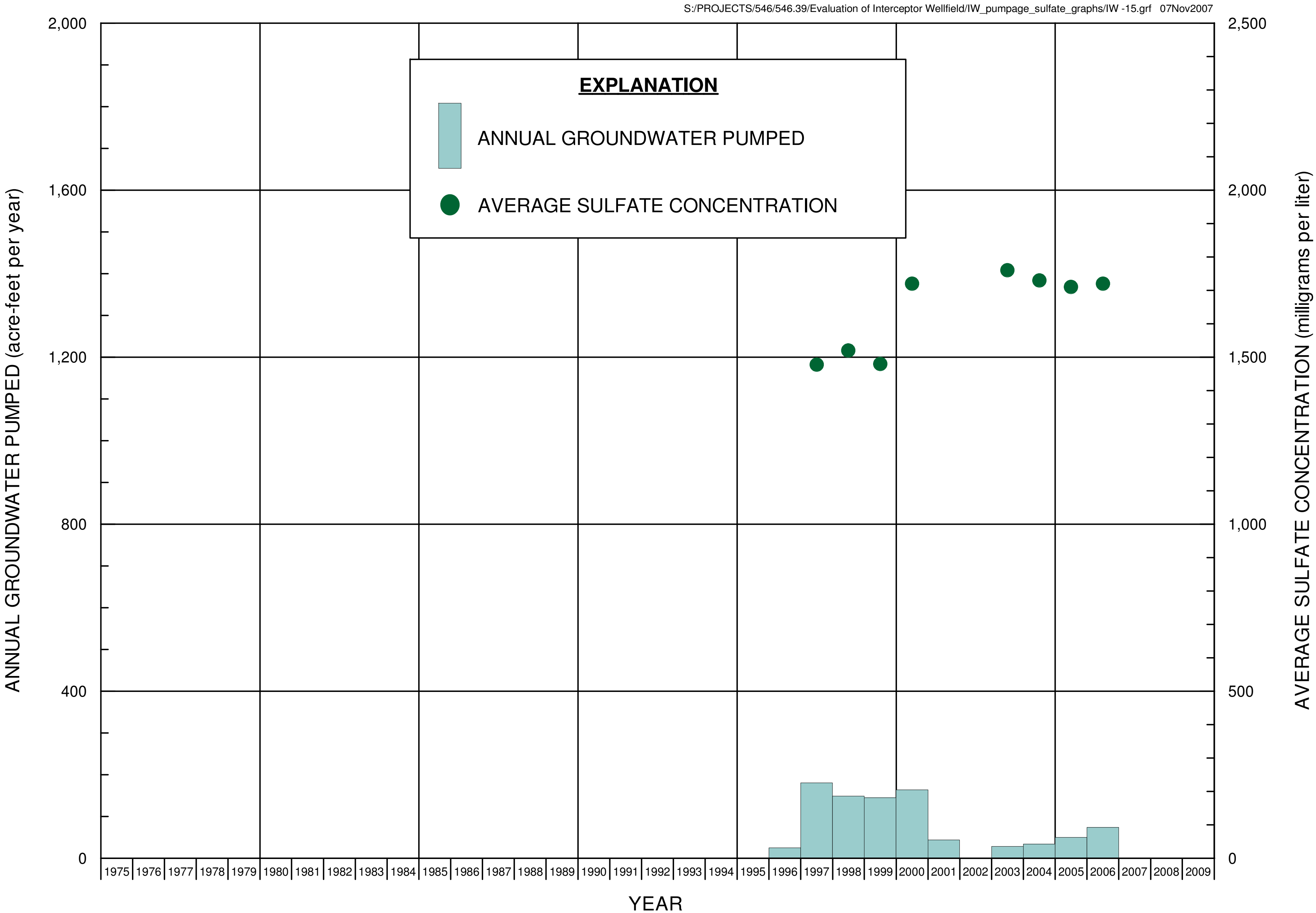

FIGURE C-15. ANNUAL GROUNDWATER PUMPED AND AVERAGE SULFATE CONCENTRATION IN GROUNDWATER FOR INTERCEPTOR WELL IW-15

ERROL L. MONTGOMERY & ASSOCIATES, INC.

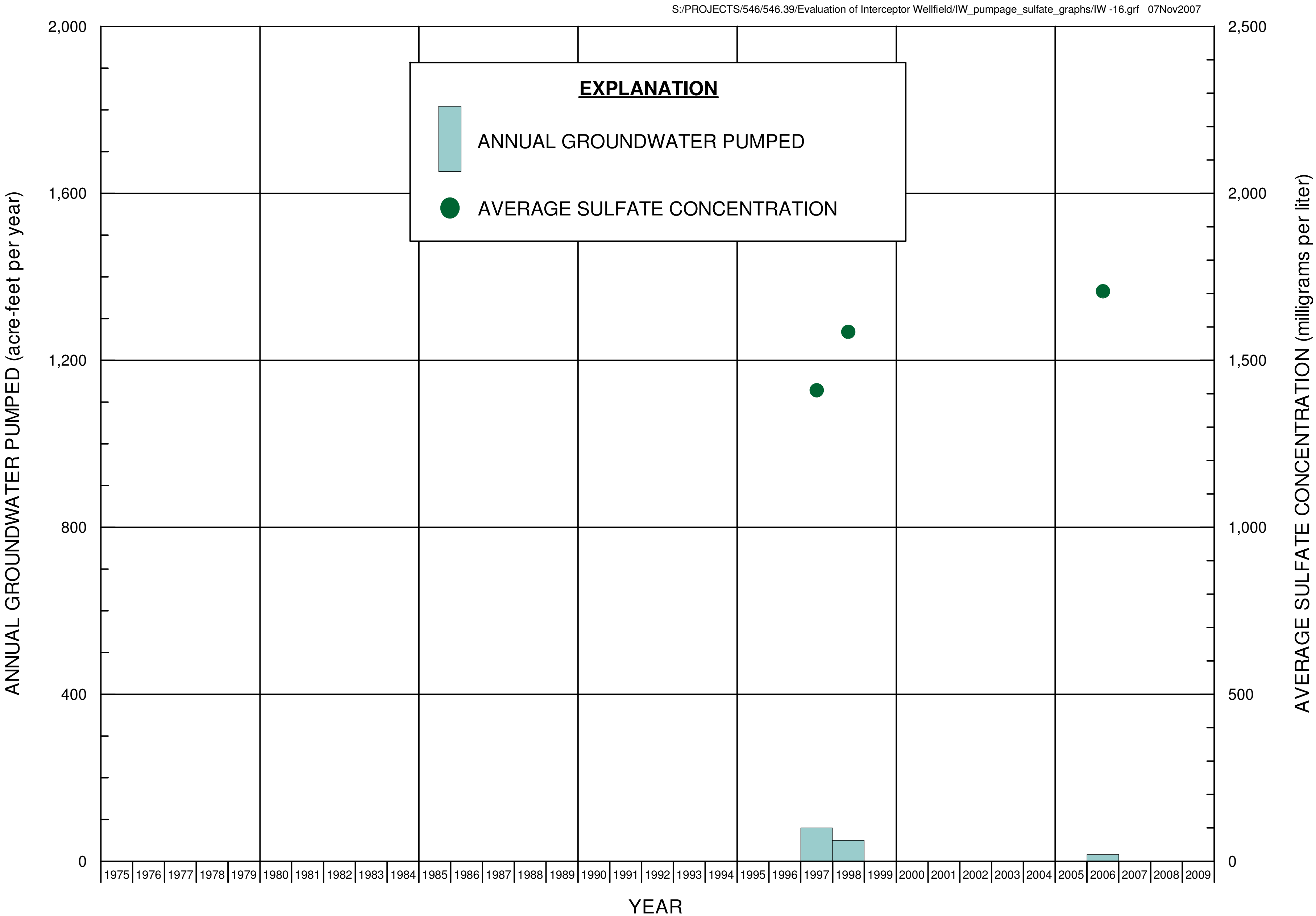

FIGURE C-16. ANNUAL GROUNDWATER PUMPED AND AVERAGE SULFATE CONCENTRATION IN GROUNDWATER FOR INTERCEPTOR WELL IW-16

ERROL L. MONTGOMERY & ASSOCIATES, INC.

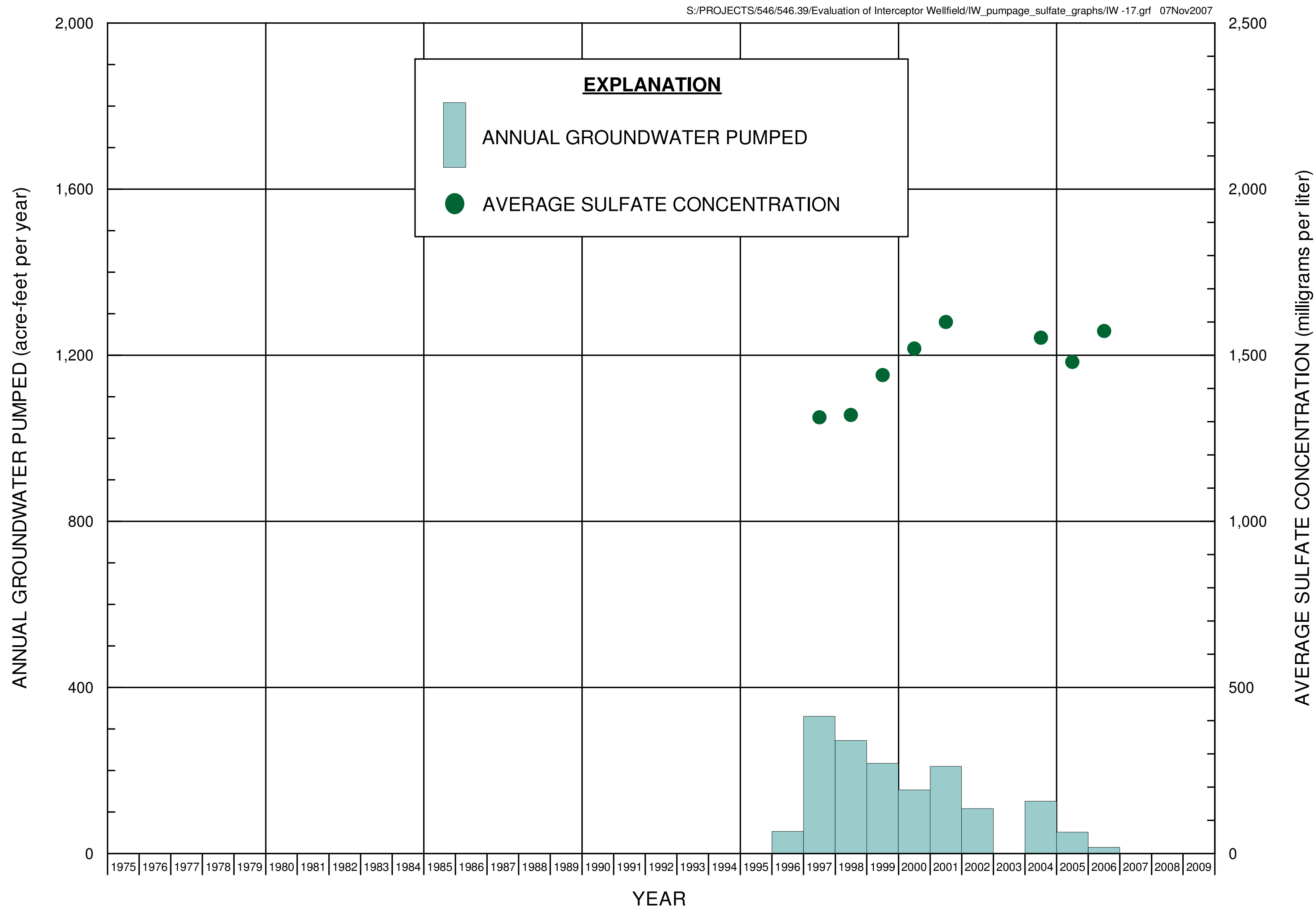

FIGURE C-17. ANNUAL GROUNDWATER PUMPED AND AVERAGE SULFATE CONCENTRATION IN GROUDNWATER FOR INTERCEPTOR WELL IW-17

ERROL L. MONTGOMERY & ASSOCIATES, INC.

S:/PROJECTS/546/546.39/Evaluation of Interceptor Wellfield/IW_pumpage_sulfate_graphs/IW -18.grf 07Nov2007

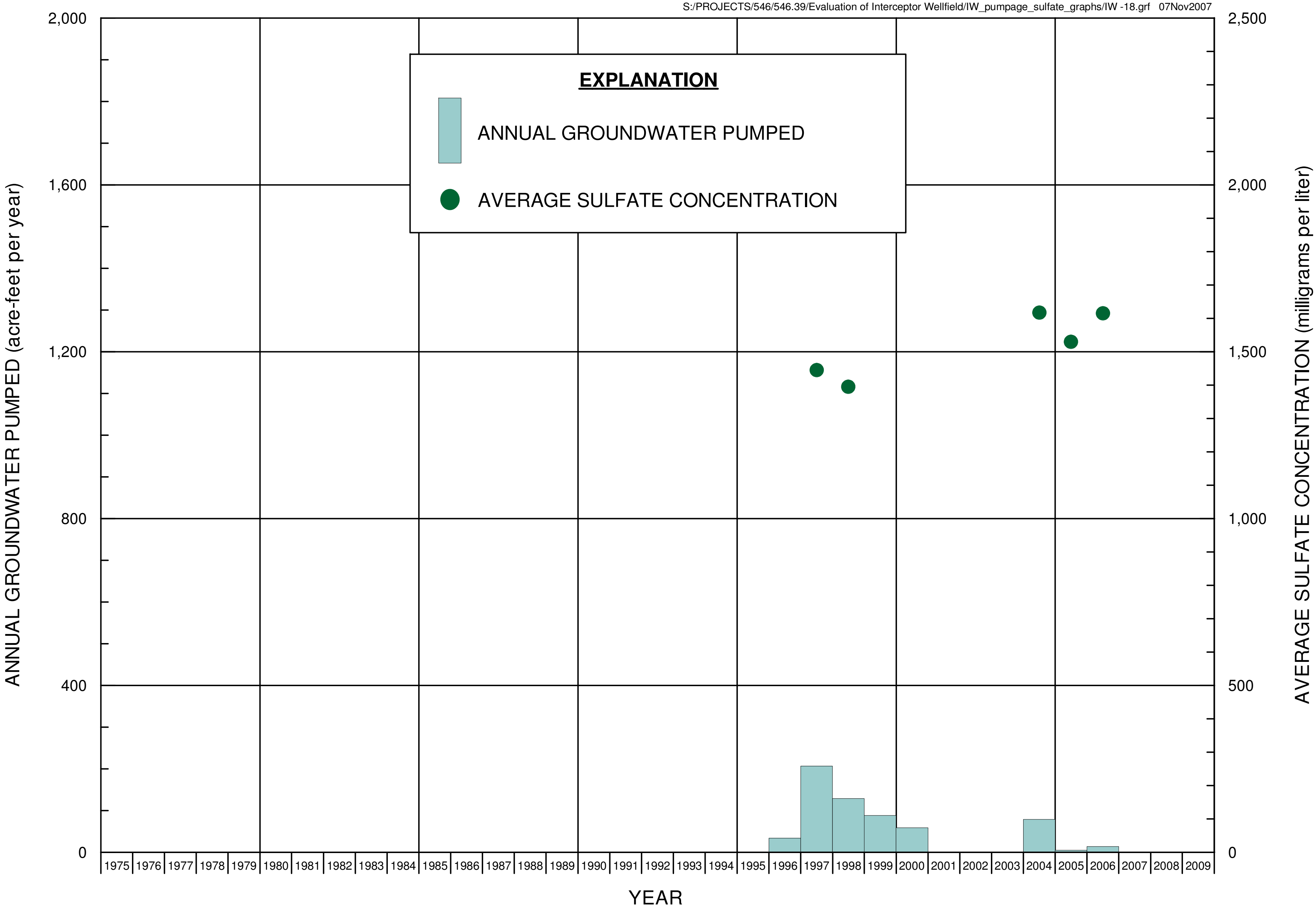

FIGURE C-18. ANNUAL GROUNDWATER PUMPED AND AVERAGE SULFATE CONCENTRATION IN GROUNDWATER FOR INTERCEPTOR WELL IW-18

ERROL L. MONTGOMERY & ASSOCIATES, INC.

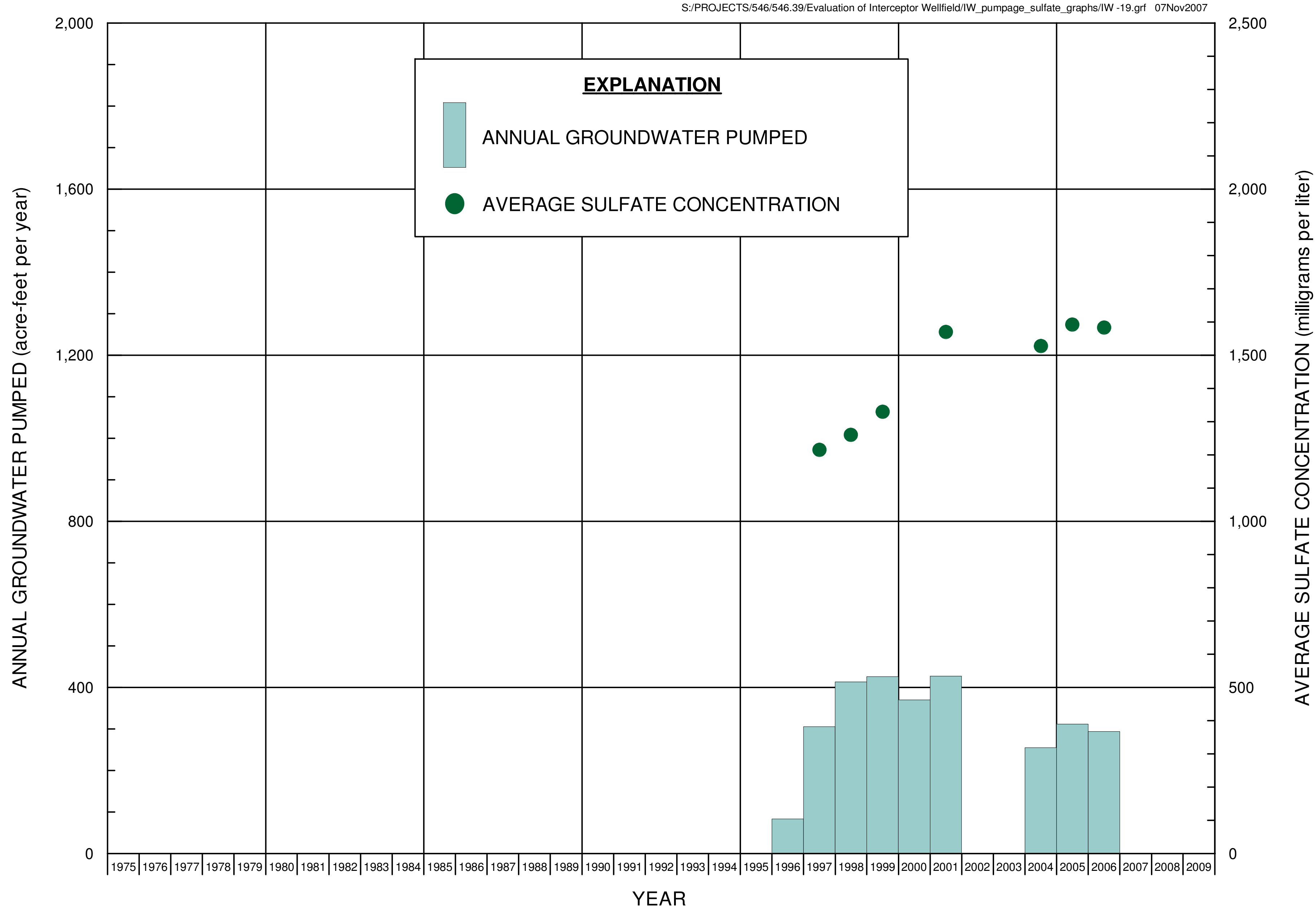

FIGURE C-19. ANNUAL GROUNDWATER PUMPED AND AVERAGE SULFATE CONCENTRATION IN GROUNDWATER FOR INTERCEPTOR WELL IW-19

ERROL L. MONTGOMERY & ASSOCIATES, INC.

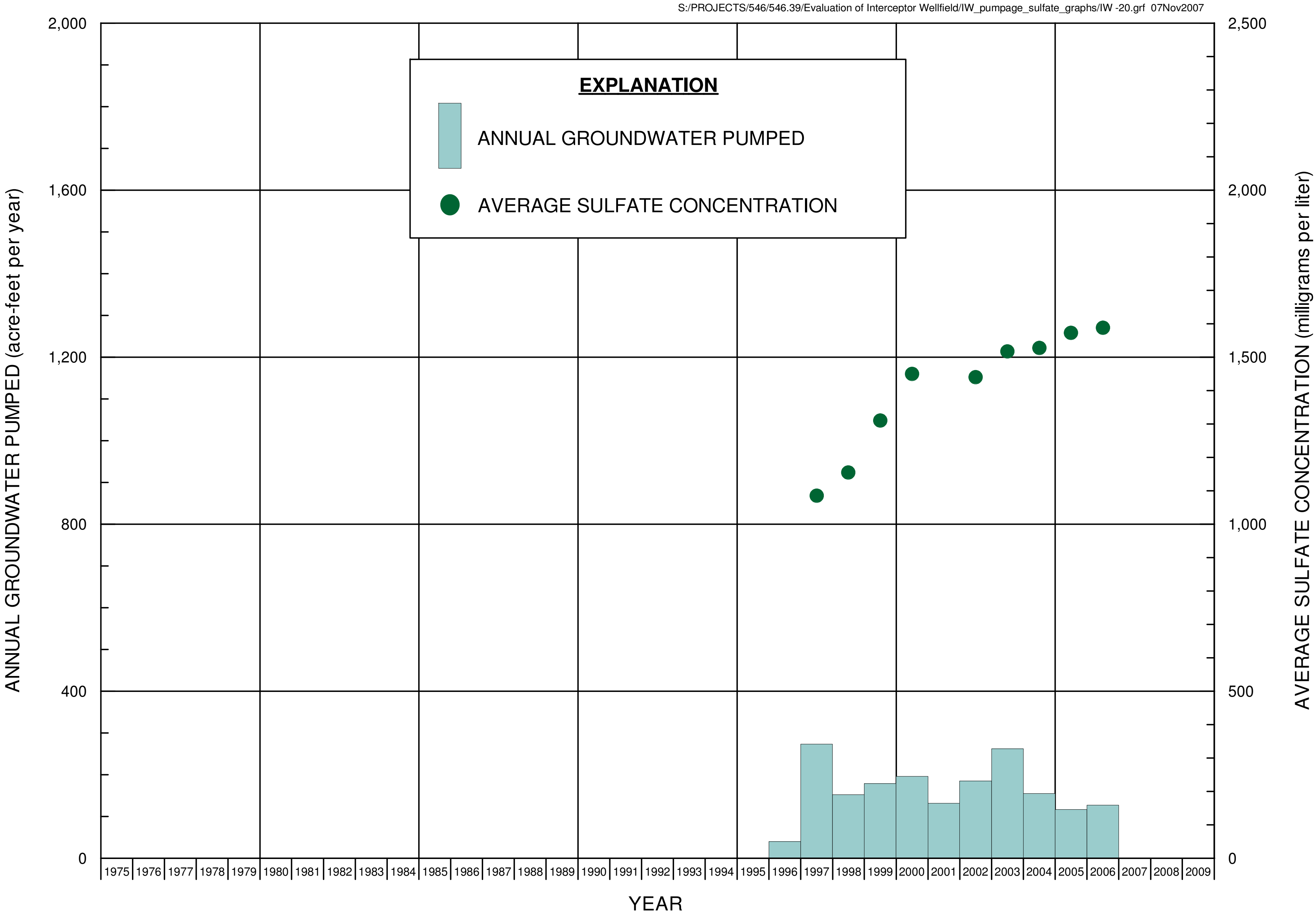

FIGURE C-20. ANNUAL GROUNDWATER PUMPED AND AVERAGE SULFATE CONCENTRATION IN GROUNDWATER FOR INTERCEPTOR WELL IW-20

ERROL L. MONTGOMERY & ASSOCIATES, INC.

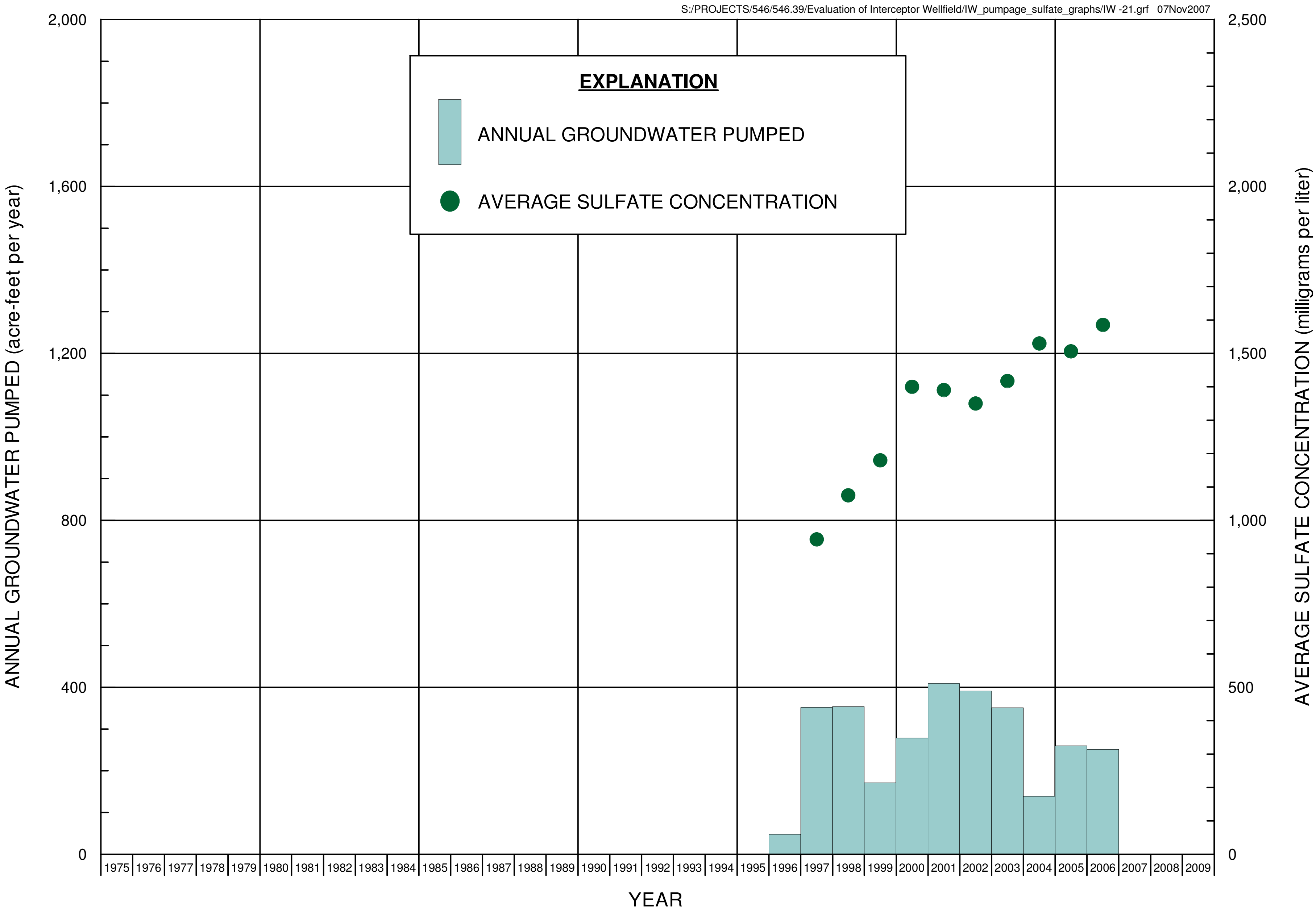

FIGURE C-21. ANNUAL GROUNDWATER PUMPED AND AVERAGE SULFATE CONCENTRATION IN GROUNDWATER FOR INTERCEPTOR WELL IW-21

ERROL L. MONTGOMERY & ASSOCIATES, INC.

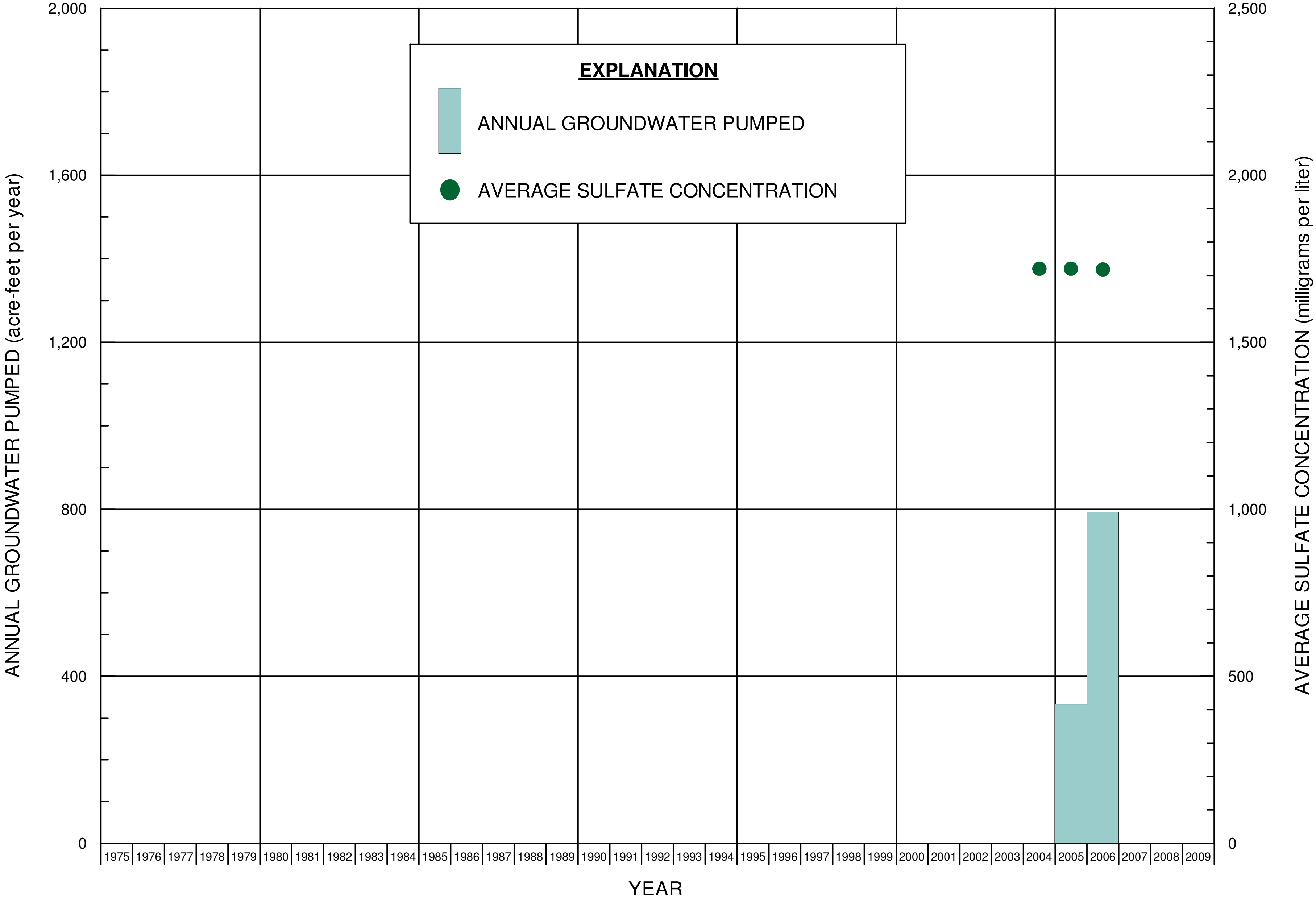

FIGURE C-22. ANNUAL GROUNDWATER PUMPED AND AVERAGE SULFATE CONCENTRATION IN GROUNDWATER FOR INTERCEPTOR WELL IW-22

ERROL L. MONTGOMERY & ASSOCIATES, INC.

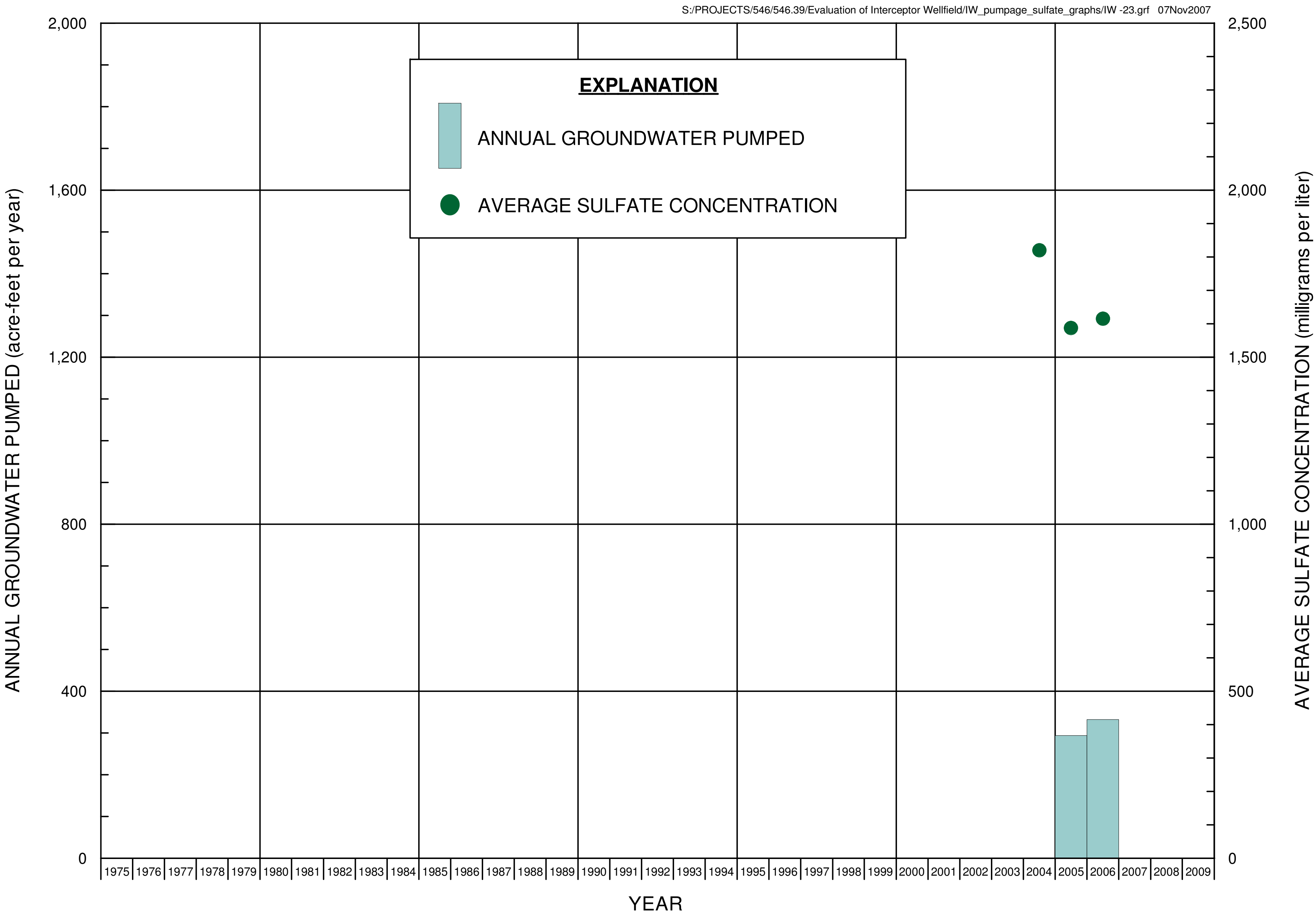

FIGURE C-23. ANNUAL GROUNDWATER PUMPED AND AVERAGE SULFATE CONCENTRATION IN GROUNDWATER FOR INTERCEPTOR WELL IW-23

ERROL L. MONTGOMERY & ASSOCIATES, INC.

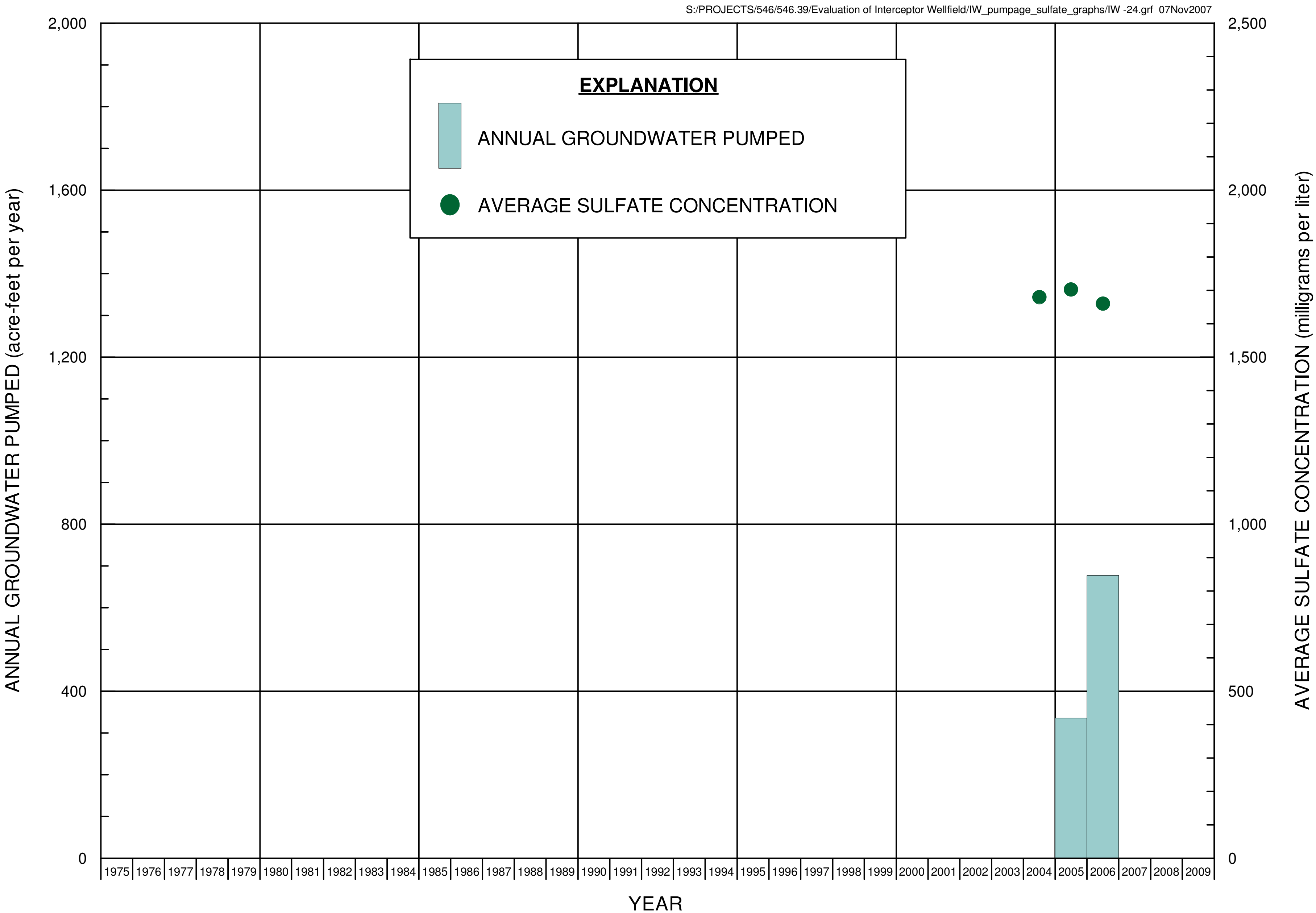

FIGURE C-24. ANNUAL GROUNDWATER PUMPED AND AVERAGE SULFATE CONCENTRATION IN GROUNDWATER FOR INTERCEPTOR WELL IW-24

ERROL L. MONTGOMERY & ASSOCIATES, INC.