Pacific Gas and Electric Company

Yvonne Meeks
Manager

Environmental Remediation
Gas T&D Department

Mailing Address
4325 South Higuera Sreet
San Luis Obispo, CA 93401
Location
6588 Ontario Road
San Luis Obispo, CA 93405
Tel: (805) 234-2257
Email: yjm1@pge.com

January 29, 2008

Mr. Aaron Yue
Project Manager
California Department of Toxic Substances Control
5796 Corporate Avenue
Cypress, CA 90630

Subject: Summary Report for Hydraulic Testing in Bedrock Wells
PG&E Topock Compressor Station, Needles, California

Dear Mr. Yue:

This letter transmits the Summary Report for Hydraulic Testing in Bedrock Wells. The document is submitted in conformance with the November 10, 2006 *Work Plan for Hydraulic Testing in Bedrock Wells, PG&E Topock Compressor Station, Needles, California* and the December 19, 2006 *Technical Addendum: Work Plan for Hydraulic Testing in Bedrock Wells, PG&E Topock Compressor Station,* as approved by the California Department of Toxic Substances Control and the Havasu National Wildlife Refuge.

PG&E appreciates your consideration for the Summary Report for Hydraulic Testing in Bedrock Wells described in this letter. Please contact me at (805) 234-2257 with any questions or concerns.

Sincerely,

Yvonne Meeks
Topock Project Manager

cc: Chris Guerre/DTSC
Kris Doebbler/DOI
John Earle/HNWR

Report

Summary Report for Hydraulic Testing in Bedrock Wells

PG&E Topock Compressor Station, Needles, California

Prepared for

Pacific Gas and Electric Company

January 2008

Prepared by

CH2MHILL

155 Grand Avenue, Suite 1000
Oakland, CA 94612

Contents

Section **Page**

Appendices

Tables

Figures

Acronyms and Abbreviations

bgs	below ground surface
btoc	below the top of casing
DTSC	California Department of Toxic Substances Control
EMFM	electromagnetic flow meter
ft/ft	feet per foot
GMP	Groundwater and Surface Water Monitoring Program
gpm	gallons per minute
gpm/ft	gallons per minute per foot
µg/L	micrograms per liter
msl	mean sea level
PG&E	Pacific Gas and Electric Company
psi	pounds per square inch
Water Board	California Regional Water Quality Control Board, Colorado River Basin Region

1.0 Introduction

Pacific Gas and Electric Company (PG&E) is addressing chromium in groundwater at the Topock Compressor Station near Needles, California under the oversight of the California Department of Toxic Substances Control (DTSC) and the United States Department of the Interior. The Topock Compressor Station is located near Needles, California close to the Arizona/California state line, as shown in Figure 1-1.

This report summarizes the results of hydraulic testing of existing bedrock wells at the PG&E Topock site between April and December, 2007. The overall purpose of the hydraulic testing was to supplement the conclusions of the *Technical Memorandum; Information Review of Groundwater Conditions in Bedrock Formations at PG&E's Topock Compressor Station* (CH2M HILL 2006a), in accordance with DTSC requirements (DTSC 2006). The *Technical Memorandum; Information Review of Groundwater Conditions in Bedrock Formations at PG&E's Topock Compressor Station* (CH2M HILL 2006) presented the available geologic and hydrogeologic data regarding groundwater conditions in bedrock formations at the Topock site and evaluated that information with respect to the site conceptual model. The information in that technical memorandum, together with the results of the hydraulic testing contained in this report, will be included in the Final RCRA Facility Investigation/Remedial Investigation for the Topock site to complete the characterization of bedrock in the vicinity of the site and the potential for impacts from past operations at the Topock Compressor Station.

The hydraulic testing activities were completed as outlined in the *Work Plan for Hydraulic Testing in Bedrock Wells* (CH2M HILL 2006b) (hereafter referred to as the Work Plan), and *Technical Addendum: Work Plan for Hydraulic Testing in Bedrock Wells* (hereafter referred to as the Addendum) (CH2M HILL 2006c). The Work Plan and Addendum describe the objectives, technical approach, and proposed field investigations for the additional bedrock investigation.

Bedrock at the Topock Compressor Station consists primarily of a Pre-Tertiary metadiorite that is unconformably overlain by a conglomerate of Miocene age. Three existing bedrock wells (PGE-07 [hereafter referred to as PGE-7], PGE-08 [hereafter referred to as PGE-8], and MW-48) were selected for testing. Figure 1-1 also shows the locations of wells where bedrock testing was conducted, observation wells that were monitored during testing, the location of the PG&E Topock Compressor Station, and other site features. The bedrock testing program was executed in accordance with DTSC's letter dated April 2, 2007 (DTSC 2007a), and Havasu National Wildlife Refuge approval letter dated March 14, 2007 (USFWS 2007).

This report summarizes the hydraulic testing activities performed from April 2007 through December 2007 at bedrock wells PGE-7, PGE-8, and MW-48, and the associated findings.

2.0 Objectives of Hydraulic Testing

As identified in DTSC letters dated November 3, 2006 (DTSC 2006) and April 2, 2007 (DTSC 2007a), the objectives of the bedrock hydraulic testing and associated activities were to:

- Conduct camera surveys in PGE-7 and PGE-8 to help verify whether these wells are screened within Miocene conglomerate or crystalline bedrock units.
- Retrofitting well PGE-7 to seal off the open portion of this well within the alluvial aquifer, leaving it open only within the bedrock for hydraulic testing, and future sampling
- Conduct a long-term pumping test in PGE-8 to evaluate the hydraulic properties of the bedrock and the degree of hydraulic communication with other bedrock wells and alluvial aquifer wells
- Conduct pumping tests in PGE-7 and MW-48 to further characterize hydraulic properties of the bedrock, and evaluate vertical gradients
- Evaluate the distribution of chromium in crystalline bedrock through collection of groundwater samples at periodic intervals during the PGE-8 test

3.0 Well Construction Details and History

This section discusses well construction information obtained from installation records and subsequent well inspections (e.g., video logs).

3.1 PGE-7

Well PGE-7 is near the northern boundary of the Topock Compressor Station, in an area known as the MW-24 bench (Figure 1-1). PGE-7 was originally installed in 1964 at 182 feet below ground surface (bgs) as a replacement/standby water supply well for the Topock Compressor Station. The original well was constructed with 14-inch steel casing, with perforations assumed from 110 feet to 180 feet bgs. In 1969, the well was deepened to 330 feet bgs, with a 7-inch-diameter blank steel liner installed to 195 feet bgs; the remainder of the hole was uncased to 330 feet bgs. A geologic log for the drilling and deepening of PGE-7 is not available in PG&E's records to provide lithologic description of the bedrock formation in this well. A schematic diagram of PGE-7 in its condition prior to and after retrofitting (described in Section 4.4) is presented in Figure 3-1.

3.2 PGE-8

Former injection well PGE-8 is located on the lower bench of the Topock Compressor Station property (Figure 1-1) and was completed in June 1969. The original boring extended to a depth of 530 feet bgs. The ground surface at this location is approximately 595 feet above mean sea level (msl). The well was drilled with a combination of mud and air rotary techniques. Figure 3-2 is a schematic well completion diagram that summarizes well construction details for PGE-8. The alluvium to metadiorite bedrock contact was estimated to be at 175 feet bgs (421 feet msl) (Dames & Moore, 1969). Because the alluvium is in direct contact with the metadiorite, it follows that the Miocene conglomerate is not present at PGE-8. During drilling, a sharp increase in groundwater specific conductance was noted below 273 feet bgs (320 feet msl) (Dames & Moore, 1969).

The boring was originally constructed with 6-inch steel casing from ground surface to 188 feet bgs (405 feet msl), and the remainder of the borehole was left open. After the injection testing in April 1970 (described below), injection of wastewater began on May 30, 1970, and pressure rapidly built to 30 pounds per square inch (psi). By June 4, 1970, pressure had built to 180 psi despite efforts to reduce pressure buildup by pouring 38 percent hydrochloric acid into the injection tubing. Upon sounding the well, it became evident that the lower 15 feet of the hole had collapsed. In June 1970, the well was cleaned out and deepened from 530 to 562 feet bgs using air rotary techniques. A Johnson well screen and liner composed of 316 stainless steel was lowered into the well and set from approximately 404.5 to 550 feet bgs (Figure 3-2). It is assumed that a sump was placed from 554 feet and the bottom of the boring.

Video logging conducted within PGE-8 as part of the current investigation revealed that a portion of the former injection infrastructure remains in the well. The sheared top of the former injection pipe was observed at approximately 362 feet below the top of casing (btoc) and extends to a depth greater than 382 feet btoc. It is presumed that the observed injection pipe is attached to a mechanical packer that was reportedly installed at a depth of 405 feet btoc. Although the pipe and packer prevents tooling access to the lower section of the well, the open 3-inch pipe allows adequate water flow within the well to complete the aquifer testing tasks described in Section 5.1. Video logging could not be conducted at depths greater than 382 feet btoc due to sediment buildup in the well. Attempts to lower the camera within the injection pipe were not successful.

3.3 MW-48

Well MW-48 is located on the Havasu National Wildlife Refuge approximately 1,000 feet northeast of the north gate to the Topock Compressor Station (Figure 1-1). MW-48 was installed in May 2006 as part of the interim measures performance monitoring drilling program and was constructed with a 2-inch-diameter, 10-foot-long PVC screen (362 to 352 feet MSL) within the Miocene conglomerate bedrock, as shown in Table 3-1.

4.0 Well Inspection and Logging Activities

PG&E completed various well inspection and logging activities at wells PGE-7, PGE-8, and MW-48 prior to hydraulic testing activities. Video log summary reports (provided by the contractor, Welenco, Inc.) are included in Appendix A. The geophysical logs and the flow logging summary report (provided by the contractor, RAS, Inc.) are provided in Appendix B and Appendix C, respectively.

4.1 PGE-7

Logging and inspection activities conducted at PGE-7 included geophysical logging (cement bond log, electric logs, natural gamma log, acoustic televiewer log, and caliper log), electromagnetic flow meter logging, and video logging. A summary of geophysical and electromagnetic flow meter (EMFM) data collected at PGE-7 is provided on Figure 4-1.

Geophysical logging was performed at PGE-7 on April 3, 2007 by Welenco, Inc. Each log was conducted from the top of casing or water table (as appropriate) to the current total depth of the well (approximately 300 feet btoc). Key findings of the geophysical logging include the following:

- Prominent fractures were observed with the acoustic televiewer at 265, 266, and 271 feet btoc. Hairline fracturing was observed at 226 and 291 feet btoc.
- In the uncased portion of the well (greater than 194 feet btoc), a relatively sharp increase in 16-64 resistivity and single-point log response is observed at approximately 226 feet btoc. This shift is likely indicative of a change in lithology.
- In the uncased portion of the well (greater than 194 feet btoc), the caliper log indicates an abrupt change in the borehole diameter from approximately 9 inches above 226 feet btoc to a very uniform borehole diameter of approximately 6.5 inches from 226 feet btoc to 300 feet btoc. The caliper data indicate a contrast in rock quality and competency at the 226 feet btoc depth and is inferred to be the top of the harder, crystalline metadiorite bedrock.
- The gamma log below 226 feet btoc indicates significant and abrupt fluctuations in log response, whereas the shallower gamma readings from 194 to 226 feet btoc are relatively uniform. This contrast in the gamma log response supports a lithology change at 226 feet btoc.
- The PGE-7 cement bond log indicates a relatively poor bond between the cement and the well casing from ground surface to 158 feet btoc. From 158 feet btoc to the bottom of the casing (194 feet btoc) more cemented intervals include: 158 to 166, 170 to 172, 176 to 180, and 188 to 192 feet btoc.

A video log of well PGE-7 was conducted on April 3, 2007 as part of the current investigation (Appendix A). A video log with poorer images was previously conducted in 1998 (E&E, 2002). The recent video log revealed that the 7-inch steel casing within this well

is in relatively good condition and extends from ground surface to approximately 194 feet btoc. The well is uncased from 194 feet btoc to the current total depth of 300 feet btoc. The original driller's log indicates that the total depth of the PGE-7 was 330 feet bgs; therefore, approximately 30 feet of material has filled the bottom of the well.

Based on the geophysical data and the video log, the top of the crystalline metadiorite bedrock appears to be approximately 226 feet btoc. The PGE-7 geophysical and video logs do not provide sufficient information to differentiate the geologic units in the open borehole interval that overlies the crystalline metadiorite bedrock. Based on nearby drilling logs, the base of the Alluvial Aquifer extends to approximately 220 feet btoc at PGE-7.

Electromagnetic flow logging, which uses a sensitive flow meter to evaluate the vertical groundwater flow component within a well, was conducted at PGE-7 on April 19 and 20, 2007 by RAS, Inc. Flow logging was conducted under both induced (pumping) and ambient (non-pumping) flow conditions within the uncased, bedrock portion of the well from 195 to 300 feet bgs to locate conductive fracture zones. EMFM measurements collected during both the induced and ambient flow tests suggest that groundwater flow within the bedrock portion of the well is below the reliable detection limit of the tool; therefore, no water-bearing intervals were identified within the metadiorite bedrock. Key findings of the EMFM logging include the following:

- PGE-7 was pumped at a rate of 13.5 gallons per minute (gpm) during induced flow testing conditions, which resulted in 2.3 feet of drawdown in the well.
- All water velocities measured were below the reliable range of the EMFM (less than 0.1 gpm) and are therefore considered approximate.
- EMFM measurements within the bedrock portion of the borehole were collected at 18 locations during induced flow testing. All water velocity measurements were less than 0.1 gpm, indicating that very little water was being produced from the bedrock section of the borehole.
- EMFM measurements collected during ambient flow testing suggest that there is a very small (less than 0.1 gpm) upward component to flow under non-pumping conditions.
- Specific water-bearing intervals were not identified during the testing because the flow velocities measured were below the reliable range of the EMFM. However, the survey did show that very little water was being produced from the bedrock interval of the borehole.

4.2 PGE-8

Logging and inspection activities conducted at PGE-8 included a cement bond log, natural gamma log, and two separate video logs. Because the well is blocked below approximately 362 feet btoc by the former injection pipe and the accessible portion of the well is cased with steel, additional logging (e.g., electric logs, EMFM log, and acoustic televiewer log) was not performed.

A cement bond log and a gamma-ray log were performed at PGE-8 on November 17, 2006 by Welenco, Inc. The cement bond log conducted at PGE-8 shows that there is a relatively

good cement bond from ground surface to 360 feet btoc. There are no key findings observed from the gamma-ray log; however, the data are comparable to the gamma-ray log conducted at the time of well construction by Schlumberger in April 1969.

Two video logs were conducted at PGE-8 as part of the current investigation. The first log was conducted in November 2006 and the second log was conducted in November 2007. The video camera used in November 2006 was too large to fit within the former injection piping, which was discovered during this logging event; therefore, a second video logging attempt was made using a smaller 2-inch-diameter camera in November 2007. Although the camera used during the November 2007 video survey was small enough to fit in the 3-inch former injection pipe, the camera tended to track either near the center of the borehole or on the opposite side of the casing from where the 3-inch pipe lay. Multiple attempts were made, but it was not possible to manipulate the camera to enter the 3-inch pipe. The smaller camera was able to fit alongside the 3-inch pipe and survey the section of the well below 360 feet btoc but above the packer, reportedly set at 405 feet. Sediment was encountered at 382 feet btoc. Thus, it appears that approximately 23 feet of sediment is has settled in on top of the packer. The presence of this sediment would greatly complicate any attempt to remove the packer from the well.

4.3 MW-48

Welenco, Inc. conducted natural gamma and electric logs at MW-48 on April 3, 2007. Shifts in both the natural gamma and electric logs (increased gamma-ray and increased resistivity) are observed at approximately 50 feet btoc and confirm a change in lithology (i.e., top of Miocene conglomerate) observed at the same depth in the lithologic log completed during drilling.

4.4 PGE-7 Retrofitting

PGE-7 was retrofitted in an attempt to create an interval that is open only within the bedrock for hydraulic testing and future sampling. The Work Plan (CH2M HILL, 2006b) identified three different options for retrofitting PGE-7 for water level and water quality monitoring. These options included:

- Installation of a flexible membrane liner (Water FLUTe™) equipped with multilevel sampling ports.
- Installation of multiple nested Barcad samplers or 1-inch-diameter mini-wells within backfill placed in the existing borehole.
- Installation of a standard 2-inch-diameter PVC monitoring well within backfill placed in the existing borehole.

The Water FLUTe™ liner was selected as the preferred method for retrofitting this well for water level monitoring. However, upon viewing the April 2007 video of PGE-7, the manufacturer of the FLUTe™ liner system concluded that there was a significant risk of puncturing the liner due to the roughness of the crystalline bedrock borehole walls. Therefore, the FLUTe™ liner technology was not implemented at PGE-7. An alternative

method using an inflatable straddle packer assembly was developed. DTSC granted approval to proceed with this approach on July 6, 2007 (DTSC, 2007b). After the straddle packer assembly was deployed and tested, it was determined that an adequate seal could not be obtained against the rough borehole walls. As a result, PG&E proposed a third well retrofit method, the construction of a sleeve within the existing well. DTSC approved this approach on September 7, 2007 (DTSC 2007c).

The following subsections summarize the details regarding the efforts made to retrofit PGE-7 using the inflatable straddle packer assembly and sleeve construction.

4.4.1 Packer Testing

Data collected during well inspection and logging activities were reviewed to select the portions of the open borehole that would be most conducive to establishing a competent seal with the packer against the borehole walls. A straddle packer assembly consisting of two 3-foot-long packers separated by 40 feet with pressure transducers within each testing interval (below the bottom packer, and between the two packers) was installed in PGE-7 on August 4, 2007. A pressure transducer, independent of the straddle packer assembly, was also installed above the upper packer to monitor water levels in the overlying alluvium. In addition, a Rediflo™ 2 pump was built into the straddle packer assembly (between the two packers) to facilitate groundwater extraction from below the upper packer. The effectiveness of the seal established by the packer against the borehole wall, and therefore between the bedrock portion of the well and the overlying alluvium, was tested by pumping groundwater with this pump and observing the hydraulic response above and below the packer. The top of the upper packer was initially set (i.e., inflated) at 235 feet btoc and the top of the lower packer was set at 275 feet btoc.

A pump test was conducted on August 14, 2007 at PGE-7 by pumping in the bedrock interval of the well. Drawdown in the portion of the well that was hydraulically connected to the alluvium (above the upper packer) indicated that the straddle packer assembly was not providing a complete seal against the rough borehole wall. In attempt to establish an adequate seal, the packer assembly was relocated to two more alternative depths within the borehole (first with the upper packer set at 243 feet btoc and lower packer at 283 feet btoc, then with the upper packer at 246 feet btoc and the lower packer at 286 feet btoc). Leakage past the packer was observed at both of these alternate depths, indicating that the packer assembly was not a viable option for isolating the bedrock section of the borehole from the overlying alluvium.

4.4.2 Sleeve Construction within PGE-7

The chosen alternative to retrofitting PGE-7 was to construct a sleeve within the existing well to seal off the portion of this well open to bedrock from the Alluvial Aquifer. Discussions with DTSC on this matter on September 5, 2007 resulted in the approval on September 7, 2007 (DTSC 2007c) to construct a sleeve within the existing well. A schematic diagram of the sleeve constructed within the PGE-7 well is provided in Figure 3-1.

The sleeve construction was completed in two phases. The initial construction of the sleeve was conducted from September 24 through 28, 2007. During this mobilization a flush-threaded, 3-inch-inner-diameter (3.5-inch-outer-diameter) mild steel casing was

installed from the top of the existing well casing to 252 feet below land surface, which is approximately 26 feet below the top of the metadiorite bedrock. The bottom 5 feet of the 3-inch sleeve was fabricated with a flush-threaded adapter, which increased the outer diameter of the sleeve to 4.5 inches to facilitate the attachment of rubber shale packers. Shale packers are conical shaped seals made of thick rubber that block the annular space between the casing and the borehole wall to provide a base to support the annular materials (sand and bentonite grout). Prior to installation, two 6.75-inch-outer-diameter (at widest point of the cone) rubber shale packers were attached to the 4.5-inch-outer-diameter portion of the sleeve. A 1-inch-outer-diameter, flush-threaded, steel tremie pipe was installed along with the sleeve casing. With the 3-inch casing and tremie pipe installed to depth, 6 feet of fine sand (RMC #0/30) were installed via tremie pipe to seat the shale packers. Following the installation of the sand, bentonite grout was installed via positive-pressure tremie from the top of sand to approximately 226 feet bgs, which is approximately the top of the metadiorite bedrock. The grout was allowed to set for approximately 24 hours before the seal was tested. Short-term specific capacity tests were performed using a submersible pump installed within the 3-inch sleeve to evaluate the seal. Bentonite was observed in the pump discharge, and drawdown was observed in the alluvial interval, indicating that the alluvial/ Miocene conglomerate portion of the well had not been hydraulically sealed from the metadiorite bedrock.

During a second field mobilization (October 15 and 16, 2007), additional bentonite grout was installed in the annular space between the 3-inch casing and the open borehole wall. The tremie pipe was reinstalled near the top of the previous grout surface, and additional grout was installed to raise the top of the grout surface to 198 feet bgs, approximately 3 feet below the bottom of the existing 7-inch steel casing. The grout was allowed to set for approximately 24 hours before the seal was retested. Short-term specific capacity tests were performed using the submersible pump previously installed within the 3-inch sleeve, which was not removed during the installation of additional grout. Testing indicated that the alluvial/Miocene conglomerate portion of the well was now hydraulically sealed from the metadiorite bedrock, as indicated by large drawdown in the sleeved section of the well, which is open to the bedrock, with no observed water level drawdown in the annular space which is open to the alluvium.

The retrofitted PGE-7 well was subsequently purged on multiple occasions following sleeve construction to verify hydraulic separation of the metadiorite bedrock portion of the well from shallower units. With each purge test, the water level in the bedrock portion of the well was drawn down a minimum of 80 feet, as monitored by a pressure transducer. Simultaneous monitoring of the depth to water in the portion of the well hydraulically connected to the alluvium (measured in the annular space between the existing 7-inch casing and the 3-inch sleeve) indicated no observable drawdown. In addition, the volume of water removed during each purge event was approximately equal to the volume of the evacuated borehole.

5.0 Hydraulic Testing

5.1 Hydraulic Test Implementation

PG&E conducted various methods of hydraulic testing at wells PGE-7BR (which was termed PGE-7 prior to the retrofit), PGE-8, and MW-48 during this investigation. Test implementation details are summarized in the following subsections.

5.1.1 PGE-7BR Recovery Test

After PGE-7 was retrofitted as a bedrock well and water from the alluvium could no longer enter the well, yield from well PGE-7BR was too low (less than 1 gpm) to conduct a constant rate extraction test. This observation is consistent with the results of the EMFM logging conducted prior to well retrofitting and yields observed from other wells at the site that are screened exclusively within the bedrock (e.g., MW-23 and MW-24BR). In consultation with DTSC, a slug test was conducted in well PGE-7 on November 14, 2007 in compliance with the approved Work Plan. As discussed in subsequent sections, recovery test analysis was performed on the water level recovery data to estimate hydraulic conductivity. A plot of water level recovery data is provided in Appendix D and the results are discussed below.

5.1.2 PGE-8 Step Test

A short-term step-rate extraction test was performed at PGE-8 in August 2007 to obtain an estimate of specific capacity and to determine an initial pumping rate for the constant rate extraction test described in Section 5.1.3. Due to the presence of injection piping at 362 feet btoc (as described above in Section 5.1.3), an electric submersible pump was set at 356 feet btoc to facilitate testing. This pump placement resulted in approximately 195 feet of available drawdown above the pressure transducer which was installed to monitor the water level throughout the test. Testing was conducted at extraction rates of 6.5, 7.5, and 10 gpm. Data collected during this test resulted in a specific capacity estimate of 0.08 gallons per minute per foot (gpm/ft), and from this estimate, 7 to 8 gpm was determined to be an acceptable initial pumping rate for constant rate testing. Although it was estimated that the well could likely yield more water than this, the duration at which higher extraction rates could be maintained if fractures began to drain during pumping was uncertain.

5.1.3 PGE-8 Pumping Test

The constant rate extraction test at PGE-8 was begun the morning of August 8, 2007 at a pumping rate between 7 and 8 gpm. Pumping continued at this rate for approximately 2 days until the morning of August 10, 2007, when it was increased to 11 gpm. After the water level in PGE-8 had stabilized for nearly 9 hours while being pumped at 11 gpm, the pumping rate was increased to 15 gpm during the evening of August 10, 2007. Within an hour of increasing the pumping rate to 15 gpm water levels in the well dropped to within a few feet of the pressure transducer. As a result, the pumping rate was reduced to 13.6 gpm and maintained until the test was completed in the afternoon of August 11, 2007.

Approximately 45,000 gallons were extracted during the 3.14-day testing period. A summary of pumping rates and water level drawdown observed during the PGE-8 constant rate extraction test is provided in Figure E-1 in Appendix E.

In DTSC's April 2, 2007 letter (DTSC 2007a), DTSC requested that if production exceeded 5 gpm while performing pump tests, PG&E should evaluate the permeability of potential fault zones with a numerical model. Because the production at PGE-8 exceeded 5 gpm, PG&E will be evaluating the permeability of potential fault zones. This work is being conducted separately, and a summary technical memorandum will be submitted to regulatory agencies at a later date.

5.1.4 PGE-8 Injection Test

Approval to re-inject groundwater extracted during PGE-8 testing (if acceptable water quality standards were met) was obtained from the California Regional Water Quality Control Board, Colorado River Basin Region (Water Board) and DTSC on July 6, and July 3, 2007, respectively (Water Board 2007; DTSC 2007d). As discussed in Section 6.2, all water samples collected from PGE-8 during extraction testing, as well as a sample collected from the storage tanks, were non-detect for hexavalent chromium. Therefore, the pumping test water met the necessary criteria for re-injection. On August 17, 2007, PG&E summarized the results of samples from PGE-8 testing and provided email notification to the Water Board and DTSC that injection testing would proceed using the water that had been pumped from PGE-8 during extraction testing (CH2M HILL 2007). The test water was stored near the well head to await the injection test.

To facilitate the injection test, 1.5-inch steel injection piping was temporarily installed within PGE-8 to 150 feet btoc (10 feet below the static water level), with a 3-foot-long inflatable packer on the lower 10 foot section of pipe. Injection testing at well PGE-8 occurred from October 17 through October 19, 2007. During this testing period, approximately 40,000 gallons of water, which were stored in tanks at the well head following extraction testing, were filtered and injected into the well over the course of approximately 2 days (44.7 hours). The difference in volume extracted and the volume reinjected is attributable to evaporation in the time between the two tests. The average injection rate during the test was 14.7 gpm, which resulted in an average wellhead pressure of approximately 100 psi. From these data, the average specific injectivity during the test is estimated to be 0.04 gpm/ft. A summary of injection rates and wellhead pressures observed during the test is provided in Table E-2 of Appendix E.

5.1.5 MW-48 Recovery Test

A slug test was conducted at monitoring well MW-48 because, based on previous purge logs, the well yield is too low to conduct a constant rate extraction test. The well was pumped down to the top of the screen on November 12, 2007, and recovery was monitored with a pressure transducer. As discussed in Section 5.2.6, recovery test analysis was performed on the water level recovery data to estimate hydraulic conductivity. A plot of water level recovery data is provided in Appendix F, and the results are discussed in Section 5.2.6.

5.2 Hydraulic Testing Results

A brief summary of historical bedrock aquifer testing and results and analyses of the aquifer tests conducted at PGE-8, PGE-7BR, and MW-48 in August through November 2007 are presented in this section. Observation wells for the testing were approved by DTSC on July 13, 2007 (DTSC 2007e).

5.2.1 History of Previous Bedrock Aquifer Testing

Table 5-1 summarizes the tests conducted during the 2007 bedrock hydraulic testing field activities contained in this report, as well as previous bedrock aquifer testing activities at the Topock site. As originally completed, PGE-8 was tested on various occasions for short durations (12 to 60 minutes) at flow rates ranging from 20 to 51 gpm, then for a longer period (26 hours) at 26 gpm during May 1969. Dames and Moore (1969) calculated a transmissivity of 10,000 gpd/ft (~1,300 ft^2/d), based on the longer duration test (using a porous media analysis). The results from the 26-hour test (rapid drawdown in early time followed by stabilized water levels for an extended period of time) show a response typical of double-porosity aquifers or leakage from overlying layers. In either case, a porous media analysis is inappropriate, and will yield erroneously high permeability value.

The Dames and Moore test in 1969 was able to achieve a constant pumping rate of 26 gpm for 26 hours; however, the yield of this well in its 2007 state was uncertain. The 1969 Dames and Moore test was conducted when this well was an open hole from 405 to 530 feet bgs before this well was used as an injection well. In April 1970, injection testing was conducted at 20 to 40 gpm with no pressure buildup observed during testing (PG&E, 1995). However, results from this injection test have similar problems in quantitative analysis as the 1969 pumping data. From a strictly qualitative perspective, the aquifer accepted water over a 24-hour period, but the data did not allow for quantitative analysis using either porous or fractured media techniques. Previous tests were designed to give the driller a general idea of whether the wells had sufficient capacity to achieve the pumping or injecting goals, and these wells were found to have in sufficient quality or duration to allow for fractured media analysis.

No historical bedrock testing data are available for PGE-7 because it was open to the alluvium prior to retrofitting that occurred as part of 2007 field activities.

Well MW-48 required 2 to 3 weeks to recover after rapidly purging dry for groundwater sampling since May 2006.

5.2.2 Ambient Gradients between Bedrock and Alluvium

The MW-24 and MW-12/MW-48 monitoring well clusters are the only well groups at the site that can be used to evaluated vertical hydraulic gradients between the alluvium and bedrock. Appendix G provides graphs of total hydraulic head between wells in these monitoring well clusters (corrected for salinity and temperature). These plots confirm that there are upward gradients from bedrock to the alluvium. Water level data were collected with pressure transducers between June 1 and August 31, 2007.

The MW-24 cluster consists of three wells. MW-24A and MW-24B are completed in alluvium, with MW-24A shallower than MW-24B. MW-24 BR is completed in bedrock and is

screened deeper than both MW-24A and MW-24B. The bedrock monitoring well MW-24BR has consistently recorded a higher total hydraulic head (corrected for salinity and temperature) than MW-24A and MW-24B over 4 years of monitoring, with calculated upward hydraulic gradients ranging from 0.002 to 0.006 feet per foot (ft/ft).

The MW-12/MW-48 cluster also indicates upward hydraulic gradients. MW-12 is screened in the alluvium, and MW-48 is screened in bedrock. The hydraulic gradients between these wells are typically between 0.002 to 0.004 ft/ft.

5.2.3 PGE-8 Pumping Test

Groundwater elevations measured in wells at Topock affected by the bedrock aquifer test typically fluctuate 0.2 to 0.6 ft/day under ambient conditions. These fluctuations are primarily due to changes in stage of the Colorado River and changes in barometric pressure. The drawdowns expected to occur in many of the observation wells during the PGE-8 testing are on the order of a few hundredths of a foot. Because the drawdowns, which can be used to further understand the aquifer hydraulic properties and groundwater flow at the site, are smaller than the typical background groundwater fluctuations, a procedure termed "deconvolution" is applied to the data to separate the changes in groundwater level due to the aquifer test pumping from that due to ambient "noise". That is, the deconvolution tools are used for aquifer test analyses to allow drawdown estimates to be inferred from such groundwater level fluctuations.

For the August 8 through 11, 2007 pump test at PGE-8, the observed water levels were deconvoluted by the method described in Halford (2006). This method involves using the Colorado River stages, barometric pressure, and background monitoring wells as input data series to synthesize estimates of what the monitoring wells' water levels would have been in the absence of pumping from PGE-8. Background monitoring wells included CW-02M and MW-35-060. These wells were assumed to be outside of any detectable influence from aquifer tests occurring at PGE-8.

First, empirical correlations between the input data series and variations in the observation well water levels were formed. The relationships between the input data series and the observation well series were calculated for a fitting period, which is a time period in which drawdown is assumed to be negligible. For this pumping test, a fitting period that brackets the aquifer test and subsequent recovery period was chosen. For most observation wells, this included data between August 5 and August 8, prior to the test, and data from between August 14 and August 23, after the test. A few of the observation wells did not have suitable data for all of the dates in these time periods; in which case, a shortened fitting period was used.

Once the correlations between the input series and observation water levels are estimated, the input series are used to create synthetic water levels for the observation well during the estimation period, which includes the pump test and the subsequent period in which most of the aquifer recovery occurs. For the PGE-8 pump test, the estimation period was between the start of pumping on August 8 and late afternoon on August 14. This allowed a recovery period equal to the length of the pumping test. These synthetic water levels are subtracted from the measured observation well water levels during the estimation period to obtain estimates of drawdown during the pump test and recovery. Plots of measured and synthetic

heads and drawdowns for the observation wells of the PGE-8 pumping test are provided in Appendix H. The response to pumping in PGE-8 is also included in Appendix H. However, it was not necessary to deconvolute the PGE-8 water level fluctuations because the drawdown due to pumping overwhelms all interferences from outside forces (for example, river and barometric fluctuations). The maximum drawdown in PGE-8 was 182 feet while pumping at 13.6 gpm. This indicates a specific capacity for PGE-8 of 0.075 gpm/ft.

For some of the wells (for example, for the MW-52 and MW-53 clusters), the pressure heads read by the transducer were not converted to total heads in time for this analysis. Therefore, in the plots in Appendix H, the measured and synthetic heads are usually referred to an elevation axis along with river stage but are sometimes referred to a pressure axis along with the barometric pressure. Use of the raw pressure transducer readings does not affect the drawdown results reported here.

A summary plot of drawdowns for the pumping test is included as Figure 5-1. The plot shows the relative distance of the observation wells' screens from the PGE-8 screen and their elevations. The indicated drawdowns next to each well screen on Figure 5-1 are maximum drawdowns inferred from the plots in Appendix H. The drawdowns are generally highest nearer to PGE-8 and in the overlying alluvium and lower farther away and in the bedrock. This pattern suggests that hydraulic conductivity in the overlying alluvium is much higher than conductivity in the bedrock.

There were three active pressure transducers in PGE-7 during the PGE-8 pumping test—one in the alluvium, one between the packers, and another in the bedrock. However, only the pressure transducer in the alluvium yielded suitable data for deconvolution analysis. The packers in PGE-7 prior to the retrofit were leaky, and therefore observed drawdowns in the lower intervals were dominated by the alluvial response.

5.2.4 PGE-8 Injection Test

The results from the injection test performed during of October 17 through October 19, 2007 were analyzed using a method similar to the analysis performed for the August 2007 pumping test, with deconvolution analysis. In this case, the typical fitting period for the synthetic series was between October 7 and October 17, prior to the start of injection, and between October 21 and October 24, after the injection test. Plots of measured and synthetic heads, drawdowns, for the observation wells of the PGE-8 injection test are provided in Appendix I. Fitting PGE-8 with a transducer to measure draw-up during the injection test was not possible with the injection equipment in place, so a plot for the injection well is not included in Appendix I.

A summary plot of the injection test water level drawdowns is included as Figure 5-2. A comparison of Figures 5-1 and 5-2 indicates that the general pattern of aquifer responses was quite similar between the pumping and injection tests (although the responses are opposite in direction). One notable exception is the upper transducer at PGE-7BR, where the alluvial aquifer response changed from 0.1 foot during the pumping to no clear indication of drawdown during the injection test. It is assumed that this change is due to the retrofit, which cut off the hydraulic connection of PGE-7BR from the alluvium.

By the time of the injection test, the middle transducer at PGE-7BR was no longer in use. The lower transducer at PGE-7BR was not in service during the pre-test fitting period and

recorded unusable data during the injection because the bedrock portion of the well was slower to equilibrate to the changes made during the retrofit than was expected.

MW-48 was still recovering from an October 3 pump-down event during the injection test and also was not suitable for deconvolution analysis.

In both the pumping and the injection tests, there were pressure transducer malfunctions that yielded either nonsensical data or insufficient data for analysis. For the pumping test, this occurred at wells MW-24BR, PT7D, and PT8D. These wells are not included on Figure 5-1. For the injection test, this occurred at wells MW-10, MW-12, MW-52S, and PT7D. These wells are not included on Figure 5-2. Potential reasons for these transducer malfunctions may include aging pressure transducers and failing batteries.

Drawdown was not detected in any of the MW-52 or MW-53 wells drilled beneath the Colorado River (California shoreline), nor was it detected in PGE-09S or PGE-09N on the Arizona side of the Colorado River.

5.2.5 Recovery Test at PGE-7BR

The well recovered 90 percent of the initial water level displacement in 24 hours after the pump-down on November 14, 2007. The Hvorslev method (Fetter, 1988) was applied to the recovery data to infer an estimated hydraulic conductivity of approximately 8.2×10^{-6} cm/sec for the metadiorite bedrock surrounding this well. The analysis was applied to the lower (bedrock) pressure transducer, which appears to have been yielding reasonable data since late October.

5.2.6 Recovery Test at MW-48

The water level in this well recovered 90 percent of the initial water level displacement in 7.2 days after the pump-down on November 12, 2007. The Hvorslev slug test analysis of this data suggests that the Miocene conglomerate in this location has an estimated hydraulic conductivity of approximately 1.9×10^{-7} cm/sec.

6.0 Results of Groundwater Sample Analyses

Groundwater samples were collected from wells PGE-7 and PGE-8 during various stages of hydraulic testing activities. This section discusses the rationale for sample collection and the analytical results.

6.1 PGE-7

Groundwater samples were collected from PGE-7 before and after well retrofit activities using the HydraSleeve™ depth-discrete sampling system and an electric submersible pump, respectively. After PGE-7 had been retrofitted such that water from the well was being produced exclusively from the bedrock interval, the well was renamed PGE-7BR.

6.1.1 PGE-7 Hydrasleeve™ Depth-Discrete Sampling

After review of the acoustic televiewer and video logs of PGE-7, HydraSleeve™ samplers were installed at four depth intervals in the bedrock (226, 239, 266, and 291 feet bgs) to obtain depth-discrete groundwater samples from potentially conductive fracture zones. In addition, one sampler was installed below the bottom of the 7-inch casing (194 feet btoc) at approximately 200 feet bgs to obtain a sample from the alluvial portion of the well. The HydraSleeve™ samplers, which are depth-specific grab groundwater sampling devices, were left in the borehole for 5 days following installation to allow time for the water column in the well to reach equilibrium after being disturbed by placement of the samplers. Each sampler was retrieved, and the samples were sent to a California-certified laboratory to be analyzed for hexavalent chromium, Title 22 metals, specific conductance, and general minerals. The HydraSleeve™ samplers did not provide sufficient sample volume for analysis of field parameters. Laboratory analytical results for these samples are summarized in Table 5-2.

Historically, hexavalent chromium concentrations in groundwater samples from PGE-7 have ranged from approximately 4,000 to 5,000 micrograms per liter (µg/L). During this investigation, similar concentrations were detected in HydraSleeve™ samples collected from all bedrock intervals (below 200 feet). Based on the results of the hydraulic testing of PGE-7BR, which indicates that the permeability of the bedrock portion of the well is extremely low in comparison to that of the overlying alluvium, and based on analysis of the PGE-7BR groundwater sample discussed in the following section, the hexavalent chromium concentrations detected throughout the fluid column are likely representative of alluvial groundwater. A summary of historic hexavalent chromium concentrations in PGE-7/ PGE-7BR and site wells screened exclusively within the bedrock is provided in Table 5-3. Data indicates that hexavalent chromium concentrations in bedrock wells are generally low to non-detect.

6.1.2 PGE-7BR Sampling

Subsequent to the retrofit, PGE-7BR was sampled with an electric submersible pump on December 19, 2007. PGE-7BR produces very little water and pumps dry long before a three-casing-volume purge can be completed. Consequently, the well was purged multiple times during a period of approximately 2 months prior to sampling. The final oxidation-reduction potential was -479 millivolts. This oxidation-reduction potential indicates a highly reducing environment in which hexavalent chromium is typically expected to transform to trivalent chromium. The hexavalent chromium concentration detected in this sample, which represents water from the bedrock, was less than laboratory detection limits (<1.0 μg/L, as shown in Table 5-3).

In a June 21, 2007 email, DTSC requested that groundwater samples be collected from PGE-7BR quarterly for three quarters (DTSC, 2007f). These samples will be collected during the first, second, and third quarterly monitoring events performed in 2008 under the Topock Groundwater and Surface Water Monitoring Program (GMP). The samples will be analyzed for hexavalent chromium, Title 22 metals, specific conductance, and general metals. The analytical results will be reported in quarterly GMP monitoring reports.

6.2 PGE-8

Groundwater samples were collected 11 times during the nearly 3-day extraction test at PGE-8. Consistent with past groundwater analytical results from this well, total dissolved chromium and hexavalent chromium was not detected above laboratory reporting limits in any PGE-8 samples collected during this investigation, as shown in Table 5-3. Analytical results for other analysis, including metals, general chemistry and minerals, were consistent throughout testing and are provided in Appendix J.

A summary of water quality measurements collected during constant rate extraction testing is also provided in Appendix J. Consistent with previous purge records, water quality measurements indicate that reducing conditions are present at PGE-8. Oxidation-reduction potential measurements ranged from -150 to -350 millivolts during pumping. Specific conductance increased from approximately 16,500 to 17,500 microSiemens per centimeter cm during the first 24 hours of pumping, then stabilized at approximately 17,500 microSiemens per centimeter for the remaining 48 hours. Measurements of pH remained constant, between 8.1 and 8.2, during testing. These measurements suggest that concentrations of hexavalent chromium that may have been injected into this well in the past would not persist in the existing geochemical environment.

7.0 Waste Management

Investigation-derived waste materials generated during hydraulic testing included incidental trash and a few thousand of gallons of groundwater from PGE-7/PGE-7BR and MW-48 testing activities. All purged groundwater from PGE-7/PGE-7BR and MW-48 was transported to the Interim Measures No. 3 treatment facility (onsite) for disposal. All water extracted from PGE-8 was re-injected into the well after confirming that the water was suitable for re-injection, as confirmed by the DTSC (2007d) and Water Board (2007).

8.0 Conclusions

A summary of conclusions obtained from the well inspection, hydraulic testing, and groundwater sampling activities conducted as part of this bedrock investigation are discussed in this section.

8.1 PGE-7

Conclusions for PGE-7 include:

- Based on the geophysical data and the video log, the top of the crystalline metadiorite bedrock appears to be approximately 226 feet btoc. The PGE-7 geophysical and video logs do not provide sufficient information to differentiate the geologic units in the open borehole interval that overlies the crystalline metadiorite bedrock. Based on nearby drilling logs, the base of the Alluvial Aquifer extends to approximately 220 feet btoc at PGE-7.
- EMFM measurements collected during both the induced and ambient flow tests suggest that groundwater flow within the bedrock portion of the well is below the reliable detection limit of the tool (approximately 1 gpm); therefore, no specific water-bearing intervals were identified.
- Borehole conditions within the bedrock portion of PGE-7 were not suitable to retrofit the well using either the FLUTe™ liner system or an inflatable straddle packer assembly.
- The alluvial portion of PGE-7 was hydraulically segregated from the bedrock interval by constructing a 3-inch sleeve, which was sealed with bentonite grout within the existing 7-inch casing.
- After PGE-7 was retrofitted as a bedrock well and water from the alluvium could no longer enter the well, yield from well PGE-7 (renamed PGE-7BR) was too low (less than 1 gpm) to conduct a constant rate extraction test; therefore, a single-well recovery test was conducted to evaluate hydraulic conductivity.
- The Hvorslev method (Fetter, 1988) was applied to the PGE-7BR water level recovery data to infer an estimated hydraulic conductivity of approximately 0.02 ft/day for the metadiorite bedrock surrounding this well.
- Depth-discrete groundwater samples were collected within the bedrock portion of PGE-7 before it was retrofitted. Based on the results of the hydraulic testing of PGE-7BR, which indicates that the permeability of the bedrock portion of the well is extremely low in comparison to that of the overlying alluvium, and based on analysis of the PGE-7BR groundwater samples discussed in the following section, the hexavalent chromium concentrations detected throughout the fluid column prior to retrofit were likely representative of alluvial groundwater.

- The analysis of a groundwater sample collected from PGE-7BR (after the retrofitting) indicated that total dissolved chromium and hexavalent chromium were less than analytical detection limits (<1.0 µg/L).

8.2 PGE-8

Conclusions for PGE-8 include:

- The video log revealed that a portion of the former injection infrastructure remains in the well. The sheared top of the former injection pipe was observed at approximately 362 feet btoc and extends to a depth greater than 382 feet btoc. It is presumed that the observed injection pipe is attached to a mechanical packer that was reportedly installed at 405 feet btoc.
- Because the well is blocked below approximately 362 feet btoc by the former injection pipe and the accessible portion of the well is cased with steel, additional logging (e.g., electric logs, EMFM log, and acoustic televiewer log) was not performed.
- The cement bond log conducted at PGE-8 shows that there is a relatively good cement bond from ground surface to 360 feet btoc.
- Data collected during a short-term step-rate extraction test resulted in a specific capacity estimate of 0.08 gpm/ft, and from this estimate, 7 to 8 gpm was determined to be the initial pumping rate for constant rate testing.
- Results from the deconvolutions of the PGE-8 pumping and injection tests indicate that the hydraulic connection between bedrock at PGE-8 and the alluvium above is stronger than the connection to surrounding bedrock. Groundwater level changes in the aquifer caused by pumping and injection at PGE-8 are detectable at greater distance in the alluvium than in bedrock
- Drawdown was not detected during the PGE-8 pumping and injection tests in any of the MW-52 or MW-53 clusters of wells drilled beneath the river.
- Drawdown was not detected during the PGE-8 pumping and injection tests in wells PGE-09N and PGE-09S on the Arizona side of the Colorado River.
- The analysis of groundwater samples collected during the constant rate extraction test indicated that total dissolved chromium and hexavalent chromium were not present in groundwater from the bedrock at a concentration greater than the laboratory detection limit.
- Water quality measurements collected during the constant rate extraction test suggest that any hexavalent chromium that may have been injected into this well in the past would not persist in the existing geochemical environment.

8.3 MW-48

Conclusions for MW-48 include:

- MW-48 is constructed with a 2-inch-diameter, 10-foot-long PVC screen (362 to 352 feet msl) within the Miocene conglomerate bedrock.
- Natural gamma and electric logs conducted at MW-48 indicate a change in lithology at approximately 50 feet btoc, which is the same depth that the top of the Miocene conglomerate is identified on the lithologic log completed during drilling.
- A single-well recovery test was conducted at MW-48. The Hvorslev slug test analysis of these data suggests that the Miocene conglomerate in this location has an estimated hydraulic conductivity of approximately 0.0005 ft/day.

9.0 Certification

This report was prepared by CH2M HILL under the supervision of the professional whose seal and signature appears hereon, in accordance with currently accepted professional practices; no warranty, expressed or implied, is made.

Fritz Carlson
Certified Hydrogeologist

Report Reviewed by:

Jennifer Low
Project Manager

10.0 References

California Department of Toxic Substances Control (DTSC). 2006. Letter. "Additional Bedrock Investigation Based Upon Review of Bedrock Technical Memorandum at Pacific Gas and Electric Company, Topock Compressor Station, Needles, California." November 3.

_____. 2007a. Letter to PG&E. "Conditional Approval of Work Plan for Hydraulic Testing in Bedrock Wells, Pacific Gas, and Electric Company (PG&E), Topock Compressor Station, Needles, California." April 2.

_____. 2007b. Email from Mr. Aaron Yue to Mr. Martin Barackman/CH2M HILL and Ms. Yvonne Meeks/PG&E. "Re: Final Version of PGE-7 Procedures" July 6.

_____. 2007c. Email from Mr. Christopher Guerre to Mr. Martin Barackman/CH2M HILL and Mr. Aaron Yue/DTSC. "Re: Proposed procedures for retrofitting well PGE-7." September 7.

_____. 2007d. Email from Mr. Aaron Yue to Yvonne Meeks/PG&E and Julie Eakins/CH2M HILL. "Re: Protocol for defining acceptability for re-injection of PGE-8 hydraulic test water." July 3.

_____. 2007f. Email from Mr. Aaron Yue to Mr. Martin Barackman/CH2M HILL and Mr. Aaron Yue/DTSC. "Fwd: Proposed modification to procedures and equipment for retrofitting PGE-7 during aquifer testing" June 21.

_____. 2007e. Email from Mr. Christopher Guerre to Mr. Isaac Wood/CH2M HILL "Re: Updated Table of Observation Wells for Bedrock Hydraulic Testing" July 13.

California Regional Water Quality Control Board, Colorado River Basin (Water Board). 2007. Email from Mr. Robert Perdue to Ms. Julie Eakins/CH2M HILL. "Re: Protocol for defining acceptability for re-injection of PGE-8 hydraulic test water." July 6.

CH2M HILL. 2006a. *Technical Memorandum: Information Review of Groundwater Conditions in Bedrock Formations at PG&E's Topock Compressor Station, Needles, California*. March 15.

_____. 2006b. *Work Plan for Hydraulic Testing in Bedrock Wells. PG&E Topock Compressor Station, Needles, California*. November 10.

_____. 2006c. *Technical Addendum: Work Plan for Hydraulic Testing in Bedrock Wells PG&E Topock Compressor Station.* December 19.

_____. 2007. Email from Ms. Julie Eakins/CH2M HILL to Mr. Aaron Yue/DTSC, Mr. Christopher Guerre/DTSC, Mr. Robert Perdue/RWQCB, Mr. Cliff Raley/RWQCB, Mr. Tom Vandenberg/SWRCB, and Ms. Yvonne Meeks/PG&E. "Water to be used for Injection Testing – PGE-8." August 17.

Dames and Moore. 1969. *Proposed System for Waste Water Disposal, Topock Compressor Station Near Needles, California.* Prepared for Pacific Gas and Electric Company. August 19.

Ecology and Environment (E&E). 2002. *Hydrogeological Testing Results, Pacific Gas and Electric Company, Topock Compressor Station, Needles, California.*

Fetter, C.W. 1988. *Applied Hydrogeology, 2nd Edition.* MacMillan Publishing Company. New York. Page 198.

Halford, K.J. 2006, Documentation of a Spreadsheet for Time-Series Analysis and Drawdown Estimation, USGS Scientific Investigation Report 2006-5024

Pacific Gas and Electric Company (PG&E). 1995. *Topock Compressor Station Bat Cave Wash, Background Geologic, Hydrogeologic, and Water Quality Information*. Prepared by Technical and Ecological Services. October.

_____. 2007. Letter from Yvonne Meeks/PG&E to Aaron Yue/DTSC. "Responses to Fort Mojave Indian Tribe and United States Geological Survey Comments on Work Plan for Hydraulic Testing in Bedrock Wells." February 23.

United States Fish and Wildlife Service, Havasu National Wildlife Refuge (USFWS). 2007. Letter to PG&E authorizing, with special conditions, PG&E's request as outlined in the *In Situ Hexavalent Chromium Reduction Pilot Test Work Plan – Upland Plume Treatment*. March 14.

Tables

TABLE 3-1
Construction of Test and Observation Wells
Summary Report for Hydraulic Testing in Bedrock Wells
PG&E Topock Compressor Station

Well ID	Depth Monitored	Ground Elevation (ft MSL)	Screen Elevation (ft MSL)	Bedrock Elevation (ft MSL)	Well Construction	Distance from PGE-8 (ft)	Distance from PGE-7 (ft)
MW-10	shallow Alluvial Aquifer	530.7	457 to 437	380	4" PVC	396.5	394.9
MW-12	Alluvial	483.0	456 to 436	NA	4" PVC	885.0	1302.0
MW-23	Miocene Conglomerate Bedrock	507.3	447 to 427	504	4" PVC	1674.4	1415.2
MW-24A	shallow Alluvial Aquifer	564.9	461 to 441	338	4" PVC	881.7	128.5
MW-24B	basal Alluvial Aquifer	564.8	372 to 362	338	4" PVC	858.8	92.9
MW-24BR	Pre-Tertiary Metadiorite Bedrock	564.0	186 to 127	338	4" PVC	901.3	133.2
MW-38D	basal Alluvial Aquifer	525.3	362 to 342	350.3	2" PVC	674.7	144.3
MW-38S	shallow Alluvial Aquifer	525.5	450 to 430	350.5	2" PVC	690.0	135.8
MW-48	Miocene Conglomerate Bedrock	483.0	362 to 352	433	2" PVC	885.2	1302.0
MW-52M	Alluvial Aquifer	459.5	389 to 386	368	1/4" tubing/ 1" BARCAD screen	2178.8	1785.0
MW-52S	Alluvial Aquifer	459.5	409 to 406	368	1/4" tubing/ 1" BARCAD screen	2178.8	1785.0
MW-9	basal Alluvial Aquifer	536.6	457 to 447	448	4" PVC	167.9	723.2
PGE-7	Alluvial (monitor above packer)	562.6	NA	337	7" steel liner	768.3	----
PGE-7BR	Pre-Tertiary Metadiorite Bedrock	562.6	311 to 233	337	6.75" open hole	768.3	----
PGE-8	Pre-Tertiary Metadiorite Bedrock	595.0	191 to 45	421	4" stainless steel.	----	768.3
PT-7D	basal Alluvial Aquifer	559	362 to 342	334	2" PVC	971.1	202.8
PT-7M	middle alluvial aquifer	559	394 to 374	334	2" PVC	966.8	198.6
PT-8D	basal Alluvial Aquifer	564	374 to 354	340	2" PVC	931.5	165.2
PT-8M	middle Alluvial Aquifer	564	402 to 382	340	2" PVC	936.0	170.1
PT-8S	shallow Alluvial Aquifer	564	437 to 417	340	2" PVC	931.6	165.3
PT-9D	basal Alluvial Aquifer	562	372 to 352	344	2" PVC	1063.0	300.1
PT-9M	middle Alluvial Aquifer	562	400 to 380	344	2" PVC	1063.3	299.5
TW-01	Alluvial Aquifer	620.6	452 to 352	350	5" PVC	625.4	211.6
MW-52D	Alluvial Aquifer	459.5	370 to 367	368	1/4" tubing/ 1" BARCAD screen	2178.8	1785.0
MW-53M	Alluvial Aquifer	459.8	370 to 360	326	1/4" tubing/ 1" BARCAD screen	2200.8	1801.6
MW-53D	Alluvial Aquifer	459.8	348 to 338	326	1/4" tubing/ 1" BARCAD screen	2200.8	1801.6
PGE-9S	Alluvial Aquifer	461.0	434 to 365	366	12" Steel	3047.9	2845.1
PGE-9N	Alluvial Aquifer	461.3	429 to 359	355	12" Steel	3056.0	2846.2

Notes:
(ft MSL) = feet above mean sea level
NA = not applicable

TABLE 5-1

Summary of Bedrock Hydraulic Testing at Topock Compressor Station

Summary Report for Hydraulic Testing in Bedrock Wells

PG&E Topock Compressor Station

Well	Test	Test Start Date	Duration	Flow Rate(s) (gpm)	Specific Capacity (gpm/ft)	Transmissivity (gpd/ft)	Hydraulic Conductivity (cm/sec)	Bedrock In Screened Interval	Report Summarizing Findings
PGE-8	Pump Test	5/28/1969	26 hours	26	0.56	10000 [1]	NC	Pre-Tertiary Metadiorite	Dames & Moore (1969)
PGE-8	Step Test	8/2/2007	Up to 45 minutes	6.5 to 30	0.08	NC	NC	Pre-Tertiary Metadiorite	This report
PGE-8	Pump Test	8/8/2007	3.25 days	7.3 to 13.6	0.08	NC	NC	Pre-Tertiary Metadiorite	This report
PGE-8	Injection Test	8/17/2007	1.86 days	14 to 17	0.04	NC	NC	Pre-Tertiary Metadiorite	This report
PGE-7BR	Slug Test	11/14/2007	24 hours	NA	NA	NA	8.2×10^{-6}	Pre-Tertiary Metadiorite	This report
MW-48	Slug Test	10/4/2007	7.2 days	NA	NA	NA	1.9×10^{-7}	Miocene Conglomerate	This report
MW-23	Slug Test	2002	15.5 hours	NA	NA	NA	1.5×10^{-6}	Miocene Conglomerate	E&E (2002)
MW-24BR	Slug Test	2002	37 hours	NA	NA	NA	9.7×10^{-7}	Pre-Tertiary Metadiorite	E&E (2002)

Notes:

NA = Not applicable, due to low well yield, recovery tests were conducted by pumping wells dry as quickly as possible at these wells, and slug test analysis yields hydraulic conductivities directly rather than transmissivities.

NC = Not calculated for this test

[1] - Transmissivity value reported by Dames & Moore (1969)

TABLE 5-2

Results of PGE-7 Hydrasleeve™ Depth-Discrete Sampling

Summary Report for Hydraulic Testing in Bedrock Wells

PG&E Topock Compressor Station

Analyte	Units	PGE-07-200-1 200 ft depth	PGE-07-226-2 226 ft depth	PGE-07-239-3 239 ft depth	PGE-07-266-4 266 ft depth	PGE-07-291-5 291 ft depth
Alkalinity	mg/L	37.5	40.0	35.5	40.0	40.0
Ammonia (NH3-N)	mg/L	3.35 J	6.31	ND (1)	ND (0.5)	ND (0.5)
Antimony, dissolved	mg/L	ND (0.003)	ND (0.003)	ND (0.003)	ND (0.003)	ND (0.003)
Arsenic, dissolved	mg/L	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)
Barium, dissolved	mg/L	ND (0.3)	ND (0.3)	ND (0.3)	ND (0.3)	ND (0.3)
Beryllium, dissolved	mg/L	ND (0.001)	ND (0.001)	ND (0.001)	ND (0.001)	ND (0.001)
Bicarbonate Alkalinity	mg/L	37.5	40.0	35.5	40.0	40.0
Boron, dissolved	mg/L	2.54	2.32	2.18	2.06	2.02
Cadmium, dissolved	mg/L	ND (0.002)	ND (0.002)	ND (0.002)	ND (0.002)	ND (0.002)
Calcium, dissolved	mg/L	335 J	540	429	602	513
Carbonate Alkalinity	mg/L	ND (5)	ND (5)	ND (5)	ND (5)	ND (5)
Chloride-CL	mg/L	6840	7250	6940	6960	7790
Chromium, dissolved	mg/L	1.28 J	4.62	3.61	4.65	4.91
Chromium, hexavalent	µg/L	1,460 J	5,590	4,090	4,740	5000
Cobalt, dissolved	mg/L	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)
Copper, dissolved	mg/L	0.103 J	0.0809	0.0848	0.0851	0.0664
Specific conductance	umhos/cm	18000	20600	20400	20500	20400
Fluoride-F	mg/L	1.96	1.99	2.10	2.05	2.22
Iron, dissolved	mg/L	0.250 J	0.0481	0.192	0.107	0.0521
Lead, dissolved	mg/L	0.0088	0.0050	0.0058	0.0072	0.0053
Magnesium, dissolved	mg/L	6.64 J	14.9	9.22	18.4	15.6
Manganese, dissolved	mg/L	0.129	0.110	0.134	0.135	0.0807
Mercury, dissolved	mg/L	ND (0.0002)	ND (0.0002)	ND (0.0002)	ND (0.0002)	ND (0.0002)
Molybdenum, dissolved	mg/L	0.0772 J	0.0790	0.0597	0.0893	0.0691
Nickel, dissolved	mg/L	ND (0.02)	ND (0.02)	ND (0.02)	ND (0.02)	ND (0.02)
Nitrate/Nitrite-N	mg/L	4.64 J	6.41	5.98	6.08	7.01
PH	pH	7.90 J	7.72 J	7.87 J	7.78 J	7.74 J
Potassium, dissolved	mg/L	69.2	68.1	55.5	82.7	63.1
Selenium, dissolved	mg/L	0.0075	0.0063	0.0051	0.0087	0.0059
Silver, dissolved	mg/L	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	0.0166
Sodium, dissolved	mg/L	4600 J	4640	3630	5460	5460
Sulfate	mg/L	943	1280	1240	1250	1320
Thallium, dissolved	mg/L	ND (0.001)	ND (0.001)	ND (0.001)	ND (0.001)	ND (0.001)
Total Dissolved Solids	mg/L	11400	13600	12600	13500	13500
Turbidity	NTU	13.8	70.0	1560	720	60.5
Vanadium, dissolved	mg/L	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)	ND (0.005)
Zinc, dissolved	mg/L	0.213 J	0.0623	0.140	0.289	0.0621

Notes:

J concentration or RL estimated by laboratory or data validation

TABLE 5-3
Hexavalent and Total Chromium Results for Bedrock Wells and PGE-7
Summary Report for Hydraulic Testing in Bedrock Wells
PG&E Topock Compressor Station

Loc ID		Sample Date		Hexavalent Chromium (µg/L)	Dissolved Chromium (µg/L)
MW-23		3/28/2001		ND (10)	ND (20)
		6/6/2001		ND (10)	ND (20)
		9/12/2001		ND (10)	ND (20)
		11/30/2001		ND (10)	ND (800)
		3/8/2002		ND (10)	19.2 (TOT)
		6/13/2002		ND (10)	3.60
		9/18/2002		ND (10)	7.20
		12/11/2002		ND (10)	9.50
		3/21/2003		ND (10)	11.9
		6/12/2003		ND (10)	1.10 J
		9/10/2003		ND (0.2)	ND (1.0)
		12/11/2003		ND (0.2)	3.30
		3/16/2004		3.30 J	ND (1.0)
		6/8/2004		10.1	10.5
		9/21/2004		6.80	7.90
		12/17/2004		1.10	1.50
		3/8/2005		ND (1.0)	2.90
		6/14/2005		8.90	7.70
		10/4/2005		ND (1.0)	ND (1.0)
		12/14/2005		8.80	10.5
		3/8/2006		11.9	ND (1.0)
		5/2/2006		16.8	18.2
		10/4/2006		15.2	14.4
		12/12/2006		1920 R	ND (1.0)J
	(FD)	12/12/2006		14.4 J	8.60 J
		3/6/2007		1020	1020
		5/2/2007		13.0	10.9
		6/27/2007	11:45 AM	---	9.70
		6/27/2007	11:47 AM	---	7.30
		6/27/2007	2:59 PM	---	55.4
		6/28/2007	8:55 AM	---	29.2
		6/28/2007	9:08 AM	---	29.7
		6/28/2007	10:00 AM	---	32.8
		6/28/2007	1:48 PM	---	20.0
		6/29/2007	8:39 AM	---	32.4
		10/4/2007		19.2	22.2
MW-24BR		3/28/2001		ND (10)	ND (20)
		6/6/2001		ND (10)	10.0 J
		9/12/2001		ND (10)	ND (20)

TABLE 5-3
Hexavalent and Total Chromium Results for Bedrock Wells and PGE-7
Summary Report for Hydraulic Testing in Bedrock Wells
PG&E Topock Compressor Station

Loc ID	Sample Date	Hexavalent Chromium (µg/L)	Dissolved Chromium (µg/L)
MW-24BR	11/29/2001	ND (10)	ND (800)
	3/8/2002	ND (10)	68.8 (TOT)
	6/13/2002	ND (10)	3.70
	9/18/2002	ND (10)	3.50
	12/12/2002	ND (10)	3.40
	3/19/2003	ND (10)	16.0
	6/13/2003	ND (10)	2.90 J
	9/12/2003	ND (0.2)	3.60 J
	12/11/2003	ND (0.2)	4.60
	3/17/2004	ND (1.0)J	4.80
	6/8/2004	ND (1.0)	ND (1.0)
	9/21/2004	ND (1.0)	ND (1.0)
	12/17/2004	ND (1.0)	3.50
	3/8/2005	ND (1.0)	ND (1.0)
	12/15/2005	ND (1.0)	ND (1.0)
	3/16/2006	ND (1.0)	1.20
	5/10/2006	1.00 R	ND (1.0)
	6/5/2006	ND (1.0)	---
	11/1/2006	ND (1.0)	ND (1.0)
	12/15/2006	ND (2.0)	1.00
	3/6/2007	ND (1.0)	ND (1.0)
	5/3/2007	ND (1.0)	ND (1.0)
	10/4/2007	ND (1.0)	ND (1.0)
MW-48	3/1/2006	---	1150
	5/18/2006	ND (1.0)	ND (1.0)
	6/6/2006	ND (1.0)	ND (1.0)
	10/6/2006	ND (1.0)	ND (1.0)
	12/15/2006	ND (2.0)	ND (1.0)
	3/7/2007	ND (1.0)	ND (1.0)
	5/1/2007	ND (1.0)	1.00
	10/4/2007	ND (1.0)	ND (1.0)
PGE-07*	3/28/2001	4530	4000
	6/6/2001	5080	4300
	9/12/2001	5400	4500
	11/29/2001	4800	4800
	12/10/2003	4740	6780
	10/13/2005	ND (1.0)	ND (1.0)
PGE-07BR**	12/19/2007	ND (1.0)	ND (1.0)

TABLE 5-3
Hexavalent and Total Chromium Results for Bedrock Wells and PGE-7
Summary Report for Hydraulic Testing in Bedrock Wells
PG&E Topock Compressor Station

Loc ID		Sample Date		Hexavalent Chromium (µg/L)	Dissolved Chromium (µg/L)
PGE-08		3/28/2001		ND (10)	13.0 J
		6/6/2001		ND (10)	26.0
		8/25/2001		ND (10)	ND (20)
		9/12/2001		ND (10)	15.0 J
		11/29/2001		ND (10)	ND (800)
		12/9/2003		ND (0.2)	3.80
		10/13/2005		ND (1.0)J	2.10
		8/8/2007	12:15 PM	ND (1.0)	2.80
		8/8/2007	1:30 PM	ND (1.0)	3.20
		8/8/2007	2:30 PM	ND (1.0)	2.80
		8/9/2007	9:00 AM	ND (1.0)	ND (1.0)
	(FD)	8/9/2007	9:00 AM	ND (1.0)	ND (1.0)
		8/9/2007	11:00 AM	ND (1.0)	1.90
		8/9/2007	3:00 PM	ND (1.0)	ND (1.0)
		8/10/2007	9:00 AM	ND (1.0)	1.50
	(FD)	8/10/2007	9:00 AM	ND (1.0)	1.30
		8/10/2007	11:00 AM	ND (1.0)	1.40
		8/10/2007	3:00 PM	ND (1.0)	1.30
		8/11/2007	9:00 AM	ND (1.0)	2.40 J
	(FD)	8/11/2007	9:00 AM	ND (1.0)	ND (1.0)J
		8/11/2007	11:00 AM	ND (1.0)	ND (1.0)

Notes:

µg/L micrograms per liter
ND parameter not detected at the listed reporting limit
FD field duplicate
J concentration or RL estimated by laboratory or data validation
R result exceeded analytical criteria for precision and accuracy; should not be used for project decision making
--- data not collected or not available
TOT total chromium

PGE-8 samples taken from 8/8/2007 through 8/11/2007, were taken during pump testing at this well.

* PGE-07 well completed, exposed to approximately 25 feet of Alluvium.

** PGE-07BR sample from the bedrock interval, after the October 2007 retrofit.

Figures

Needles-1 gage station
(approx. 13 miles upstream)

Park Moabi Supply Well
(approx. 1300 feet west)

PARK
MOABI

Colorado River

PG&E Parcel No. 650-151-08

RRB

MW-35-60
MW-35-135
MW-29
MW-49 Cluster
MW-47-115
MW-47-55
TW-4
MW-33 Cluster
MW-50-095
MW-50-200
TW-5
MW-19
MW-31-60
MW-31-135
TW-3D
TW-2D
TW-2S
MW-20 Cluster
MW-25
MW-39 Cluster
MW-42 Cluster
MW-40S
MW-40D
PT-7 Cluster
MW-51
MW-26

PT-1 Cluster
PT-2 Cluster
PT-3 Cluster
PT-4 Cluster
PT-5 Cluster
PT-6 Cluster
PTI-1 Cluster
MW-46-175
MW-46-205
MW-28-25
MW-28-90
MW-44 Cluster
MW-36 Cluster
MW-45-095
MW-34 Cluster
MW-30-30
MW-30-50
MW-27 Cluster
MW-32-35
MW-32-20
MW-53D
MW-53M
MW-52 Cluster
MW-43 Cluster
MW-22
MW-21
MW-23
PGE-9N
PGE-9S
I-3

MW-41 Cluster
CW-4D
CW-4M
CW-3D
CW-3M
OW-3 Cluster
IW-2
OW-2 Cluster
CW-2M
CW-2D
MW-13
MW-37S
MW-37D
MW-18
OW-1 Cluster
OW-5 Cluster
MW-14
IW-3
CW-1D
CW-1M
MW-17

BALCH AVE

BN&SF RAILROAD

INTERSTATE 40

NEW
EVAPORATION
PONDS
MW-4
MW-7
MW-8
MW-16
MW-6
MW-5
MW-15
MW-3
MW-1

FORMER
EVAPORATION
POND SITE

PG&E

DEBRIS RAVINE

TOPOCK
COMPRESSOR
STATION

See Inset

MW-11
MW-24BR
MW-24B
MW-38S
MW-38D
MW-10
MW-9
PT-9 Cluster
PT-8 Cluster
MW-24A
PGE-7
MW-12
MW-48
TW-1
PGE-8

Inset

MW-11
PT-9 Cluster
PT-7 Cluster
PT-8 Cluster
MW-24A
MW-24BR
MW-24B
MW-12
MW-48
MW-38S
PGE-7
MW-38D
TW-1
MW-10
MW-9
PGE-8

LEGEND

- MW-48 — Bedrock Test Well
- MW-23 — Bedrock Testing Observation Well
- Extraction Well
- Injection Well
- Surface Water Gauge
- Monitoring Well
- PG&E Property Boundary

N

0 800 1,600
Feet

FIGURE 1-1
WELLS INSTRUMENTED WITH PRESSURE TRANSDUCERS DURING BEDROCK HYDRAULIC TESTING

SUMMARY REPORT FOR HYDRAULIC
TESTING IN BEDROCK WELLS
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

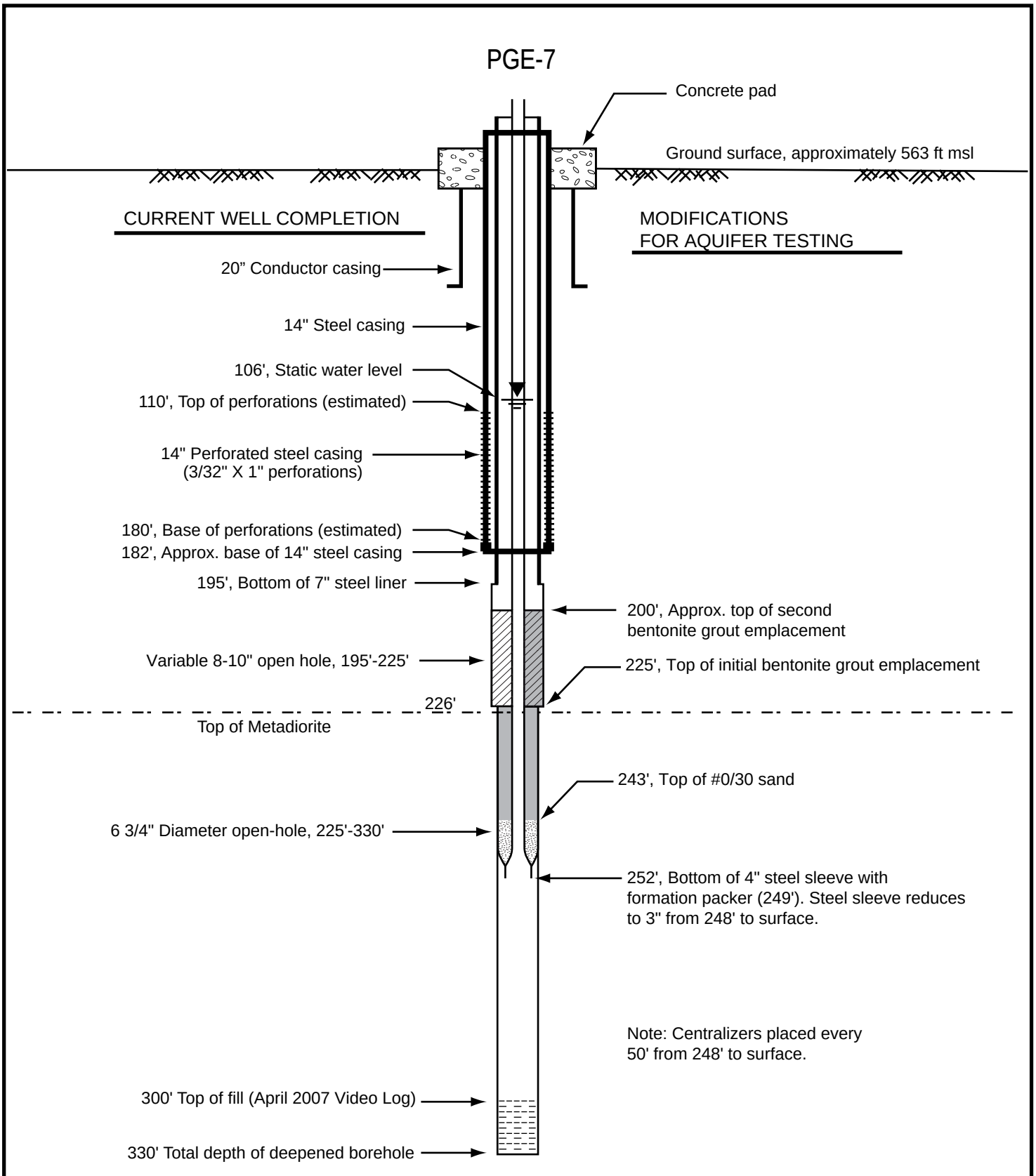


DIAGRAM NOT TO SCALE

All depths in feet below ground surface (bgs)

PGE-7 is an inactive water supply well that was deepened and re-completed in 1969 as an open-hole bedrock "monitoring well".

FIGURE 3-1
WELL SCHEMATIC DIAGRAM OF INACTIVE SUPPLY WELL PGE-7
SUMMARY REPORT FOR HYDRAULIC TESTING
IN BEDROCK WELLS
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

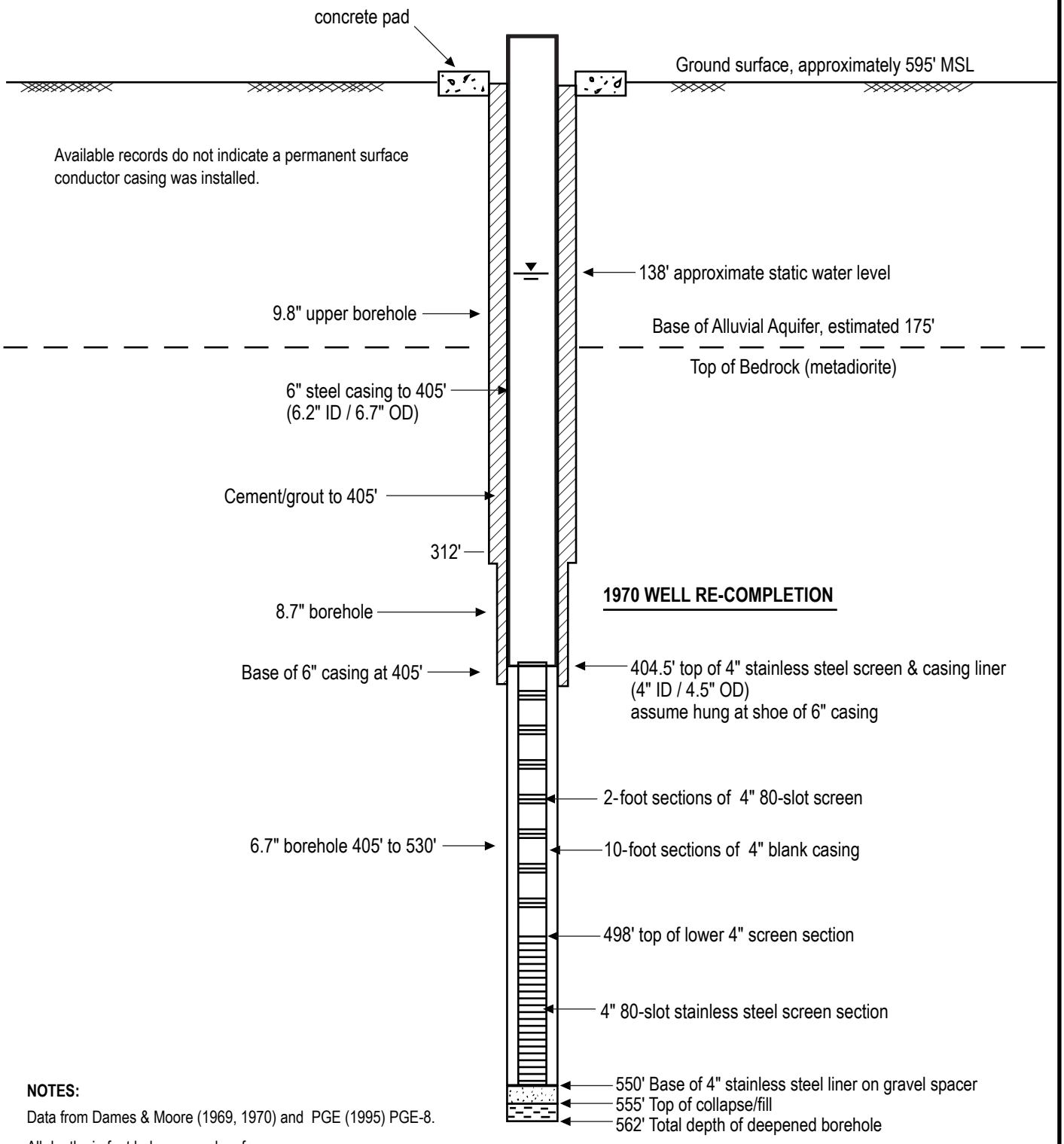
CH2MHILL

ES102006003BAO_Figure_3_Schematic_PGE7.ai_102607_lho

Not to Scale

Schematic Well Diagram

PGE – 8



NOTES:

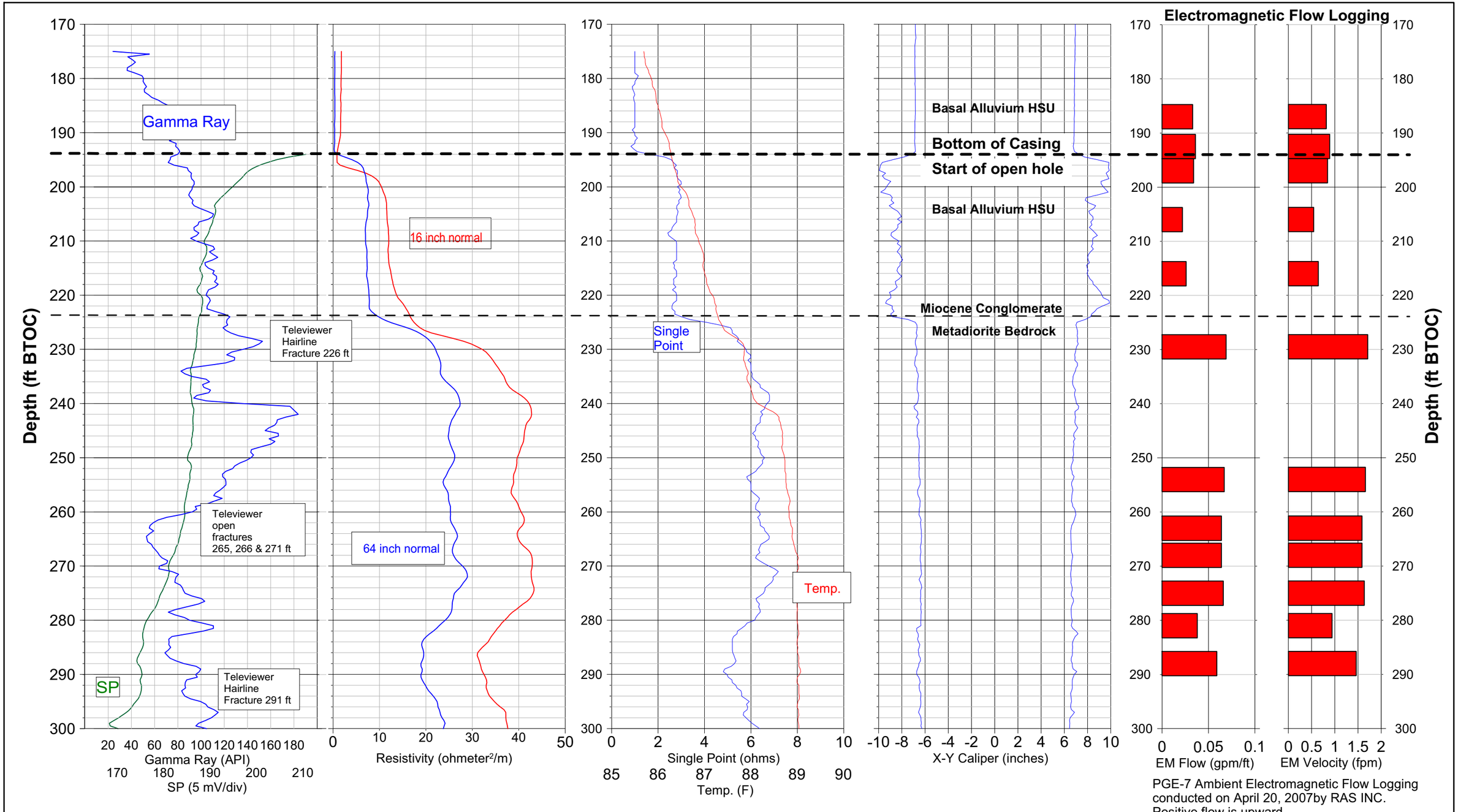
Data from Dames & Moore (1969, 1970) and PGE (1995) PGE-8.

All depths in feet below ground surface.

Well PGE-8 was initially completed June 1969 with 6" casing to 405' and open-hole from 405' to 530'. PGE-8 was deepened to 562' and 4" screen & casing liner installed June 1970.

Pipe and packer equipment installed for injection 1969-1974 not shown. The sheared top of a 3-inch injection pipe (362') is attached to a mechanical packer that was reportedly installed to a depth of 405' btoc. Sediment has accumulated in the well up to 382' btoc.

FIGURE 3-2
WELL SCHEMATIC DIAGRAM OF INACTIVE SUPPLY WELL PGE-8
SUMMARY REPORT FOR HYDRAULIC TESTING IN BEDROCK WELLS
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA



PGE-7 Ambient Electromagnetic Flow Logging conducted on April 20, 2007by RAS INC. Positive flow is upward.

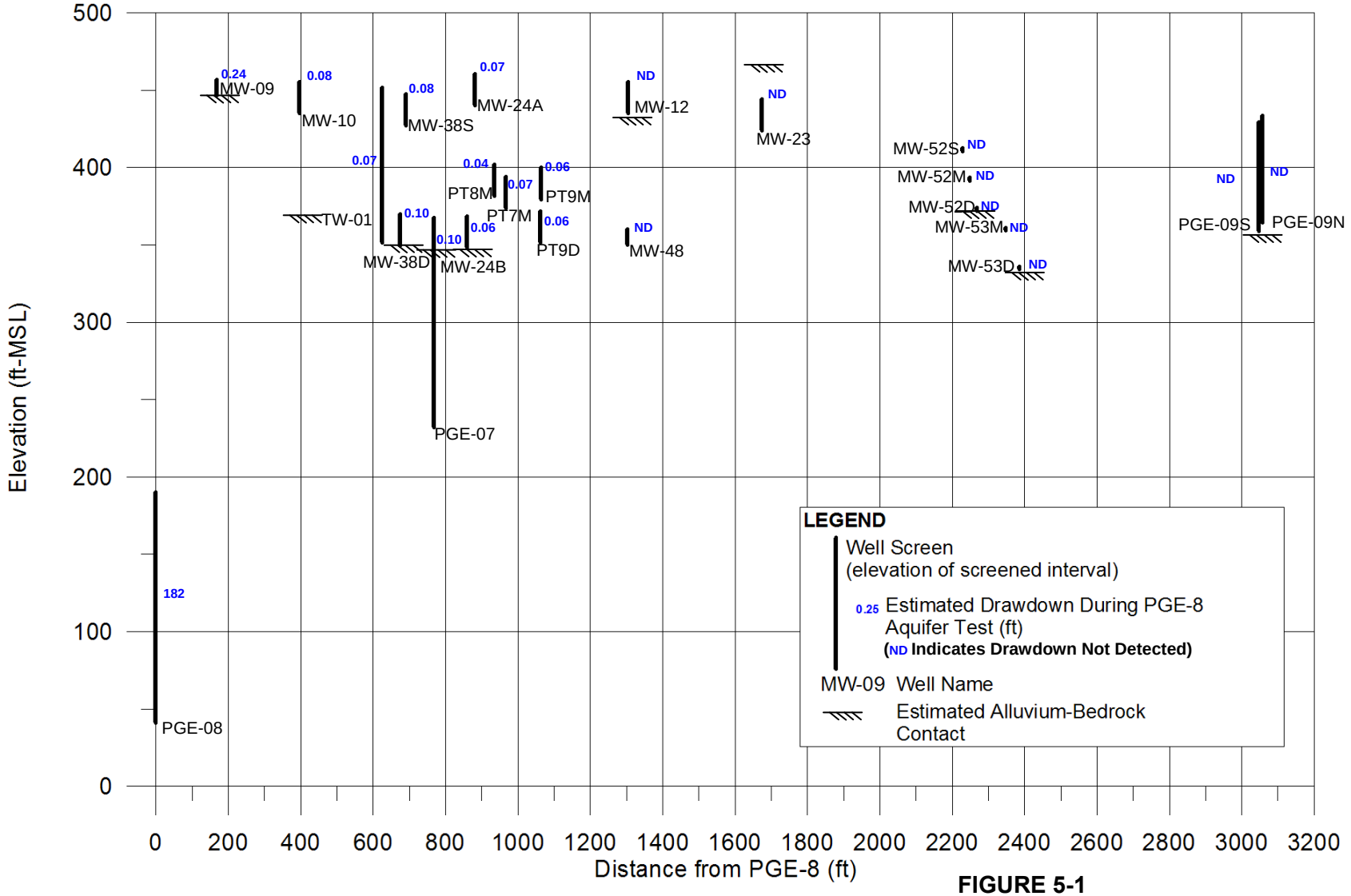
NOTES:

1) PGE-7 geophysical logs conducted on April 3, 2007 by Welenco, Inc.
2) The interpreted geologic and hydrostratigraphic units (HSUs) for well PGE-7 are based on PG&E historical records, PGE-7 geophysical and video logs, and drilling logs from nearby wells. No drilling lithologic log is available for PGE-7 well installation (1964) or open-hole well deepening (1969).

FIGURE 4-1
SUMMARY OF GEOPHYSICAL AND ELECTROMAGNETIC FLOW LOGGING AT WELL PGE-7
SUMMARY REPORT FOR HYDRAULIC TESTING IN BEDROCK WELLS
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

\\zinfandel\proj\PacificGasElectricCo\TopockProgram\Project2007FieldActivities\HydraulicTestingWellAbandonment\Reporting\HydraulicTestingReport\PGE_Draft\Figures\workfiles

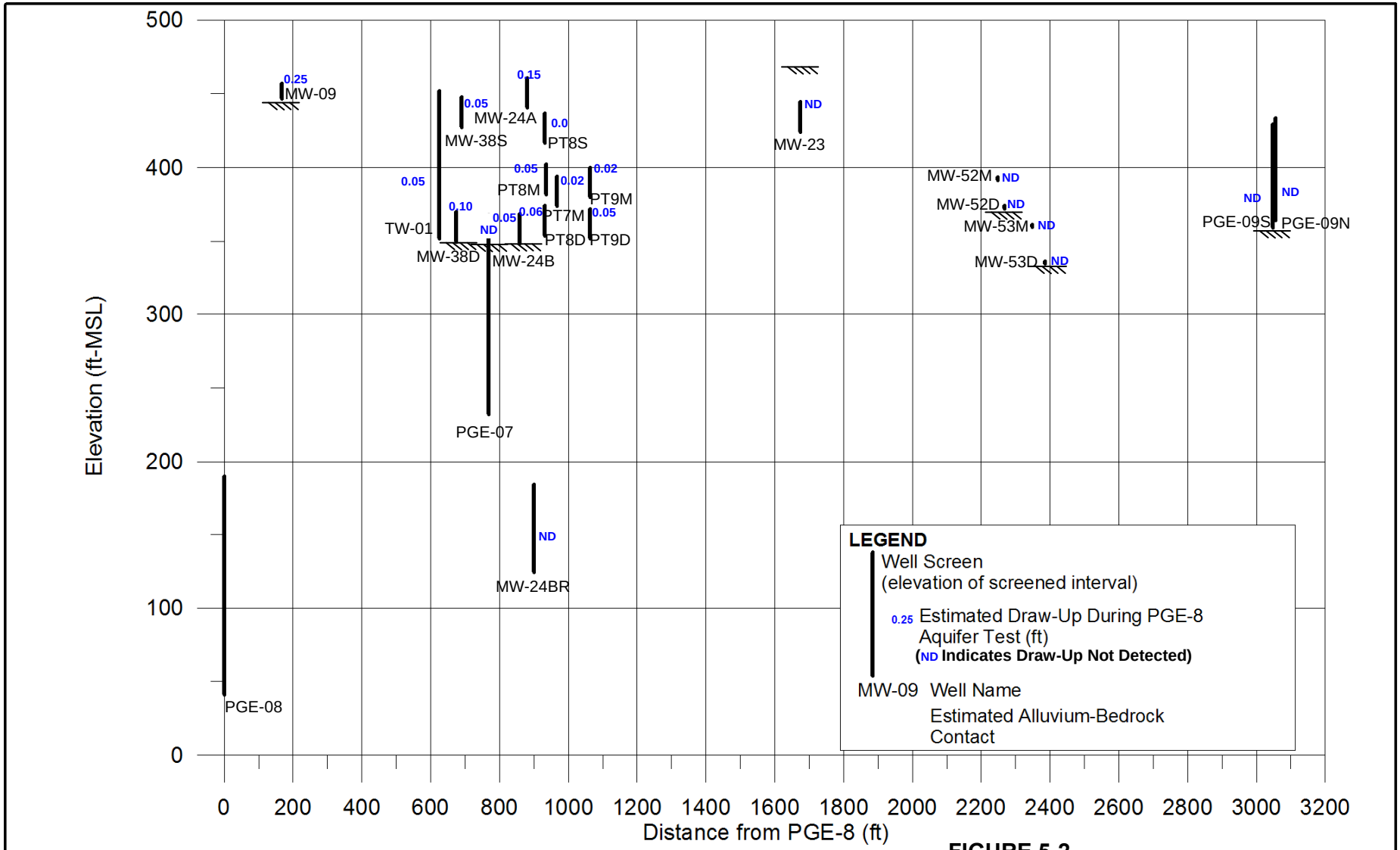


NOTE: THE DRAWDOWN REPORTED FOR PGE-07 IS FROM THE ALLUVIAL INTERVAL

FIGURE 5-1
ESTIMATED MAXIMUM DRAWDOWNS RESULTING FROM PGE-8 PUMPING TEST
SUMMARY REPORT FOR HYDRAULIC TESTING IN BEDROCK WELLS
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

\\odin\proj\topock\deconvolution\Figures\NewPumpingResults_12-28-07



NOTE: THE DRAWDOWN REPORTED FOR PGE-07 IS FROM THE ALLUVIAL INTERVAL

FIGURE 5-2
ESTIMATED MAXIMUM DRAW-UPS RESULTING FROM PGE-8 INJECTION TEST
SUMMARY REPORT FOR HYDRAULIC TESTING IN BEDROCK WELLS
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

\\odin\proj\topock\deconvolution\Figures\New_Injection_Results_Dec19

Appendix A
Video Reports

Vid-Pac — Wellbore Video Report — welenco (800) 445-9914

Company: CH2MHILL **Job Ticket:** 7251 **Run No.:** 1
Address: 2285 Corporate Circle #200 **Well Number:** PGE-7
City: Henderson **State:** NV **Zip:** 89074 **Survey Date:** April 3, 2007
Requested By: Isaac **P.O.:** **Well Owner:**
Copy To: **Camera:** CCV Color Flip Camera - Short L.H.
Reason For Survey: General Inspection **Zero Datum:** Top of Casing
Operator: John Burbano **Lat.:** 34° 42' 53.8" **Long.** 114° 29' 35.6" **Sec:** 8 **Twp:** 7N **Rge:** 24E **Meridian:** San Bernardino
Location: Topock Compressor Station **Well Depth:** **Van:** TO-5
Casing I.D. At Surface: 7" **I.D. Reference:** Well Records **Casing Corrosion:** Moderate

(NOTE: Latitude and Longitude values determined using a recreational GPS accurate to +/- 45'. The SEC, TWP, RGE and Meridian then determined using the TRS conversion program, accuracy not guaranteed.

SELECTED WELLBORE SNAPSHOTS	TRUE DEPTHS (SideScan - Feet)	WELLBORE / CASING INFORMATION
		Downview Depths are 7" deeper than SideScan Depths
0015' (See Other Side) 0040' (See Other Side) 	0'	Recording Starts - Zeroed on Sideview Lens at Top of Casing
	15-107'	Sideview - Scaling
	40'	Sideview - "Geico" The Lizard
0108' (See Other Side) 0130' 	108'	Sideview - Static Water Level
	130'	Sideview - Moderate Build-up
	194'	Sideview - Bottom of Steel Liner
0194' (See Other Side) 0252' (See Other Side) 	252'	Sideview - Bed Rock
	300'	Downview of Fill, End of Survey
0300' (See Other Side) 		

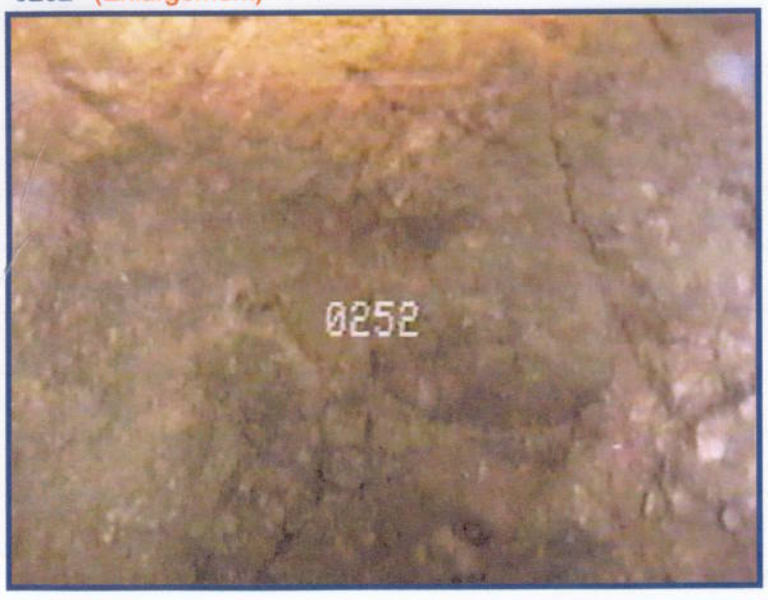
0015' (Enlargement)

0040' (Enlargement)

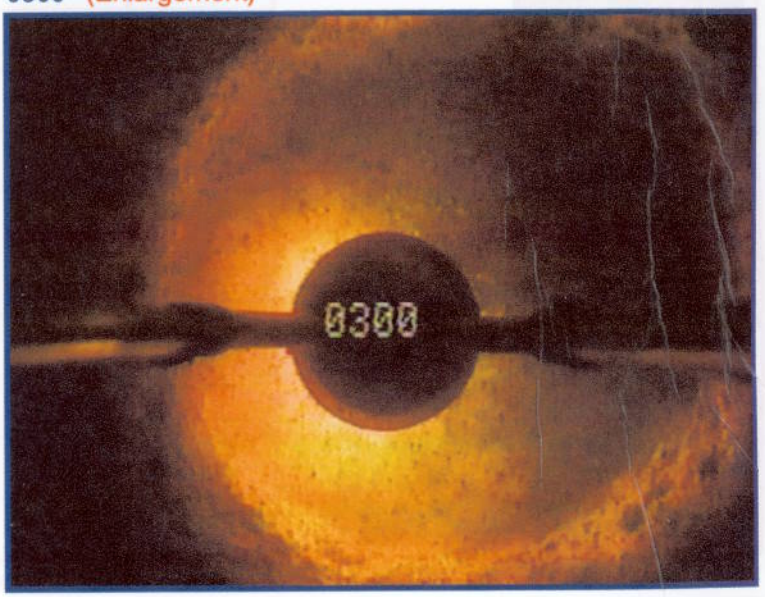
0108' (Enlargement)

0194' (Enlargement)

0252' (Enlargement)



0300' (Enlargement)



Vid-Pac

Wellbore Video Report

welenco

Company CAL M HILL
Address
City State Zip
Requested by BARRY P.O.
Copy to
Reason for Survey GENERAL INSPECTION, LOOK FOR PACKER
Operator DAN IHDE

Job Ticket 8459 Run No. ONE
Well No. PG&E 8
Survey Date 11-13-07
Well Owner PG&E
Camera SUM SIDE SCAN
Zero Datum TOP OF CASING
Well Depth Vehicle No. T-03

Location PG&E COMPRESSOR STATION, TOPOC
Casing I.D. at Surface 6 I.D. Reference MEASURED Build-Up

Survey Start Time: 10:47
Survey End Time: 12:00

34 42 50
114 29 37

TRUE DEPTHS	WELLBORE/CASING INFORMATION
0 FT	RECORDING STARTS, ZEROED ON SIDE VIEW
	CAMERA RUNNING TO ONE SIDE DUE
	TO NO CENTRALIZERS SET TRYING
	TO ACCESS PACKER
140	STATIC WATER LEVEL - POOR VISIBILITY
237	TOP OF WIRE - SOUNDING CABLE
249	SEVERAL SECTIONS OF WIRE
382	NO VISIBILITY - END OF SURVEY
362	TOP OF PIPE SECTION

Notes: NO CENTRALIZERS

welenco, inc.
5201 Woodmere Dr.
Bakersfield, CA 93313
www.welenco.com
e-mail: welenco@welenco.com
Phone: (800) 445-9914
Fax: (661) 834-2550
CA Contractor Lic. #722372

Vid-Pac — Wellbore Video Report

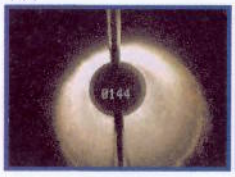
welenco
(800) 445-9914

Company: Ch2MHILL **Job Ticket:** 6819 **Run No.:** 1
Address: 33 New Mongomery Street Suite 2000 **Well Number:** PGE-8
City: San Francisco **State:** CA **Zip:** 94105 **Survey Date:** November 17, 2006
Requested By: Isaac Woods **P.O.:** **Well Owner:** PG & E
Copy To: **Camera:** CCV S.S. Color Camera - Long L.H.
Reason For Survey: General Inspection **Zero Datum:** Top of Casing
Operator: Larry Hock **Lat.:** 34° 42' 50.3" **Long.** 114° 29' 39.6" **Sec:** 8 **Twp:** 7N **Rge:** 24E **Meridian:** San Bernardinc
Location: PG & E Facility (Topock) **Well Depth:** 560' **Van:** L-18
Casing I.D. At Surface: 6" **I.D. Reference:** Estimate from Video **Casing Corrosion:** Light

(NOTE: Latitude and Longitude values determined using a recreational GPS accurate to +/- 45'. The SEC, TWP, RGE and Meridian then determined using the TRS conversion program, accuracy not guaranteed

SELECTED WELLBORE SNAPSHOTS

144'



145' (See Other Side)

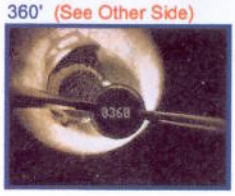
152' (See Other Side)

165'

203' (See Other Side)

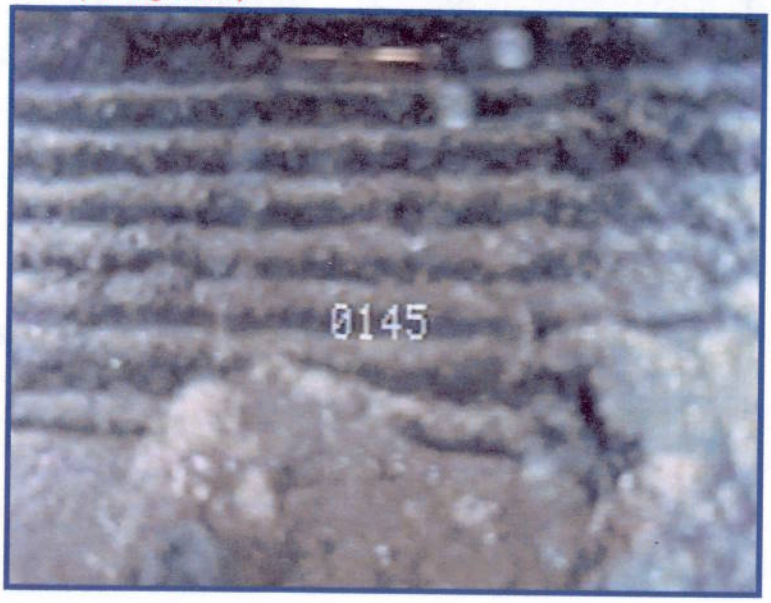
305' (See Other Side)

360' (See Other Side)

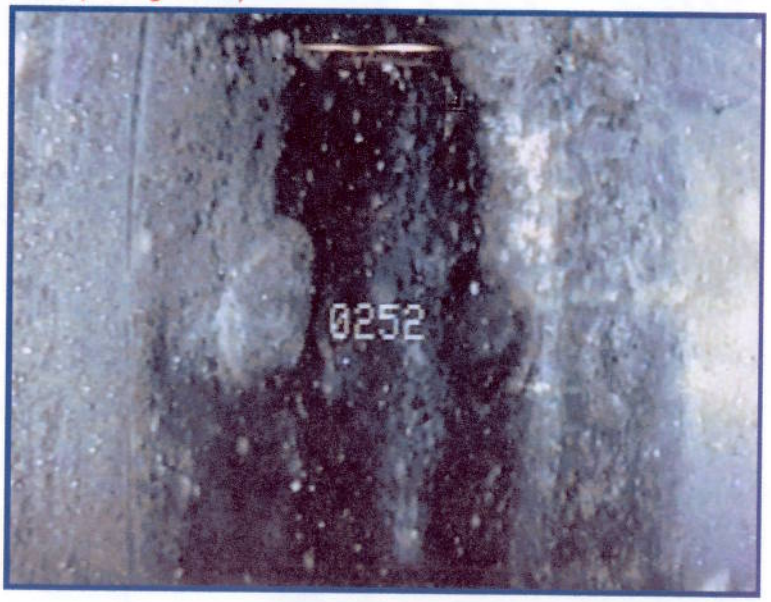


TRUE DEPTHS (SideScan - Feet)	WELLBORE / CASING INFORMATION
	Downview Depths are 22" deeper than SideScan Depths
0'	Recording Starts - Zeroed on Sideview Lens at top of casing
39'	Stop recording, pull out of well, clean lens
35'	Resume survey
139'	Static water level
144'	Downview of casing @ 145'
145'	Casing joint
165'	Casing joint
203'	Nodule on casing wall
252'	Marks on casing wall
305'	Casing joint
360'	Fish in hole, possible pipe in well, unable to get camera past this point
359'	Stop recording and survey

145' (Enlargement)



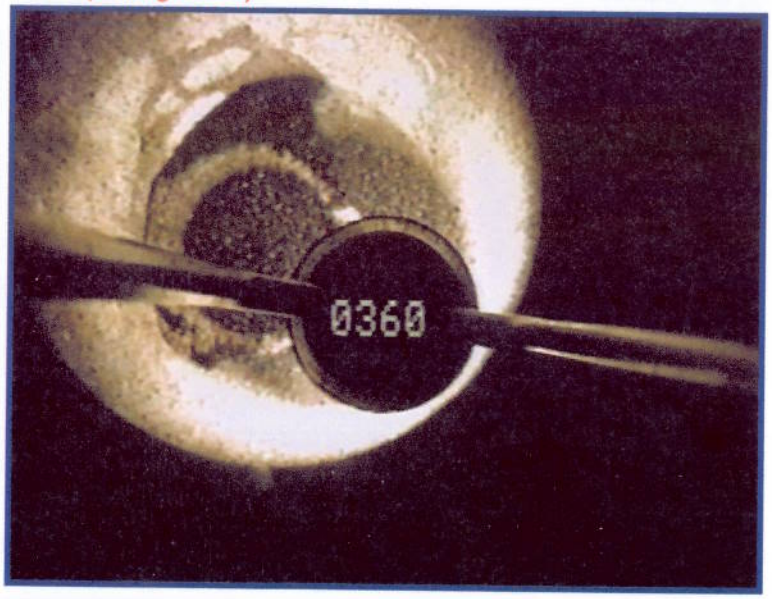
152' (Enlargement)



203' (Enlargement)

305' (Enlargement)

360' (Enlargement)



Appendix B
Geophysical Logs

welenco

5201 Woodmere Drive, Bakersfield, CA 93313-- www.welenco.com--(800) 445-9914
California Contractor's License No. 722373

INDUCTION - GAMMA RAY LOG

FILING NO.

COMPANY CH2M HILL

WELL MW-48

FIELD Topock

STATE California COUNTY San Bernardino

LOCATION:
PG&E Compressor Station, Topock site.

OTHER SERVICES:
None

JOB NO.
7251

SEC: ____ TWP: ____ RGE: ____ LAT.: ____ LONG.: ____ MERIDIAN.: ____

Permanent Datum: Top of Casing , Elev. ____ Ft. Elev.: K.B. ____ Ft.
Log Measured From: Top of Casing , 0 Ft. Above Perm. Datum D.F. ____ Ft.
Drilling Measured From: Ground Level G.L. ____ Ft.

Date	Apr. 03, 2007			
Type Of Log	Ind/Gamma			
Run	One			
Depth-Driller	130 Ft	Ft	Ft	Ft
Depth-Logger	135 Ft	Ft	Ft	Ft
Top Logged Interval	0 Ft	Ft	Ft	Ft
Btm. Logged Interval	134 Ft	Ft	Ft	Ft
Type Fluid In Hole	Water			
Fluid Level	N/A Ft	Ft	Ft	Ft
Max Temp	N/A °F	°F	°F	°F
Operating Rig Time	N/A Hr	Hr	Hr	Hr
Van No. / Location	LV-1 / Bfld			
Recorded By	Dan Ihde			
Witnessed By	Issac Woods			

RUN	BOREHOLE RECORD			CASING RECORD			
NO.	BIT	FROM	TO	SIZE	TYPE	FROM	TO
1	In	Ft	Ft	2.5 In	PVC	Surf Ft	130 Ft
2	In	Ft	Ft	In		Ft	Ft
3	In	Ft	Ft	In		Ft	Ft

Miscellaneous Information

Remarks:

A recreational GPS accurate to +/- 45 feet set for Datum NAD27 was used to calculate Latitude, Longitude & Elevation values. The Section, Township, and Range then determined using the TRS program (TRS accuracy is not guaranteed). The TRS program converts Latitude and Longitude to Section, Township, and Range. The NOTICE at the bottom of this heading also applies.

Tool zeroed at Top of PVC Casing, 2 feet above ground level.

Perforated Intervals:

Line Speed:

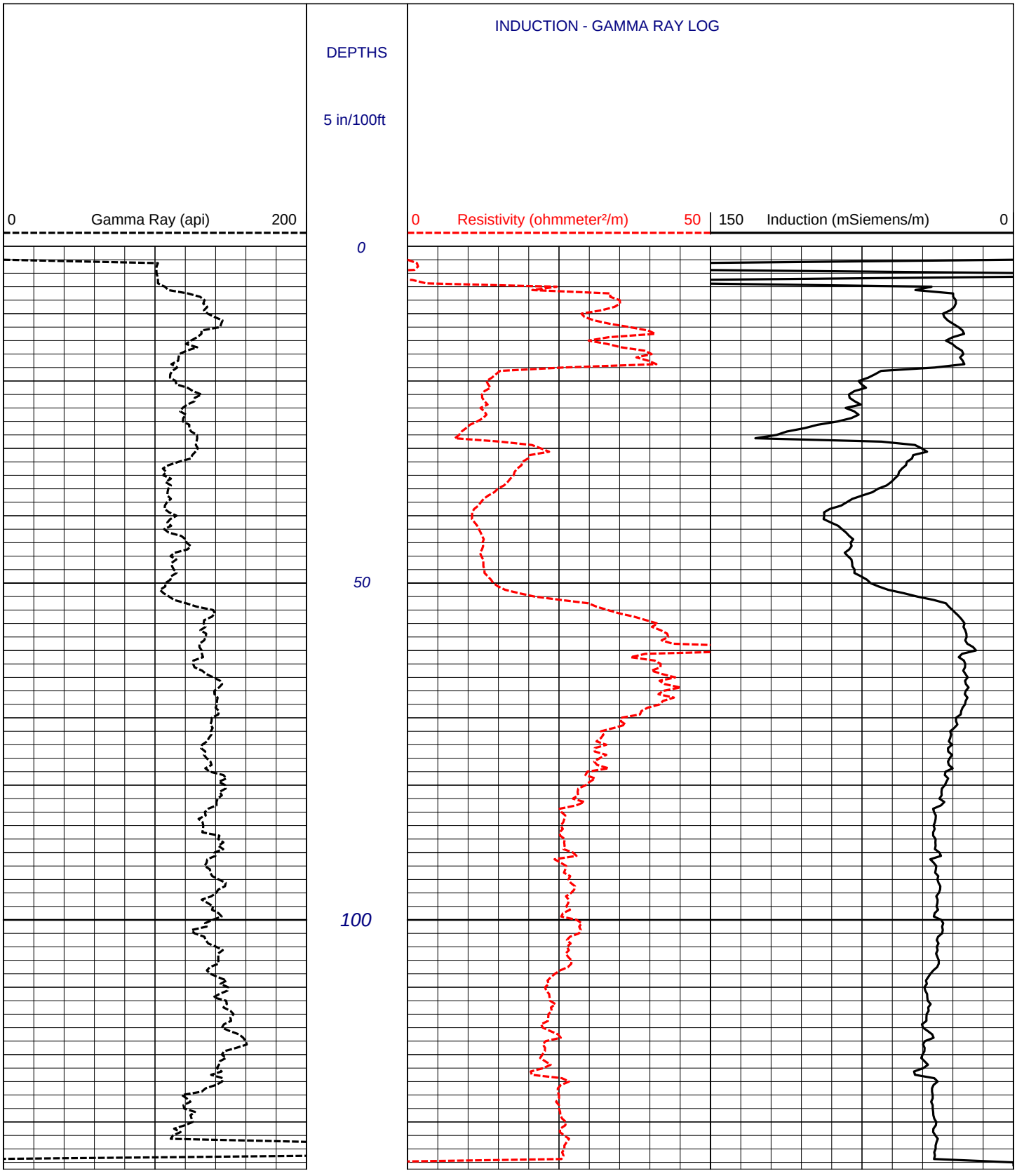
Borehole Volume Calculations:

Other Information:

NOTICE: All interpretations are opinions based on inferences from electrical and other measurements and we do not guarantee the accuracy or correctness of any verbal or written interpretation, and we shall not, except in the case of gross or willful negligence on our part, be liable or responsible for any loss, costs, damages or expenses incurred or sustained by anyone resulting from any interpretation made by one of our officers, agents or employees. These interpretations are also subject to our General Terms and Conditions as set out in our current Price Schedule.

welenco, inc. April 03, 2007

CH2M HILL MW-48 Apr 3, 2007



Log Page No. 1 of 1 Pages

Page Length: 0 - 137 Feet (137 Feet)

Time: 10:56:33 AM

Date: Apr 03, 2007

welenco

Phone: (800) 445-9914
Fax: (661) 834-2550

CBL

PGE-7

COMPANY	CH2M Hill
WELL	PGE-7
FIELD	Topock
COUNTRY	
STATE	CA
COUNTY	San Bernardino
LAT.:	
LONG.:	

OTHER SERVICES

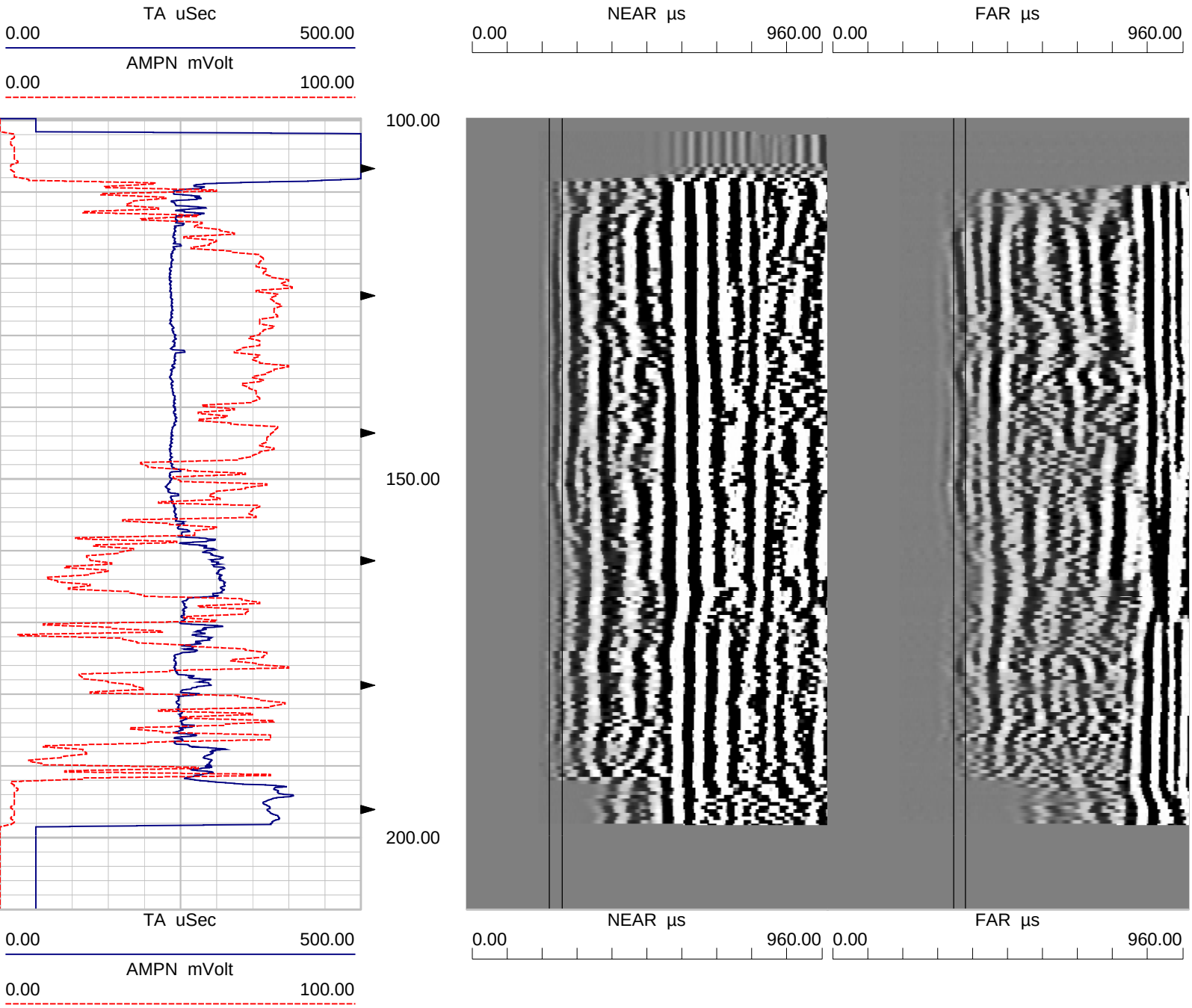
Perm. Da..	Elev	KB	0.00
Log. Datum		DF	0.00
Drill Datum		GL	0.00

DATE	03 Apr 07		
RUN#	0	0	0
TYPE OF LOG			
DEPTH DRILLER	0.00	0.00	0.00
DEPTH LOGGER	0.00	0.00	0.00
LOG DEEPEST	0.00	0.00	0.00
LOG SHALLOW	0.00	0.00	0.00
FLUID IN HOLE			
SALINITY			
DENSITY			
LEVEL			
MAX TEMP °C	0.00	0.00	0.00
RIG TIME			
RECORDED BY			
WITNESSED BY			

RUN#	BIT RECORD SIZE	FROM	TO	CASING RECORD SIZE	WEIGHT	FROM	TO
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00

ROBERTSON GEOLOGGING TECHNOLOGY

REMARKS (C:\Dans\2007Logs\7251ElgCalCbl\7251CBL-2.hed)



Depth: 99.00 ft Date: 03 Apr 2007 Time: 15:38:16 File: "C:\WinLogger\DATA\7251CBL-2.CBL"

welenco
(800)445-9914

BHTV DATA PROCESSING
RGLDIP vsn 6.2
AMPLITUDE/TRAVEL-TIME LOG

09 Apr 2007

CH2M Hill

Borehole: PGE-7

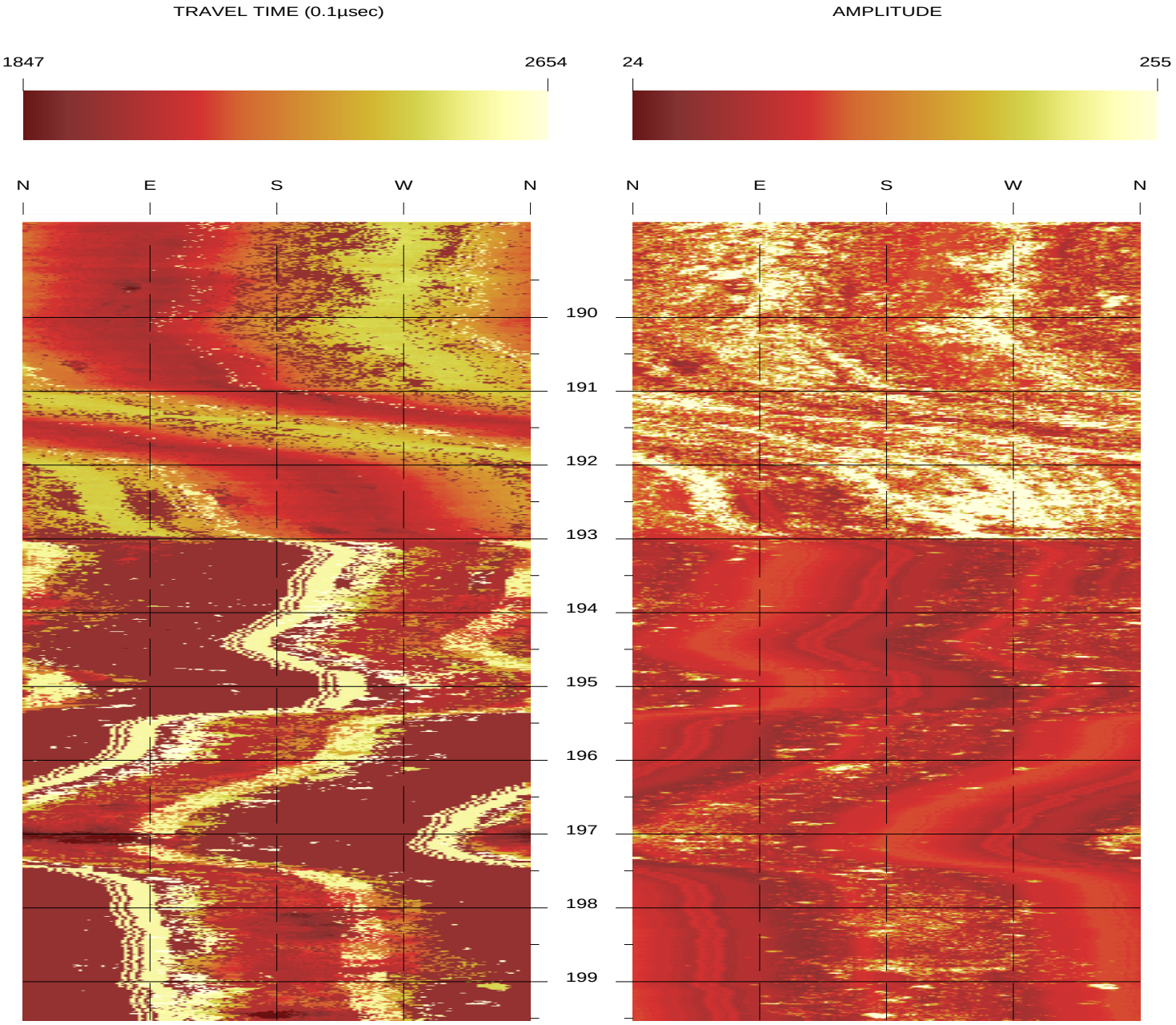
Topock

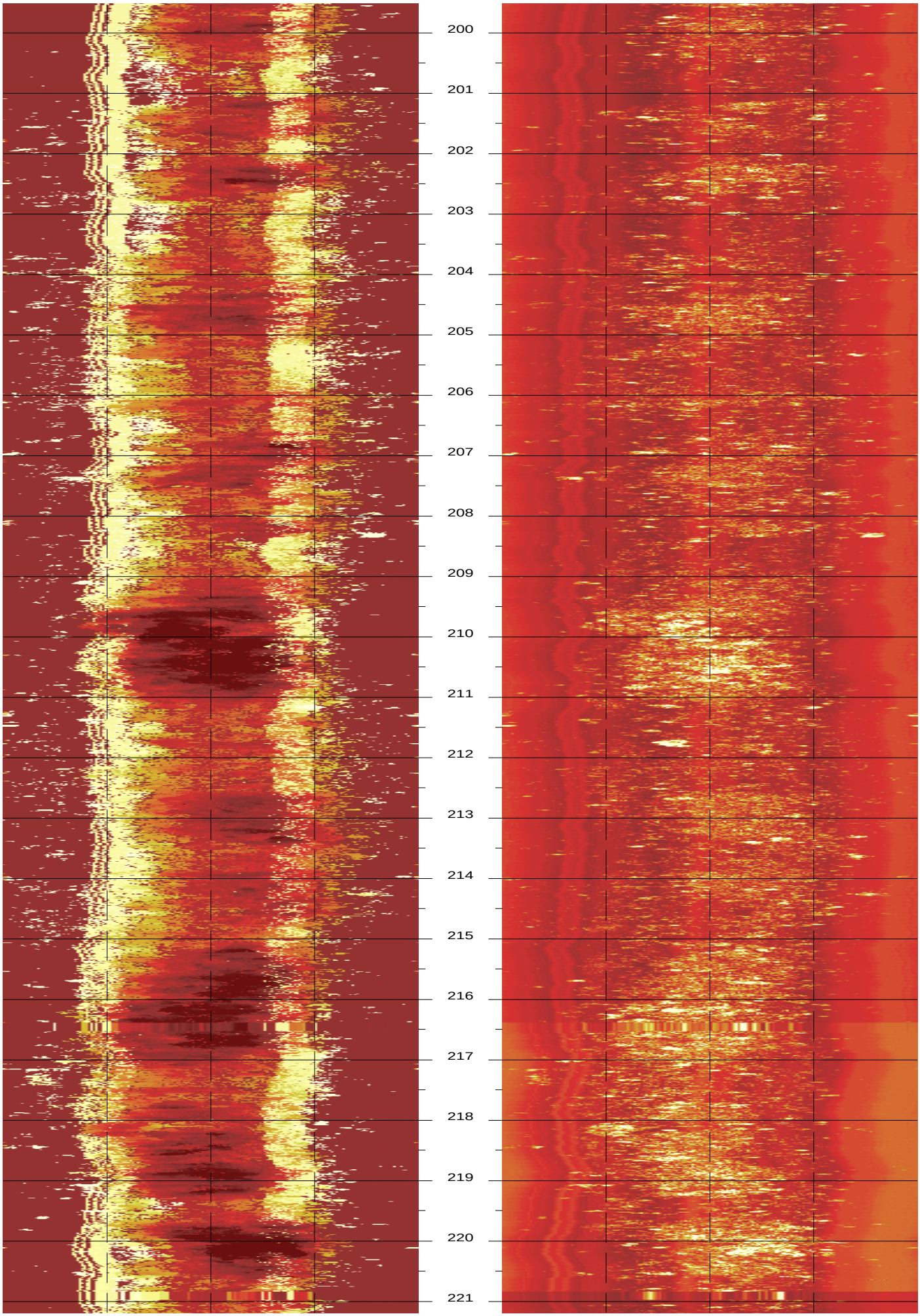
top of borehole.....
East: _
North:_
Elev: _

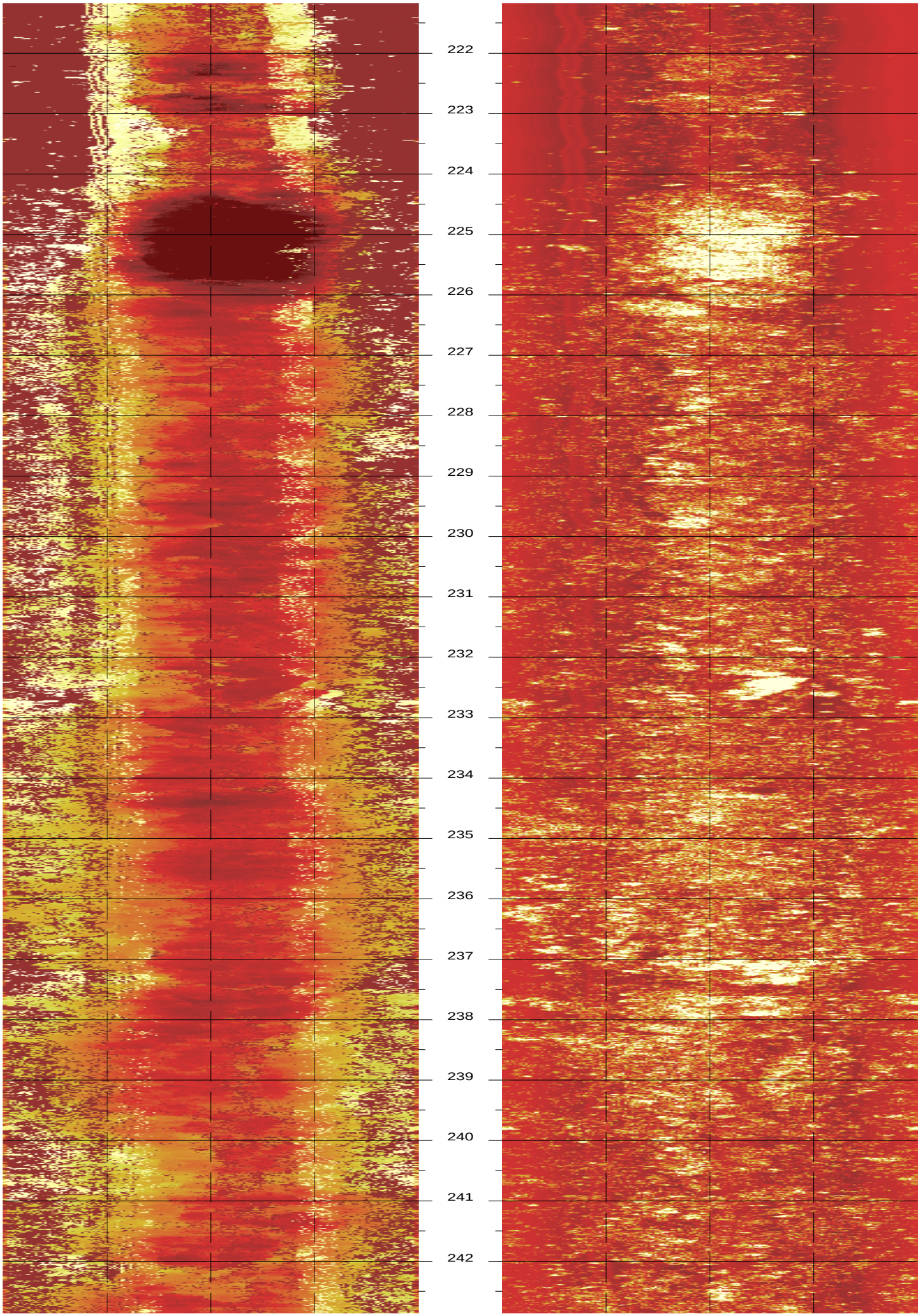
North ref. is magnetic
Depth units are feet
Vertical scale: 1/25

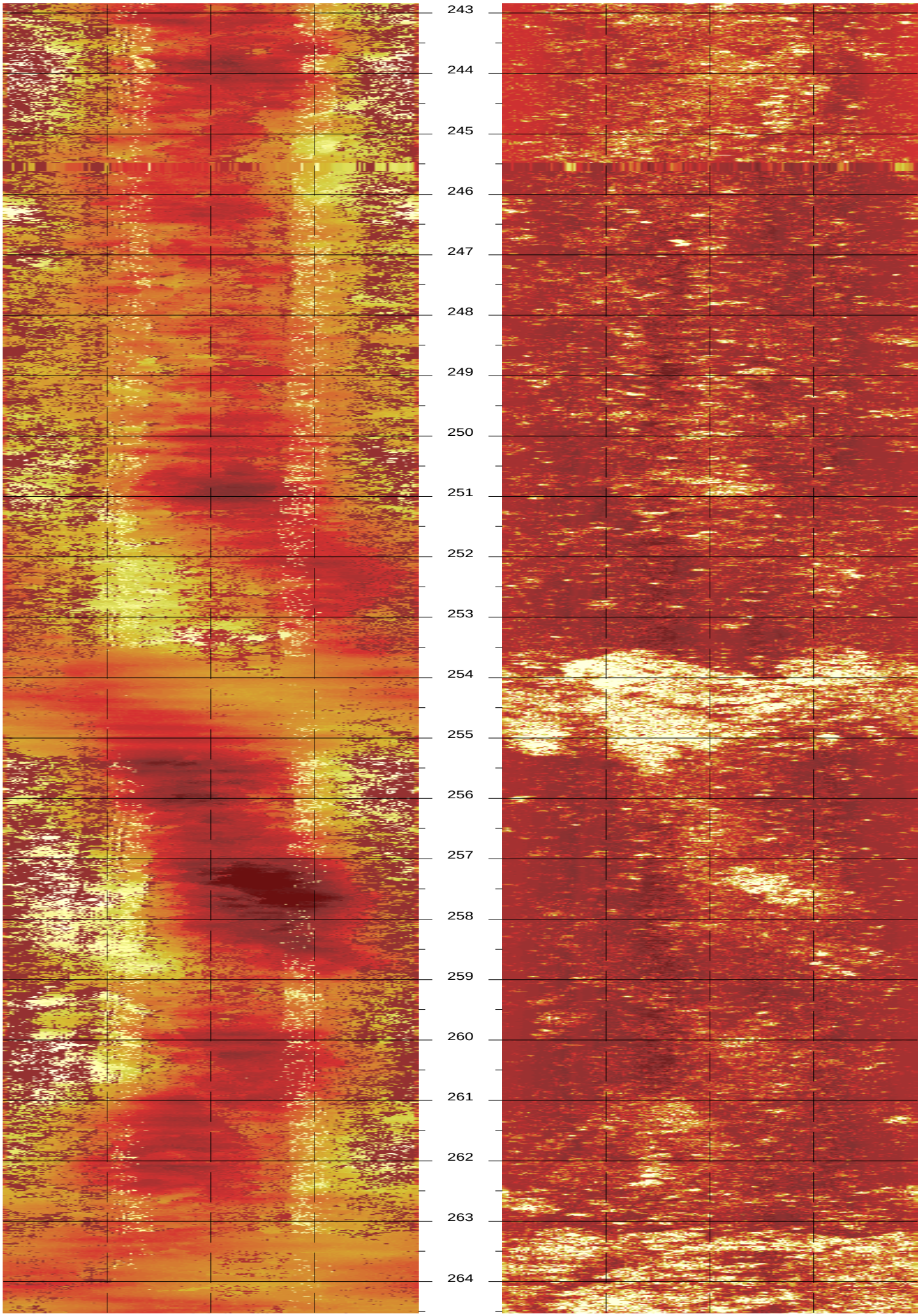
Zone from 306.132 to 189.024ft
Format BHTV-NESWN

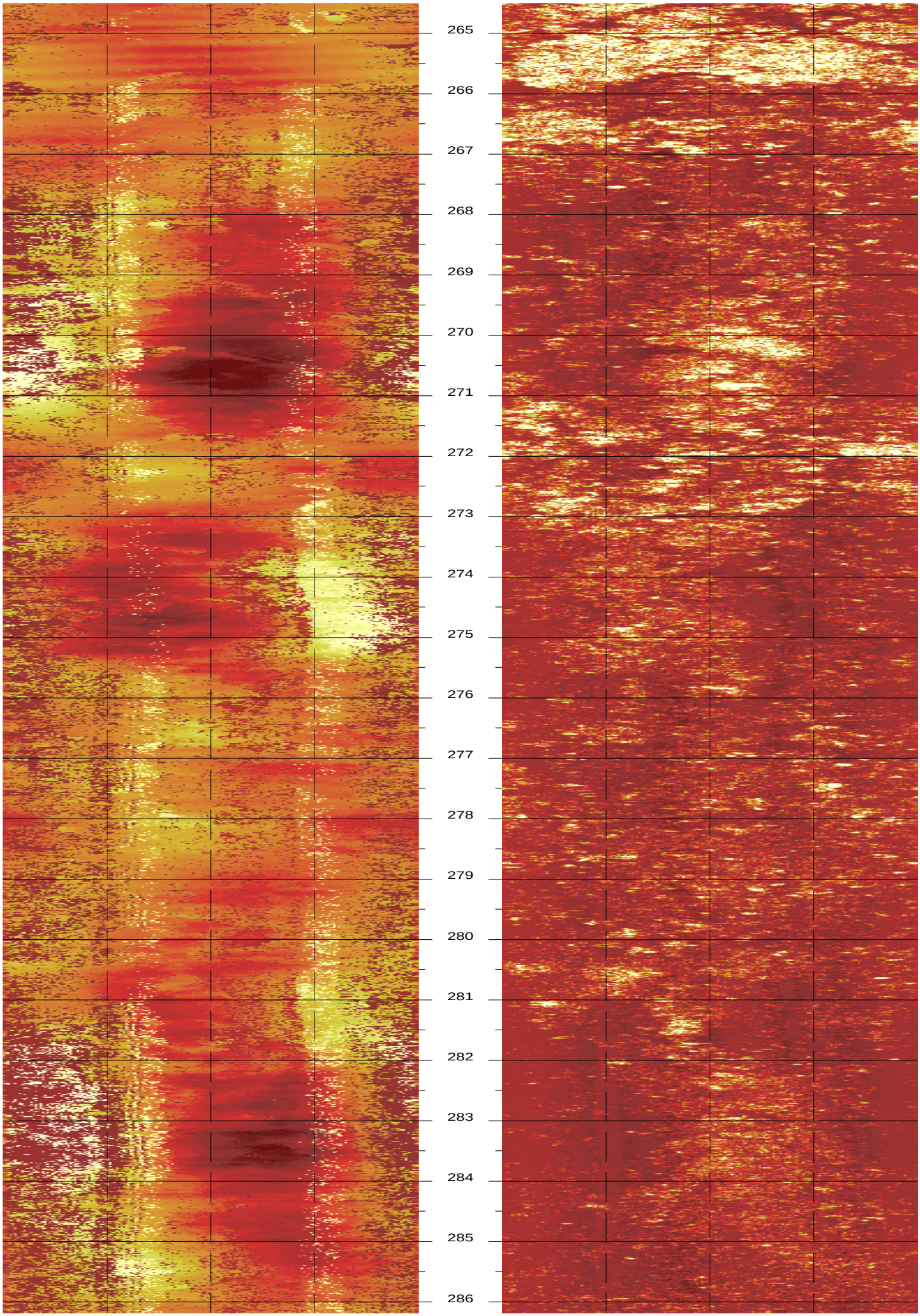
Borehole diam: 6.750inch
data intervals.....
azimuth: 2.000deg
depth: 0.008ft

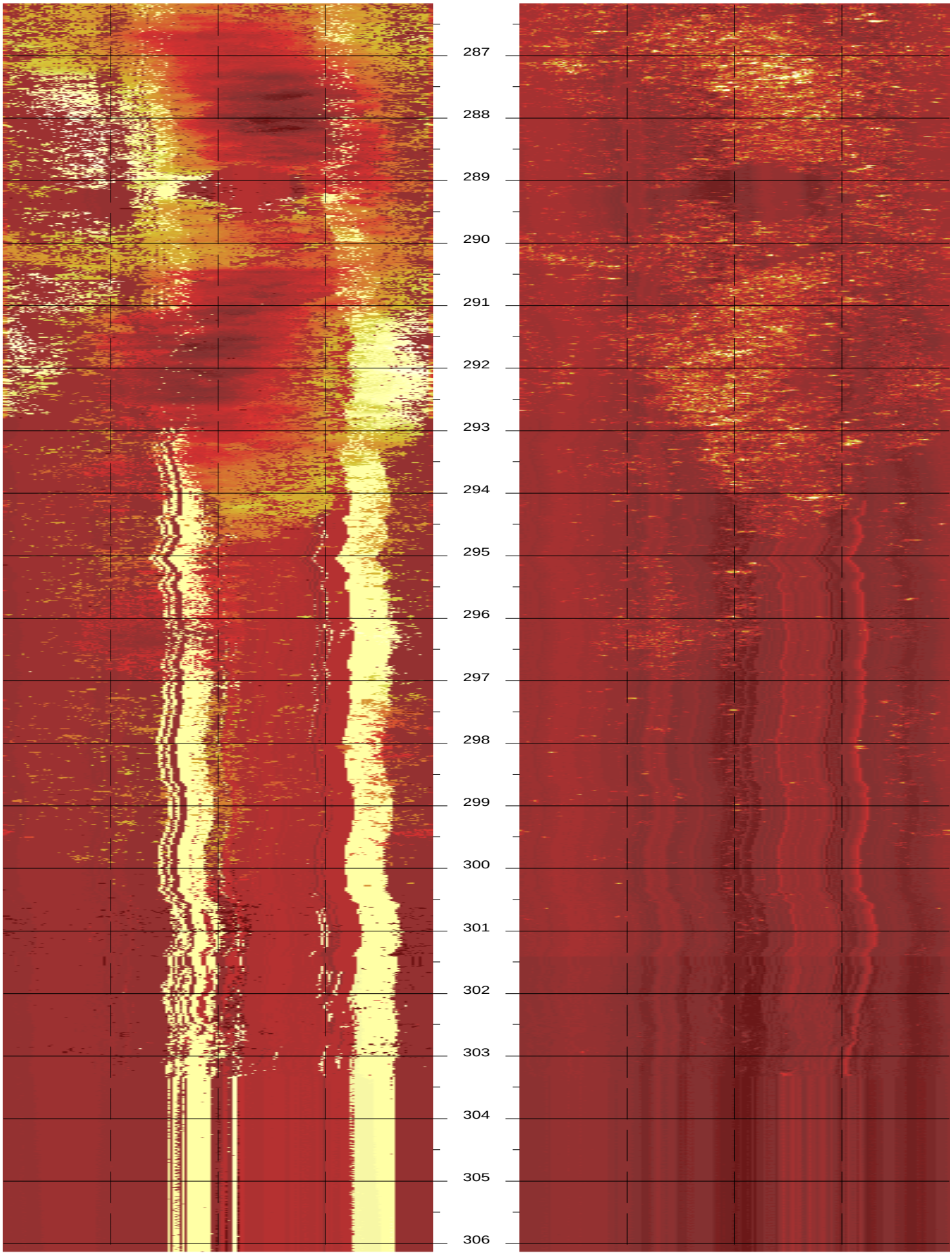



200
201
202
203
204
205
206
207
208
209
210
211
212
213
214
215
216
217
218
219
220
221


222
223
224
225
226
227
228
229
230
231
232
233
234
235
236
237
238
239
240
241
242


243
244
245
246
247
248
249
250
251
252
253
254
255
256
257
258
259
260
261
262
263
264


265
266
267
268
269
270
271
272
273
274
275
276
277
278
279
280
281
282
283
284
285
286


287
288
289
290
291
292
293
294
295
296
297
298
299
300
301
302
303
304
305
306

welenco
(800)445-9914

BHTV DATA PROCESSING
RGLDIP vsn 6.2
INTERPRETED BHTV DIPS LOG

09 Apr 2007

CH2M Hill

Borehole: PGE-7

Topock

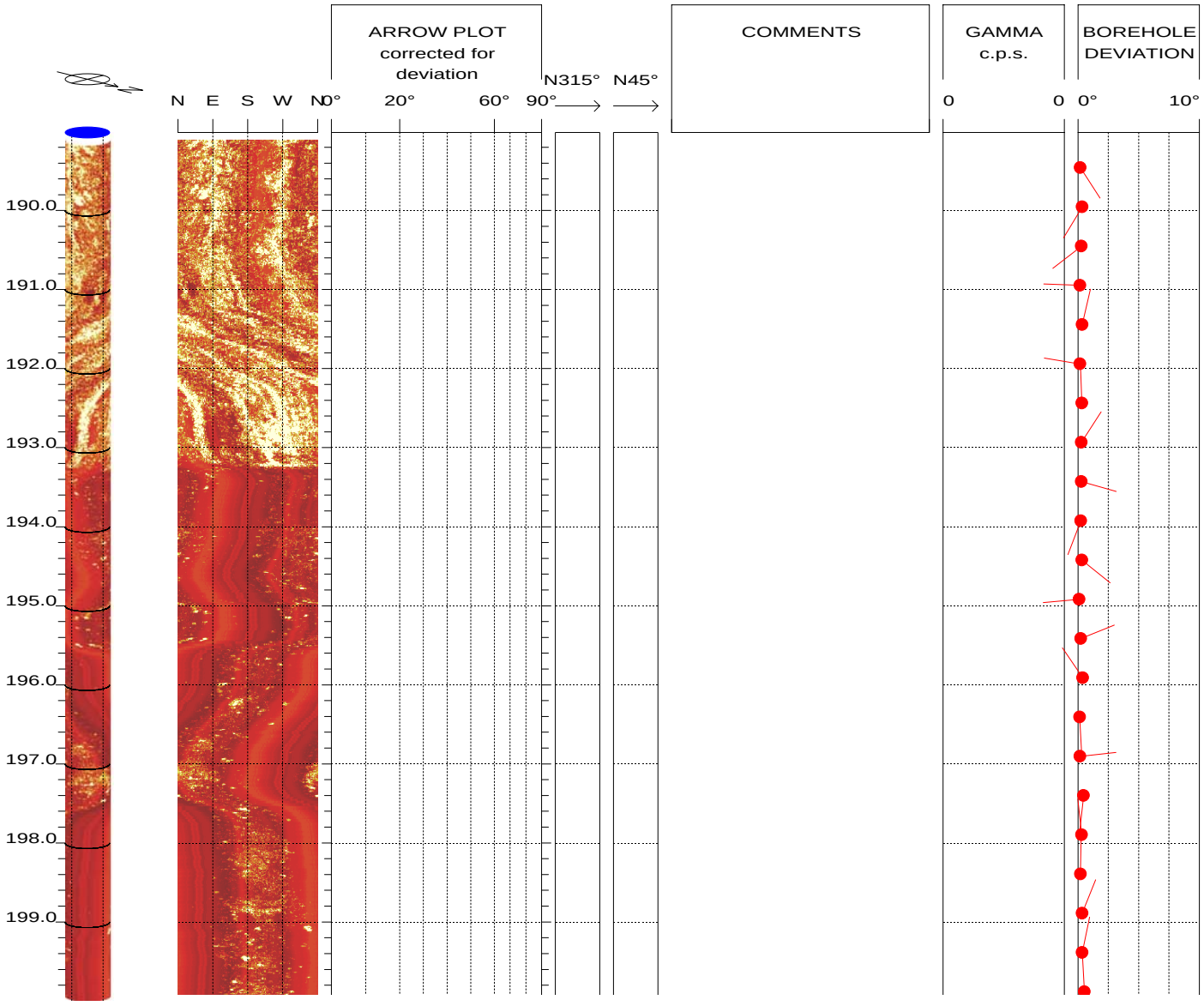
top of borehole.....
East: _
North:_
Elev: _

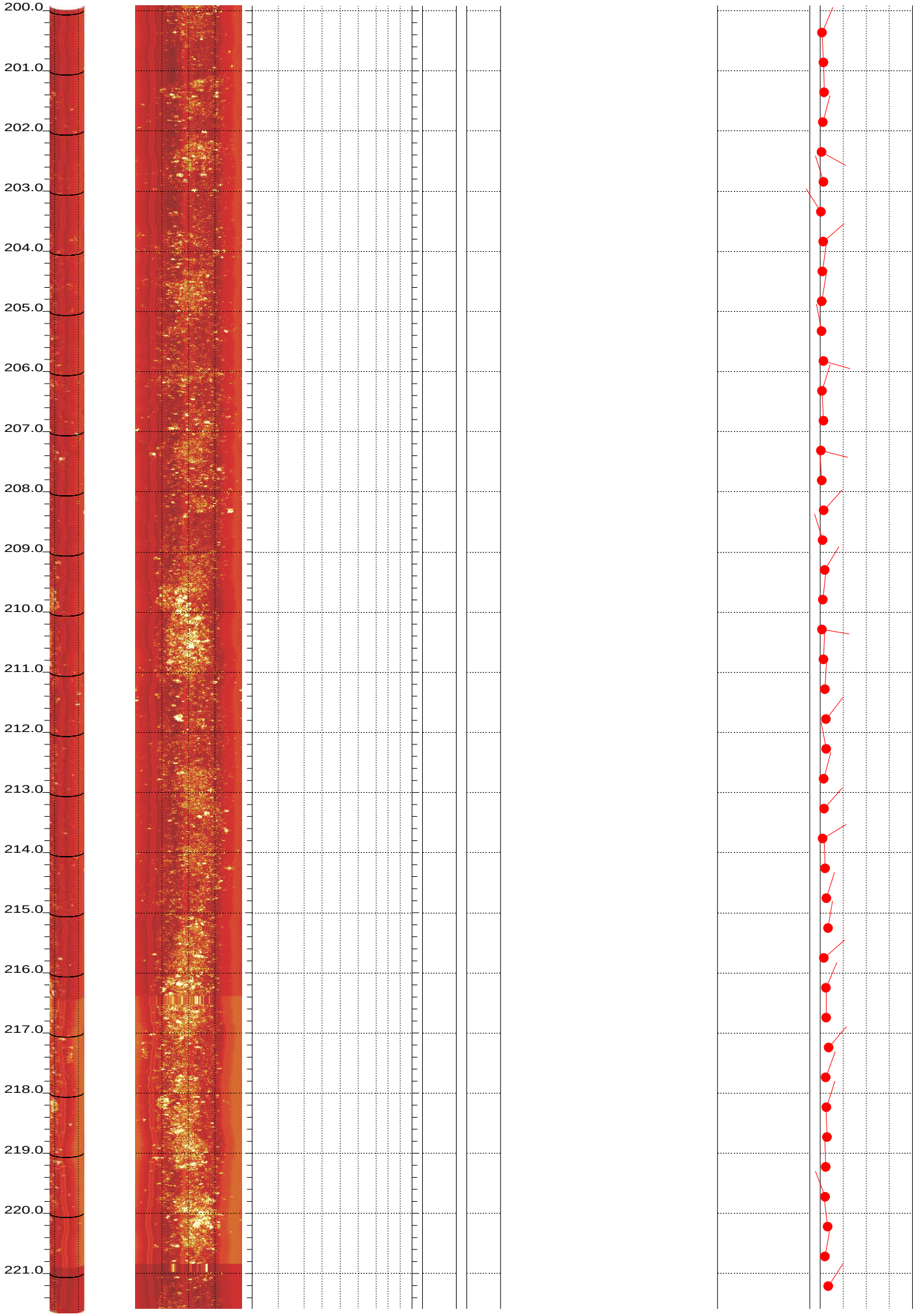
North ref. is magnetic
Depth units are feet
Vertical scale: 1/25
Horiz scale = 1.00x Vert scale

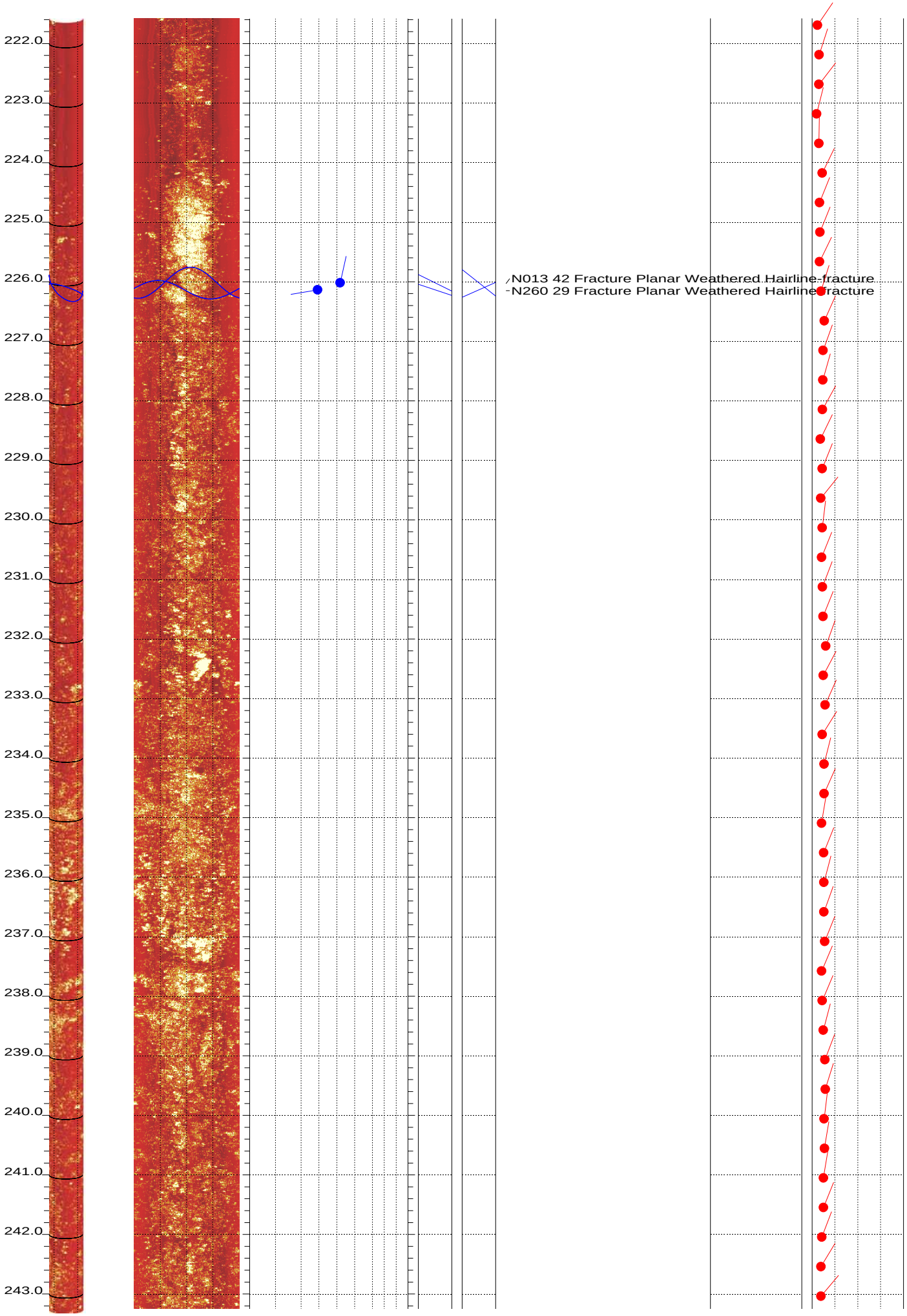
Zone from 306.132 to 189.024ft
Format: BHTV-NESWN

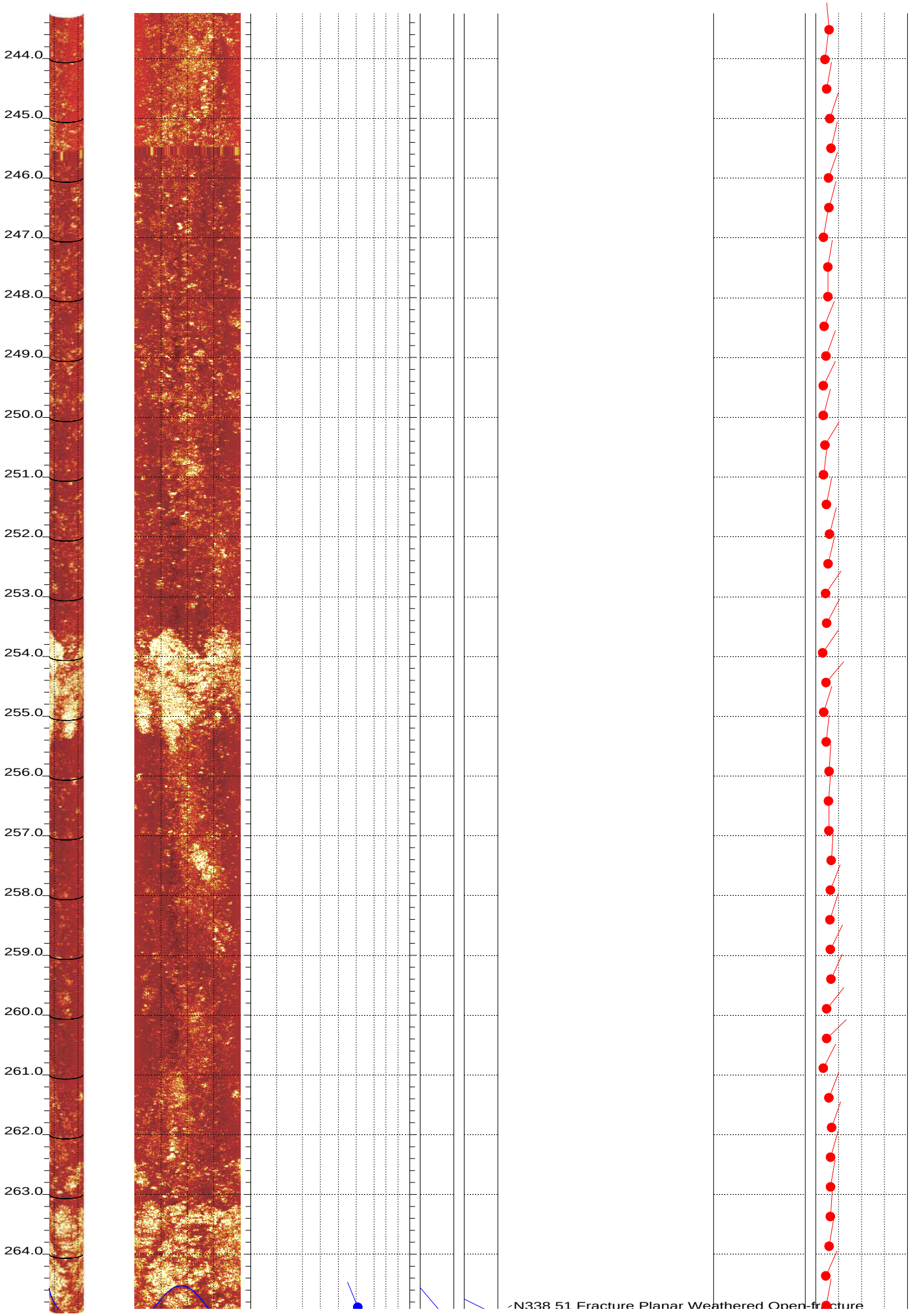
Borehole diam: 6.750inch
Vertical = borehole-axis
Image: Amplitude

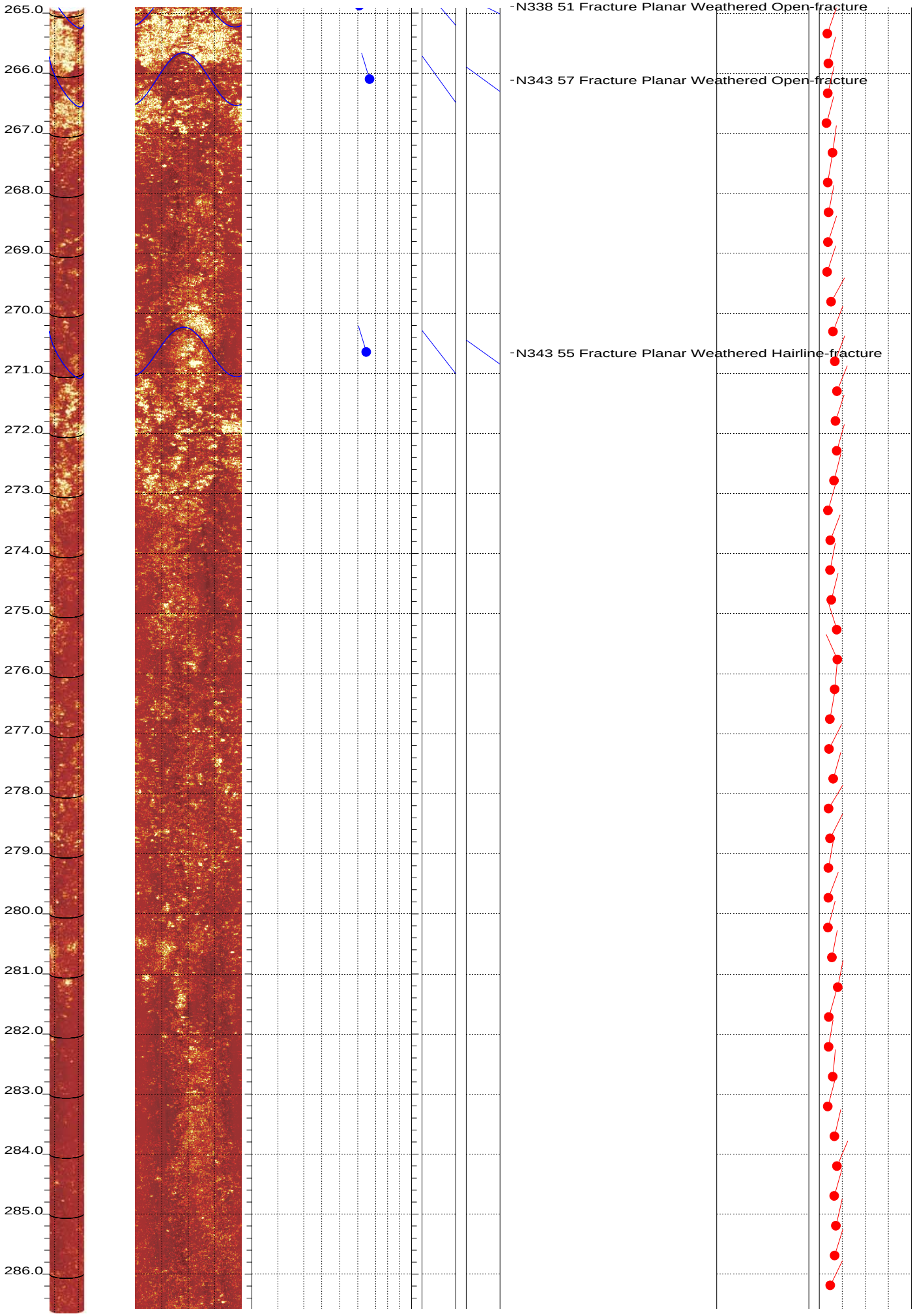
Stratigraphic dips
Non-stratigraphic dips
Identified units

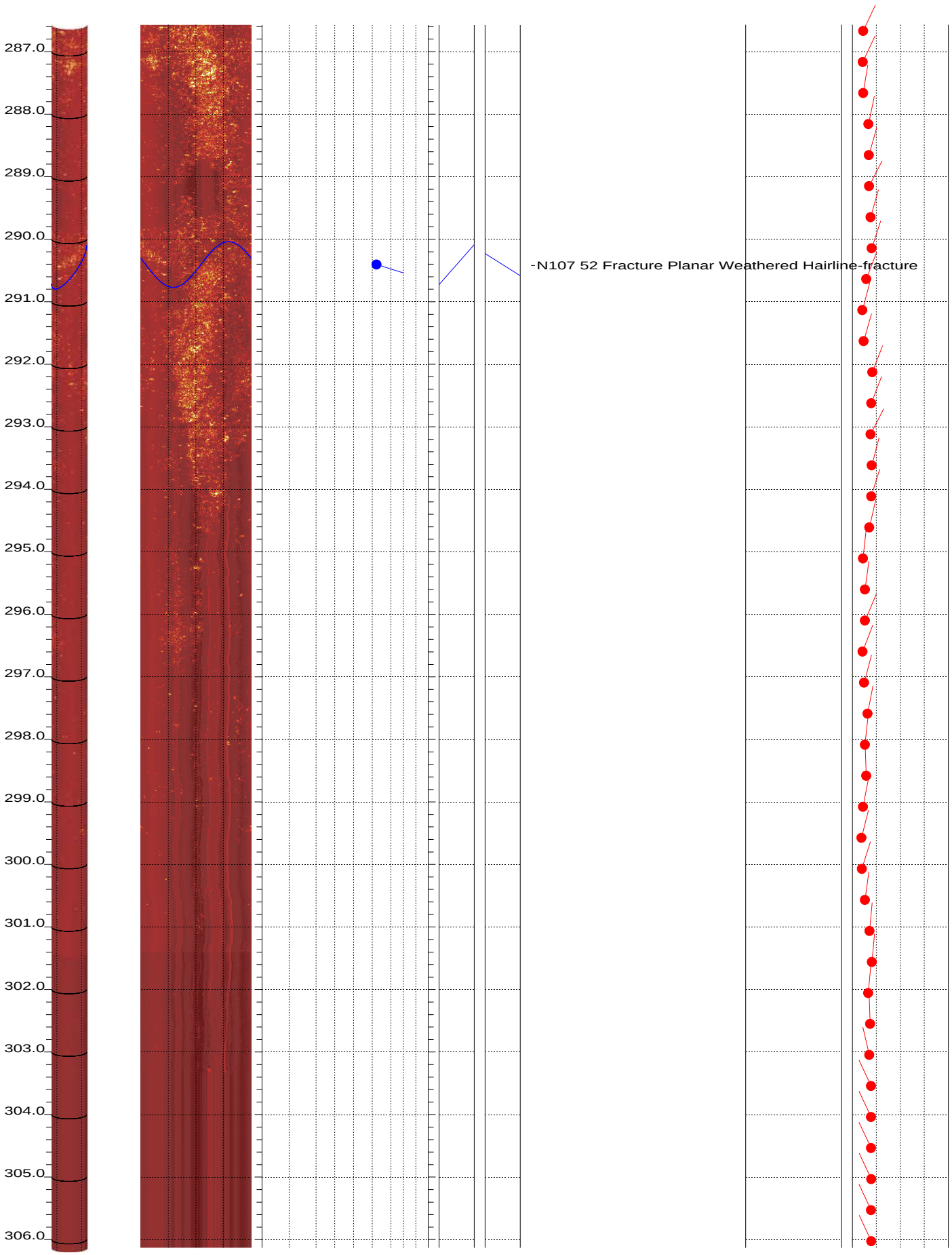



200.0
201.0
202.0
203.0
204.0
205.0
206.0
207.0
208.0
209.0
210.0
211.0
212.0
213.0
214.0
215.0
216.0
217.0
218.0
219.0
220.0
221.0


222.0
223.0
224.0
225.0
226.0
227.0
228.0
229.0
230.0
231.0
232.0
233.0
234.0
235.0
236.0
237.0
238.0
239.0
240.0
241.0
242.0
243.0
N013 42 Fracture Planar Weathered Hairline fracture
N260 29 Fracture Planar Weathered Hairline fracture


244.0
245.0
246.0
247.0
248.0
249.0
250.0
251.0
252.0
253.0
254.0
255.0
256.0
257.0
258.0
259.0
260.0
261.0
262.0
263.0
264.0
N338 51 Fracture Planar Weathered Open-fracture


265.0
266.0
267.0
268.0
269.0
270.0
271.0
272.0
273.0
274.0
275.0
276.0
277.0
278.0
279.0
280.0
281.0
282.0
283.0
284.0
285.0
286.0
-N338 51 Fracture Planar Weathered Open-fracture
-N343 57 Fracture Planar Weathered Open-fracture
-N343 55 Fracture Planar Weathered Hairline-fracture


287.0
288.0
289.0
290.0
291.0
292.0
293.0
294.0
295.0
296.0
297.0
298.0
299.0
300.0
301.0
302.0
303.0
304.0
305.0
306.0
-N107 52 Fracture Planar Weathered Hairline-fracture

welenco
(800)445-9914

DIP DATA INTERPRETATION
RGLDIP vsn 6.2
FRACTURE ANALYSIS LOG

09 Apr 2007

CH2M Hill

Borehole: PGE-7

Topock

top of borehole.....
East:_
North:
Elev:_

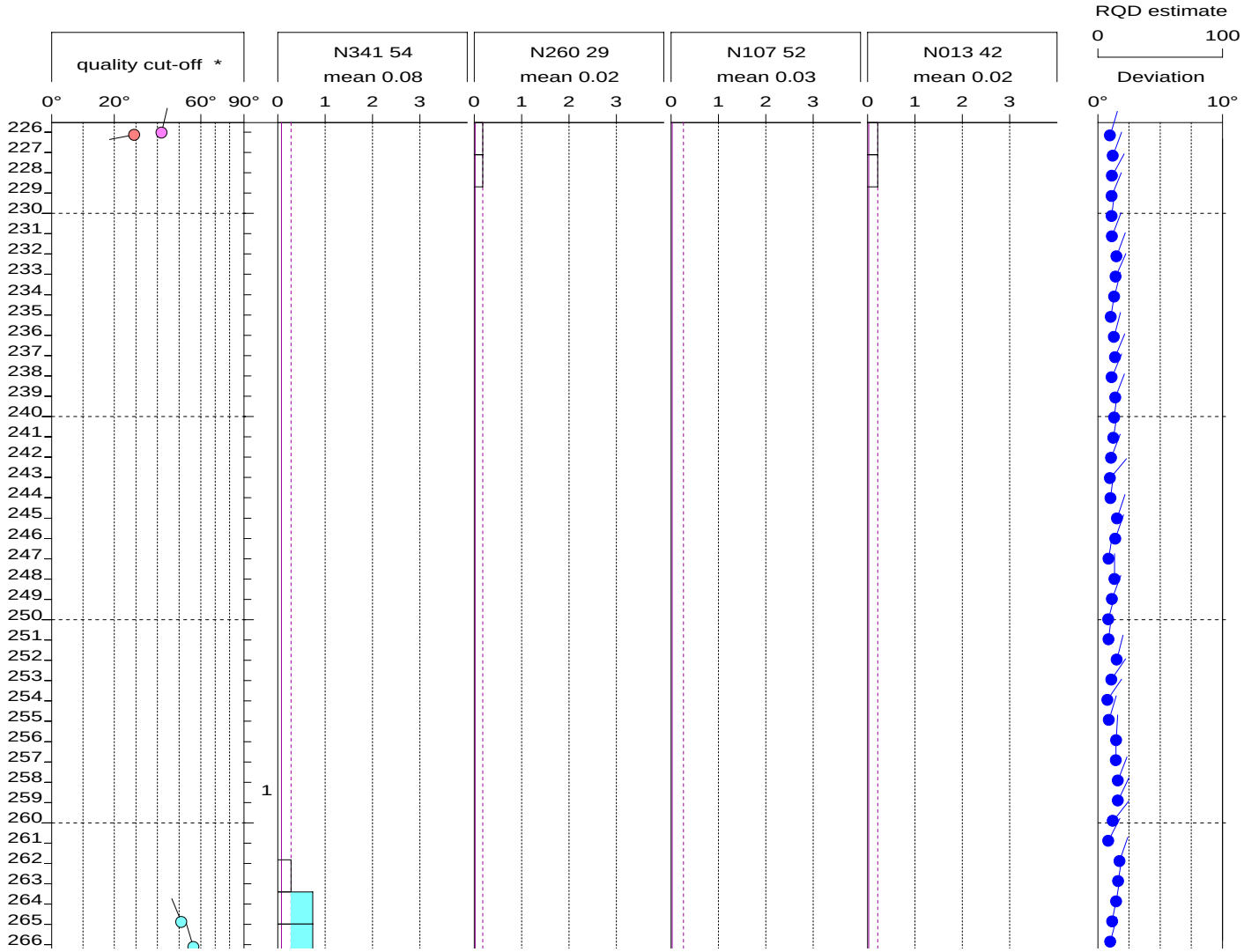
North ref: magnetic
Depth units are feet
Vertical scale: 1/100

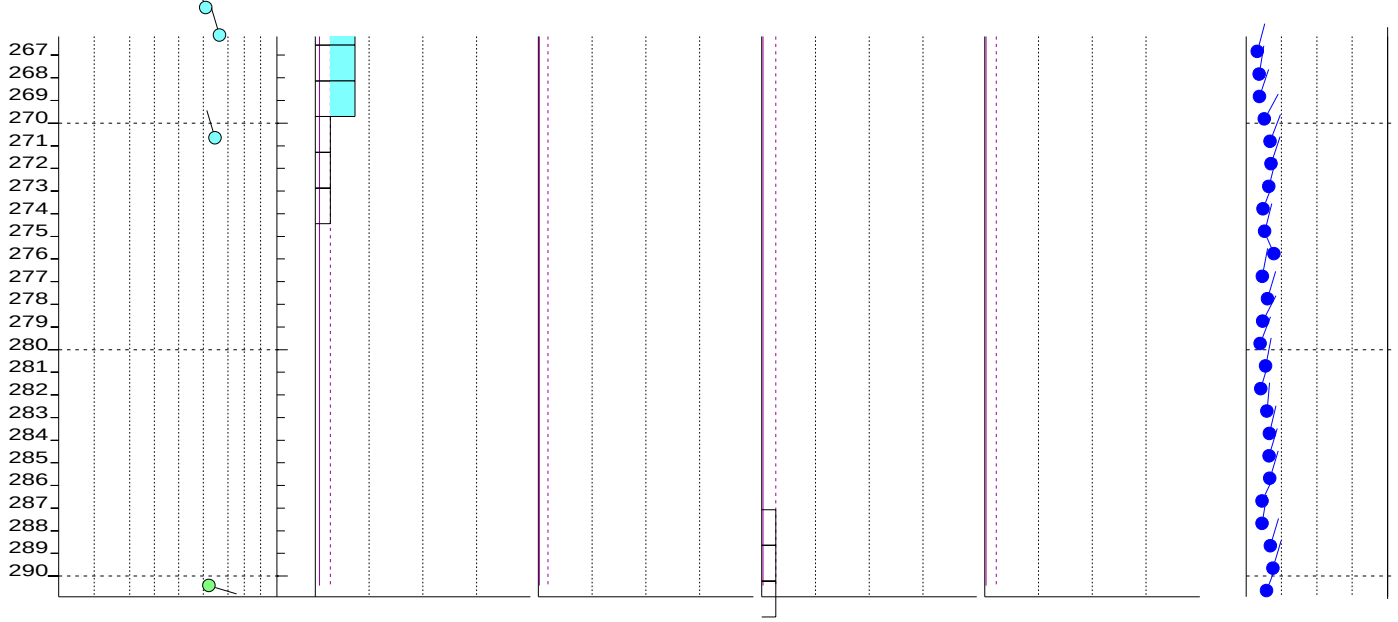
Zone from 290.919 to 225.531ft
Mean dip format: dip-azimuth and dip
Frequency histogram parameters:

measurement distance 4.734ft
step distance 1.578ft

Interpretation 1

Dip data sets .....
BHTV dips
Highlighted dips: Bedding
open symbols not used in mean-dip/zone-axis calculation




267
268
269
270
271
272
273
274
275
276
277
278
279
280
281
282
283
284
285
286
287
288
289
290

LETTER REPORT

During the period from April 18th to April 20th, 2007, RAS, Inc., of Golden, CO, conducted electromagnetic flow meter ("EMFM") logging in one well (PGE-7) at the PG&E Topock Compressor Site near Needles, California. The principal objective of this study was to evaluate the open-hole, bedrock portion of the wellbore in order to identify the location and magnitude of water bearing intervals. In addition, prior to the EMFM logging, RAS also conducted development pumping activities (step drawdown type aquifer testing). After each day of pumping activities, RAS recorded the overnight pressure recovery. Following the development pumping, RAS conducted EMFM logging during both pumping and ambient conditions in well PGE-7.

Well PGE-7 was cased to 192 feet with 7 inch I.D. steel casing and open hole from 192 to 300 feet. Depth to water was measured at 110.4 feet (all depths referenced to top of steel casing).

The electromagnetic flow meter is a modern method to evaluate vertical groundwater flow velocity and direction (up or down) in a wellbore. The EMFM is based on Faradays Law and includes employment of a flexible rubber skirt to divert all the borehole vertical flow through a calibrated flow tube. By recording the output of the EMFM and using advanced computer analysis software, the advective velocity and vertical direction (+ for upflow and – for downflow) of groundwater flow within a well can be evaluated. The practical lower detection limit for vertical flow with the EMFM is 0.10 gallons per minute (gpm) with a maximum flow rate of 4 gpm.

On April 18th, prior to EMFM logging, RAS conducted a step drawdown test at well PGE-7[1] to develop the well and evaluate appropriate pumping rates for EMFM testing. Prior to pumping, the depth to water was 107.8 feet below top of inner steel casing (fbtoisc). During the pumping rates of 5.6, 10.6 and 13.5 gpm, maximum drawdown of 1.1, 2.1 and 2.7 feet, respectively, were observed. At the completion of pumping activities, a Hermit 3000 and pressure transducer were deployed to measure pressure recovery overnight. Please refer to attached Figure 2 for the recorded recovery data. These data suggest that the aquifer immediately surrounding the well completely recovered prior to the following day's flow meter testing.

On April 19th, RAS conducted EMFM logging during pumping of well PGE-7. Prior to pumping and EMFM logging, the depth to water was 107.79 fbtoisc. Testing with the EMFM was conducted during pumping at 13.2 gpm with an observed maximum drawdown of 2.3 feet. Based on review of the caliper log, acoustic televiewer log and other geologic considerations (bedrock interval, open

[1] All logging and water level data was referenced in feet below top of the inner steel casing.

hole alluvium interval and depth of casing), eighteen (18) stations were tested with the EMFM. These results are presented below in Table 1.

In summary, the resulting flow measurements from the EMFM logging in the bedrock interval are below the reliable detection limit and suggest no to very low flow (less than 0.1 gpm). As such, vertical flow conditions in the bedrock portion of the well (~220-300 feet) during pumping cannot be confirmed. Pumping was conducted at 13.2 gpm with a maximum drawdown of 2.2 feet. While the data qualitatively suggests very low vertical flow, the flow rate measured is considered by RAS to be below the practical quantitative lower limit of the EMFM (0.10 gpm). As such, these reported flow rates should not be used for any quantitative purposes (i.e. estimation of interval specific hydraulic conductivity or transmissivity).

EMFM measurements within the casing (above 197 ftbtoisc) indicate flow of 2.9–3.2 gpm. This flow rate was considerably less than the observed pumping rate of 13.2 gpm but near the maximum range of the EMFM. These data suggest that all flow occurring in PGE-7 is from the alluvium interval, the interval from 196 to 220 feet being the open hole portion of this alluvium unit. Immediately following the EMFM pumping test, a Hermit 3000 and pressure transducer were installed to record pressure recovery overnight. These data are presented in Figure 4 below, and suggest again, that the aquifer recovered quickly and completely before the subsequent day's ambient flow characterization.

On April 20th RAS conducted EMFM testing during ambient (non-pumping) conditions. The EMFM survey suggested that the ambient flow conditions contain a vertical component, but with a very low flow rate (<0.1 gpm). This flow rate is below the practical detection limit for the EMFM. As such, no reliable identification of water bearing intervals in the bedrock portion of the well can be accomplished with these data. The depth to water was 107.85 fbtc at the time of EMFM testing. Please refer to Table 1 for a summary of the EMFM results collected during ambient conditions.

CONCLUSIONS AND RECOMMENDATIONS

The EMFM survey qualitatively suggests no flow to very weak flow, i.e. less than the reliable detection limit of 0.10 gpm, during both pumping and ambient pressure conditions for the bedrock interval. The EMFM survey data suggest that all flow originated from the alluvium portion of Well PGE-7. The open hole pressure data (depth to water) collected during pumping also suggest that flow in the well is dominated by the porous medium and is not fracture flow.

To properly characterize the bedrock interval, test methods with much lower quantification limits for hydraulic conductivity would be required for this low permeability bedrock. These tests should be conducted in an environment where the alluvium is hydraulically isolated from the bedrock.

Isolating the bedrock interval with single and straddle packers would isolate the alluvium from the bedrock interval and allow characterization of the bedrock interval. Specifically, vertical hydraulic gradient, bulk hydraulic conductivity of the bedrock interval and hydraulic conductivity of selected intervals of the bedrock could be evaluated. During the interval specific hydraulic conductivity evaluation, if sufficient flow was observed, interval specific sampling could also be conducted during packer testing. The vertical distribution of water quality could be characterized by this interval specific groundwater sampling. Hydrophysical logging could also be incorporated to identify the low flow water bearing intervals prior to straddle packer testing to aid selected packer test intervals.

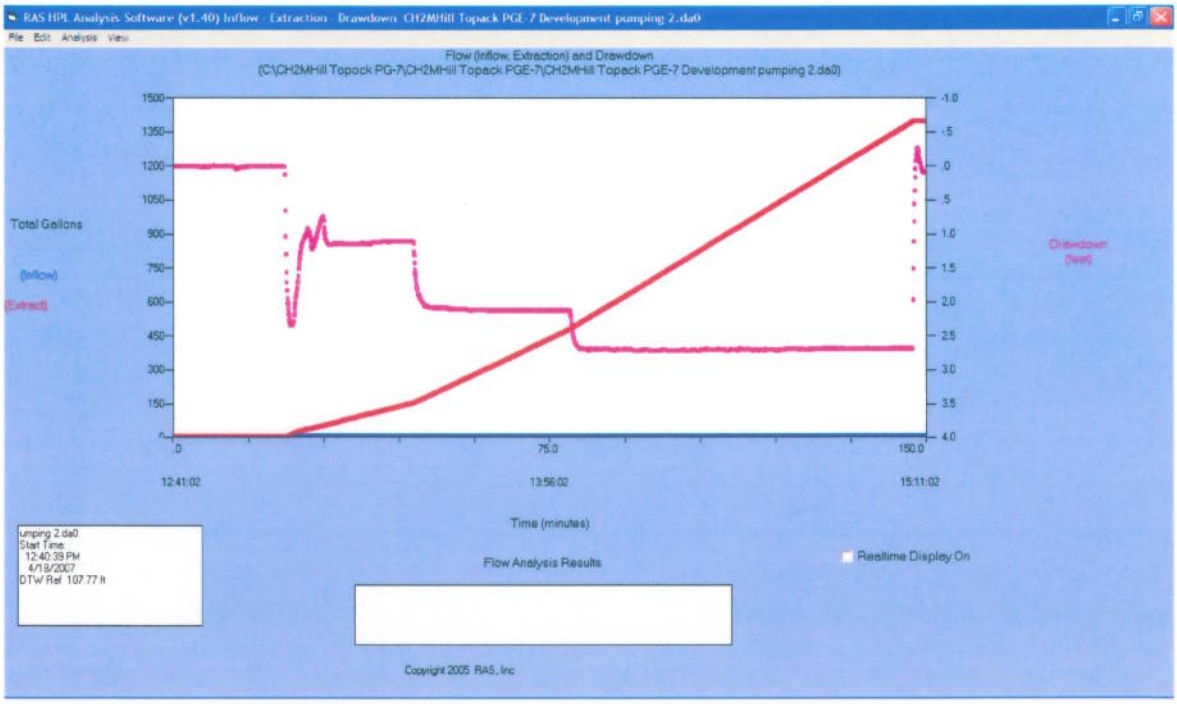


Figure 1. Pumping and Drawdown Data During Development Pumping Prior To EMFM Testing, Well PGE-7, PG&E Site, Topock, California. Three pumping rates of 5.6, 10.6 and 13.5 gpm, with observed associated drawdowns of 1.1, 2.1 and 2.7 feet, respectively, were observed. Observation of note includes the rapid stabilization of drawdown at each pumping rate.

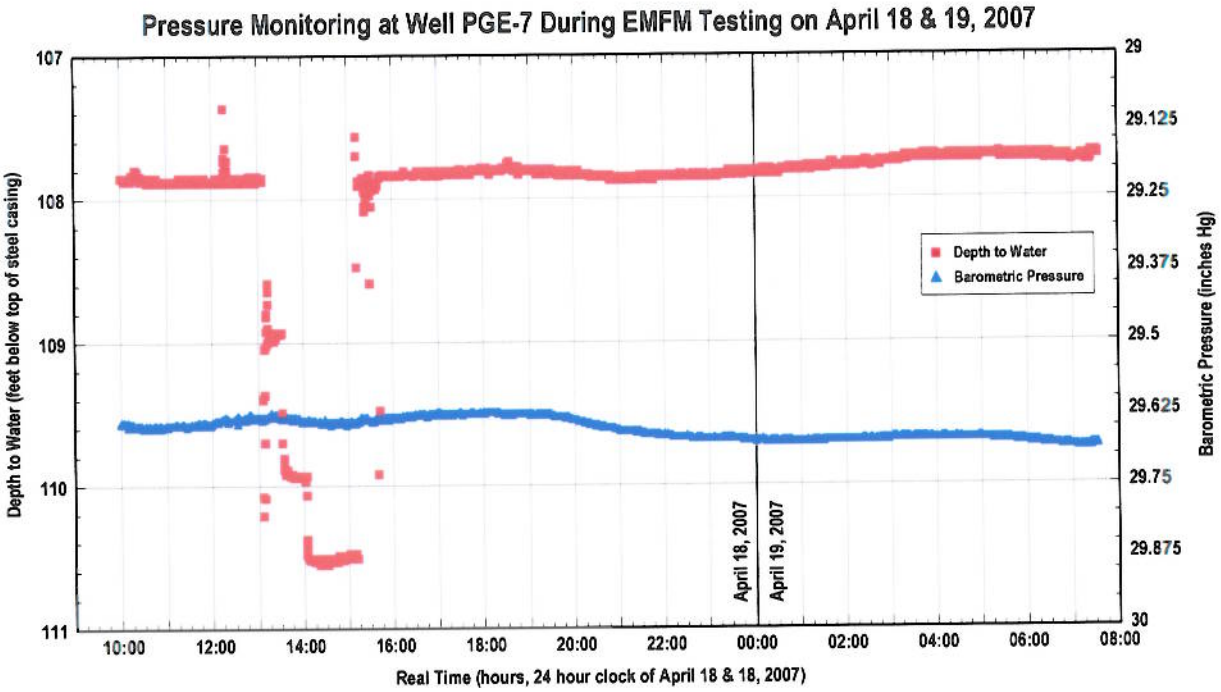


Figure 2. Recovery Pressure and Barometric Pressure After Development Pumping, Well PGE-7, PG&E Site, Topock, California. (Elapsed Time of 312 minutes @ 15:12 4/18/07). Correction for barometric effect has not been made to this data set.

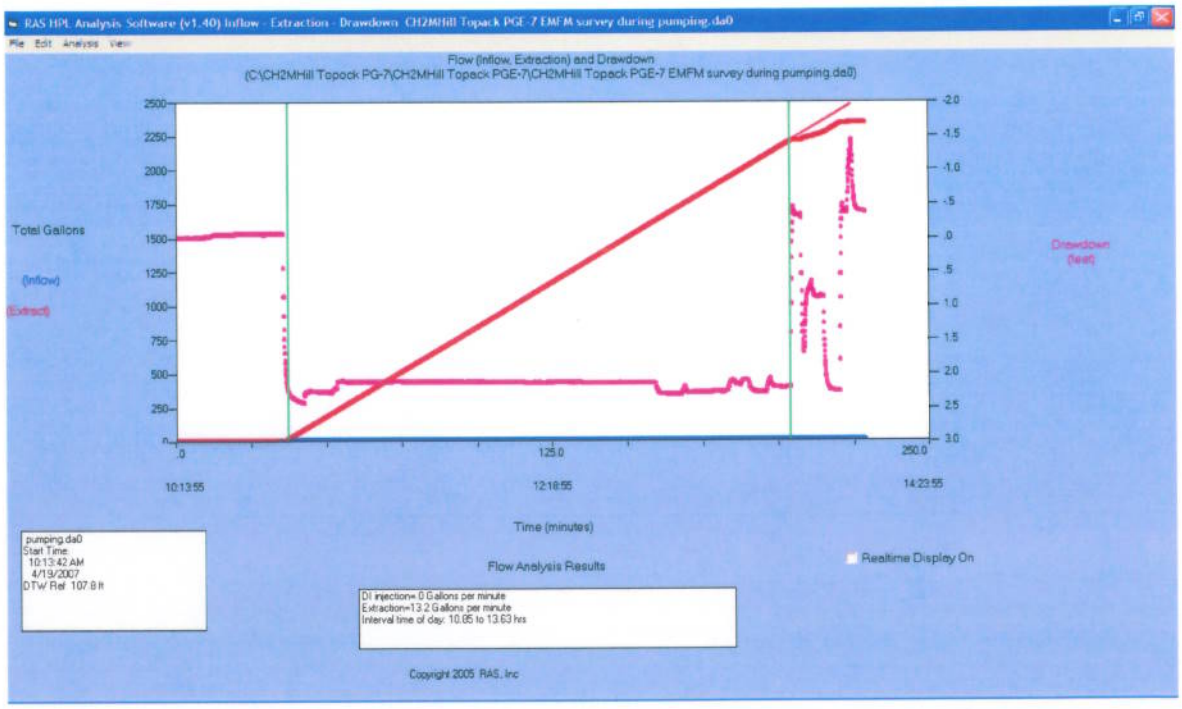


Figure 3. Pumping and Drawdown Data During EMFM Testing, Well PGE-7, PG&E Site, Topock, California. One pumping rate of 13.2 gpm, with observed drawdown of 2.1 feet. As during development pumping, the rapid stabilization of drawdown at each pumping rate is noteworthy.

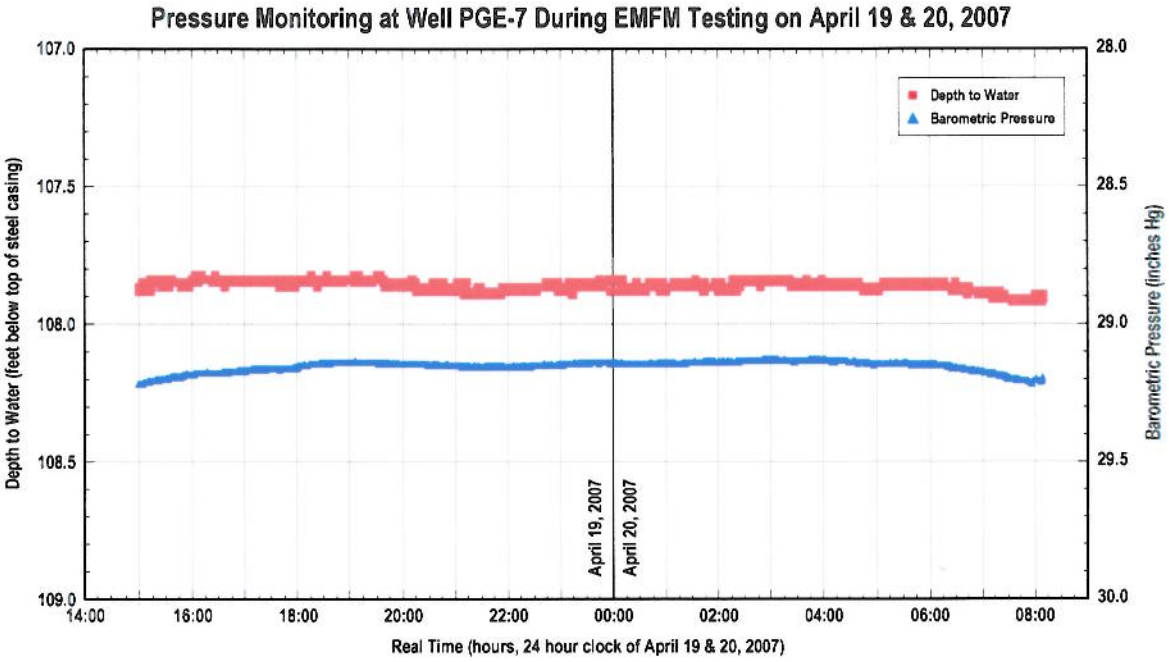


Figure 4. Recovery Pressure and Barometric Pressure After EMFM Testing During Pumping, Well PGE-7, PG&E Site, Topock, California. (Elapsed Time of 0 minutes @ 15:00 4/19/07). Correction for barometric effect has not been made to this data set.

Depth (ftbtoisc)	Ambient Flow (gpm)	Corrected Ambient Flow[2] (gpm)	Ambient Velocity (fpm)	Pumping Flow (gpm)	Corrected Pumping Flow (gpm)	Corrected Pumping Velocity (fpm)	Estimated flow rate for intervals without diverter (gpm)	Comments
115	0.012	**<0.10 (0.033)**	0.82					Measurement inside casing
127	0.01	**<0.10 (0.031)**	0.77					Measurement inside casing
147	0.013	**<0.10 (0.034)**	0.84					Measurement inside casing
167	0.01	**<0.10 (0.031)**	0.77					Measurement inside casing
187	0.012	**<0.10 (0.033)**	0.82	2.9	**2.921**	72.28		Measurement inside casing
192.5	0.015	**<0.10 (0.036)**	0.90	3.11	**3.131**	77.47		Measurement inside casing
197	0.013	**<0.10 (0.034)**	0.84	-0.017	0.004	0.09	0.40	Well Diameter greater than diverter
206	0.001	**<0.10 (0.022)**	0.54	0.044	0.065	1.61	**4.74**	Well Diameter greater than diverter
216	0.005	**<0.10 (0.026)**	0.64	-0.029	-0.008	-0.20	-0.52	Well Diameter greater than divertor
226				-0.016	0.005	0.12	**0.25**	Well Diameter greater than divertor
229.5	0.048	**<0.10 (0.069)**	1.7075	-0.006	**<0.10 (0.015)**	0.37		Good fit of divertor in well
240.5				-0.023	**<0.10 (-0.002)**	-0.05		Good fit of divertor in well
254	0.046	**<0.10 (0.067)**	1.6580	-0.023	**<0.10 (-0.002)**	-0.05		Good fit of divertor in well
263	0.043	**<0.10 (0.064)**	1.5837	-0.023	**<0.10 (-0.002)**	-0.05		Good fit of divertor in well
268	0.043	**<0.10 (0.064)**	1.5837	-0.023	**<0.10 (-0.002)**	-0.05		Good fit of divertor in well
275	0.045	**<0.10 (0.066)**	1.6332	-0.025	**<0.10 (-0.004)**	-0.10		Good fit of divertor in well
281	0.017	**<0.10 (0.038)**	0.9403	-0.03	**<0.10 (-0.009)**	-0.22		Good fit of divertor in well
288	0.038	**<0.10 (0.059)**	1.4600	-0.03	**<0.10 (-0.009)**	-0.22		Good fit of divertor in well

Table 1. Summary of EM Flowmeter Results, Well PGE-7, PG&E Site, Topock, California. Numbers in bold are corrected flow estimates and provide the best estimate of flow for the given borehole conditions. The number in parentheses is the actual flow rate estimated from the EMFM, however, RAS believes these values are below the practical quantification limit of the EMFM (0.10 gpm).

[2] Flow direction is denoted by + for upward and – for downard flow.

CH2M Hill

Borehole: PGE-7

Topock

top of borehole.....
East:_
North:
Elev:_

North ref: magnetic
Depth units are feet

Zone from 290.919 to 225.531ft
Mean dip format: dip-azimuth and dip

Interpretation 1

Dip data sets .....
BHTV dips

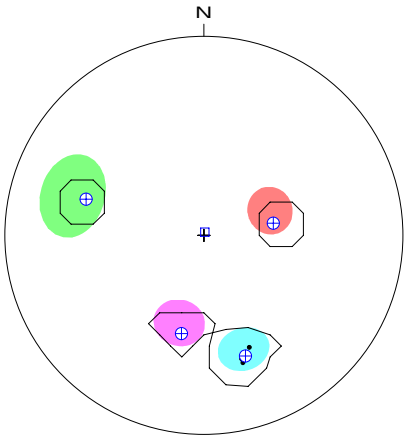
PGE-7
Zone 0. 225.531 - 290.919ft
Deviation 1.30 N 15.90

dipdata sets.....
BHTV dips
• Highlighted dips: Bedding

	mean dip	n	f
N341 54	N341 54	3	(0.08)
N260 29	N260 29	1	(0.00)
N107 52	N107 52	1	(0.00)
N013 42	N013 42	1	(0.00)

intersections

	N341 54	N260 29	N107 52	N013 42
N341 54		28 N274	31 N045	40 N033
N260 29	28 N274		10 N189	21 N308
N107 52	31 N045	10 N189		35 N051
N013 42	40 N033	21 N308	35 N051	



equal-area lower-hemisphere 0-90

contour-levels 1,

⊕ m
□ we

Zone 1. 225.531 - 290.919f
Deviation 1.28 N 15.94

dipdata sets.....

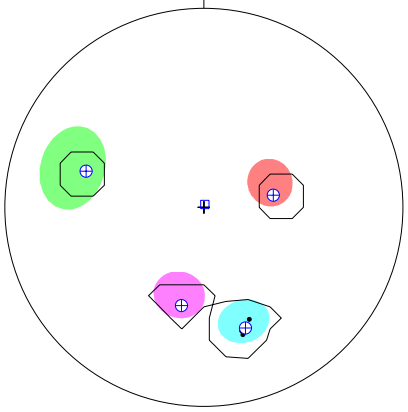
BHTV dips

- Highlighted dips: Bedding

	mean dip	n	f
N341 54	N341 54	3	(0.08)
N260 29	N260 29	1	(0.00)
N107 52	N107 52	1	(0.00)
N013 42	N013 42	1	(0.00)

intersections

	N341 54	N260 29	N107 52	N013 42
N341 54		28 N274	31 N045	40 N033
N260 29	28 N274		10 N189	21 N308
N107 52	31 N045	10 N189		35 N051
N013 42	40 N033	21 N308	35 N051	



⊕ m

□ we

equal-area lower-hemisphere 0-90

contour-levels 1,

welenco

CEMENT BOND \ VDL LOG

FILING NO.

COMPANY Ch2M HILL
WELL PGE-8
FIELD TOPOCK
COUNTY SAN BERNARDINO STATE ARIZONA

LOCATION: PG&E Facility Topock

OTHER SERV:
Gamma Ray

JOB NO.
6819

SEC 8 TWP 7N RGE 24E

PERMANENT DATUM: Ground Level ELEV:

LOG MEASURED FROM G.L. 0 FT ABOVE PERM DATUM

DRILLING MEASURED FROM Ground Level

ELEVATION:
KB.
DF.
GL.

DATE	11/17/2006		
TYPE OF LOG	Cement Bond		
RUN NO.	One		
DEPTH - DRILLER	560		
DEPTH - LOGGER	360		
BOTTOM LOGGED INT	357		
TOP LOGGED INT	140		
TYPE FLUID IN HOLE	Water		
FLUID LEVEL	140		
MAX TEMP DEG F			
OPERATING RIG TIME	N/A		
EQUIP. LOCATION	L-18 BFL		
OPERATOR	L. HOCK		
WITNESSED BY	R. DeLaParra		

RUN NO.	BORE HOLE RECORD BIT	FROM	TO	CASING RECORD SIZE	TYPE	FROM	TO
				6"	Steel	0	405
				4"	Steel	405	550

EQUIPMENT DATA

LOG TYPE	CEMENT BOND		
RUN NO.	ONE		
TOOL MODEL NO.	SIE		
TOOL SERIAL NO.	T-116		
DIAMETER	2.125		
DETECTOR TYPE	PIEZO		
DETECTOR LENGTH	3'		
UNITS/DIV.	N/A		
SENSITIVITY	1.0		
TIME CONSTANT	N/A		
ZERO DIV L OR R	0-L		
SPEED-FPM	18		
FLUID LEVEL	139		
FORMATION FACTOR	N/A		
PUMP RATE-GPM	N/A		
PUMP RATE-GPM	N/A		
PUMP RATE-GPM	N/A		

SOURCE TYPE	STRENGTH	SPACING	MODEL NO	SERIAL NO.

PERFORATIONS:

REMARKS:

NOTICE:
All interpretations are opinions based on inferences from electrical or other measurements and we cannot, and do not guarantee the accuracy or correctness of any interpretations, and we shall not, except in the case of gross or willful negligence on our part, be liable or responsible for any loss, costs, damages or expenses incurred or sustained by anyone resulting from any interpretation made by one of our officers, agents or employees. These interpretations are also subject to our General Terms and Conditions as set out in our current Price Schedule.

WELENCO, INC.

DEPTHS

200 Microseconds 1200

VARIABLE DENSITY LOG

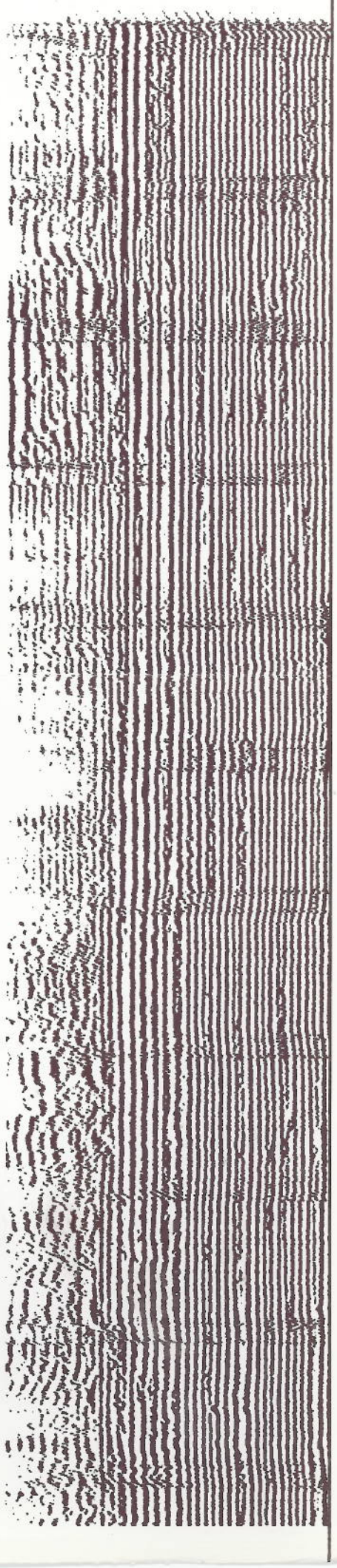
150

200

250

300

350



welenco

5201 Woodmere Drive, Bakersfield, CA 93313– www.welenco.com–(800) 445-9914
California Contractor's License No. 722373

GAMMA RAY LOG

FILING NO.

COMPANY Ch2M HILL

WELL PGE-8

FIELD Topock

STATE Arizona COUNTY San Bernardino

LOCATION: PG & E Facility (Topock)

OTHER SERVICES: CBL/Video

JOB NO. 6819

SEC: 8 TWP: 7N RGE: 24E LAT.: 34° 42' 50.4" LONG.: 114° 29' 39.6" MERIDIAN: San Bernardino

Permanent Datum: Ground Level, Elev. _____ Ft. Elev.: K.B. _____ Ft.
Log Measured From: Ground Level, 0 Ft. Above Perm. Datum D.F. _____ Ft.
Drilling Measured From: Ground Level G.L. _____ Ft.

Date	Nov. 17, 2006			
Type Of Log	Gamma Ray			
Run	One			
Depth-Driller	560 Ft	Ft	Ft	Ft
Depth-Logger	360 Ft	Ft	Ft	Ft
Top Logged Interval	0 Ft	Ft	Ft	Ft
Btm. Logged Interval	353 Ft	Ft	Ft	Ft
Type Fluid In Hole	Water			
Fluid Level	139 Ft	Ft	Ft	Ft
Max Temp	°F	°F	°F	°F
Operating Rig Time	Hr	Hr	Hr	Hr
Van No. / Location	L-18 / Bfld			
Recorded By	Larry Hock			
Witnessed By	R. De La Parra			

RUN NO.	BOREHOLE RECORD BIT	FROM	TO	CASING RECORD SIZE	TYPE	FROM	TO
1	In	Ft	Ft	6 In	Steel	0 Ft	405 Ft
2	In	Ft	Ft	4 In	Steel	405 Ft	550 Ft
3	In	Ft	Ft	In		Ft	Ft

Miscellaneous Information

Remarks:

A recreational GPS accurate to +/- 45 feet set for Datum NAD27 was used to calculate Latitude, Longitude & Elevation values. The Section, Township, and Range then determined using the TRS program (TRS accuracy is not guaranteed). The TRS program converts Latitude and Longitude to Section, Township, and Range. The NOTICE at the bottom of this heading also applies.

Perforated Intervals:

Line Speed:

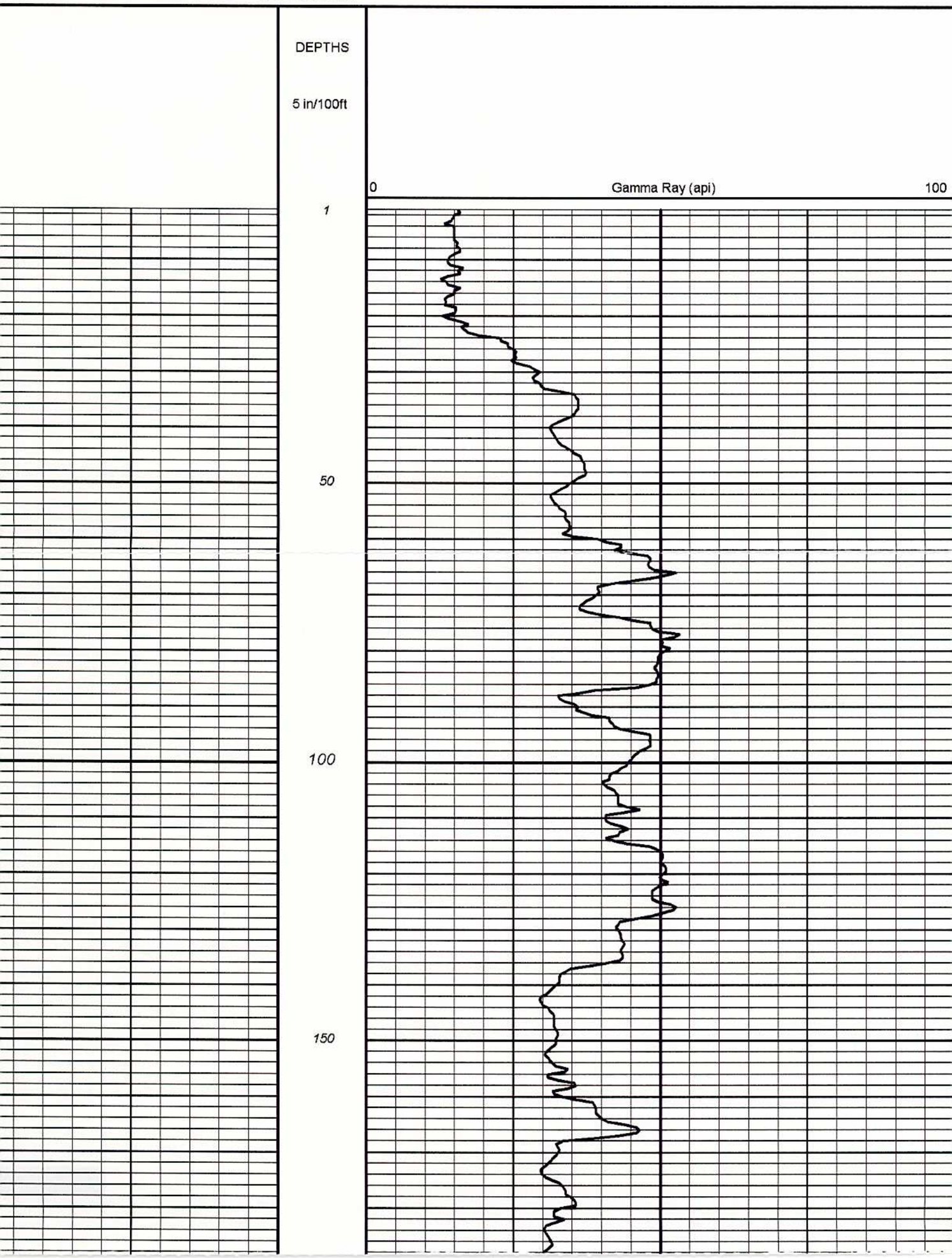
Borehole/Annular Volume Calculations:

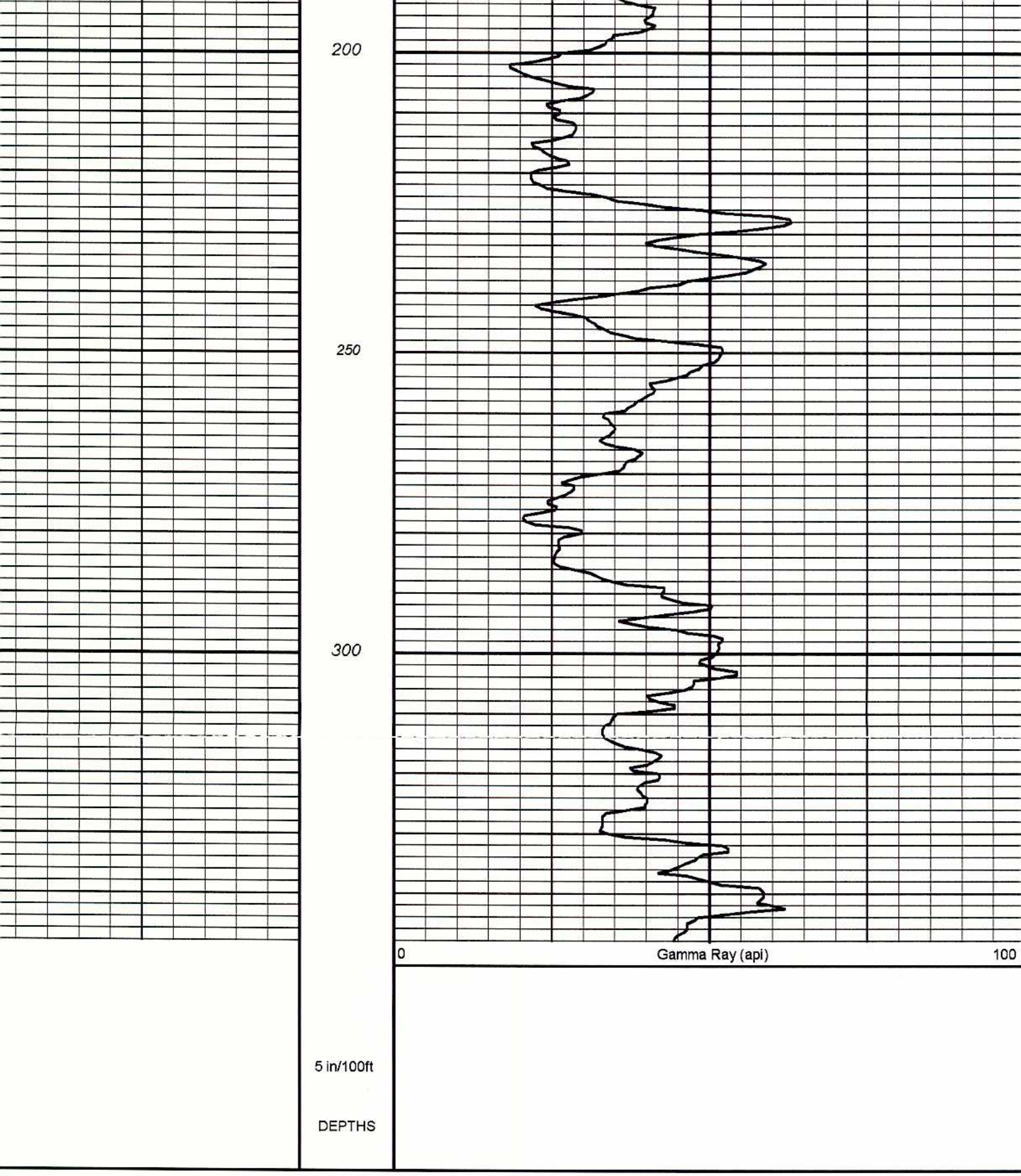
Other Information:

NOTICE: All interpretations are opinions based on inferences from electrical and other measurements and we do not guarantee the accuracy or correctness of any verbal or written interpretation, and we shall not, except in the case of gross or willful negligence on our part, be liable or responsible for any loss, costs, damages or expenses incurred or sustained by anyone resulting from any interpretation made by one of our officers, agents or employees. These interpretations are also subject to our General Terms and Conditions as set out in our current Price Schedule. ***welenco, inc. November 21, 2006***

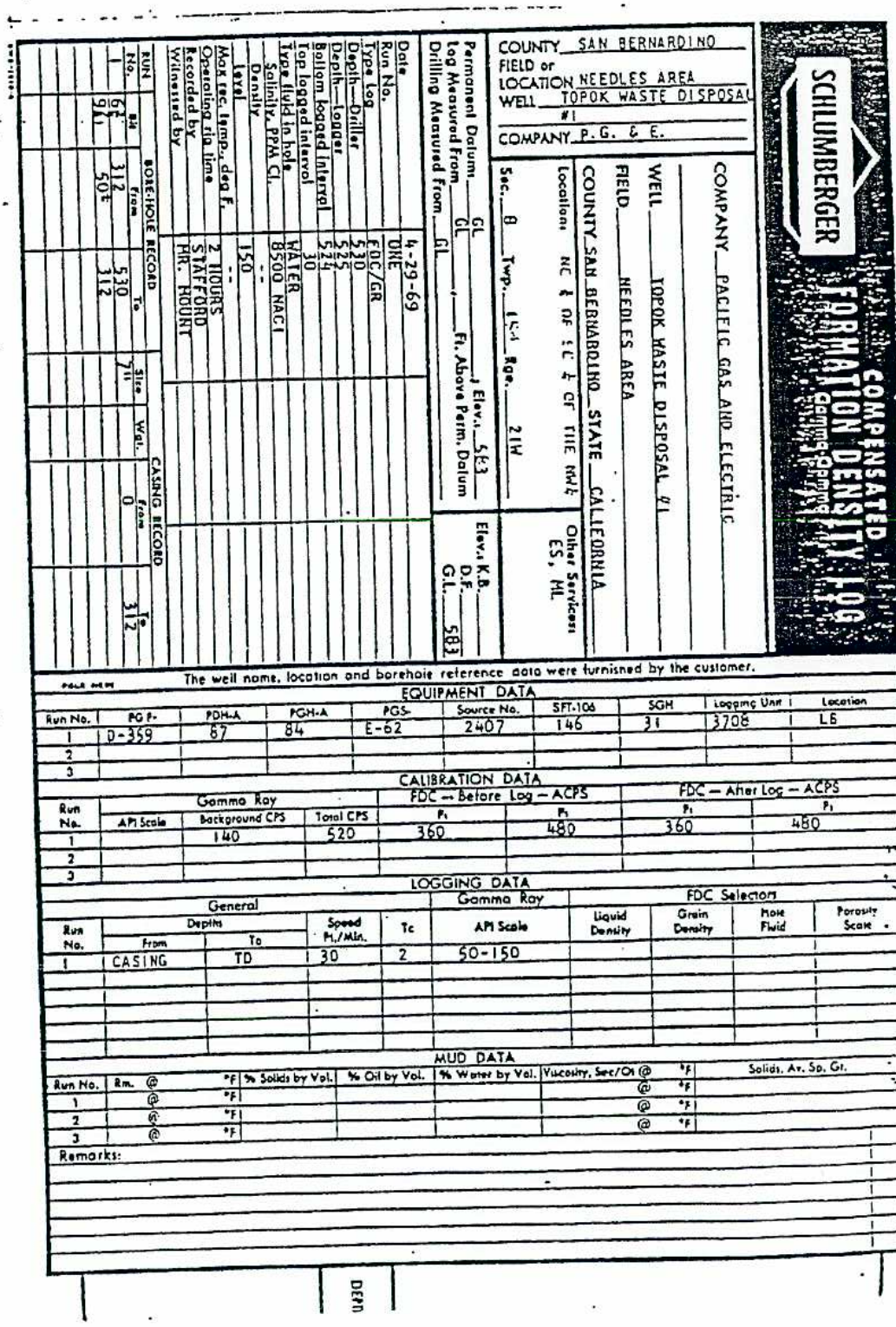
Geophysical Well Log

Ch2M HILL PGE-8 Nov 17, 2006 C:\.....6819.lhf




200
250
300
0
Gamma Ray (api)
100
5 in/100ft
DEPTHS

PGE-8 April 1969
Geophysical Log #2



SCHLUMBERGER

COMPENSATED FORMATION DENSITY LOG

COMPANY PACIFIC GAS AND ELECTRIC

WELL TOPOK WASTE DISPOSAL #1

FIELD NEEDLES AREA

COUNTY SAN BERNARDINO STATE CALIFORNIA

Location: NE ¼ NE ¼ SE ¼ OF THE NW ¼

Sec. 8 Twp. 11N Rge. 21W

Other Services: ES, ML

Elev.: K.B. —
D.F. —
G.L. 583

COUNTY SAN BERNARDINO
FIELD or LOCATION NEEDLES AREA
WELL TOPOK WASTE DISPOSAL #1
COMPANY P. G. & E.

Permanent Datum GL
Log Measured From GL, Ft. Above Perm. Datum
Drilling Measured From GL

Elev.: 583

Date	4-29-69
Run No.	ONE
Type Log	FDC/GR
Depth—Driller	530
Depth—Logger	525
Bottom logged interval	524
Top logged interval	30
Type fluid in hole	WATER
Salinity, PPM Cl.	8500 NACl
Density	150
Level	--
Max rec. temp., deg F.	2 HOURS
Operating rig time	STAFFORD
Recorded by	MR. HOURT
Witnessed by	

BOREHOLE RECORD

Run No.	Bit From	Bit To	Size
1	312	530	7⅞
1	50±	312	

CASING RECORD

Run No.	Wgt.	From	To
1		0	312

The well name, location and borehole reference data were furnished by the customer.

EQUIPMENT DATA

Run No.	PG P-	PDM-A	PGM-A	PGS-	Source No.	SFT-106	SGH	Logging Unit	Location
1	D-359	67	84	E-62	2407	146	31	3708	LB
2									
3									

CALIBRATION DATA

Run No.	Gamma Ray			FDC — Before Log — ACPS		FDC — After Log — ACPS	
	API Scale	Background CPS	Total CPS	P1	P2	P1	P2
1		140	520	360	480	360	480
2							
3							

LOGGING DATA

Run No.	General Depths From	To	Speed Ft./Min.	Tc	Gamma Ray API Scale	FDC Selectors Liquid Density	Grain Density	Hole Fluid	Porosity Scale
1	CASING	TD	30	2	50-150				

MUD DATA

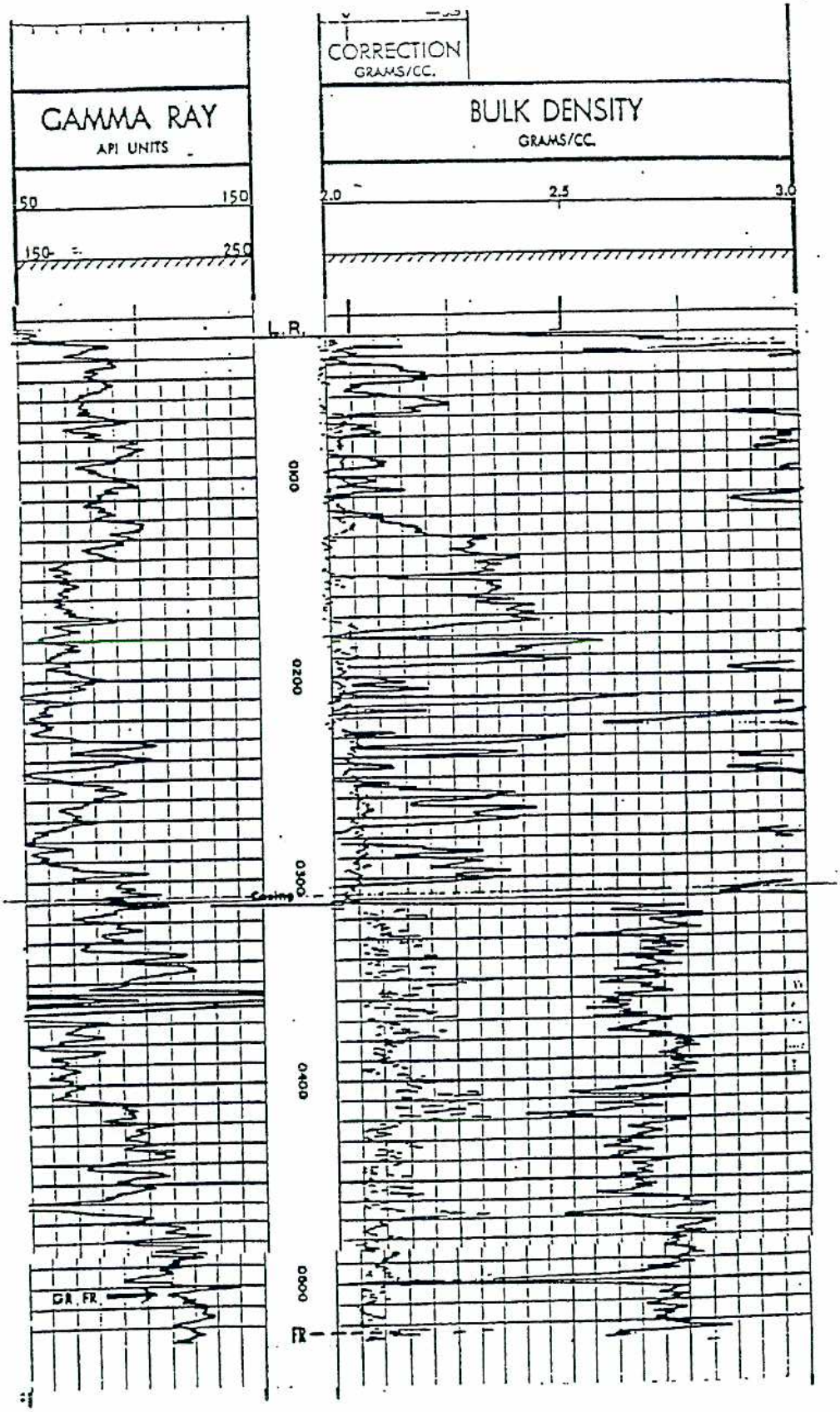
Run No.	Rm. @ °F	% Solids by Vol.	% Oil by Vol.	% Water by Vol.	Viscosity, Sec/Qt @ °F	Solids, Av. Sp. Gr.
1	@ °F				@ °F	
2	@ °F				@ °F	
3	@ °F				@ °F	

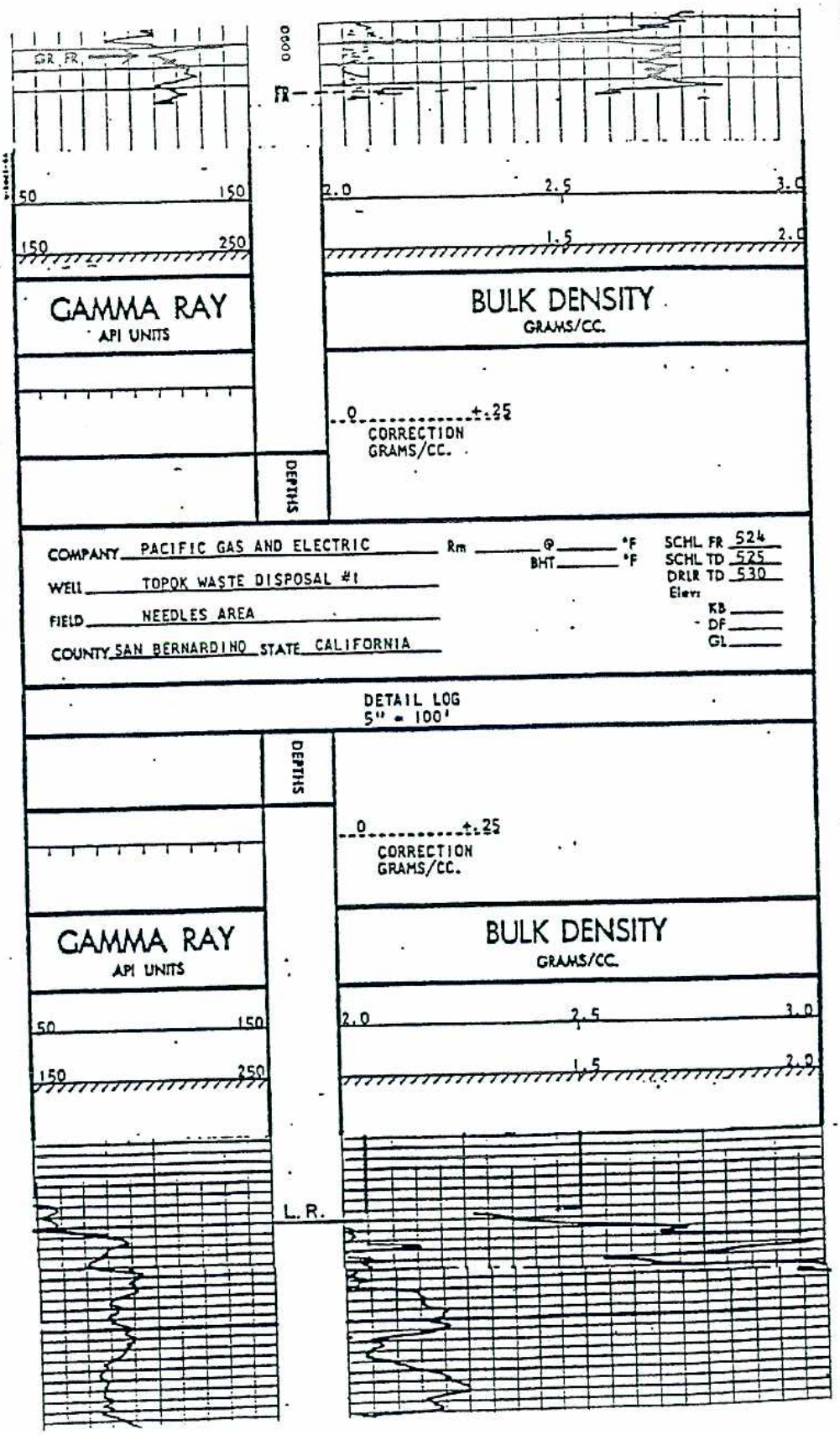
Remarks:

DEPTH

POOR QUALITY ORIGINAL

PG40323921

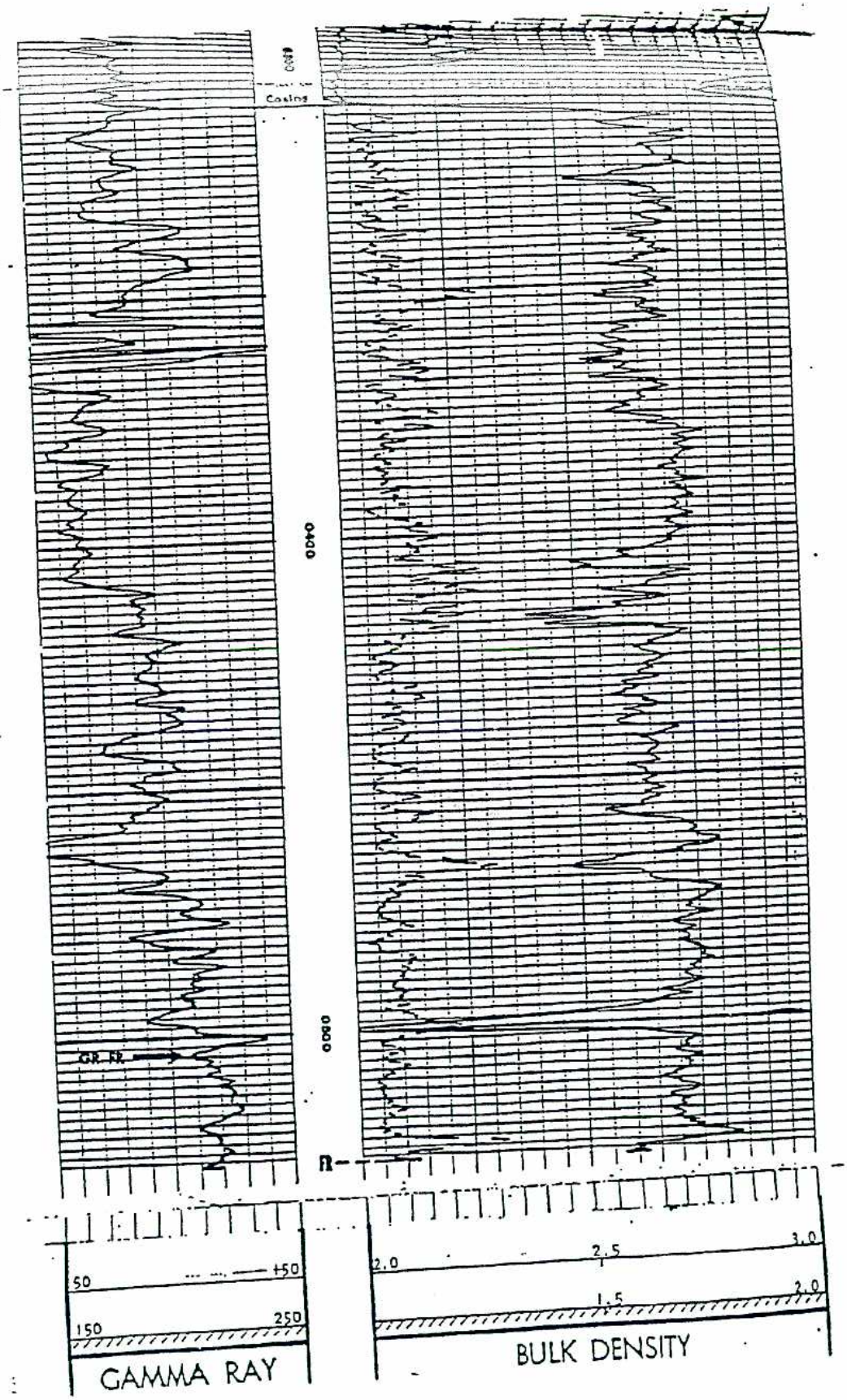




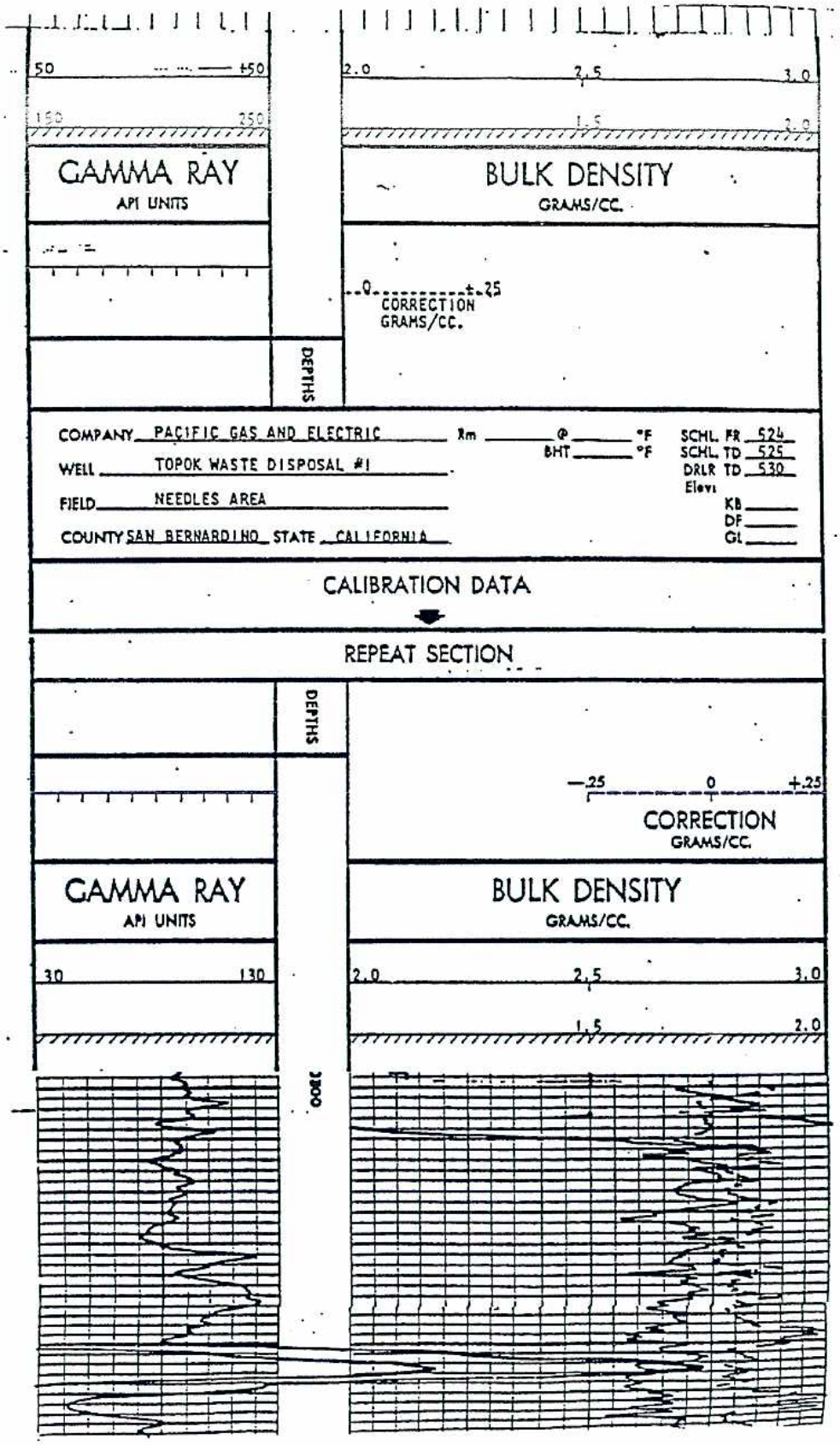
POOR QUALITY
ORIGINAL

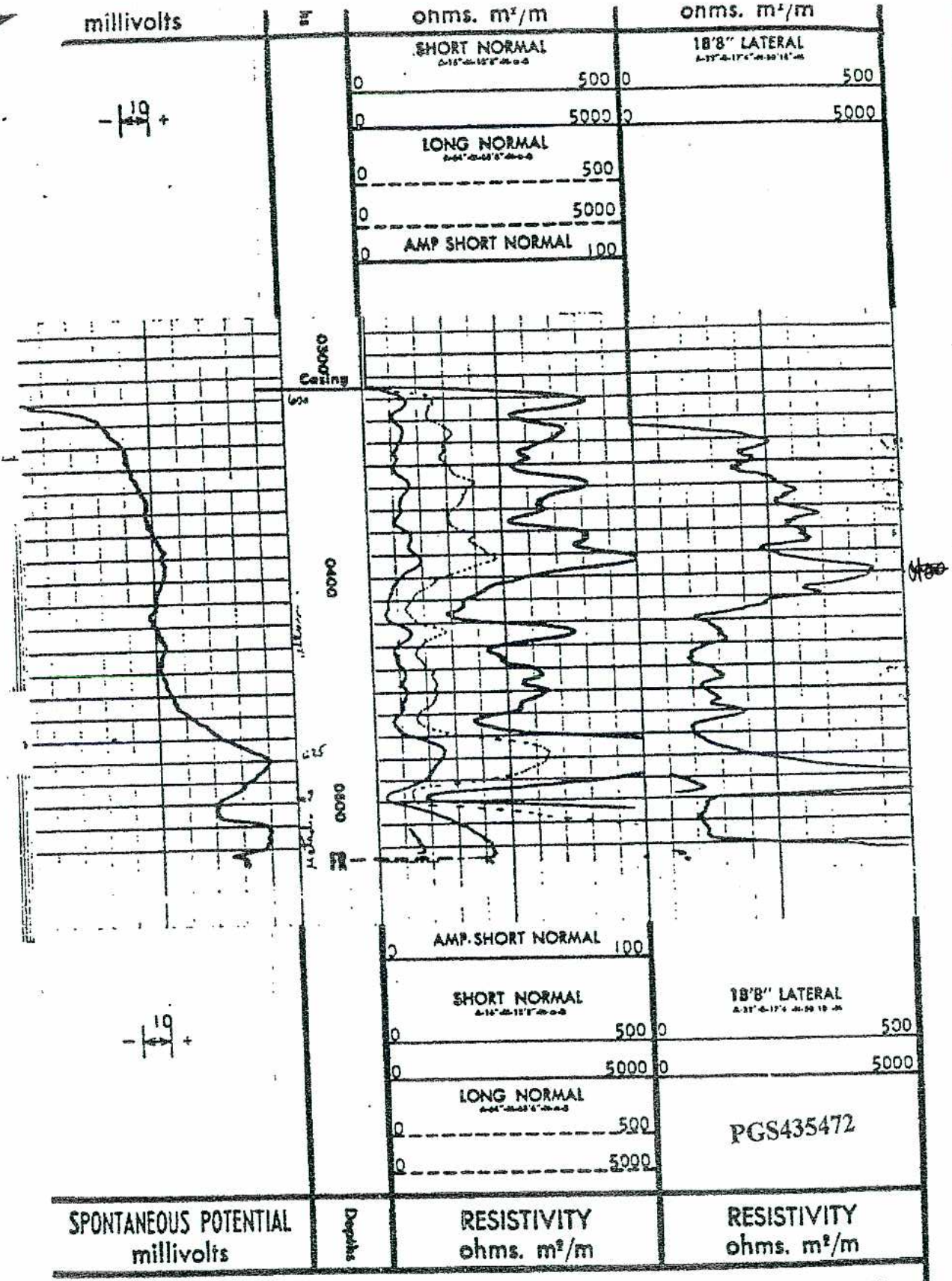
PG40323923

POOR QUALITY
ORIGINAL



POOR QUALITY ORIGINAL





PGS435472

COMPANY PACIFIC GAS AND ELECTRIC

WELL TOPOK WASTE DISPOSAL #1

FIELD NEEDLES AREA

COUNTY SAN BERNARDINO STATE CALIFORNIA

Rm 0.58 @ 85 °F

Rmf 0.58 @ 85 °F

Rmc @ °F

BHT 85 °F

SCHL. FR 524

SCHL. TD 525

DRLR TD 530

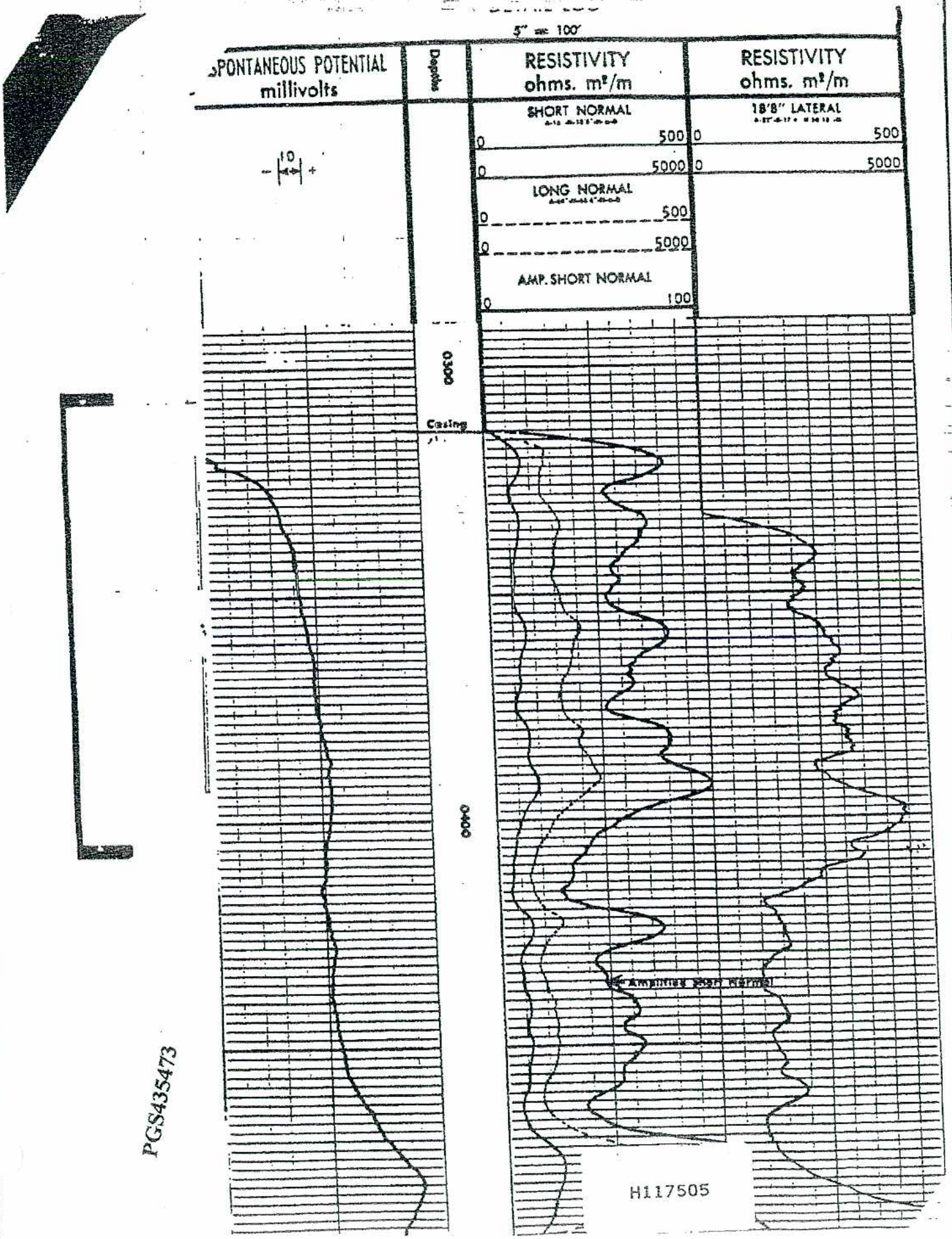
Elev:

KB

DF

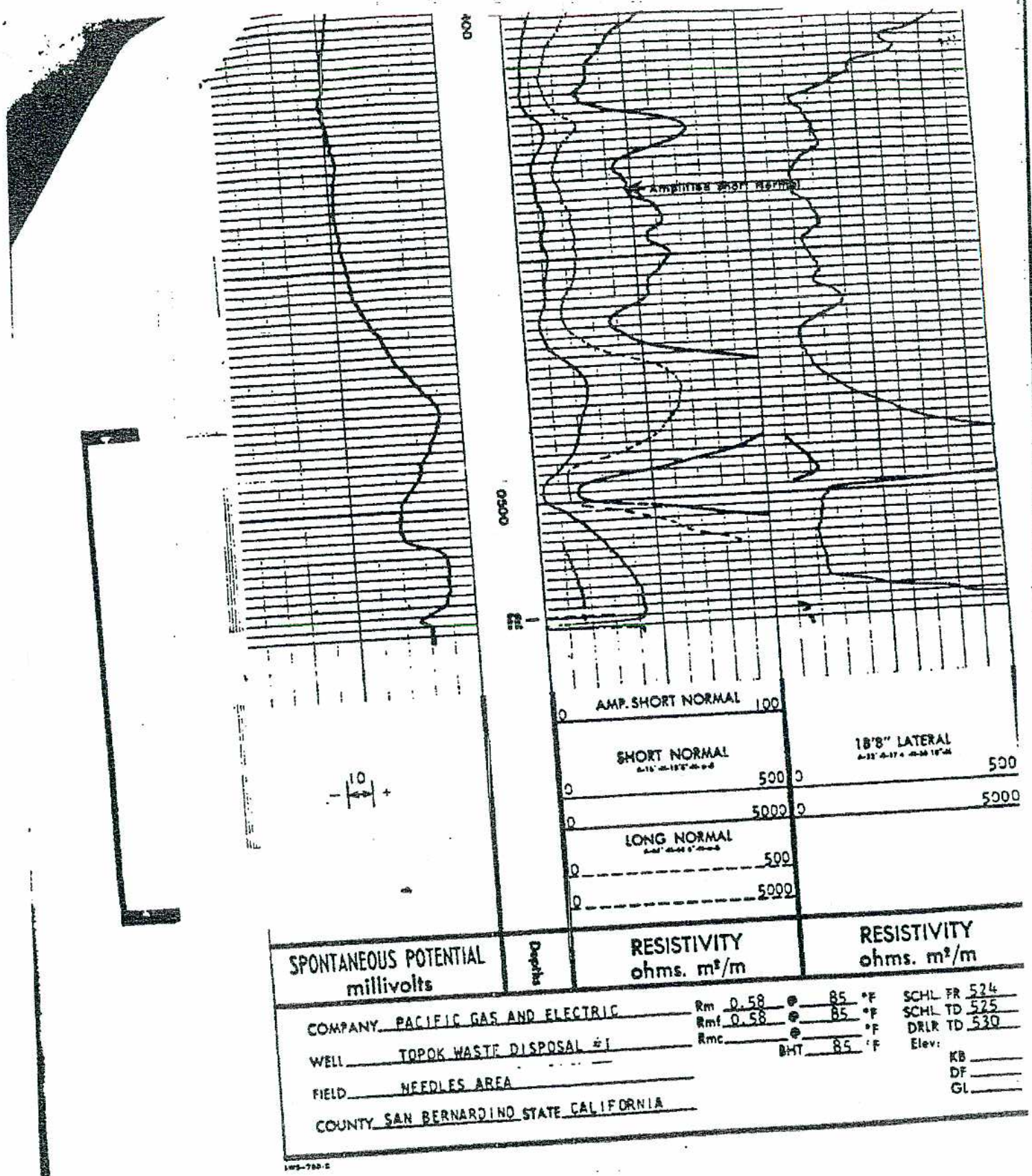
GL

H117504



PGS435473

H117505



H117506

PGS435474

Attachment D
PGE-8 Natural Gamma Log from November 2006

welenco

5201 Woodmere Drive, Bakersfield, CA 93313– www.welenco.com–(800) 445-9914
California Contractor's License No. 722373

GAMMA RAY LOG

FILING NO.

COMPANY Ch2M HILL

WELL PGE-8

FIELD Topock

STATE Arizona COUNTY San Bernardino

LOCATION: PG & E Facility (Topock)

OTHER SERVICES: CBL/Video

JOB NO. 6819

SEC: 8 TWP: 7N RGE: 24E LAT.: 34° 42' 50.4" LONG.: 114° 29' 39.6" MERIDIAN: San Bernardino

Permanent Datum: Ground Level, Elev. _____ Ft. Elev.: K.B. _____ Ft.
Log Measured From: Ground Level, 0 Ft. Above Perm. Datum D.F. _____ Ft.
Drilling Measured From: Ground Level G.L. _____ Ft.

Date	Nov. 17, 2006			
Type Of Log	Gamma Ray			
Run	One			
Depth-Driller	560 Ft	Ft	Ft	Ft
Depth-Logger	360 Ft	Ft	Ft	Ft
Top Logged Interval	0 Ft	Ft	Ft	Ft
Btm. Logged Interval	353 Ft	Ft	Ft	Ft
Type Fluid In Hole	Water			
Fluid Level	139 Ft	Ft	Ft	Ft
Max Temp	°F	°F	°F	°F
Operating Rig Time	Hr	Hr	Hr	Hr
Van No. / Location	L-18 / Bfld			
Recorded By	Larry Hock			
Witnessed By	R. De La Parra			

RUN NO.	BOREHOLE RECORD BIT	FROM	TO	CASING RECORD SIZE	TYPE	FROM	TO
1	In	Ft	Ft	6 In	Steel	0 Ft	405 Ft
2	In	Ft	Ft	4 In	Steel	405 Ft	550 Ft
3	In	Ft	Ft	In		Ft	Ft

Miscellaneous Information

Remarks:

A recreational GPS accurate to +/- 45 feet set for Datum NAD27 was used to calculate Latitude, Longitude & Elevation values. The Section, Township, and Range then determined using the TRS program (TRS accuracy is not guaranteed). The TRS program converts Latitude and Longitude to Section, Township, and Range. The NOTICE at the bottom of this heading also applies.

Perforated Intervals:

Line Speed:

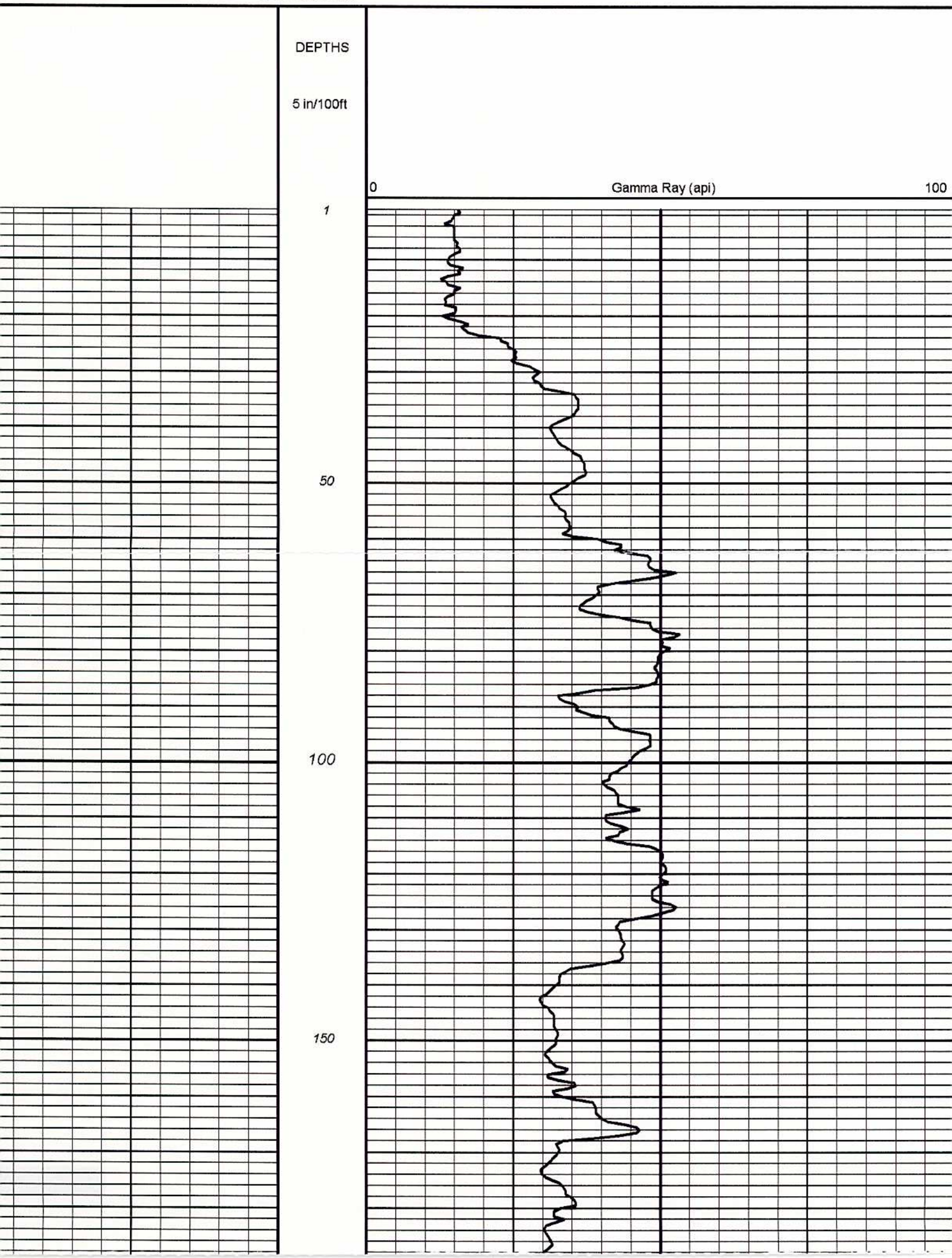
Borehole/Annular Volume Calculations:

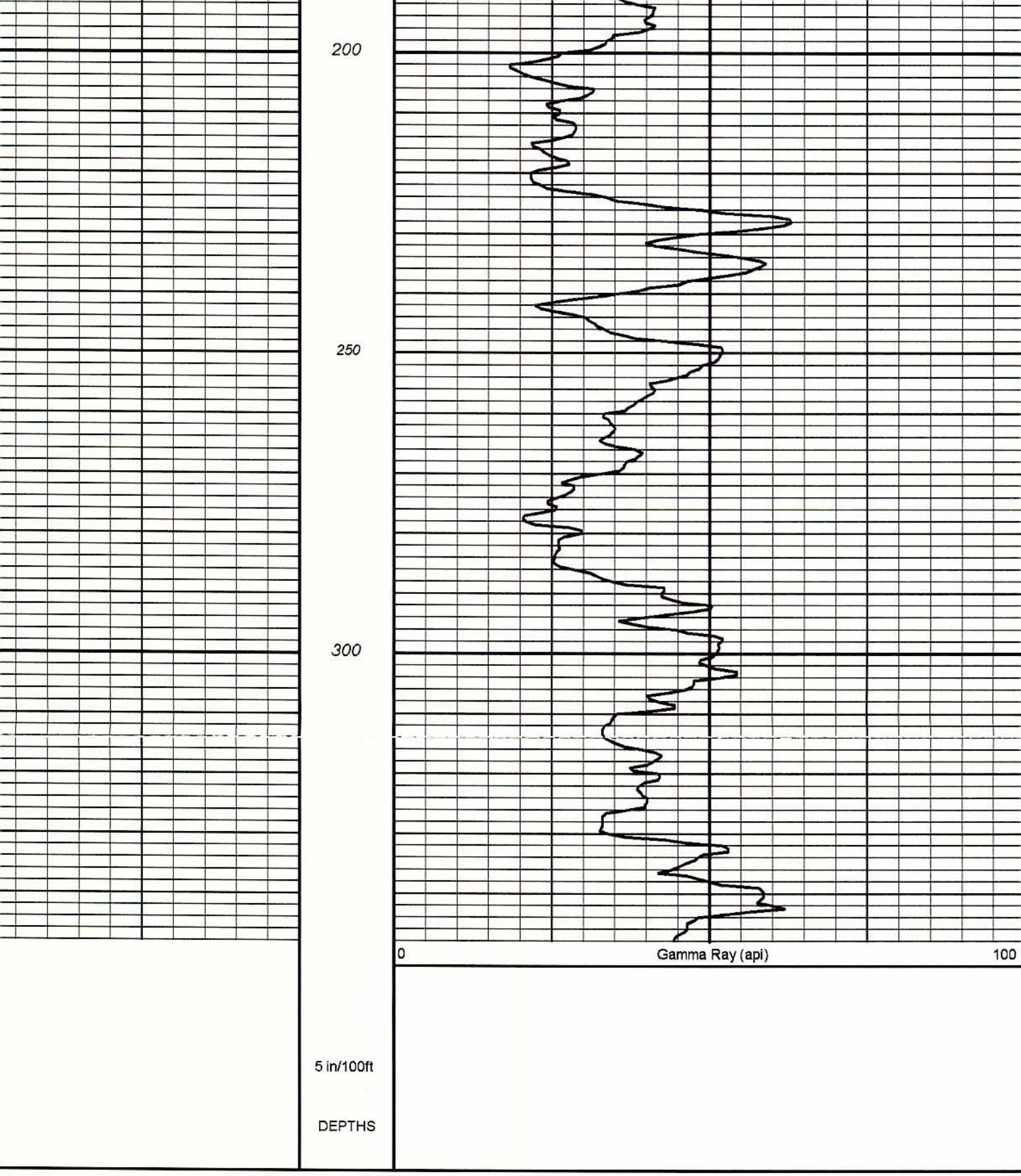
Other Information:

NOTICE: All interpretations are opinions based on inferences from electrical and other measurements and we do not guarantee the accuracy or correctness of any verbal or written interpretation, and we shall not, except in the case of gross or willful negligence on our part, be liable or responsible for any loss, costs, damages or expenses incurred or sustained by anyone resulting from any interpretation made by one of our officers, agents or employees. These interpretations are also subject to our General Terms and Conditions as set out in our current Price Schedule. ***welenco, inc. November 21, 2006***

Geophysical Well Log

Ch2M HILL PGE-8 Nov 17, 2006 C:\.....6819.lhf




200
250
300
0
Gamma Ray (api)
100
5 in/100ft
DEPTHS

Appendix C
Flow Logging

LETTER REPORT

During the period from April 18th to April 20th, 2007, RAS, Inc., of Golden, CO, conducted electromagnetic flow meter ("EMFM") logging in one well (PGE-7) at the PG&E Topock Compressor Site near Needles, California. The principal objective of this study was to evaluate the open-hole, bedrock portion of the wellbore in order to identify the location and magnitude of water bearing intervals. In addition, prior to the EMFM logging, RAS also conducted development pumping activities (step drawdown type aquifer testing). After each day of pumping activities, RAS recorded the overnight pressure recovery. Following the development pumping, RAS conducted EMFM logging during both pumping and ambient conditions in well PGE-7.

Well PGE-7 was cased to 192 feet with 7 inch I.D. steel casing and open hole from 192 to 300 feet. Depth to water was measured at 110.4 feet (all depths referenced to top of steel casing).

The electromagnetic flow meter is a modern method to evaluate vertical groundwater flow velocity and direction (up or down) in a wellbore. The EMFM is based on Faradays Law and includes employment of a flexible rubber skirt to divert all the borehole vertical flow through a calibrated flow tube. By recording the output of the EMFM and using advanced computer analysis software, the advective velocity and vertical direction (+ for upflow and – for downflow) of groundwater flow within a well can be evaluated. The practical lower detection limit for vertical flow with the EMFM is 0.10 gallons per minute (gpm) with a maximum flow rate of 4 gpm.

On April 18th, prior to EMFM logging, RAS conducted a step drawdown test at well PGE-7[1] to develop the well and evaluate appropriate pumping rates for EMFM testing. Prior to pumping, the depth to water was 107.8 feet below top of inner steel casing (fbtoisc). During the pumping rates of 5.6, 10.6 and 13.5 gpm, maximum drawdown of 1.1, 2.1 and 2.7 feet, respectively, were observed. At the completion of pumping activities, a Hermit 3000 and pressure transducer were deployed to measure pressure recovery overnight. Please refer to attached Figure 2 for the recorded recovery data. These data suggest that the aquifer immediately surrounding the well completely recovered prior to the following day's flow meter testing.

On April 19th, RAS conducted EMFM logging during pumping of well PGE-7. Prior to pumping and EMFM logging, the depth to water was 107.79 fbtoisc. Testing with the EMFM was conducted during pumping at 13.2 gpm with an observed maximum drawdown of 2.3 feet. Based on review of the caliper log, acoustic televiewer log and other geologic considerations (bedrock interval, open

[1] All logging and water level data was referenced in feet below top of the inner steel casing.

hole alluvium interval and depth of casing), eighteen (18) stations were tested with the EMFM. These results are presented below in Table 1.

In summary, the resulting flow measurements from the EMFM logging in the bedrock interval are below the reliable detection limit and suggest no to very low flow (less than 0.1 gpm). As such, vertical flow conditions in the bedrock portion of the well (~220-300 feet) during pumping cannot be confirmed. Pumping was conducted at 13.2 gpm with a maximum drawdown of 2.2 feet. While the data qualitatively suggests very low vertical flow, the flow rate measured is considered by RAS to be below the practical quantitative lower limit of the EMFM (0.10 gpm). As such, these reported flow rates should not be used for any quantitative purposes (i.e. estimation of interval specific hydraulic conductivity or transmissivity).

EMFM measurements within the casing (above 197 ftbtoisc) indicate flow of 2.9–3.2 gpm. This flow rate was considerably less than the observed pumping rate of 13.2 gpm but near the maximum range of the EMFM. These data suggest that all flow occurring in PGE-7 is from the alluvium interval, the interval from 196 to 220 feet being the open hole portion of this alluvium unit. Immediately following the EMFM pumping test, a Hermit 3000 and pressure transducer were installed to record pressure recovery overnight. These data are presented in Figure 4 below, and suggest again, that the aquifer recovered quickly and completely before the subsequent day's ambient flow characterization.

On April 20th RAS conducted EMFM testing during ambient (non-pumping) conditions. The EMFM survey suggested that the ambient flow conditions contain a vertical component, but with a very low flow rate (<0.1 gpm). This flow rate is below the practical detection limit for the EMFM. As such, no reliable identification of water bearing intervals in the bedrock portion of the well can be accomplished with these data. The depth to water was 107.85 fbtc at the time of EMFM testing. Please refer to Table 1 for a summary of the EMFM results collected during ambient conditions.

CONCLUSIONS AND RECOMMENDATIONS

The EMFM survey qualitatively suggests no flow to very weak flow, i.e. less than the reliable detection limit of 0.10 gpm, during both pumping and ambient pressure conditions for the bedrock interval. The EMFM survey data suggest that all flow originated from the alluvium portion of Well PGE-7. The open hole pressure data (depth to water) collected during pumping also suggest that flow in the well is dominated by the porous medium and is not fracture flow.

To properly characterize the bedrock interval, test methods with much lower quantification limits for hydraulic conductivity would be required for this low permeability bedrock. These tests should be conducted in an environment where the alluvium is hydraulically isolated from the bedrock.

Isolating the bedrock interval with single and straddle packers would isolate the alluvium from the bedrock interval and allow characterization of the bedrock interval. Specifically, vertical hydraulic gradient, bulk hydraulic conductivity of the bedrock interval and hydraulic conductivity of selected intervals of the bedrock could be evaluated. During the interval specific hydraulic conductivity evaluation, if sufficient flow was observed, interval specific sampling could also be conducted during packer testing. The vertical distribution of water quality could be characterized by this interval specific groundwater sampling. Hydrophysical logging could also be incorporated to identify the low flow water bearing intervals prior to straddle packer testing to aid selected packer test intervals.

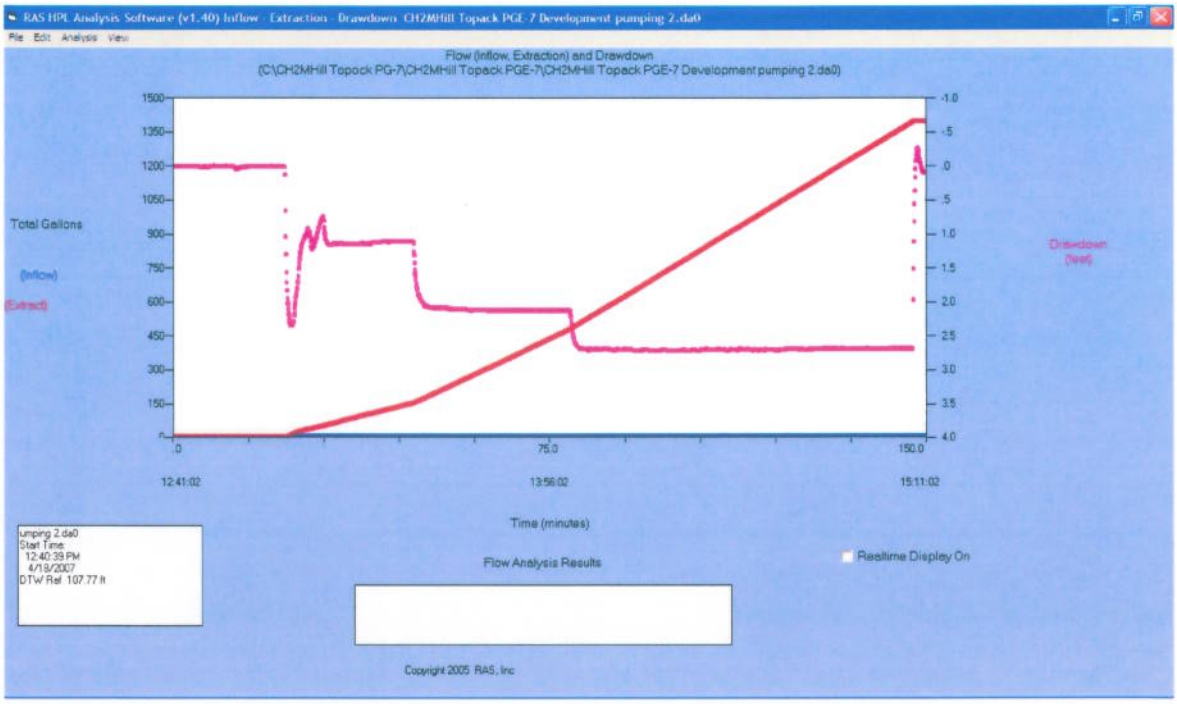


Figure 1. Pumping and Drawdown Data During Development Pumping Prior To EMFM Testing, Well PGE-7, PG&E Site, Topock, California. Three pumping rates of 5.6, 10.6 and 13.5 gpm, with observed associated drawdowns of 1.1, 2.1 and 2.7 feet, respectively, were observed. Observation of note includes the rapid stabilization of drawdown at each pumping rate.

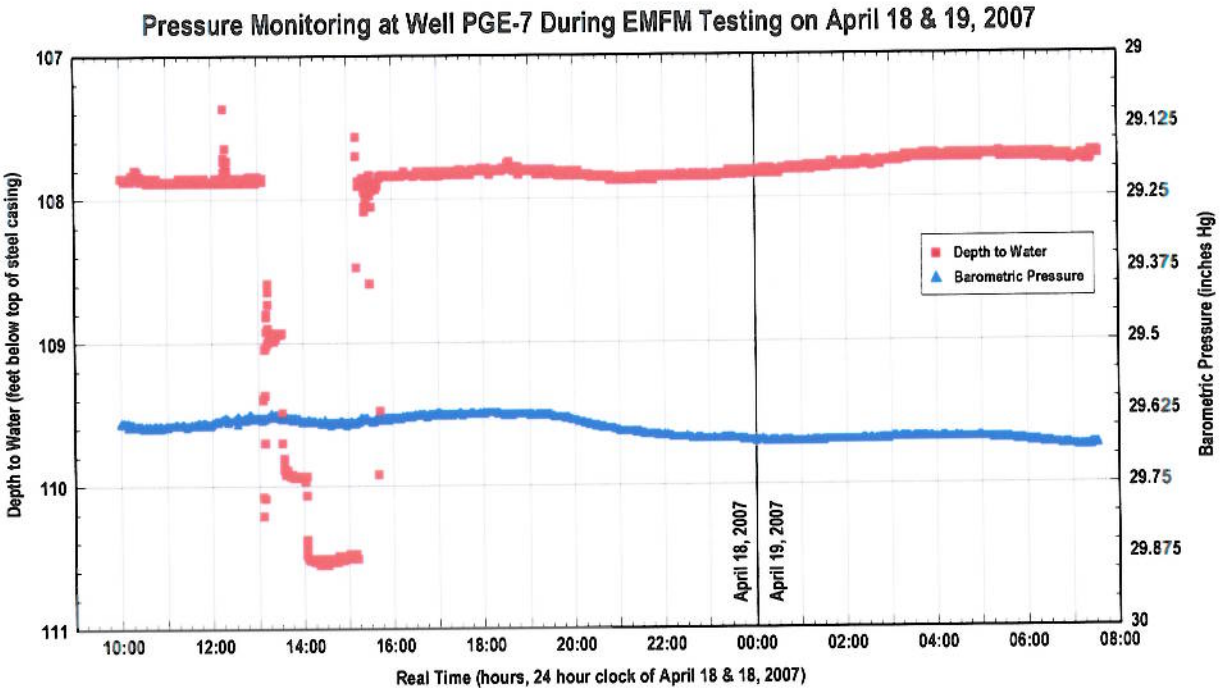


Figure 2. Recovery Pressure and Barometric Pressure After Development Pumping, Well PGE-7, PG&E Site, Topock, California. (Elapsed Time of 312 minutes @ 15:12 4/18/07). Correction for barometric effect has not been made to this data set.

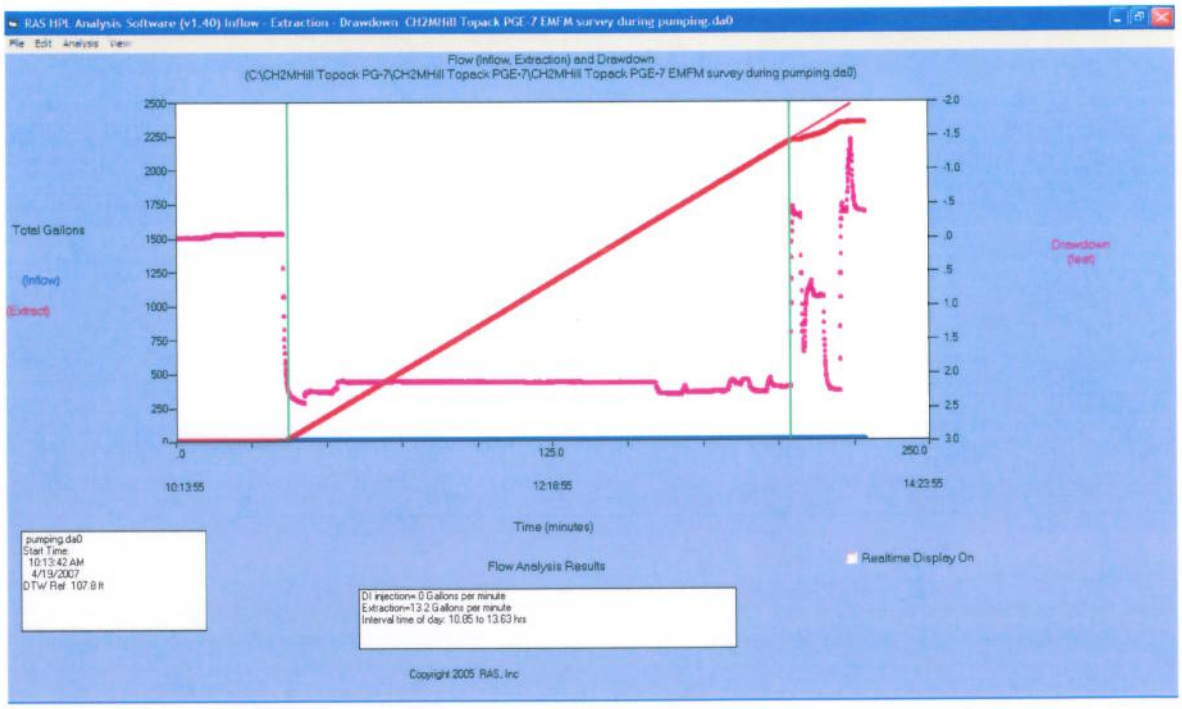


Figure 3. Pumping and Drawdown Data During EMFM Testing, Well PGE-7, PG&E Site, Topock, California. One pumping rate of 13.2 gpm, with observed drawdown of 2.1 feet. As during development pumping, the rapid stabilization of drawdown at each pumping rate is noteworthy.

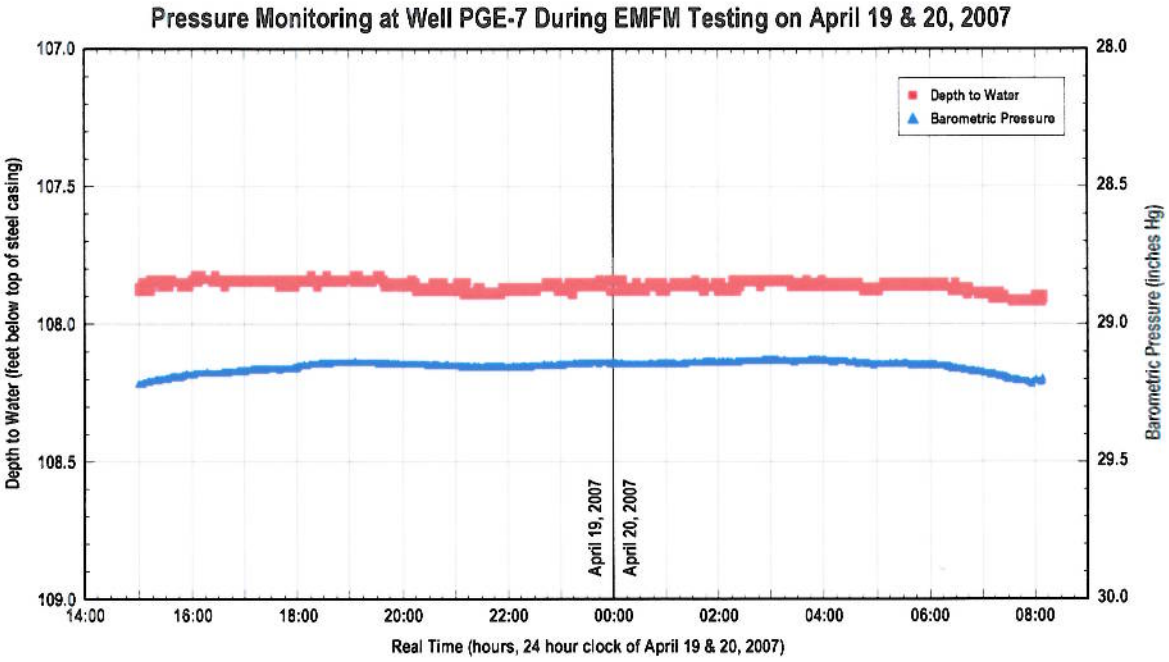


Figure 4. Recovery Pressure and Barometric Pressure After EMFM Testing During Pumping, Well PGE-7, PG&E Site, Topock, California. (Elapsed Time of 0 minutes @ 15:00 4/19/07). Correction for barometric effect has not been made to this data set.

Depth (ftbtoisc)	Ambient Flow (gpm)	Corrected Ambient Flow[2] (gpm)	Ambient Velocity (fpm)	Pumping Flow (gpm)	Corrected Pumping Flow (gpm)	Corrected Pumping Velocity (fpm)	Estimated flow rate for intervals without diverter (gpm)	Comments
115	0.012	**<0.10 (0.033)**	0.82					Measurement inside casing
127	0.01	**<0.10 (0.031)**	0.77					Measurement inside casing
147	0.013	**<0.10 (0.034)**	0.84					Measurement inside casing
167	0.01	**<0.10 (0.031)**	0.77					Measurement inside casing
187	0.012	**<0.10 (0.033)**	0.82	2.9	**2.921**	72.28		Measurement inside casing
192.5	0.015	**<0.10 (0.036)**	0.90	3.11	**3.131**	77.47		Measurement inside casing
197	0.013	**<0.10 (0.034)**	0.84	-0.017	0.004	0.09	0.40	Well Diameter greater than diverter
206	0.001	**<0.10 (0.022)**	0.54	0.044	0.065	1.61	**4.74**	Well Diameter greater than diverter
216	0.005	**<0.10 (0.026)**	0.64	-0.029	-0.008	-0.20	-0.52	Well Diameter greater than divertor
226				-0.016	0.005	0.12	**0.25**	Well Diameter greater than divertor
229.5	0.048	**<0.10 (0.069)**	1.7075	-0.006	**<0.10 (0.015)**	0.37		Good fit of divertor in well
240.5				-0.023	**<0.10 (-0.002)**	-0.05		Good fit of divertor in well
254	0.046	**<0.10 (0.067)**	1.6580	-0.023	**<0.10 (-0.002)**	-0.05		Good fit of divertor in well
263	0.043	**<0.10 (0.064)**	1.5837	-0.023	**<0.10 (-0.002)**	-0.05		Good fit of divertor in well
268	0.043	**<0.10 (0.064)**	1.5837	-0.023	**<0.10 (-0.002)**	-0.05		Good fit of divertor in well
275	0.045	**<0.10 (0.066)**	1.6332	-0.025	**<0.10 (-0.004)**	-0.10		Good fit of divertor in well
281	0.017	**<0.10 (0.038)**	0.9403	-0.03	**<0.10 (-0.009)**	-0.22		Good fit of divertor in well
288	0.038	**<0.10 (0.059)**	1.4600	-0.03	**<0.10 (-0.009)**	-0.22		Good fit of divertor in well

Table 1. Summary of EM Flowmeter Results, Well PGE-7, PG&E Site, Topock, California. Numbers in bold are corrected flow estimates and provide the best estimate of flow for the given borehole conditions. The number in parentheses is the actual flow rate estimated from the EMFM, however, RAS believes these values are below the practical quantification limit of the EMFM (0.10 gpm).

[2] Flow direction is denoted by + for upward and – for downard flow.

Appendix D
PGE-7 Recovery Test

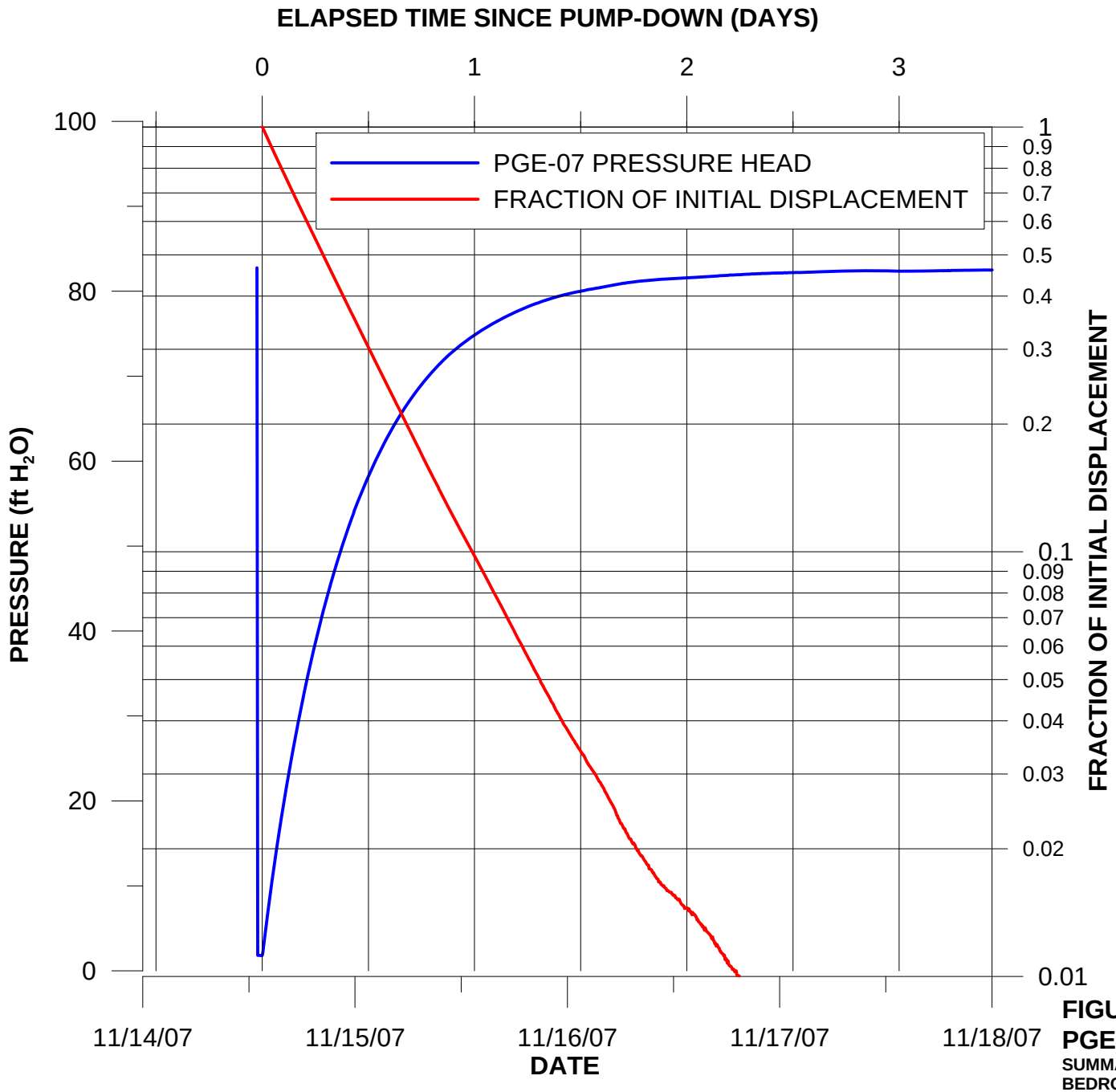
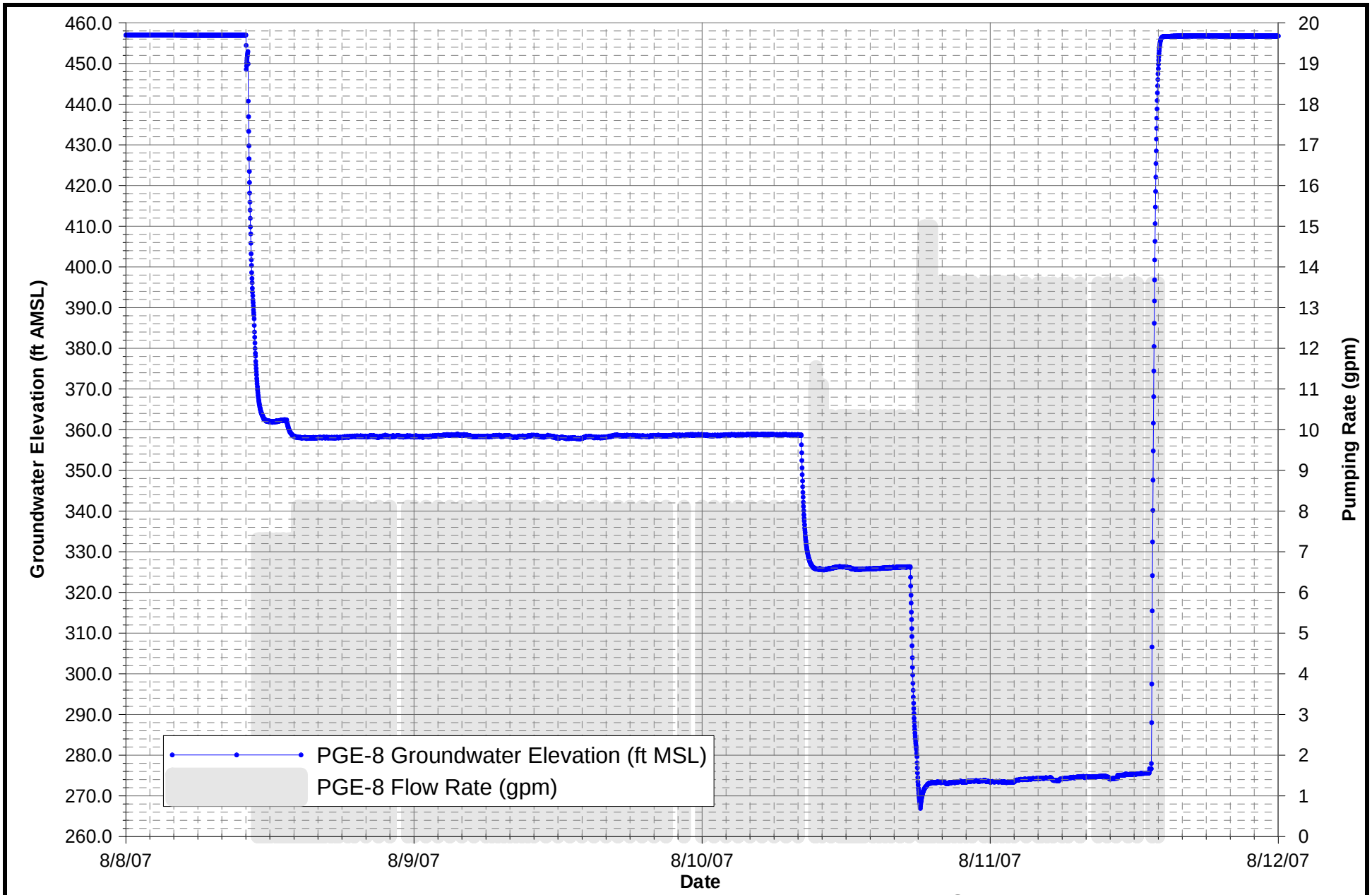


FIGURE D-1
PGE-07 RECOVERY TEST RESULTS
SUMMARY REPOT FOR HYDRAULIC TESTING IN BEDROCK WELLS
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

\\odin\proj\topock\deconvolution\SlugTests

Appendix E
PGE-8 Flow and Injection Rates



Note: Data subject to review.

FIGURE E-1
PGE-8 PUMPING TEST
SUMMARY REPORT FOR HYDRAULIC TESTING
IN BEDROCK WELLS
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

\\zinfandel\proj\PacificGasElectricCo\TopockProgram\Project2007FieldActivities\HydraulicTestingWellAbandonment\Reporting\HydraulicTestingReport\PGE_Draft\Figures\workfiles

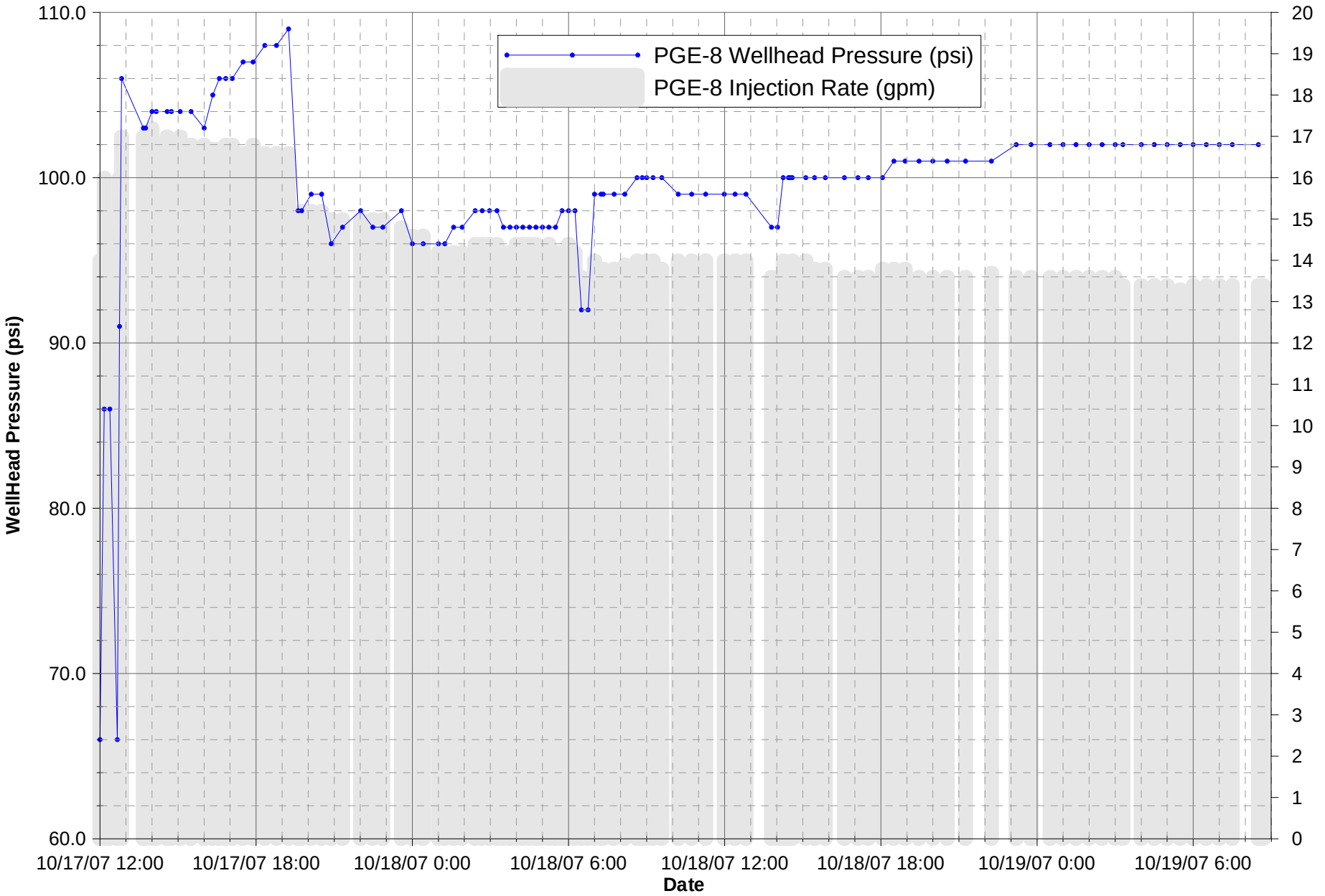


FIGURE E-2
PGE-8 INJECTION TEST
SUMMARY REPORT FOR HYDRAULIC TESTING
IN BEDROCK WELLS
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

Note: Data subject to review.

CH2MHILL

Appendix F
MW-48 Recovery Test

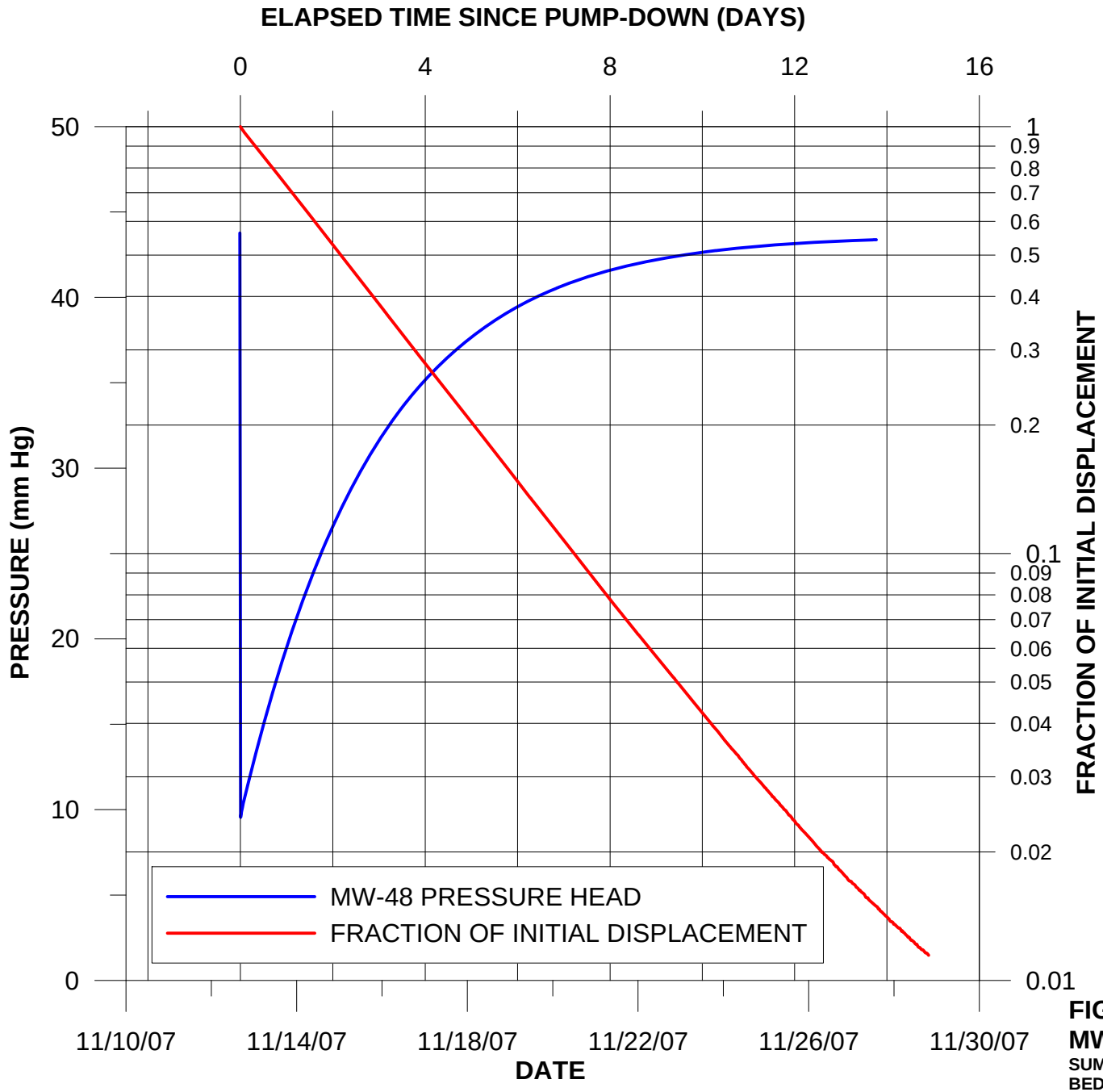
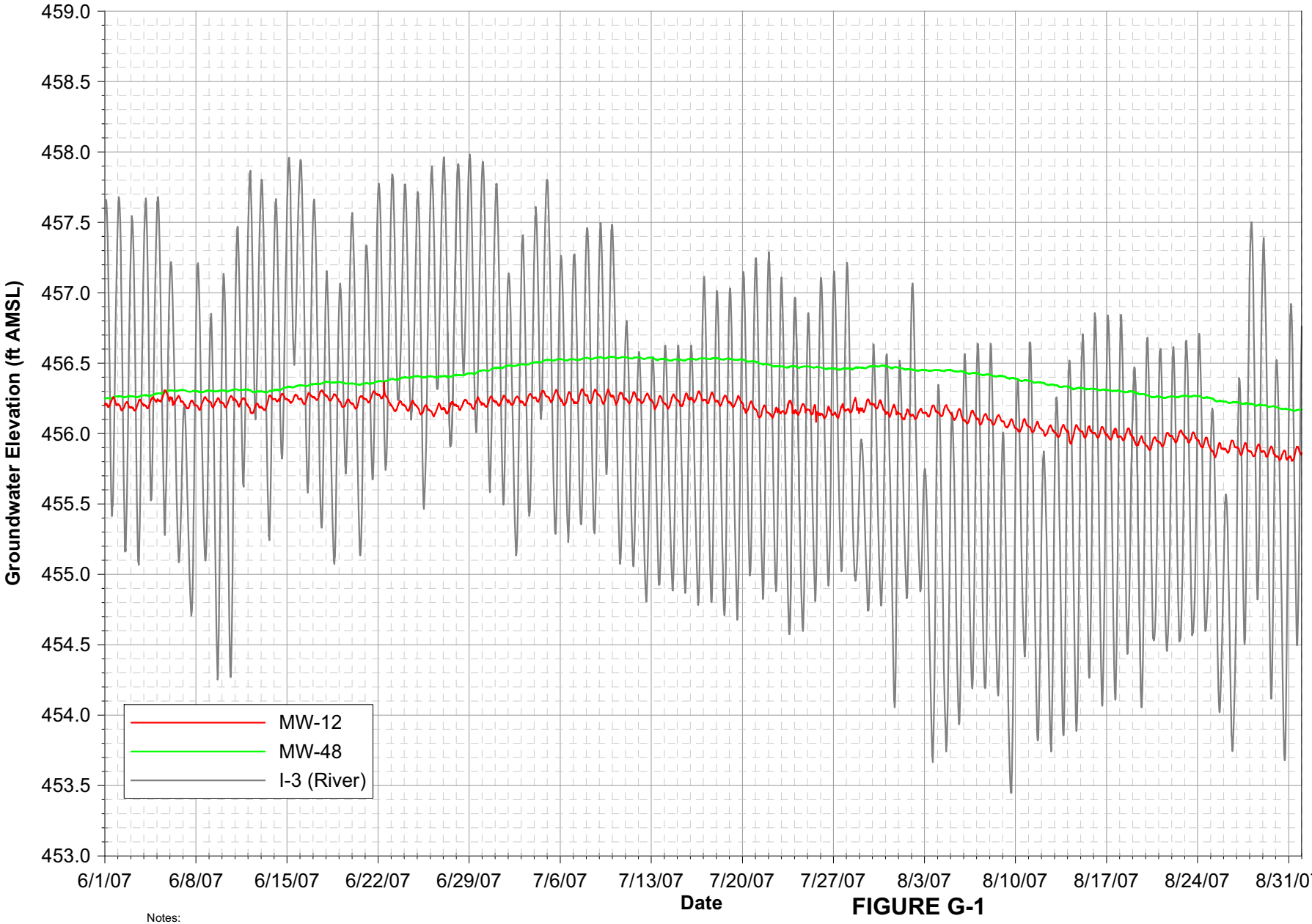


FIGURE F-1
MW-48 RECOVERY TEST RESULTS
SUMMARY REPOT FOR HYDRAULIC TESTING IN BEDROCK WELLS
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

\\odin\proj\topock\deconvolution\SlugTests

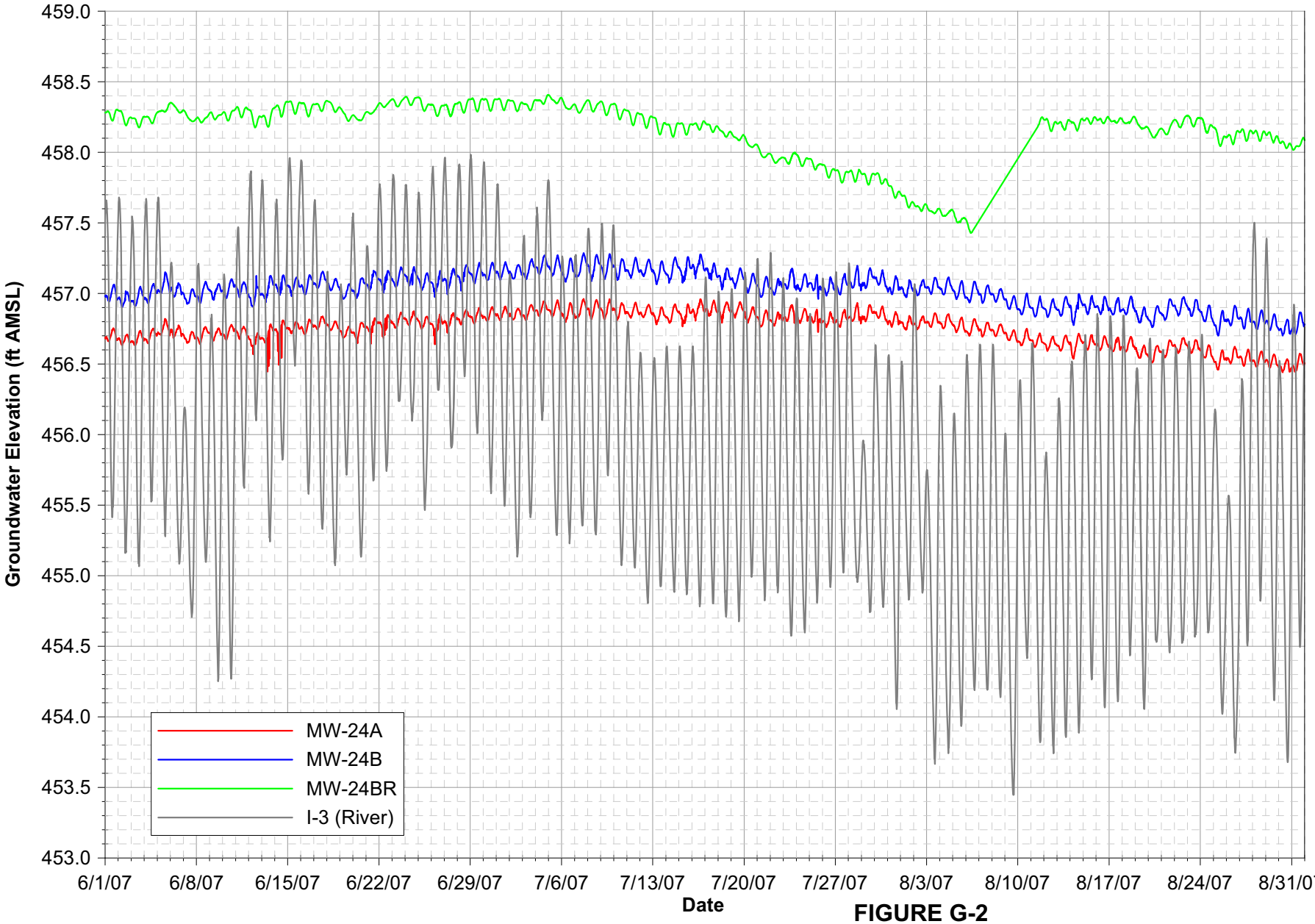
Appendix G
Hydrographs of Bedrock and Selected Alluvial Wells



Notes:
Data subject to review.

FIGURE G-1
MW-48 AND MW-12 HYDROGRAPHS
SUMMARY REPORT FOR HYDRAULIC TESTING IN BEDROCK WELLS
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL



Notes:
Data subject to review.

FIGURE G-2
MW-24 CLUSTER HYDROGRAPHS
SUMMARY REPORT FOR HYDRAULIC TESTING IN BEDROCK WELLS
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

Appendix H
Deconvoluted Observation Well Data From August 2007 PGE-08 Pumping Test

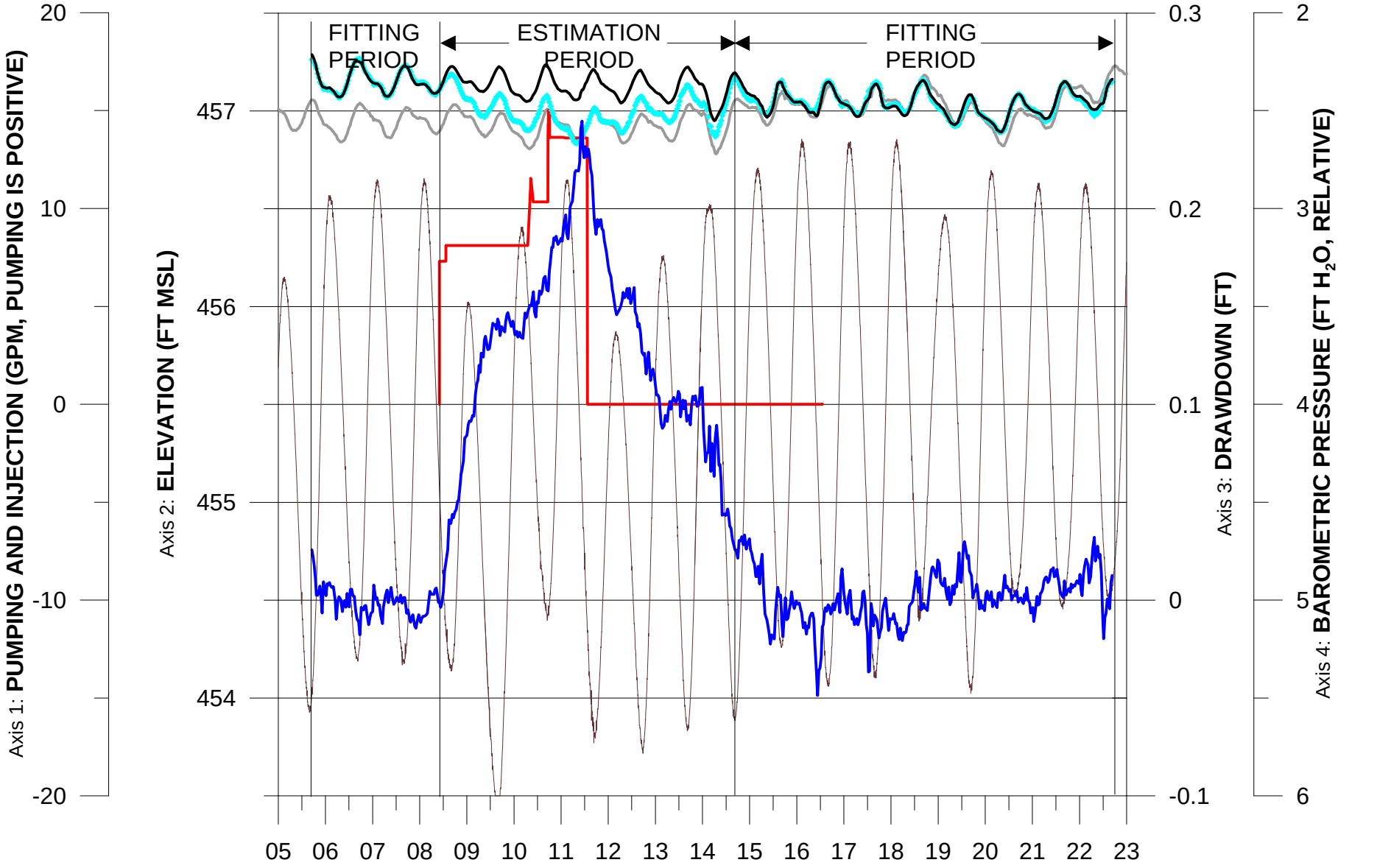
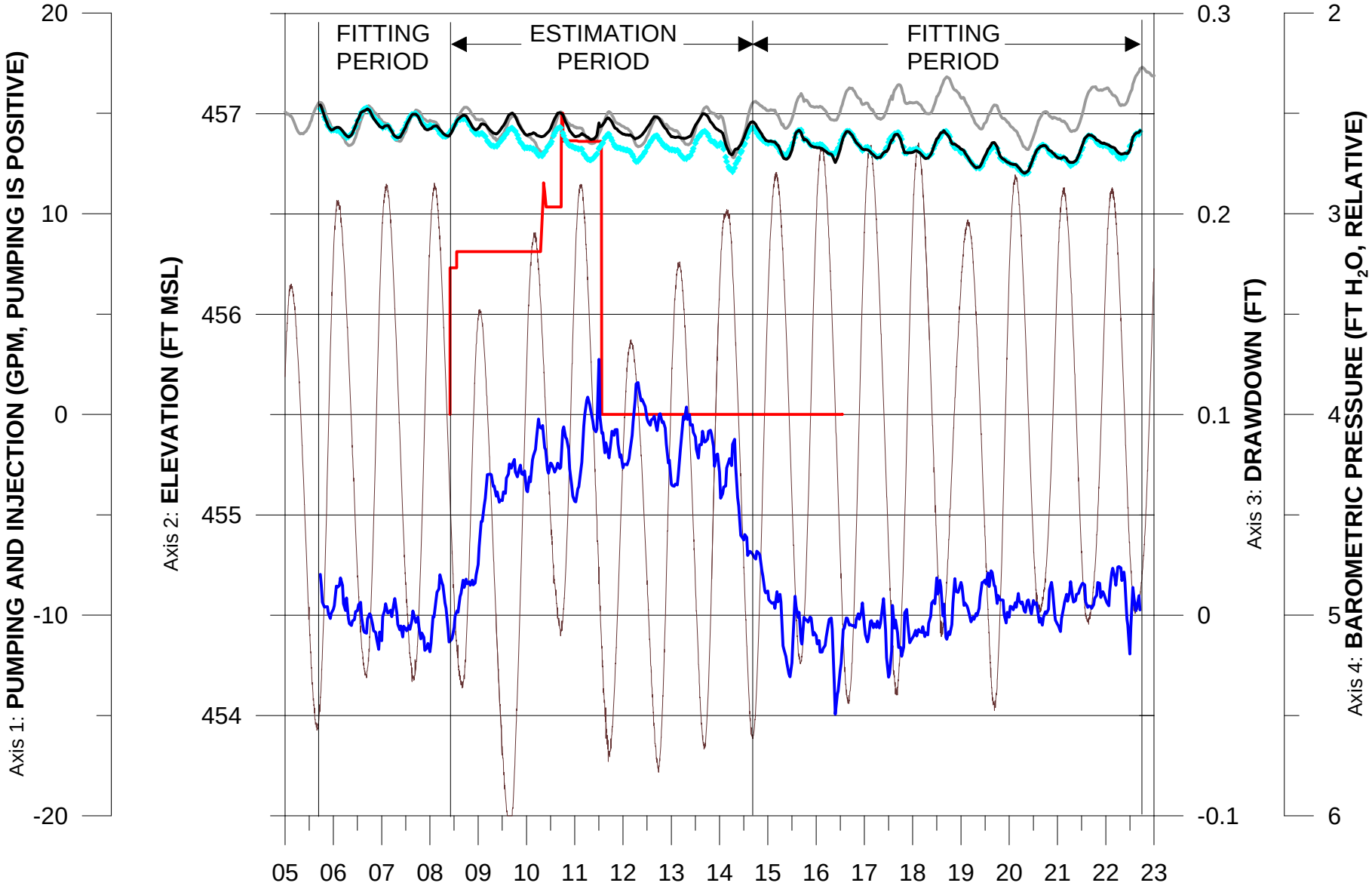


FIGURE H-1
DECONVOLUTION OF MW-09 RESPONSE DURING AUGUST 2007 PGE-08 PUMPING TEST
SUMMARY REPORT FOR HYDRAULIC TESTING IN BEDROCK WELLS
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

\\odin\proj\topock\deconvolution\Figures\New_Injection_Results_Dec19\



LEGEND

- PGE-08 Pumping/Injection (Axis 1)
- Measured Head At Observation Well (Axis 2)
- Synthetic Head At Observation Well (Axis 2)
- I-3 (Colorado River) (Axis 2)
- Drawdown (-up) At Observation Well (Axis 3)
- Barometric Pressure (Axis 4)

FIGURE H-2
DECONVOLUTION OF MW-10 RESPONSE DURING AUGUST 2007 PGE-08 PUMPING TEST

SUMMARY REPORT FOR HYDRAULIC TESTING IN BEDROCK WELLS
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

\\odin\proj\topock\deconvolution\Figures\New_Injection_Results_Dec19\

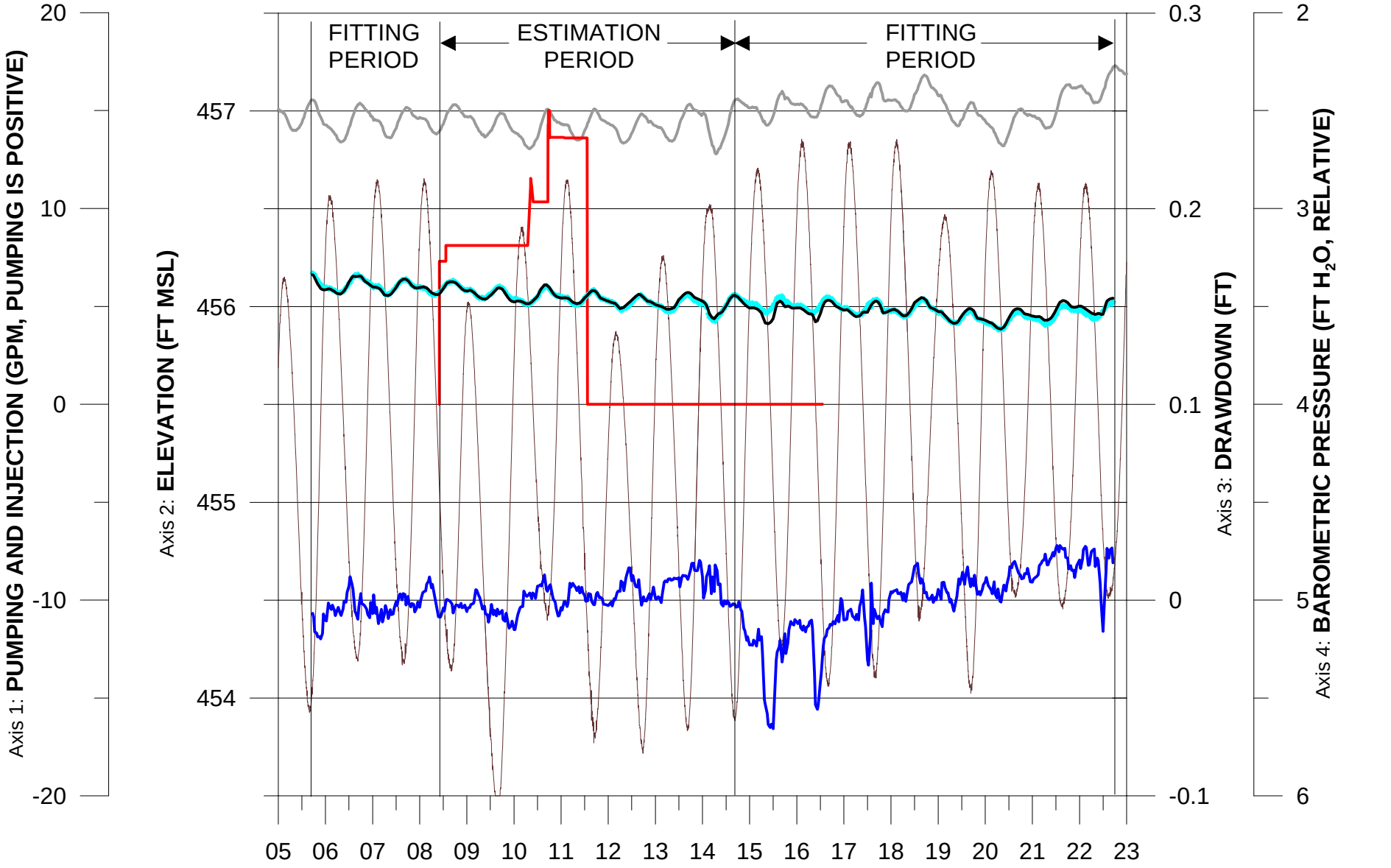


FIGURE H-3
DECONVOLUTION OF MW-12 RESPONSE DURING AUGUST 2007 PGE-08 PUMPING TEST
SUMMARY REPORT FOR HYDRAULIC TESTING IN BEDROCK WELLS
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

\\odin\proj\topock\deconvolution\Figures\New_Injection_Results_Dec19\

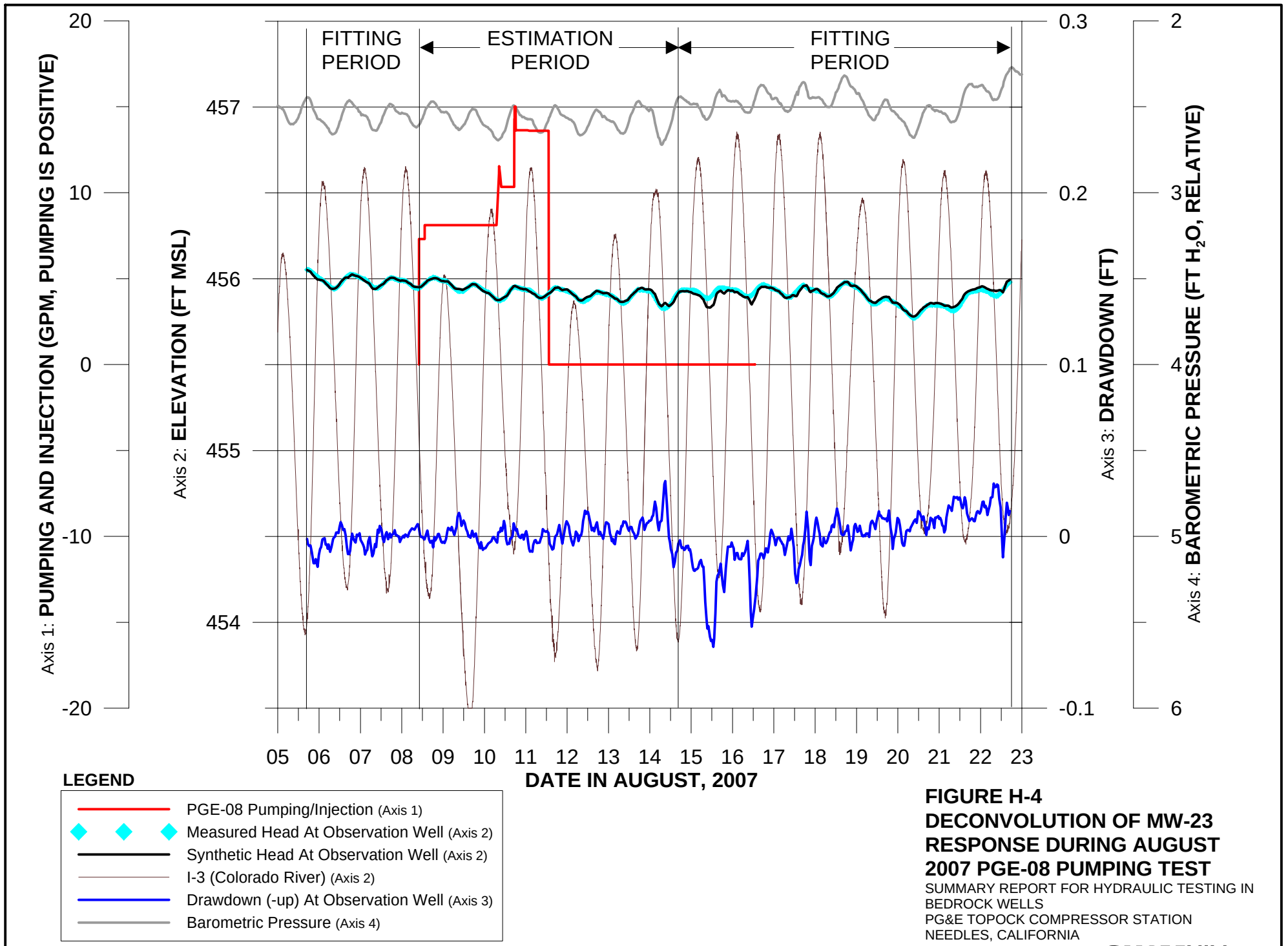


FIGURE H-4
DECONVOLUTION OF MW-23 RESPONSE DURING AUGUST 2007 PGE-08 PUMPING TEST
SUMMARY REPORT FOR HYDRAULIC TESTING IN BEDROCK WELLS
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

\\odin\proj\topock\deconvolution\Figures\New_Injection_Results_Dec19\

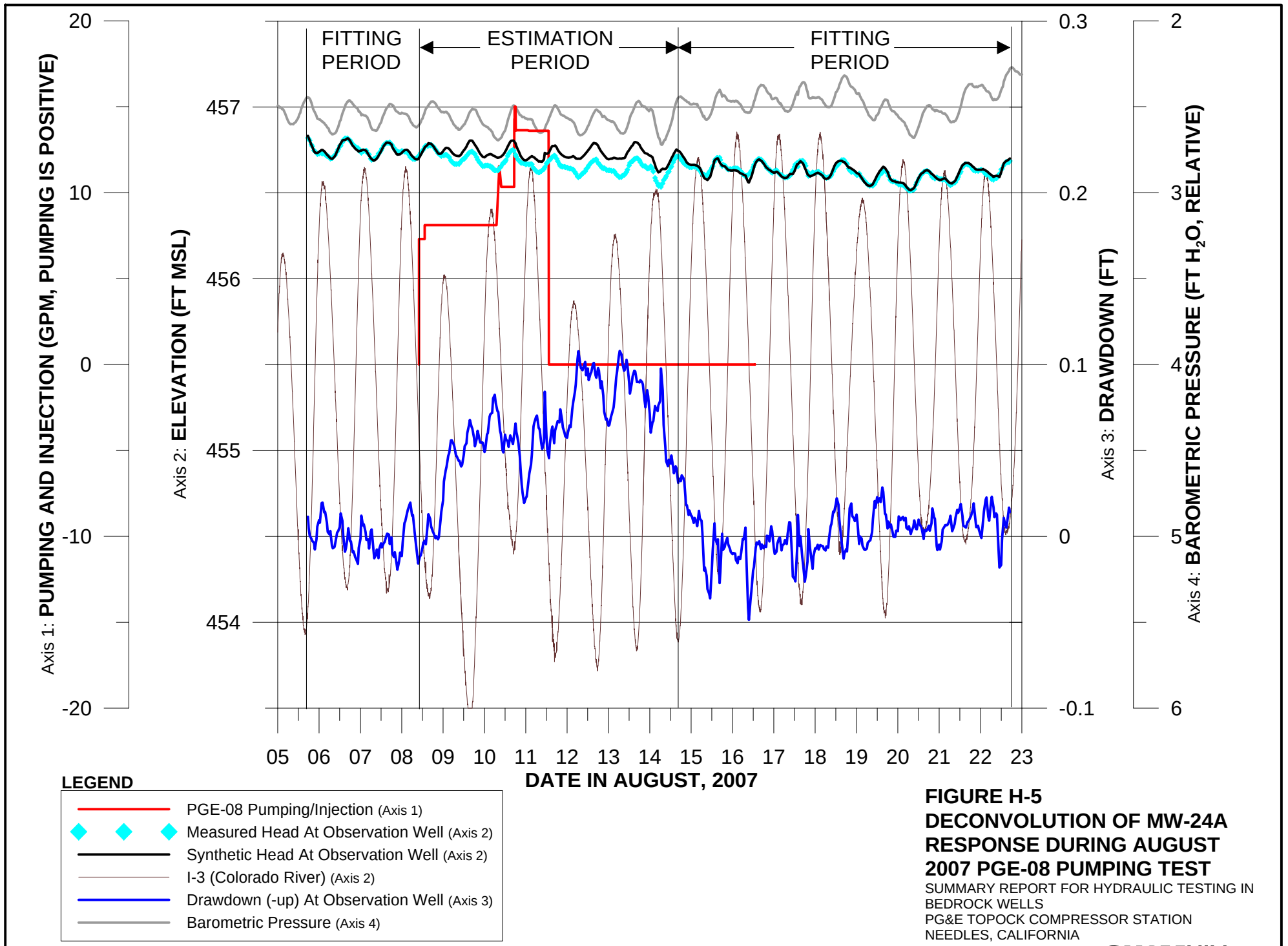


FIGURE H-5
DECONVOLUTION OF MW-24A RESPONSE DURING AUGUST 2007 PGE-08 PUMPING TEST
SUMMARY REPORT FOR HYDRAULIC TESTING IN BEDROCK WELLS
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

\\odin\proj\topock\deconvolution\Figures\New_Injection_Results_Dec19\

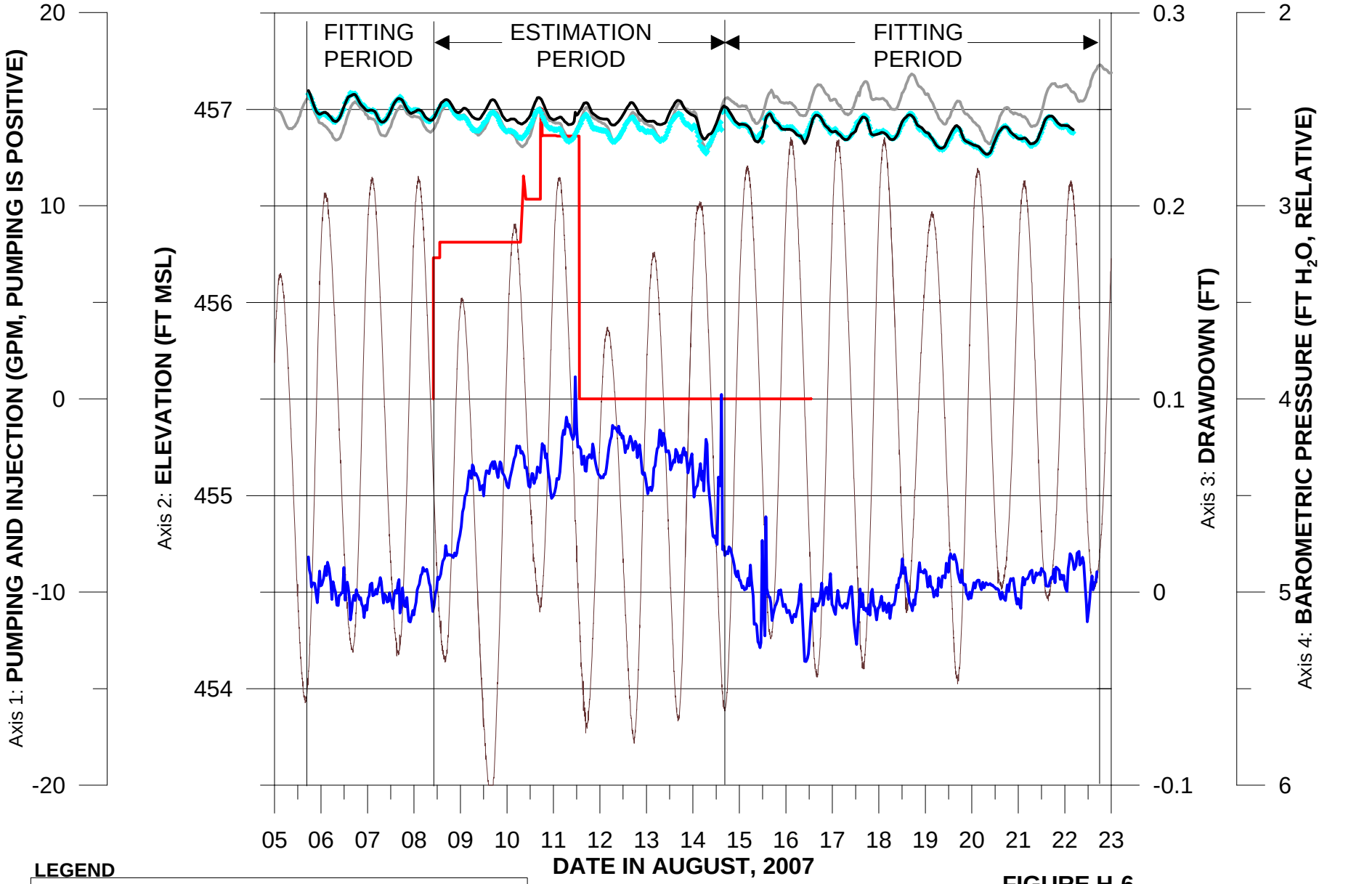


FIGURE H-6
DECONVOLUTION OF MW-24B RESPONSE DURING AUGUST 2007 PGE-08 PUMPING TEST
SUMMARY REPORT FOR HYDRAULIC TESTING IN BEDROCK WELLS
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

\\odin\proj\topock\deconvolution\Figures\New_Injection_Results_Dec19\

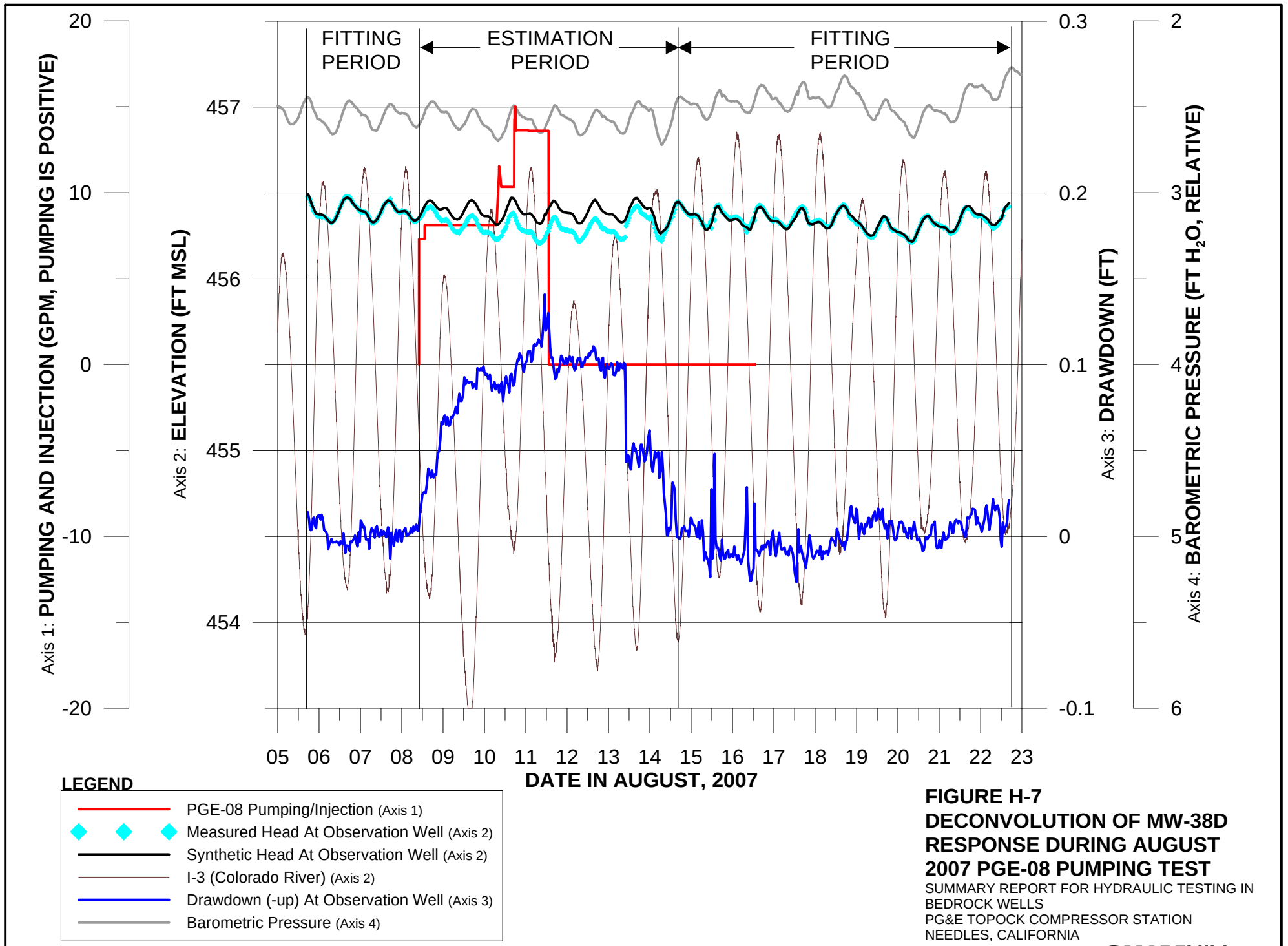


FIGURE H-7
DECONVOLUTION OF MW-38D RESPONSE DURING AUGUST 2007 PGE-08 PUMPING TEST
SUMMARY REPORT FOR HYDRAULIC TESTING IN BEDROCK WELLS
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

\\odin\proj\topock\deconvolution\Figures\New_Injection_Results_Dec19\

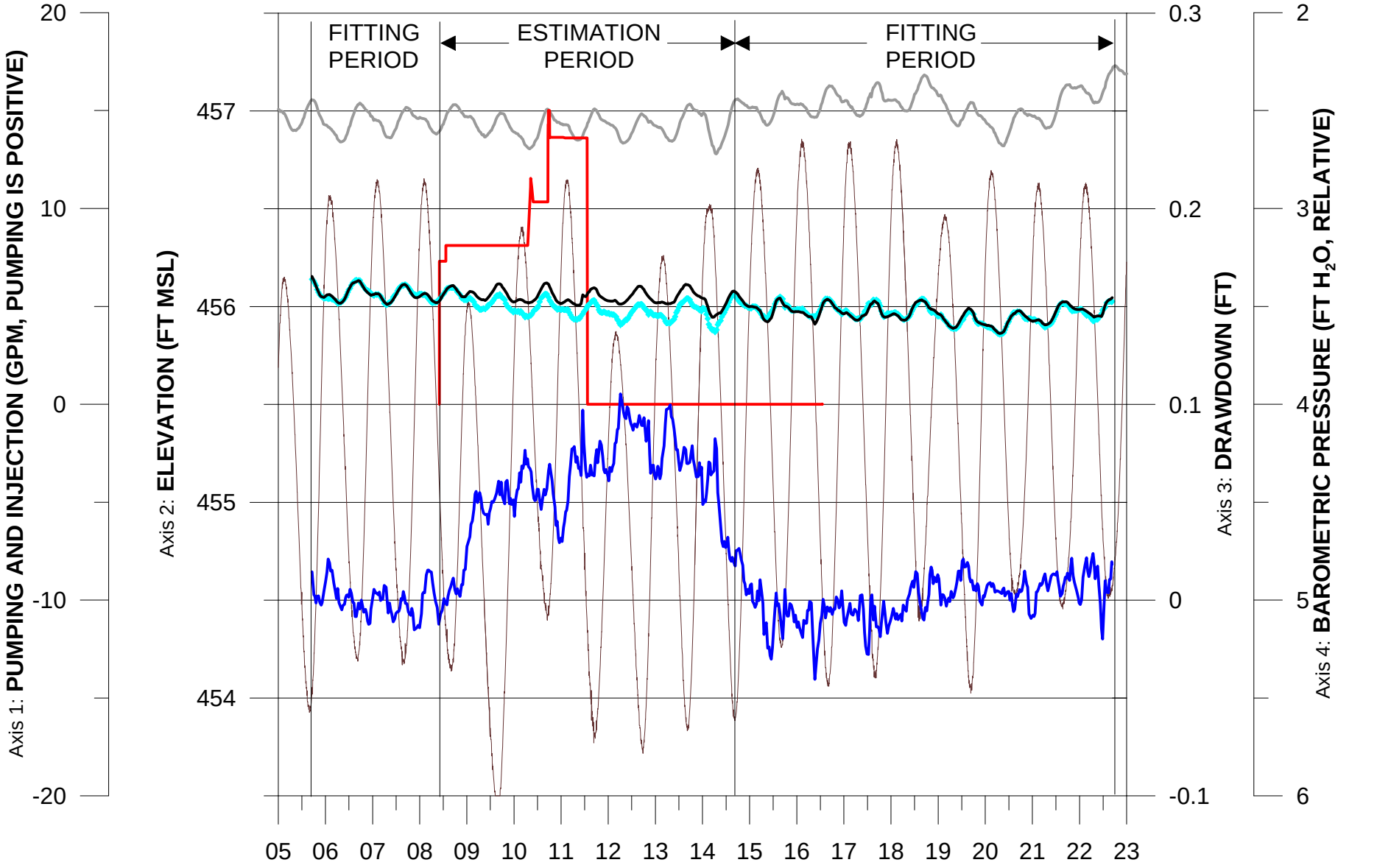


FIGURE H-8
DECONVOLUTION OF MW-38S RESPONSE DURING AUGUST 2007 PGE-08 PUMPING TEST
SUMMARY REPORT FOR HYDRAULIC TESTING IN BEDROCK WELLS
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

\\odin\proj\topock\deconvolution\Figures\New_Injection_Results_Dec19\

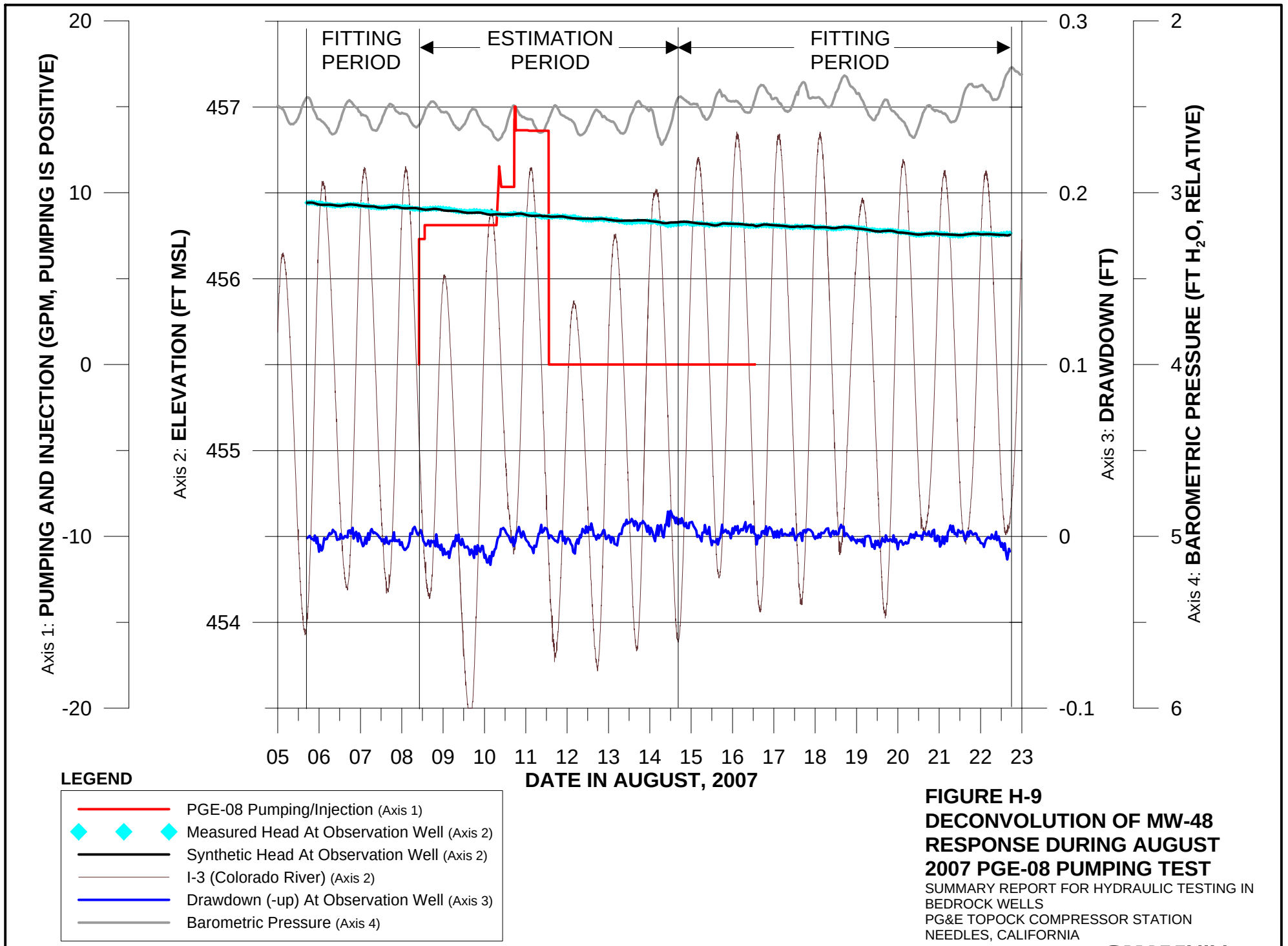


FIGURE H-9
DECONVOLUTION OF MW-48 RESPONSE DURING AUGUST 2007 PGE-08 PUMPING TEST
SUMMARY REPORT FOR HYDRAULIC TESTING IN BEDROCK WELLS
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

\\odin\proj\topock\deconvolution\Figures\New_Injection_Results_Dec19\

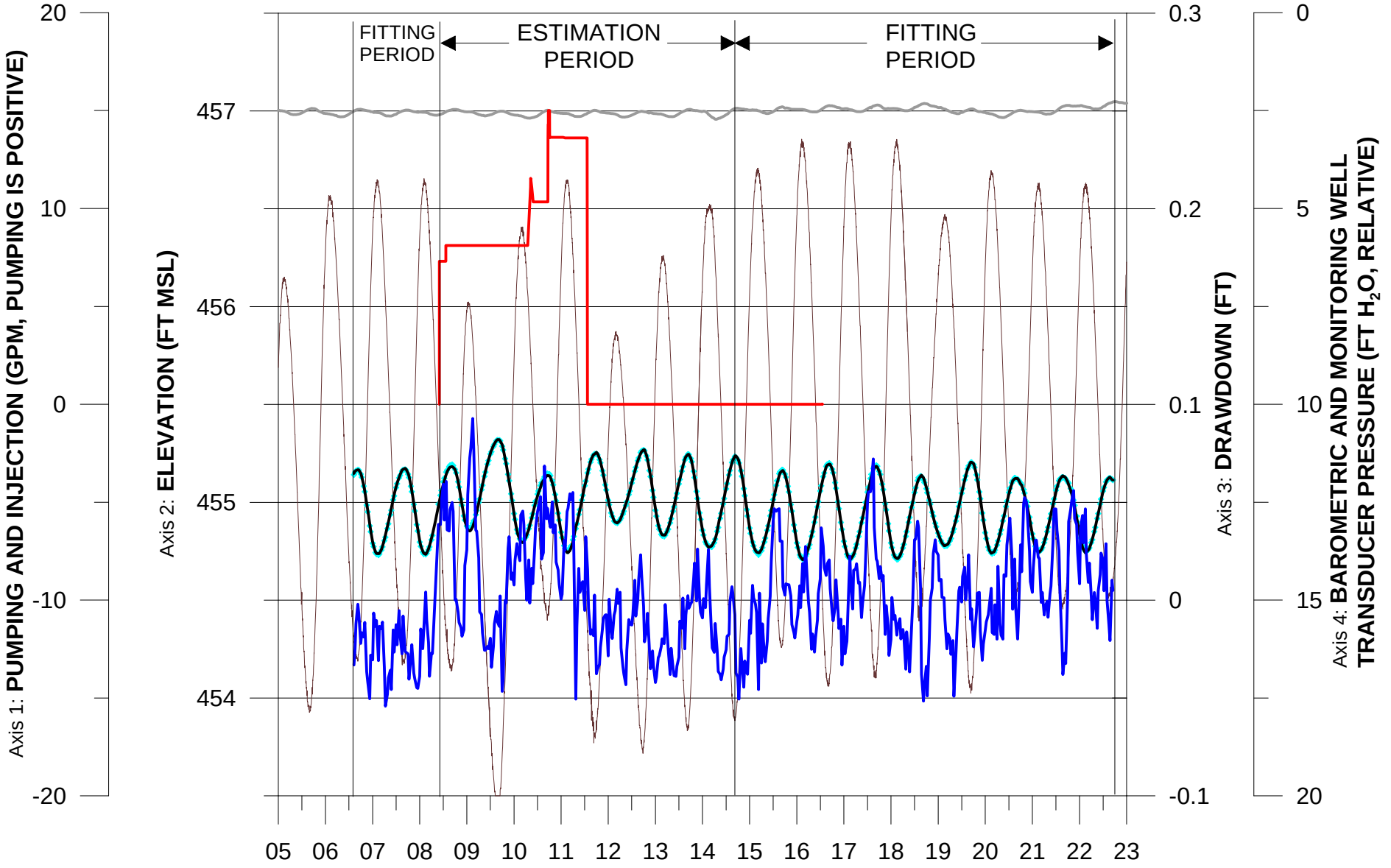


FIGURE H-10
DECONVOLUTION OF MW-52D RESPONSE DURING AUGUST 2007 PGE-08 PUMPING TEST
SUMMARY REPORT FOR HYDRAULIC TESTING IN BEDROCK WELLS
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

\\odin\proj\topock\deconvolution\Figures\New_Injection_Results_Dec19\

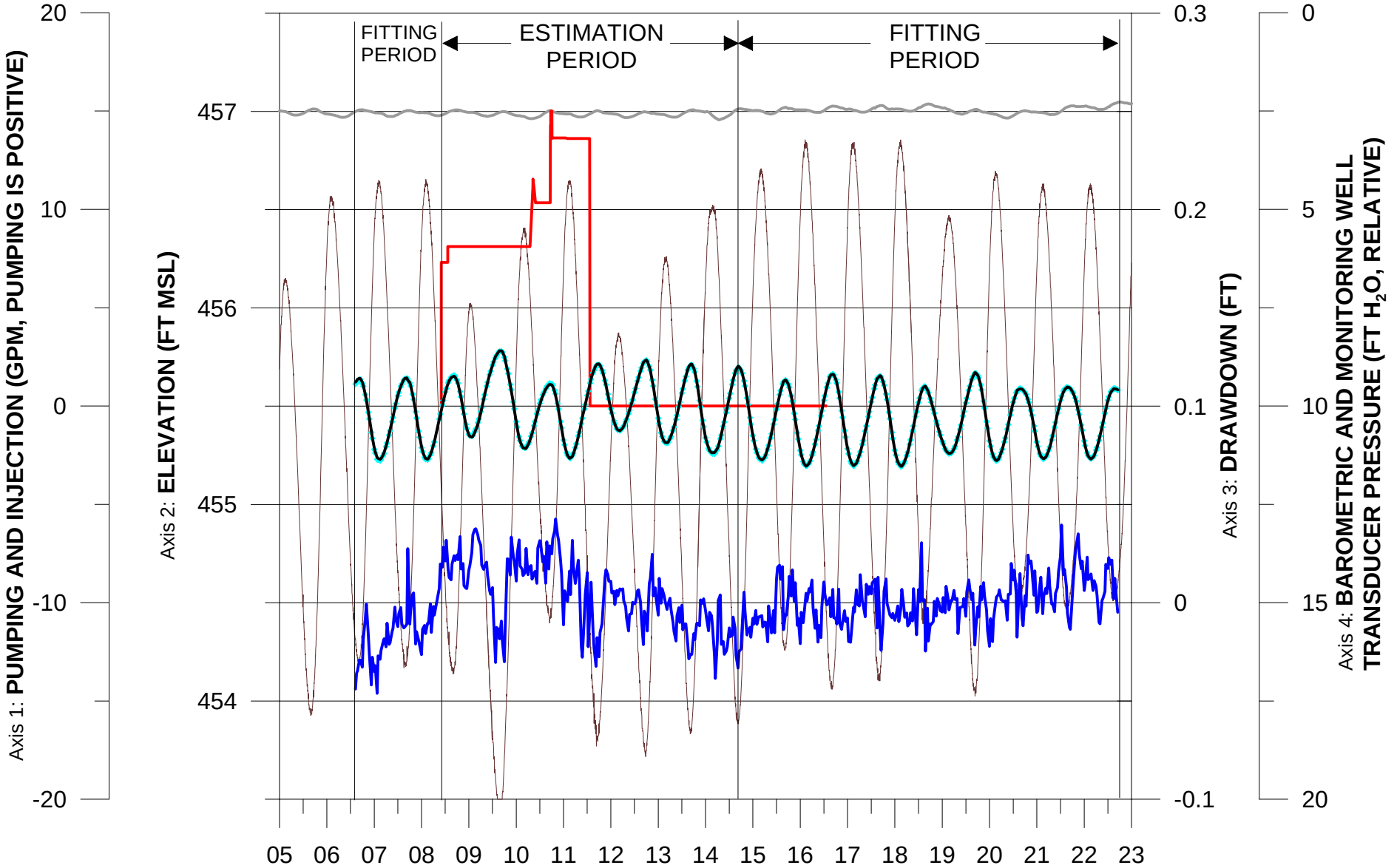


FIGURE H-11
DECONVOLUTION OF MW-52M RESPONSE DURING AUGUST 2007 PGE-08 PUMPING TEST
SUMMARY REPORT FOR HYDRAULIC TESTING IN BEDROCK WELLS
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

\\odin\proj\topock\deconvolution\Figures\New_Injection_Results_Dec19\

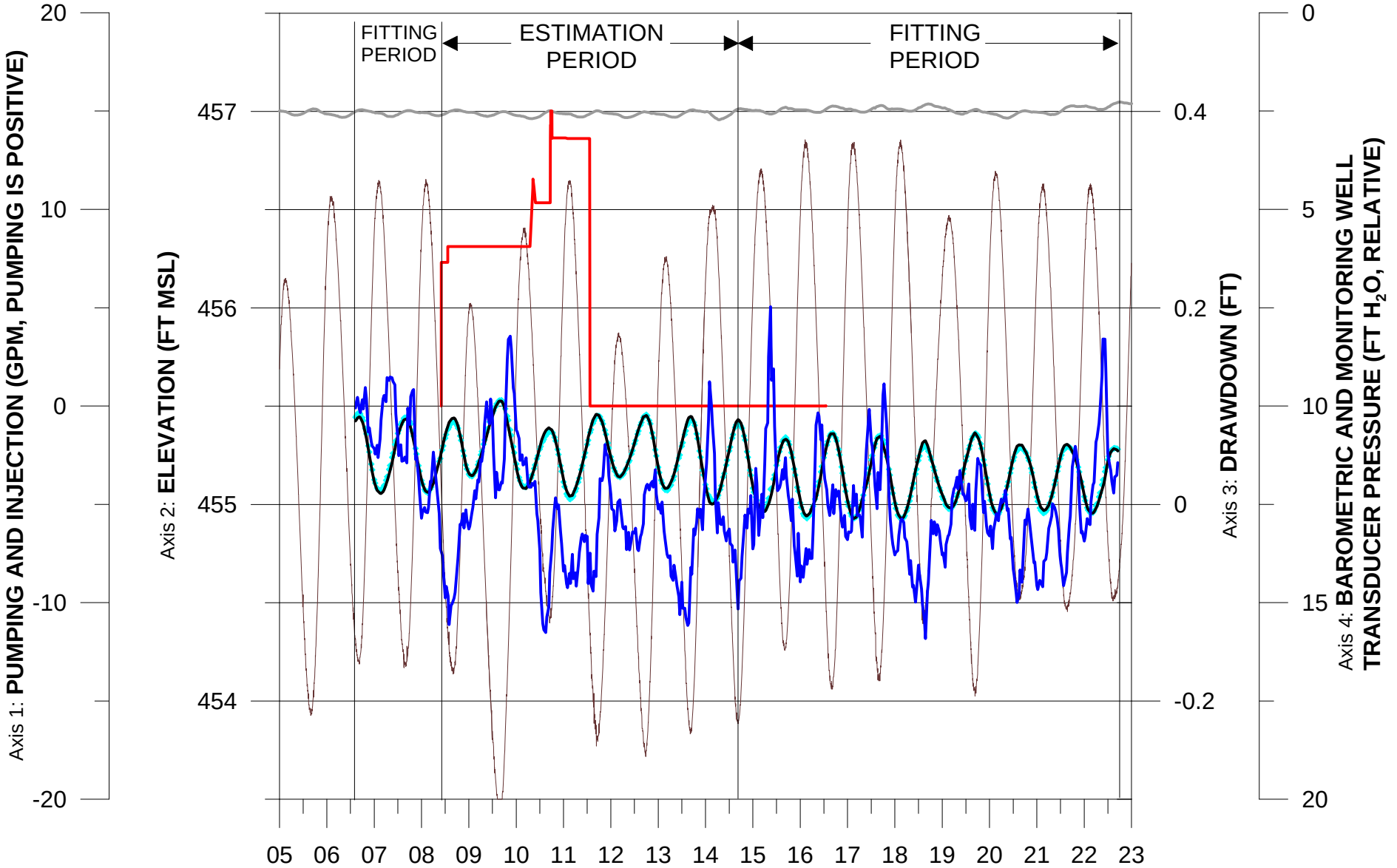


FIGURE H-12
DECONVOLUTION OF MW-52S RESPONSE DURING AUGUST 2007 PGE-08 PUMPING TEST
SUMMARY REPORT FOR HYDRAULIC TESTING IN BEDROCK WELLS
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

\\odin\proj\topock\deconvolution\Figures\New_Injection_Results_Dec19\

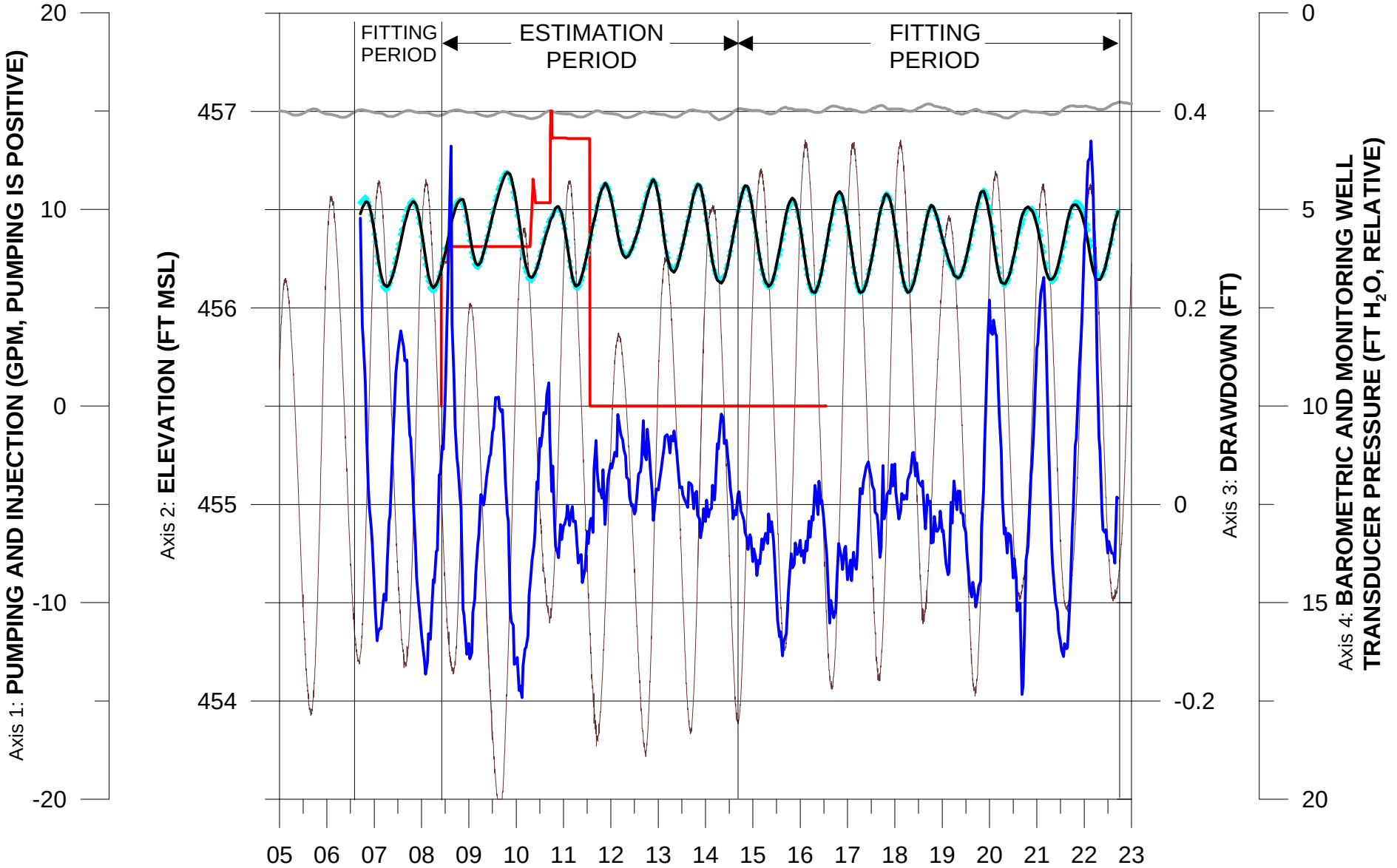


FIGURE H-13
DECONVOLUTION OF MW-53D RESPONSE DURING AUGUST 2007 PGE-08 PUMPING TEST

SUMMARY REPORT FOR HYDRAULIC TESTING IN BEDROCK WELLS
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

\\odin\proj\topock\deconvolution\Figures\New_Injection_Results_Dec19\

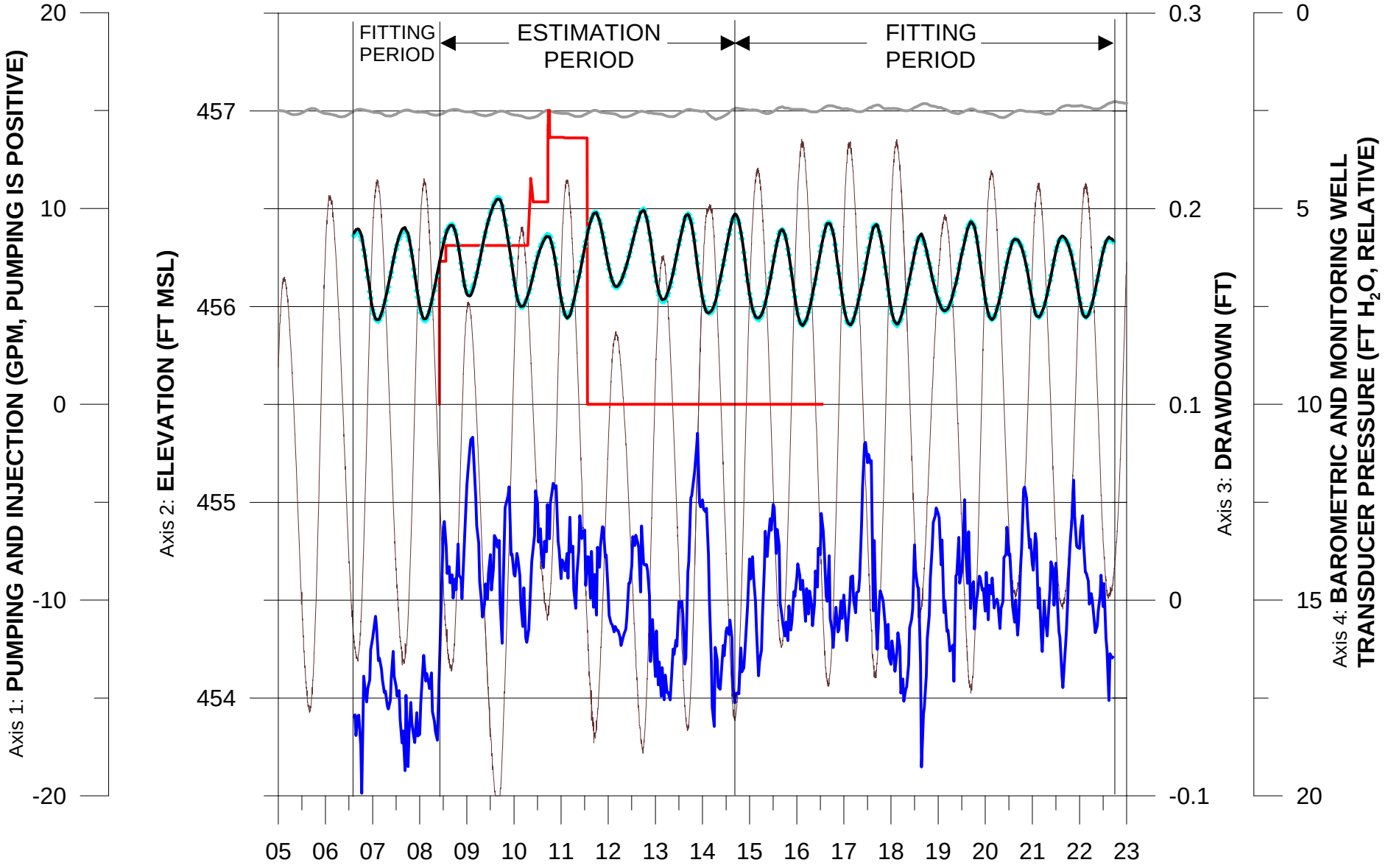


FIGURE H-14
DECONVOLUTION OF MW-53M RESPONSE DURING AUGUST 2007 PGE-08 PUMPING TEST
SUMMARY REPORT FOR HYDRAULIC TESTING IN BEDROCK WELLS
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

\\odin\proj\topock\deconvolution\Figures\New_Injection_Results_Dec19\

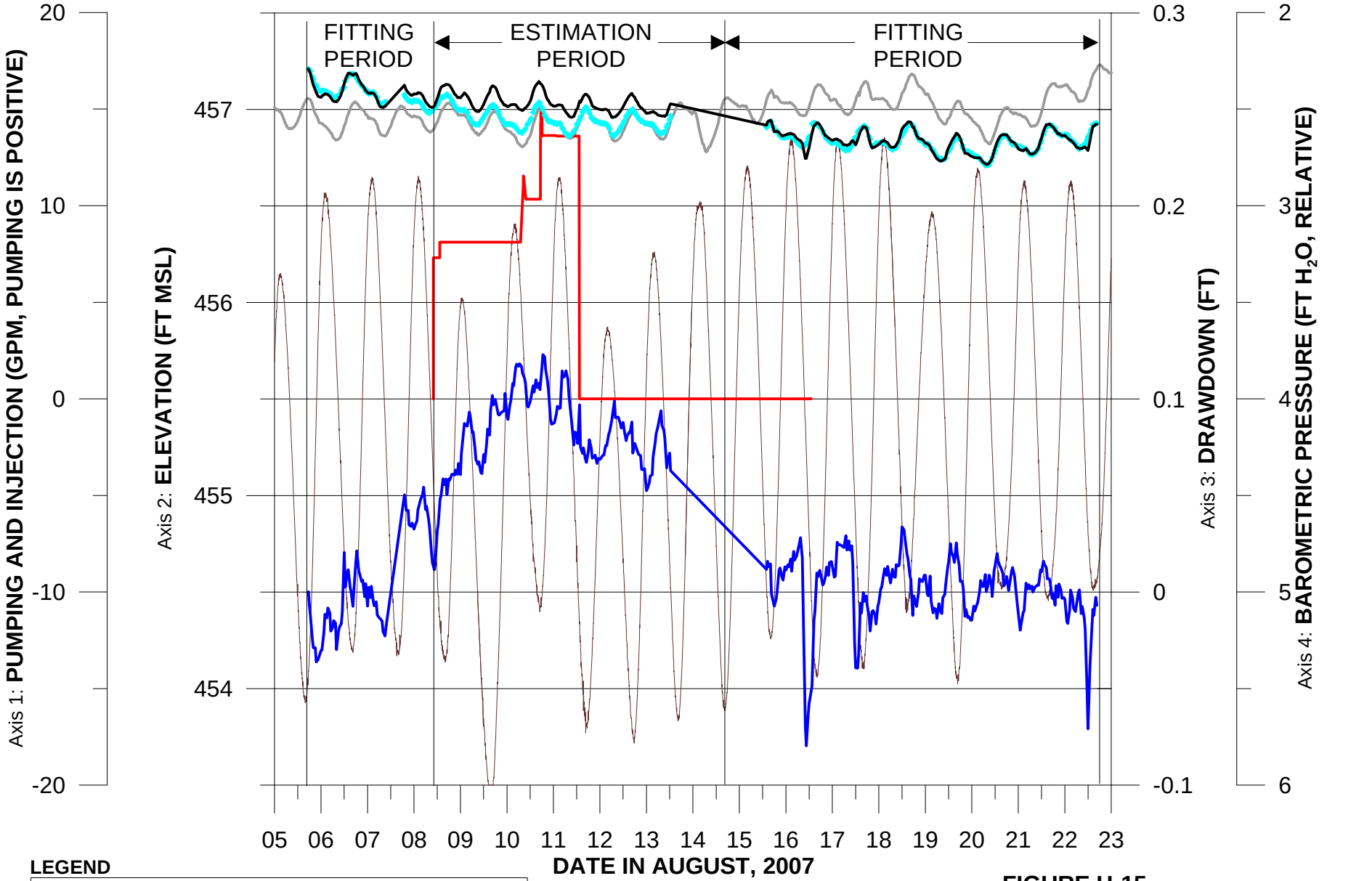


FIGURE H-15
DECONVOLUTION OF PGE-07 RESPONSE DURING AUGUST 2007 PGE-08 PUMPING TEST
SUMMARY REPORT FOR HYDRAULIC TESTING IN BEDROCK WELLS
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

\\odin\proj\topock\deconvolution\Figures\New_Injection_Results_Dec19\

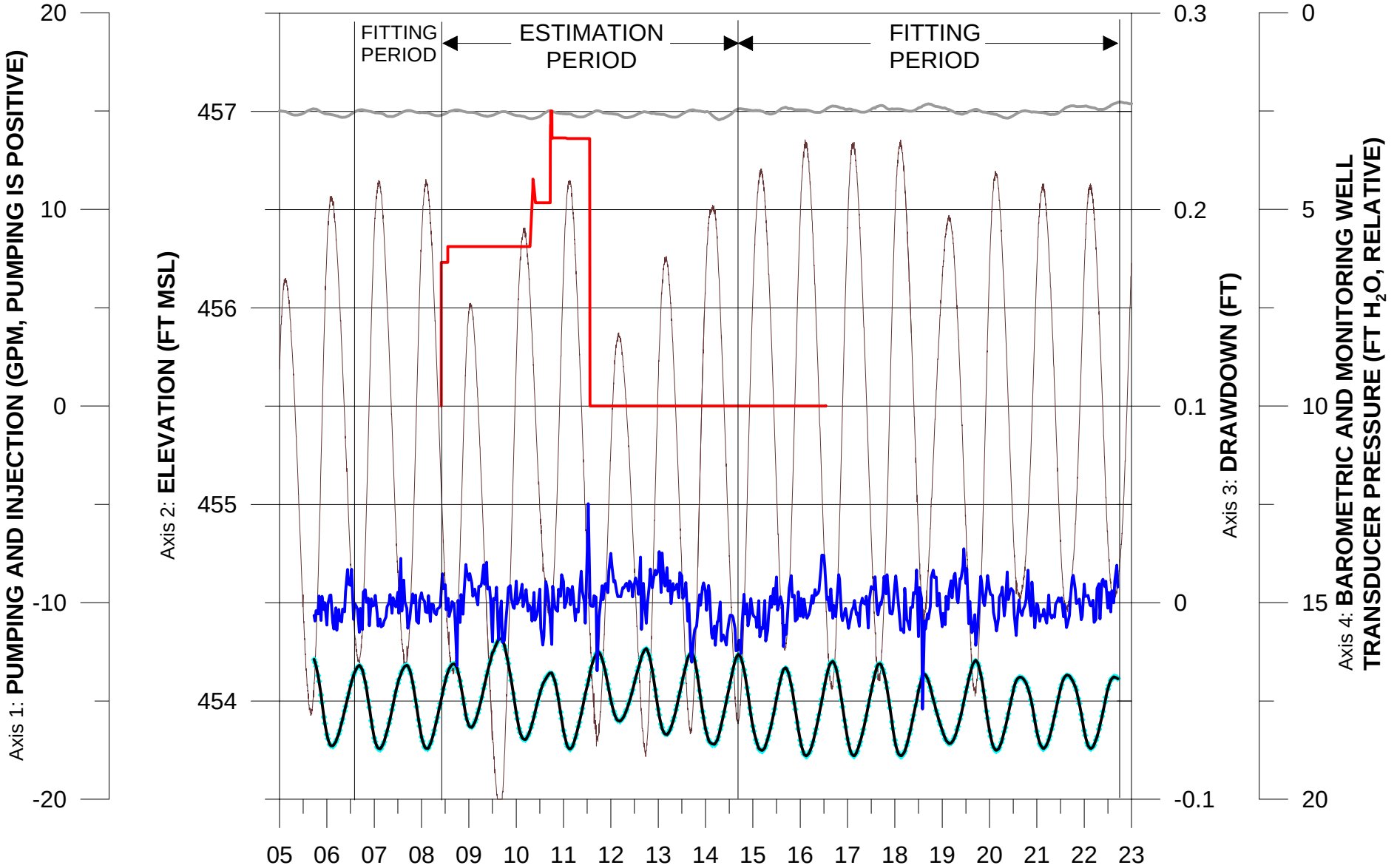


FIGURE H-16
DECONVOLUTION OF PGE-09N RESPONSE DURING AUGUST 2007 PGE-08 PUMPING TEST
SUMMARY REPORT FOR HYDRAULIC TESTING IN BEDROCK WELLS
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

\\odin\proj\topock\deconvolution\Figures\New_Injection_Results_Dec19\

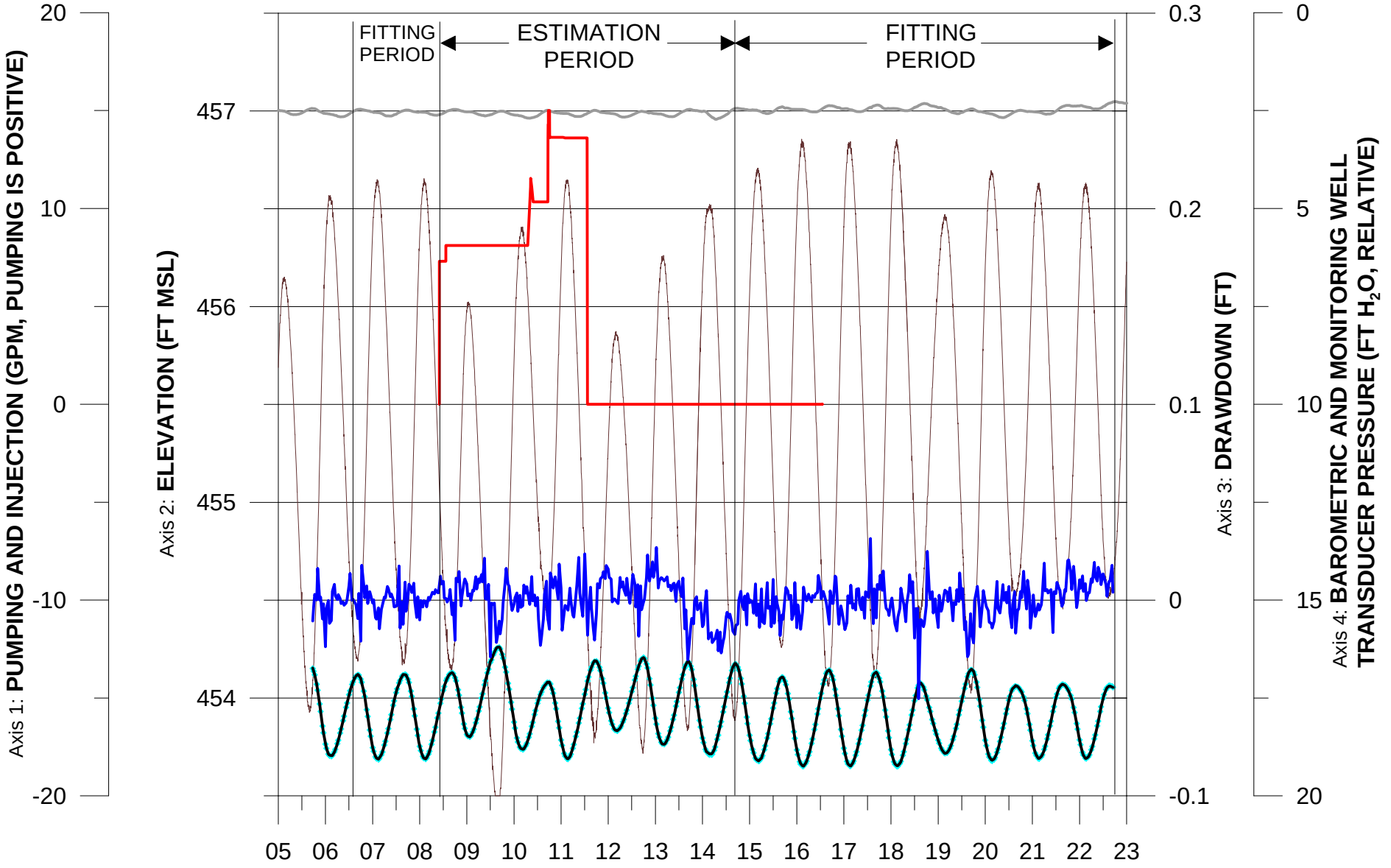


FIGURE H-17
DECONVOLUTION OF PGE-09S RESPONSE DURING AUGUST 2007 PGE-08 PUMPING TEST
SUMMARY REPORT FOR HYDRAULIC TESTING IN BEDROCK WELLS
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

\\odin\proj\topock\deconvolution\Figures\New_Injection_Results_Dec19\

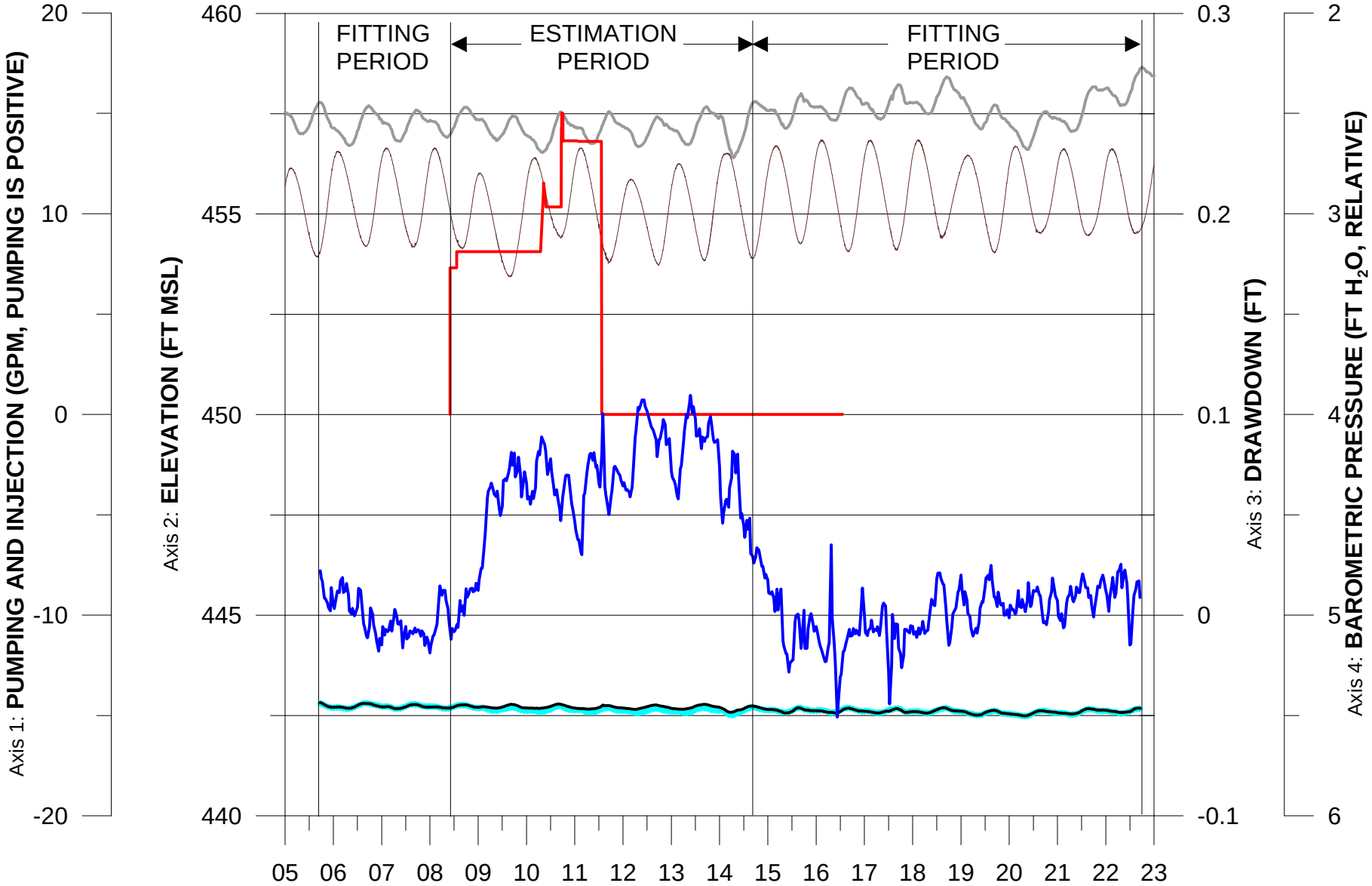


FIGURE H-18
DECONVOLUTION OF PT7M RESPONSE DURING AUGUST 2007 PGE-08 PUMPING TEST
SUMMARY REPORT FOR HYDRAULIC TESTING IN BEDROCK WELLS
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

\\odin\proj\topock\deconvolution\Figures\New_Injection_Results_Dec19\

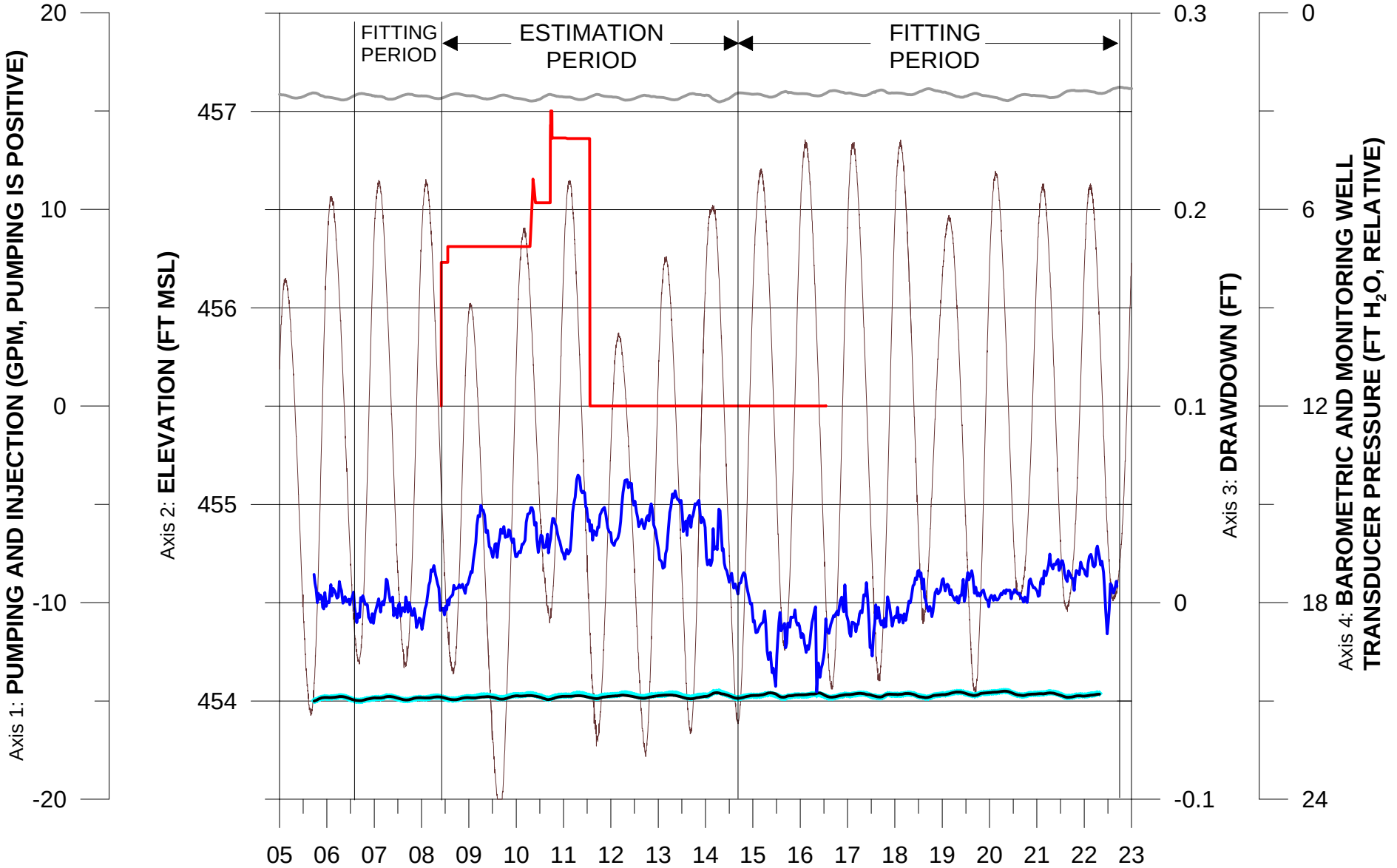


FIGURE H-19
DECONVOLUTION OF PT8M RESPONSE DURING AUGUST 2007 PGE-08 PUMPING TEST

SUMMARY REPORT FOR HYDRAULIC TESTING IN BEDROCK WELLS
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

\\odin\proj\topock\deconvolution\Figures\New_Injection_Results_Dec19\

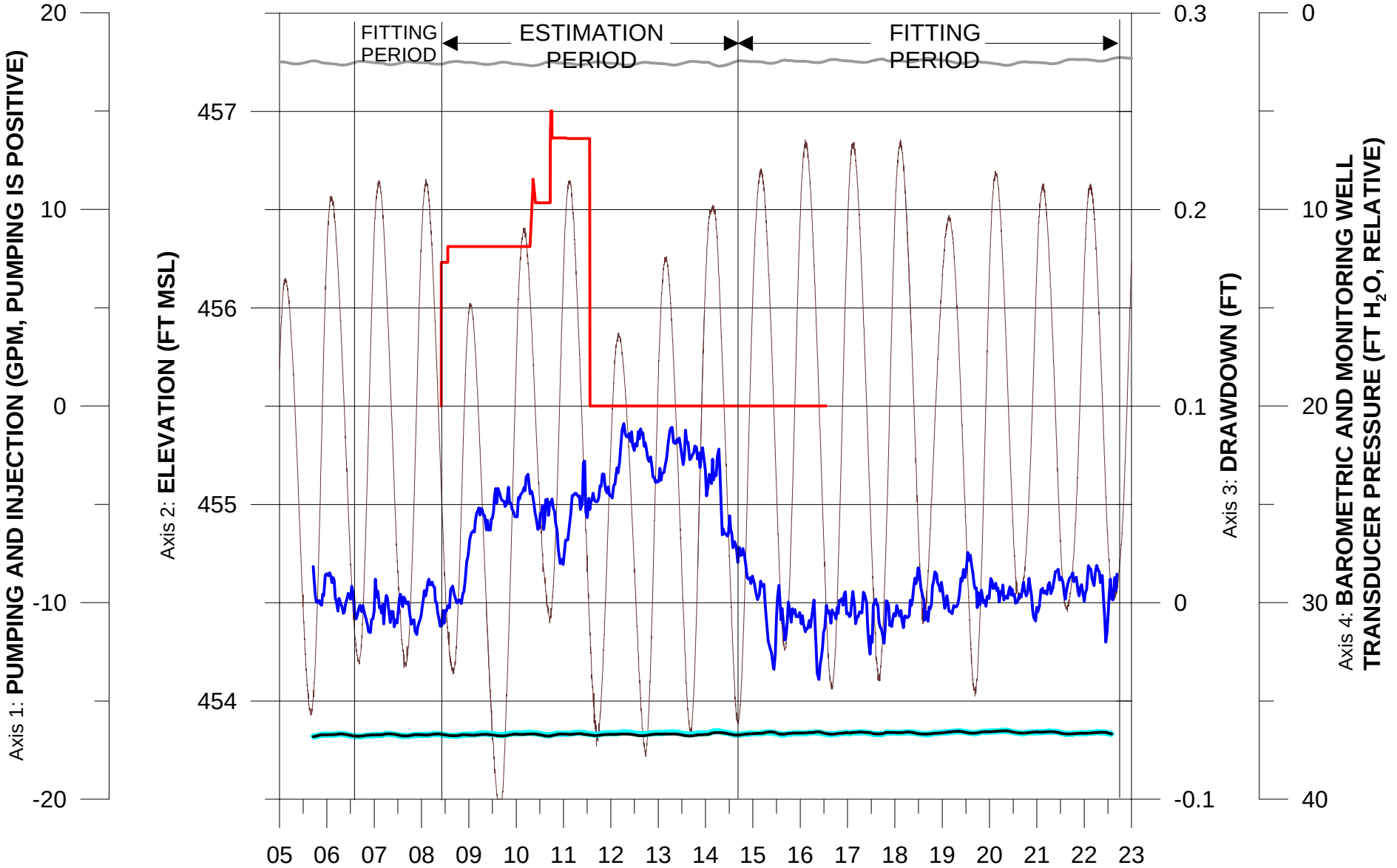
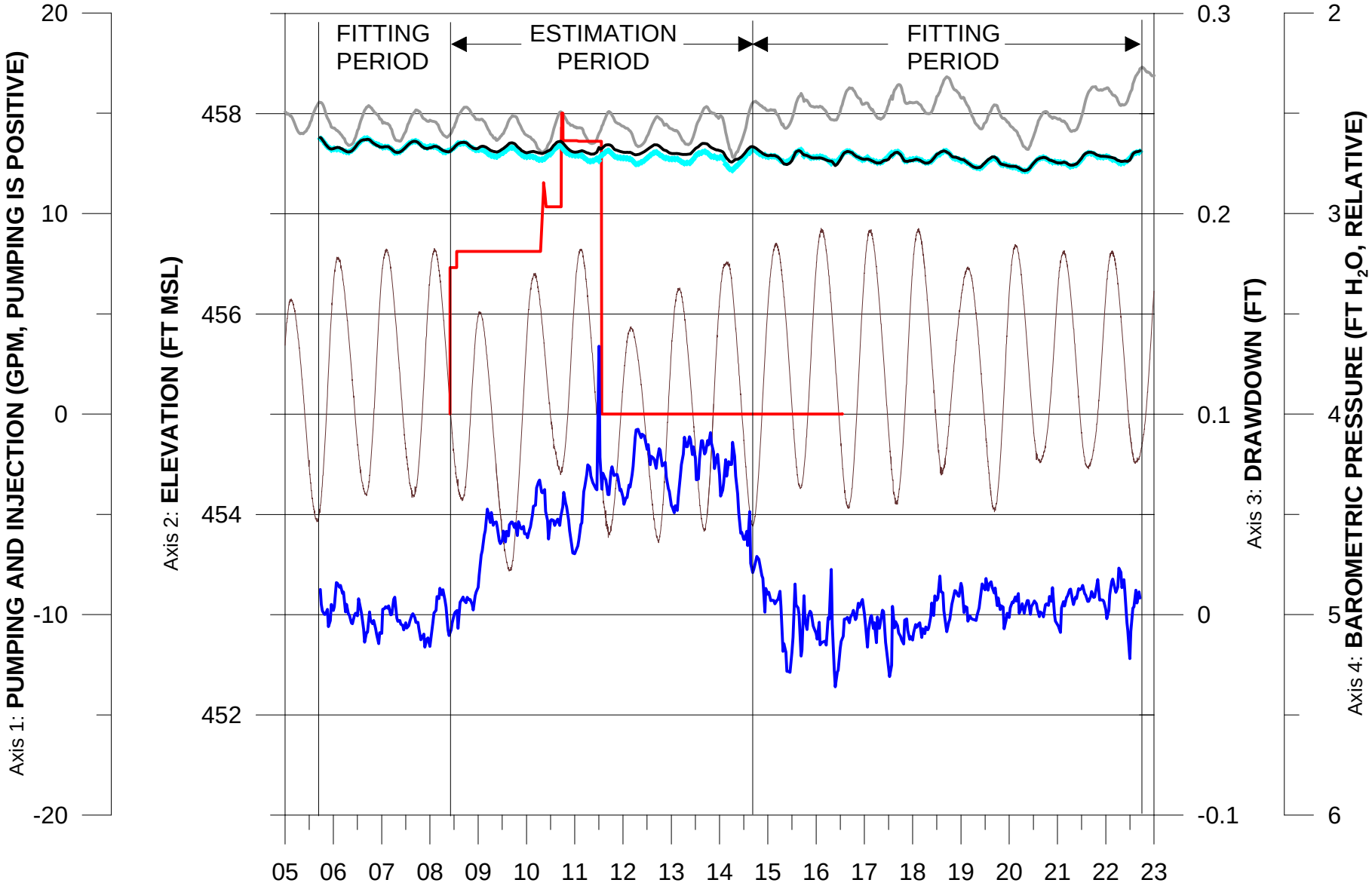


FIGURE H-20
DECONVOLUTION OF PT8S RESPONSE DURING AUGUST 2007 PGE-08 PUMPING TEST
SUMMARY REPORT FOR HYDRAULIC TESTING IN BEDROCK WELLS
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

\\odin\proj\topock\deconvolution\Figures\New_Injection_Results_Dec19\



LEGEND

- PGE-08 Pumping/Injection (Axis 1)
- Measured Head At Observation Well (Axis 2)
- Synthetic Head At Observation Well (Axis 2)
- I-3 (Colorado River) (Axis 2)
- Drawdown (-up) At Observation Well (Axis 3)
- Barometric Pressure (Axis 4)

FIGURE H-21
DECONVOLUTION OF PT9D RESPONSE DURING AUGUST 2007 PGE-08 PUMPING TEST
SUMMARY REPORT FOR HYDRAULIC TESTING IN BEDROCK WELLS
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

\\odin\proj\topock\deconvolution\Figures\New_Injection_Results_Dec19\

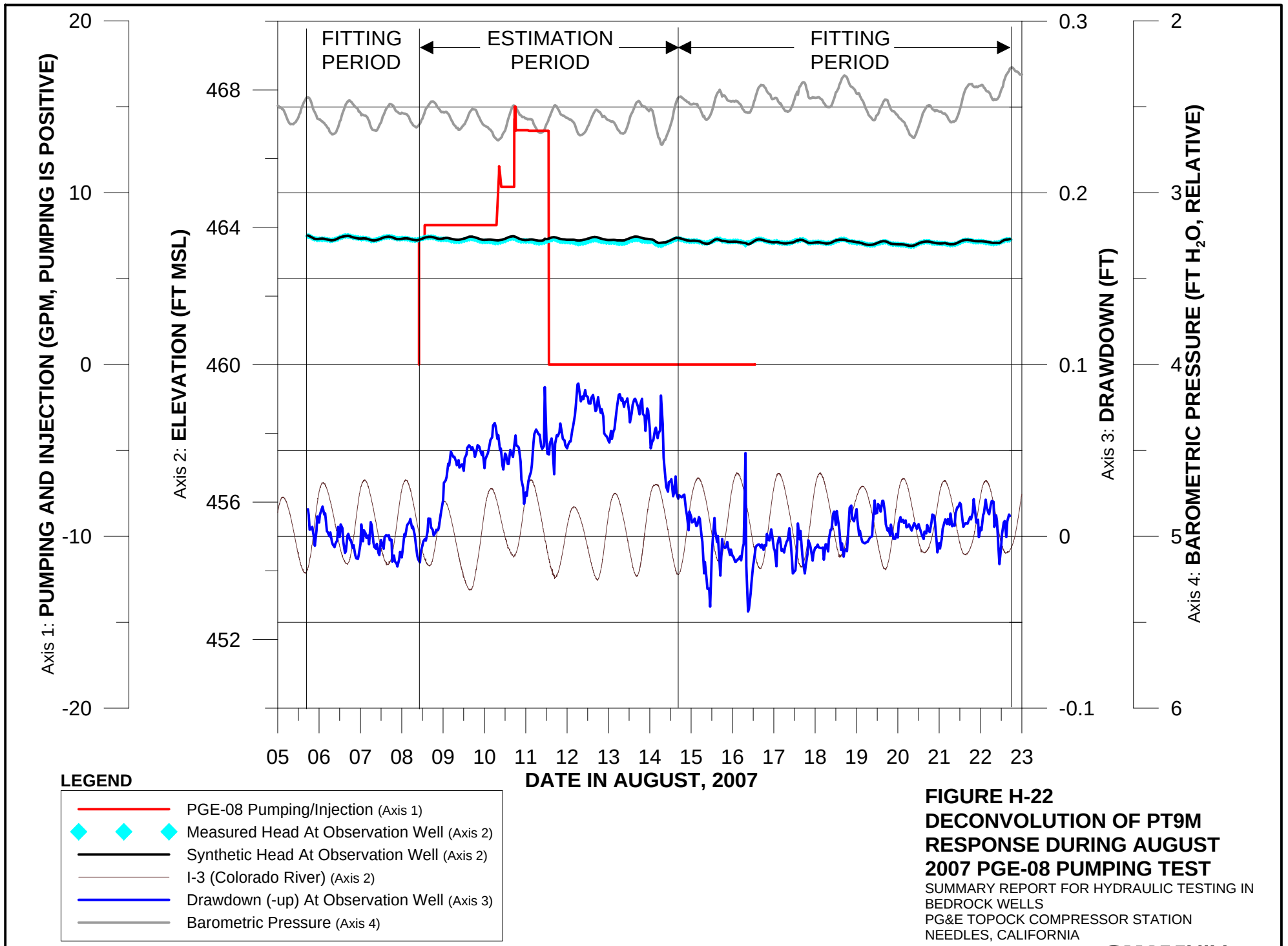


FIGURE H-22
DECONVOLUTION OF PT9M RESPONSE DURING AUGUST 2007 PGE-08 PUMPING TEST
SUMMARY REPORT FOR HYDRAULIC TESTING IN BEDROCK WELLS
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

\\odin\proj\topock\deconvolution\Figures\New_Injection_Results_Dec19\

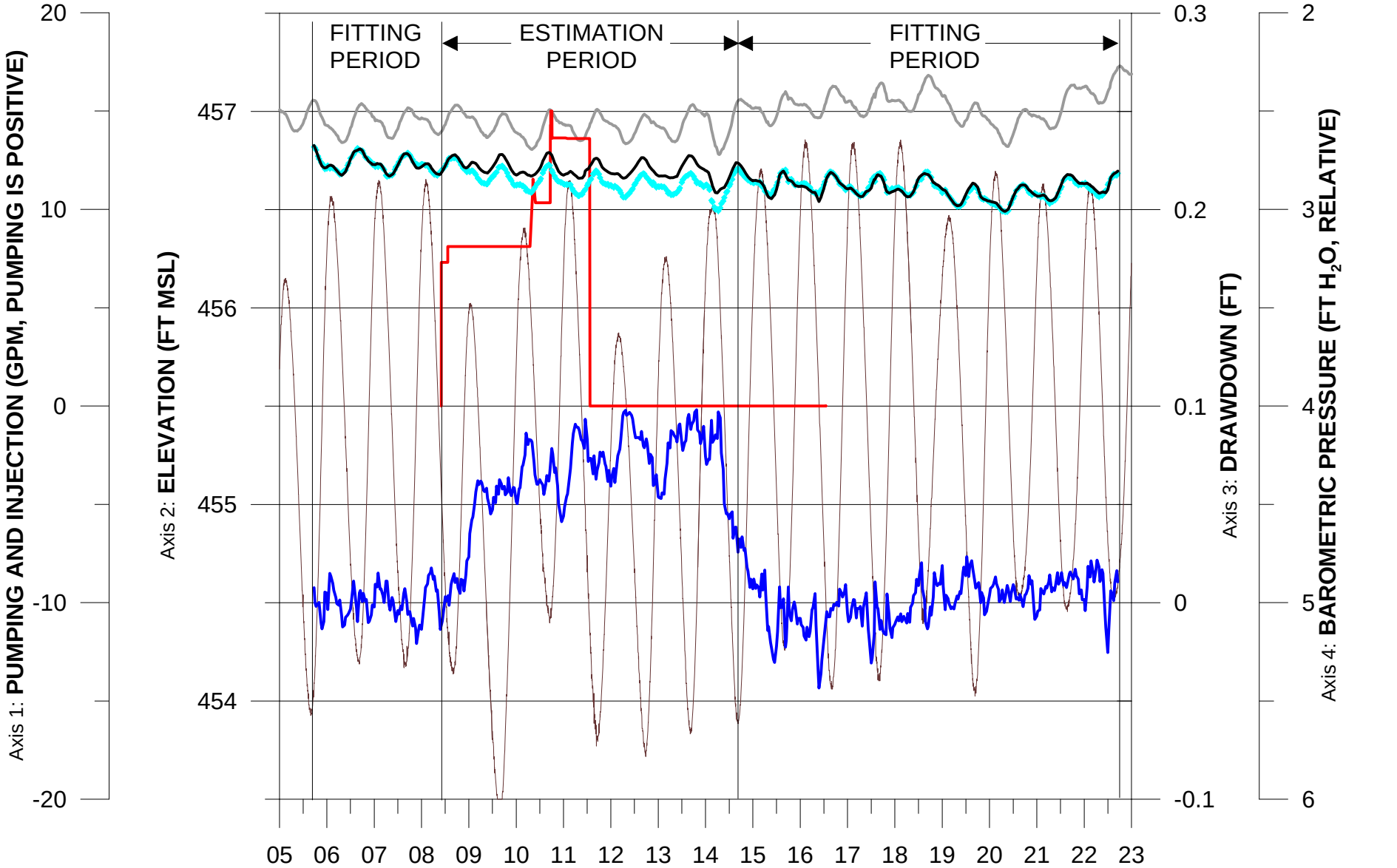


FIGURE H-23
DECONVOLUTION OF TW-01 RESPONSE DURING AUGUST 2007 PGE-08 PUMPING TEST

SUMMARY REPORT FOR HYDRAULIC TESTING IN BEDROCK WELLS
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

\\odin\proj\topock\deconvolution\Figures\New_Injection_Results_Dec19\

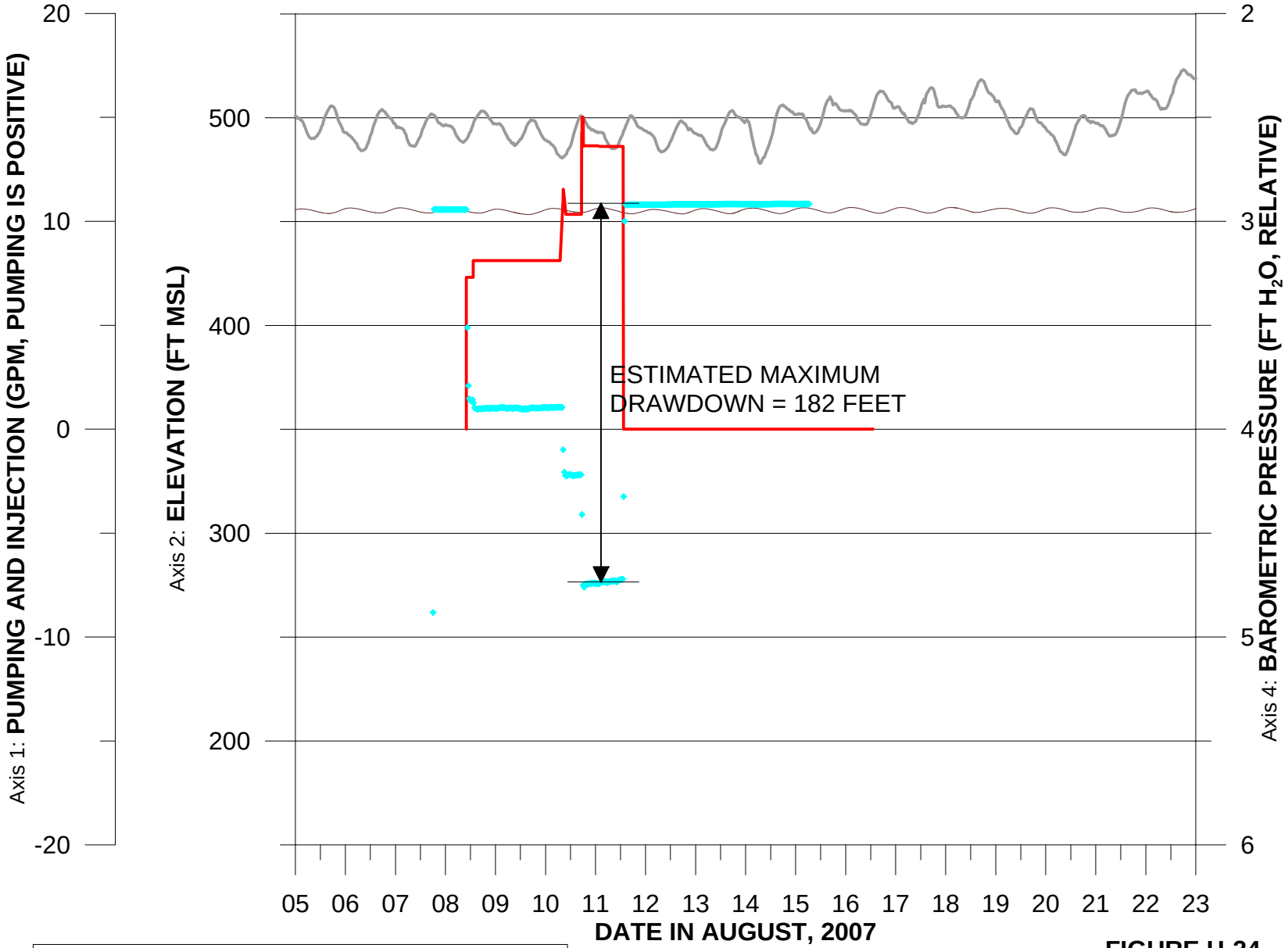


FIGURE H-24
PGE-08 WATER LEVEL RESPONSE DURING AUGUST 2007 PGE-08 PUMPING TEST
Summary Report for Hydraulic Testing in Bedrock Wells
PG&E Topock Compressor Station
Needles, California

CH2MHILL

\\odin\proj\topock\deconvolution\Figures\New_Injection_Results_Dec19\

Appendix I
Deconvoluted Observation Well Data From October 2007 PGE-08 Injection Test

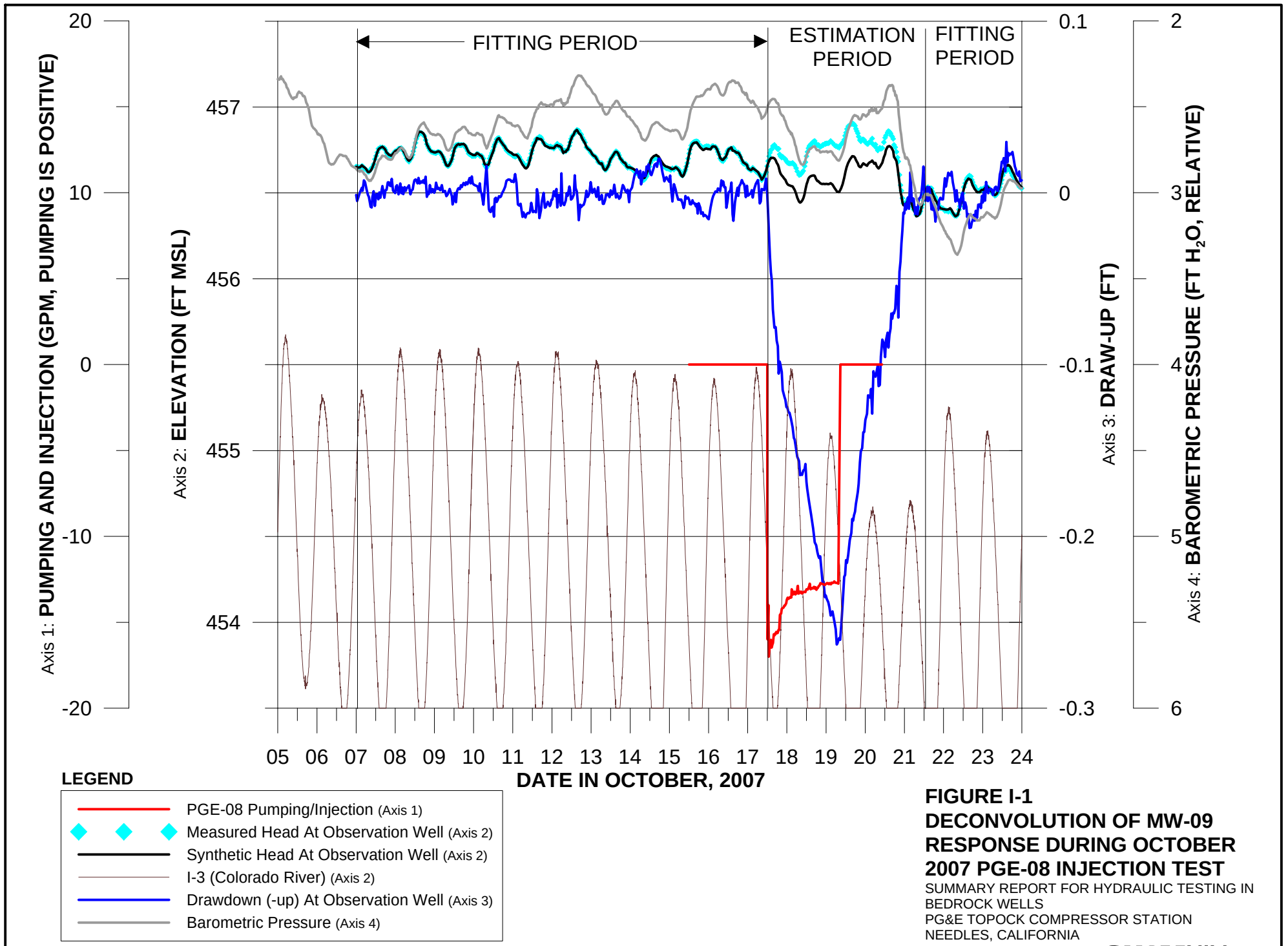


FIGURE I-1
DECONVOLUTION OF MW-09 RESPONSE DURING OCTOBER 2007 PGE-08 INJECTION TEST
SUMMARY REPORT FOR HYDRAULIC TESTING IN BEDROCK WELLS
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

\\odin\proj\topock\deconvolution\Figures\New_Injection_Results_Dec19\

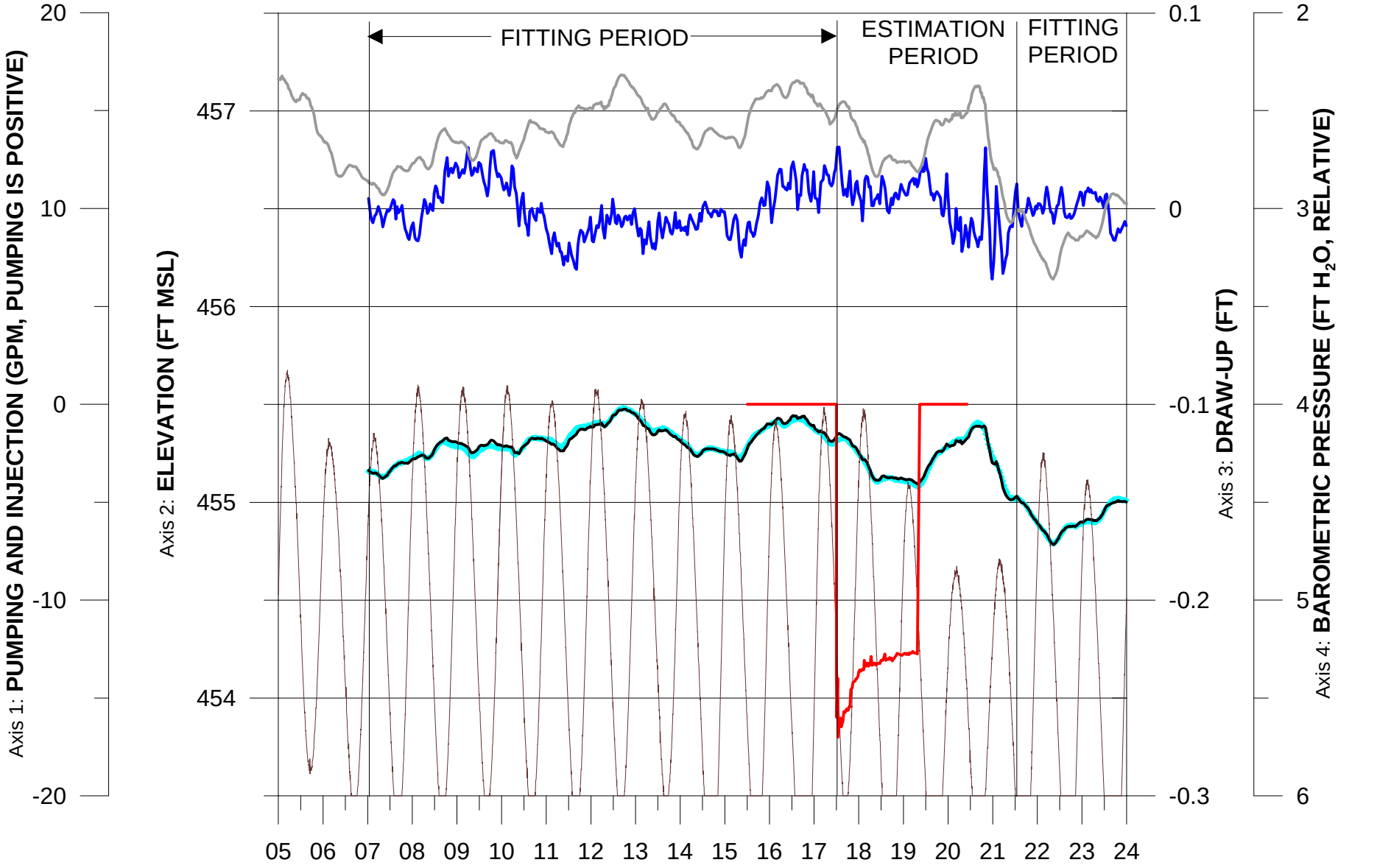


FIGURE I-2
DECONVOLUTION OF MW-23 RESPONSE DURING OCTOBER 2007 PGE-08 INJECTION TEST
SUMMARY REPORT FOR HYDRAULIC TESTING IN BEDROCK WELLS
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

\\odin\proj\topock\deconvolution\Figures\New_Injection_Results_Dec19\

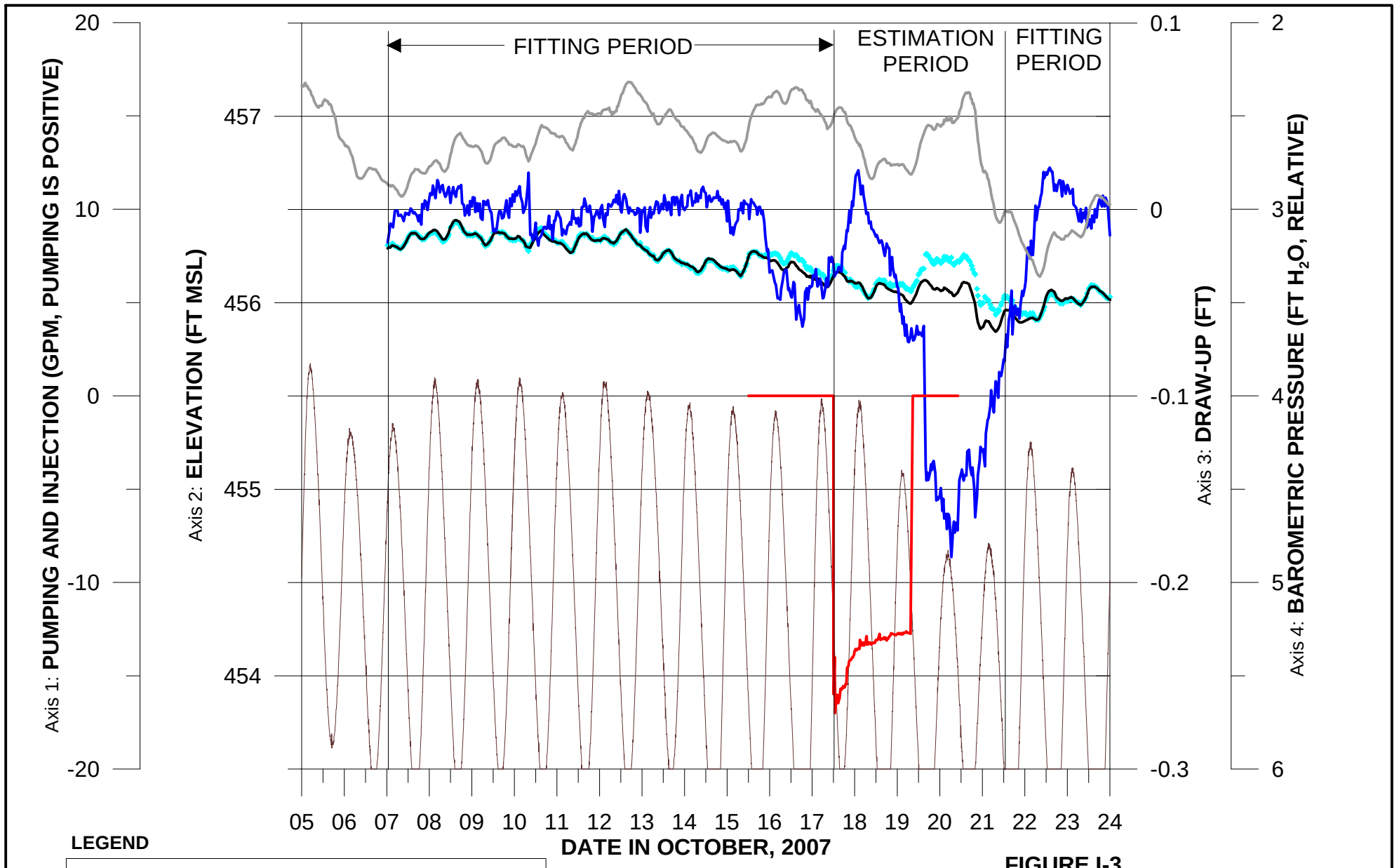


FIGURE I-3
DECONVOLUTION OF MW-24A RESPONSE DURING OCTOBER 2007 PGE-08 INJECTION TEST

SUMMARY REPORT FOR HYDRAULIC TESTING IN BEDROCK WELLS
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

\\odin\proj\topock\deconvolution\Figures\New_Injection_Results_Dec19\

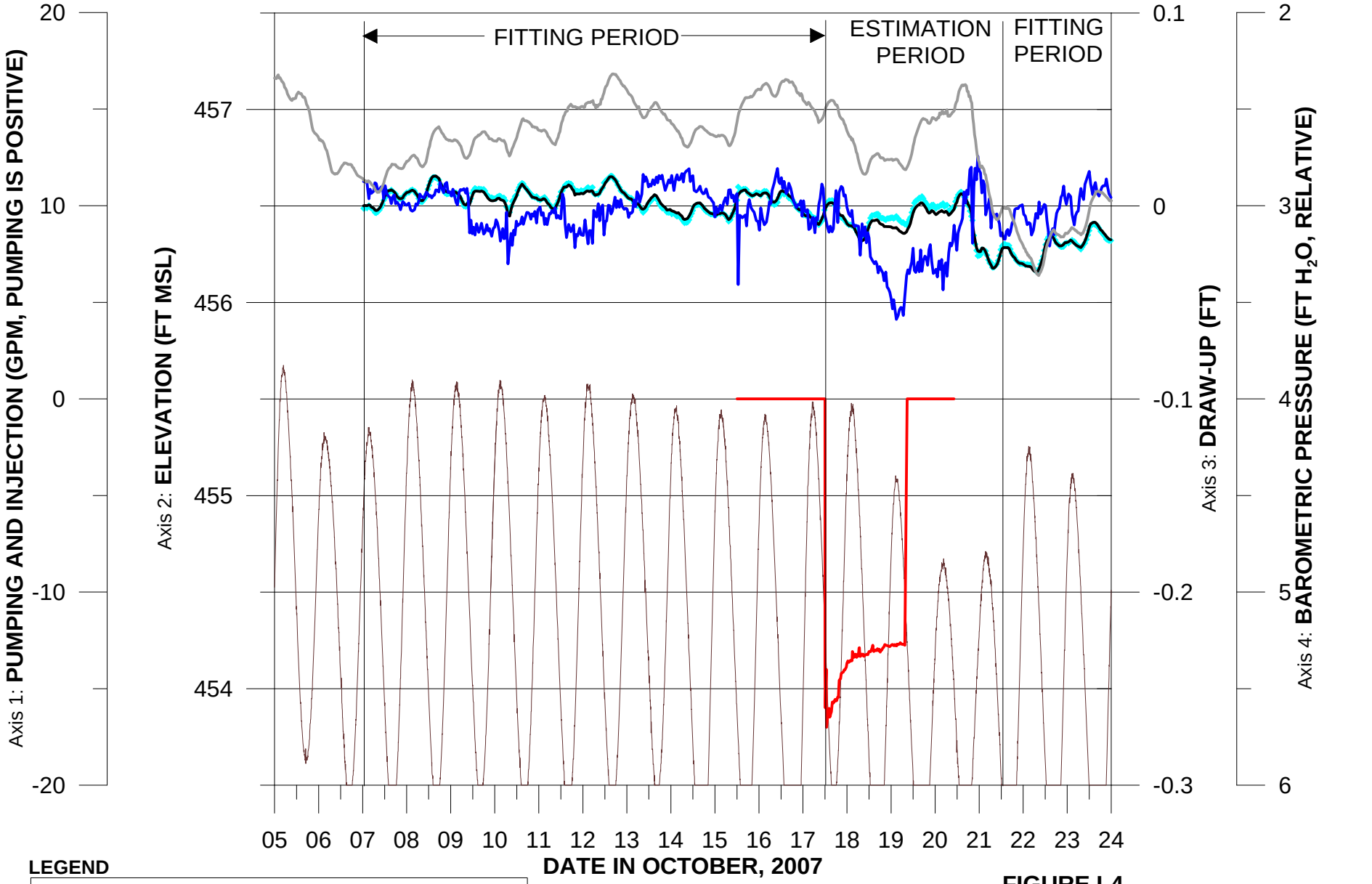


FIGURE I-4
DECONVOLUTION OF MW-24B RESPONSE DURING OCTOBER 2007 PGE-08 INJECTION TEST
SUMMARY REPORT FOR HYDRAULIC TESTING IN BEDROCK WELLS
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

\\odin\proj\topock\deconvolution\Figures\New_Injection_Results_Dec19\

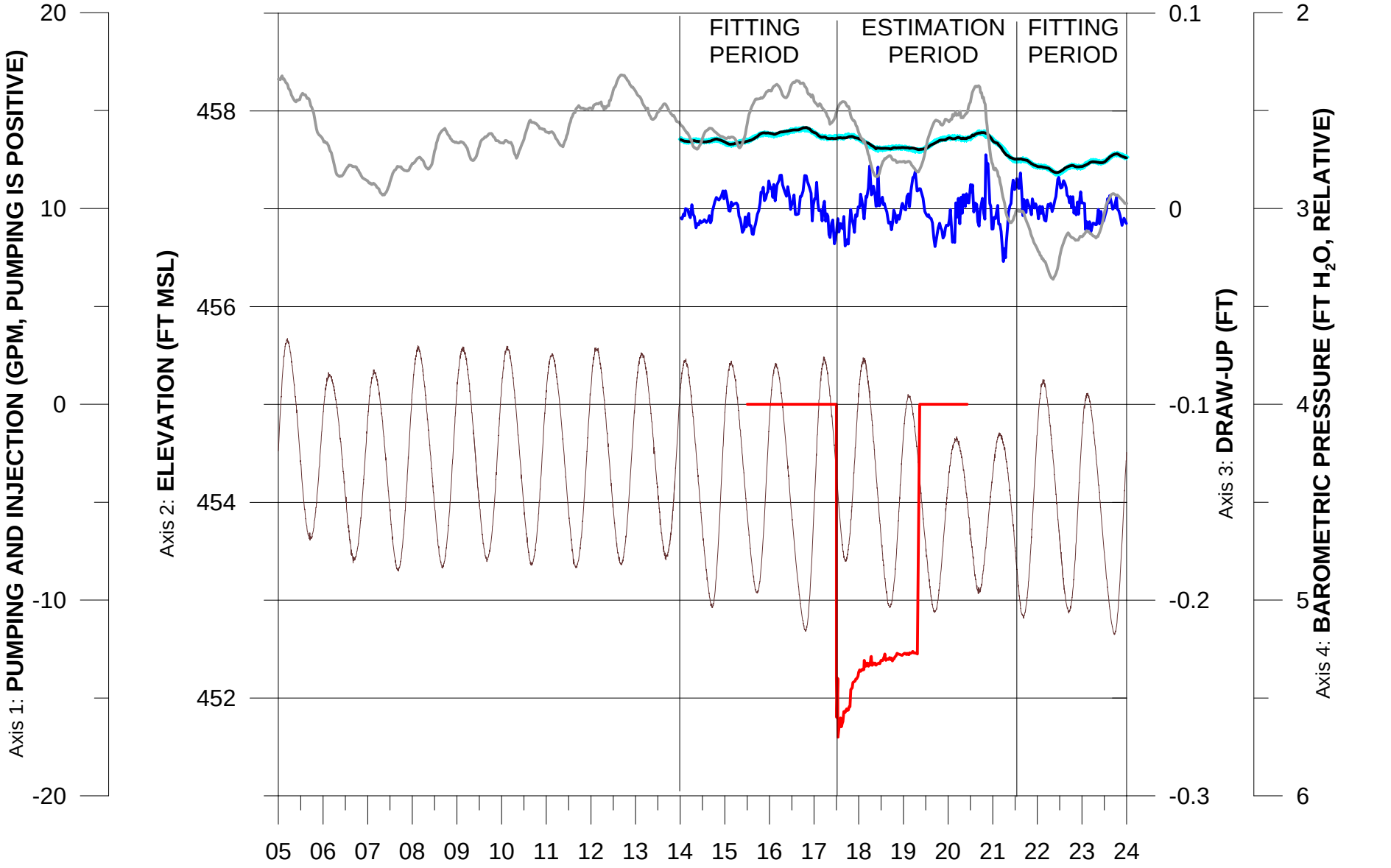


FIGURE I-5
DECONVOLUTION OF MW-24BR RESPONSE DURING OCTOBER 2007 PGE-08 INJECTION TEST
SUMMARY REPORT FOR HYDRAULIC TESTING IN BEDROCK WELLS
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

\\odin\proj\topock\deconvolution\Figures\New_Injection_Results_Dec19\

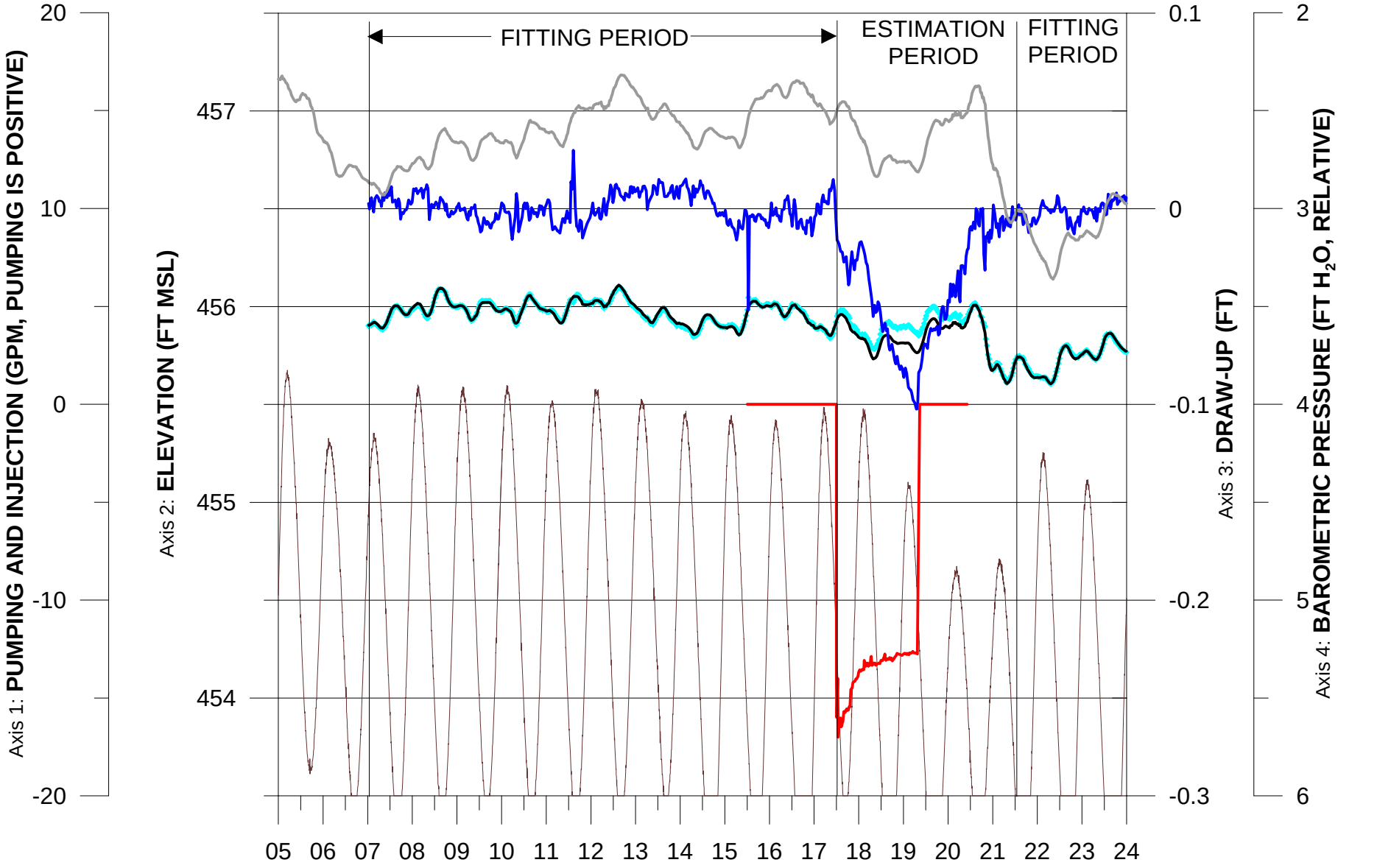


FIGURE I-6
DECONVOLUTION OF MW-38D RESPONSE DURING OCTOBER 2007 PGE-08 INJECTION TEST
SUMMARY REPORT FOR HYDRAULIC TESTING IN BEDROCK WELLS
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

\\odin\proj\topock\deconvolution\Figures\New_Injection_Results_Dec19\

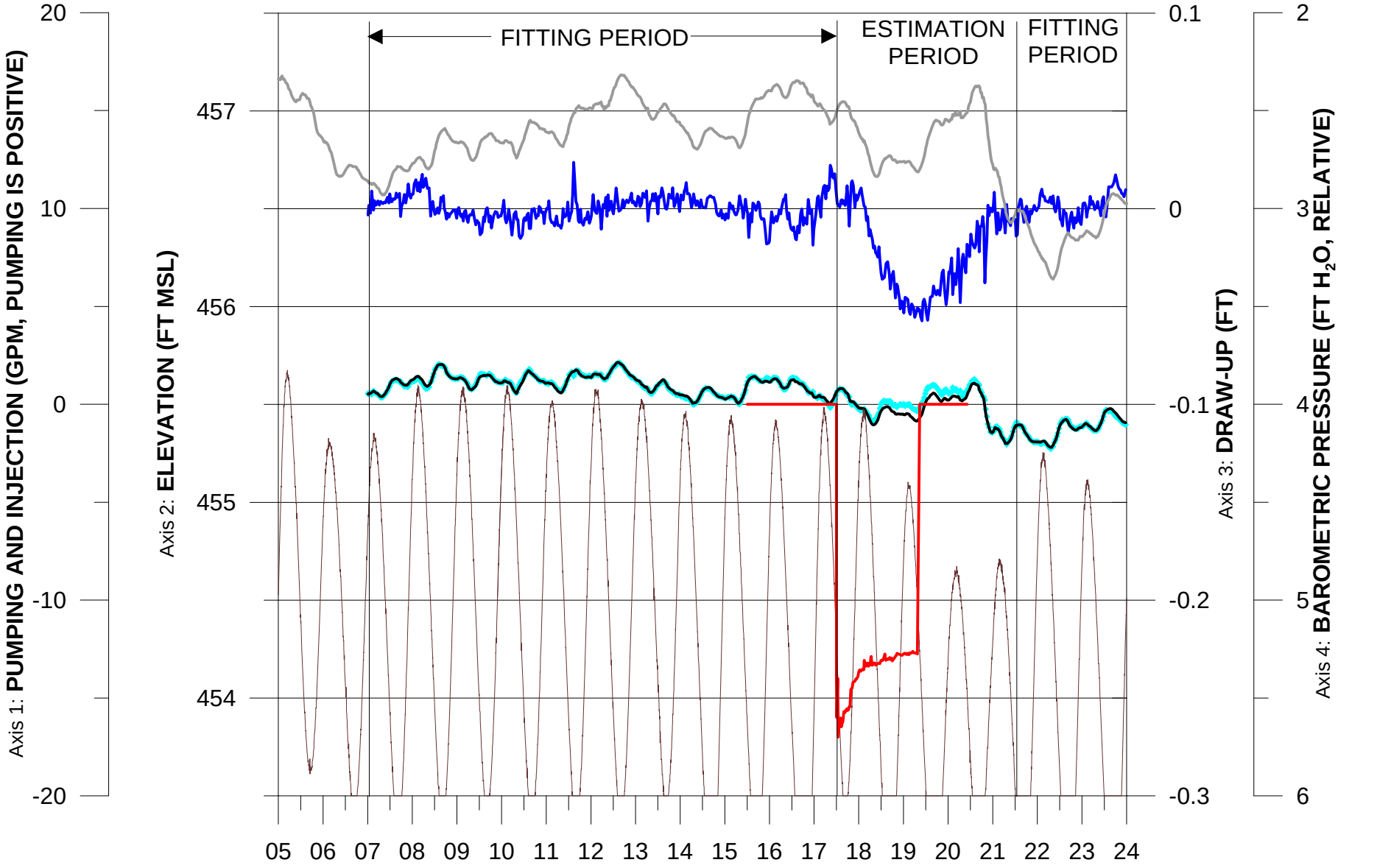


FIGURE I-7
DECONVOLUTION OF MW38S RESPONSE DURING OCTOBER 2007 PGE-08 INJECTION TEST
SUMMARY REPORT FOR HYDRAULIC TESTING IN BEDROCK WELLS
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

\\odin\proj\topock\deconvolution\Figures\New_Injection_Results_Dec19\

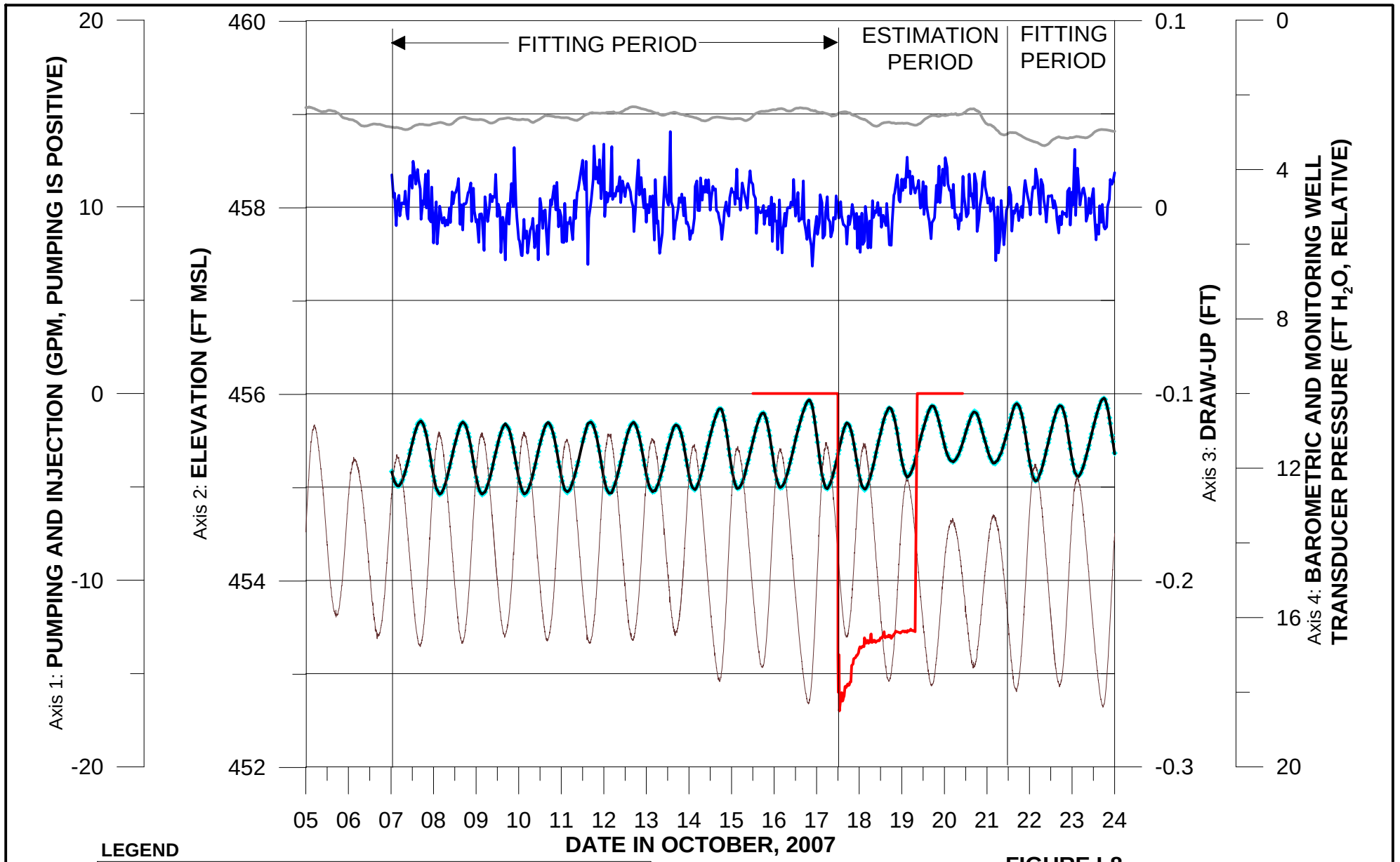


FIGURE I-8
DECONVOLUTION OF MW-52D RESPONSE DURING OCTOBER 2007 PGE-08 INJECTION TEST

SUMMARY REPORT FOR HYDRAULIC TESTING IN BEDROCK WELLS
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

\\odin\proj\topock\deconvolution\Figures\New_Injection_Results_Dec19\

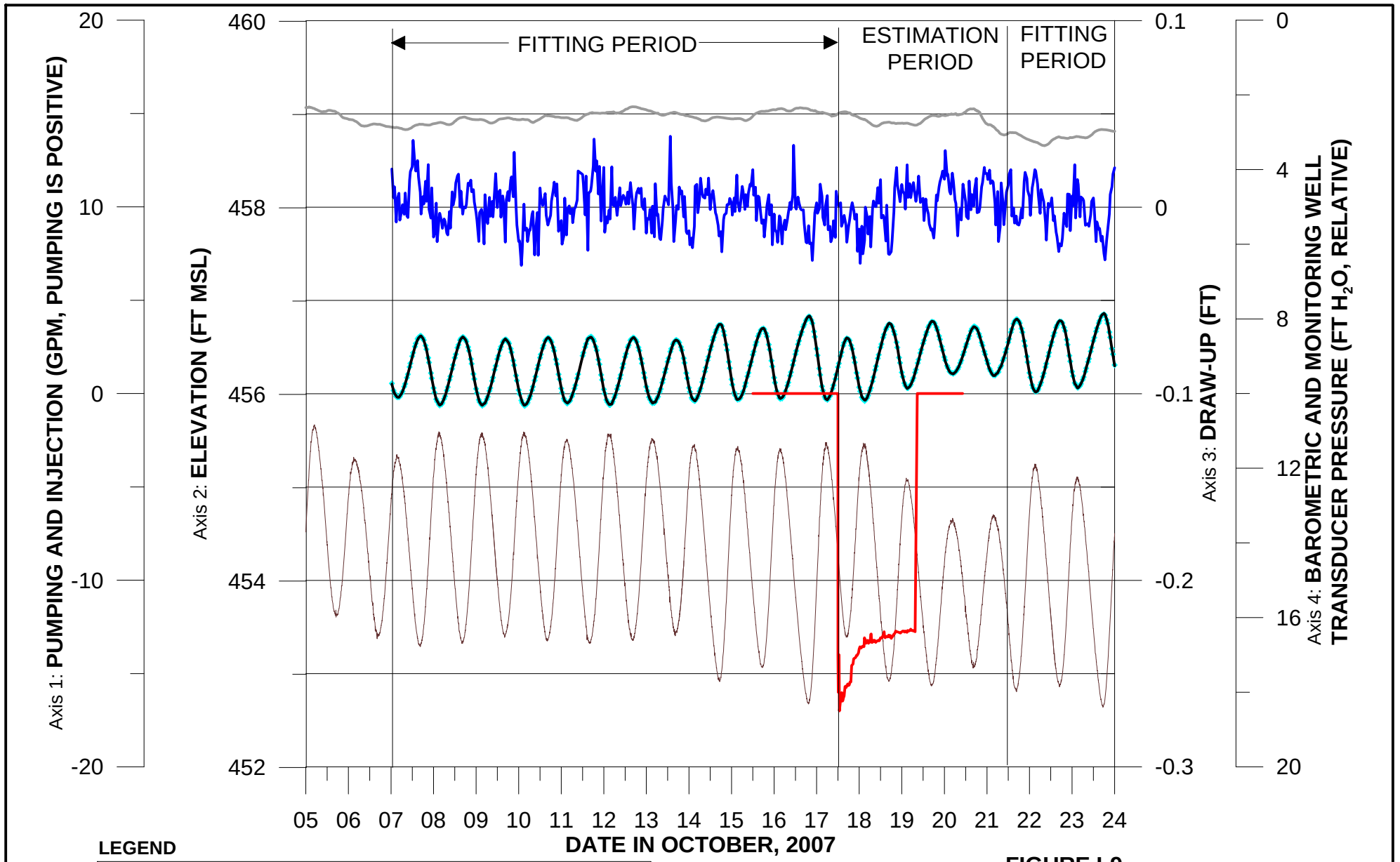


FIGURE I-9
DECONVOLUTION OF MW-52M RESPONSE DURING OCTOBER 2007 PGE-08 INJECTION TEST

SUMMARY REPORT FOR HYDRAULIC TESTING IN BEDROCK WELLS
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

\\odin\proj\topock\deconvolution\Figures\New_Injection_Results_Dec19\

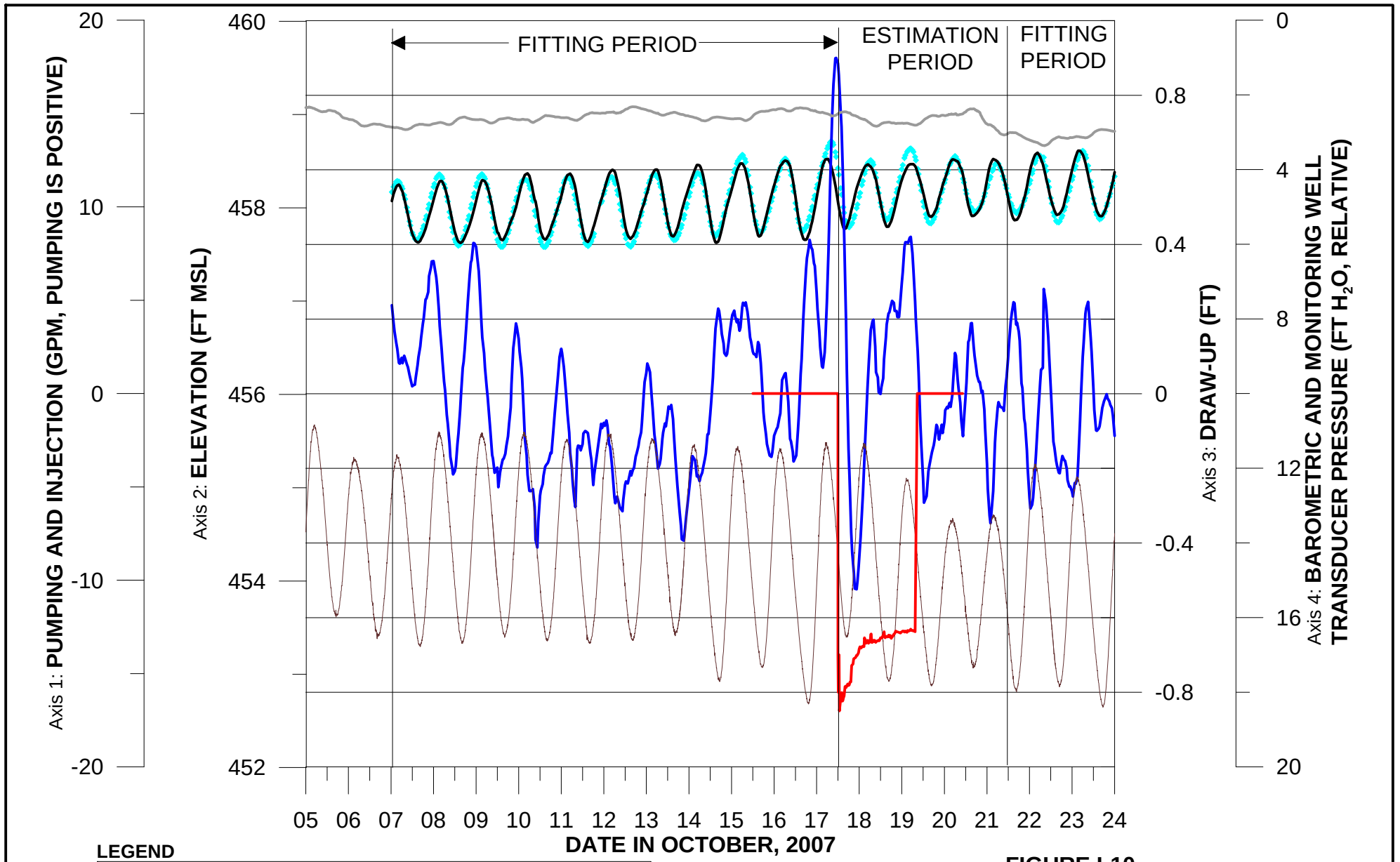


FIGURE I-10
DECONVOLUTION OF MW-53D RESPONSE DURING OCTOBER 2007 PGE-08 INJECTION TEST

SUMMARY REPORT FOR HYDRAULIC TESTING IN BEDROCK WELLS
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

\\odin\proj\topock\deconvolution\Figures\New_Injection_Results_Dec19\

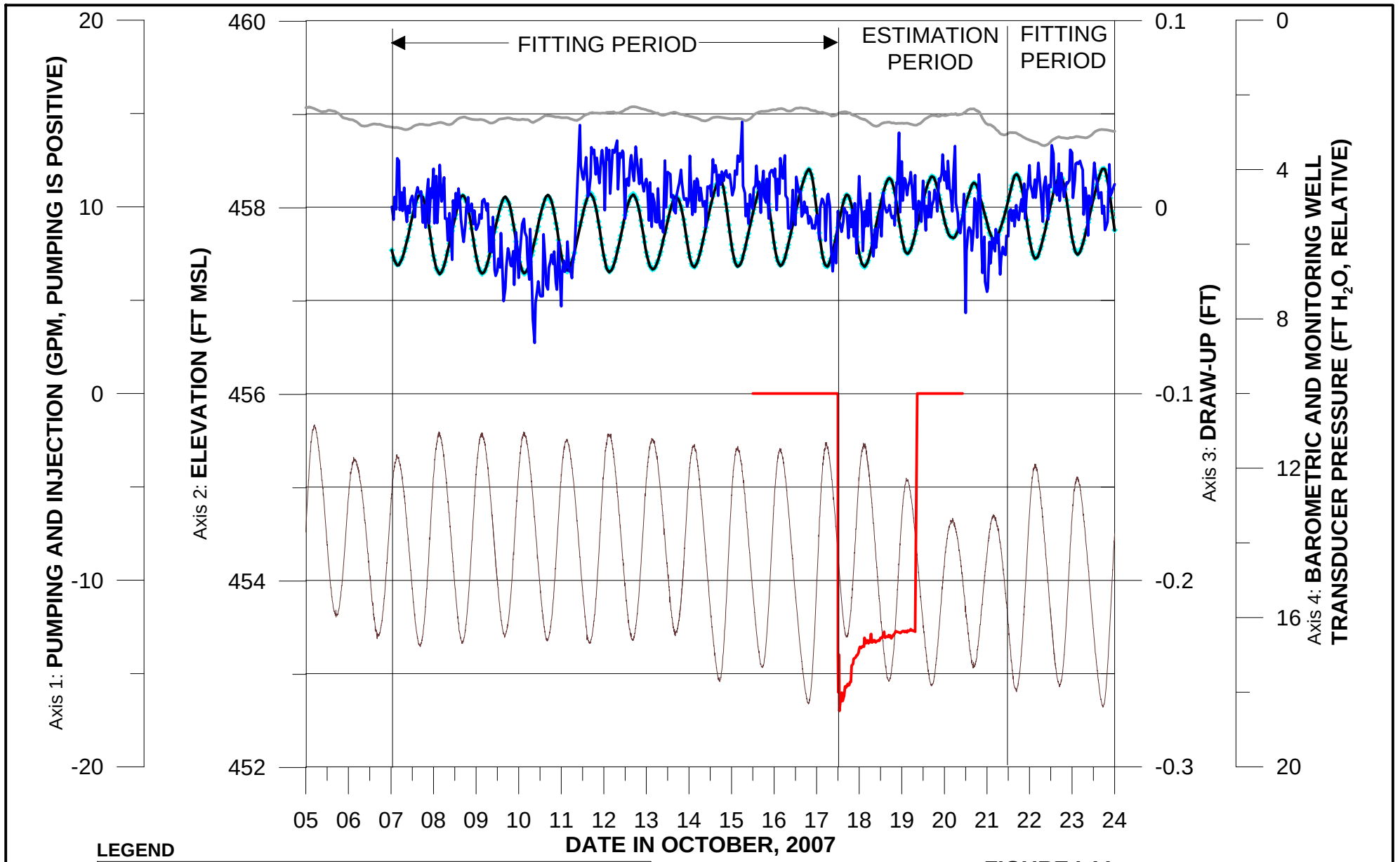
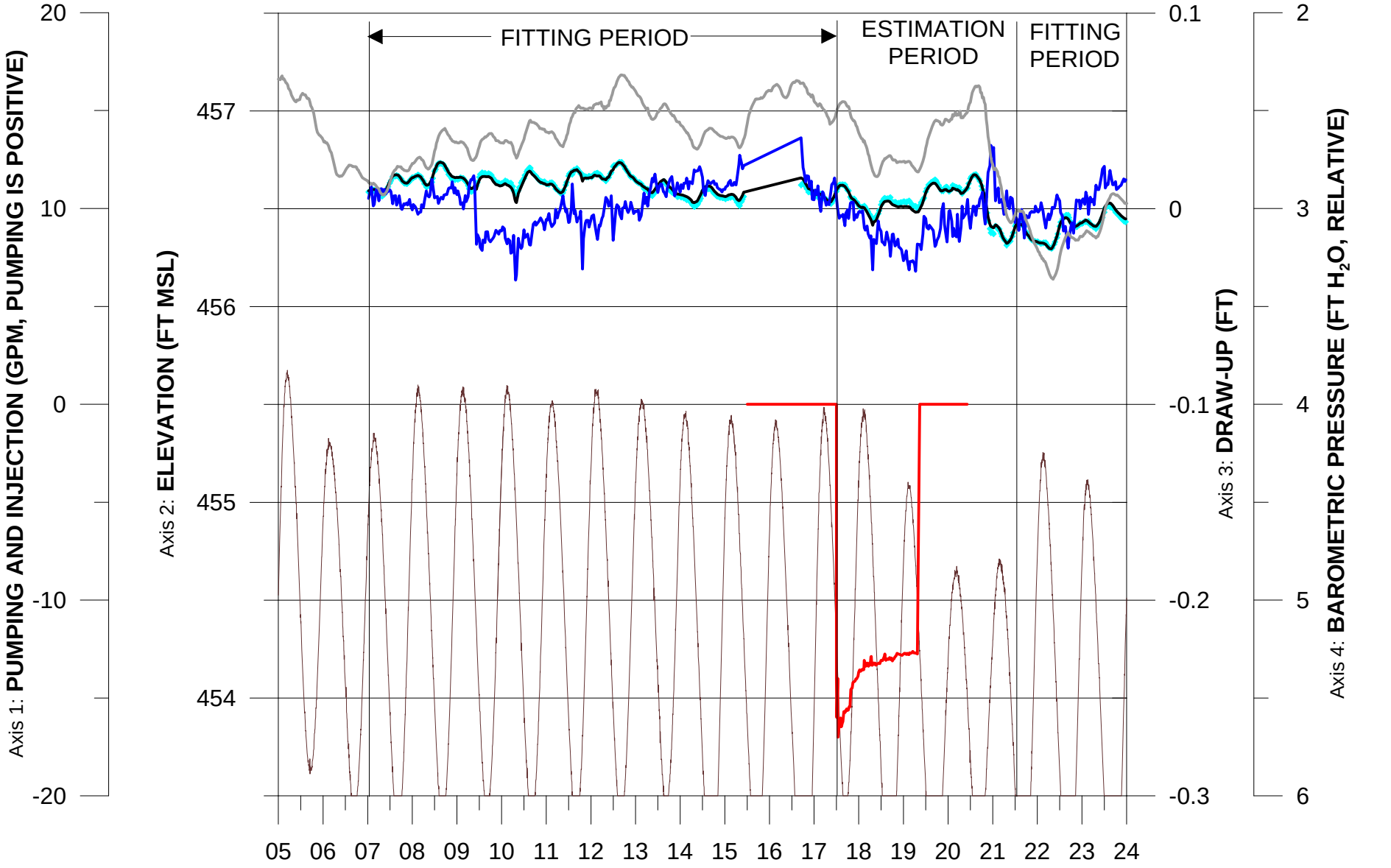


FIGURE I-11
DECONVOLUTION OF MW-53M RESPONSE DURING OCTOBER 2007 PGE-08 INJECTION TEST

SUMMARY REPORT FOR HYDRAULIC TESTING IN BEDROCK WELLS
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

\\odin\proj\topock\deconvolution\Figures\New_Injection_Results_Dec19\



LEGEND

- PGE-08 Pumping/Injection (Axis 1)
- Measured Head At Observation Well (Axis 2)
- Synthetic Head At Observation Well (Axis 2)
- I-3 (Colorado River) (Axis 2)
- Drawdown (-up) At Observation Well (Axis 3)
- Barometric Pressure (Axis 4)

FIGURE I-12
DECONVOLUTION OF PGE-07 RESPONSE DURING OCTOBER 2007 PGE-08 INJECTION TEST
SUMMARY REPORT FOR HYDRAULIC TESTING IN BEDROCK WELLS
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

\\odin\proj\topock\deconvolution\Figures\New_Injection_Results_Dec19\

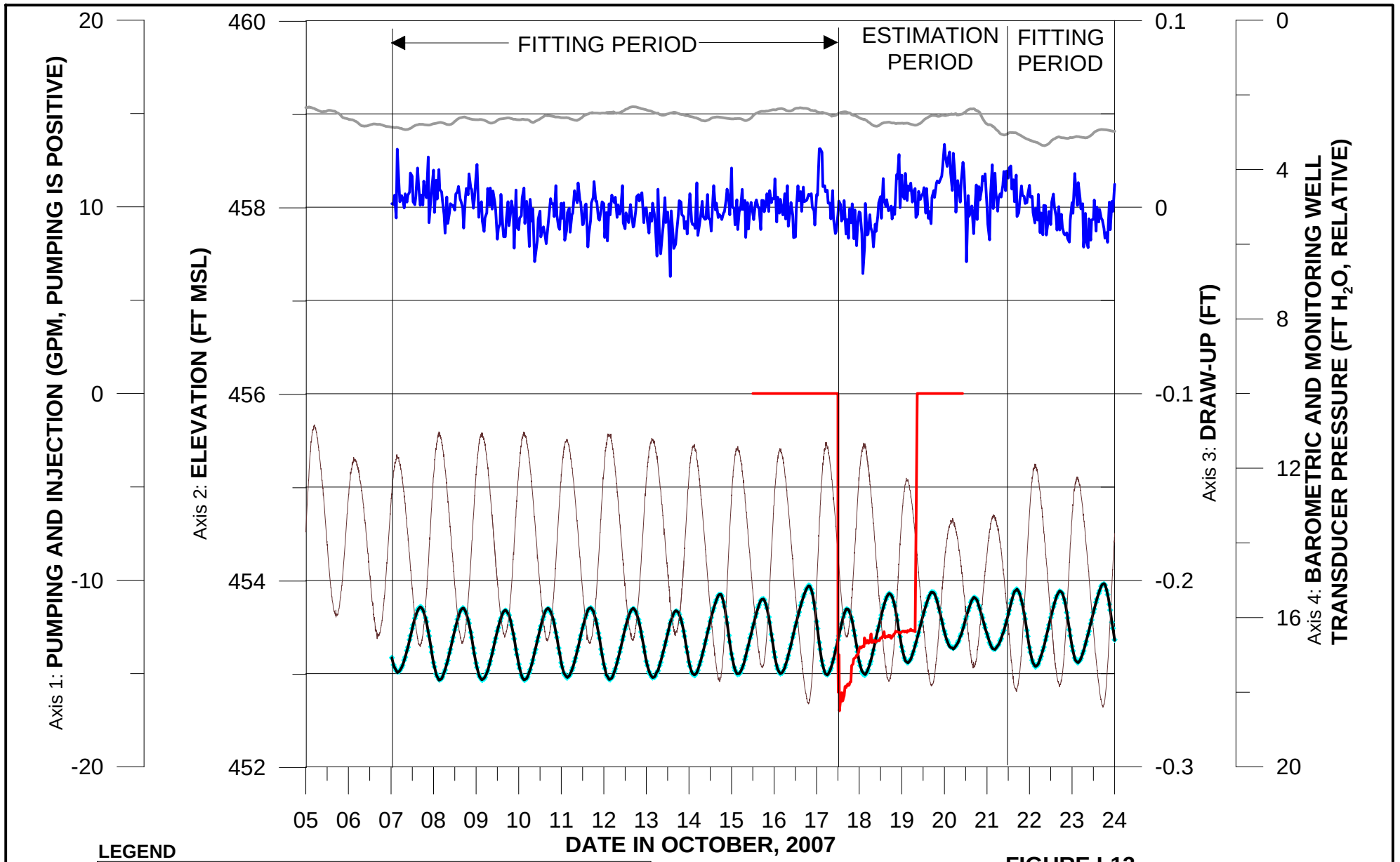


FIGURE I-13
DECONVOLUTION OF PGE-09N RESPONSE DURING OCTOBER 2007 PGE-08 INJECTION TEST

SUMMARY REPORT FOR HYDRAULIC TESTING IN BEDROCK WELLS
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

\\odin\proj\topock\deconvolution\Figures\New_Injection_Results_Dec19\

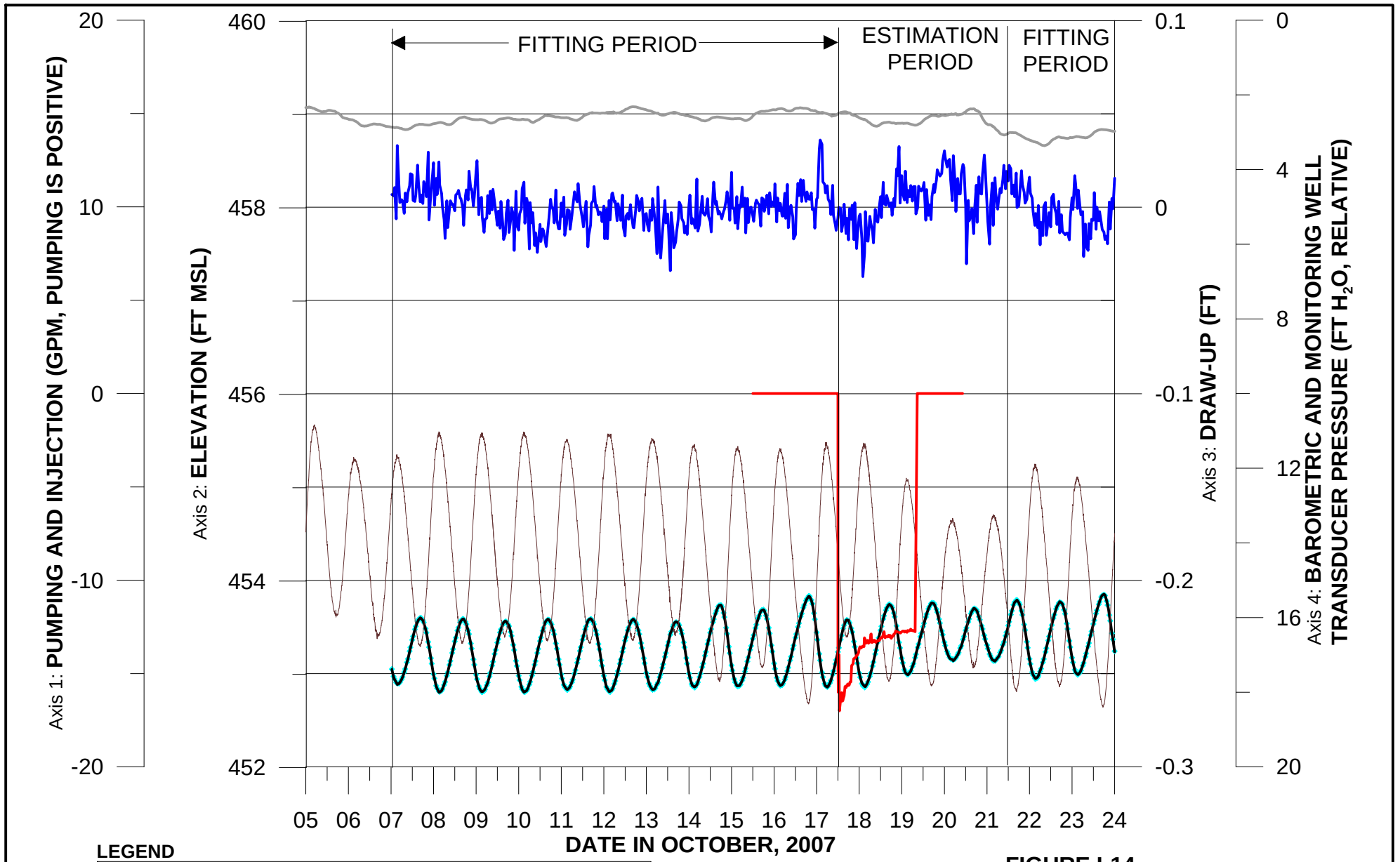


FIGURE I-14
DECONVOLUTION OF PGE-09S RESPONSE DURING OCTOBER 2007 PGE-08 INJECTION TEST

SUMMARY REPORT FOR HYDRAULIC TESTING IN BEDROCK WELLS
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

\\odin\proj\topock\deconvolution\Figures\New_Injection_Results_Dec19\

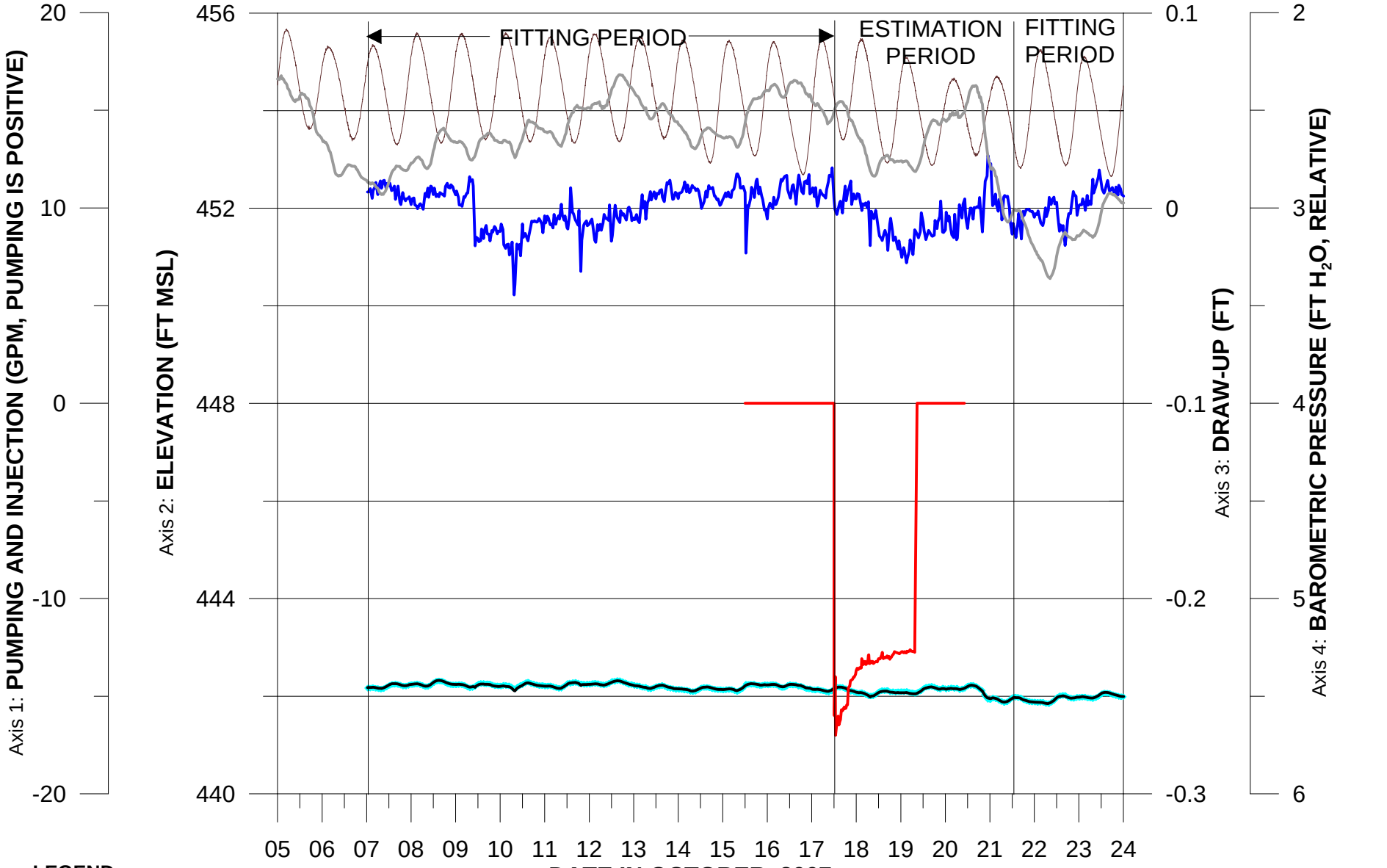


FIGURE I-15
DECONVOLUTION OF PT7M RESPONSE DURING OCTOBER 2007 PGE-08 INJECTION TEST
SUMMARY REPORT FOR HYDRAULIC TESTING IN BEDROCK WELLS
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

\\odin\proj\topock\deconvolution\Figures\New_Injection_Results_Dec19\

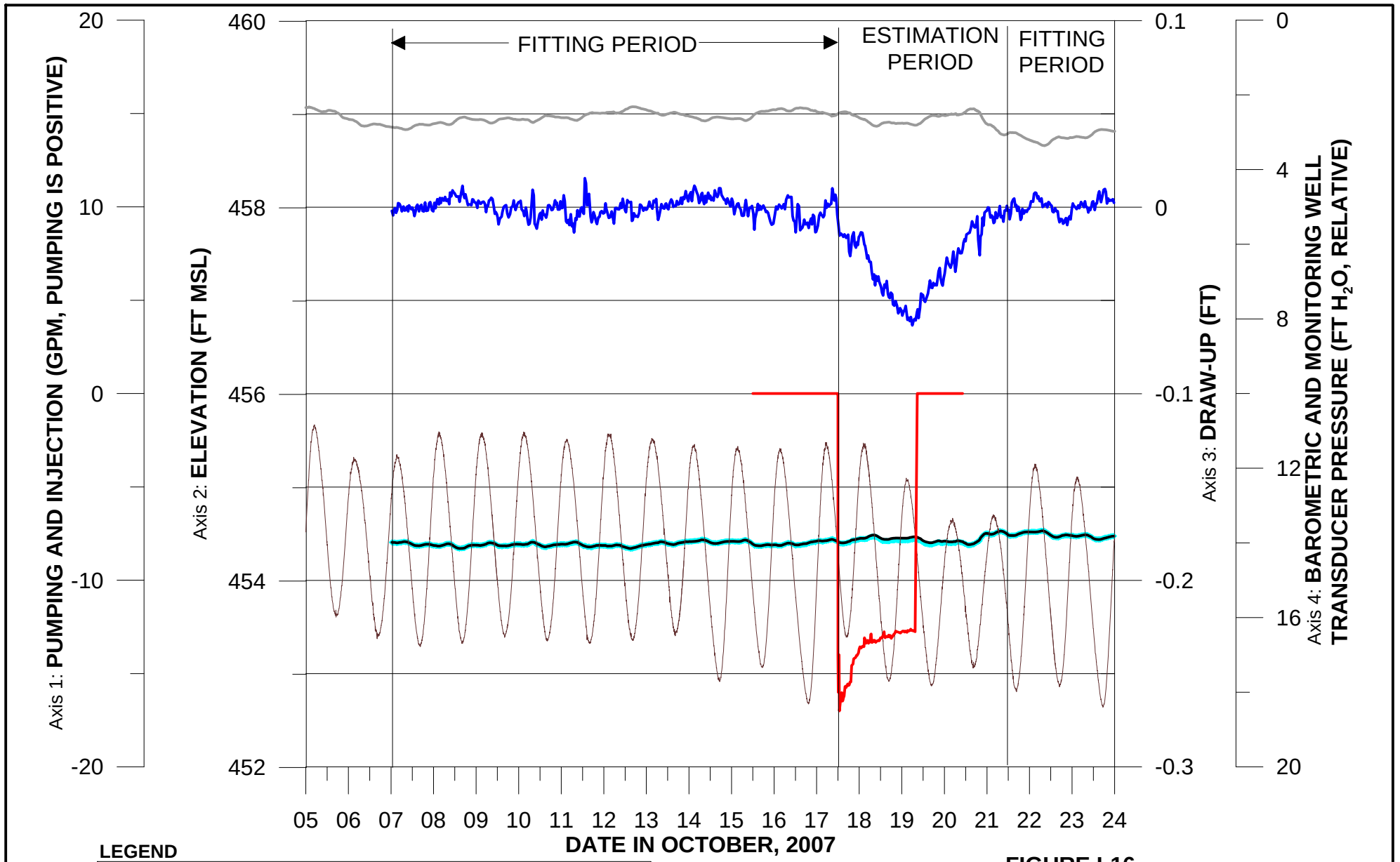


FIGURE I-16
DECONVOLUTION OF PT8D RESPONSE DURING OCTOBER 2007 PGE-08 INJECTION TEST
SUMMARY REPORT FOR HYDRAULIC TESTING IN BEDROCK WELLS
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

\\odin\proj\topock\deconvolution\Figures\New_Injection_Results_Dec19\

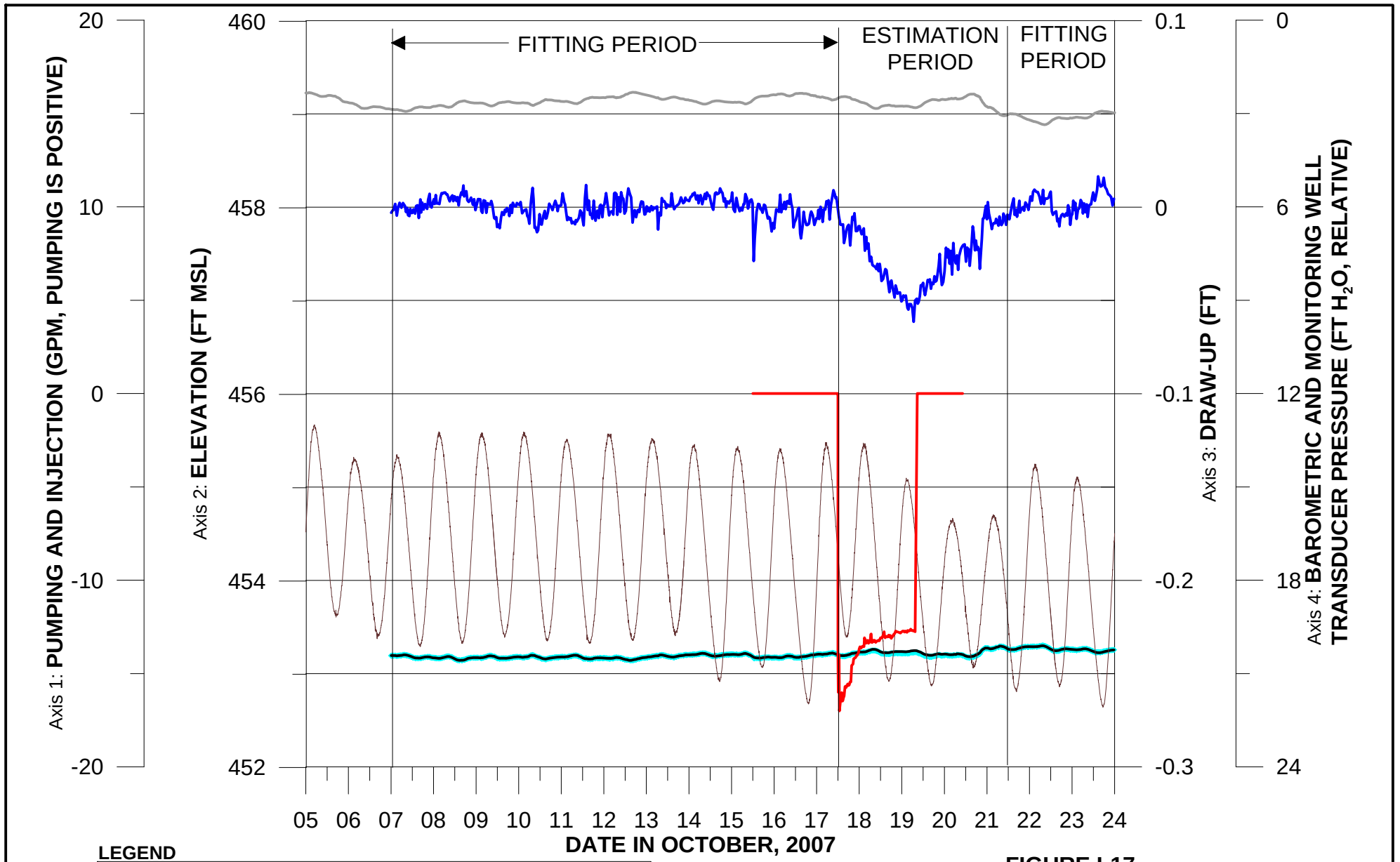


FIGURE I-17
DECONVOLUTION OF PT8M RESPONSE DURING OCTOBER 2007 PGE-08 INJECTION TEST

SUMMARY REPORT FOR HYDRAULIC TESTING IN BEDROCK WELLS
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

\\odin\proj\topock\deconvolution\Figures\New_Injection_Results_Dec19\

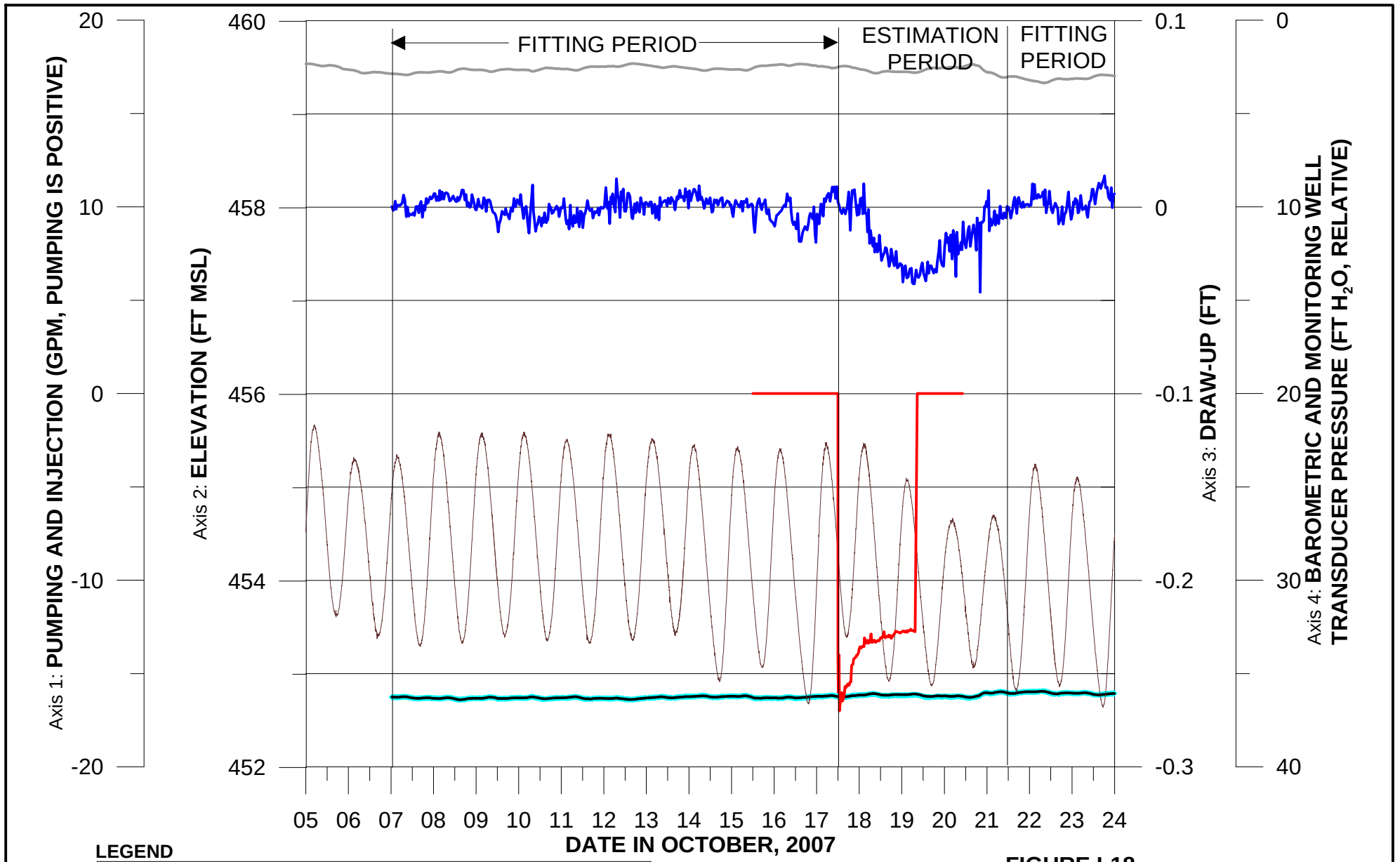


FIGURE I-18
DECONVOLUTION OF PT8S RESPONSE DURING OCTOBER 2007 PGE-08 INJECTION TEST
SUMMARY REPORT FOR HYDRAULIC TESTING IN BEDROCK WELLS
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

\\odin\proj\topock\deconvolution\Figures\New_Injection_Results_Dec19\

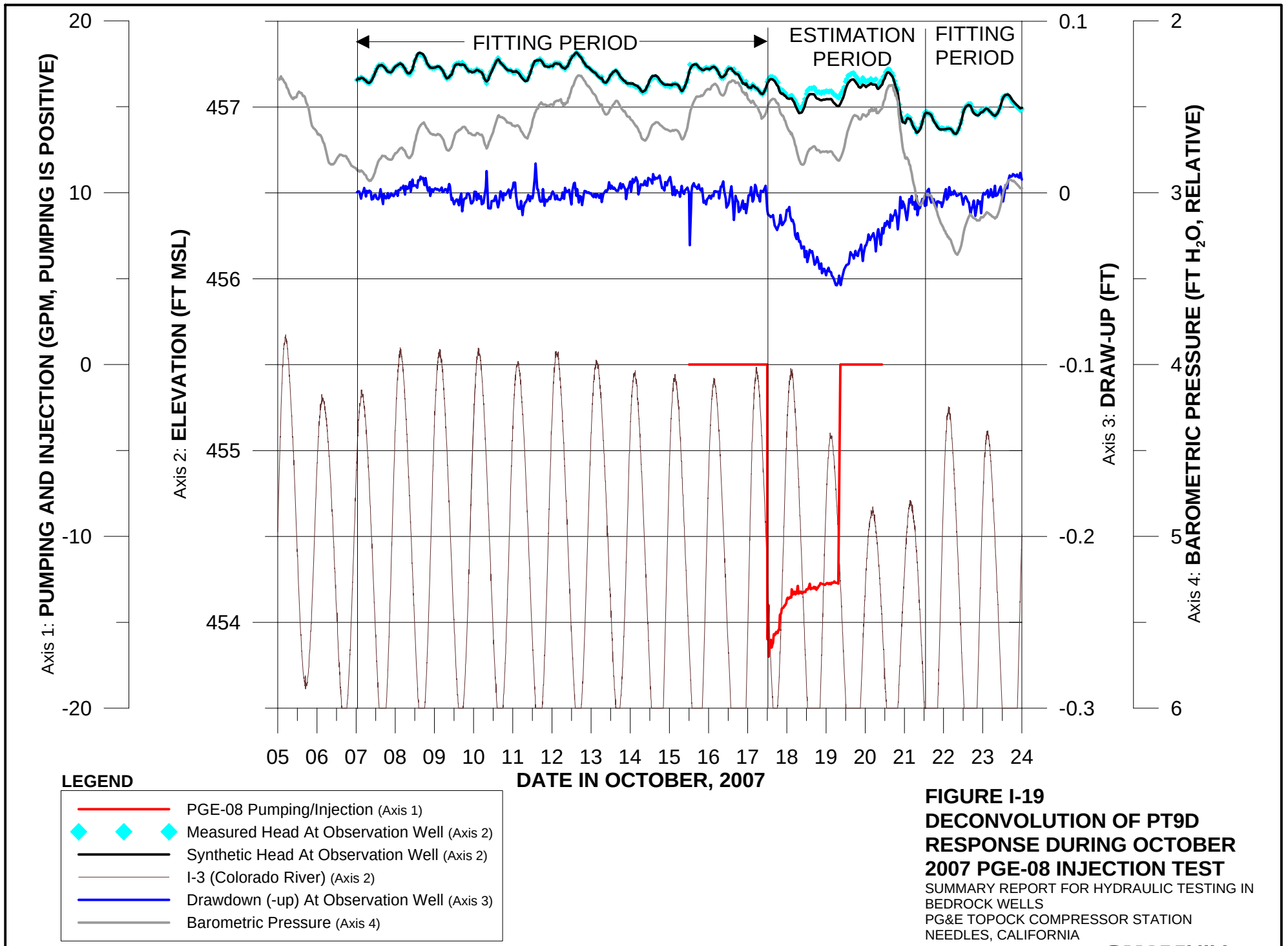


FIGURE I-19
DECONVOLUTION OF PT9D RESPONSE DURING OCTOBER 2007 PGE-08 INJECTION TEST
SUMMARY REPORT FOR HYDRAULIC TESTING IN BEDROCK WELLS
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

\\odin\proj\topock\deconvolution\Figures\New_Injection_Results_Dec19\

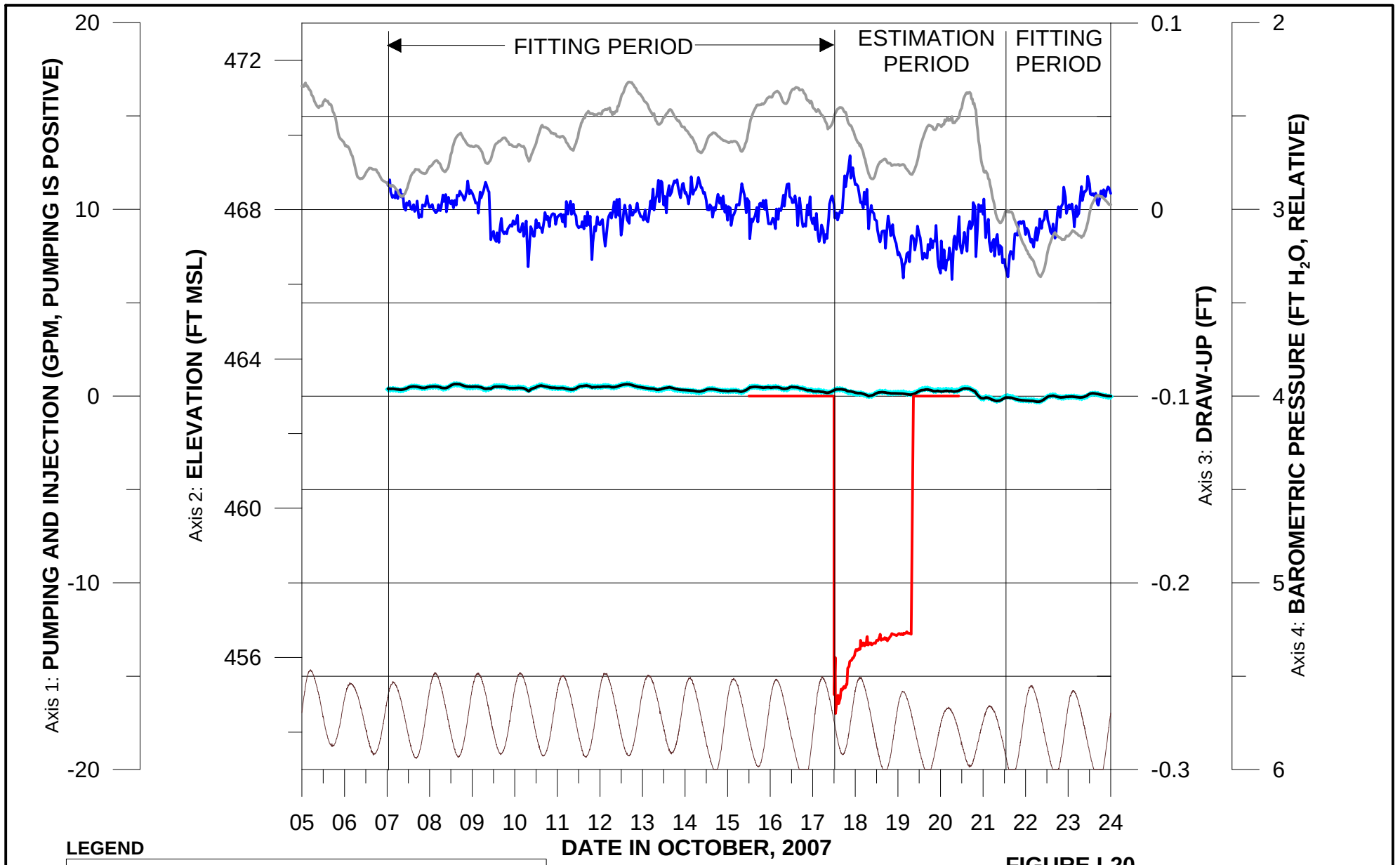


FIGURE I-20
DECONVOLUTION OF PT9M RESPONSE DURING OCTOBER 2007 PGE-08 INJECTION TEST
SUMMARY REPORT FOR HYDRAULIC TESTING IN BEDROCK WELLS
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

\\odin\proj\topock\deconvolution\Figures\New_Injection_Results_Dec19\

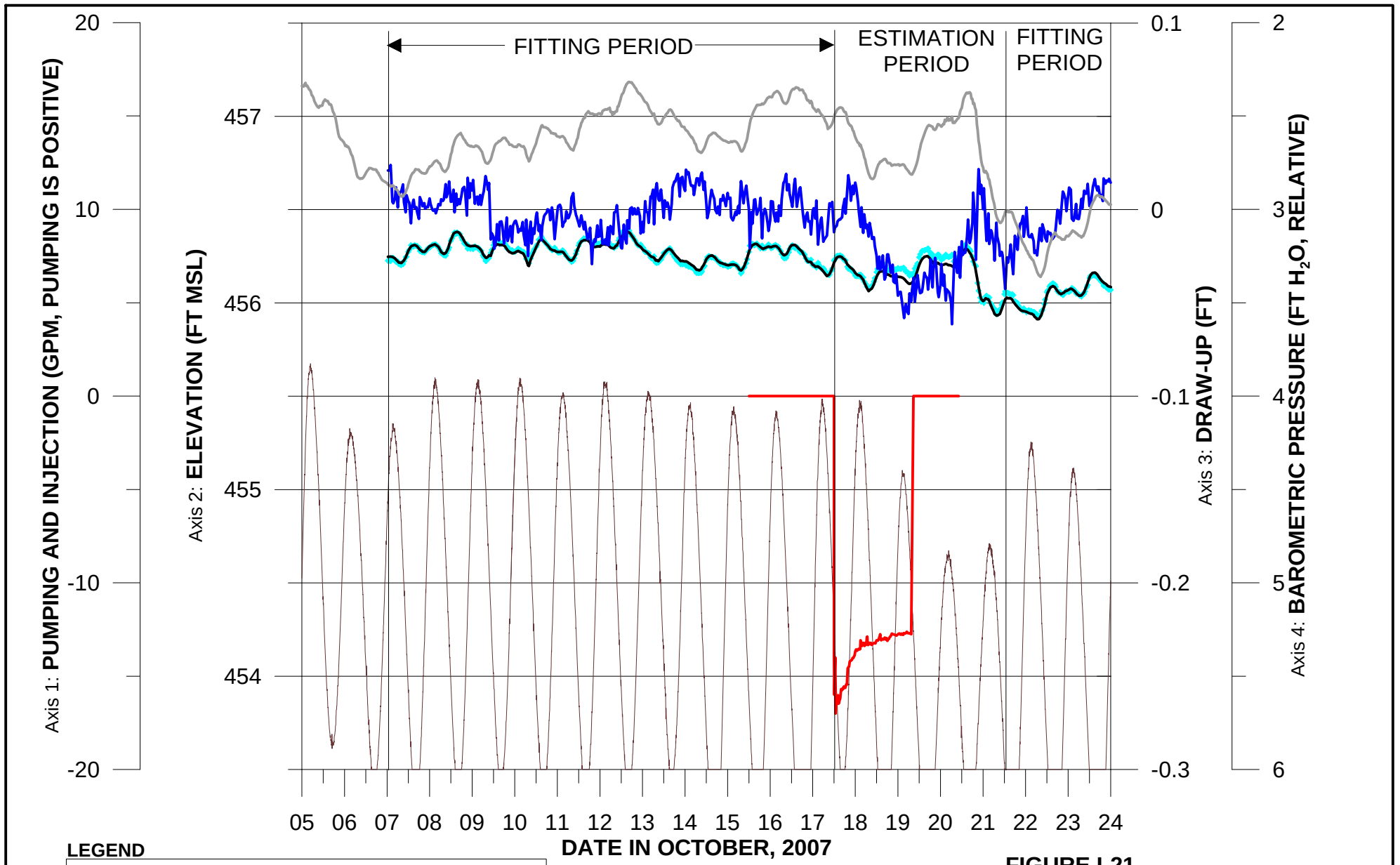


FIGURE I-21
DECONVOLUTION OF TW-01 RESPONSE DURING OCTOBER 2007 PGE-08 INJECTION TEST
SUMMARY REPORT FOR HYDRAULIC TESTING IN BEDROCK WELLS
PG&E TOPOCK COMPRESSOR STATION
NEEDLES, CALIFORNIA

CH2MHILL

\\odin\proj\topock\deconvolution\Figures\New_Injection_Results_Dec19\

Appendix J
Water Quality Measurements During Pump Testing

TABLE J-1
Results of Groundwater Analyses from PGE-8 Pump Testing, August 2007
Summary Report for Hydraulic Testing in Bedrock Wells
PG&E Topock Compressor Station

		Sample ID:	PGE-08	PGE-08 (FD)	PGE-08	PGE-08	PGE-08	PGE-08 (FD)	PGE-08	PGE-08	PGE-08	PGE-08 (FD)	PGE-08	PGE-08	PGE-08	PGE-08 (FD)	PGE-08
		Date:	8-8-07	8-8-07	8-8-07	8-8-07	8-9-07	8-9-07	8-9-07	8-9-07	8-10-07	8-10-07	8-10-07	8-10-07	8-11-07	8-11-07	8-11-07
		Time:	12:15 P.M	12:15 P.M	1:30 P.M	2:30 P.M	9:00 A.M	9:00 A.M	11:00 A.M	3:00 P.M	9:00 A.M	9:00 A.M	11:00 A.M	3:00 P.M	9:00 A.M	9:00 A.M	11:00 A.M
Group	**Analyte**	**Units**	**Analytical Results**														
Anion	Chloride	mg/L	5950	---	6060	6030	6300	6190	6340	6450	6280	6410	6390	7330	6530	6570	6610
	Nitrate as Nitrogen	mg/L	ND (1.0)	---	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
	Sulfate	mg/L	2270	---	2230	2170	1710	1670	1690	1640	1480	1500	1490	1980	1480 J	1290 J	1280
General	Alkalinity, as carbonate	mg/L	ND (5.0)	---	ND (5.0)	5.00	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)	ND (5.0)
	Alkalinity, bicarb as CaCO3	mg/L	45.0	---	40.0	35.0	37.5	40.0	37.5	35.0	42.5	40.0	40.0	40.0	40.0	37.5	40.0
	Alkalinity, total as CaCO3	mg/L	45.0	---	40.0	40.0	37.5	40.0	37.5	35.0	42.5	40.0	40.0	40.0	40.0	37.5	40.0
	pH	PHUNITS	8.35 J	---	8.29 J	8.32 J	8.42 J	8.44 J	8.40 J	8.38 J	8.23 J	8.41 J	8.44 J	8.45 J	8.30 J	8.45 J	8.46 J
	Specific conductance	µS/cm	18200	---	18400	18200	18900	19000	19000	18800	19200	19200	18300	17000	18200	19500	18000
	Total dissolved solids	mg/L	12200	---	11700	12500	13100	13200	13100	13100	12600	13200	13500	12900	13000	12900	12500
	Total Kjeldahl Nitrogen	mg/L	3.68	---	3.30	3.33	2.79	2.27	2.53	2.26	2.33	2.25	2.38	2.33	2.39	2.39	2.23
	Total organic carbon	mg/L	1.42	1.46	1.38	1.34	0.897	0.86	0.872	0.827	0.866	0.519	0.655	0.535	0.429	0.389	0.383
	Turbidity	NTU	0.642	---	0.64	0.697	0.386	0.484	0.637	0.418	0.444	0.399	0.355	0.483	0.525 J	0.298 J	0.448
Metals (Dissolved)	Chromium, dissolved	µg/L	2.80	---	3.20	2.80	ND (1.0)	ND (1.0)	1.90	ND (1.0)	1.50	1.30	1.40	1.30	2.40 J	ND (1.0)J	ND (1.0)
	Hexavalent chromium	µg/L	ND (1.0)	---	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)	ND (1.0)
	Manganese, dissolved	µg/L	371	---	596	730	850	869	748	753	1280	1190	999	---	818	776	739
	Calcium, dissolved	mg/L	556	---	550	594	819	808	788	617	401	388	376	---	336	306	327
	Iron, dissolved	mg/L	0.371	---	0.258	0.274	0.133	0.126	0.111	ND (0.02)	0.146	0.147	0.0882	---	0.0883	0.0841	0.0802
	Magnesium, dissolved	mg/L	16.6	---	18.6	17.4	17.5	22.0	24.2	17.2	19.1	24.8	24.4	---	15.4	13.8	20.7
	Potassium, dissolved	mg/L	75.6	---	61.2	79.5	99.7	102	80.1	67.7	49.6	54.9	59.4	---	41.1	36.6	64.7
	Sodium, dissolved	mg/L	3050	---	2940	3120	4300	4130	3480	4870	2510	2700	3030	---	3250	3270	3480

Notes:

ND	parameter not detected at the listed reporting limit (listed in the adjacent parenthesis)
J	analyte was present but reported value is estimated
FD	field duplicate
---	data not collected or not available

µg/L	micrograms per liter
mg/L	milligrams per liter
NTU	nephelometric turbidity units
µS/cm	microSiemens per centimeter

Dissolved Metals were either lab filtered or field filtered, analyzed by SW6010B or SW6020A.

Appendix K
CD with Deconvolution Files