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Aquifer Testing and Dewatering Analysis
Heitz Trucking
4919 Tidewater Avenue, Unit B
Oakland, California

Prepared for

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EXECUTIVE SUMMARY

Applied Remedial Technologies, Inc. (ART) has conducted a Hydrogeologic Assessment that included a groundwater aquifer test and performance of construction dewatering analysis for Heitz Trucking (formerly DiSalvo Trucking) facility located at 4919 Tidewater Avenue, Oakland, California (Site). This assessment was conducted to obtain a better understanding of the aquifer properties of the underlying subsurface material. Results of this assessment will be used in the preparation of the Final Design which may include excavation and dewatering activities as part of remediation to be conducted at the Site.

Soil borings from previous onsite environmental investigations indicate the area beneath the Site was likely filled to create land and lift the surface roughly 5 feet above the high tide line (Gentech, *1994 Soil and Groundwater Investigation*). The underlying artificial fill material is comprised primarily of gravel and sand which may contain debris such as concrete or asphalt as well as silt and clay. The fill is underlain by organic clay with thin interbeds of organic or plant material (Bay Mud). The isopach map shows the estimated thickness of the artificial fill where the base of the fill is defined as the top of the clay material. The clay unit forms a sort of bowl with the thickness of the fill material increasing to the north-east, varying from about 1.5 feet near the southern corner and 4 to 5 feet along the north property boundary to greater than 9 feet along Tidewater Avenue (ERAS, *2006 Report of Environmental Investigations*).

A constant-rate aquifer test was performed using well EW-1 to estimate the aquifer parameters of the subsurface fill materials. These aquifer parameters were then used to construct a numerical groundwater flow model to evaluate several dewatering alternatives and simulate the response of the aquifer system to the recommended dewatering alternative. The model was calibrated to a transient condition by simulating the EW-1 constant-rate aquifer test. Following the non-pumping (steady state) simulation and transient calibration of the model, dewatering conditions were simulated by lowering the water table to the bottom of the fill material, which is the proposed excavation depth at the site (except in the vicinity of the former UST area), using a combination of perimeter and internal dewatering wells. These dewatering wells were assumed to be installed in a manner such that the bottom of each of the proposed dewatering wells is expected to lie 5 feet within the bay mud underlying the fill material (well completion depth varying from approximately 8 to 14 feet below ground surface (bgs) for the varying fill material depth of approximately 3 to 9 feet, respectively). The procedures and conclusions from our aquifer testing activities and construction dewatering analysis for the proposed remediation activities can be summarized as follows:

- A constant-rate aquifer test was performed on well EW-1 to estimate the aquifer parameters of the subsurface fill material, and also to determine the extent of hydraulic communication between the fill material and the clay unit/Bay Mud underlying the fill material. EW-1 is an 8-inch diameter well that is screened from a depth of approximately 1 foot to 11 feet bgs. As part of the aquifer testing activities, newly installed observation wells (OB-3, OB-4, OB-5, and OB-6) and some of the existing on-site monitoring wells (MW-2 and MW-3) were monitored electronically to estimate the response of water levels during the aquifer test. Water levels were monitored in the pumping well and observation wells for 48-hours prior to initiating the step drawdown test. Prior to commencement of the constant-rate aquifer test, a step-drawdown test was also performed to assess the sustainable yield of the pumping well for a 48-hour constant-rate pumping test. Based on the results of the step-drawdown test, a 48.5-hour constant-rate pumping test was performed on well EW-1 at a constant discharge rate of 1.91 gallons per minute (gpm). After cessation of the aquifer test, aquifer recovery data was also recorded for the pumping and monitoring wells for a period of 27.5 hours.

- Estimates of T and S_y for the fill material ranged from 50 ft^2/day to 153 ft^2/day, and 0.006 to 0.056, respectively. Assuming a saturated thickness of 7 feet for the fill material, estimates of the hydraulic conductivity (K) ranged from 7 ft/day to 22 ft/day.

- During the duration of the constant-rate aquifer test, no drawdown was observed in observation well OB-5, which is screened only in the Bay Mud and is located approximately 7 feet from the pumping well EW-1. This implies that pumping from the fill material will exhibit minimal or no influence on the groundwater levels in the Bay Mud.

- A groundwater flow model was constructed using the parameters obtained from the aquifer test, site lithologic logs, and groundwater elevations. These aquifer parameters were further modified during the steady state simulation and transient calibration simulation to obtain the final calibrated aquifer parameters that would be used in evaluating and simulating the proposed dewatering system at the Site. The groundwater flow model was calibrated to the transient condition by simulating the EW-1 constant-rate aquifer test. Both the steady state simulation and transient calibration simulation results were found to be representative of the observed site conditions.

- The proposed dewatering system, comprising 47 extraction wells along the perimeter and the interior of the Site, was simulated using the calibrated groundwater flow model. Each of these dewatering wells is proposed to be installed in a manner such that the bottom of each of the proposed dewatering wells is expected to lie only in the top portion of the clay unit which lies beneath the fill material.

Several simulations were performed to evaluate the effectiveness of the proposed dewatering system, and also to evaluate the effects of various aquifer parameters including groundwater levels, storage coefficient, hydraulic conductivity, and hydraulic communication between the zones (represented by the leakance) on the time to dewater the site.

- Results of the dewatering simulation under the Base Simulation condition (initial groundwater levels are assumed at a depth of approximately 1.5 to 2.5 feet bgs at the site and S_y for the fill material is 0.02) indicated that the Site would take approximately 60 days to dewater to bottom of the fill material. As the dewatering results in the drop in groundwater levels at the Site, the extraction rate would decrease from an initial rate of approximately 50 gpm to a stable rate of approximately 0.5 gpm after 60 days.

- As S_y, which is defined as the drainable porosity of the sediments, is the key physical parameter controlling the time required to dewater, dewatering simulations were performed with a range of S_y values so as to understand the impacts of higher S_y on the dewatering of the site. Results of the dewatering simulations indicated that the time required to dewater the fill material (model layer 1) increased significantly when the S_y was increased. For such a condition, additional wells would be required to completely dewater the site within a limited time frame.

- Model sensitivity analysis indicate that changes in the aquifer parameter values of hydraulic conductivity and leakance can result in a significant change in the time required to dewater the site. An increase in hydraulic conductivity and a decrease in leakance values from the final calibrated values will increase the time required to dewater the site significantly. In such a condition, the flow rates of the simulated dewatering wells may need to increased or additional wells may be required to completely dewater the site. However, a decrease in hydraulic conductivity and an increase in leakance values will decrease the time required to dewater the site.

Even though changes in aquifer parameters effects the drawdowns and time to dewater the site, the drawdown results obtained from the Base Simulation was considered most representative because it is based on the calibrated values obtained from the transient calibration model runs, which were further based on the observed behavior of the aquifer during the EW-1 constant rate aquifer test.

1.0 INTRODUCTION

Applied Remedial Technologies, Inc. (ART) was retained by R.W.L. Investments, Inc. to provide hydrogeologic assessment by conducting a groundwater aquifer test and construction dewatering analysis for the Heitz Trucking (formerly DiSalvo Trucking) facility located at 4919 Tidewater Avenue, Oakland, California (Site). The scope of work and the objectives were presented in a proposal by ART dated March 30, 2006. This assessment was conducted to obtain a better understanding of the aquifer properties of the underlying subsurface (fill) material. Results of this assessment will be used in the preparation of the Final Design which may include excavation and dewatering activities as part of remediation to be conducted at the Site.

The scope of work objectives, project background, geological setting and hydrogeology, scope of services provided (and the deviations there from), and the results are presented below.

1.1 Scope of Work Objectives

The primary objectives of this analysis, per the scope of work and the objectives presented in ART's March 30, 2006 proposal and the April 5, 2006 work plan, are as follows:

- Perform an Aquifer/Dewatering Test (Test) to characterize the hydraulic parameters, including hydraulic transmissivity (T), conductivity (K), storativity (S) and specific yield (S_y), of the fill material, and also determine the pumping capacity of the proposed dewatering well.
- Using the results of the aquifer testing activities and data from previous site investigations, develop a numerical groundwater flow model to simulate the response of the aquifer system to dewatering.
- Calibrate the groundwater flow model by simulating the EW-1 constant-rate aquifer test.
- Using the calibrated groundwater flow model, evaluate the effectiveness of the recommended dewatering alternative, and estimate the numbers, locations, and pumping rates of wells/extraction points required to maintain groundwater levels below the proposed excavation depth.
- Estimate the drawdowns for the recommended dewatering alternative.
- Evaluate the impacts and effectiveness of proposed mitigation measures like sheet piling on the existing groundwater flow, and on the proposed dewatering activities.

1.2 Project Background, Geologic Setting, and Hydrogeology

The Site is located in the southwestern part of Oakland, in the eastern part of the San Francisco Bay Area. The San Francisco Bay Area occupies the central part of the Santa Clara Valley, a broad alluvial valley that slopes gently northward towards San Francisco Bay and is flanked by alluvial fans deposited at the foot of the Diablo Range to the east and the Santa Cruz Mountains to the west. The upland surfaces rising abruptly approximately four miles to the east of the Site are known as the East Bay Hills. The Site is at an elevation of approximately five feet above Mean Sea Level according to the USGS *Oakland East Quadrangle California 7.5 Minute Series* topographic map. Regionally, topography in the area of the Site slopes down to the west towards San Francisco Bay. However, the area of the Site is generally very flat with little topographic change.

The Site contains a large concrete warehouse and loading dock building, an office trailer and maintenance building. Outside yard areas are located along the northwest side of the building and a much larger outside yard area is located between the buildings. The Owner is planning to demolish the current buildings and after the required remediation, the Site is planned to be redeveloped for residential purposes. The Site is listed as a fuel leak case and is being overseen by the Alameda County Environmental Health Department (ACEHD). Previous and ongoing environmental investigations conducted at the Site show elevated concentrations of petroleum hydrocarbons (predominantly diesel) in soil beneath the Site, and volatile organic compounds (VOCs) and petroleum hydrocarbons including diesel, and gasoline constituents benzene, toluene, ethylbenzene and xylenes (BTEX) in groundwater beneath the Site.

Soil borings from previous onsite environmental investigations indicate the area beneath the Site was likely filled to create land and lift the surface roughly 5 feet above the high tide line (Gentech, *1994 Soil and Groundwater Investigation*). The Site is underlain by artificial fill comprised of gravel and sand which may contain debris such as concrete or asphalt as well as silt and clay. The fill is underlain by organic clay with thin interbeds of organic or plant material. This material was often logged as peat in previous investigations. The isopach map shows the estimated thickness of the artificial fill where the base of the fill is defined as the top of the clay/peat material. The clay unit forms a sort of bowl with the thickness of the fill material increasing to the north east, varying from about 1.5 feet near the southern corner and 4 to 5 feet along the north property boundary to greater than 9 feet along Tidewater Avenue (ERAS, *2006 Report of Environmental Investigations*).

The regional groundwater flow follows the topography, moving from areas of higher elevation to areas of lower elevation. The regional groundwater flow direction in the area of the Site is estimated to be to the west towards San Francisco Bay. During various groundwater monitoring episodes from April 14, 1994 to August 19, 2005, depth to groundwater has been measured in the monitoring wells from 1.14 to 3.88 feet below top-of-casing. Groundwater appears to be unconfined. The groundwater gradient at the site ranges from 0.003 foot/foot to 0.04 foot/foot. However, given the close proximity of the Tidal Canal, the groundwater beneath the Site is probably under tidal influence with daily fluctuations in groundwater flow direction (ERAS, *2005 Technical Summary Report*), and hence there may not be a dominant groundwater gradient.

2.0 AQUIFER TESTING ACTIVITIES

As per our proposal dated March 30, 2006 and work plan dated April 4, 2006, ART performed an aquifer test to characterize the hydraulic properties of the subsurface fill material and to obtain additional subsurface hydrogeologic information at the site. Results of the aquifer testing activities were used to provide recommendations for the temporary construction dewatering system that would be installed at the site prior to commencement of excavation activities.

Prior to Aquifer Testing activities, three 2-inch diameter observation wells (wells OB-3, OB-4, and OB-6) screened in the fill material, one 2-inch diameter observation well (OB-5) screened in the clay unit/Bay Mud, and an 8-inch dewatering well (EW-1) were installed by ERAS on the Site property. The observation wells were installed for the purpose of monitoring groundwater elevations and aquifer response during the constant-rate aquifer test. Figure 2 shows the locations of the observation wells and the dewatering well. Well installation, construction, and well development details have been provided in the May 12, 2006 *Report of Environmental Investigations* by ERAS.

Aquifer testing activities included the performance of a step-drawdown test, followed by a constant-rate pumping test, and aquifer recovery observation. The step drawdown test was performed on April 22, 2006 to assess the sustainable yield of the pumping well for a 48-hour constant-rate pumping test. Based on the results of the step-drawdown test, a 48-hour constant-rate pumping test was performed from April 25, 2006 to April 27, 2006 at a constant discharge rate of 1.91 gallons per minute (gpm). Aquifer recovery was recorded for all the wells from April 27, 2006 to April 28, 2006 after cessation of the constant-rate pumping test.

The following sections provide a brief description of the equipment set-up for the aquifer testing activities, the aquifer step test, and the constant-rate aquifer test procedures and results.

2.1 *Aquifer Testing Set-Up*

This section provides a brief description of the equipment set-up used for the step and constant-rate aquifer tests. The aquifer testing was performed using the newly installed on-site dewatering well EW-1 as the pumping well (Figure 2). The dewatering well EW-1 is an 8-inch diameter well, which was installed to a depth of approximately 11 feet below ground surface (bgs) in a 36-inch diameter borehole. The bottom of the borehole extended approximately 3 feet into the underlying clay unit. Well EW-1 is screened in the fill material, and the upper portion of the clay unit from approximately 1 to 11 feet bgs. In addition, pea gravel was placed around the well casing all the way to the surface. Groundwater was extracted using a submersible pump (GrundFos RedFlo 2, which is capable of pumping at variable flow rates) with the flow regulated by a manual valve. The extracted groundwater was then discharged into one upright 15,000-gallon Baker Tank using 1½-inch flexible PVC hose. The submersible pump was placed at a depth of approximately 11 feet below ground surface (bgs). An in-line totalizer, connected to the submersible pump, was used to monitor the flow rate during the constant-rate pump test.

Pressure transducer units (MiniTrolls) with built-in dataloggers and barometric correction were installed in the newly installed observation wells and some of the existing on-site monitoring wells to electronically monitor the response of water levels during the aquifer test. The transducers were set approximately two feet above the bottom of the well for the monitoring wells and above the pump for the pumping well EW-1 (approximately 9 feet bgs). The selected wells included newly installed observation wells OB-3, OB-4, and OB-6, and existing monitoring wells MW-2 and MW-3, which are predominately screened in the fill material, and well OB-5, which is screened in the clay unit (Bay Mud) underlying the fill material. The dataloggers were linked to a computer terminal for real-time display of water levels during the pumping test. Water levels were also monitored in the pumping well and observation wells for 48-hours prior to initiating the step drawdown test. The water levels were then allowed to recover for approximately 67-hours prior to initiating the pumping phase of the aquifer test.

During the pumping and recovery portions of the test, the data loggers were set to record data at different intervals to adequately capture the drawdown and recovery responses needed for hydraulic parameter analysis. Prior to commencement of the pump test, the total depth of all the wells was recorded, and a baseline set of static water-level measurements was manually collected from each well using a Solinst electric-sounder. Water levels in the observation wells were manually collected on a periodic basis to verify and assess the accuracy of the equipment being used for the test.

2.3 Step Drawdown Pumping Test

The step drawdown pumping test was conducted on April 22, 2006 to determine the flow rate and test duration for the constant-rate pumping test at a sustainable yield. Prior to commencement of the test, water levels in each of the wells were manually measured using a Solinst electric-sounder. The dewatering well was then pumped for a specified period at different pumping rates (steps) while monitoring changes in the water levels. The water levels and corresponding times were recorded during each pumping step to allow for analysis of the drawdown attributed to each step, and also to provide information needed for selection of the pumping rate for the long-term constant-rate test.

The step-drawdown test in pumping well EW-1 consisted of five pumping steps. The total available drawdown in pumping well EW-1 was approximately 7 feet. Step pumping rates of 1.65, 2.2, 3.85, 5.35, and 7 gallons per minute (gpm) were used, and the test lasted a total of 170 minutes. The step rates of 1.65, 2.2, 3.85, 5.35, and 7 gpm were run for 45, 20, 45, 40 and 20 minutes, respectively. A constant flow rate was maintained throughout the duration of each step. The flow rate was increased to a new step after the drawdown in the pumping well (well EW-1) stabilized. The transducer reading and flow rate was tabulated and graphed throughout the step-drawdown test. For the step rates of 1.65, 2.2, 3.85, and 5.35, the drawdown in EW-1 was observed to stabilize at approximately 0.8, 1.1, 2.3, and 4.3 feet, respectively. The drawdown in EW-1 increased from an approximate rate of 0.01 feet per minute (fpm) during the later stages of the step test rate of 1.65 gpm to 0.04 fpm during the later stages of the step test rate of 5.35 gpm. However, after 20 minutes of pumping at a rate of 7 gpm from well EW-1, the water levels dropped below the transducer settings. After completion of the step-drawdown test, the data were downloaded from the data logger onto a portable computer. A graph showing drawdown results from the step-drawdown test is shown in Appendix A. Based on the step-drawdown test data, a rate of 1.9 gpm was selected to perform the long term constant-rate test.

2.4 Constant-Rate Aquifer Test

The objective of the constant-rate aquifer test was to impose a hydraulic stress on the water bearing zone by pumping from the selected pumping well, and then monitoring the drawdowns in the observation wells. The resulting drawdown data were then used to assess the degree of hydraulic communication between wells, the response of the fill material and Bay Mud to pumping, and provide estimates of transmissivity (T), hydraulic conductivity (K), storativity (S), and specific yield (S_y) for the fill material. These data were also used to estimate the extent of hydraulic communication between the fill material and the Bay Mud. The long-term constant rate pumping tests included the three components described below:

- **Background Period** – Prior to pumping each well, static, non-pumping water levels were monitored to determine the trend of changes in water level, if any, and to provide a basis for determining drawdown due to pumping. This portion of the test was used to assess regional water level trends and to estimate the barometric efficiency of each observation well. During the background phase, water levels were monitored in the pumping well and observation wells for a period of 2-days prior to initiating the pumping phase.

- **Pumping Period** – During the pumping phase, a constant pumping rate of 1.91 gpm was maintained during a 48.5-hour period while monitoring drawdown effects in nearby observation wells.

- **Recovery Period** – The period of time immediately following cessation of the pumping period during which the water levels in the monitored wells rise back to nearly static, non-pumping levels. During the recovery phase, recovering water levels were monitored in the pumping well and observations wells for a period of 27.5 hours after cessation of the pump test.

A discussion of each period of the constant rate pumping test is provided below.

The constant-rate pumping test was conducted between April 25th and 27th, 2006 using well EW-1. Background water levels were monitored in each observation well for approximately two days prior to the start of pumping. Well EW-1 was then pumped at a rate of 1.91 gpm for a total of 48.5 hours. A constant pumping rate was maintained throughout the duration of the test.

During the constant-rate performance of the pumping test, water levels were electronically monitored in the selected observation wells. As part of the equipment check process, the instantaneous flow rate and total flow volume were periodically recorded. Also, manual water level data for the observation and pumping wells were collected periodically using a Solinst electric-sounder.

During the constant-rate aquifer pumping test, the water level in pumping well EW-1 decreased approximately 4 feet in response to pumping. As stated earlier, pumping well EW-1 was screened across the fill material and the upper portion of the clay unit underlying the fill material. Hence, drawdowns were observed in all the observation wells screened in the fill material. The drawdowns ranged from 0.47 feet (well MW-3 located approximately 95 feet from EW-1) to 1.99 feet (well OB-3 located 7.5 feet from EW-1) for the wells screened in the fill material. The maximum decrease in water levels in all the observation wells is shown in Table 2. However, no drawdown was observed in observation well OB-5, which is screened only in the Bay Mud and is located approximately 7 feet from the well EW-1. Water levels in OB-5 exhibited an overall decreasing trend during the background, pumping, and recovery periods. This implies that OB-3 is not hydraulically connected to the fill material, and the decrease in water levels can be attributed to a regional trend. Hence, pumping from the fill material will exhibit minimal or no influence on the Bay Mud.

After completion of the pumping test, recovery was monitored for approximately 27.5 hours. During the recovery phase, the transducers were not moved and the data logger was configured to record data periodically, as was done for the constant-rate pumping test (more frequently at first and less frequently as the water levels recovered). Once the recovery phase of the test was completed, the data were downloaded from the data logger onto to a portable computer.

2.5 Data Analysis and Results

The purpose of the constant rate aquifer pumping tests was to monitor the aquifer's response to pumping, and to use the data to estimate aquifer parameters such as transmissivity (T), storativity (S), and specific yield (S_y). Estimates of the aquifer parameters were then used to estimate the dewatering volumes. This section presents a discussion of the constant rate aquifer pumping test data analysis and results.

2.5.1 Data Analysis

Following the constant-rate pumping test, graphs of drawdown versus time were produced for the pumping and observation wells. Graphs were produced for the pumping period and recovery period of the test, and are included in Appendix A.

2.5.2 External Effects on Water Levels

Prior to analysis of the data, several factors that could potentially affect aquifer pumping test data were considered. These factors included: (1) equipment accuracy; (2) changes in barometric pressure; and (3) local fluctuations in groundwater levels.

2.5.2.1 Equipment Accuracy

As a check for equipment accuracy, manual water level measurements in the monitoring wells were compared to the electronic data measured by the transducers. It was observed that drawdowns derived from the pressure transducer data and manual data were equivalent.

2.5.2.2 Changes in Barometric Pressure

Each of the transducers (with built-in data loggers) also has a built-in barometric correction incorporated to the collected data. Based on the barometric pressure readings during the test, the water level data reported by the transducers are automatically corrected to account for these barometric pressure changes. However, to assess the accuracy of the barometric corrections, hourly barometric pressure readings were also obtained for the *Metro Oakland International Airport* weather station, corresponding to the duration of the aquifer testing activities. The barometric pressure data indicated minimal changes in the pressure during the duration of the aquifer testing activities. Hence, no barometric corrections were applied for the drawdown data in the observation wells.

2.5.2.3 Local Fluctuations in Groundwater Levels

To evaluate the effect of local fluctuations in groundwater levels during the pumping test, water levels were monitored manually and electronically in each of the wells during the background, pumping, and recovery periods. Prior to initiating the step-drawdown test, background period data indicates that Site water levels were generally dropping in all the wells. This could be attributed to the seasonal decrease of groundwater levels. To account for the effects of declining water levels during the constant-rate pumping test, a linear water level trend correction was applied to the pumping and recovery water level data in the observation wells. The correction factors were estimated from the trends observed during the background phase of the test for each well, and averaged approximately 0.134 feet per day (ft/day) for the wells screened in the fill material. A graph and a typical calculation for estimating the correction factor for EW-1 is shown in Appendix A.

2.5.3 Aquifer Parameter Analysis and Results

Several different techniques were used to analyze data from the constant rate pumping tests. The computer program Aqtesolv™ was used to assist with the aquifer parameter analysis. This program combines statistical parameter estimation methods with interactive curve-matching capabilities. Based on the available lithology, drawdown data from the constant-rate pumping test were analyzed using the Neuman unconfined curve-matching method to estimate the T and S_y (*Neumann, 1972*) and the Theis unconfined curve-matching method to estimate the T and S (*Theis, 1935*) for all the wells screened in the fill material. Recovery data for the test was also analyzed using the Theis recovery method to provide an additional estimate of T (*Theis, 1935*). In addition, T was also estimated, for comparison purposes, using the 'Distance-Drawdown' method (Cooper-Jacob), from the data obtained at the end of the pumping period. A brief discussion of the constant rate test results is presented below.

As stated previously, pumping well EW-1 is screened across the fill material (comprised primarily of sand and other coarse grained materials) and approximately 3 feet into the clay unit underlying the fill material. As the hydraulic conductivities of coarse grained materials (sands and gravel) are generally observed to be one or two order magnitude greater than those observed in fine grained (silt and clay) zones (*Freeze and Cherry*), the pumping from EW-1 can be allocated primarily to the fill material. This was further collaborated by the observation that pumping from EW-1 resulted in drawdowns in all the observation wells screened across the fill material; however, no drawdown was observed in well OB-5, which was screened in the clay unit.

Results of the parameter analysis for the constant-rate pumping test are summarized in Table 1. Estimates of T and S_y for the fill material ranged from 50 ft^2/day to 153 ft^2/day, and 0.006 to 0.056, respectively. Assuming a saturated thickness of 7 feet for the fill material, estimates of the hydraulic conductivity (K) ranged from 7 ft/day to 22 ft/day. Also, T was estimated to be 99 ft^2/day using the 'Distance-Drawdown' method (Cooper-Jacob). This value of T corresponds to a K value of 14 ft/day. Hence, an average value of 94 ft^2/day, 13 ft/day, and 0.027 was estimated for the T, K, and S_y for the fill material underlying the Site.

2.5.4 Summary

A constant-rate aquifer pumping test was performed to estimate aquifer parameters such as transmissivity (T), storativity (S), and specific yield (S_y) for the fill material beneath the Site. Hydraulic conductivity (K) was then evaluated from the ratio of the T and b (saturated thickness for the unconfined condition and the aquifer thickness for the confined condition). Estimates of the aquifer parameters were used to construct a groundwater flow model to evaluate the various dewatering alternatives and simulate the response of the aquifer system to proposed dewatering alternative.

Estimates of T and S_y for the fill material ranged from 50 ft^2/day to 153 ft^2/day, and 0.006 to 0.056, respectively. Assuming a saturated thickness of 7 feet for the fill material, estimates of the hydraulic conductivity (K) ranged from 7 ft/day to 22 ft/day. However, for the purpose of the modeling effort, average values of 15 ft/day and 0.02 were initially assumed for the K and S_y, respectively, for the fill material.

Also, no drawdown was observed in observation well OB-5, which is screened only in the Bay Mud and is located approximately 7 feet from the pumping well EW-1 during the duration of the constant-rate aquifer test. This implies that pumping from the fill material will exhibit minimal or no influence on the groundwater levels in the clay unit underlying the subsurface fill materials.

The aquifer parameter values adopted for the modeling exercise were further adjusted while performing the calibration simulations using the three-dimensional numerical flow model.

3.0 DEWATERING EVALUATION

The results of the aquifer test analysis were used to construct a numerical groundwater flow model to simulate the response of the aquifer system to dewatering. The groundwater model developed for this evaluation is a three layer three-dimensional (3-D) numerical model that has been used as a tool to simulate pre-pumping or steady state and transient calibration conditions, estimate the extraction rates of the proposed dewatering system, and simulate the response of the aquifer system to dewatering. The results of the aquifer system response to the proposed dewatering were then applied to estimate the time frame and costs required to implement and complete the proposed remedial activities at the site.

This section provides a brief description of the numerical groundwater flow model construction, simulation of the steady state model, calibration of the transient condition by simulating the EW-1 constant-rate pump test, sensitivity analysis, and results of the dewatering simulations. The model input and calibration parameters were obtained from the aquifer test analysis, lithologic logs for the on-site monitoring wells, and water level data from the monitoring wells.

3.1 Numerical Groundwater Code Description

MODFLOW2000, which is the United States Geological Survey (USGS) Modular Three-Dimensional Finite Difference Groundwater Flow Model code, was selected as the numerical code for performing the groundwater flow simulations and simulating the response of the aquifer system to dewatering. The most recent version of the graphical interface program Groundwater Modeling System (GMS) Version 5.1 was used to assemble and construct the input files for the model. GMS is a pre-processor and post-processor that facilitates data preparation, manipulation, visualization, and presentation of MODFLOW2000® input and output files. This program provides a high degree of automation and flexibility in the development of the model and reduces the time required to construct input files and process output files.

The groundwater flow simulations require the use of different MODFLOW2000® packages depending upon the boundary conditions or the various external stresses that need to be simulated for a given model domain. The following MODFLOW2000® packages were utilized during the groundwater flow simulations:

- .BAS The primary package used for model initialization, layer definition, initial potentiometric conditions, water budget balance, definition of the types of simulations;
- .BCF For layer hydraulic properties and elevation control;

- .WEL To simulate the extraction from dewatering well EW-1 during the transient calibration simulation;
- .DRN To simulate the extraction from the dewatering wells during the dewatering simulations;
- .HFB To simulate the shoring/cut-off wall surrounding the proposed development;
- .PCG2 For utilization of the Preconditioned Conjugate Gradient matrix equation solver; and,

3.2 Model Geometry and Grid

The model domain dimensions were positioned relatively distant from the proposed Project boundaries to minimize impact of the imposed boundary conditions on the predictive performance of the model. Such distancing is used to reduce the effects of errors from input uncertainties on the model results. In plan view, the model's grid blocks are mutually perpendicular lines that are spaced on a 5 foot by 5 foot grid. Model solution nodes are located at the center of each cell and the model grid is oriented northeast-southwest. Row numbers increase in the south-westerly direction, column numbers increase in the southeasterly direction. The vertical thickness of the aquifer (approximately 20 feet) was represented in the model by three layers of grid cells, which represent the two separate lithologic zones observed beneath the Site that may be influenced by dewatering activities. The vertical multi-layer system was derived from the conceptual model, and is assumed to represent two geologically different aquifer units: Layer 1 represents the fill material; Layers 2 and 3 represents the clay unit / Bay Mud, which is primarily comprised of silty clay / clayey materials. The clay unit is represented by model layers 2 and 3 so as to properly represent the proposed mitigation measure (sheet pile/cut-off wall) during the dewatering simulations and also determine the effects of the proposed mitigation system on dewatering at the Site. The bottom of the proposed sheet pile/cut-off wall is assumed to lie within Layer 2. Layer 1 of the model domain is designated as unconfined, whereas the underlying Layers 2 and 3 are fully convertible from confined to unconfined conditions. The flow between the layers is represented by the vertical hydraulic conductivity or leakance, except for the bottom most layer.

3.3 Layer Elevations

Layer surface and bottom elevations were assigned in GMS using the lithologic data from all boring logs and monitoring wells within the domain and simulated in MODFLOW2000® using the .BAS package. Layer/flow zone thicknesses, input as top and bottom elevations for each layer, are required to simulate groundwater flow in the layers. The elevations are used by the model to determine aquifer thicknesses, and subsequently calculate the transmissivity of the aquifer zones based on the thicknesses of each zone.

Initially, the ground surface elevations for the model were obtained from the logs of on-site and off-site soil borings and the on-site monitoring well network, and manually entered through the GMS interface. In areas where little or no data was available, additional ground elevation values were manually input through the GMS interface based on visual comparison with USGS topographic map. The completed ground surface elevation data set was translated to the top of Layer 1 (using the krigging interpolation method), and contoured within GMS until it matched the surface features of the topographic map.

Similarly, the depth of the fill material was also obtained from the logs of on-site and off-site soil borings and the on-site monitoring well network. In areas where little or no data was available, it was assumed that the fill bottom was at a minimum of 3 feet below ground surface (representing our assumption that 3 feet of fill was placed over the Bay Mud during the construction of this area. These additional fill depth elevation values were manually input through the GMS interface based on visual comparison with USGS topographic map. The completed ground surface elevation data set was translated to the bottom of model layer 1 (using the krigging interpolation method), and contoured within GMS until it matched the surface features of the topographic map.

Based on the interpreted surfaces from the on-site and off-site boring logs, and the depth of the assumed mitigation measure (sheet pile/cut-off wall), model layers 2 and 3 were assigned a thickness of 5 and 8, feet, respectively, at the site and its immediate vicinity. After completion of this exercise, the layer surfaces were exported directly to MODFLOW2000® using the GMS interface.

3.4 Boundary Conditions

A model's boundary is the interface between the model area and the surrounding environment. Groundwater flow conditions along the perimeter boundary of the model domain were largely defined from existing well data and topographic features. Data collected from the on-site wells and the USGS topo map, were used to define the boundary areas within the model domain. To the extent possible, the boundary conditions were established in areas distant from the location of the Site so that uncertainties in their values would have minimal impact on the simulation results.

The perimeter boundary conditions were assigned using a combination of no-flow and general head boundaries. General heads were assigned to boundaries that simulated either inflow to or outflow from the model domain. The initial specified head boundary nodes were estimated by projecting the inferred groundwater elevations in the central portion of the model domain to the edges of the model boundaries. General head boundaries were adjusted during the calibration process.

The regional groundwater flow follows the topography, moving from areas of higher elevation to areas of lower elevation. Groundwater flow in the model domain is estimated to be from the north direction to the southeast/west direction towards San Francisco Bay. It is assumed that the majority of groundwater inflow and outflow in the model domain occurs predominantly along the north and southeast/west boundaries of the model domain in the system; hence, these boundaries of the model domain were designated as general head boundaries.

No-flow boundaries were assigned to areas where groundwater flow is interpreted to be parallel to the perimeter of the model domain or where no groundwater flow into the model domain was expected. As the majority of flow into or out of the model domain is assumed to be across the north and southeast/west boundaries of the model domain, the east boundaries of the model domain are designated as a no-flow boundary. Figure 3 depicts the boundary conditions associated with the model domain for all the model layers.

It is expected that flow across or related to a particular model boundary may change during and as the result of dewatering activities. However, due to the placement of mitigation measures (sheet pile/cut-off wall) along the perimeter of the Site boundary, any change in the boundary condition is expected to have minimal effect on the groundwater conditions at the site and its vicinity.

3.5 Aquifer Properties

Input data for MODFLOW2000® include aquifer top and bottom elevations, hydraulic conductivity, anisotropy, specific yield, and specific storage. Specific yield and specific storage values were only used during transient simulation runs. The .BCF package of MODFLOW2000® was used to simulate the remaining aquifer properties within the model domain.

Horizontal hydraulic conductivity (K_h) values were assigned to each model cell to simulate flow within the hydrostratigraphic zones of the model. As stated in Section 2.5.4, an initial K_h value of 15 ft/day, which was estimated from the constant-rate aquifer test, was assigned to the fill material (model layer 1). However, the initial estimate of the hydraulic conductivity of the clay unit/Bay Mud was based on available lithologic logs and literature values, and was assigned an initial value of 0.001 ft/day. These initial hydraulic conductivity values for the model layers were further refined during the steady state and transient calibration simulations of the model by incorporating additional zones of K_h. In addition, to provide a complete coverage of the model domain, the K_h values in outlying areas, not influenced by the aquifer tests, were assigned to be similar to those observed at the site. The final calibrated K_h values for the model layers are shown in the succeeding sections.

The hydraulic communication between flow zones can be simulated using either leakance [ratio of thickness over vertical hydraulic conductivity (K_v)], or vertical anisotropy (K_h/K_v). For our model simulations, the leakance of the model layers, which is obtained from the vertical hydraulic conductivity (K_v) and thickness values for each layer, was used to simulate the hydraulic communication between the different flow zones. At present, there are no vertical hydraulic conductivity (K_v) data available for the soils underlying the site. Because field measurements of K_v are not available, a typical ratio of horizontal-to-vertical hydraulic conductivity was used as a means of estimating and distributing values of K_v. Based on the conceptual model of groundwater flow and the assumption that horizontal flow is dominant, the vertical conductivity values for a given cell in all the model layers were assumed to be approximately one order of magnitude lower than the horizontal conductivity for that cell. Leakance values were then calculated using the following equation:

$$\text{Leakance} = \{1/2Qz_u/K_{zu} + 1/2Qz_u/K_{zL}\}^{-1};$$

where,

$1/2Qz_u$	-	the half-thickness of the upper layer;
$1/2Qz_u$	-	the half-thickness of the lower layer;
K_{zu}	-	the vertical conductivity of the upper layer;
K_{zL}	-	the vertical conductivity of the lower layer.

Based on the above formula, and the assumed K_v and thickness values for the layers, the initial leakance values assigned to the fill material (model layer 1) and the clay unit (model layer 2) were 0.001 and 1, respectively. Leakance values were refined graphically during the steady state and transient calibration simulations until a consistent correlation was reached between the predicted and observed head values.

For the transient simulation runs in MODFLOW, the storage coefficient term is required. Storage coefficient is defined as the volume of water that an aquifer releases from or takes into storage per unit surface area of the aquifer per unit change in head. In MODFLOW, the BCF package is used to assign the storage coefficient values to the model layers using the primary and secondary storage coefficients. The primary storage coefficient is always the specific yield (S_y) or unconfined storage coefficient for an unconfined layer and the confined storage coefficient for a confined layer. The secondary storage coefficient is always the specific yield (S_y), and is only applied by the model if the model layer becomes unconfined. The initial primary storage coefficient value in the fill material (model layer 1) was assigned from the estimated aquifer parameters. The initial primary storage coefficient terms assigned to the clay unit/Bay Mud were assumed from literature values for similar materials. *Freeze and Cherry* state that the

S_y values typically lies within a range of 0.01 (for clays) to 0.3 (for coarse sands), and the confined storage coefficient range in value from 0.005 to 0.00005. Based on the results of the constant-rate aquifer test and the literature values, the initial storage coefficient values assigned to the preliminary model simulations were 0.02 and 0.001 to the fill material (model layer 1) and the clay unit/Bay Mud (model layers 2 and 3), respectively.

Storage coefficient values were refined graphically during the transient calibration simulation until a reasonable correlation was reached between the predicted and observed head values.

3.6 Recharge

Recharge due to precipitation was not used in this model presentation as most of the domain area is paved, and minimal infiltration of rainfall to the groundwater would have occurred at the site.

3.7 Groundwater Extraction

Following the calibration of the groundwater flow model under ambient (non-pumping) steady state conditions, the .WEL package of MODFLOW2000® was used to simulate the transient calibration run and the .DRN package of MODFLOW2000® was used to simulate the groundwater extraction from the dewatering wells.

Prior to performing the dewatering simulations, the transient calibration of the model was also performed by simulating the EW-1 constant rate aquifer test. The extraction rate of the well (1.9 gpm) was allocated to the fill material.

For the dewatering simulations, twelve perimeter wells, approximately 50 feet apart, and two internal wells were simulated. Each of these wells was screened across model layers 1 and 2. GMS proportioned the extraction of the wells from each layer based on the transmissivities of the layers. However, in certain simulations, the wells had a tendency to go dry due to solver limitations. In such cases, the .DRN package was utilized, where each of the dewatering wells was set up as a drain cell. The drawdown observed in a dewatering well was simulated by setting the bottom elevation of the drain cell below the bottom of model layer 1 such that it would simulate the condition of the groundwater level below the proposed excavation depth of below the fill material. The hydraulic conductance value for each drain cell is estimated from the product of the cell area (5 x 5 ft cell) and the hydraulic conductivity of the subsurface material at that location (approximately 20 ft/day). For the modeling effort, the hydraulic conductance value allotted to each drain cell was 500 ft^3/day.

3.8 Groundwater Flow Model Calibration

This section presents the calibration of the groundwater flow model performed to assess the model parameters. Calibration is the process by which model parameters, such as hydraulic conductivity, are adjusted within typical model criteria ranges and until the difference between observed and simulated hydraulic head values are within limits of acceptability. Before a groundwater flow model can be used for predictive simulation, it is necessary to obtain a reasonable correlation between the simulated and observed hydraulic head conditions under natural flow conditions. Because of the complexity of hydrogeologic systems, initial estimates of model parameters generally do not produce results that are completely consistent with observed field conditions. Hence a calibration process is performed, in which estimated model parameters defining the modeled system are adjusted, until an acceptable match between the modeled and observed values is achieved. An ideal calibration process involves calibrating a steady state model to groundwater levels within a monitoring well network in non-pumping or ambient conditions. However, due to limited availability of groundwater level data within the model domain (only four monitoring wells are installed within the model domain), comparison of observed and simulated groundwater levels in monitoring wells is minimal. Hence, a statistical calibration of the steady state model (convergence and residual statistics) was not performed.

However, a qualitative evaluation of the calibration can be made by evaluating the shape and gradient of the simulated potentiometric surface of a calibrated model. Hence, model parameters and boundary conditions were adjusted in a systematic manner until a reasonable fit of the shape and gradient of the observed and simulated potentiometric surface for the fill material was obtained.

The water budget for the steady state simulation showed that there was approximately 1.58 ft^3/d (0.91%) discrepancy between the inflow and outflow of the steady state model. The *ASTM Standard D 5981-96* considers a water budget discrepancy of less than 5% adequate.

3.9 Groundwater Flow Model Transient Calibration

Prior to conducting the dewatering simulations, a transient calibration simulation was performed to evaluate whether the groundwater flow model is capable of reliably predicting responses to aquifer stresses such as an aquifer pump test. The transient groundwater flow model was calibrated by simulating the EW-1 constant-rate aquifer test, and comparing predicted and observed drawdown values. A "transient" model run was performed using the hydraulic head data from the final steady state simulation as the initial condition. Groundwater extraction from the fill material was simulated at a constant rate of 1.9 gallons per minute (gpm) from well EW-1 for a period of 2.021 days (48.50 hours).

Simulation of the EW-1 constant-rate pumping test also provided the final storage coefficients for the subsurface fill material. If the transient *calibration* simulation indicates that the modeled correlation between the predicted and observed responses is insufficient, then the model calibration must be revisited. This was done by adjusting the model input parameters, like hydraulic conductivity and storage coefficient, until a good correlation is obtained. Once the results of the model calibration simulation are acceptable, then the model can be used confidently for making predictive simulations.

Predicted and observed drawdowns at selected observation points were compared to verify if the model was capable of accurately simulating pumping stresses in the vicinity of the extraction well. Table 2 summarizes the observed and simulated drawdowns of the observation wells at the end of the pump test. Figures 4A, 4B, and 4C show the drawdown vs. time plots of some of the observation wells in the fill material for the duration of the pumping test.

Based on the simulated drawdowns, the model adequately predicted the behavior of the observed drawdown during the tests. Any discrepancies between the observed and predicted drawdown for the test can be attributed to the "coarse" discretization of the model grid and localized variations in aquifer characteristics. Also, the water budget for the transient simulation showed that there was approximately 0.18 ft^3/d (0.02%) discrepancy between the inflow and outflow of the steady state model. The *ASTM Standard D 5981-96* considers a water budget discrepancy of less than 5% adequate.

3.10 Calibrated Aquifer Parameters

Based on the results of the steady state and transient calibration simulations, the final calibrated hydraulic conductivity assigned to the clay unit/Bay Mud (model layers 2 and 3) was 0.001 ft/day. However, different hydraulic conductivity zones were assigned to model layer 1 (fill material). This can be attributed to localized heterogeneities within the subsurface fill materials. Figure 5 shows the calibrated K zones and values for the fill material (Layer 1) within the model domain.

As stated previously, the primary storage coefficient is always the specific yield (S_y) or unconfined storage coefficient for an unconfined layer and the confined storage coefficient for a confined layer. The secondary storage coefficient is always the specific yield (S_y), and is only applied by the model if the model layer becomes unconfined. The S_y assigned to model layer 1 (fill material) was 0.02 and 0.01 to model layers 2 and 3 (clay unit/Bay Mud). The secondary storage coefficient value of 0.012 was only assigned to model layers 2 and 3.

3.11 Sensitivity Analysis

This section presents the results of sensitivity analysis simulations performed on the calibrated model. After the model was calibrated under the transient condition, a sensitivity analysis was performed to identify which model input parameters have the most impact on the degree of calibration.

The sensitivity analyses conducted generally were limited to those model parameters found to have significant effect on results during calibration and during the ambient condition predictive simulations. The implications of the sensitivity analysis are dependent on the accuracy of the input data, as is the case with any model results. A general, qualitative, sensitivity analysis of the model was performed during the initial stages of the model calibration to determine which parameters most affect the calibration process. Based upon this analysis, it was found that horizontal hydraulic conductivity (K_h), storativity or specific yield (S_y) and leakance in model layer 1 (fill material), were the most sensitive model parameters (given the anticipated range of each model parameter) for the steady state condition and transient calibrated conditions. Also during calibration, other poorly constrained model parameters, such as the boundary conditions that represented upgradient inflow and downgradient outflow conditions, and horizontal and vertical hydraulic conductivity in Layers 2 and 3 were found to affect the calibration only in a limited way. Hence, further sensitivity analysis of the boundary conditions was not necessary as changes in these values had relatively little impact at the Site area in comparison with that observed for the K_h, S_y, and leakance parameters.

During the sensitivity analysis, the sensitive model parameters, such as K_h, S_y, and leakance, were increased or decreased in a systematic way for each layer. This approach assesses the sensitivity of model results to individual parameters, the uncertainty of model predictions, and the potential need for addressing parameter uncertainty in the future. Model sensitivity was examined by observing changes in the mean absolute residual, bias of the resulting simulated water levels, and the water balance at the site.

Sensitivity analysis of K_h was performed by decreasing and increasing the calibrated value by an order-of-magnitude, while values of the remaining parameters were held constant. Increasing the K_h by an order of magnitude resulted in increasing the transmissivity of the model layers, which resulted in a moderate variation in the overall calibration of groundwater flow within the model domain, and an increase in the quantity of underflow into the system. Decreasing the K_h by an order of magnitude resulted in decreasing the transmissivity of the model layers, which resulted in a decrease in the quantity of underflow into the groundwater system.

Similar analysis of the sensitivity of the model to variations in the leakance also indicated variations in the overall calibration of groundwater flow within the model domain. Increasing the leakance values by an order of magnitude resulted in an increase in the communication between the model layers 1 through 3, an increased variation in the overall calibration of groundwater flow within the model domain, and a minimal increase in the quantity of underflow into the system. Decreasing the leakance by an order of magnitude resulted in decreasing the communication between the model layers 1 through 3. However, only moderate variation in the overall calibration of groundwater flow within the model domain and negligible change in the quantity of underflow into the groundwater system was observed.

In summary, an increase or decrease in the K_h by an order of magnitude has moderate effects on the overall calibration, and significant effects in the groundwater underflow into the system, and a change in the leakance has moderate effects on the extent of hydraulic communication between layers 1 through 3.

3.12 Dewatering Simulations

The calibrated groundwater model was used to assess the extraction rates and associated dewatering effects for the proposed dewatering system alignment.

Dewatering of the site can be defined as the need to physically drain saturated sediments within the footprint of the excavation. The key physical parameters controlling the rate of dewatering and the extent of produced drawdown are the drainable porosity of the sediments (specific yield) and the hydraulic conductivity. Other parameters like the initial water levels and the pumping rates of the dewatering wells can also affect the timeframe to dewater the site.

The objective of the dewatering simulations was to simulate dewatering of the site to the bottom of the fill material underlying the Site. The depth of the fill material underlying the Site ranges from 1.5 feet to 9 feet below ground surface (bgs) within the footprint of the proposed excavation. This implies that for all the transient simulations which assumed that initial water levels were approximately 1.5 to 2.5 feet bgs, the modeled drawdown condition in which the 4-foot and 5-foot drawdown contours will envelop the Site would provide the necessary dewatering of the fill material.

This proposed dewatering design involved the placement of 47 extraction wells along the perimeter and the interior of the Site. Each of these wells is proposed to be installed in a manner such that the bottom of each of the proposed dewatering wells is expected to lie only in the top portion of the clay unit which lies beneath the fill material. The locations of the dewatering wells shown in Figure 3 were estimated during the dewatering simulations.

For the dewatering simulations, the .DRN package was utilized to simulate Site dewatering, and each of the dewatering wells was set up as a drain cell. As stated previously, the drawdown observed in a dewatering well was simulated be setting the bottom elevation of the drain cell just above the bottom of model layer 1 (as this would represent a condition in which the groundwater levels will be below the base of the proposed excavation), and the hydraulic conductance allotted to each drain cell was 500 ft^3/day.

The following "transient" model simulations were performed using the hydraulic head data from the final steady state simulation as the initial condition. Each simulation was for 180 days, as it represented the time period under which the drawdowns reached a steady state condition under most simulation conditions. In addition, the effect of several parameters on the rate of dewatering, time of dewatering, and the extent of the produced drawdowns was also evaluated.

- Estimating the drawdown contours for the existing groundwater levels condition at the Site. This simulation provided the pumping duration required to dewater the site under present conditions, the initial pumping rates required to dewater the site, and the drawdowns observed at and near the site.

- Evaluating the effects of the starting water levels at the site. This was performed by simulating a higher groundwater level condition at the site, and comparing the results with the results of the present day groundwater level dewatering simulation.

- Evaluating the effects of aquifer parameters like hydraulic conductivity, leakance, and storativity (storage coefficient) of the model layers on the dewatering of the site.

3.12.1 Results of Dewatering Simulations

Results of the numerical modeling simulation indicated that the time to dewater the site and the rate of dewatering was dependant upon numerous parameters. The following is a discussion of the dewatering simulations results:

- ***Base Condition - Transient Calibration Simulation*** – Figures 6A through 6C provide the results of the dewatering simulation for the present day groundwater levels. This simulation assumes that the dewatering wells pump at an initial rate of 50 gpm, the initial groundwater levels are assumed at a depth of approximately 1.5 to 2.5 feet bgs at the site, , and the hydraulic parameters are the final calibrated parameters obtained from the transient calibration simulations. It should be noted that the initial S_y of the upper sand zone (model layer 1) in this simulation is 0.02. The time estimated to dewater the site (as represented by the 4.5-foot and 5-foot drawdown contours in Figure 6C) would be approximately 60 days (Figure 6C).

- *Effects of Groundwater Levels* – An increase in the groundwater levels in the fill material beneath the Site will increase the time to dewater the Site.

- *Effects of Storativity* – As stated previously, the specific yield (S_y) is the primary parameter used to estimate the time required to dewater the site; hence, it is necessary to understand the impacts of higher or lower S_y to the dewatering of the site. Therefore, sensitivity analysis was performed to understand the impacts of the S_y on dewatering the site. Results of these simulations indicated that the time required to dewater the fill material (model layer 1) increased significantly when the S_y was increased. For such a condition, additional wells would be required to completely dewater the site within a limited time frame under such a condition.

- *Effects of Hydraulic Conductivity* – An increase in the hydraulic conductivity by twice the model calibrated values results in a decrease in the total drawdown at the site under the same pumping conditions as the Base simulation. Hence, increased flow rates in the existing wells or additional wells would be required to completely dewater the site. A decrease in the hydraulic conductivity to half the original calibrated values in the model layers results in decreasing the time to dewater the Site.

- *Effects of Leakance* – An increase in the leakance values by an order of magnitude times the original calibrated values in all the model layers resulted in decreasing the time to dewater the site. A decrease in the leakance values by one order of magnitude in model layers 1 and 2 did not dewater the site until the end of the simulation run (160 days). Additional wells would be required to completely dewater the site under such a condition.

3.13 Summary of Dewatering Simulations

Results of the dewatering simulations indicate the following:

- Results of the dewatering simulation under the Base Simulation condition (initial groundwater levels are assumed at a depth of approximately 1.5 to 2.5 feet bgs at the site and S_y for the fill material is 0.02) indicated that the Site would take approximately 60 days to dewater to bottom of the fill material. As the dewatering causes groundwater levels to drop at the site, the extraction rate would decrease from an initial rate of approximately 50 gpm to a stable rate of approximately 0.5 gpm after 60 days.

- An increase in the specific yield S_y values for an unconfined layer (model layer 1 – fill material) greatly increases the time to dewater the Site.

- Model sensitivity analysis indicate that changes in the aquifer parameter values of hydraulic conductivity and leakance can result in a significant change in the time required to dewater the site. An increase in hydraulic conductivity and a decrease in leakance values from the final calibrated values will increase the time required to dewater the site significantly. In such a condition, the flow rates of the simulated dewatering wells may need to increased or additional wells may be required to completely dewater the site.

- Even though changes in aquifer parameters effects the drawdowns and time to dewater the site, the results of the Base Simulation were considered most representative because it is based on the calibrated values obtained from the transient calibration model run, which was further based on the observed behavior of the aquifer during the short-term constant rate aquifer test.

4.0 CONCLUSIONS AND RECOMMENDATIONS

A constant-rate aquifer test was performed using well EW-1 to estimate the aquifer parameters of the subsurface fill materials. These aquifer parameters were then used to construct a numerical groundwater flow model to simulate the response of the aquifer system to dewatering. The model was calibrated to a transient condition by simulating the EW-1 constant-rate aquifer test. Following the non-pumping (steady state) simulation and transient calibration of the model, dewatering conditions were simulated by lowering the water table to the proposed excavation depth at the site (approximately 4 to 5.5 feet bgs) using a combination of perimeter and internal dewatering wells. The conclusions from our aquifer testing activities and dewatering analysis for the proposed development can be summarized as follows:

- A constant-rate aquifer test was performed on well EW-1 to estimate the aquifer parameters of the subsurface materials. EW-1 is an 8-inch diameter dewatering well that is screened in the fill material and the upper portion of the clay unit from approximately 1 foot to 11 feet bgs.. As part of the aquifer testing activities, newly installed observation wells and two of the existing on-site monitoring wells were monitored electronically to estimate the response of water levels during the aquifer test. Water levels were monitored in the pumping well and observation wells for 48-hours prior to initiating the step drawdown test. Prior to commencement of the constant-rate aquifer test, a step-drawdown test was also performed to assess the sustainable yield of the pumping well for a 48-hour constant-rate pumping test. Based on the results of the step-drawdown test, a 48.5-hour constant-rate pumping test was performed on well EW-1 at a constant discharge rate of 1.91 gallons per minute (gpm). After cessation of the aquifer test, aquifer recovery data was also recorded for the pumping and monitoring wells for a period of 27.5 hours.

- Estimates of T and S_y (Table 1) for the fill material ranged from 50 ft^2/day to 153 ft^2/day, and 0.006 to 0.056, respectively. Assuming a saturated thickness of 7 feet for the fill material, estimates of the hydraulic conductivity (K) ranged from 7 ft/day to 22 ft/day.

- During the duration of the constant-rate aquifer test, no drawdown was observed in observation well OB-5, which is screened only in the Bay Mud and is located approximately 7 feet from the pumping well EW-1. This implies that pumping from the fill material will exhibit minimal or no influence on the groundwater levels in the clay unit underlying the subsurface fill materials.

- A groundwater flow model was constructed using the parameters obtained from the aquifer test, site lithologic logs, and groundwater elevations. These aquifer parameters were further modified during the transient calibration simulation to obtain the final calibrated aquifer parameters that would be used in evaluating and simulating the proposed dewatering system at the Site. The groundwater flow model was calibrated to the transient condition by simulating the EW-1 constant-rate aquifer test. Both the steady state simulation and transient calibration simulation results were found to be representative of the observed site conditions.

- The proposed dewatering system, comprising 47 extraction wells along the perimeter and the interior of the Site, was simulated using the calibrated groundwater flow model. Each of these dewatering wells is proposed to be installed in a manner such that the bottom of each of the proposed dewatering wells is expected to lie only in the top portion of the clay unit which lies beneath the fill material. Several simulations were performed to evaluate the effectiveness of the proposed dewatering system, and also to evaluate the effects of various aquifer parameters including groundwater levels, storage coefficient, hydraulic conductivity, and hydraulic communication between the zones (represented by the leakance) on the time to dewater the site.

- Results of the dewatering simulation under the Base condition (initial groundwater levels are assumed at a depth of approximately 1.5 to 2.5 feet bgs at the site and S_y for the fill material is 0.02) indicated that the Site would take approximately 60 days to dewater to bottom of the fill material. As the dewatering results in the drop in groundwater levels at the Site, the extraction rate would decrease from an initial rate of approximately 50 gpm to a stable rate of approximately 0.5 gpm after 60 days.

- As S_y, which is defined as the drainable porosity of the sediments, is the key physical parameter controlling the time required to dewater, dewatering simulations were performed with a range of S_y values so as to understand the impacts of higher S_y on the dewatering of the site. Results of the dewatering simulations indicated that the time required to dewater the fill material (model layer 1) increased significantly when the S_y was increased. For such a condition, additional wells would be required to completely dewater the site within a limited time frame.

- Model sensitivity analysis indicate that changes in the aquifer parameter values of hydraulic conductivity and leakance can result in a significant change in the time required to dewater the site. An increase in hydraulic conductivity and a decrease in leakance values from the final calibrated values will increase the time required to dewater the site significantly. In such a condition, the flow rates of the simulated dewatering wells may need to increased or additional wells may be required to completely dewater the site. However, a decrease in hydraulic conductivity and an increase in leakance values will decrease the time required to dewater the site.

Even though changes in aquifer parameters effects the drawdowns and time to dewater the site, the drawdown results obtained from the Base Simulation was considered most representative because it is based on the calibrated values obtained from the transient calibration model runs, which were further based on the observed behavior of the aquifer during the EW-1 constant rate aquifer test.

5.0 LIMITATIONS

This report has been prepared by Applied Remedial Technologies, Inc. (ART) for the exclusive use of R.W.L. Investments, Inc. (RWL; Client) as it pertains to the Heitz Trucking (formerly DiSalvo Trucking) facility located at 4919 Tidewater Avenue in Oakland, California.

ART professional services have been performed using the degree of care and skill ordinarily exercised under similar circumstances by other engineers, geologists, and/or scientists practicing in this field. No other warranty, express or implied, is made as to the professional advice in this report.

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Prior to use of this report by any party other than the Client, the party should notify ART of such intended use. The attached report my not contain sufficient information for purposes of other parties or other uses. Any use or reliance on this report by a third party shall be at such party's sole risk.

The findings set forth in the attached report are strictly limited in time and scope to the date of the services described herein, and not on scientific tasks or procedures beyond the services agreed upon, or the time and budgeting constraints imposed by the Client. Any conditions and factors, including land use and contaminant plume migration, may change over passage of time, additional investigation may be required to update the site conditions (on-site and off-site), which may require the findings in the report to be reevaluated.

6.0 REFERENCES

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Applied Remedial Technologies, Inc. (ART), May 15, 2006, *Temporary Shoring and Cut-Off Design."*

TABLES

TABLE 1 - CONSTANT-RATE AQUIFER PUMPING TEST RESULTS

4919 Tidewater Avenue, Oakland, CA

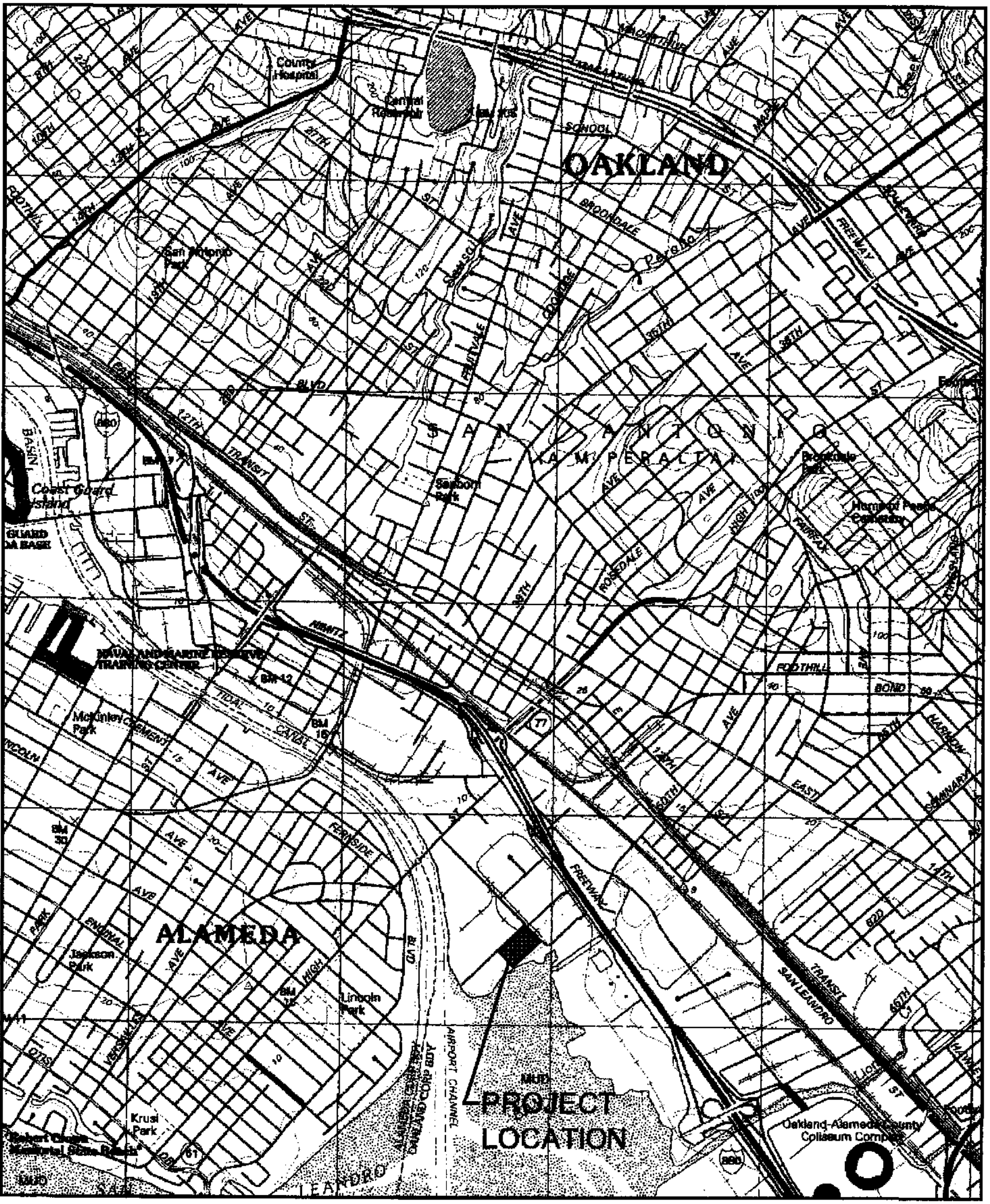
Pumping Well and Pumping Parameters	Observation Well	Distance from Pumping Well (feet)	Response Observed	Maximum Drawdown (feet)	Evaluation of Drawdown (D) or Recovery (R) Data	Method of Analysis	Transmissivity T (ft^2 / day)	Thickness b (ft)	Hydraulic Conductivity		Storativity S	Specific Yield Sy
									(ft/day)	(cm/sec)		
EW-1	MW-2	15.75	Y	1.55	D	Neumann	50	7	7	0.0025	0.017	0.056
Total Q = 1.91 gpm					D	Theis	95	7	14	0.0048	0.030	--
Pump On : 05/25/2006					R	Theis Recovery	73	7	10	0.0037	--	--
Pump Off : 05/27/2006												
Duration Pumped = 2910 mins	MW-3	97	Y	0.47	D	Neumann	71	7	10	0.0036	0.002	0.015
					D	Theis	143	7	20	0.0072	0.009	--
					R	Theis Recovery	153	7	22	0.0077	--	--
	OB-3	7.5	Y	1.99	D	Neumann	74	7	11	0.0037	0.012	0.040
					D	Theis	99	7	14	0.0050	0.026	--
					R	Theis Recovery	89	7	13	0.0045	--	--
	OB-4	16.75	Y	1.50	D	Neumann	84	7	12	0.0042	0.006	0.019
					D	Theis	116	7	17	0.0059	0.012	--
					R	Theis Recovery	94	7	13	0.0048	--	--
	OB-6	18.75	Y	1.48	D	Neumann	69	7	10	0.0035	0.001	0.006
					D	Theis	109	7	16	0.0055	0.004	--
					R	Theis Recovery	89	7	13	0.0045	--	--
			Estimate of Shallow Zone using the Distance-Drawdown Method				99	7	14	0.0050	--	--
					AVERAGE ARITHMETIC ESTIMATES		94	7	13	0.0047	0.012	0.027

TABLE 2 - TRANSIENT CALIBRATION - RESULTS OF EW-1 CONSTANT-RATE PUMP TEST

4919 Tidewater Avenue, Oakland, CA

Well Name	Drawdown (ft)		Residuals (ft)
	Observed	Simulated	
MW-2	1.55	1.37	0.18
MW-3	0.47	0.32	0.15
OB-3	1.99	1.91	0.08
OB-4	1.50	1.28	0.22
OB-6	1.48	1.2	0.28

FIGURES



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VICINITY MAP

-

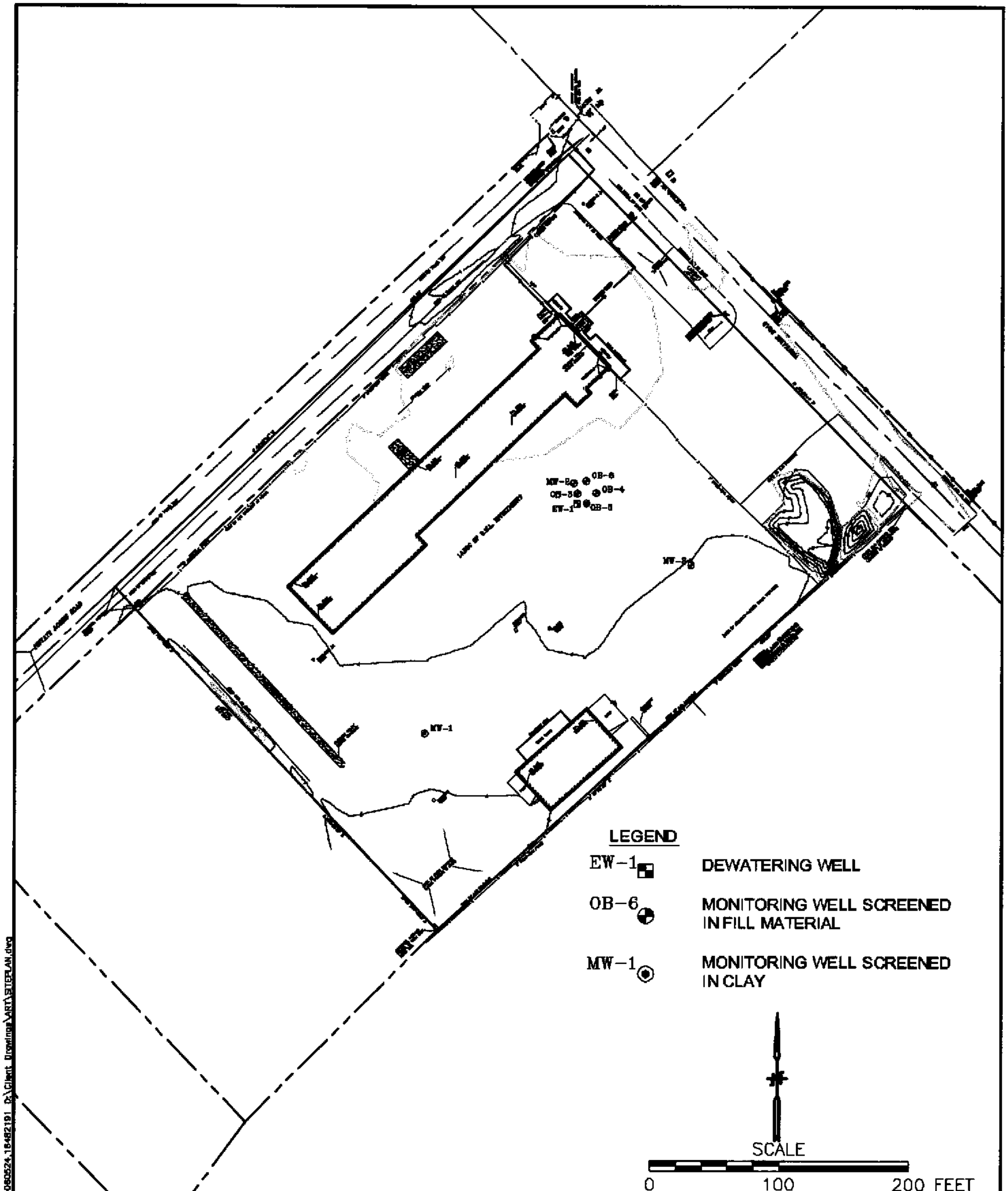
-

OAKLAND, CALIFORNIA

FIGURE NO

1

DRAWN	JOB NO.	APPROVED	DATE	REVISION DATE
PPV	-	VO	5-23-06	3-10-99



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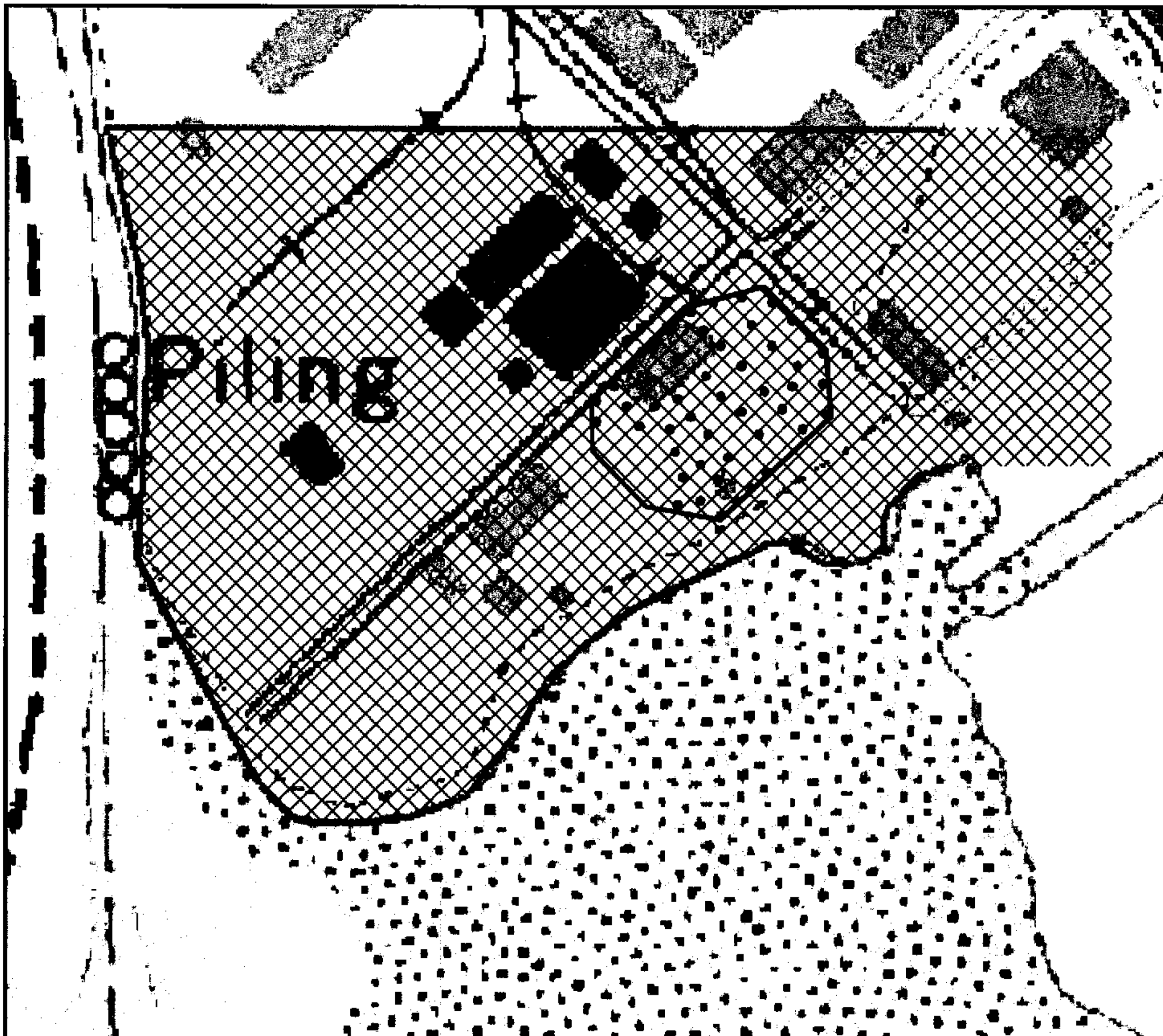
SITE PLAN AND EXISTING WELL LOCATIONS

HEITZ TRUCKING
4919 TIDEWATER AVENUE
OAKLAND, CALIFORNIA

FIGURE NO
2

DRAWN	JOB NO.	APPROVED	DATE	REVISION DATE
PPV	-	VO	5-23-06	3-10-99



LEGEND

● PROPOSED DEWATERING WELLS

SHEET PILE / CUT-OFF WALL

GENERAL HEAD BOUNDARY

MODEL DOMAIN

Applied Remedial Technologies
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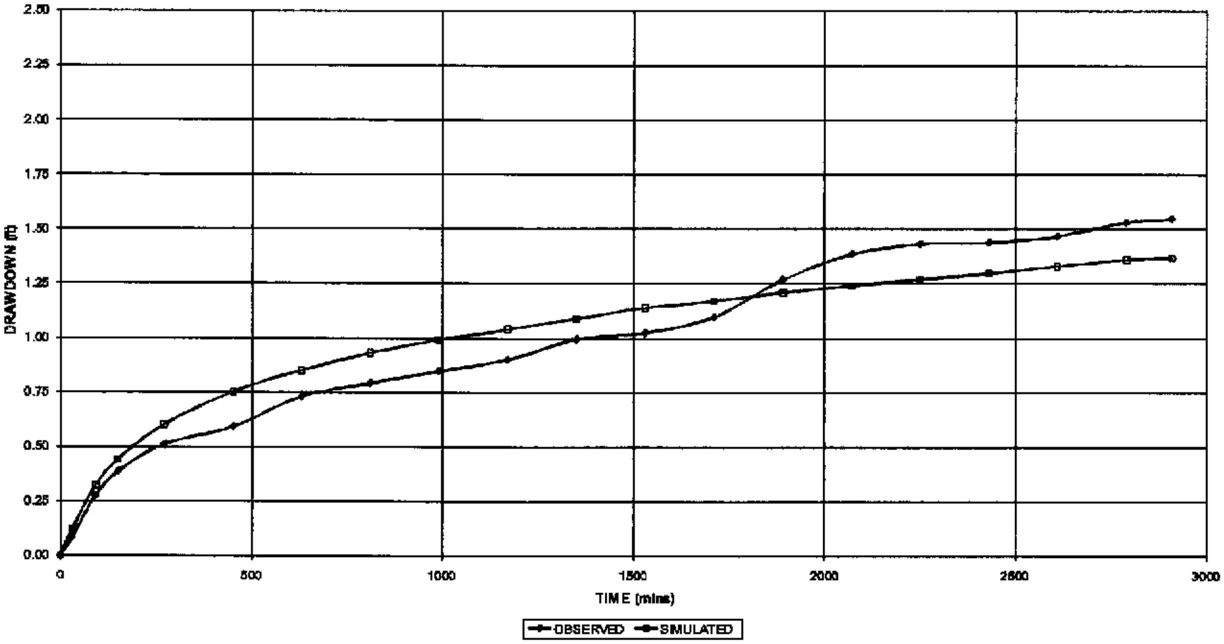
MODEL DOMAIN AND BOUNDARY CONDITIONS

HEITZ TRUCKING
4919 TIDEWATER AVENUE
OAKLAND, CALIFORNIA

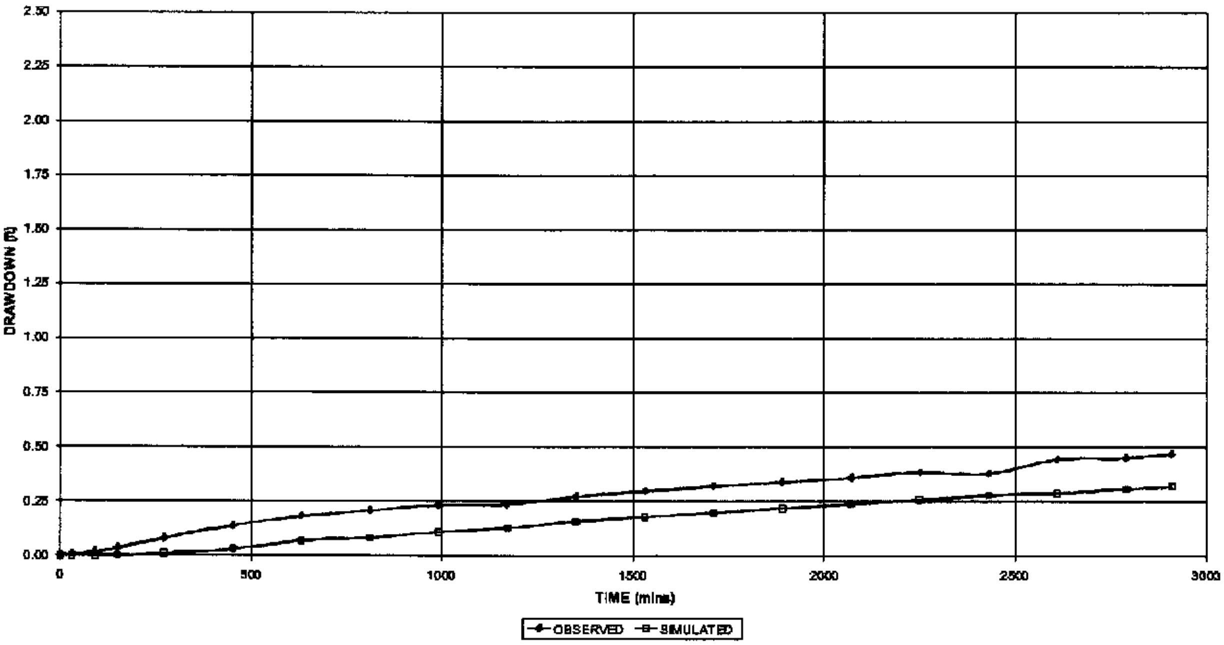
FIGURE NO
3

DRAWN	JOB NO.	APPROVED	DATE	REVISION DATE
PPV	-	VO	5-23-06	3-10-99

TIME-DRAWDOWN CURVE COMPARISON - WELL MW-2



TIME-DRAWDOWN CURVE COMPARISON - WELL MW-3



20060524.15462195 O:\Client Drawings\ART\FIGURE 4.dwg

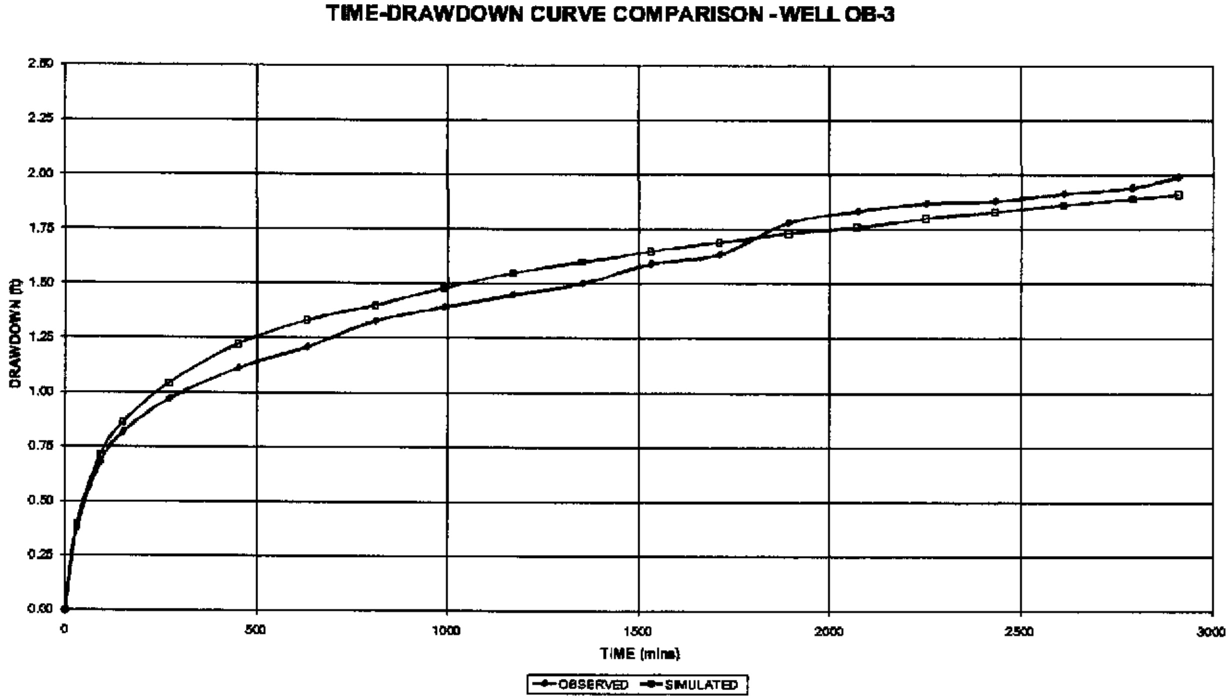
Applied Remedial Technologies
Environmental / Radiological / Geotechnical / Construction Services

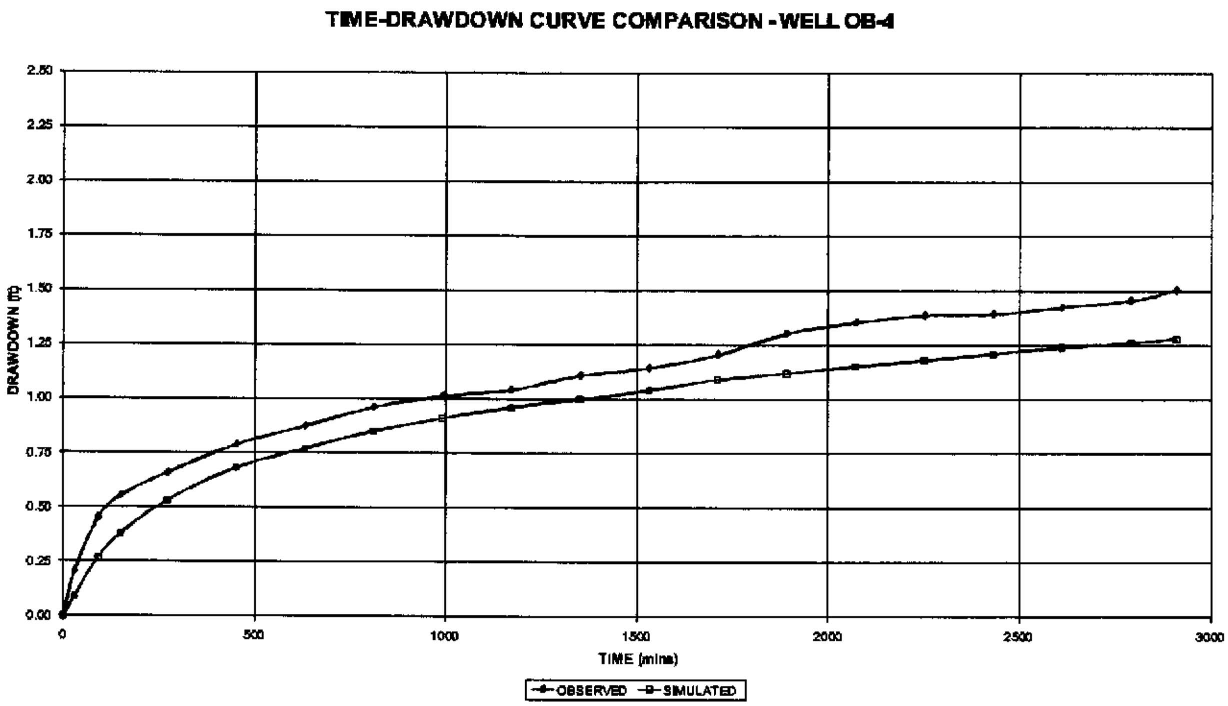
TIME-DRAWDOWN CURVE
MW-2 AND MW-3

HEITZ TRUCKING
4919 TIDEWATER AVENUE
OAKLAND, CALIFORNIA

FIGURE NO
4A

DRAWN	JOB NO.	APPROVED	DATE	REVISION DATE
PPV	-	VO	5-23-06	3-10-99





20060524.1545664 p:\Client Drawings\ART\FIGURE 4.dwg

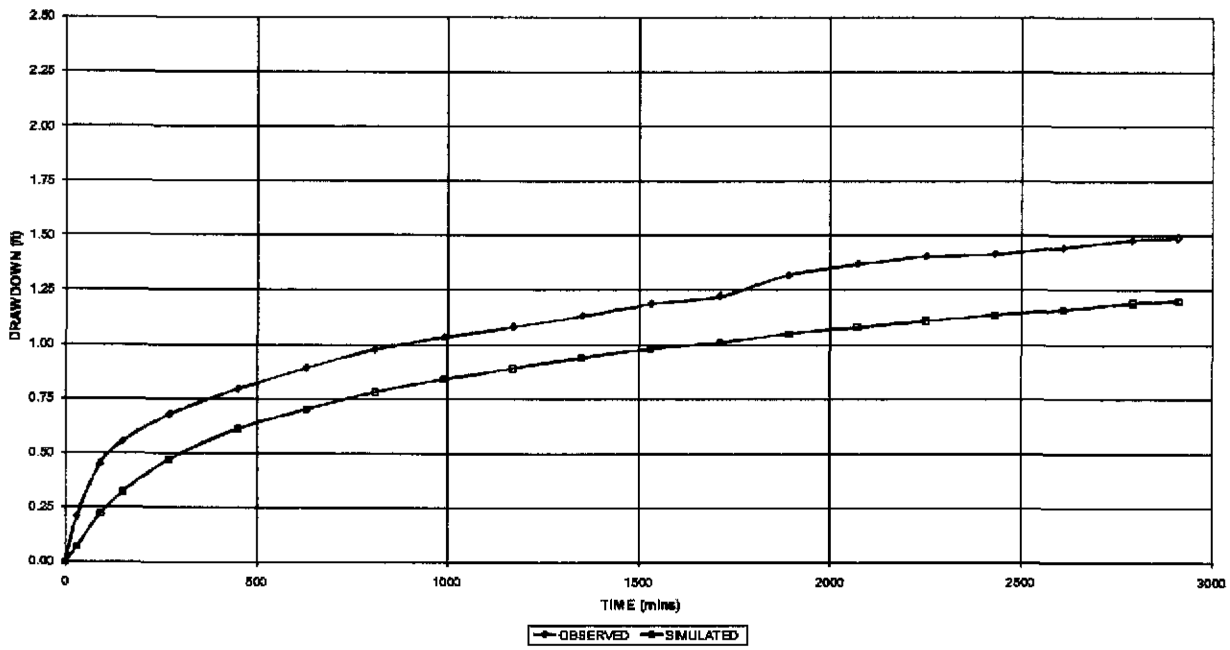
Applied Remedial Technologies
Environmental / Radiological / Geotechnical / Construction Services

TIME-DRAWDOWN CURVE
OB-3 AND OB-4
HEITZ TRUCKING
4919 TIDEWATER AVENUE
OAKLAND, CALIFORNIA

FIGURE NO
4B

DRAWN	JOB NO.	APPROVED	DATE	REVISION DATE
PPV	-	VO	5-23-06	3-10-99

TIME-DRAWDOWN CURVE COMPARISON - WELL OB-6



20060524.13491704 G:\Client Drawings\ART\FIGURE 4.dwg

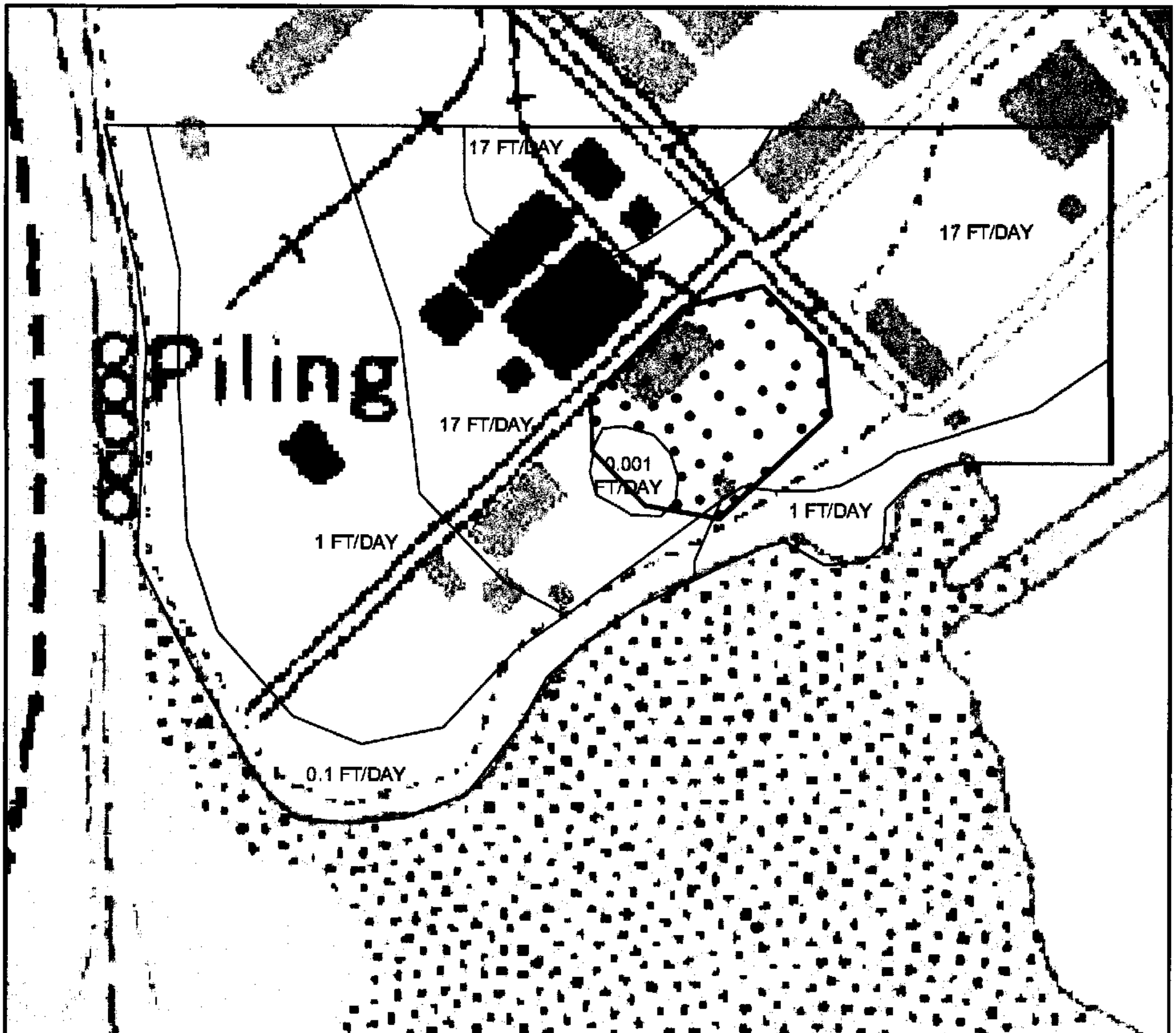
Applied Remedial Technologies
Environmental / Radiological / Geotechnical / Construction Services

TIME-DRAWDOWN CURVE
OB-6

HEITZ TRUCKING
4919 TIDEWATER AVENUE
OAKLAND, CALIFORNIA

FIGURE NO
4C

DRAWN	JOB NO.	APPROVED	DATE	REVISION DATE
PPV	-	VO	5-23-06	3-10-99



LEGEND

● PROPOSED DEWATERING WELLS

—— SHEET PILE / CUT-OFF WALL

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HYDRAULIC CONDUCTIVITY 'K' ZONES
FILL MATERIAL (MODEL LAYER 1)

HEITZ TRUCKING
4919 TIDEWATER AVENUE
OAKLAND, CALIFORNIA

FIGURE NO
5

DRAWN	JOB NO.	APPROVED	DATE	REVISION DATE
PPV	-	VO	5-23-06	3-10-99

LEGEND

● PROPOSED DEWATERING WELLS

▬▬▬ SHEET PILE / CUT-OFF WALL

Applied Remedial Technologies
Environmental / Radiological / Geotechnical / Construction Services

SIMULATED DRAWDOWN FOR PROPOSED DEWATERING SYSTEM - DAY 1

HEITZ TRUCKING
4919 TIDEWATER AVENUE
OAKLAND, CALIFORNIA

FIGURE NO
6A

DRAWN	JOB NO.	APPROVED	DATE	REVISION DATE
PPV	-	VO	5-23-06	3-10-99

LEGEND

● PROPOSED DEWATERING WELLS

——— SHEET PILE / CUT-OFF WALL

20060524.1624:1942 C:\Client Drawings\ART\FIGURE 6B.dwg

Applied Remedial Technologies
Environmental / Radiological / Geotechnical / Construction Services

SIMULATED DRAWDOWN FOR PROPOSED DEWATERING SYSTEM - DAY 30

HEITZ TRUCKING
4919 TIDEWATER AVENUE
OAKLAND, CALIFORNIA

FIGURE NO
6B

DRAWN	JOB NO.	APPROVED	DATE	REVISION DATE
PPV	-	VO	5-23-06	3-10-99

LEGEND

● PROPOSED DEWATERING WELLS

——— SHEET PILE / CUT-OFF WALL

Applied Remedial Technologies

Environmental / Radiological / Geotechnical / Construction Services

SIMULATED DRAWDOWN FOR PROPOSED DEWATERING SYSTEM - DAY 60

HEITZ TRUCKING
4919 TIDEWATER AVENUE
OAKLAND, CALIFORNIA

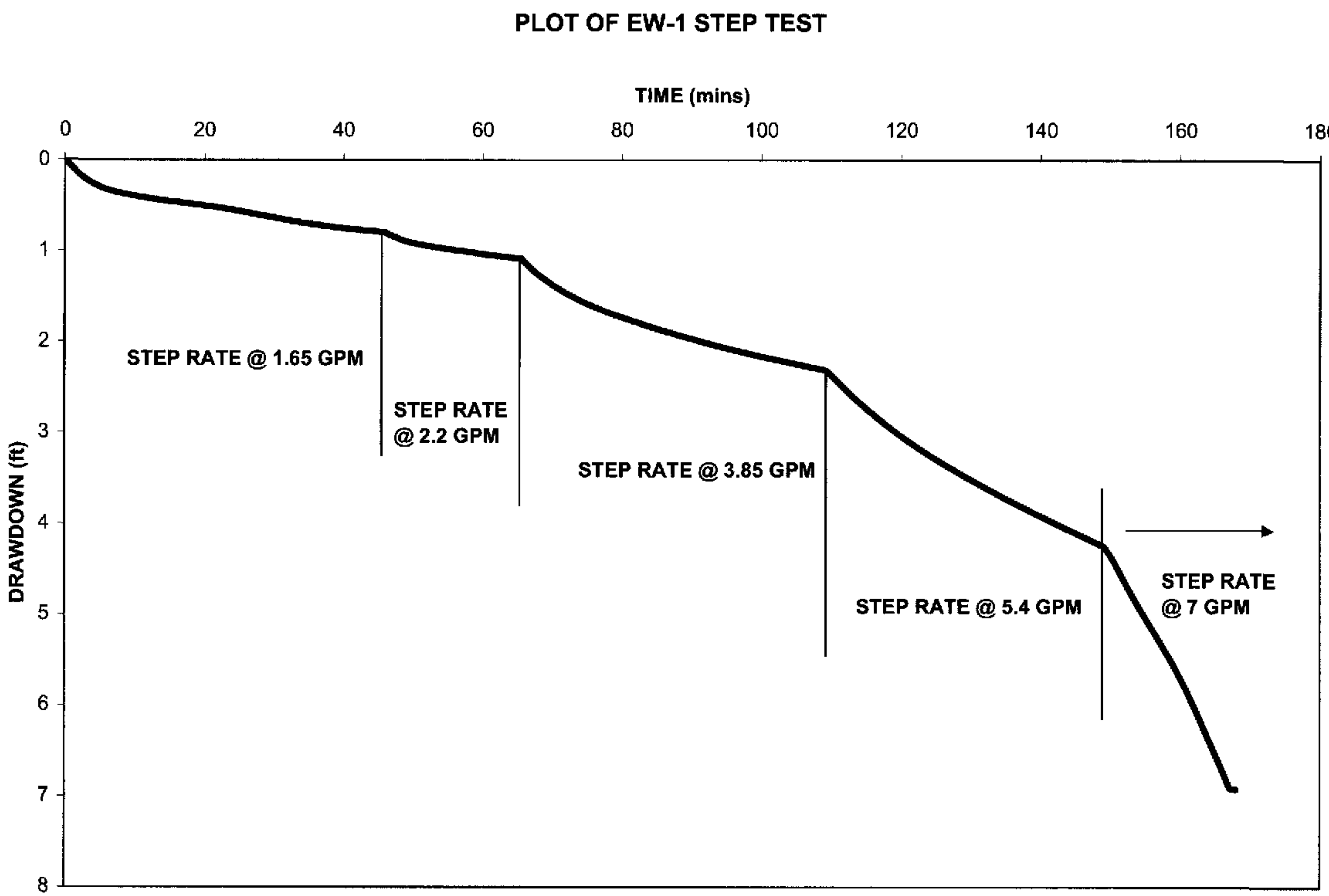
FIGURE NO

6C

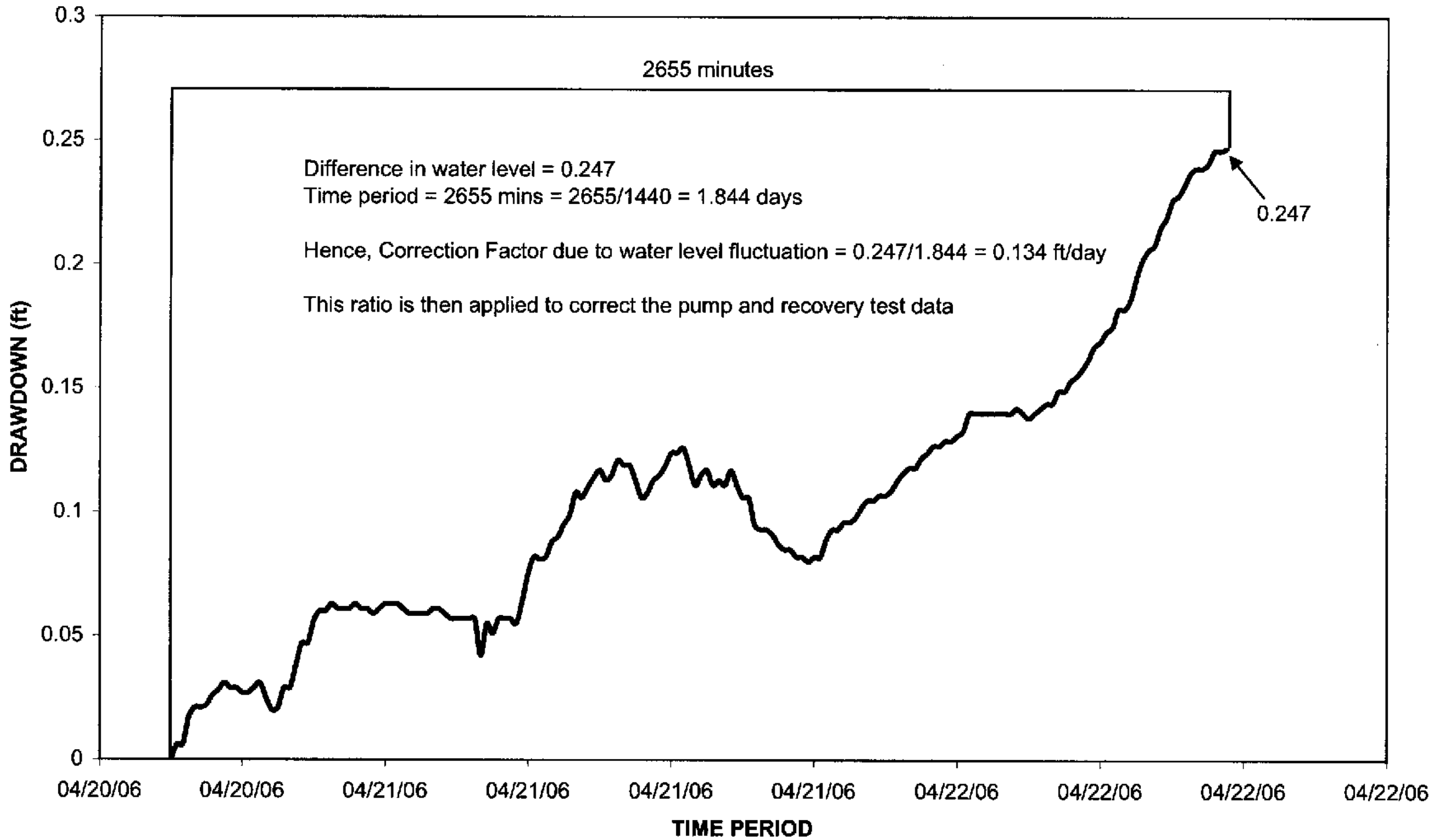
DRAWN	JOB NO.	APPROVED	DATE	REVISION DATE
PPV	-	VO	5-23-06	3-10-99

APPENDIX A

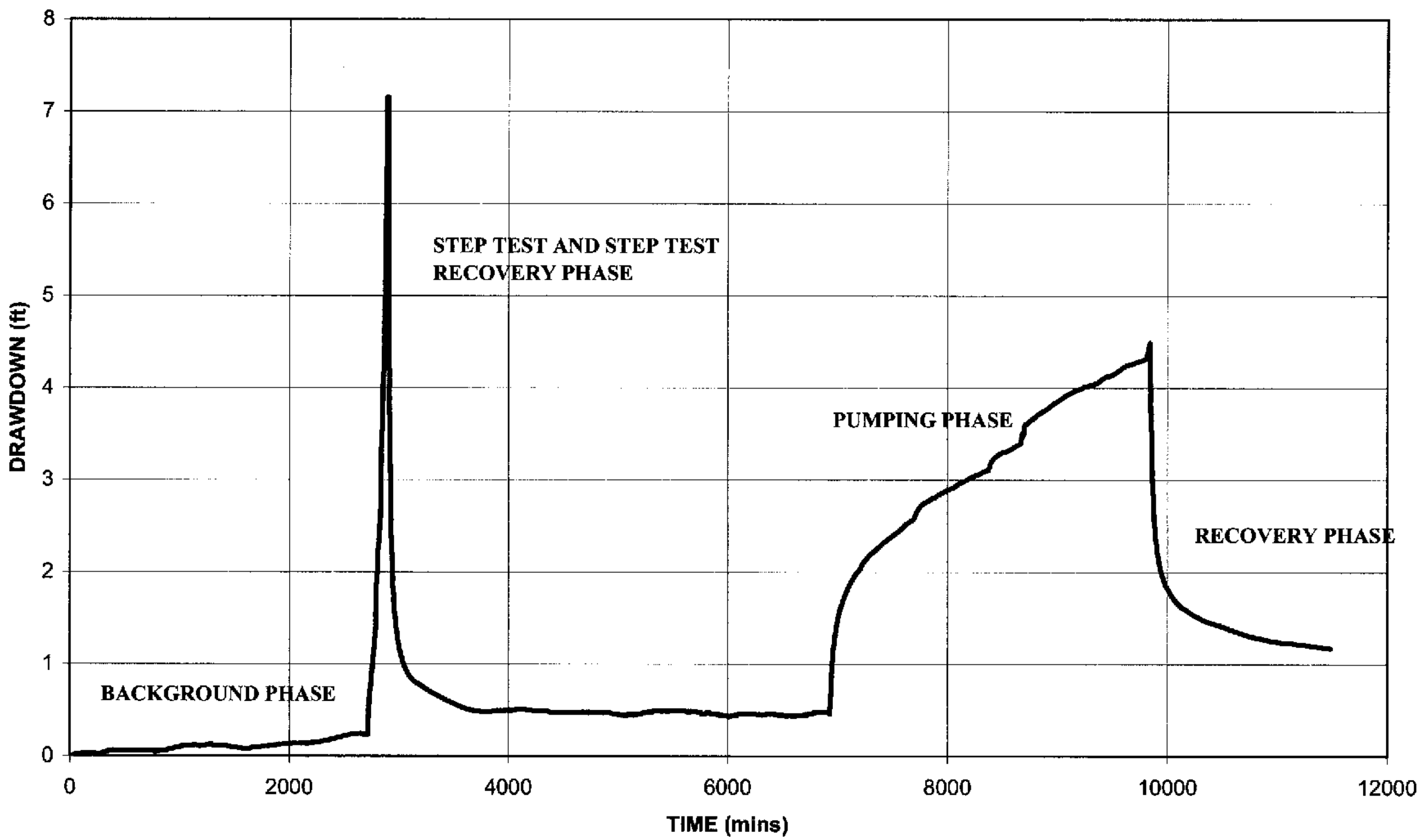
GRAPHS AND FIGURES OF AQUIFER TEST RESULTS

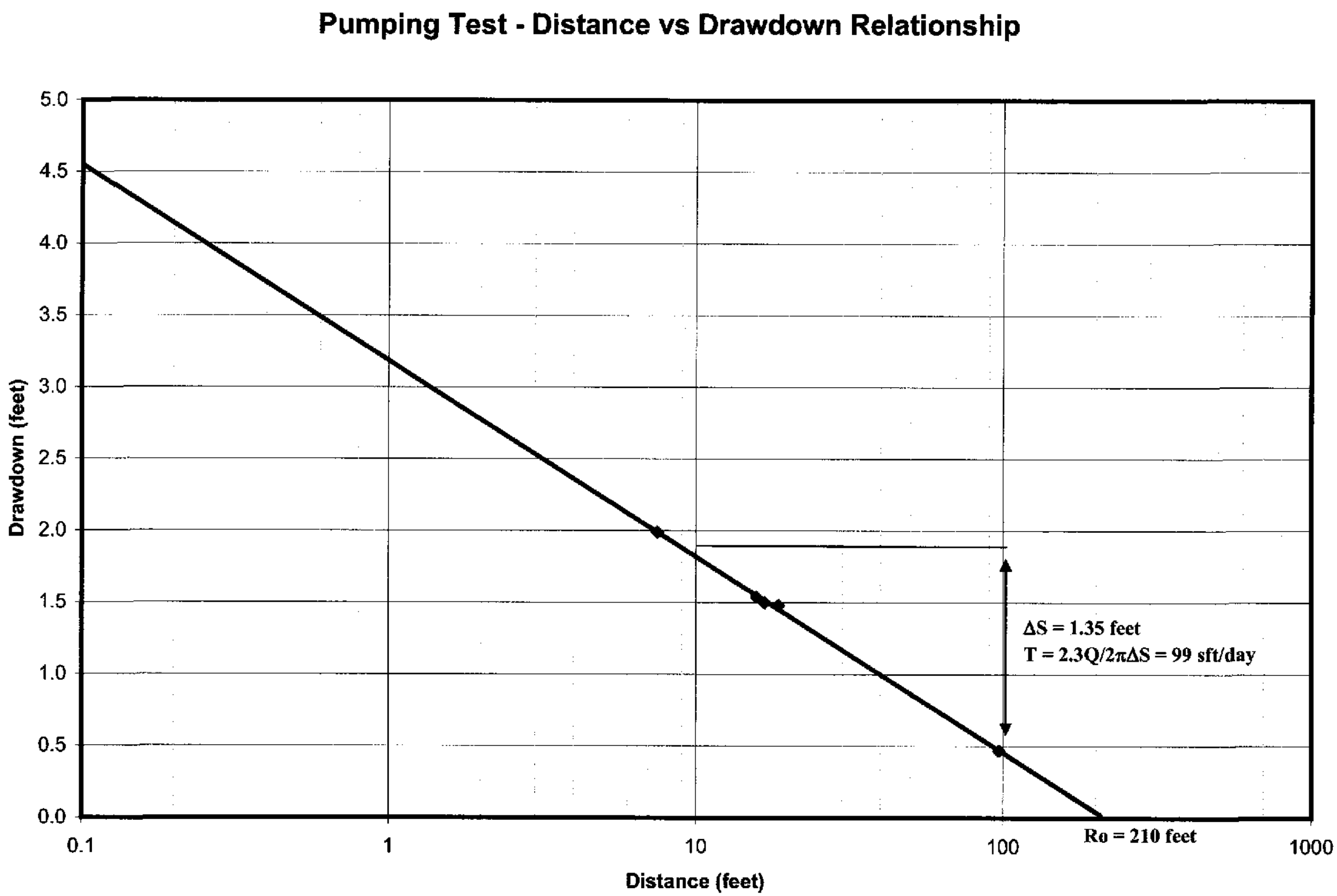

PLOT OF EW-1 STEP TEST
TIME (mins)
0
20
40
60
80
100
120
140
160
180
DRAWDOWN (ft)
0
1
2
3
4
5
6
7
8
STEP RATE @ 1.65 GPM
STEP RATE @ 2.2 GPM
STEP RATE @ 3.85 GPM
STEP RATE @ 5.4 GPM
STEP RATE @ 7 GPM

CORRECTION FACTOR DUE TO WATER LEVEL FLUCTUATION
EW-1 BACKGROUND DATA

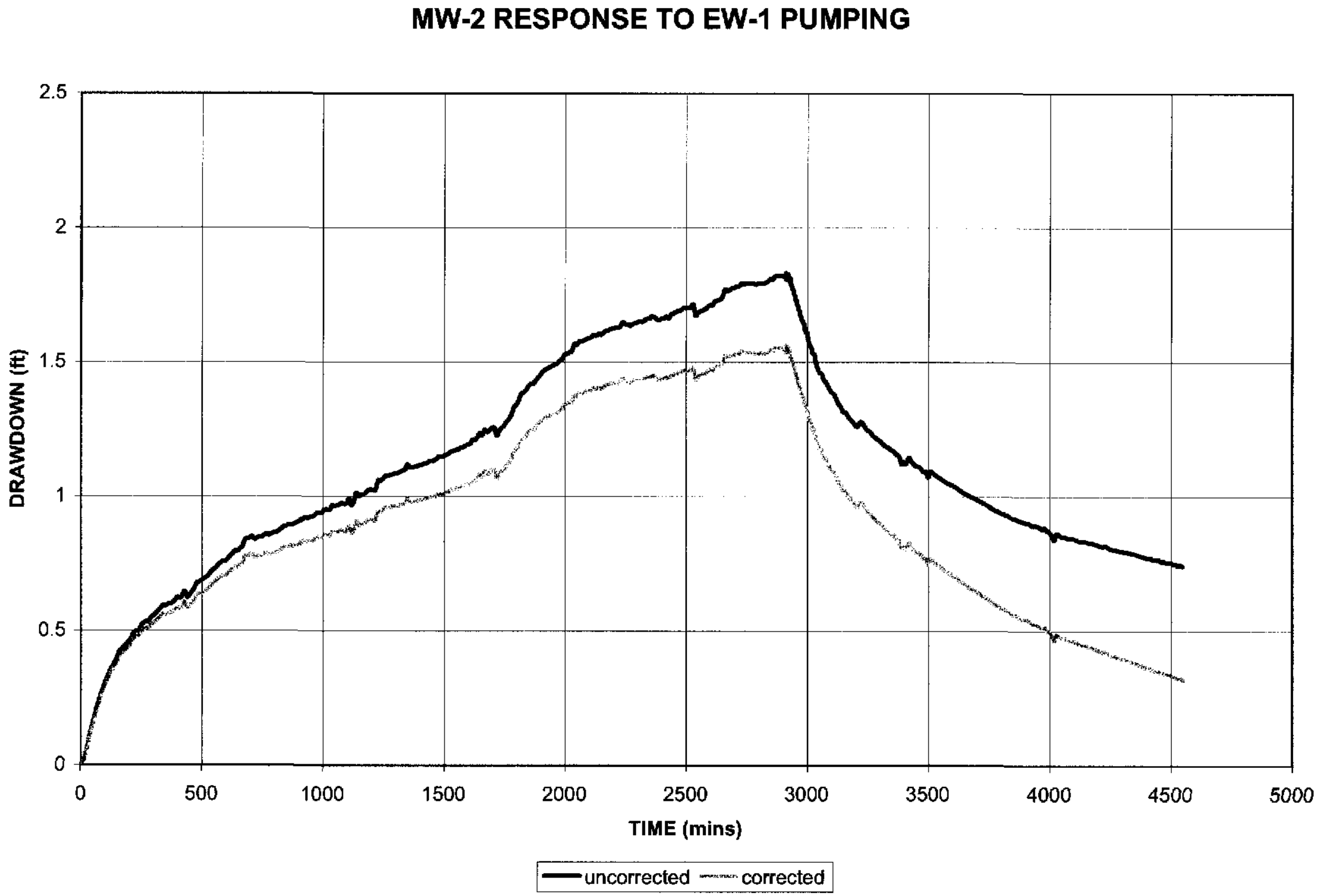


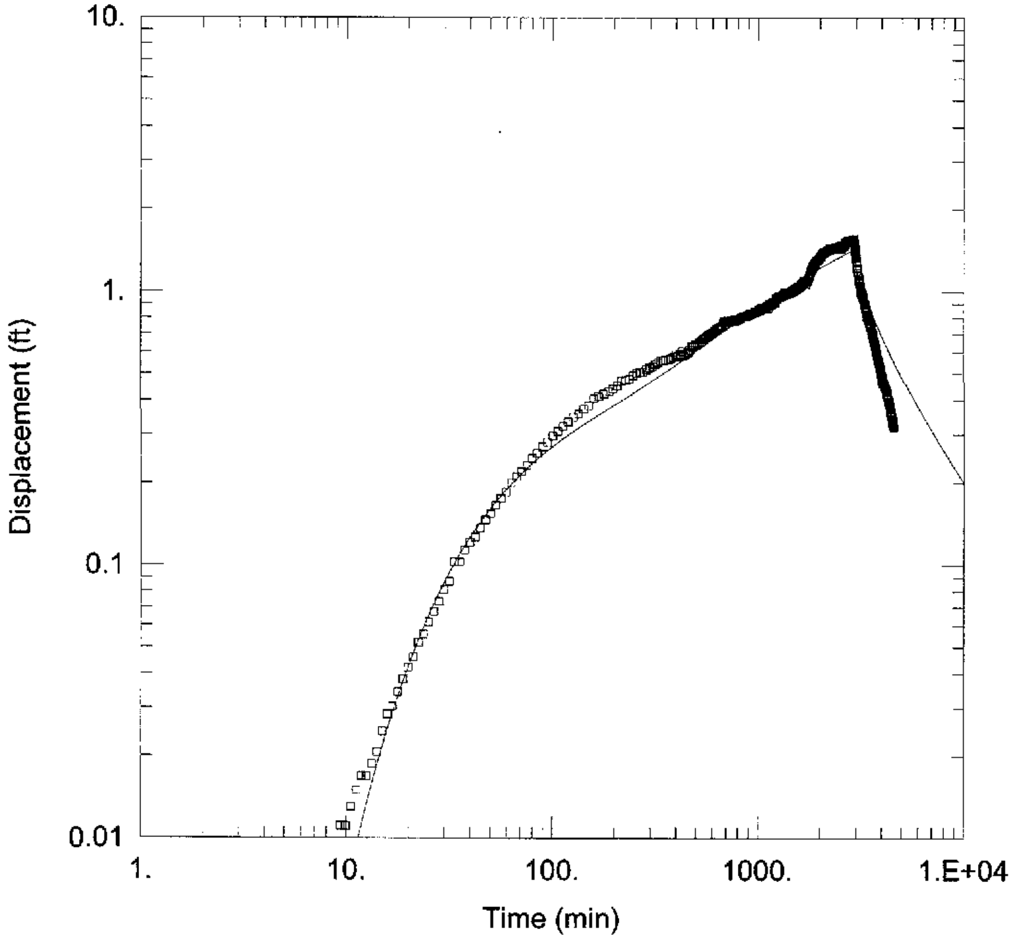
CHANGES IN WATER LEVELS DURING THE BACKGROUND, STEP-TEST, PUMPING, AND RECOVERY PHASES IN DEWATERING / PUMPING WELL EW-1





Pumping Test - Distance vs Drawdown Relationship
Drawdown (feet)
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0.1
1
10
100
1000
Distance (feet)
ΔS = 1.35 feet
T = 2.3Q/2πΔS = 99 sft/day
Ro = 210 feet


MW-2 RESPONSE TO EW-1 PUMPING
DRAWDOWN (ft)
0
0.5
1
1.5
2
2.5
TIME (mins)
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
uncorrected
corrected



MW-2 RESPONSE TO EW-1 PUMPING AT 1.91 GPM (NEUMAN)

PROJECT INFORMATION

Company: Applied Remedial Technologies
Client: R.W.L. Investments, Inc.
Project: 170-1
Location: 4919 Tidewater Ave., Oakland
Test Well: EW-1
Test Date: 04/25/06

AQUIFER DATA

Saturated Thickness: 7. ft

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
EW-1	0	0

Observation Wells

Well Name	X (ft)	Y (ft)
▫ MW-2	-15	-4

SOLUTION

Aquifer Model: Unconfined

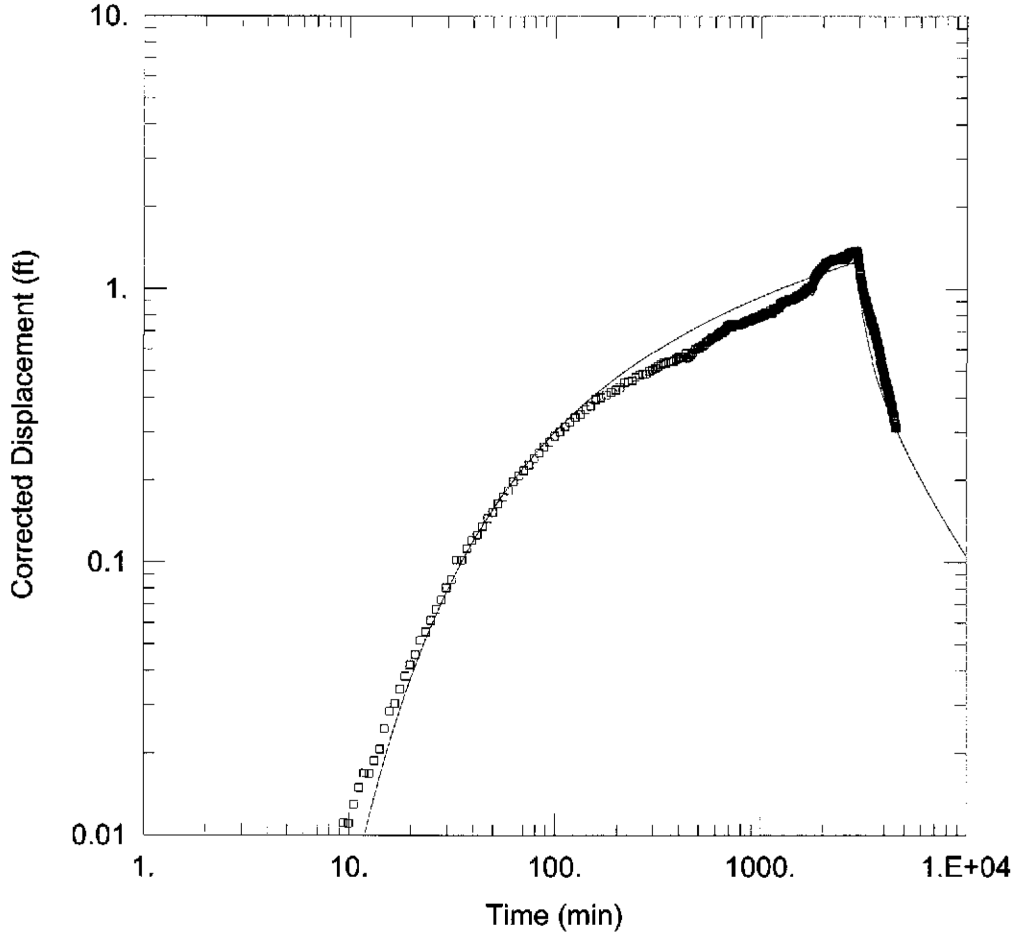
Solution Method: Neuman

T = 49.45 ft^2/day

S = 0.0168

Sy = 0.07196

ß = 0.6



MW-2 RESPONSE TO EW-1 PUMPING AT 1.91 GPM (THEIS)

PROJECT INFORMATION

Company: Applied Remedial Technologies
Client: R.W.L. Investments, Inc.
Project: 170-1
Location: 4919 Tidewater Ave., Oakland
Test Well: EW-1
Test Date: 04/25/06

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
EW-1	0	0

Observation Wells

Well Name	X (ft)	Y (ft)
▫ MW-2	-15	-4

SOLUTION

Aquifer Model: Unconfined

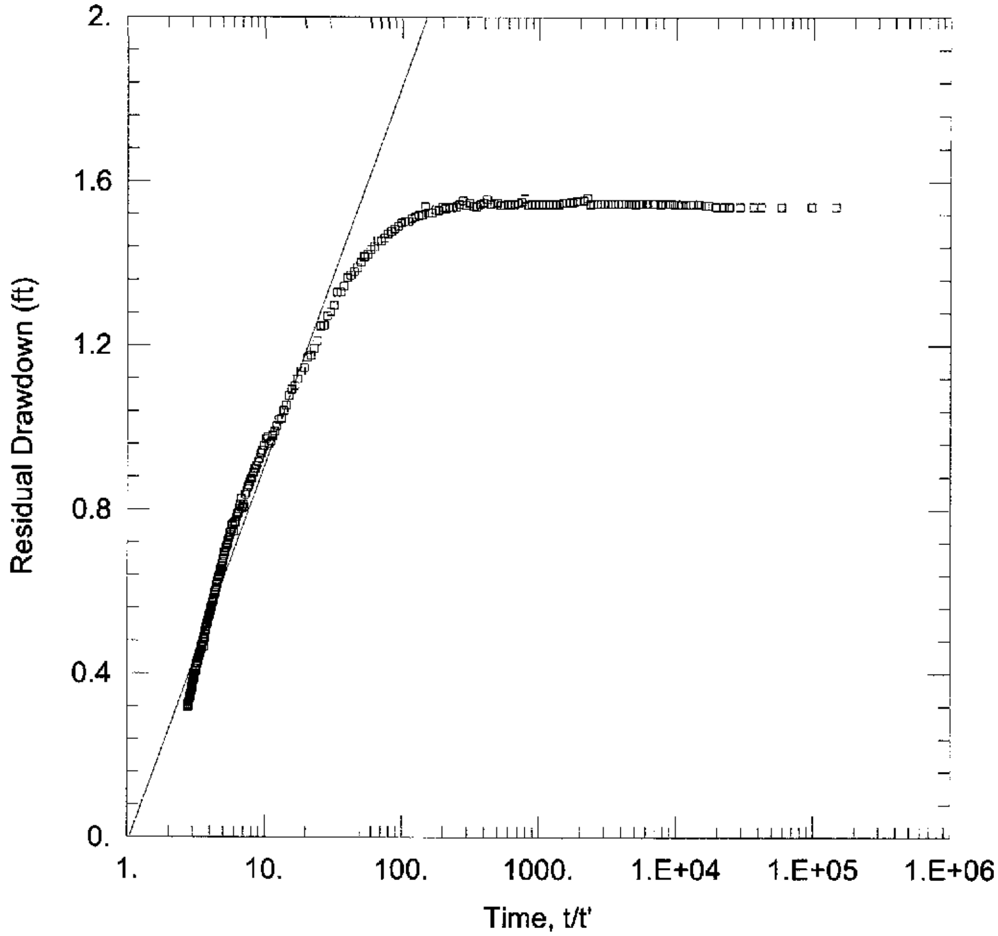
Solution Method: Theis

T = 95.07 ft^2/day

S = 0.03

Kz/Kr = 0.1

b = 7. ft



MW-2 RESPONSE TO EW-1 PUMPING AT 1.91 GPM (RECOVERY)

PROJECT INFORMATION

Company: Applied Remedial Technologies
Client: R.W.L. Investments, Inc.
Project: 170-1
Location: 4919 Tidewater Ave., Oakland
Test Well: EW-1
Test Date: 04/25/06

AQUIFER DATA

Saturated Thickness: 7. ft

Anisotropy Ratio (Kz/Kr): 0.122

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
EW-1	0	0

Observation Wells

Well Name	X (ft)	Y (ft)
▫ MW-2	-15	-4

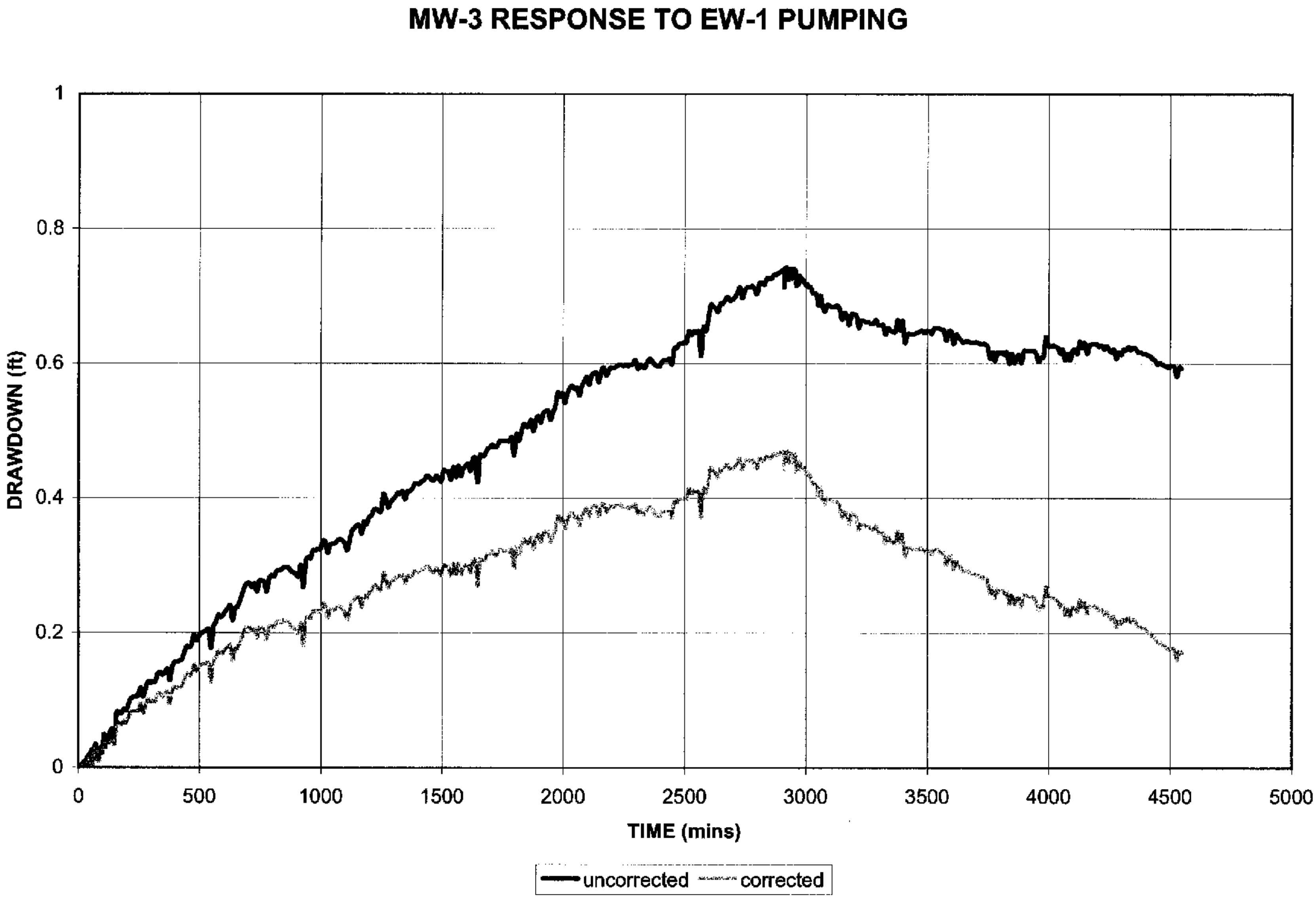
SOLUTION

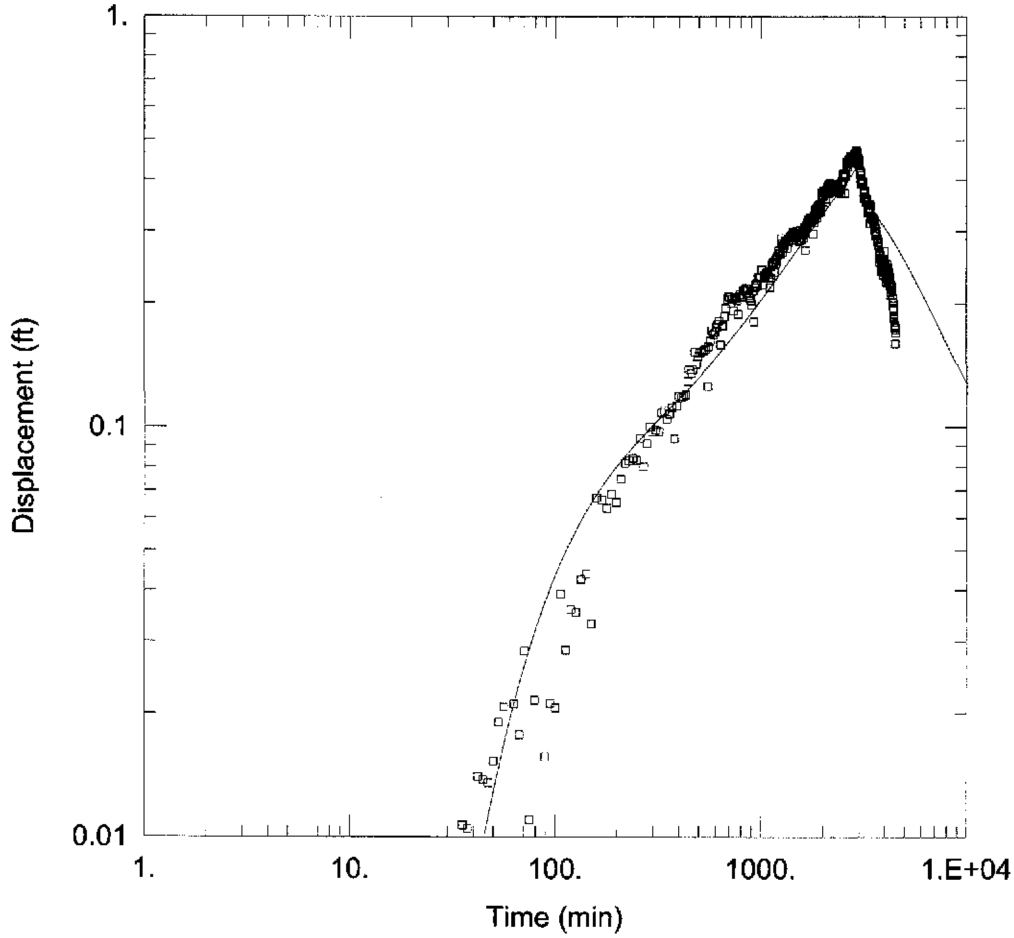
Aquifer Model: Confined

Solution Method: Theis (Recovery)

T = 72.93 ft^2/day

S/S' = 1.037


MW-3 RESPONSE TO EW-1 PUMPING
DRAWDOWN (ft)
1
0.8
0.6
0.4
0.2
0
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
TIME (mins)
uncorrected
corrected



MW-3 RESPONSE TO EW-1 PUMPING AT 1.91 GPM (NEUMAN)

PROJECT INFORMATION

Company: Applied Remedial Technologies
Client: R.W.L. Investments, Inc.
Project: 170-1
Location: 4919 Tidewater Ave., Oakland
Test Well: EW-1
Test Date: 04/25/06

AQUIFER DATA

Saturated Thickness: 7. ft

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
EW-1	0	0

Observation Wells

Well Name	X (ft)	Y (ft)
□ MW-3	92	-30

SOLUTION

Aquifer Model: Unconfined

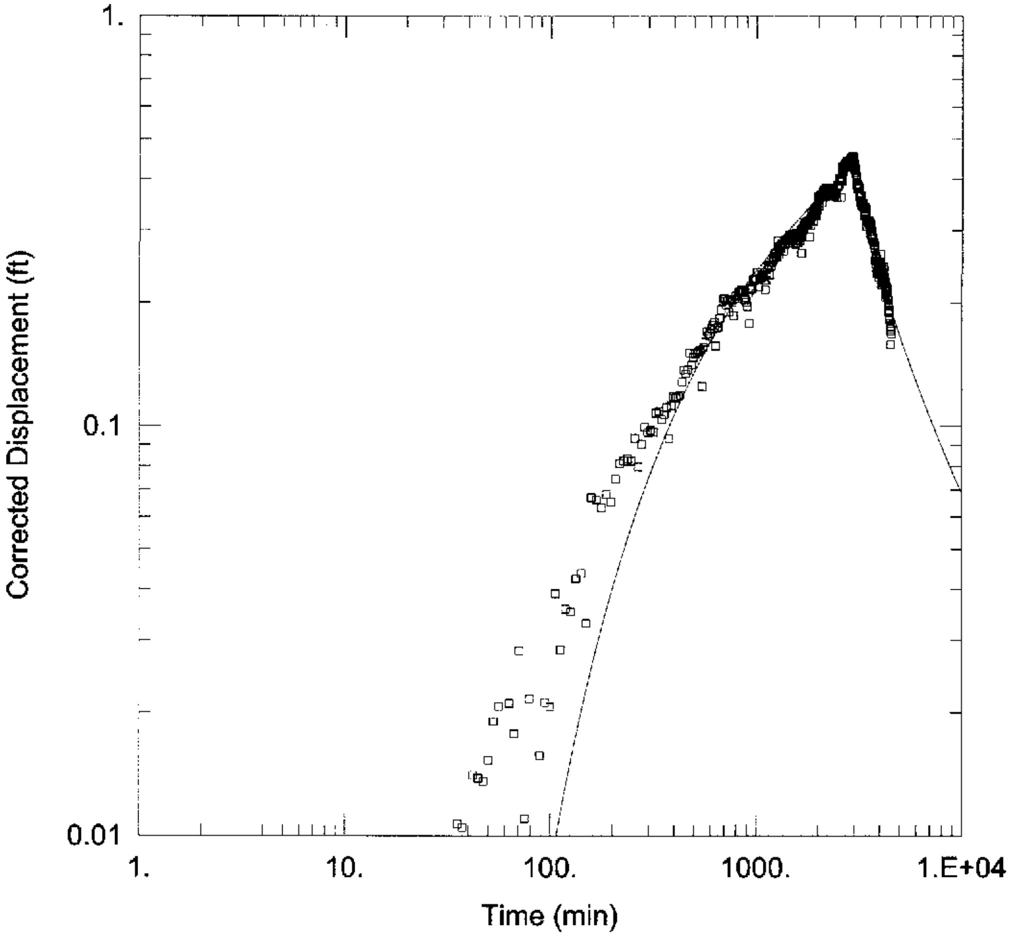
Solution Method: Neuman

T = 70.9 ft^2/day

S = 0.002016

Sy = 0.01448

ß = 1.5



MW-3 RESPONSE TO EW-1 PUMPING AT 1.91 GPM (THEIS)

PROJECT INFORMATION

Company: Applied Remedial Technologies
Client: R.W.L. Investments, Inc.
Project: 170-1
Location: 4919 Tidewater Ave., Oakland
Test Well: EW-1
Test Date: 04/25/06

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
EW-1	0	0

Observation Wells

Well Name	X (ft)	Y (ft)
▫ MW-3	92	-30

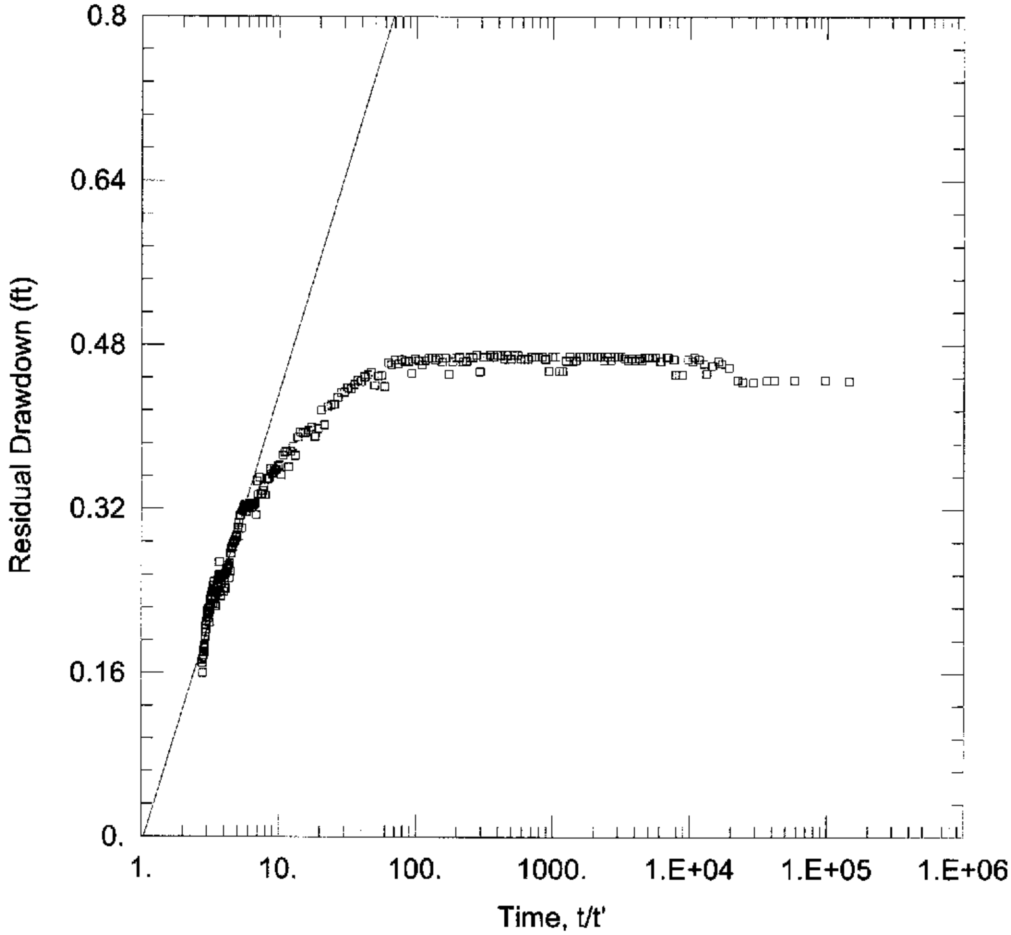
SOLUTION

Aquifer Model: Unconfined

Solution Method: Theis

T = 142.9 ft^2/day
Kz/Kr = 0.1

S = 0.009087
b = 7. ft



MW-3 RESPONSE TO EW-1 PUMPING AT 1.91 GPM (RECOVERY)

PROJECT INFORMATION

Company: Applied Remedial Technologies
Client: R.W.L. Investments, Inc.
Project: 170-1
Location: 4919 Tidewater Ave., Oakland
Test Well: EW-1
Test Date: 04/25/06

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
EW-1	0	0

Observation Wells

Well Name	X (ft)	Y (ft)
□ MW-3	92	-30

SOLUTION

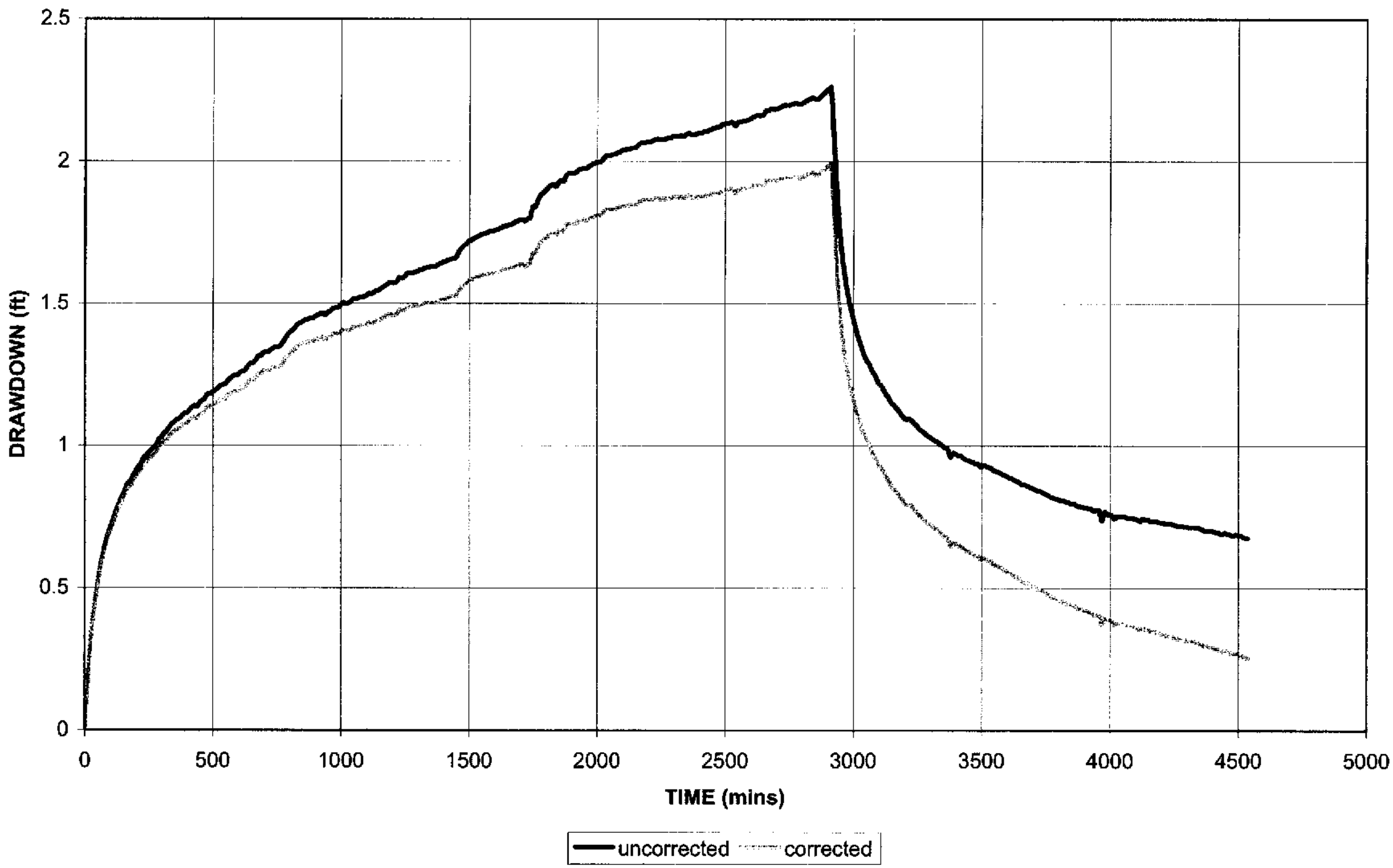
Aquifer Model: Confined

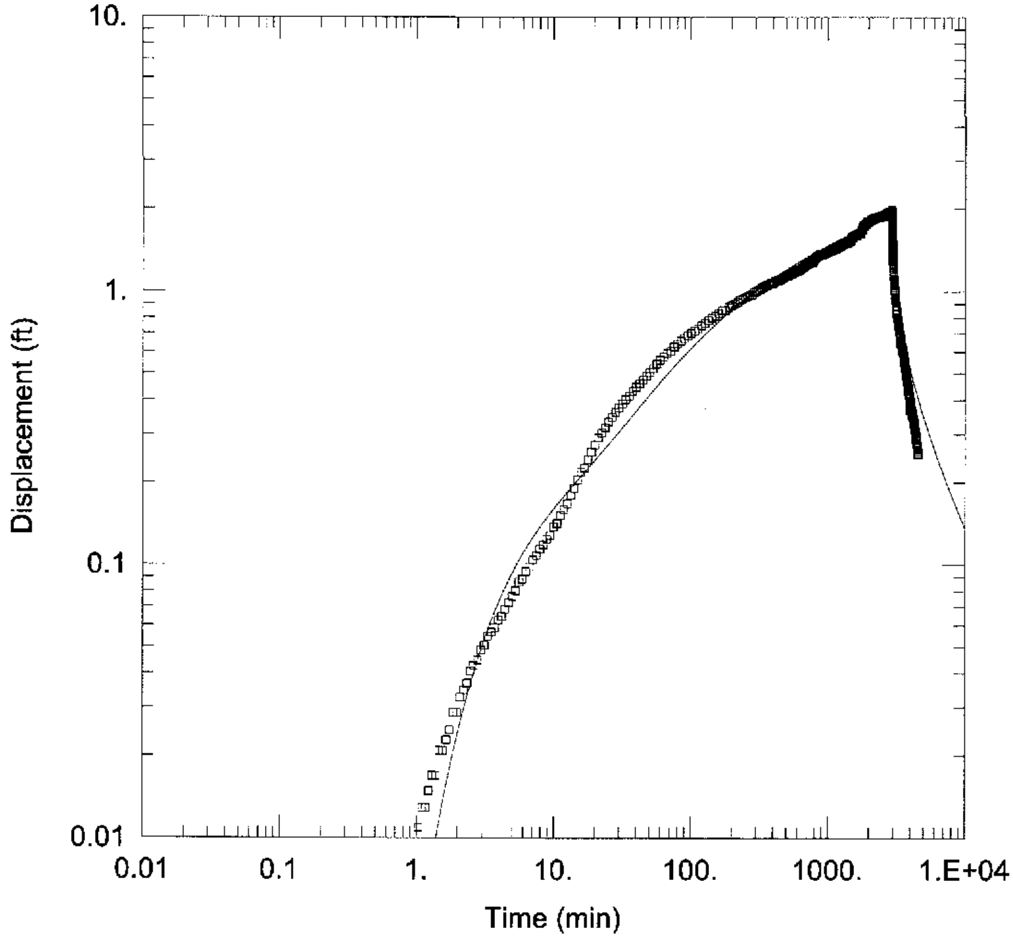
Solution Method: Theis (Recovery)

T = 153. ft^2/day

S/S' = 1.041

OB-3 RESPONSE TO EW-1 PUMPING





OB-3 RESPONSE TO EW-1 PUMPING AT 1.91 GPM (NEUMAN)

PROJECT INFORMATION

Company: Applied Remedial Technologies
Client: R.W.L. Investments, Inc.
Project: 170-1
Location: 4919 Tidewater Ave., Oakland
Test Well: EW-1
Test Date: 04/25/06

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
EW-1	0	0

Observation Wells

Well Name	X (ft)	Y (ft)
□ OB-3	-4	-6.15

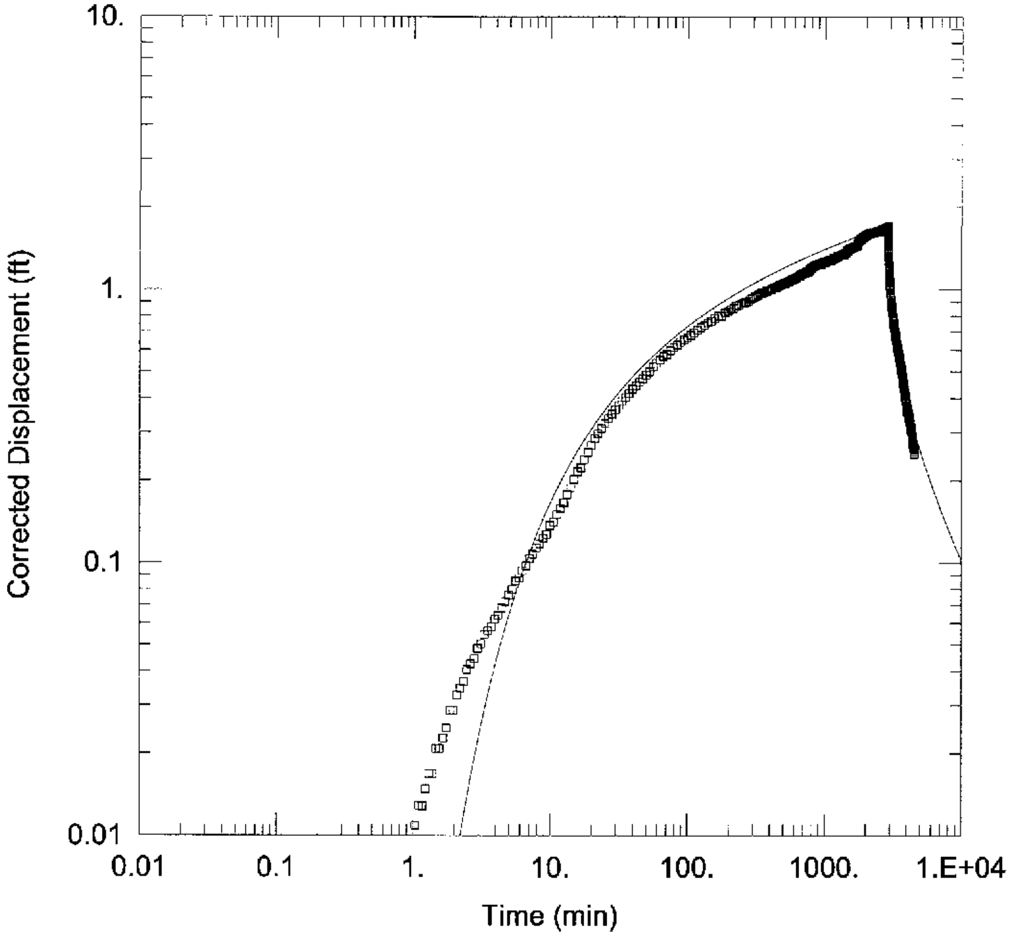
SOLUTION

Aquifer Model: Unconfined

Solution Method: Neuman

T = 74.03 ft^2/day
Sy = 0.04017

S = 0.01179
ß = 0.8



OB-3 RESPONSE TO EW-1 PUMPING AT 1.91 GPM (THEIS)

PROJECT INFORMATION

Company: Applied Remedial Technologies
Client: R.W.L. Investments, Inc.
Project: 170-1
Location: 4919 Tidewater Ave., Oakland
Test Well: EW-1
Test Date: 04/25/06

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
EW-1	0	0

Observation Wells

Well Name	X (ft)	Y (ft)
▫ OB-3	-4	-6.15

SOLUTION

Aquifer Model: Unconfined

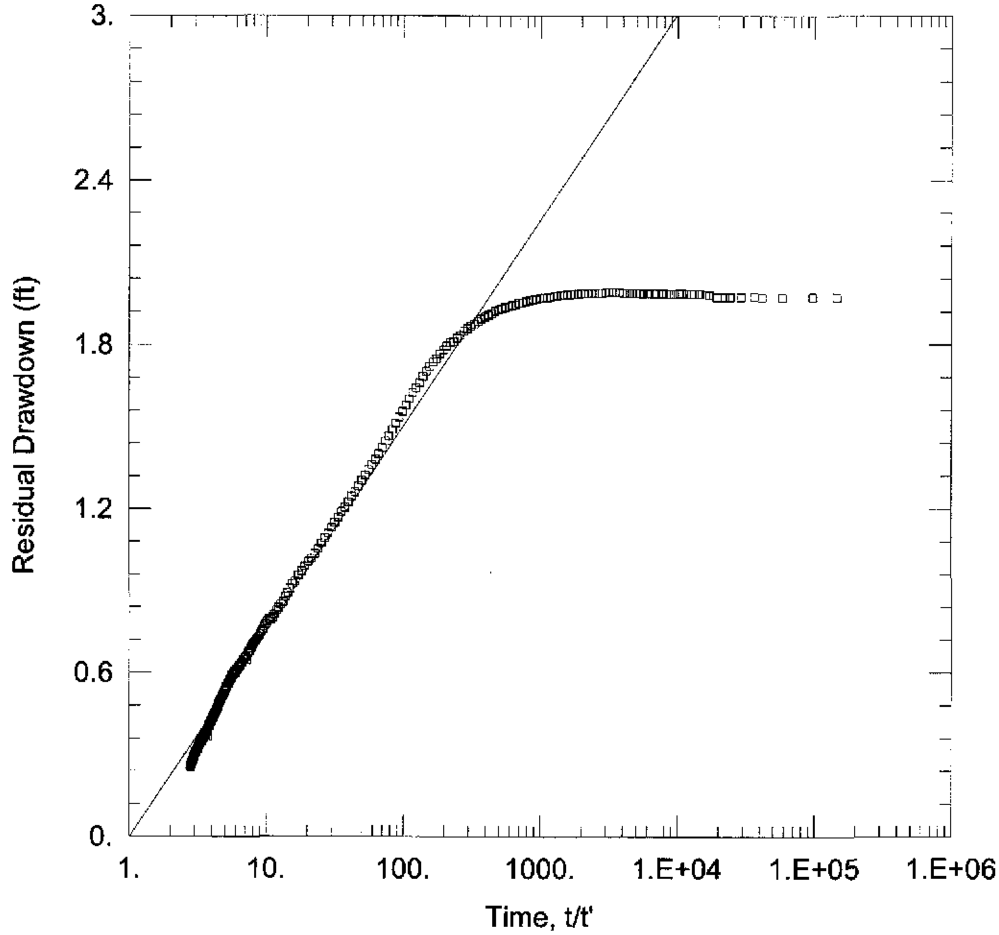
Solution Method: Theis

$T = 98.52\ ft^2/day$

$S = 0.02554$

$Kz/Kr = 0.7283$

$b = 7.\ ft$



OB-3 RESPONSE TO EW-1 PUMPING AT 1.91 GPM (RECOVERY)

PROJECT INFORMATION

Company: Applied Remedial Technologies
Client: R.W.L. Investments, Inc.
Project: 170-1
Location: 4919 Tidewater Ave., Oakland
Test Well: EW-1
Test Date: 04/25/06

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
EW-1	0	0

Observation Wells

Well Name	X (ft)	Y (ft)
▫ OB-3	-4	-6.15

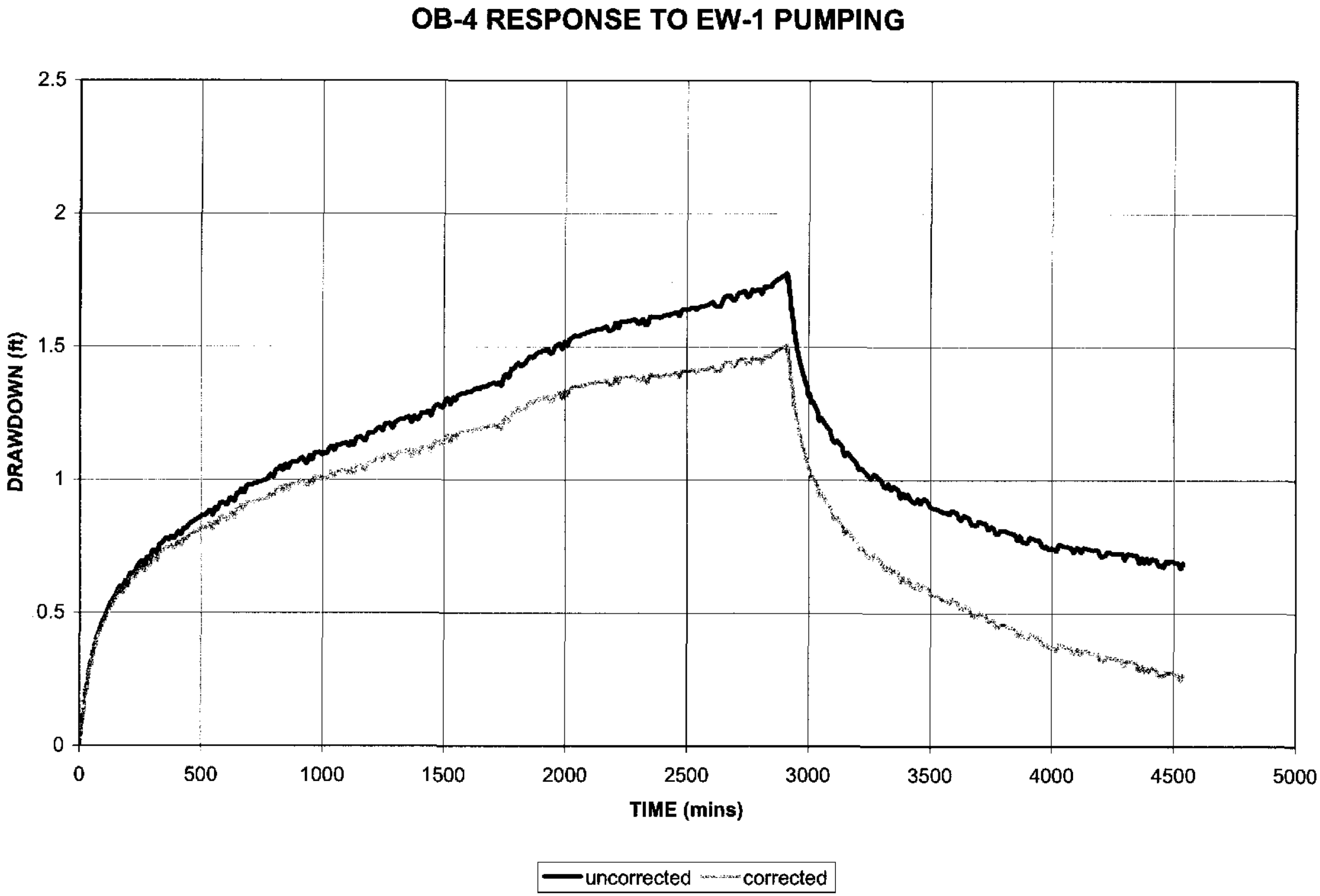
SOLUTION

Aquifer Model: Confined

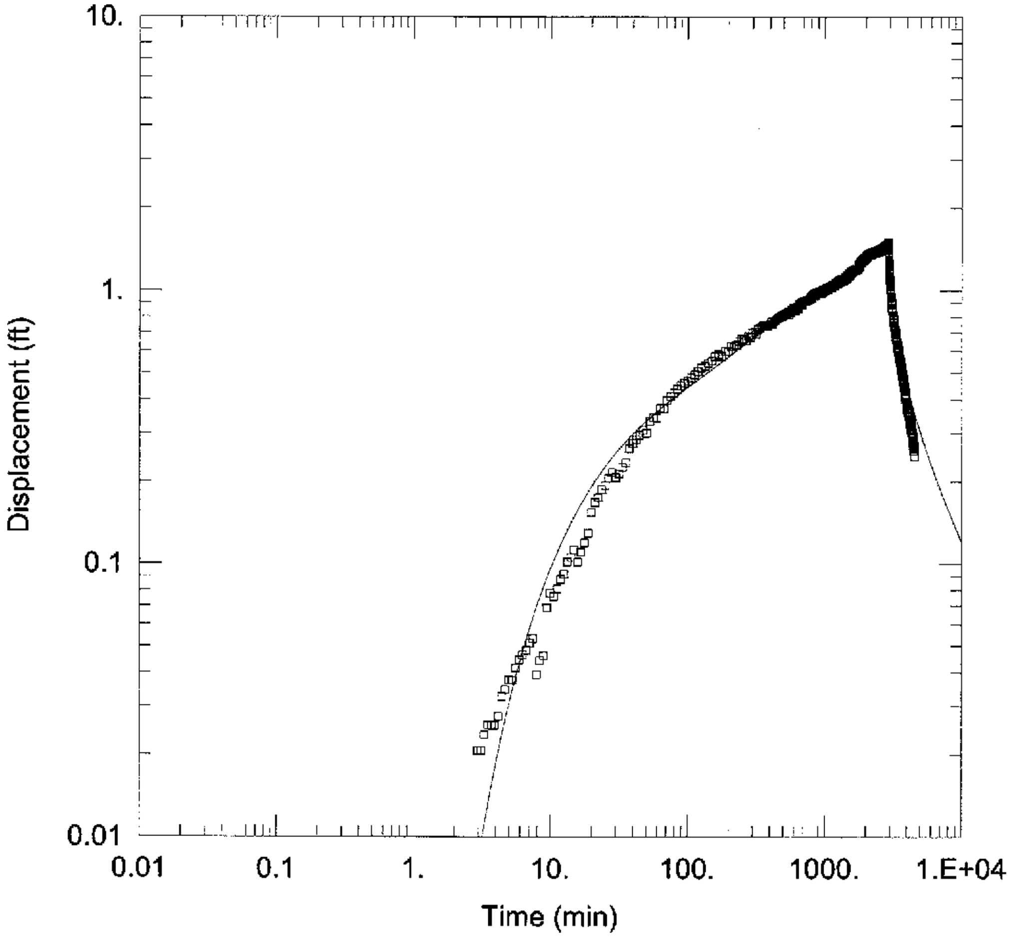
Solution Method: Theis (Recovery)

T = 89.45 ft^2/day

S/S' = 1.01



OB-4 RESPONSE TO EW-1 PUMPING
DRAWDOWN (ft)
2.5
2
1.5
1
0.5
0
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
TIME (mins)
uncorrected
corrected



OB-4 RESPONSE TO EW-1 PUMPING AT 1.91 GPM (NEUMAN)

PROJECT INFORMATION

Company: Applied Remedial Technologies
Client: R.W.L. Investments, Inc.
Project: 170-1
Location: 4919 Tidewater Ave., Oakland
Test Well: EW-1
Test Date: 04/25/06

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
EW-1	0	0

Observation Wells

Well Name	X (ft)	Y (ft)
▫ OB-4	3	-16.4

SOLUTION

Aquifer Model: Unconfined

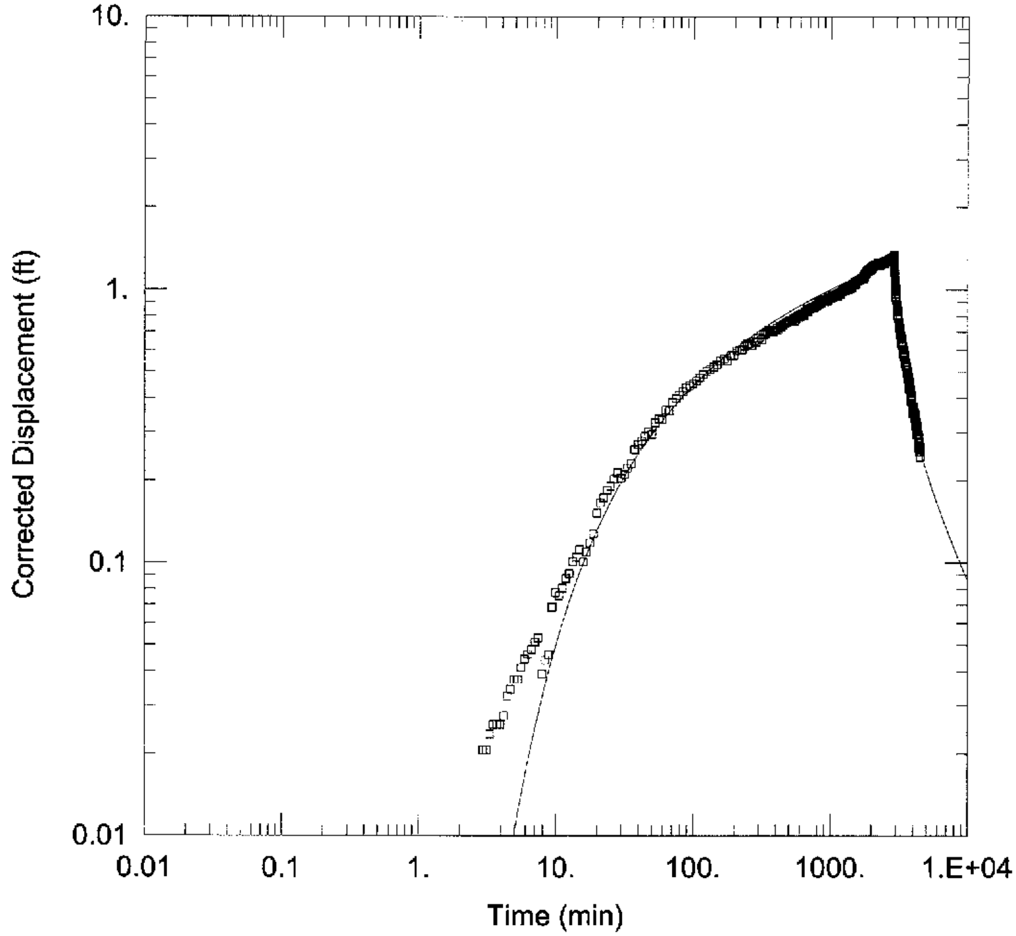
Solution Method: Neuman

T = 84.08 ft^2/day

Sy = 0.01888

S = 0.006066

ß = 0.2



OB-4 RESPONSE TO EW-1 PUMPING AT 1.91 GPM (THEIS)

PROJECT INFORMATION

Company: Applied Remedial Technologies
Client: R.W.L. Investments, Inc.
Project: 170-1
Location: 4919 Tidewater Ave., Oakland
Test Well: EW-1
Test Date: 04/25/06

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
EW-1	0	0

Observation Wells

Well Name	X (ft)	Y (ft)
□ OB-4	3	-16.4

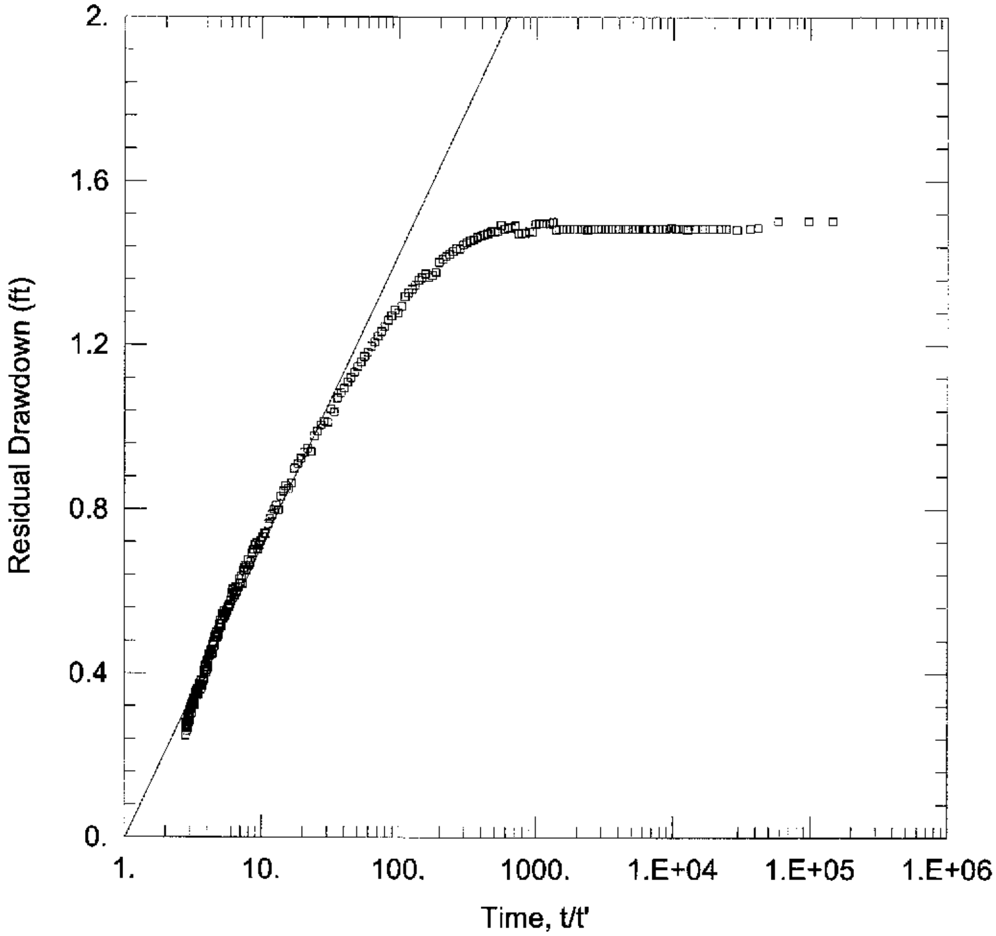
SOLUTION

Aquifer Model: Unconfined

Solution Method: Theis

T = 116.3 ft^2/day
Kz/Kr = 0.1

S = 0.01235
b = 7. ft



OB-4 RESPONSE TO EW-1 PUMPING AT 1.91 GPM (THEIS RECOVERY)

PROJECT INFORMATION

Company: Applied Remedial Technologies
Client: R.W.L. Investments, Inc.
Project: 170-1
Location: 4919 Tidewater Ave., Oakland
Test Well: EW-1
Test Date: 04/25/06

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
EW-1	0	0

Observation Wells

Well Name	X (ft)	Y (ft)
OB-4	3	-16.4

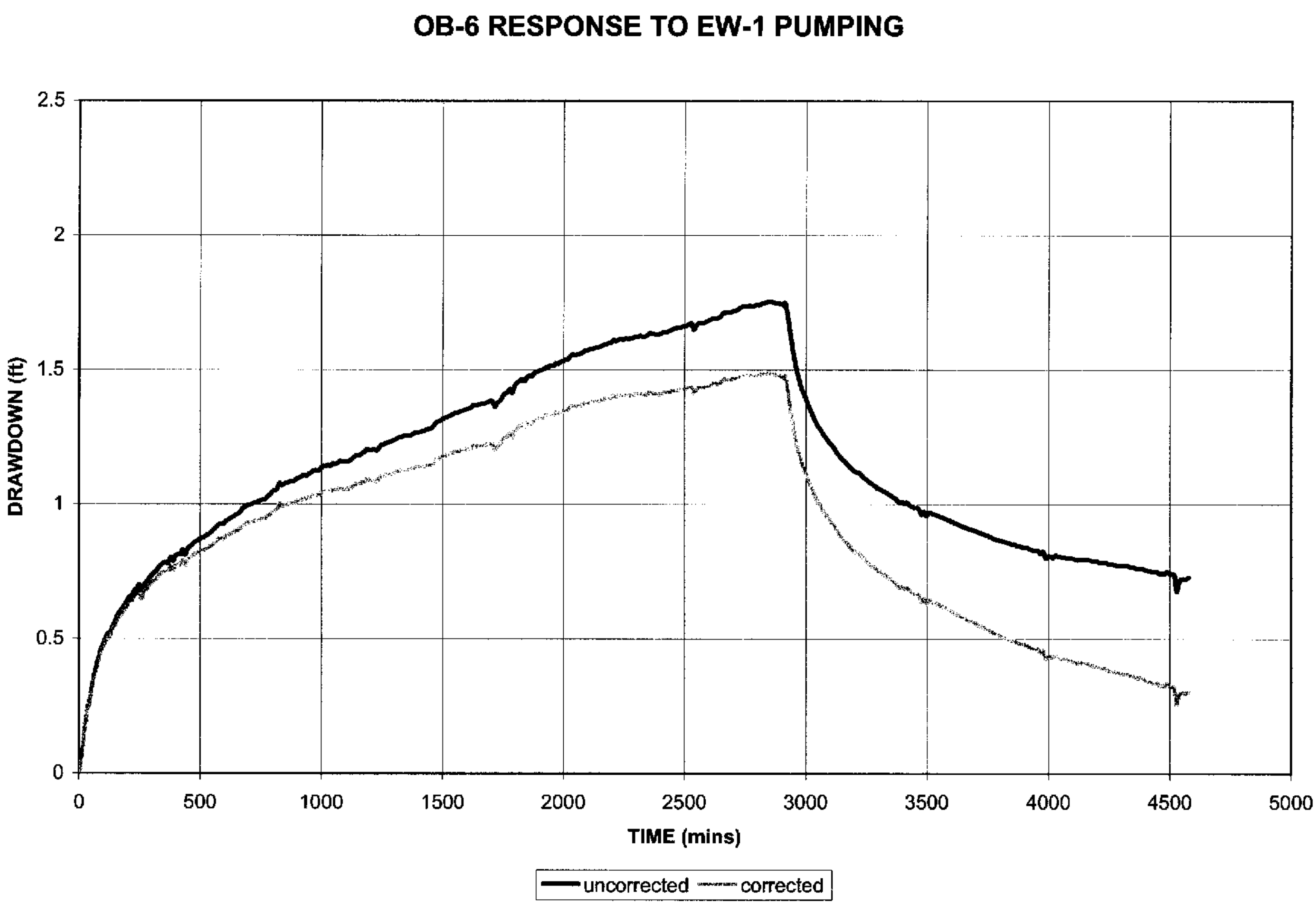
SOLUTION

Aquifer Model: Confined

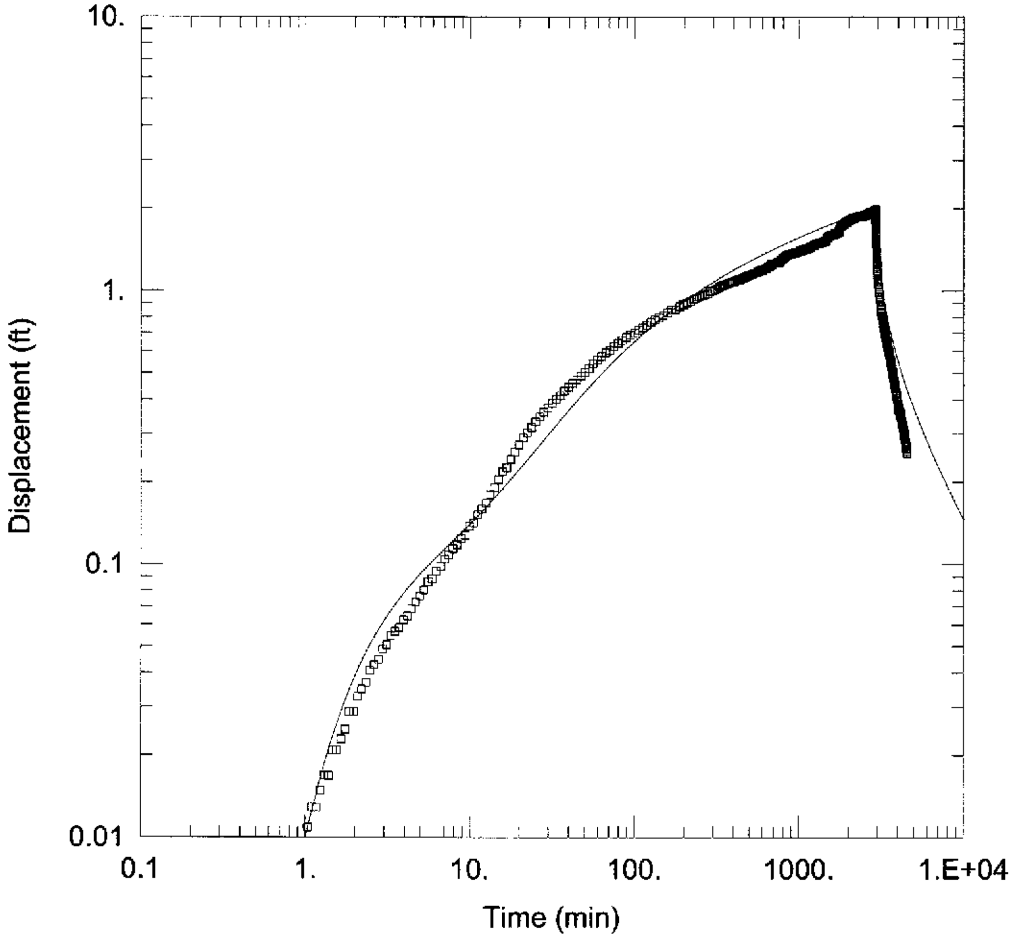
Solution Method: Theis (Recovery)

T = 94.34 ft^2/day

S/S' = 1.015



OB-6 RESPONSE TO EW-1 PUMPING
DRAWDOWN (ft)
2.5
2
1.5
1
0.5
0
0
500
1000
1500
2000
2500
3000
3500
4000
4500
5000
TIME (mins)
uncorrected
corrected



OB-6 RESPONSE TO EW-1 PUMPING AT 1.91 GPM (NEUMAN)

PROJECT INFORMATION

Company: Applied Remedial Technologies
Client: R.W.L. Investments, Inc.
Project: 170-1
Location: 4919 Tidewater Ave., Oakland
Test Well: EW-1
Test Date: 04/25/06

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
EW-1	0	0

Observation Wells

Well Name	X (ft)	Y (ft)
□ OB-6	-5	-18.1

SOLUTION

Aquifer Model: Unconfined

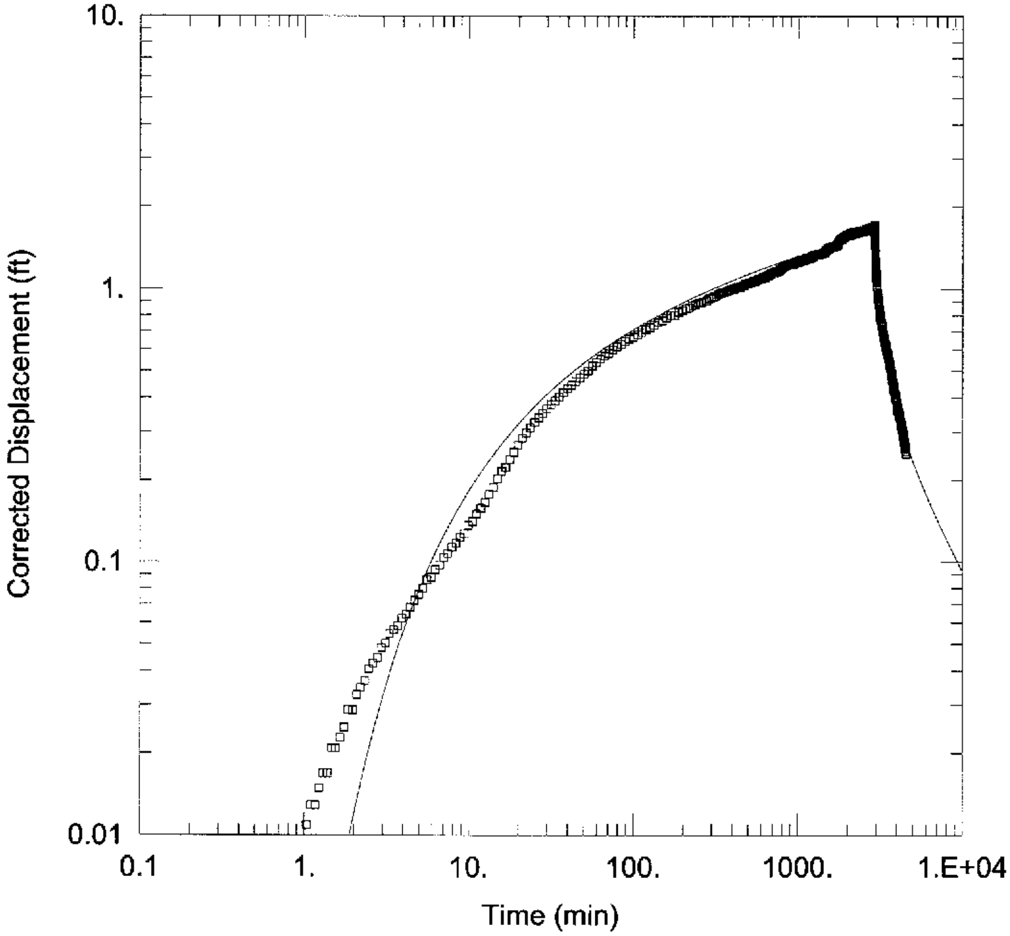
Solution Method: Neuman

T = 68.92 ft^2/day

Sy = 0.006386

S = 0.001169

ß = 1.5



OB-6 RESPONSE TO EW-1 PUMPING AT 1.91 GPM (THEIS)

PROJECT INFORMATION

Company: Applied Remedial Technologies
Client: R.W.L. Investments, Inc.
Project: 170-1
Location: 4919 Tidewater Ave., Oakland
Test Well: EW-1
Test Date: 04/25/06

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
EW-1	0	0

Observation Wells

Well Name	X (ft)	Y (ft)
OB-6	-5	-18.1

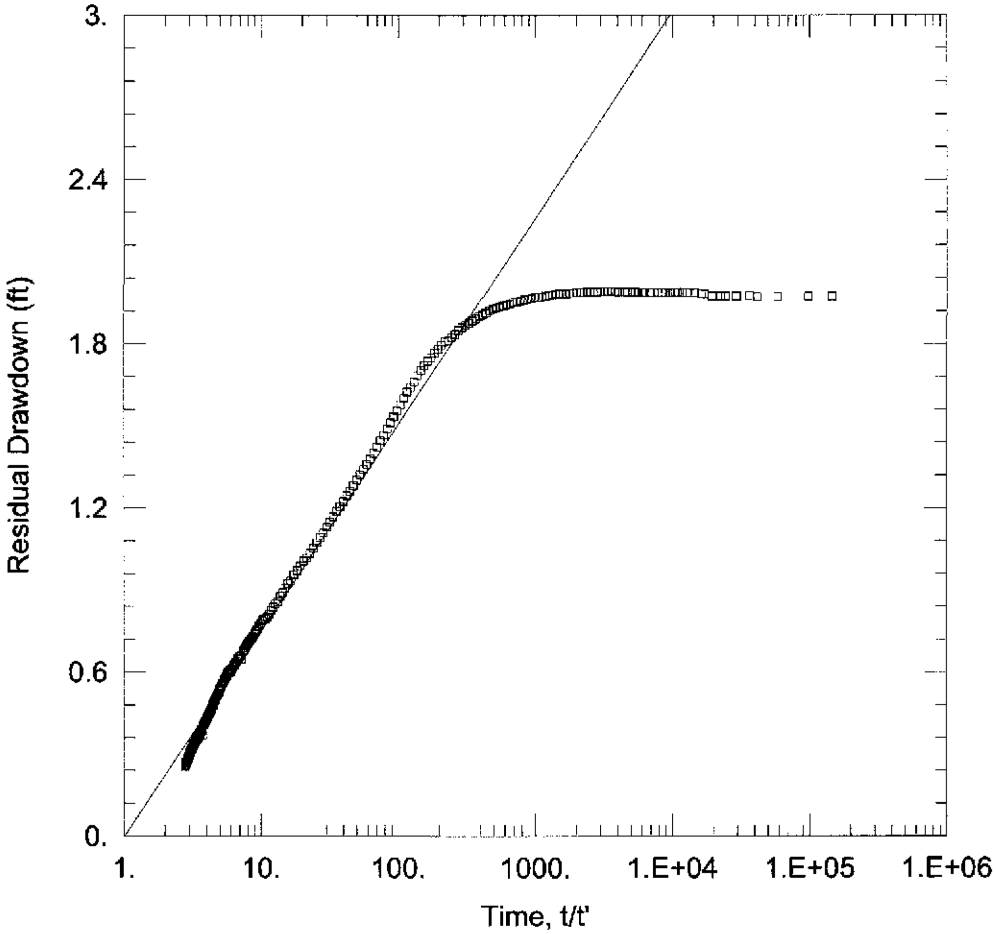
SOLUTION

Aquifer Model: Unconfined

Solution Method: Theis

T = 109. ft^2/day
Kz/Kr = 0.1

S = 0.003559
b = 7. ft



OB-6 RESPONSE TO EW-1 PUMPING AT 1.91 GPM (RECOVERY)

PROJECT INFORMATION

Company: Applied Remedial Technologies
Client: R.W.L. Investments, Inc.
Project: 170-1
Location: 4919 Tidewater Ave., Oakland
Test Well: EW-1
Test Date: 04/25/06

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
EW-1	0	0

Observation Wells

Well Name	X (ft)	Y (ft)
□ OB-6	-5	-18.1

SOLUTION

Aquifer Model: Confined

Solution Method: Theis (Recovery)

T = 89.3 ft^2/day

S/S' = 1.01