FINAL

Site Investigation Report

Smoky Canyon Mine, Caribou County, Idaho

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APPENDIX G

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Technical Memorandum No. 3: Wells Formation Aquifer Testing

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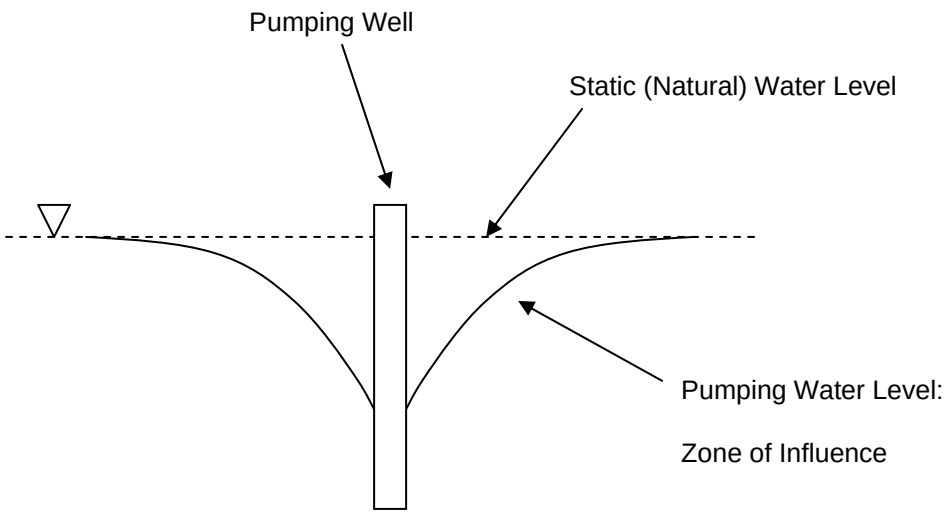
1.0 INTRODUCTION

An aquifer test was conducted at the J.R. Simplot Company (Simplot) Smoky Canyon Mine over the period from May 18 to June 9, 2004. The test was performed as part of the groundwater investigation for the Smoky Canyon Mine Site Investigation (SI). The scope and objectives of the SI are described in the SI Work Plan (MFG, 2003a) and the Field Sampling Plan (MFG, 2003b). The primary purpose of the aquifer test is to provide hydrologic information for the Wells Formation that will be used to assist in characterizing the groundwater flow system and movement of constituents in the bedrock underlying the mine area.

The general set-up of an aquifer test includes a pumping well and one or more observation wells. Observation wells need to be within the zone of influence (sometimes referred to as the cone of influence; see diagram below) of the pumping well to measure the changes in water level during various pumping conditions (i.e., drawdown and recovery phases). As a well is pumped, the water level is drawn down in an expanding cone around the well. The size of the cone and rate of water level change are dependent on the pumping rate and aquifer properties. Primarily, the rate of water level change is used to estimate the properties of an aquifer.



The Industrial Well (also known as the deep well) was used as the pumping well and the Culinary Well was used as the observation well. Because of the mine's operational water requirements, the aquifer test had to be scheduled for a time when the water supply pumps could be shut down. The test was performed during a mine "turn-around" time when the mill and pipeline are shut down for approximately two weeks to conduct annual maintenance. Although the mill operation did not require any water during turn-

around, the culinary needs limited the length of time the groundwater pump could be shut off.

The aquifer test included a preparation drawdown phase, a recovery phase and the final drawdown phase. The preparation drawdown phase was a period of continuous, near constant-rate pumping conducted to provide a static drawdown water level for the recovery test. The recovery phase was performed immediately after the pump was shut off from the preparation phase pumping, and provided data regarding the increase (recovery) in water level from the static drawdown level. The final drawdown phase had similar pumping conditions as the preparation drawdown, and was performed to evaluate the rate of water level decrease (drawdown) in the aquifer. The final drawdown phase was necessary because data were only available for one of the two primary monitoring wells during the preparation drawdown phase.

Data obtained from the aquifer test help characterize the flow properties of the Wells Formation in the vicinity of the observation wells. The formation properties that will be characterized are transmissivity, storativity and hydraulic conductivity. Transmissivity is the rate of flow across a section of unit width and has dimensions of Length^3/Time x Length or Length^2/Time. Storativity is the volume of water released from an aquifer per unit surface area for a unit decline in hydraulic head across the surface and is unit-less. Hydraulic conductivity is a parameter that describes the rate of groundwater flow through the aquifer and has units of Length/Time. Hydraulic conductivity is calculated by multiplying the transmissivity by the saturated aquifer thickness.

This report summarizes the setup of the aquifer test, testing procedures, data analysis methods, and the results obtained.

2.0 TEST SETUP

As noted above, the aquifer test utilized the mine's industrial water-supply well, GW-IW (also known as the Industrial Well or the Deep Well), as the pumping well and the nearby culinary water-supply well, GW-CW, as the primary observation well. The Industrial Well draws water from the Wells Formation and the Culinary Well is screened primarily within the Wells Formation. Continuous water level monitoring was also conducted at the Wells Formation Consent Order monitoring well (GW-CO). Although distant from the Industrial Well, periodic water level monitoring was conducted at the other site monitoring wells completed in the Wells Formation including the deep well along lower Pole Canyon Creek (GW-16), the deep well just northwest of Hoopes Spring (GW-18) and the deep well in middle South Fork Sage Creek (MC-MW-1). Well completion details for all of the wells used in the test are summarized in Table 1, the location of the wells are shown on Figure 1 and well construction logs are included in Appendix A.

2.1 Hydrogeological Setting and Well Logs

An east-west hydrogeological cross section through the location of the Industrial Well and Culinary Well is shown in Figure 2. These wells are located on the western flank of the Boulder Creek Anticline. The Wells Formation outcrops within the core of the anticline approximately 400 feet east of the location of the Industrial Well. The Wells Formation generally consists of a 600 to 2,400 feet thick unit of calcareous sandstone, siliceous limestone and sandy beds that have porosities of around 15 percent (Connor, 1980). At the location of the test wells, the Wells Formation is overlain by the Phosphoria Formation and then the lowermost portion of the Dinwoody Formation. The Phosphoria Formation is typically described as shale and cherty shale and is generally considered a barrier to ground water flow except when highly fractured (Ralston, 1979). Fractured chert beds, including the Rex Chert Member, of the Phosphoria Formation may have relatively high hydraulic conductivities. It is estimated that the Wells Formation is greater than 1,000 feet in this area (Montgomery et. al. 1967) and is bounded at its base by the West Sage Valley Branch Fault, a low angle thrust fault whose trace is exposed approximately 7,000 feet east of the Industrial Well.

The Industrial Well is completed to a depth of 1,320 feet (ft) below ground surface (bgs). The well head is at an elevation of 7,226 ft above mean sea level (amsl) and the ground surface is at an elevation of 7,225 ft amsl. The top of the Wells Formation was encountered at a depth of approximately 435 ft bgs (6,791 ft amsl). The well is open (perforated steel casing, well screen, and open hole) from a depth of 640 ft to 1,320 ft

bgs (6,585 to 5,905 ft amsl). The open portion of the well lies entirely within the Wells Formation. The water level before pumping began on May 18, 2004 was at approximately 617 ft bgs (6,608 ft amsl), indicating that the upper portion of the Wells Formation is unsaturated at this location. The top of the pump is set at 755 ft bgs (6,471 ft amsl) and the bowls extend 15 ft below.

The Culinary Well is located 228 feet west of the Industrial Well and has a ground surface elevation of about 7,231 ft amsl. The well is completed to a depth of 1,000 ft bgs (6,231 ft amsl) and, when the pump is installed, the pump is set a about 640 ft bgs. The top of the Wells Formation was encountered at a depth of approximately 520 ft bgs (6,711 ft amsl). The well is open (perforated steel casing) from 330 ft to 390 ft bgs (6,901 to 6,841 ft amsl) across the Rex Chert. The well is also open (perforated steel casing and well screen) from 570 ft to 940 ft bgs (6,661 to 6291 ft amsl) across the Wells Formation. During the construction of this well in 1981, a downward hydraulic gradient was observed indicating that the well is in a recharge portion of a ground water flow system (Ralston, 1981). The water level in the Culinary Well is estimated to be approximately the same as the Industrial Well prior to pumping on May 18 (estimated static elevation of 6,620 ft amsl). This water level also indicates that the upper portion of the Wells Formation is unsaturated at this location.

The Consent Order Well is located 5,588 feet north of the Industrial Well and is screened across 50 feet of the upper Wells Formation. The top of the well column (well head) is at an elevation of approximately 7,231 ft amsl and the ground surface is at about 7,230 ft amsl. The top of the Wells Formation was encountered at a depth of 510 ft bgs (6,720 ft amsl). The well has a total depth of 722 ft bgs and a screened interval of 599 ft bgs to 650 ft bgs. The water level in the well prior to pumping the Industrial Well was approximately 590 ft bgs (6,640 ft amsl), indicating that the upper portion of the Wells Formation is also unsaturated at this location.

The wells included for periodic water level measurements are completed within similar elevations. The well depths and completion elevations are listed on Table 1.

The Industrial Well and Culinary Well are located immediately north of Smoky Creek which was flowing at the time of the aquifer test. Smoky Creek is in contact with the Wells Formation where it outcrops east of the well locations. Smoky Creek and the other creeks in the area typically lose water into the Wells Formation as they pass over areas where the formation subcrops, forming recharge boundaries within the formation. The Consent Order Well is also very close to this boundary. The other wells completed in the Wells Formation around the Smoky Canyon Mine (GW-16, GW-18, and MC-MW-1) are likely influenced by similar boundaries created by the interaction of Pole Canyon Creek, Sage Creek and South Fork Sage Creek with the Wells Formation.

2.2 Pumping Well Configuration Details

The Industrial Well has a dedicated Johnston (Johnston Pump Co.) 450 horsepower vertical turbine pump that is capable of pumping approximately 1,600 gallons per minute (gpm) over a head of about 860 feet. As noted above, the top of the pump is set at 755 feet bgs (6,471 ft amsl). The well discharge is hard-piped to the mine buildings and to the tailings ponds, and no well access points are present before these discharge locations. The pumping rate is measured with an ADMAC AE Magnetic Flowmeter installed in the well house along the piping prior to any pipeline diversions

Water level data is measured with a pneumatic water level indicator (bubbler) that is set at the top of the pump. An air compressor located in the well house automatically supplies the pneumatic water level indicator; however, the air flow rate (pressure) is manually regulated. Water level data and pump flow rate data are both electronically recorded and stored at the mine. Total flow and pump amperage meters are located in the well house. Data are recorded directly to a computer located in a mill office using the DeltaV Digital Automation System (Emerson Process Management, Fisher-Rosemount Systems, Inc.). The pumping rate and water level data are stored on this computer, which retains the data for a period of five months. The pneumatic water level indicator in place in the Industrial Well logged water levels at 2-minute intervals prior to May 18 and was set to monitor water levels at 10-second intervals starting on May 18.

3.0 TEST PROCEDURES

The aquifer test was conducted in three phases, a preparation drawdown phase (pre-test monitoring), a recovery phase (pump shut down) and a final drawdown phase. The major tasks involved in each of these phases are described in the following paragraphs.

3.1 Preparation Drawdown Phase Monitoring

The purpose of the preparation drawdown phase of the aquifer test was to provide adequate conditions for performing an aquifer recovery test. The preparation drawdown pumping in the Industrial Well began on May 18, 2004. The Industrial Well had not been used for water supply since January 27, 2004 and the water level was likely at or near the natural level for this date. Industrial Well water levels were recorded with the pneumatic water level indicator over this time period. The water level in the Industrial Well on May 18 just before pumping started (elevation of approximately 6,608 ft AMSL) was considered to be the static (steady state) water level for the duration of the Wells Formation aquifer tests. The only pumping occurred in the Culinary Well to provide approximately 50 to 70 gpm for the mine. Immediately following the start of pumping in the Industrial Well, the Culinary Well pump was shut off and the pump and piping were removed from the well.

The Industrial Well pump was maintained at a near constant rate (approximately 1,000 gpm) from May 18 until the pump was shut down to start the recovery test on June 3 at 5:46 A.M. The near constant pumping rate was maintained to provide a baseline drawdown level for the recovery test. Although the actual pumping rate remained relatively constant over the preparation phase period, a problem with the flow-rate data recorder in the in-line flow meter resulted in flow-rate data that were in error. An electrical data collection card in the flow meter had malfunctioned sometime during the winter shut-down period and was causing the data recording error. The card was replaced on the morning of May 21 and the flow meter began reporting the actual flow rates on May 21 at 9:40 A.M. As a result, the flow meter erroneously reported flow rates of approximately 2,000 gpm (greater than the pump's capacity) from May 18 until May 21. Based on the flow rate data collected following the card replacement, the average pumping flow rate over the period from May 18 to June 3 is estimated to be 1,017 gpm. A graph of the flow rate logged in the Industrial Well is presented in Figure 3.

The only significant change in the actual pumping rate from May 18 to June 3 was a power supply loss that resulted in a series of pump shut-down periods beginning the

evening of May 31. The initial pump shut-down occurred on May 31 at 8:30 P.M. and lasted for approximately 4 hours and 20 minutes (until about June 1 at 12:50 A.M.). The pump was shut down for shorter durations on June 1 from 1:30 A.M. to 3:00 A.M., from 11:10 A.M. to 1:20 P.M. and from 4:10 P.M. to 5:50 P.M. As a result, the water level in the well rose approximately 10 feet from the evening of May 31, prior to the initial shut down, to the afternoon of June 1, following the last shut-down, the pump operated again at approximately 1,000 gpm from June 1 at 5:50 P.M. to the start of the recovery test. The groundwater level was drawn down a total of approximately 120 feet just prior to starting the recovery test. Water levels measured in the Industrial, Culinary and Consent Order Wells during the period before the aquifer tests began are displayed on Figure 4.

3.2 Manual Water Level Measurements

Prior to installing pressure transducers in the Culinary and Consent Order Wells, the water levels were measured manually with an electric water level indicator. The manually measured water level in the Consent Order Well was verified during the placement of the MiniTroll pressure transducer. The manual Culinary Well water level measurement indicated the water level to be approximately 362 ft bgs; however, the pressure transducer did not read a water column at this elevation. The pressure transducer found that the actual water level in the well occurred at a depth of approximately 654 ft bgs. Groundwater from the upper screened interval within the Rex Chert (6,902 to 6,842 ft bgs) flows into the well and down the inside of the casing, but does not raise the water column within the well to this height. The water level indicator apparently tracks against the side of casing and obtains a false reading at the point where water is flowing into the well and down the sides of the casins.

In addition to manually measuring the water levels in the Culinary and Consent Order Wells, water levels in the deep wells in lower Pole Canyon (GW-16), near Hoopes Spring (GW-18) and along middle South Fork Sage Creek (MC-MW-1) were also manually measured. These water levels were measured on the afternoon of June 2, the day before the recovery test began, to provide pre-recovery test water level data in other Site Wells Formation monitoring wells. The June 2 water level elevations in the lower Pole Canyon deep well, the Hoopes Spring deep well and the middle South Fork Sage Creek deep well were 6,635.4 ft AMSL, 6,631.4 ft AMSL and 6,635.0 ft AMSL, respectively. Water levels were also measured in these monitoring wells on June 6 just before the recovery test was concluded and on June 9 just before the final drawdown test was concluded. These water levels are also listed on Table 2.

3.3 Monitoring Well Instrumentation Details

The Culinary Well and Consent Order Well were instrumented with In-Situ MiniTroll pressure transducers and data logging systems on June 1, 2004. A MiniTroll with a maximum range of 100 psi (approximately 224 feet of head change) was installed in Culinary Well, and a MiniTroll with a maximum range of 30 psi (approximately 67 feet of head change) was installed in the Consent Order well. The MiniTroll pressure transducers have an accuracy of 0.1 percent of the total pressure measured and a resolution of 0.01 feet. The MiniTroll in the Culinary Well was placed at a depth of approximately 683.5 feet below the top of casing, which initially measured a head of 28.88 feet of groundwater above the transducer. The MiniTroll in the Consent Order Well was placed at a depth of approximately 605 feet below the top of casing and initially measured a head of 13.29 feet of groundwater above the transducer.

Both pressure transducers were programmed to record water levels on one-minute intervals from the time of installation to the start of the aquifer tests. The pressure transducer in the Culinary Well was reprogrammed to collect data on logarithmically increasing intervals (beginning with intervals that were less than one second in duration) at the start of each aquifer test (i.e., the recovery and draw down tests). The data collection interval (one minute) at the Consent Order Well was not re-adjusted at the start of each test because the interval was considered adequate to capture any potential water level changes that may result from varying the Industrial Well pumping rate.

3.4 Recovery Test (Pump Shut-Down Phase)

The recovery test was conducted to provide an initial estimate of the Wells Formation transmissivity in the Industrial Well vicinity. The Industrial Well pump was shut off on June 3 at 5:46 A.M. to start the recovery test. A logarithmic data collection interval (starting with a rapid data collection interval and increasing the interval over time up to a maximum of 1 minute intervals) was initiated in the Culinary Well pressure transducer concurrent with the shut down of the Industrial Well pump. Water level monitoring in the Consent Order well continued at 1-minute intervals and the Industrial Well was programmed to collect water level data on 10-second intervals.

Recovery test data were collected from the time pumping was discontinued to the time pumping resumed on June 6 at 1:24 P.M. The rate of water level recovery observed in the Industrial Well and the Culinary Well indicated that full recovery would not be obtained for at least two weeks. As a result, the duration of the recovery test was primarily related to the maximum time that the mill and mine buildings could operate without a supply of potable water. The recovery test Industrial, Culinary and Consent Order Well water level data are displayed on Figure 4.

From the beginning to the end of the recovery test, the Industrial Well water level increased approximately 103 feet, to within 17 feet of the pre-pumping level; and the Culinary Well water level increased approximately 39 feet, to within approximately 6 feet of the estimated pre-pumping level. The Consent Order Well water level increased approximately 0.33 feet during the recovery period, however this water level rise may not be related to the stop of pumping at the Industrial Well, as discussed further below. These water levels are listed in Table 2.

3.4.1 Conditions Affecting Recovery Data Collection

As noted above, the water level in the Industrial Well is measured with a pneumatic water level indicator. The water level data is collected automatically; however, the air flow rate to the bubbler must be manually adjusted to the correct rate for a given water level range. After the pump was shut off, the initial rise in the Industrial Well increased to a level that was greater than the initial air flow could measure. This resulted in inaccurate Industrial Well water level measurements for approximately the first 3 hours of the recovery test. The air flow problem was identified and corrected on June 3 at 8:30 A.M. This 3-hour period of data for the Industrial Well is unusable in the analysis of the recovery test.

The recovery rate of a well following pumping is typically fast immediately following the discontinuation of pumping and then slows as time progresses (hence, the logarithmic data collection interval). The rate of groundwater inflow and the change in this rate are used to estimate the transmissivity value. Typically, recovery data is analyzed from the time the pump is shut off to either the time when pumping begins again or when the water level has reached steady state (i.e., water level does not rise anymore). The Industrial Well pump has a check valve located along the discharge line in the well house, rather than at the line intake, so, when the pump is shut off, the water in the discharge line between the intake and the check valve (approximately 3,100 gallons) drains back into the well casing. This created a rapid water level rise in both the Industrial Well and the Culinary Well immediately following the pump shut-down that is an artifact of the pump construction, and is not related to the recovery of the formation water level. The effect this initial rapid rise has on the data analysis is discussed in Section 4.1.

3.5 Final Drawdown Test (Pump Start-Up Phase)

The drawdown test was conducted to provide another estimate of the Wells Formation transmissivity in the Industrial Well vicinity. During the drawdown test, the transmissivity value is estimated by analyzing the rate of groundwater removal from the cone of depression that develops around the pumping well. The drawdown test began

concurrently with the end of the recovery test on June 6 at 1:24 P.M. when the Industrial Well pumping was resumed. Similar to the recovery test, a logarithmic data collection interval (starting with a rapid data collection interval and increasing the interval over time up to a maximum of 1-minute intervals) was initiated in the Culinary Well pressure transducer at the start of the drawdown test. Water level monitoring in the Consent Order well continued at 1-minute intervals and the Industrial Well data continued to be collected on 10-second intervals.

The pumping rate was resumed at 1,000 gpm for the drawdown test. For the first 60 seconds of pumping, the pump does not have any back-pressure, and operates at a rate exceeding 2,500 gpm. Once the line becomes pressurized, the pump operates at the previous setting of approximately 1,000 gpm. This creates a rapid draw-down effect in the formation in the early part of the test, followed by a short period where water levels plateau. The effect on data analysis is discussed in Section 4.1.

Drawdown test data were collected from the time pumping began through the completion of the test on June 9 at 10:52 A.M. The data collected through June 9 were considered sufficient for the analysis of transmissivity. The rate of water level drawdown observed in the Industrial Well during the preparation drawdown phase indicated that a full drawdown would not be obtained for approximately another week. The drawdown test Industrial, Culinary and Consent Order well water level data are displayed on Figure 4 and summarized in Table 2.

From the beginning to the end of the draw-down test, the Industrial Well water level decreased approximately 89 feet, the Culinary Well water level decreased approximately 38 feet, and the water level in the Consent Order well decreased approximately 0.05 feet. These water levels are listed in Table 2. The MiniTroll pressure transducers were then removed from the Culinary and Consent Order wells and the drawdown test was concluded.

4.0 DATA ANALYSIS

The aquifer tests provide data that can be used to characterize groundwater transport properties of the Wells Formation aquifer. Estimates of aquifer transmissivity and storativity provided in Sections 4.1 and 4.2 employ curve-matching techniques where drawdown and recovery data collected over time are compared to theoretical type curves. This section provides a general summary of the time-drawdown data collected and discusses the potential influence of operational and hydrogeologic conditions. This analyses aids in qualifying the data analyses that follow in Sections 4.1 and 4.2. A semi-log graph of time-drawdown data obtained from the aquifer test are presented in Figure 5.

4.1 Preparation and Final Drawdown Phase Data

The water level data for the Culinary and Industrial Wells display a significant hydraulic connection between these wells. Pumping the Industrial Well at a rate of 1,000 gpm produces approximately 120 feet of drawdown within the well and 45 feet of drawdown in the Culinary Well. Water level data from the Consent Order Well do not conclusively indicate that the well is influenced by pumping at the Industrial Well (Figures 4 and 7).

The Industrial Well preparation drawdown phase data represent the only complete record of the response of the well pumped from a near steady (non-pumping) water level to a near steady pumping water level. The initial data (approximately the first 10 minutes) in the preparation drawdown phase is influenced by the greater pumping rate resulting from minimal back-pressure and casing storage effects (approximately the first 3 minutes). The remaining preparation drawdown phase data can be divided into four straight line segments, labeled A through D in Figure 5. Time-drawdown graphs of data obtained from the Industrial Well and Culinary Well during the final drawdown phase can also be divided into similar segments. In the plots of the data collected from the Industrial Well, the slope of the segments B and C are very similar, segment D does not appear in the final drawdown phase data due to the limited data collection period, and the slope of segment A differs between the preparation and final drawdown phases. The difference in the slope of segment A may be related to the incomplete recovery of groundwater levels following pump shut-down and prior to the final drawdown phase.

After considering the effects that well construction and installation of pumping equipment have on drawdown during pumping, there are a number of explanations for the deflections in the slope of the time drawdown data. Typically, increasing slope in the semi-log graph, as observed in segment B, is interpreted as a negative (no-flow)

boundary and decreasing slope, as observed in segment C, is interpreted as a positive (recharge) boundary. A response combination similar to that of segments B and C may also be explained by delayed yield or leakage, or by the effect referred to as slow-drainage (Driscoll 1986). Slow drainage occurs in highly stratified aquifers partially penetrated by a pumping well. A high vertical gradient is required to induce vertical flow from productive zones not screened by the pumping well. Excessive drawdown is required (segment B) before this yield is induced (segment C). In either case, boundary effect or slow drainage, analysis of data from segments B and C will result in transmissivity values that are not representative of the formation. Analysis of the late-time data represented by segment D of the preparation drawdown phase are therefore regarded as most representative of the formation.

4.1.1 Drawdown Data Analysis

The drawdown data were analyzed by the Theis method and by the Cooper-Jacob method. The Theis method is curve-fitting graphical method that provides estimates of the transmissivity and storativity based on the shape of the time-drawdown curve plotted on a log-log scale. The Cooper-Jacob method is a simplified form of the Theis method that is generally only valid for the analysis of later time data. The Cooper-Jacob method also employs a curve-fitting graphical method, but utilizes the shape of the time-drawdown recovery curve plotted on a semi-log scale. The Theis and Cooper-Jacob methods are based on the following assumptions:

- The aquifer has an infinite areal extent;
- The aquifer is homogeneous, isotropic and has a uniform thickness;
- The aquifer is confined;
- The water level is nearly static prior to performing the test;
- Groundwater flows horizontally to the pumping well;
- The pumped well penetrates and is screened across the entire thickness of the aquifer;
- Pumping was conducted at a constant rate prior to performing the test;
- Groundwater flow is in unsteady state (i.e., the hydraulic gradient is not zero and the change in water surface elevation is not negligible);

- The well diameter is small enabling the storage in the well to be neglected; and
- Water is released instantaneously from storage with the decline of hydraulic head (Kruseman and De Ridder, 1994).

Slight variations of these assumptions do not limit the application of the Theis or Cooper-Jacob methods to the estimation of hydraulic properties. For example, neither the Industrial or Culinary Wells fully penetrate the Wells Formation aquifer.

The Theis curve fits for the drawdown test (June 3 through 6) for the Industrial and Culinary Well are displayed on Figures 10 and 11, and the Cooper-Jacob curve fits are displayed on Figures 12 and 13. The Theis method transmissivity values estimated for the Industrial and Culinary Wells are 0.85 ft^2/min and 1.80 ft^2/min (9,156 and 19,388 gpd/ft), respectively. The Cooper-Jacob method transmissivity values estimated for the Industrial and Culinary Wells are 0.91 ft^2/min and 1.69 ft^2/min (9,802 and 18,203 gpd/ft), respectively. The Theis method storativity values estimated for the Industrial and Culinary Wells are 1.3 and 2.77 x 10^{-04}, respectively. The Cooper-Jacob method storativity values estimated for the Industrial and Culinary Wells are 1.13 and 5.54 x 10^{-04}, respectively. Storativity values obtained through these analyses for the pumping well are typically regarded as questionable because of potential influences of the pump and well and will not be used. The curve matches are based on the later time data as previously discussed.

Theis and Cooper-Jacob curve fits for the preparation phase pumping (May 18 to June 3) for the Industrial Well data are displayed on Figures 14 and 15. Estimated transmissivity using the Theis method is 0.77 ft^2/min and using the Cooper-Jacob method is 0.81 ft^2/min (8,294 and 8,725 gpd/ft respectively). The estimated storativity using both methods is 5.58; however, because the estimate is based on data from the pumping well, this value is questionable and will not be used.

4.2 Recovery Phase Data

A semi-log graph of time-drawdown data obtained from the Industrial and Culinary Wells during the recovery test is presented in Figure 6. Data from the Culinary well can be divided into three nearly straight line segments labeled A through C. Recovery data from the Industrial Well are in error for the first 160 minutes of recovery due to the problem with the pneumatic water level indicator. The remaining data align closely with the segments labeled B and C in the Culinary Well. The rapid recovery rates represented by Segments A and C may be influenced by the contribution of recharge or vertical leakage (e.g., loss from Smoky Creek to the Wells Formation). Projection of segment C in the Culinary Well to the zero drawdown point results in a time of full recovery of about 8000

minutes. This is much less than the time required to obtain full drawdown during pumping (22,881 minutes), indicating that recovery is being influenced by a variation in the storativity of the aquifer or by a recharge effect. For the recovery data, analysis of the trend of the entire data set rather than the trend in any particular segment is regarded as most representative of the formation.

4.2.1 Recovery Data Analysis

The recovery data were analyzed with the Theis recovery method of characterizing the hydraulic properties (transmissivity) of confined aquifers. The Theis recovery method is based on the following assumptions:

- The aquifer has an infinite areal extent;
- The aquifer is homogeneous, isotropic and has a uniform thickness;
- The aquifer is confined;
- The water level is nearly static prior to performing the test;
- Groundwater flows horizontally to the pumping well;
- Pumping was conducted at a constant rate prior to performing the test;
- Groundwater flow is in unsteady state (i.e., the hydraulic gradient is not zero and the change in water surface elevation is not negligible);
- The well diameter is small enabling the storage in the well to be neglected; and
- Water is released instantaneously from storage with the decline of hydraulic head (Kruseman and De Ridder, 1994).

Slight variations of these assumptions do not limit the application of the Theis recovery method to the estimation of hydraulic properties.

The Theis recovery method is a curve-fitting graphical method that provides an estimate of transmissivity based on the shape of the time-drawdown recovery curve plotted on a semi-log scale. The water level is plotted against a dimensionless time parameter that is a ratio of the total time since pumping started to draw-down the well (t) to the time since the pump was discontinued to start the recovery test (t'). Note that the dimensionless time ratio results in the start of the test being displayed on the right side of the graph and

the end of the test is displayed on the left side of the graph. The Theis recovery curve matches for the Industrial and Culinary Wells are displayed on Figures 8 and 9. The transmissivity values estimated from the Industrial and Culinary Well data are approximately 1.26 ft^2/min and 1.86 ft^2/min (13,572 and 20,034 gallons per day/ft), respectively. Note that the general trend of the recovery data for the Industrial and Culinary Wells are matched rather than particular line segments as previously discussed.

5.0 DISCUSSION

Hydraulic properties of the Wells Formation were calculated from aquifer test data to help characterize groundwater transport properties. Data obtained from the three phases of the aquifer test (i.e., preparation drawdown, recovery, and final drawdown phases) indicate that, when pumped at a rate of 1,000 gpm, the Wells Formation aquifer in the vicinity of the test wells behaves in a confined to semi-confined manner with significant delayed yield or slow drainage characteristics. Based on the analyses of these data, estimated transmissivity values range from approximately 0.8 ft^2/min to 1.9 ft^2/min (8,600 to 20,000 gpd/ft). The transmissivity values calculated utilizing the data collected from the Culinary Well, 1.7 ft^2/min to 1.9 ft^2/min, are about twice as high as the values calculated using the data from the Industrial Well, 0.8 ft^2/min to 0.9 ft^2/min (with the exception of the recovery test).

The analyses of data collected from the Culinary Well and from the Industrial Well during recovery are regarded as more reliable from a data quality standpoint than the data collected from the pumping well during pumping, since the influence of well efficiency, well piping, and well bore storage are minimized. This transmissivity range represents the nearby aquifer conditions that are present within an area that is not affected by boundary conditions.

The saturated thickness of the Wells Formation screened by the test well is approximately 700 feet. Using this as the effective thickness of the aquifer and a transmissivity value of 1.8 ft^2/min (from Culinary Well data) results in an average hydraulic conductivity of 3.7 ft/day (1.3×10^{-3} cm/sec). This is at the upper end of hydraulic conductivities considered typical of limestone or sandstone aquifers (Freeze and Cherry, 1979). An increase in the effective thickness would result in a decrease in the hydraulic conductivity estimate (conductivity is calculated by dividing the transmissivity by the thickness).

The transmissivity value calculated from this test (1.8 ft^2/min) is greater than Ralston's (1981) estimate of 0.5 ft^2/min by about a factor of 3.5. Ralston's (1981) test was performed in the Industrial Well just after the well was drilled and developed, but before much supply water pumping had occurred. Static ground water level in the Industrial Well at the time of the Ralston's test was 6,936 ft amsl, approximately 300 feet higher than the estimated level of 6,608 ft amsl at the time of the testing conducted in 2004. It is also possible that the testing performed in 1981 was influenced by the uppermost zones in the aquifer that were unsaturated at the time of the testing in 2004. The differences between the 1981 and 2004 aquifer tests may therefore reflect the fact that different portions of the aquifer were tested.

6.0 REFERENCES

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Driscoll, F.G., 1986, Groundwater and Wells, Johnson Division, St. Paul, MN.

Freeze, R.A., Cherry, J.A. 1979. **Groundwater**. Prentice Hall, Inc. Englewood Cliffs, New Jersey.

Kruseman, G.P., De Ridder, N.A. 1994. *Analysis and Evaluation of Pumping Test Data. Second Edition*. International Institute for Land Reclamation and Improvement, Publication 47.

Ralston, D.R. 1981. *Hydrogeology of the Smoky Canyon Mine Site, Results of Well Drilling and Pump Testing*. Prepared for J.R. Simplot Company, October.

TABLES

TABLE 1

Summary of Well Construction Details

Well ID	Description	UTM Coordinates (m)		Top of Well Casing Elevation (ft amsl)	Ground Surface Elevation (ft amsl)	Screened Interval Elevation (ft msl)		Top Wells Formation Elevation (ft amsl)	Estimated Static GW Elev. (ft amsl)	Screen Type	Sceened Formation	Distance from GW-IW (ft)
		Easting	Northing			Top	Bottom					
GW-IW	Industrial Well	488,997	4,728,165	7,226	7,225	6,586	6,441	6,768	6,608	16-in perforated steel	Wells	0
						6,451	6,256			10-in plastic screen	Wells	
						6,256	5,906			open hole	Wells	
GW-CW	Culinary Well	488,930	4,728,185	7,232	7,231	6,902	6,842	6,713	6,620	6-in perforated steel	Rex Chert	228
						6,662	6,462			6-in perforated steel	Wells	
						6,522	6,292			4-in plastic screen	Wells	
GW-CO	Consent Order Well	489,407	4,729,819	7,231.3	7,229.8	6,632	6,581	6,721.3	6640	4-in stainless steel screen	Wells	5,588
MC-MW-1	Middle South Sage, deep	489,463	4,720,748	6,780.1	6,778.6	6,620	6,570	-	-	-	Wells	24,377
GW-16	Pole Canyon, deep	490,912	4,725,123	6,854.4	6,852.9	6,624	6,574	6,794.4	-	4-in 0.020 slot PVC screen	Wells	11,791
GW-18	Hoopes Spring, deep	490,529	4,721,794	6,675.6	6,674.1	6,621	6,571	-	-	-	Wells	21,494

TABLE 2

Smoky Canyon Mine 2004 Aquifer Test Groundwater Elevations

Well	Groundwater Elevations (ft MSL)			
	Prior to Preparation Drawdown Phase	Start of Recovery Test	Start of Final Drawdown Test	Completion of Final Drawdown Test
	May 18	June 3	June 6	June 9
Industrial Well	6,608	6,489	6,592	6,503
Culinary Well	6,620 ***	6,573	6,614	6,576
Consent Order Well	-	6,639	6,640	6,640
Deep Pole Canyon Well	-	6,635	6,636	6,636
Deep Hoopes Well	-	6,631	6,632	6,632
Deep South Sage Well	-	6,635	6,635	6,635

Note:
1. The Deep Pole Canyon, Hoopes and South Sage Wells were measured on June 2 rather than June 3.
2. *** indicates that the May 18 Culinary Well water level is an estimated value, no measurements were taken.

TABLE 3

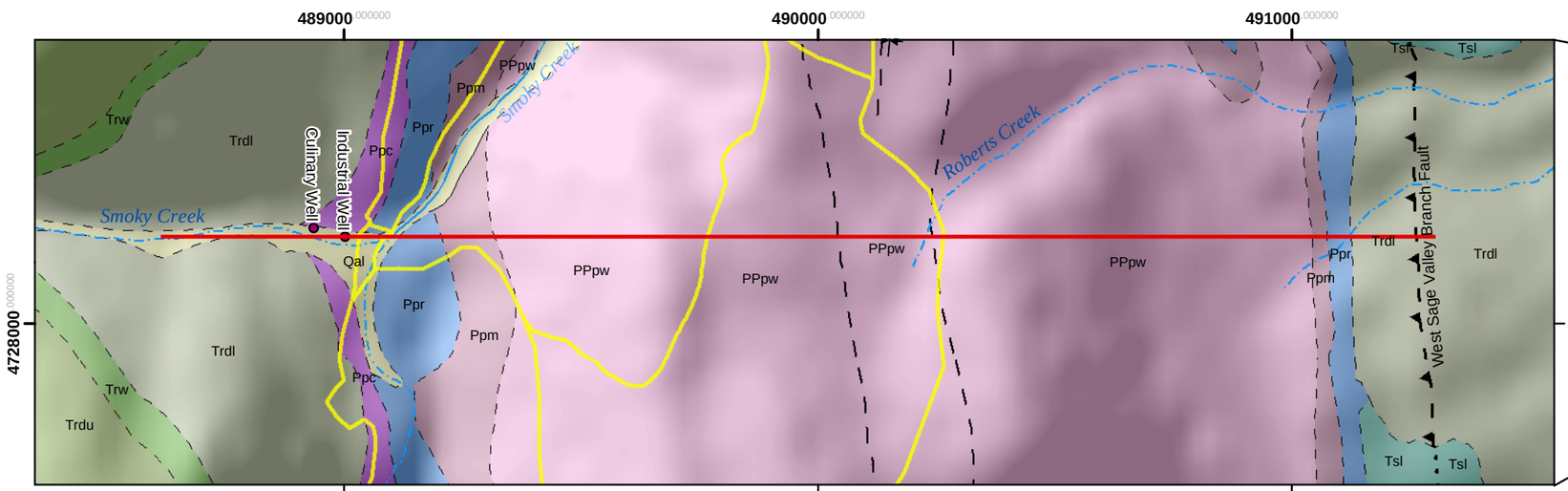
Summary of Smoky Canyon Mine June 2004 Aquifer Test Data Analyses

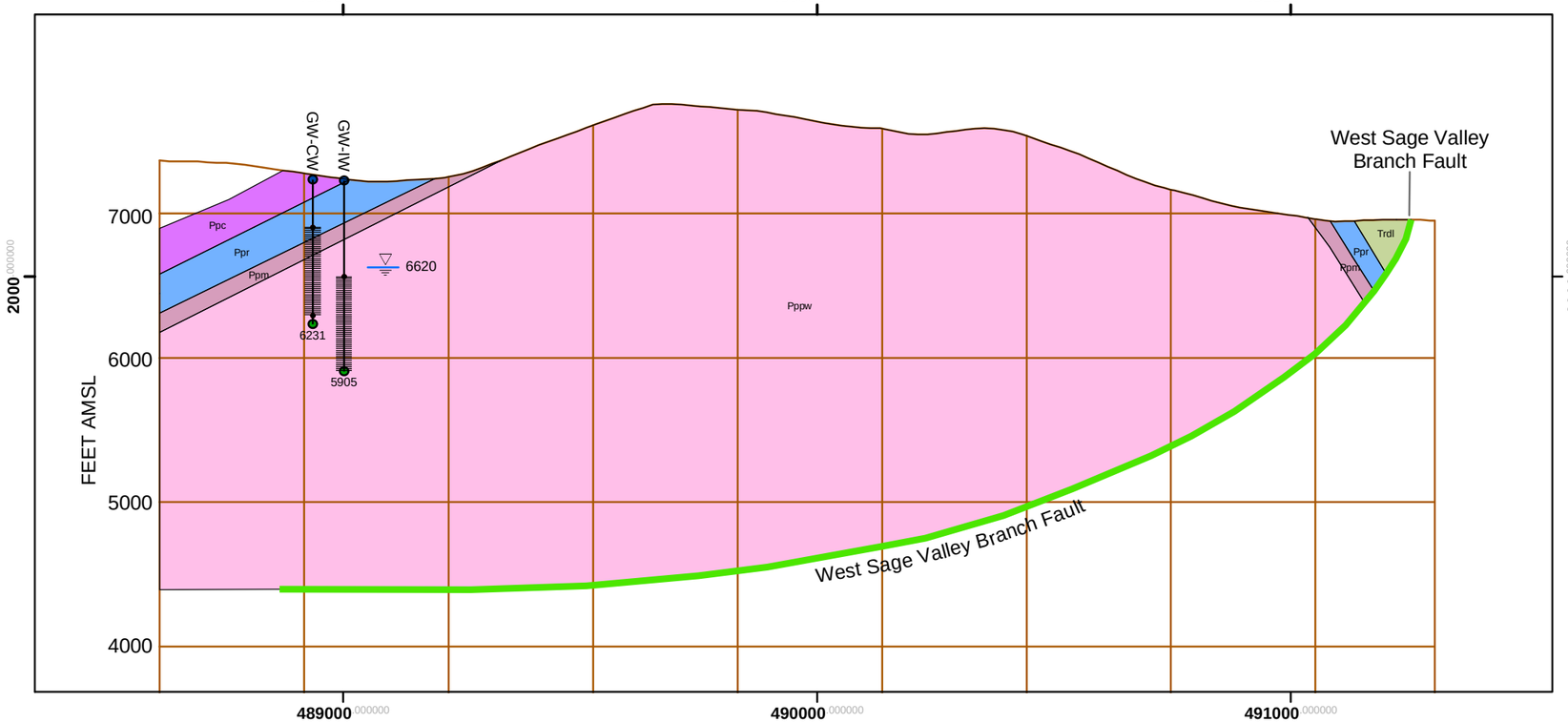
Well	Test	Method	Transmissivity		Hydraulic Conductivity (ft/day)	Storativity	Comments
			sq. ft/min	gallons per day per foot			
GW-IW	Recovery Phase	Theis Recovery	1.26	13,572	2.59		
	Preparation Drawdown Phase	Theis	0.77	8,294	1.58	5.58	Storativity value is questionable (Section 4.1)
	Preparation Drawdown Phase	Cooper-Jacob	0.81	8,725	1.67	5.58	Storativity value is questionable (Section 4.1)
	Final Drawdown Phase	Theis	0.85	9,156	1.75	1.3	Storativity value is questionable (Section 4.1)
	Final Drawdown Phase	Cooper-Jacob	0.91	9,802	1.87	1.13	Storativity value is questionable (Section 4.1)
GW-CW	Recovery	Theis Recovery	1.86	20,034	3.83		
	Drawdown	Theis	1.80	19,388	3.70	0.000277	
	Drawdown	Cooper-Jacob	1.69	18,203	3.48	0.000554	

Note:
1. Hydraulic conductivity is based on an assumed effective saturated thickness of 700 feet.

FIGURES

07-JUL-2004 N:\ARCPRJ2\010109\0442-004-900\PLT\AQUIFER-TEST\XS-1AA-GEODTL.MXD





0 1,000 2,000 Feet

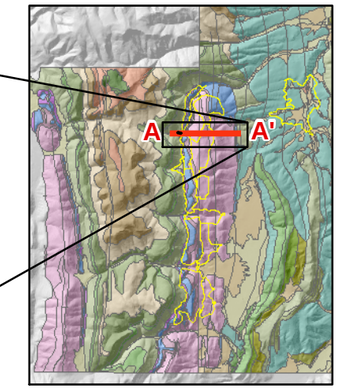
HORIZONTAL SCALE

0 1,000 2,000 Feet

VERTICAL SCALE

WORKING DRAFT

Location Map



LEGEND

J.R. SIMPLOT COMPANY

SMOKY CANYON MINE SITE

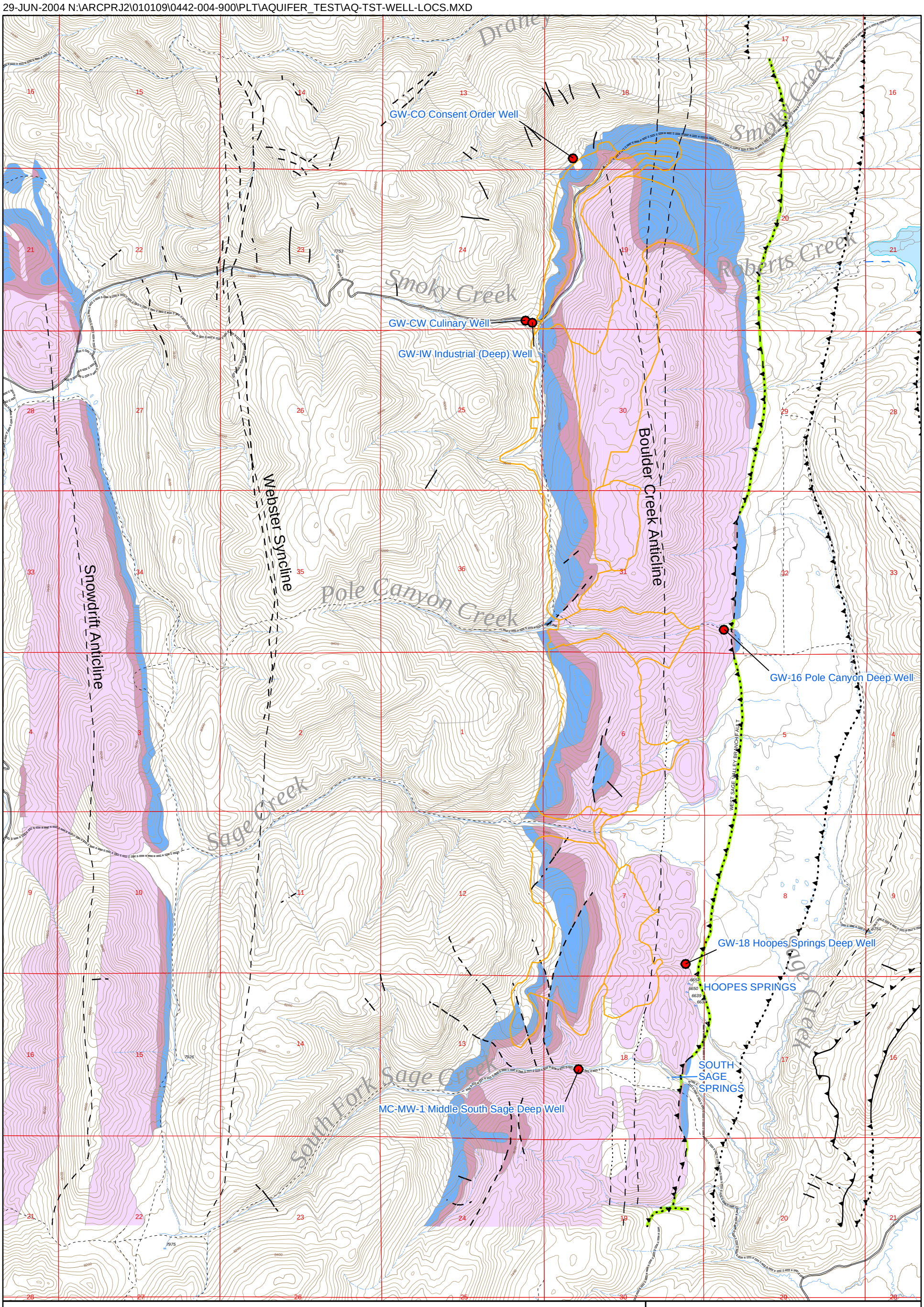
FIGURE 1

CROSS SECTION A-A'

PRJ: 0442-004-900	DATE: JUL 07, 2004	
REV: 0	BY: MCP	CHK: RTD

NEWFIELDS

29-JUN-2004 N:\ARCPRJ2\010109\0442-004-900\PLT\AQUIFER_TEST\AQ-TST-WELL-LOCS.MXD



LEGEND

Groundwater Well

Selected Geology

Ppr - Rex Chert

Ppm - Phosphoria Formation

PPpw - Wells Formation

Notes:
Elevations for springs are at ground surface

N

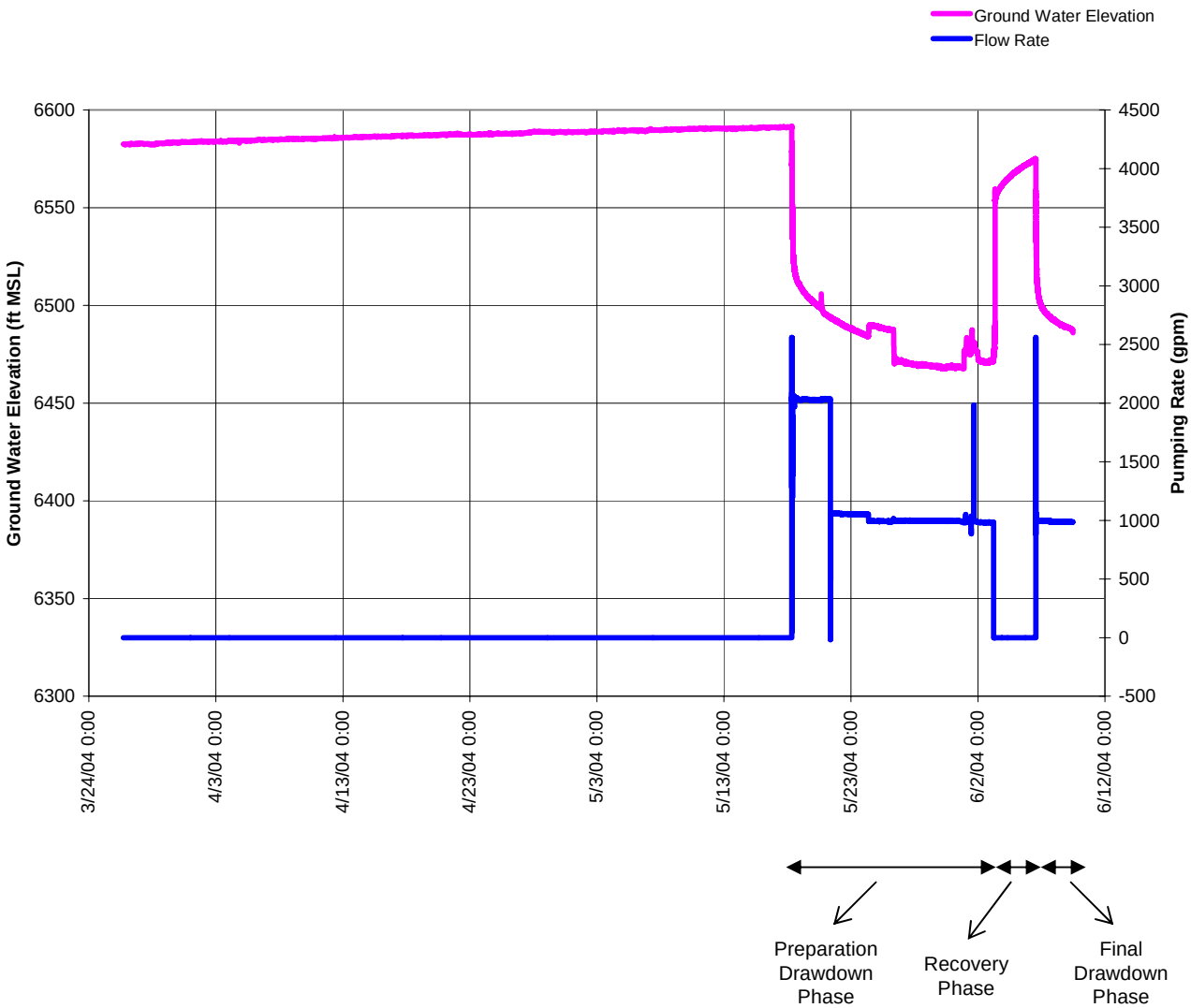
0 3,000 6,000
Feet

J.R. SIMPLOT COMPANY
SMOKY CANYON MINE

FIGURE 2
JUNE 2004
AQUIFER TEST
MONITORING WELL
LOCATIONS

PRJ: 0442-004-900	DATE: JUN 29, 2004	
REV: 0	BY: MCP	CHK: RTD

NEWFIELDS



J.R. SIMPLOT COMPANY
Smoky Canyon Mine

FIGURE 3

Water Level and Pumping Rate Measured in the Industrial Well

0442-004-900	DATE: 6/22/04	
REV: 0	BY: RTD	CHK: KJT

NEWFIELDS

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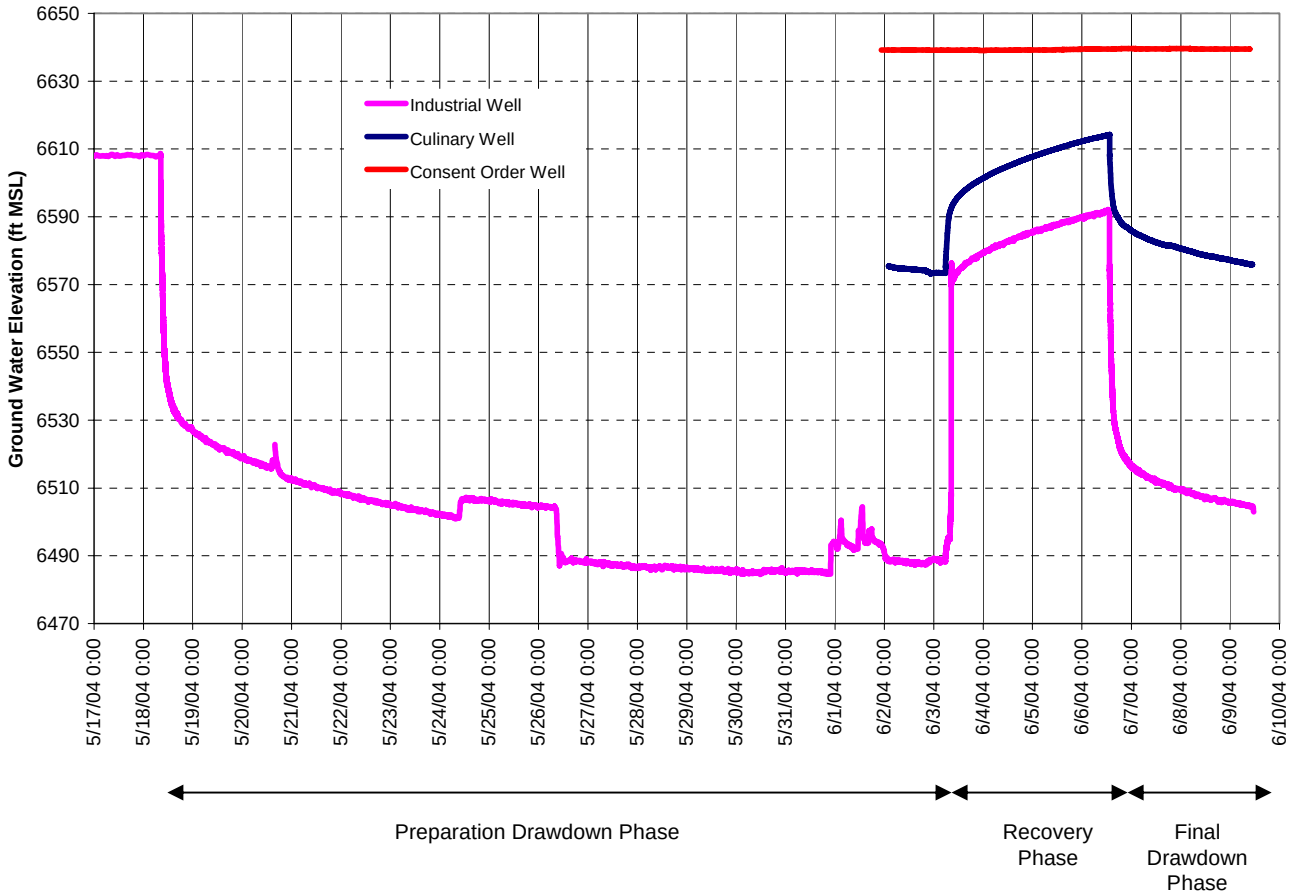

J.R. SIMPLOT COMPANY Smoky Canyon Mine		
FIGURE 4 Water Level Data for the Industrial, Culinary and Consent Order Wells		
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REV: 0	BY: RTD	CHK: KJT
NEWFIELDS		

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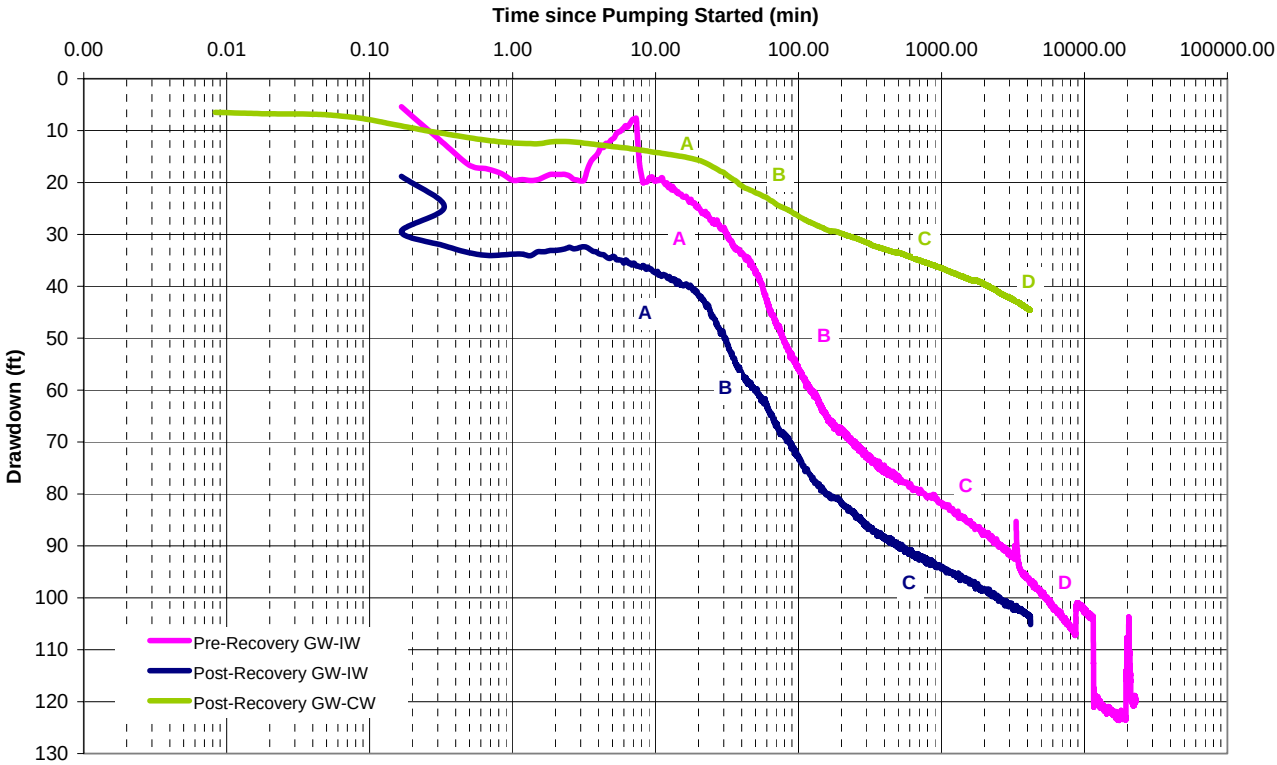

Note:

1. Pre-Recovery refers to the Preparation Drawdown Phase
2. Post-Recovery refers to the Final Drawdown Phase
3. GW-IW refers to the Industrial Well
4. GW-CW refers to the Culinary Well

J.R. SIMPLOT COMPANY Smoky Canyon Mine		
FIGURE 5 Time-Drawdown Graph for Drawdown Phases, Industrial and Culinary Wells		
0442-004-900	DATE: 6/22/04	
REV: 0	BY: RTD	CHK: KJT
NEWFIELDS		

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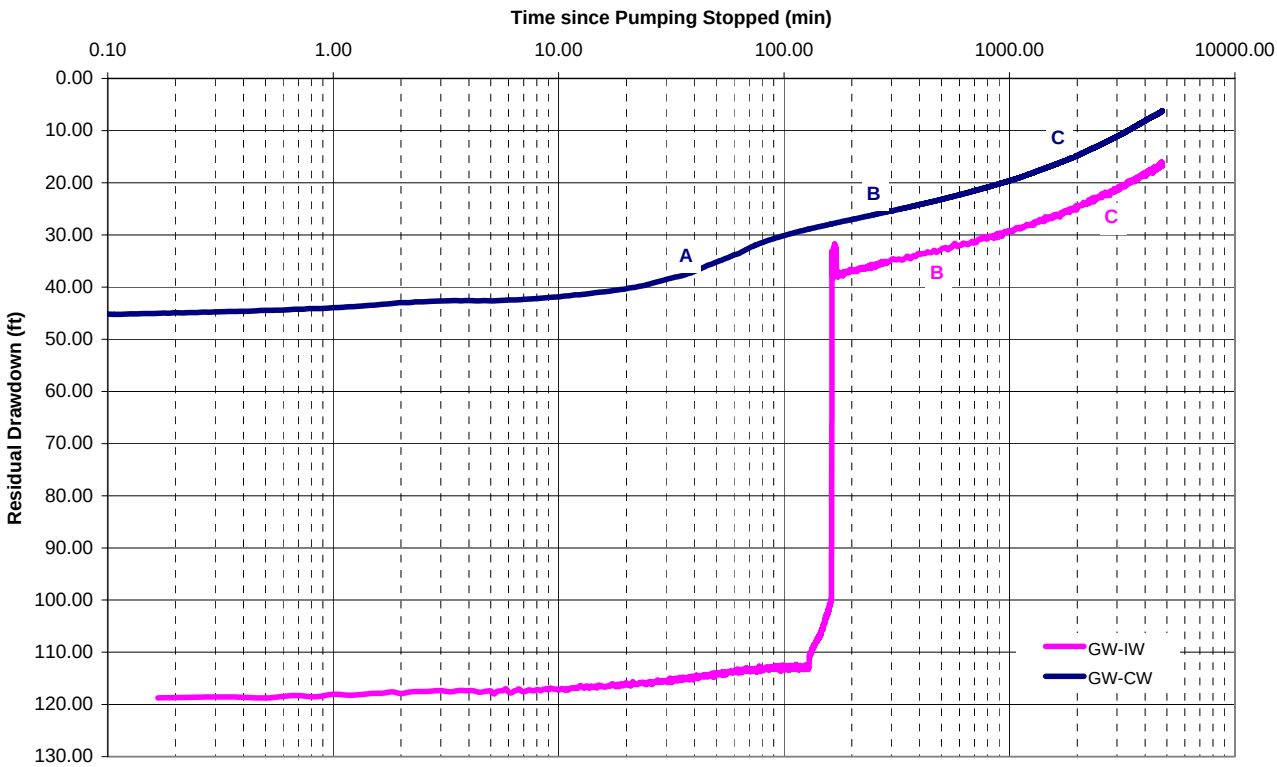

Note:

1. GW-IW refers to the Industrial Well
2. GW-CW refers to the Culinary Well
3. Segment A is not available for GW-IW because of a brief malfunction with the water level indicator

J.R. SIMPLOT COMPANY Smoky Canyon Mine		
FIGURE 6 Time-Drawdown Graph for Recovery Phase, Industrial and Culinary Wells		
0442-004-900	DATE: 6/22/04	
REV: 0	BY: RTD	CHK: KJT
NEWFIELDS		

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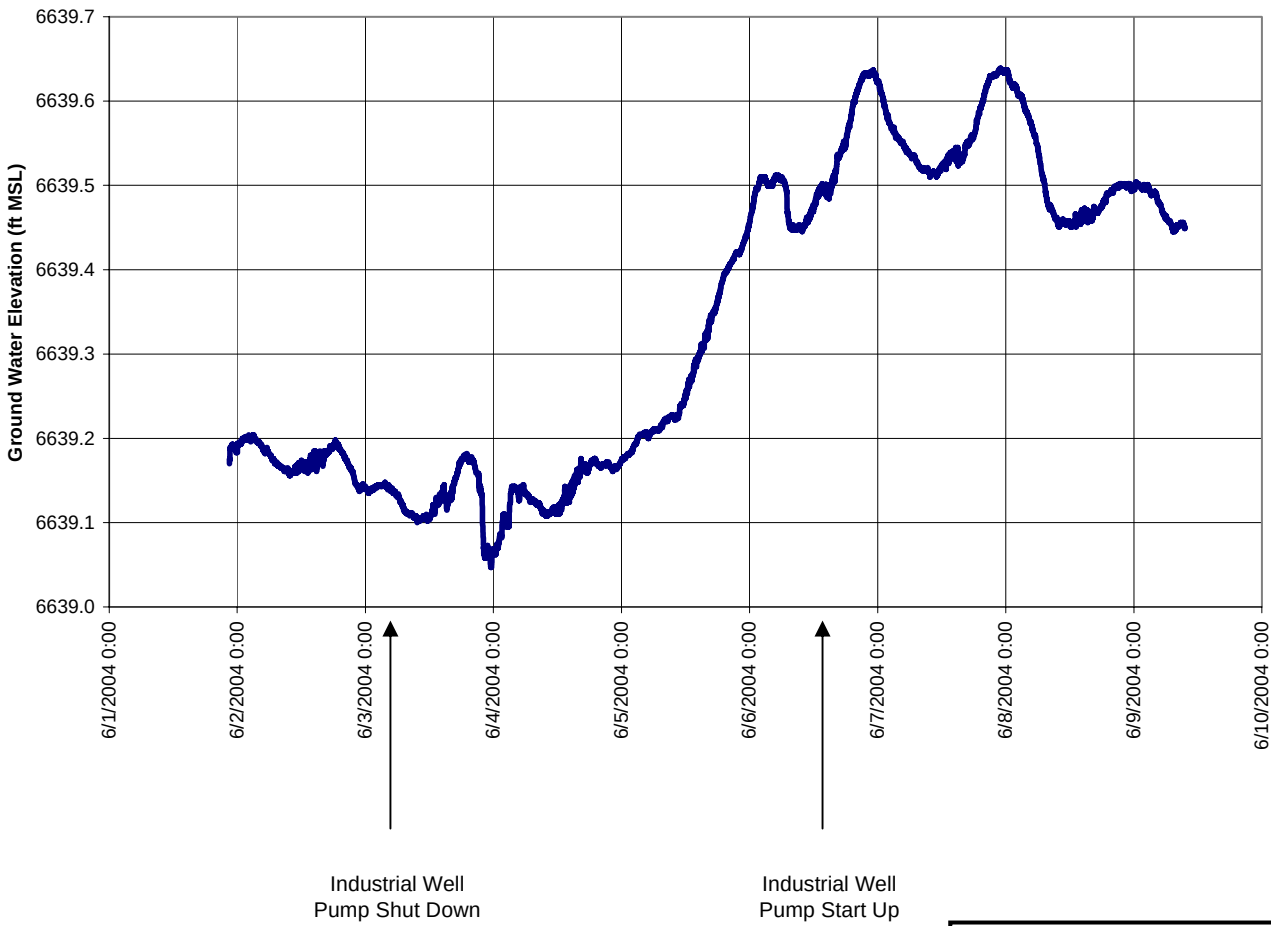


J.R. SIMPLOT COMPANY
Smoky Canyon Mine

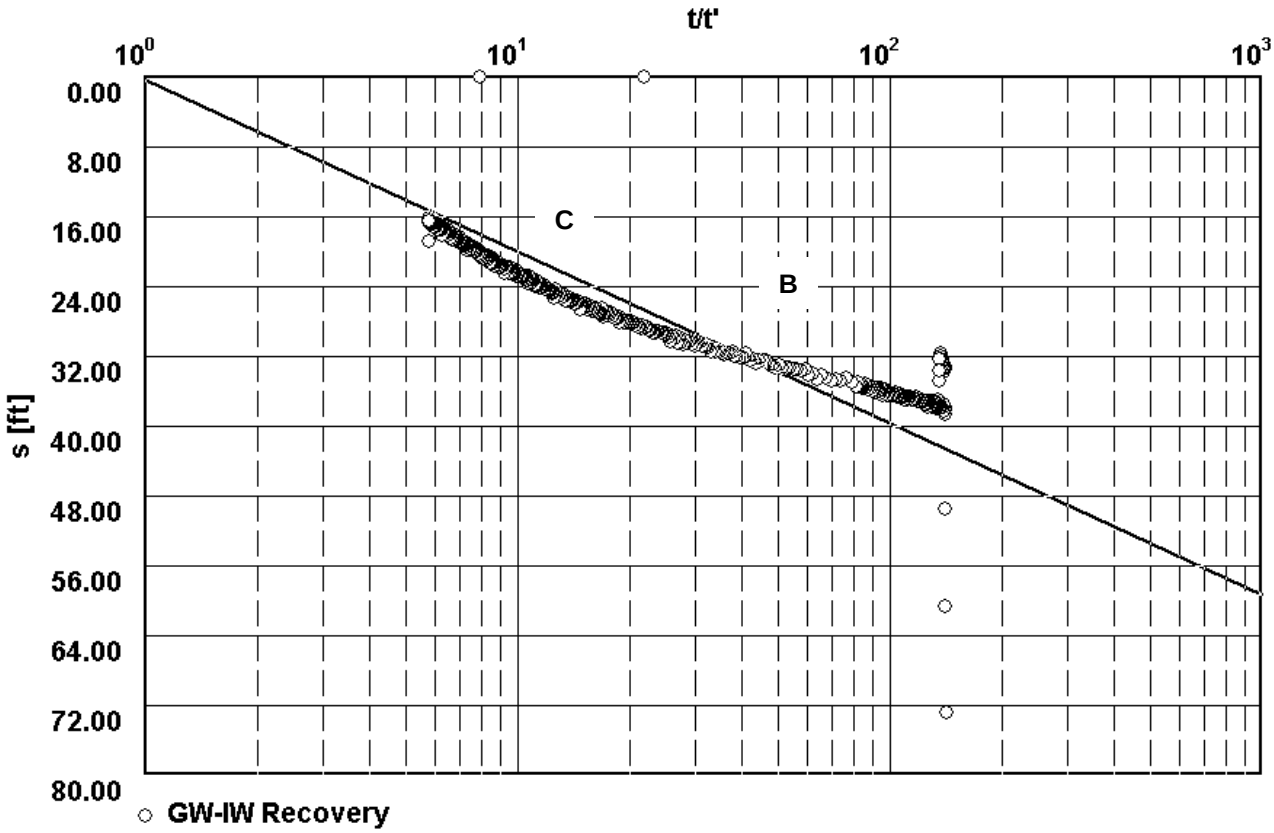
FIGURE 7

Water Level Measured in the Consent Order Well

0442-004-900	DATE: 6/22/04	
REV: 0	BY: RTD	CHK: KJT

NEWFIELDS

S:\Jobs\0442-004-900-Simplot-Smoky\0109\Task30\Groundwater\AquiferTest\AquiferTestMemo\AqTest_Figures.ppt



Transmissivity [ft^2/min]: 1.26×10^0

Note:

1. S [ft] is the total drawdown in the well
2. t is the total time since the time of pumping started to drawdown the well
3. t' is the total time since the pump was discontinued to start the recovery test
4. The line is the curve-fit line used to calculate the transmissivity

J.R. SIMPLOT COMPANY Smoky Canyon Mine		
FIGURE 8 Analysis of Recovery Test, Theis Recovery Method for the Industrial Well		
0442-004-900	DATE: 6/22/04	
REV: 0	BY: RTD	CHK: KJT
NEWFIELDS		

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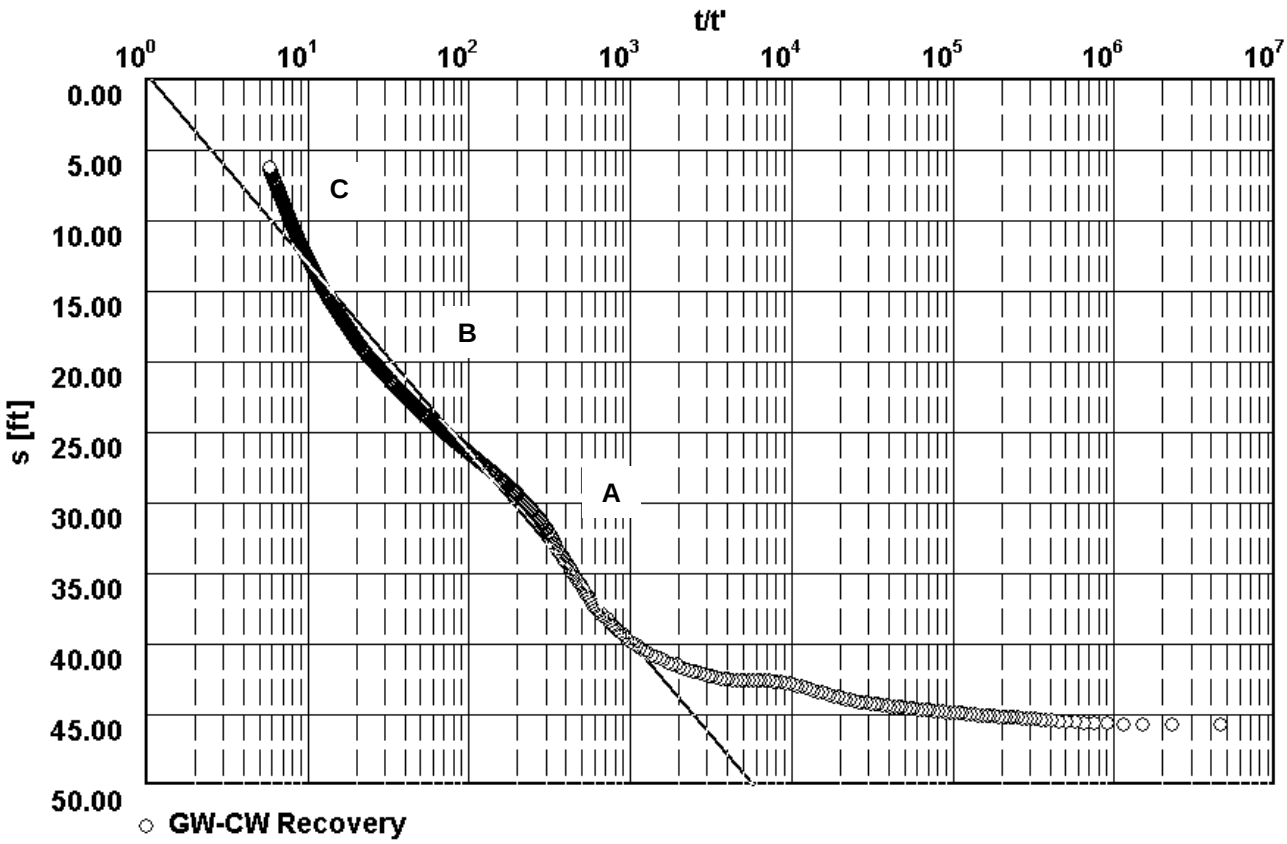

Transmissivity [ft^2/min]: 1.86×10^0

Note:

1. S [ft] is the total drawdown in the well
2. t is the total time since the time of pumping started to drawdown the well
3. t' is the total time since the pump was discontinued to start the recovery test
4. The line is the curve-fit line used to calculate the transmissivity

J.R. SIMPLOT COMPANY Smoky Canyon Mine		
FIGURE 9 Analysis of Recovery Test, Theis Recovery Method for the Culinary Well		
0442-004-900	DATE: 6/22/04	
REV: 0	BY: RTD	CHK: KJT
NEWFIELDS		

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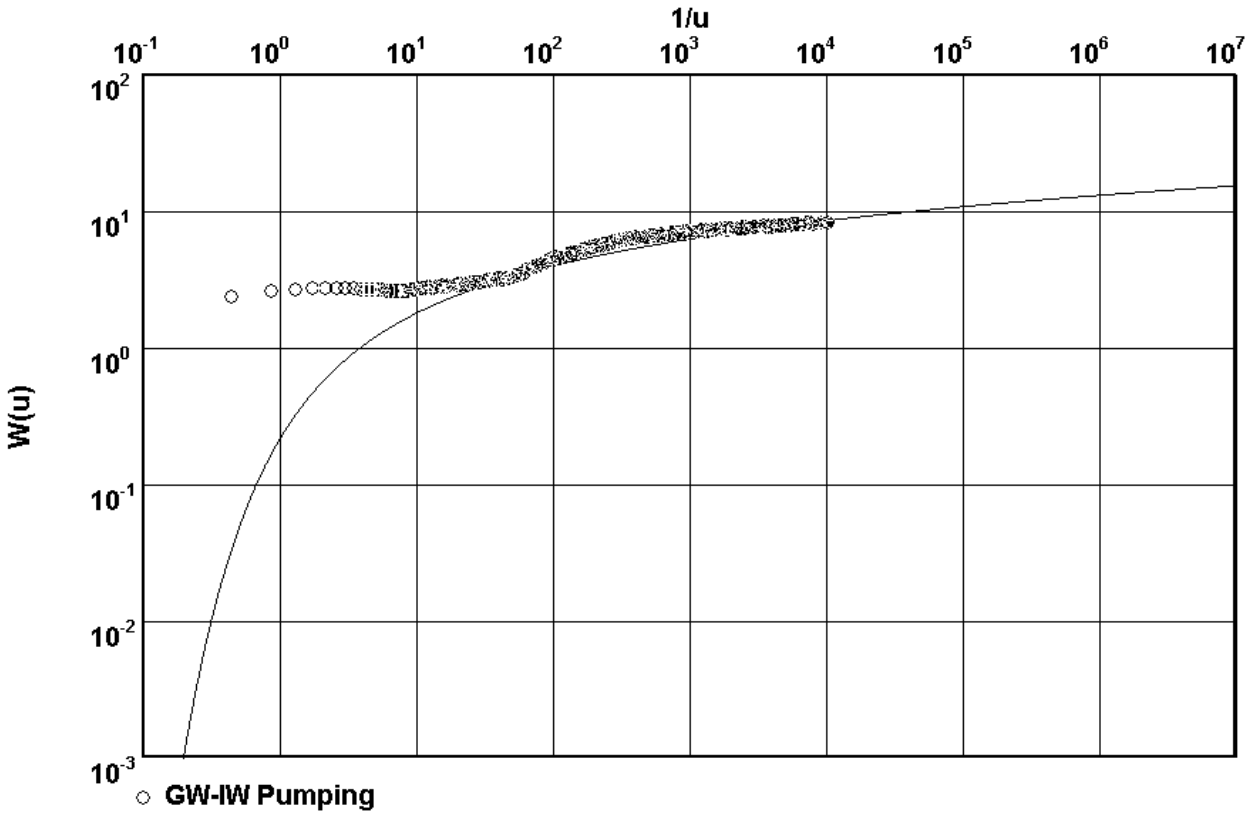

Transmissivity [ft^2/min]: 8.48×10^{-1}

Storativity: 1.30×10^{0}

Note:

1. W(u) is the well function
2. 1/u is a value based on the radial distance from the pumping well, storage coefficient, transmissivity and the time of pumping
3. The smooth line is the curve fit-line that is used to calculate the transmissivity

J.R. SIMPLOT COMPANY Smoky Canyon Mine		
FIGURE 10 Analysis of Final Drawdown Phase, Theis Method for the Industrial Well		
0442-004-900	DATE: 6/22/04	
REV: 0	BY: RTD	CHK: KJT
NEWFIELDS		

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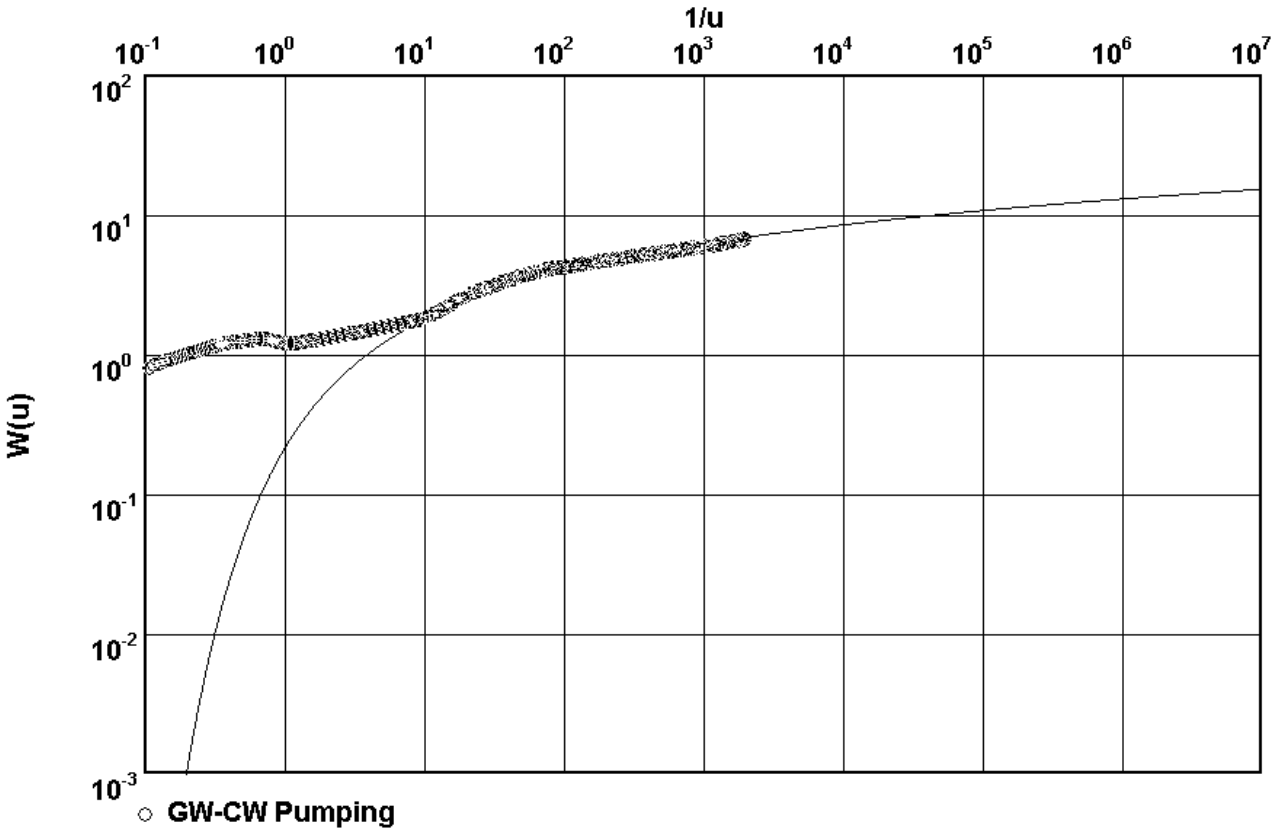

Transmissivity [ft^2/min]: 1.80×10^{0}

Storativity: 2.77×10^{-4}

Note:

1. W(u) is the well function
2. 1/u is a value based on the radial distance from the pumping well, storage coefficient, transmissivity and the time of pumping
3. The smooth line is the curve fit-line that is used to calculate the transmissivity

J.R. SIMPLOT COMPANY Smoky Canyon Mine		
FIGURE 11 Analysis of Final Drawdown Phase, Theis Method for the Culinary Well		
0442-004-900	DATE: 6/22/04	
REV: 0	BY: RTD	CHK: KJT
NEWFIELDS		

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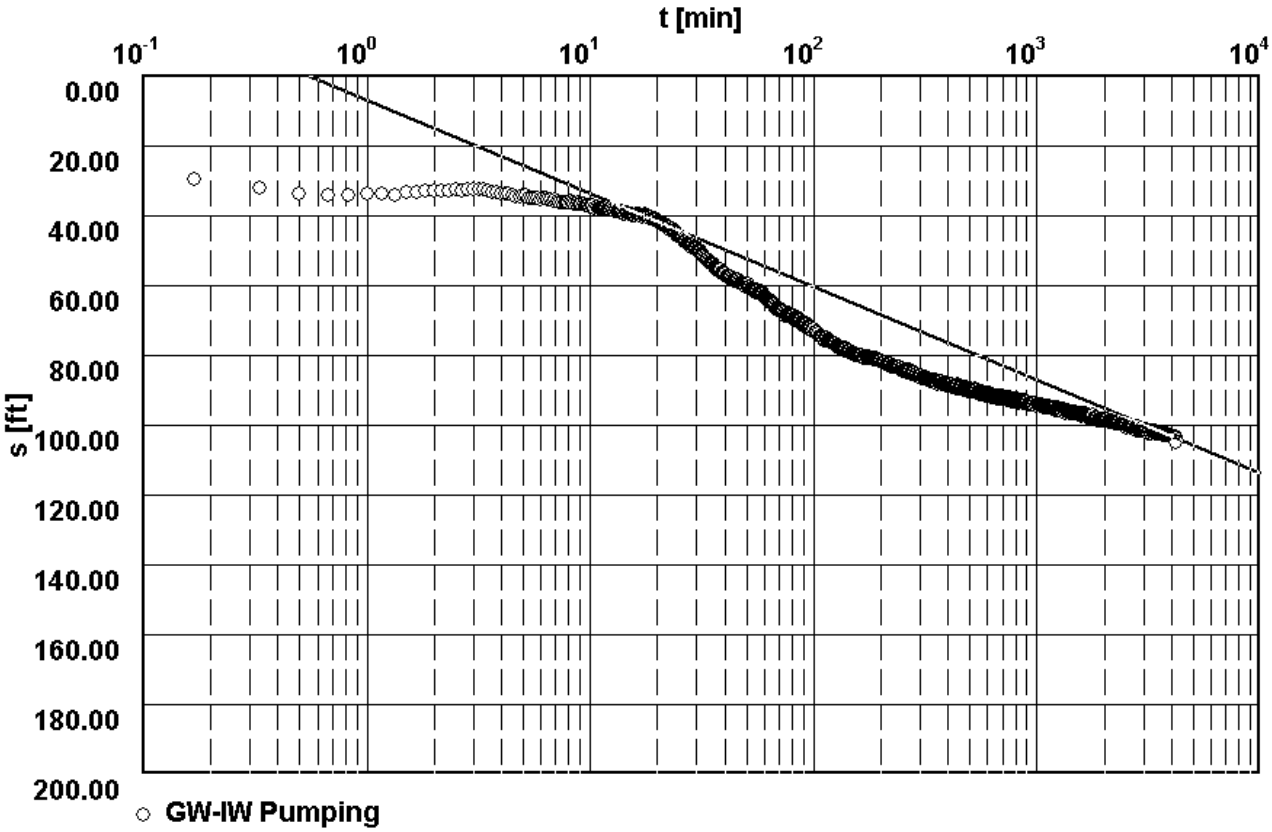

Transmissivity [ft^2/min]: 9.07×10^{-1}

Storativity: 1.13×10^{0}

Note:

1. S [ft] is the total drawdown in the well
2. t is the total time since the time of pumping started to drawdown the well
3. The line is the curve-fit line used to calculate the transmissivity

J.R. SIMPLOT COMPANY Smoky Canyon Mine		
FIGURE 12 Analysis of Final Drawdown Phase, Cooper-Jacob Method for the Industrial Well		
0442-004-900	DATE: 6/22/04	
REV: 0	BY: RTD	CHK: KJT
NEWFIELDS		

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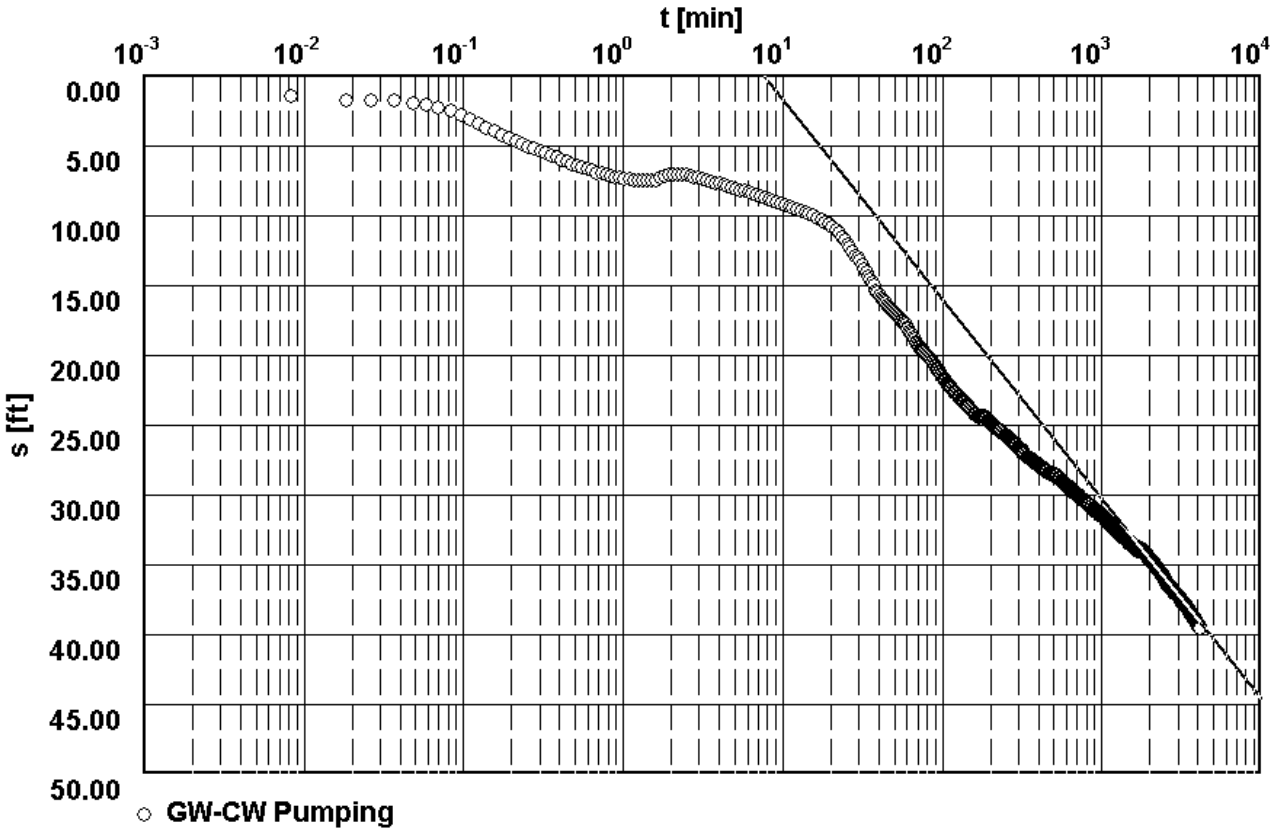

Transmissivity [ft^2/min]: 1.69×10^{0}

Storativity: 5.54×10^{-4}

Note:

1. S [ft] is the total drawdown in the well
2. t is the total time since the time of pumping started to drawdown the well
3. The line is the curve-fit line used to calculate the transmissivity

J.R. SIMPLOT COMPANY Smoky Canyon Mine		
FIGURE 13 Analysis of Final Drawdown Phase, Cooper-Jacob Method for the Culinary Well		
0442-004-900	DATE: 6/22/04	
REV: 0	BY: RTD	CHK: KJT
NEWFIELDS		

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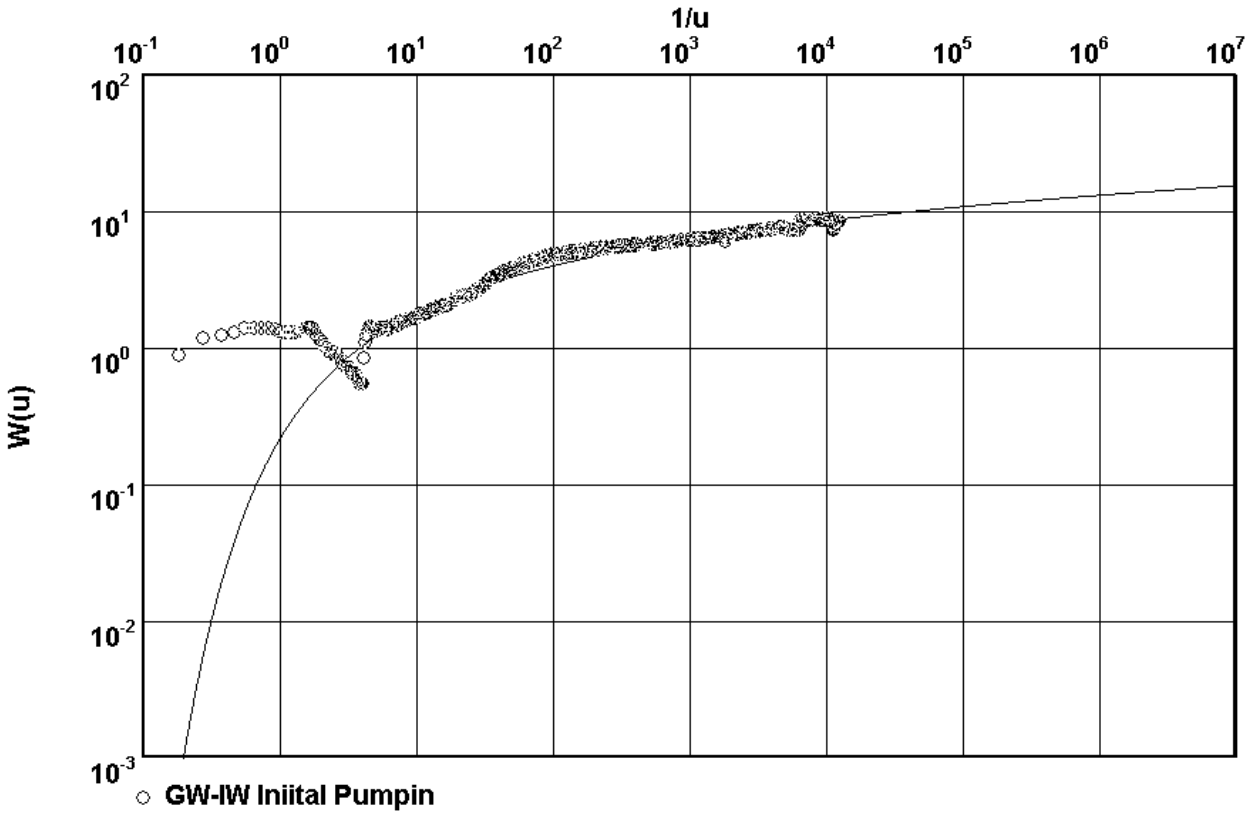

Transmissivity [ft^2/min]: 7.72×10^{-1}

Storativity: 5.58×10^{0}

Note:

1. W(u) is the well function
2. 1/u is a value based on the radial distance from the pumping well, storage coefficient, transmissivity and the time of pumping
3. The smooth line is the curve fit-line that is used to calculate the transmissivity

J.R. SIMPLOT COMPANY Smoky Canyon Mine		
FIGURE 14 Analysis of Preparation Drawdown Phase, Theis Method for the Industrial Well		
0442-004-900	DATE: 6/22/04	
REV: 0	BY: RTD	CHK: KJT
NEWFIELDS		

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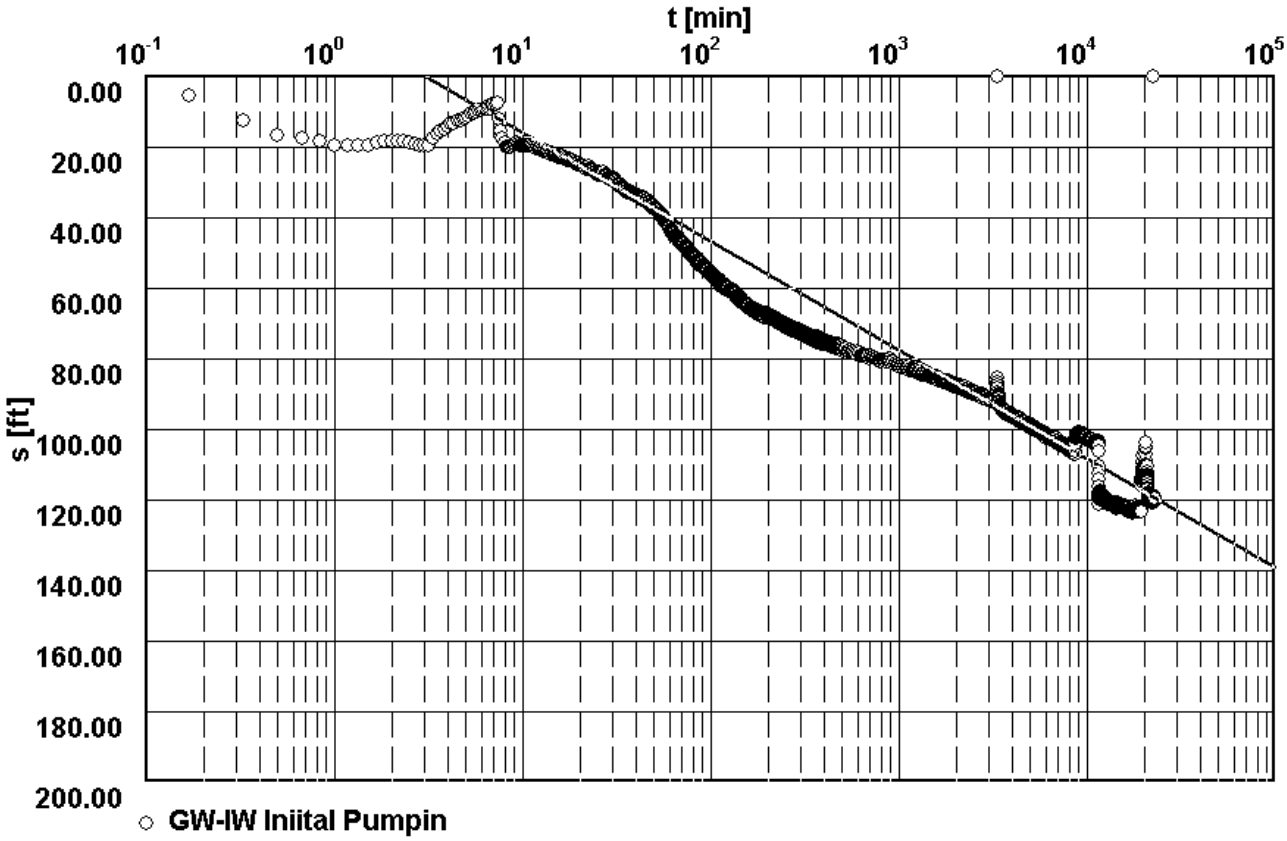


Transmissivity [ft^2/min]: 8.06 x 10^{-1}

Storativity: 5.58 x 10^{0}

Note:

1. S [ft] is the total drawdown in the well
2. t is the total time since the time of pumping started to drawdown the well
3. The line is the curve-fit line used to calculate the transmissivity

J.R. SIMPLOT COMPANY Smoky Canyon Mine		
FIGURE 15 Analysis of Preparation Drawdown Phase, Cooper-Jacob Method for the Industrial Well		
0442-004-900	DATE: 6/22/04	
REV: 0	BY: RTD	CHK: KJT
NEWFIELDS		

S:\Jobs\0442-004-900-Simplot-Smoky\0109\Task30\Groundwater\AquiferTest\AquiferTestMemo\AqTest_Figures.ppt

APPENDIX 1

Well Construction and Geologic Information

MAR 3 0 1983

Bob,
This is a copy of the log. When I said the louvered pipe was the same, I was wrong it is 10" instead of 12" the rest as far as the louvers it is the same.
Sandy

0 - 10	Clay Dry
0 - 15	Clay Wet
5 - 18	Blue Shale
8 - 21	Brown Sandstone
1 - 57	Black Shale w/ Chert & Clay Lancing
7 - 90	Hard Black Shale w/ Chert Lancing
0 - 93	Black Shale
3 - 97	Hard Shale w/ Chert
7 - 110	Streaks of hard & soft black shale
0 - 120	Soft black shale - Chert Lancing
0 - 147	Hard Black Shale - Chert Lancing
7 - 152	Soft Black Shale
52 - 177	Hard Black Shale w/ Chert Lancing
77 - 185	Soft Black Shale w/ Chert Lancing
85 - 190	Hard Black Shale
90 - 194	4' Cavern
4 - 210	Hard Black Shale w/ Chert
0 - 215	Hard Black Shale w/ Super Chert REX CHERT
5 - 232	Hard Black Shale w/ Chert Stringers
2 - 235	3' Cavern
35 - 275	Gray Limestone - hard fractured
75 - 276	Sandstone
76 - 277	Gray Limestone ?
77 - 280	Limestone
80 - 282	Sandstone
82 - 290	Light gray Limestone - Light Brown Sandstone
90 - 300	Light Brown Sandstone
00 - 307	Black Shale - Oolitic
07 - 330	Soft Sandstone
30 - 435	Black Shale - Hard
435 - 455	Limestone w/ quartz stringers
455 - 487	Limestone w/ quartz stringers
487 - 500	Limestone w/ mud stone

Industrial Well

500-511 Mud Stone w/ Sandstone
511-519 Mud Stone w/ Sandstone less
519-538 Sandstone w/ Limestone
538-550 Sandstone
550-560 Sandstone
560-587 Sandstone w/ Limestone
587-600 Red Sandstone w/ Limestone or Chert
600-610 Red Sandstone w/ Chert
610-618 Red Sandstone - Limestone some Shale
618-632 Sandy/Sandstone - Chert
632-640 Red Sandstone w/ Chert
640-657 Brown & Red Sandstone
657-672 Brown Sandstone & Sand
672-685 Sandy w/ Sandstone
685-722 Sandy w/ Sandstone
722-723 Limestone w/ Chert
723-730 Sandstone w/ Little Limestone (Sandy)
730-740 Sandstone w/ Little Limestone Stringers
740-757 Sanstone w/ Little Limestone Stringers
757-760 Limestone w/ Sandstone
760-770 Limestone
770-782 Limestone - quartz - some sandstone
782-787 Limestone
787-800 Limestone
800-810 Limestone w/ Black Shale
810-820 Limestone w/ Black Shale
820-830 Limestone w/ Black Shale
830-840 Limestone w/ Black Shale
840-850 Limestone w/ Black Shale
850-860 Limestone w/ Black Shale - some sandstone
860-870 Limestone w/ Black Shale - some Sandstone
870-880 Sandstone - Limestone - some Shale cuttings
880-890 Limestone
890-900 Limestone

'00-910 Limestone
'10-920 Limestone - some Sandstone
20-930 Limestone - Shale Cuttings - Sandstone
'30-939 Limestone - some Sandstone
'39-950 Limestone - Gray Dolomite
'50-960 Limestone - Gray Dolomite
'60-970 Limestone - Gray Dolomite
'70-980 Limestone - Gray Dolomite
'80-990 Limestone - Gray Dolomite
0-1000 Limestone - Gray Dolomite
-1010 Limestone - Gray Dolomite
-1020 Limestone - Gray Dolomite
0-1030 Limestone - Gray Dolomite
0-1040 Limestone - Gray Dolomite
-1050 Limestone - Gray Dolomite
-1060 Limestone - Gray Dolomite
-1070 Limestone - Gray Dolomite
-1080 Limestone - Gray Dolomite
-1090 Limestone - Gray Dolomite
-1100 Limestone - Gray Dolomite
-1107 Limestone - Gray Dolomite
-1110 Limestone - Some Sandstone
-1120 Limestone - Some Sandstone
-1130 Limestone - Some Sandstone
-1140 Limestone - Gray Dolomite
-1150 Limestone - Gray Dolomite
-1160 Limestone - Gray Dolomite
-1170 Limestone - Gray Dolomite
-1180 Limestone - White Sandstone
-1190 Limestone - White Sandstone
-1200 Limestone - White Sandstone
-1210 Gray Limestone
-1220 Gray Limestone
-1230 Limestone & Ortho Quartz

-1240 Limestone & Ortho Quartz Sand
-1250 Gray Limestone
-1260 Gray Limestone
-1270 Gray Limestone
-1280 Gray Limestone & Ortho Quartz
-1290 White & Gray Ortho Quartzite (Limey)
-1300 Gray & White Crystalline Limestone - Ortho Quartzite
-1310 Gray Crystalline Dolomite
-1320 Gray Crystalline Dolomite Hard

LEGAL PAD (8½ x 14 IN.) 50

W. S. C. SALT LAKE CITY, UTAH 841

lic level
83 ft

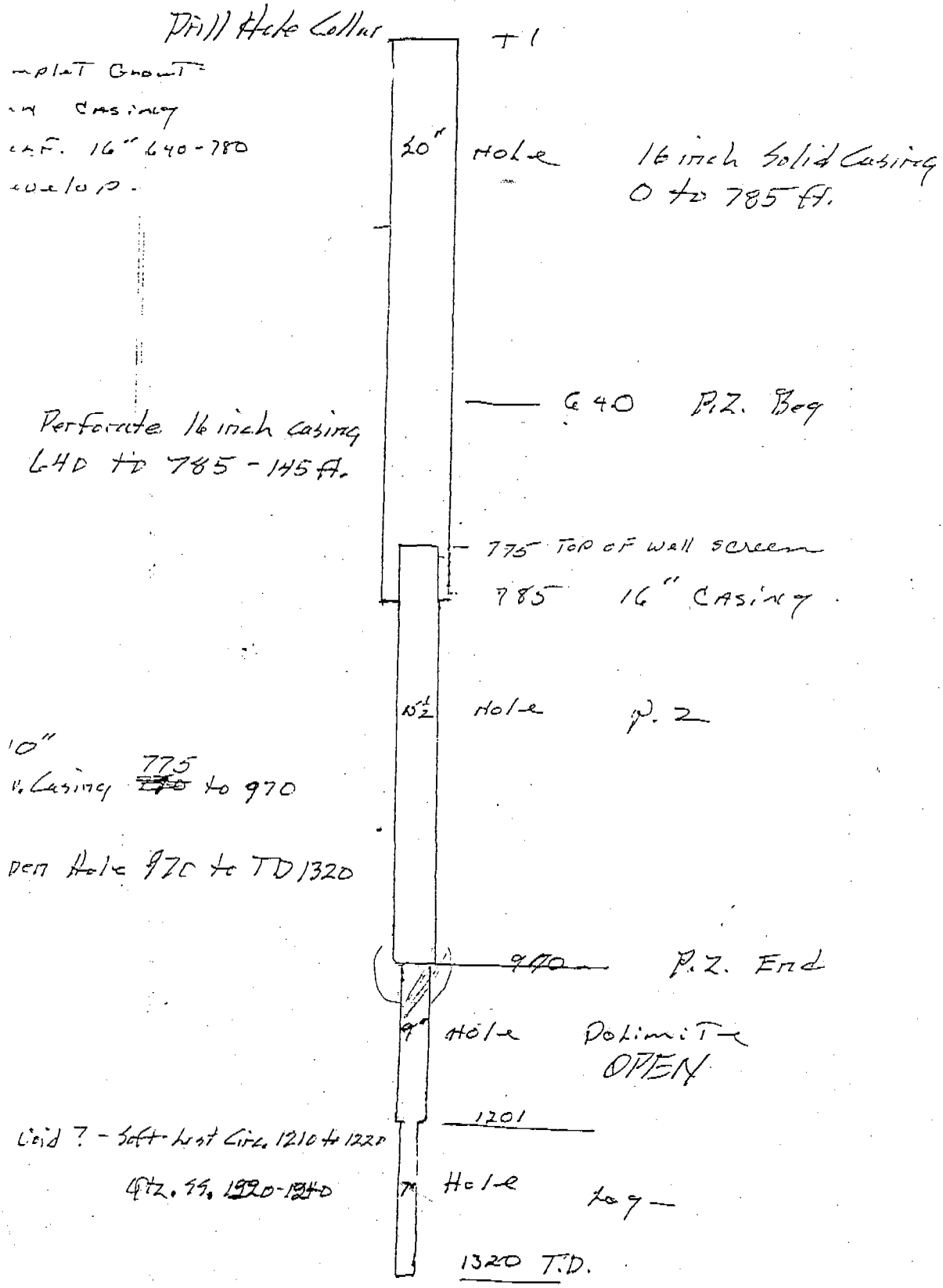
644
240 SHOTS ✓20'
1
664
665'6" weld Joint
667
1 204 SHOTS ✓17'
684
1 240 SHOTS ✓20'
704
705'8" weld Joint
708
1 ~~192~~ SHOTS ✓16'
724
11 240 SHOTS ~~20'~~
144 ~~13'~~ SHOT
744 384
745'10" weld Joint
747
complete 360 ✓ SHOTS 15' 180
742 11
480 ✓ SHOTS 20'
complete
782 11 480

1956 SHOTS
144
2100

534.60
786.40
21.00

144
685
720
152
64
40

Industrial Well - Casing Schedule



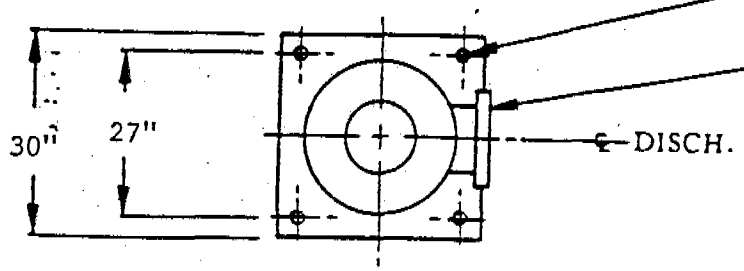
JIMORY #2 WATER WELL Thermal Drill File

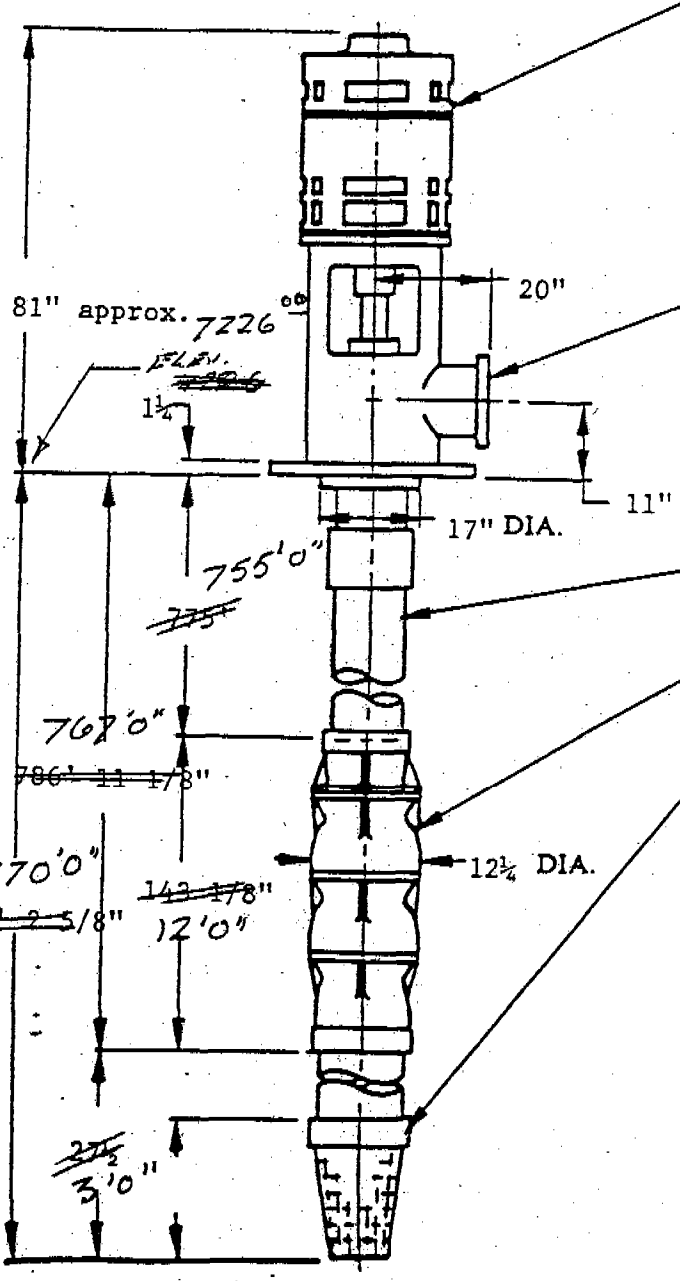
INDUSTRIAL WELL PUMP SETTING

JOHNSTON VERTICAL TURBINE PUMP

ACTUAL PUMP SETTING 11/9/83

Bowls set 20 ft above the screen





GENERAL ELECTRIC
VERTICAL Hollow SHAFT MOTOR
HP— 450 PHASE— 3 CYCLE— 60
VOLTAGE— 460 RPM— 1760
ENCLOSURE— WP-1

TYPE "A" DISCHARGE HEAD— 24½ x 10

CONDITIONS:
U.S. GALLONS PER MINUTE— 1600
TOTAL DYNAMIC HEAD IN FT.— 868
LIQUID— Water
SPEC. GRAV. 1.0 @ 60 °F. TEMP.

COLUMN ASSEMBLY— 10" x 3" x 1 15/16"

BOWL ASSEMBLY— 14 STAGE 13 CMC

SUCTION PIPE & CONE STRAINER—

CUSTOMER J. R. Simplot
PO#
DEALER
PO#
JOHNSTON SERIAL NO. ITT 49021
JOHNSTON QUOTATION NO.

NOTE: DO NOT USE FOR CONSTRUCTION UNLESS CERTIFIED

Casing Specs
O.D. Screen 10¾"
I.D. 10.128"
O.D. Top of Screen 11¾"
I.D. Well Casing 15½"

JOHNSTON PUMP CO.

Table 1. Construction details for test wells at the Smoky Canyon site.

Site	Depth (ft)	Casing Diameter and Type, Top and Bottom	Perforated Interval (ft)
Pole Canyon	900	8-inch steel: +1.5 to 35 feet	----
		6-inch steel: +1.5 to 430 feet	----
		4-inch plastic: 300 to 900 feet	430-900
Smoky Junction (Culinary Well)	1000	8-inch steel: +1.5 to 360 feet	----
		6-inch steel: +2 to 770 feet	330-390; 570-770
		4-inch plastic: 710 to 940 feet	710-940
Lower Smoky	130	8-inch steel: +1.5 to 22 feet	----
		4-inch plastic: +1.5 to 130 feet	22-130

from: Ralston (1981)

HOLE No. Smoky Junction
LOCATION Smoky WW 2-B

GONDA MINE

COORDINATES _____ N. _____ E.

DATE 7-2-81
ELEV. _____

SAMPLE NO.		DEPTH FROM	DEPTH TO	% P_2O_5	% MgO	GAMMA RAY LOG	LITHOLOGY AND DRILLING LOG
27-470		300	305				Shale, mudstone
27-471		305	310				Very cherty phos. rock (fish scales)
27-472		310	315				Very cherty phos. rock (fossils/nodules), mud
27-473	80	315	320				Very cherty phos. rock (very hard; blue)
27-474		320	325				Same
27-475		325	330				Same
27-476		330	335				Same
27-477	80	335	340				Cherty phos. rock & mud @ 239'
27-478		340	345				Mud to soft mud w/hard layers
27-479		345	350				Same
27-480		350	355				Mud with hard layers
27-481	80	355	360				Shale & mudstone (light cream color)
27-482		360	370				Black shale & mudstone (Water @ 361')
W ore							
27-483		370	375				Harder shale & mudstone
27-484	80	375	380				Same
27-485		380	385				Mudstone, silty limestone
27-486		385	390				Fine, black shale; silty limestone
27-487		390	395				Fine shale, silty limestone, calcite
27-488	100	395	400				Hard, cherty, nodular shale; mudstone, bl. sand
27-489		400	405				Hard, cherty, nodular shale
27-490		405	410				Black, shaley, oolitic sand; shale; mudstone
27-491		410	415				Black, shaley sand; mudstone
27-492	120	415	420				Shale (some coarse oolitic); mudstone
27-493		420	425				Shale; mudstone
27-494		425	430				Shale (some coarse oolitic); calcite
27-495	140	430	435				Hard shale, mudstone
27-496		435	445				Dark gray to light gray @ 447'
27-497		445	450				Shale, mudstone, calcite
27-498		450	455				Hard, cherty shale w/calcite veins
27-499	160	455	460				Hard, fine shale
27-500		460	465				Same
27-501		465	470				Same
27-502	180	470	480				Same
27-503		480	487				Same
27-504		487	495				Shale, fine oolites
27-505	200	495	500				Coarsely oolitic shale; shale
27-506		500	505				Coarsely oolitic shale-altered
26-507		505	510				Fine, oolitic shale & mudstone
27-508	220	510	520				Shale, mudstone, limestone
27-509		520	525				Limestone
27-511		530	535				Same
27-512	240	535	540				Same
27-513		540	545				Same
27-514		545	550				Same
27-515		550	555				Same
27-516	260	555	560				Same
27-517		560	565				Same
27-518		565	570				Same
27-519		570	575				Limestone within layers of orange sandstone
27-520	280	575	580				Same
27-521		580	585				Same

Culinary Well

WW-2B

REX CHERT

Hn' Ppop

MEADE PEAK

25
25
175
18
367
70
437

Ppg.

Grandeur

DRILL HOLE LOG
CONDA MINE

HOLE NO. SMOKY JUNCTION
LOCATION SMOKY WW 2-B

COORDINATES _____ N. _____ E.

DATE 9-2-81
ELEV. _____

SAMPLE NO.	DEPTH FROM	DEPTH TO	% P_2O_5	% MgO	GAMMA RAY LOG	LITHOLOGY AND DRILLING LOG
27-523	595	605				Sandstone w/some limestone
27-524	605	615				Sandstone w/some limestone; buff, tan
27-525	615	630				Same
27-626	630	640				Sandstone; buff, tan
27-627	640	655				Same
27-628	655	665				Sandstone-soft
27-629	665	673				Same
27-630	673	680				Same
27-631	680	690				Sandstone; soft, pink
27-632	690	695				Sandstone; pink & tan; hard/med. hard
27-634	695	705				Same
27-635	705	715				Same (white, soft, fine)
27-636	715	725				Same
27-637	725	730				Same (medium hard)
27-638	730	740				Same
27-639	740	750				Same
27-640	750	755				Same
27-641	755	765				Same
27-642	765	774				Same (color change to pink)
27-643	774	780				Same
27-644	780	793				Same (pink & tan)
27-645	793	800				Same (tan)
27-646	800	805				Same (white, hard)
From Driller's Log - 805' to 1000'						From Driller's Log 805' to 1000' Light sandstone; streaks of limestone

Gitt
1 L.e.

Trt THAYNES Trd DINWOODY

Ppc CHERTY SHALE MEM
Ppr RED CHERT MEM
Ppm MEADE PEAK MEM
PPwu WELLS FMN

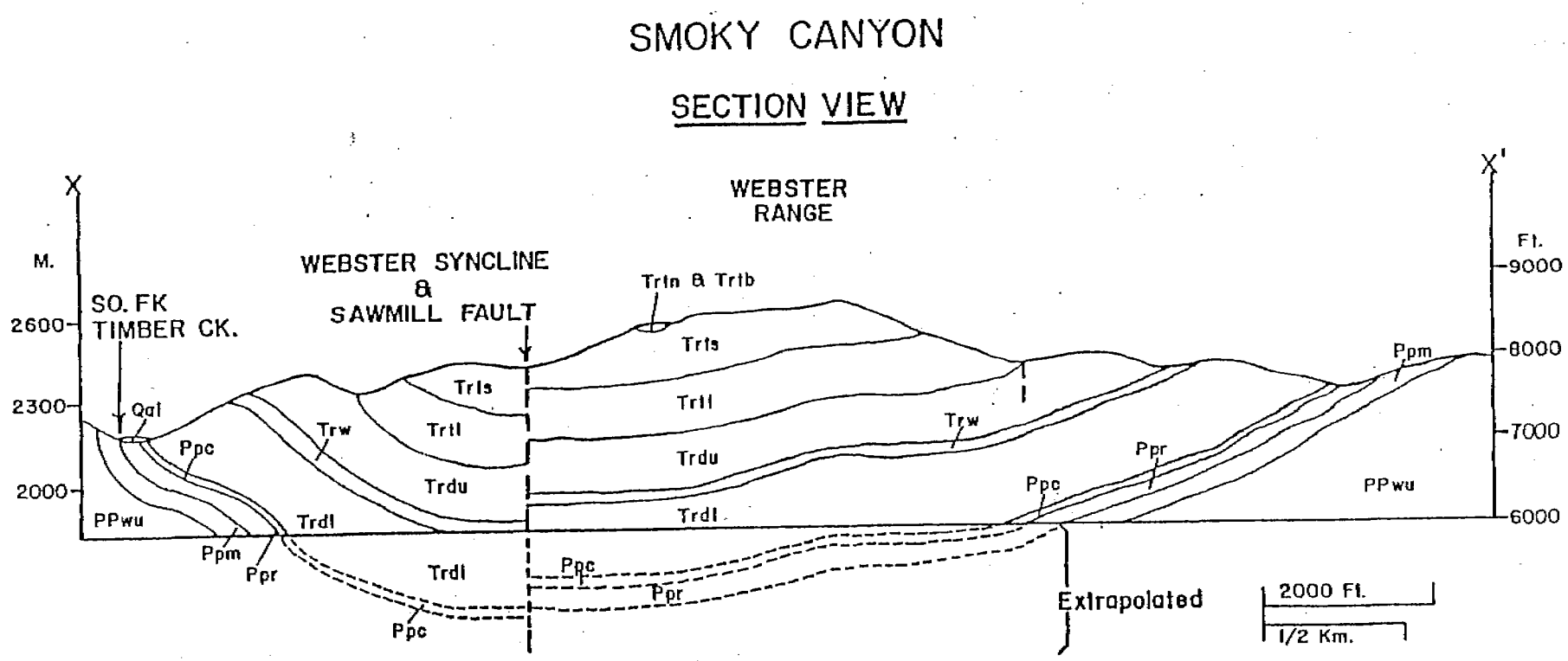
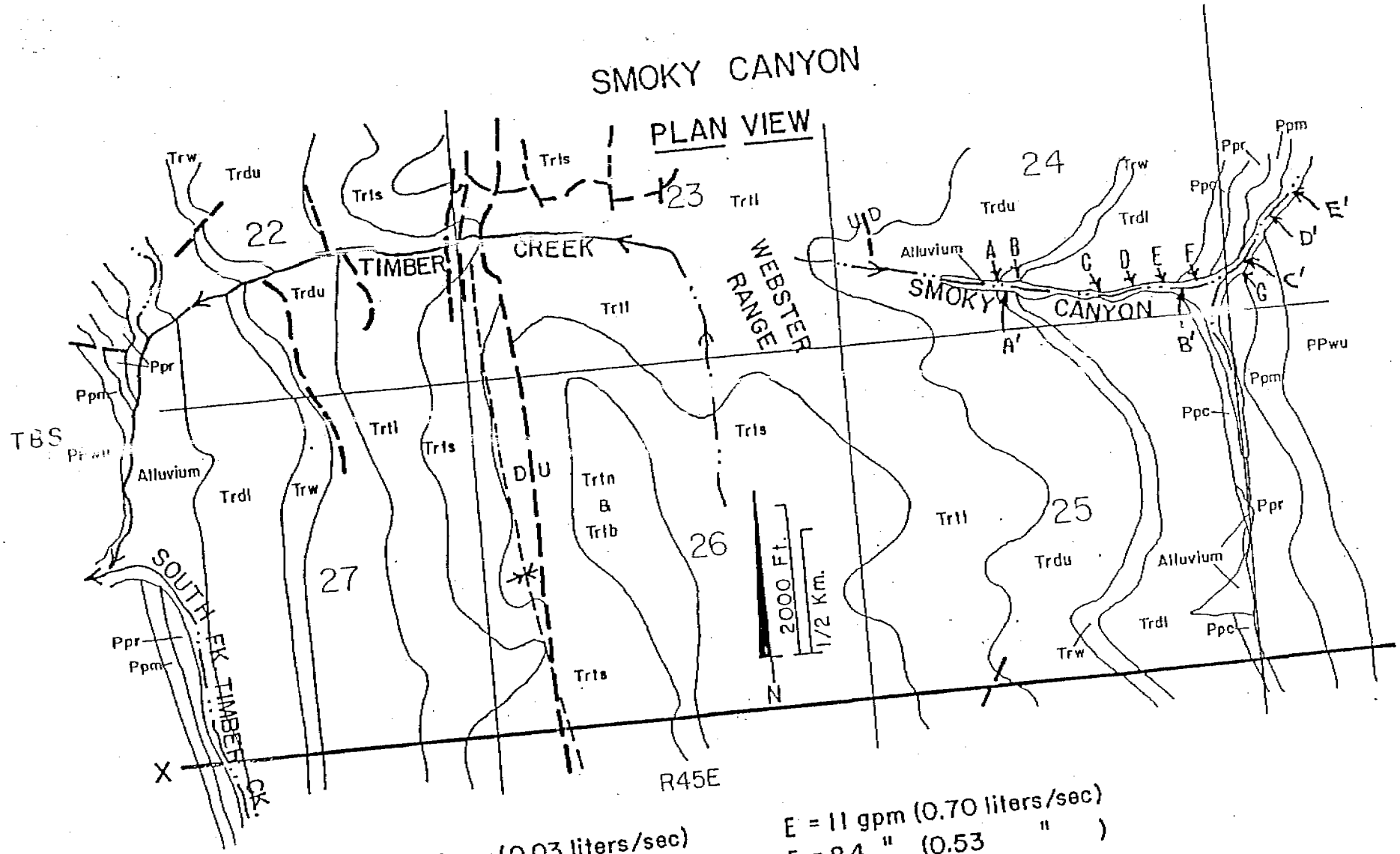


Figure 5b. Geologic section view of Smoky Canyon (Modified after Montgomery and others, 1967, Plate 2).



A = .47 gpm (0.03 liters/sec)
B = 0
C = 8.9 " (0.56 ")
D = 0
E = 11 gpm (0.70 liters/sec)
F = 8.4 " (0.53 ")
G = 0

Figure 5a. Geologic plan view of Smoky Canyon showing stream measurement sites and spring locations (after Montgomery and others, 1967, Plate 2).

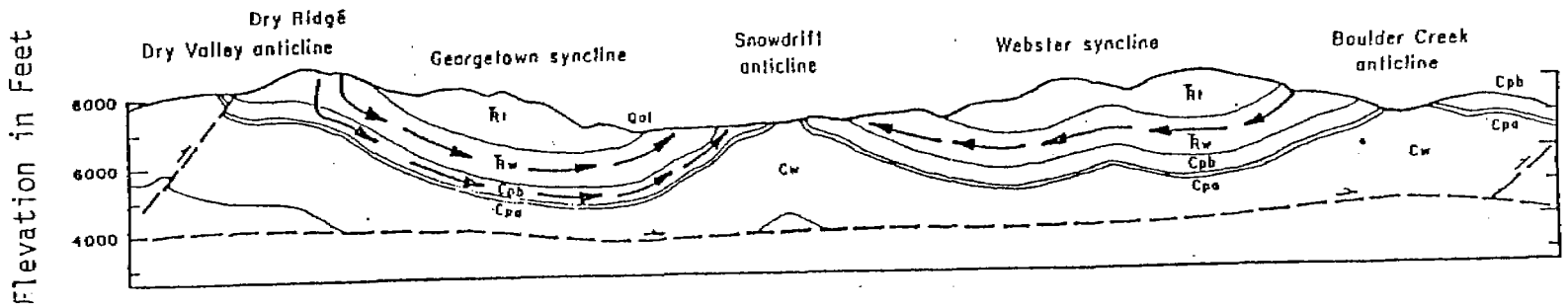
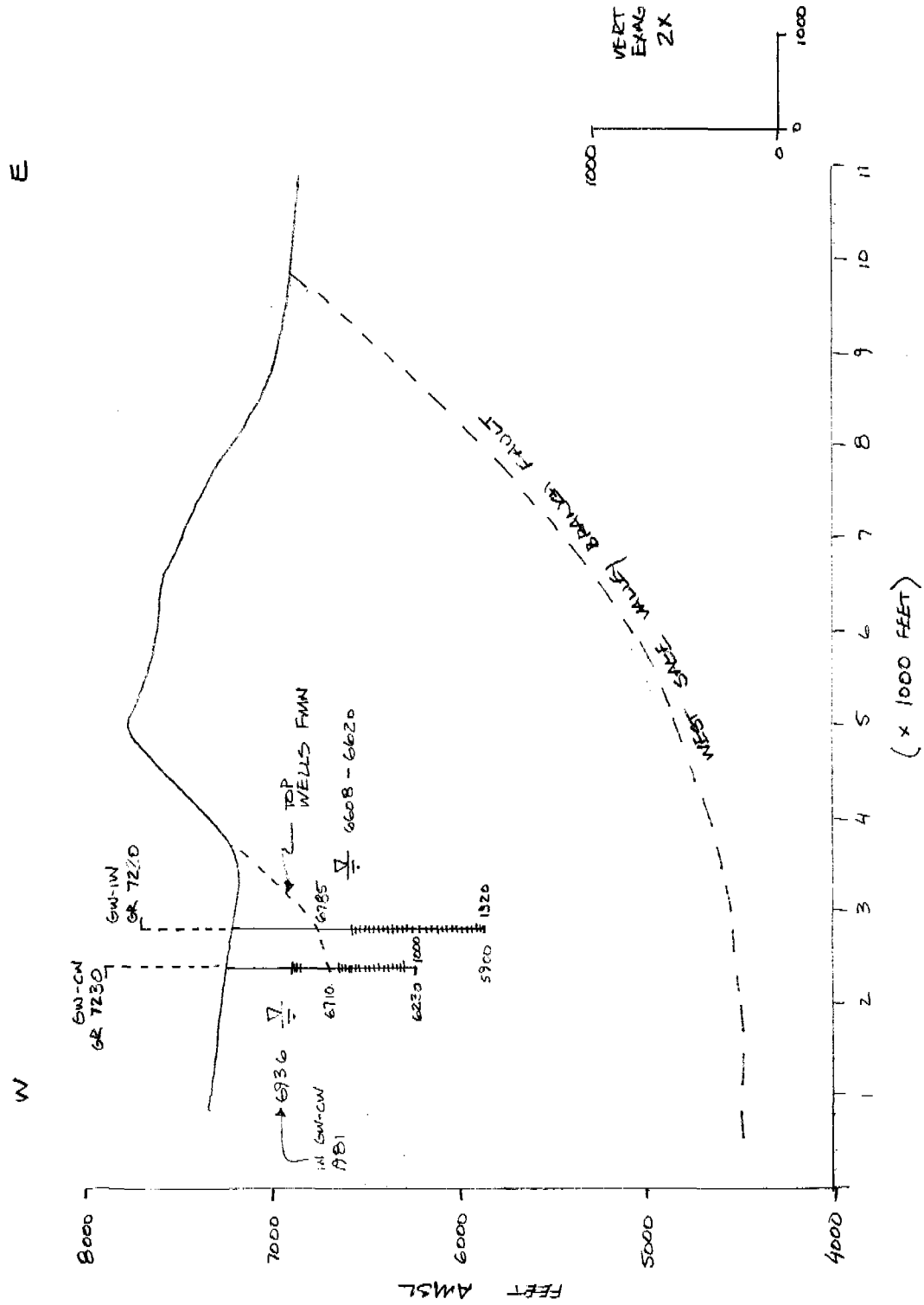


Figure 3. Hypothetical ground-water flow paths (arrows) in complex geologic structures of study area. Adapted from Mansfield (1927).

SIMPLOT SMOKY CANYON MINE

B COTTON 6·15·04

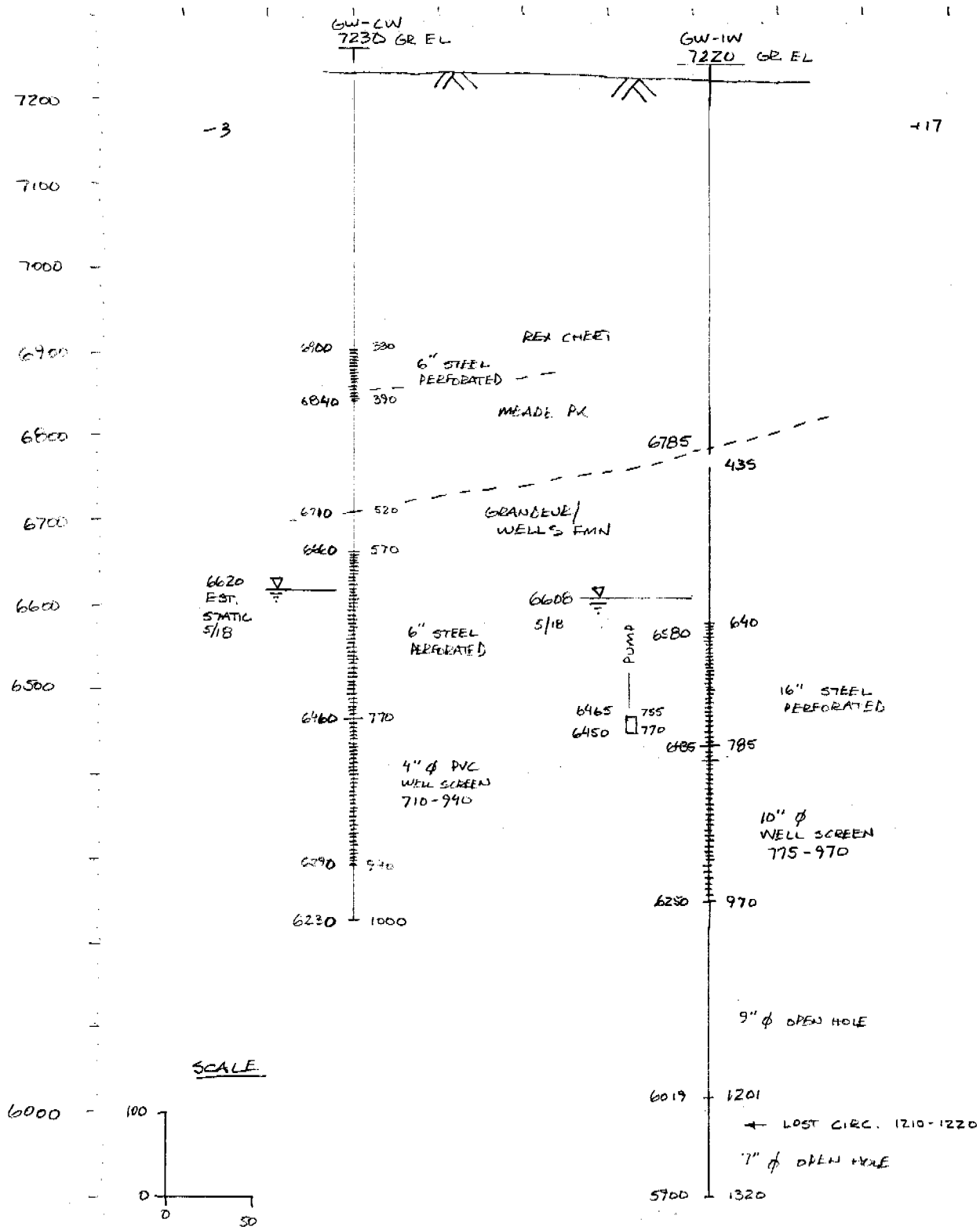
E-W GEOLOGIC CROSS SECTION AT SMOKY CREEK



SIMPLOT SMOKY CANYON MINE

B COTTON 6-15-04

DETAIL SECTION SHOWING WELL COMPLETIONS



WELL CONSTRUCTION SUMMARY

WELL NO. C-1 (deep well)

SITE NAME:
Simplot Smoky Canyon Mine – Panel C

PROJECT NO:
2560432

WELL LOCATION:
North end of C-Panel

DRILLING SUMMARY

Total Depth: 722 ft

Borehole Dia: 16-in

Drilling Co: Thomas Drilling

Driller Name: Tyson Thomas

Drill Rig: Air Rotary

Bit(s): Tri-cone & Hammer

Drilling Fluid(s): Air, water, foam

Ground Elev: 7218 ft (GPS)

Top Casing Elev:

WELL DESIGN

Basis: Geologic Log X Geophysical Log _____

Casing Strings: (C = casing; S = screen)

From:	To:	Diam.	From:	To:	Diam.
+1.5 ft	31 ft	16” C1			
+1.0	500	10” C2			
+0.5	539	4” C3			
539	599	4” C4			
599	650	4” S1			
650	660	4” C4			

Casing:	C1	16-in black steel blank
	C2	10-in black steel blank
	C3	4-in black steel blank
	C4	4-in stainless steel blank
	S1	4-in stainless steel (0.020” slot factory)

Centralizers: 396 ft, 437 ft, 477 ft, 517 ft, 558 ft, 619 ft, 639 ft, 659 ft.

Filter Material: Silica sand 8-12 mesh (0.093-0.055 in) @ 589-662 ft; 6-9 mesh, 10-20 mesh, & 20-40 mesh @ 572-589 ft

Grout/Cement: Bentonite grout (25% solids) @ 40-572 ft; Cement grout @ 0-40 ft

Other:

CONSTRUCTION TIME LOG

TASK	START		FINISH	
Drilling:				
16”	7-1-03	12:00	7-1-03	12:30
10”	7-1-03	17:00	7-2-03	17:15
9 7/8”	7-3-03	08:30	7-17-03	10:00
Casing:				
16”	7-1-03	13:00	7-1-03	14:00
10”	7-7-03	12:00	7-10-03	13:40
4”	7-19-03	11:40	7-19-03	17:50
Filter:	7-20-03	06:00	7-20-03	16:00
Seal:	7-20-03	16:00	7-21-03	18:00
Develop	7-21-03		7-23-03	
Other:				
Surface	7-23-03		7-23-03	

Decontamination: High pressure wash rig and equipment before and after drilling & well install

Development: Surge with drill rig compressor; pump with submersible

Water Yield:

Based on development, well yield estimate = 15 gpm

Comments:
Depth to water approx. 575 ft on 7-23-03

MAXIM TECHNOLOGIES, INC.
3380 Americana Terrace, Ste. 201
Boise, ID 83706
(208) 389-1030
FAX: (208) 389-1183

WELL CONSTRUCTION SUMMARY

WELL NO. GW-16

SITE NAME: Simplot Smoky Canyon Mine – AOC Sage Valley

PROJECT NO: 010109.30

WELL LOCATION: Pole Canyon Below Dump; near GW-15

DRILLING SUMMARY

Total Depth: 280 ft | **Borehole Dia**: 10-in

Drilling Co: Thomas Drilling | **Driller Name**: Tyson Thomas

Drill Rig: Air Rotary | **Bit(s)**: Hammer

Drilling Fluid(s): Air, water, foam

Ground Elev: | **Top Casing Elev**: 6854.4 ft

WELL DESIGN

Basis: Geologic Log X Geophysical Log _____

Casing Strings: (C = casing; S = screen)

From:	To:	Diam.	From:	To:	Diam.
+3.2 ft	100 ft	10” C1			
0.0	180	8” C2			
+2.9	230	4” C3			
230	280	4” S1			

Casing:	C1	10-in black steel blank
	C2	8-in black steel blank
	C3	4-in Sch 80 PVC blank
	S1	4-in Sch 80 PVC (0.020” slot factory)

Centralizers: 100 ft, 180 ft, 280 ft.

Filter Material: Silica sand 8-12 mesh (0.093-0.055 in) @ 225-280 ft (107 bags).

Grout/Cement: Bentonite grout (25% solids) @ 30-225 ft; Cement grout @ 0-30 ft (32 bags).

Other:

CONSTRUCTION TIME LOG

TASK	START		FINISH	
Drilling:				
0-100’	10-4-03	10:00	10-4-03	16:00
100-150	10-6-03	10:00	10-6-03	16:00
150-280	10-7-03	08:00	10-7-03	16:30
Casing:				
10”	10-4-03	10:00	10-4-03	16:00
8”	10-6-03	10:00	10-6-03	16:00
4”	10-8-03	11:00	10-8-03	12:00
Filter:	10-8-03	12:00	10-8-03	14:00
Seal:	10-8-03	14:00	10-8-03	15:00
Develop	10-20-03			
Other:				
Surface	10-8-03			

Decontamination: High pressure wash rig and equipment before and after drilling & well install

Development: See Well Development Record

Water Yield:

15-20 gpm during development

Comments:

Depth to water approx. 217.5 ft bgs on 10-20-03

MFG, INC.
4900 Pearl East Circle, Suite 300W
Boulder, Colorado 80301-6118
(303) 447-1823
FAX: (303) 447-1836

LOG OF BORING BY CUTTINGS

BORING NO: MC-MW-1

SITE NAME: Simplot Manning Creek Lease – Panel F	**PROJECT NO.:** 2560432	**BORING LOCATION:** Along South Fork Sage Creek NE Panel F
DRILLING COMPANY: Thomas Drilling	**DRILLER:** Tyson Thomas	**ELEVATION AND DATUM:** 6780.1 ft (top of inside casing)
DRILLING METHOD: Air Rotary with Foam		**DATE STARTED:** 10/15/03 / **DATE FINISHED:** 10/17/03
SITE & TYPE OF CASING: 10-in diameter steel (0-10 ft); 4-in sch-80 PVC (0-210 ft); screen (160-210 ft)		**DRILL BIT:** 9 7/8 hammer / **COMPLETION DEPTH:** 210 feet
SAMPLER METHOD: Sieve from grab drill cuttings; bucket samples at 5-ft intervals		**LOGGED BY:** Deb Schiavone / **CHECKED BY:** Doug Rogness
DEPTH TO GROUNDWATER: 145.1 ft below GS (10-19-03); PVC casing stkup = 3.0 ft (approx.)		

DRILLING TIME RECORD					DEPTH (ft)		DRILLING ACTION	CALC. CONTENT	DESCRIPTION AND DRILLERS NOTES: (material, color, texture, hardness and other notes)
DEPTH		TIME							
FROM	TO	FROM	TO	MIN	FROM	TO			
0	10	15:30	16:00	30	0	4	E	M	SOIL-ALLUVIUM. Sandy clay with gravel; dry; brown; fine-medium grained sand.
10	30	08:30	09:30	60	4	8	CI	S	ALLUVIUM. Gravel with sand; dry; brown; trace clay; fine-coarse grained sand.
30	50	09:30	10:30	60	8	93	EI	N	WELLS FORMATION. Sandstone; dry; light brown; slightly calcareous 18-22 ft; crunchy light gray limestone interbeds 22-38 ft; slightly weathered; very calcareous; light brown-gray calcareous sandstone 38-82 ft; slightly weathered; light gray dolomite interbeds 82-93 ft.
50	70	10:30	11:30	60	93	210	Rr	M-V	WELLS FORMATION. Sandstone; light gray-brown; slightly weathered & fractured; dolomite interbeds 114-135 ft; light gray; occasional limestone interbeds; dolomite interbeds 173-193 ft; light gray; moderately calcareous.
70	90	11:30	12:30	60					
90	110	12:30	13:30	60					
110	130	13:30	14:30	60					
130	150	14:30	16:00	90					Note: Encountered groundwater at depth of about 160 feet; appears to be making about 30-40 gpm after drilling.
150	170	16:00	17:00	60					
170	190	09:00	10:30	90					
190	210	10:30	12:00	90					

ABBREVIATIONS:

DRILLING ACTION		CALC. CONTENT
E: even, smooth	r: Slightly rough	N: Non-calc.
C: Crunchy	R: Moderately rough	S: Slightly
I: Intermittently rough	R: Very rough	M: Moderately
		V: Very

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3380 Americana Terr., Ste. 201
Boise, ID 83706
(208) 389-1030
FAX: (208) 389-1183

WELL CONSTRUCTION SUMMARY

WELL NO. GW-18

SITE NAME: Simplot Smoky Canyon Mine – AOC Sage Valley

PROJECT NO: 010109.30

WELL LOCATION: Slightly uphill from Hoopes Spring; near GW-17

DRILLING SUMMARY

Total Depth: 105 ft | **Borehole Dia**: 10-in

Drilling Co: Thomas Drilling | **Driller Name**: Tyson Thomas

Drill Rig: Air Rotary | **Bit(s)**: Hammer

Drilling Fluid(s): Air, water, foam

Ground Elev: | **Top Casing Elev**: 6675.6 ft

WELL DESIGN

Basis: Geologic Log X Geophysical Log _____

Casing Strings: (C = casing; S = screen)

From:	To:	Diam.	From:	To:	Diam.
+3.1 ft	7.1 ft	10" C1			
+2.7	55	4" C2			
55	105	4" S1			

Casing:	C1	10-in black steel blank
	C2	4-in Sch 80 PVC blank
	S1	4-in Sch 80 PVC (0.020" slot factory)

Centralizers: 50 ft, 104 ft.

Filter Material: Silica sand 8-12 mesh (0.093-0.055 in) @ 50-105 ft (108 bags).

Grout/Cement: Bentonite grout (25% solids) @ 20-50 ft; Cement grout @ 0-20 ft.

Other:

CONSTRUCTION TIME LOG

TASK	START		FINISH	
Drilling:				
0-20'	9-27-03	15:30	9-27-03	17:30
20-60	9-29-03	10:00	9-29-03	14:00
60-105	10-1-03	08:30	10-1-03	11:30
Casing:				
10"	9-27-03	15:30	9-27-03	17:30
4"	10-1-03	11:30	10-1-03	12:30
Filter:	10-1-03	12:30	10-2-03	09:30
Seal:	10-2-03	09:30	10-2-03	11:30
Develop	10-22-03			
Other:				
Surface	10-2-03			

Decontamination: High pressure wash rig and Equipment before and after drilling & well install

Development: See Well Development Record

Water Yield: >50 gpm during development

Comments: Depth to water approx. 42.1 ft on 10-22-03. Ran out of sand on 10-1; finish filter placement 10-2.

MFG, INC.
4900 Pearl East Circle, Suite 300W
Boulder, Colorado 80301-6118
(303) 447-1823
FAX: (303) 447-1836

APPENDIX 2

Aquifer Testing Data
(Excel files on CD with Site Investigation Report Volume 2)