SECTION 18

WATER RESOURCES

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LIST OF REVISIONS DURING PERMIT TERM

REV. NUMBER	REVISION DESCRIPTION	DATE APPROVED

18 WATER RESOURCES

18.1 Surface Water Resources

The Navajo Mine Permit Area (North Area and Areas 2-4 North) covers approximately 26.2 square miles (16,730 acres) of high desert terrain consisting of badlands, grasslands, and mesas. The Permit Area is sparsely vegetated with generally low cover values (Section 15 – Vegetation).

The permit and adjacent areas lie within the San Juan River Basin, a tributary to the Colorado River. The San Juan River Basin covers approximately 12,900 square miles, of which the Permit Area occupies approximately 0.2 percent of the total watershed area. Table 18-1 provides typical drainage basin and discharge characteristics of the San Juan River near Shiprock, New Mexico, as recorded by the United States Geological Survey (USGS) for the water year 1980. More specific detail on the discharge and chemical characteristics of the San Juan River is available from the USGS, Water Resources Division (WRD), Surveillance Section, in Albuquerque, New Mexico.

Several ephemeral or intermittent streams pass through the permit and adjacent areas and eventually drain into the San Juan River to the north. These streams are the Chaco River, Bitsui Wash, Chinde Wash, Hosteen Wash, Barber Wash, Neck Arroyo, Lowe Arroyo, Cottonwood Arroyo, and Pinabete Arroyo (Exhibit 18-1, Exhibit 18-2, and Exhibit 18-3).

The ephemeral channels which cross the permit and adjacent areas all carry occasional flows of water in response to precipitation events. These flows are used by sheep or other livestock which might be in the vicinity when the channels are carrying water. However, livestock normally use stock watering ponds which have been constructed to catch surface flows from some of the tributary drainages. The location of stock watering ponds on and near the Permit Area are shown on Exhibit 16-3. Stock watering is the primary use of surface water flows. Surface water is not used for drinking by humans, irrigation, or other purpose.

18.1.1 Perennial and Intermittent Streams

18.1.1.1 Chaco River

The Chaco River is an ephemeral stream which lies to the west of the Permit Area. The Chaco River has a watershed area of about 4,350 square miles, of which the Permit Area occupies approximately 0.6 percent of the total. The flow direction of the Chaco River is from south to north. Table 18-2 provides drainage basin and discharge characteristics for the Chaco River at Waterflow, New Mexico. As seen from Table 18-2, discharges range from 0.0 cubic feet per second (cfs) to 7,300 cfs. Total suspended sediment (TSS) concentrations reach as high as 140,000 milligrams per liter (mg/l).

18.1.1.2 Bitsui Wash

Bitsui Wash is located on pre-law ground near the northernmost portion of the Permit Area and flows from the Navajo Indian Irrigation Project (NIIP), east of the Permit Area, into the Permit Area, then turns north to the San Juan River. Under natural conditions, Bitsui Wash would flow ephemerally during times of high precipitation. However, due to the existence of NIIP and its associated irrigation return flows and sewage lagoon discharges, this stream flows intermittently.

As near as can be determined from USGS quadrangle maps, the pre-mining Bitsui Wash drainage was about 12 square miles in area. Because of internal drainage to Watson and Dodge pits, the present drainage area for Bitsui Wash is about 9.5 square miles. All mining disturbance within the present Bitsui Wash drainage predates the Surface Mining Control and Reclamation Act of 1977 (SMCRA). Upon final regrading of Watson and Dodge mine pits, the Bitsui area will be comparable to its pre-mining area.

18.1.1.3 Chinde Wash

Chinde Wash is located near the southern boundary of Navajo Mine North Area and flows from the NIIP, east of the Permit Area, through the Permit Area to the Chaco River, west of the Permit Area.

Exhibit 18-1 shows the watershed area and drainage configuration for the Chinde Wash watershed. As with Bitsui Wash, under natural conditions Chinde Wash would flow ephemerally or only in response to runoff from precipitation events. However, due to the existence of NIIP and its associated irrigation return flow and direct discharges, Chinde Wash flows perennially through the year with short term peak flows caused by precipitation or NIIP direct canal discharges.

Chinde Wash has a drainage area of about 54.2 square miles of which about 10 percent lies within the Permit Area. However, the present watershed area of Chinde Wash is about 42.7 square miles. An additional 12.5 square miles does not contribute to the present Chinde watershed as it is diverted by the NIIP Ojo Amarillo Canal into Cottonwood Arroyo.

18.1.1.3.1 Pre-Mine and Existing Channel Gradients, Cross-Sections and Flow Conditions

Pre-mine channel characteristics for Chinde Arroyo are based upon pre-mine topographic maps at a scale of 1" = 100' and surveyed (July, 1987) cross-sections upstream and downstream of the leased boundary. The survey results from the July, 1987 survey of Chinde cross-sections upstream and downstream of the mine lease are found in Permit NM-0003C, Chapter 30, Appendix 30-G. Cross-sections OU-1 through OU-4 refer to cross-sections upstream of the mine lease. Cross-sections OD-1 through OD-5 refer to cross-sections downstream of the mine lease. Approximate locations of the surveyed cross-sections along with the map derived cross-sections used in the pre-mining HEC2 analysis, are found in Permit NM-0003C, Chapter 30, Appendix 30-G.

The pre-mining channel is generally incised and the geometry is very irregular throughout the channel length. The channel exhibits an average gradient of 0.99 percent across the mine lease. A pre-mining longitudinal profile which was developed from topographic maps is provided in Figure 18-1. Longitudinal profiles associated with the surveyed cross-sections up and downstream from the mine lease, associated with the July, 1987 conditions are also shown in Figure 18-1. These profiles clearly show the areas of sediment deposition upstream of the Chinde diversion at the original lease boundary and the headcut migration up to the base of the Big-Fill. These changes in channel conditions up and downstream of the lease must be considered in the design of a permanent diversion.

Figure 18-1 also shows nickpoints along the channel both down and upstream of the reclaimed section. Channel slopes vary from about 0.45 percent for the aggrading segment between cross-sections OU-2 and OU-4 to over two percent in the badlands areas above cross-sections OU-1 and in the pre-mine channel upstream of the confluence with the Chaco River. Other than the aggrading segment above the original lease boundary, existing and pre-mine slopes generally exceed 0.7 percent.

The downstream nickpoints may pose long term problems to the stability of the reclaimed section. Long term stability problems can result because the stream will erode the channel convexity as it seeks to establish a uniform "equilibrium" profile. This process generally results in a progression of erosional pulses upstream until a uniform channel gradient or equilibrium state is achieved.

A HEC2 backwater flow analysis of the pre-mining channel and flood plain system was completed to characterize velocities and flow conditions in the pre-mine channel. The HEC2 backwater analysis routine provides water surface profiles for specified discharges, channel gradients and channel geometries. Pre-mining cross-sections extending one mile up and downstream of the Navajo Mine lease boundary were entered into the program. A starting water surface slope approximately the average channel gradient of 1.0 percent was assumed. The pre-mining HEC2 analysis was performed for the peak flow from a 6-hour rainfall with 10-yr., 25-yr., and 100-yr. recurrence intervals. The HEC2 backwater analysis for the pre-mining stream channel produced supercritical flow conditions in several locations and relatively high velocities along several reaches for all three peak flow events. Results of the backwater analysis are found in Permit NM-0003C, Chapter 30, Appendix 30-J.

18.1.1.3.2 Pre-Mine Channel Meander

The pre-mine Chinde Arroyo exhibits a relatively straight channel with very few meandering reaches. It has an average channel sinuosity of 1.22. Several meanders located in the pre-mining channel within the lease area were measured for linear wavelength, channel wavelength, amplitude, and meander width.

Chinde Arroyo linear wavelengths range from 130 to 490 feet; channel wavelengths range from 215 to 545 feet and amplitudes range from 60 to 207 feet.

Peak flows and sediment yields were predicted for the 6-hr. rainfall event on 2-, 10-, 25-, and 100-yr. frequencies. Design storm precipitation values are provided on Table 18-3 for various design return periods. Area l reductions are provided for each of the drainage basins analyzed. Using the precipitation values of the Chinde drainage basin area, predictions were performed for pre-mining conditions on Chinde Wash, see Appendix 18.A. Post-mining predictions are reported in Appendix 18.S.

Results of the SEDCAD+ runs for pre-mining conditions show peak concentrations of suspended solids exceeding 50,000 mg/l for rainfall events of a 2-yr. frequency or larger. Sediment yields increase from 2,252 tons for a 2-yr., 6-hr rainfall to 22,398 tons for a 100-yr., 24-hr rainfall.

SEDCAD+ modeling results were compared with field observation in order to determine the accuracy of the modeling. Since only a few rainfall events produce sufficient runoff to deliver samples to the single stage sediment samplers, few samples are available for comparison. Furthermore, extremely large runoff events usually destroy the single stage sediment samplers. Also, a sampler does not produce a representative depth-integrated sample. Nevertheless, the sample results do provide order-of-magnitude comparisons.

From a review of quarterly hydrologic monitoring reports submitted to the Office of Surface Mining (OSM), analytical results from samples collected on July 29, 1986 are compared with SEDCAD+ modeling results. These samples were obtained from the runoff response to 3.53 inches of precipitation over the period July 19 through July 24. The samples were not collected until July 29 because the single-stage sediment samples were buried in debris from a flood event. Estimated peak flows at monitoring stations CD-1 and CD-2, located on Chinde Wash above and below the mine, were 277 cfs and 183 cfs, respectively. These peak flows would compare with the peak runoff from an event comparable to that resulting from a 10-yr., 6-hr design precipitation for the location CD-1 above the mine and an event between the 2-yr., 6-hr and the 10-yr., 6-hr event for the location CD-2 below the mine. It is likely that the Big-Fill Culvert associated with the rail crossing, attenuates flows, producing the lower peak flow below the mine.

Measured TSS and settleable solids (SS) concentrations in the sediment samplers suggest that the model underestimates settleable solids levels but overestimates the total suspended sediment concentrations by more than one order-of-magnitude. It is possible that natural flocculation of clays within the single stage sediment sampler could elevate the measured settleable solids levels above what would be measured during the event. On the other hand, the sample collected by the single stage sediment sampler may not have been

representative of the peak flow but of a lower flow condition. In this case the measured TSS and SS concentrations should be less that the predicted peak concentrations obtained from SEDCAD+.

Other samples from storm runoff events show total suspended sediment concentrations of the magnitude predicted by SEDCAD+. For example, analytical results of samples collected on Chinde Wash in July, 1976, September, 1980, and July, 1984 showed total suspended sediment concentrations of 277,000 mg/l, 183,000 mg/l and 397,420 mg/l, respectively. Flow measurements were not obtained for these samples so it is difficult to compare with SEDCAD+ modeling results.

It is unlikely that monitoring of sediment concentrations on the major arroyos flowing through the Permit Area will be sufficient to calibrate or validate the SEDCAD+ modeling results. The sediment dynamics are too complex and variable to allow for representative sampling and accurate modeling. Recognizing the pitfalls of interpreting sediment concentration data from the major arroyos, the Navajo Mine has embarked on extensive plot studies of sediment yield to compare pre- and post-mining conditions and to demonstrate best technology currently available (Section 41.4.3). Despite the inaccuracy and limitations of modeling sediment yields and concentrations using SEDCAD+ or any other event based model, the modeling results are useful for relative comparison of pre- and post-mining conditions (Section 41.4.3).

18.1.1.4 Hosteen Wash

Hosteen Wash is an ephemeral stream located in the northern portion of Area 2. The drainage area extends from the NIIP (east of the Permit Area) through the Permit Area to the Chaco River to the west. Exhibit 18-3 shows the watershed area and drainage configuration for the Hosteen Wash watershed. The Hosteen Wash watershed area is about 9.1 square miles. Approximately 3.7 square miles of this drainage is disturbed by mining activity.

Peak flows and sediment yields were predicted for the 6-hr. rainfall event on 2-, 10-, 25-, and 100-yr. frequencies. Predictions were performed for pre-mining conditions for Hosteen Wash. Post-mining predictions are reported in Section 41.4.3.2.

The peak flows and sediment yields were predicted through the use of the SEDCAD+ computer program (Schwab and Warner, 1987) following the methodology and assumptions described in Section 18.1.2.1. Watershed subdivisions used for Hosteen Wash are provided on the SEDCAD+ Watershed Map (Exhibit 18-3). Input parameters and output results for each subwatershed are provided in Appendix 18.B. All input parameters are included in the output results. Sediment yields in Hosteen Wash were predicted to increase from 2,805 tons for the 2-yr., 6-hr precipitation event to 19,646 tons for the 100-yr., 6-hr precipitation event.

18.1.1.5 Barber Wash

Barber Wash is an ephemeral stream, which flows only in response to runoff from precipitation events. The drainage area extends from just east of the permit boundary through the Permit Area towards the Chaco River to the west. Exhibit 18-3 shows the watershed area and drainage configuration for the Barber Wash watershed. The Barber Wash watershed area is about 5.3 square miles. Approximately 1.4 square miles of this drainage is disturbed by mining activities.

Peak flows and sediment yields were predicted for the 6-hr. rainfall event on 2-, 10-, 25-, and 100-yr. frequencies. Predictions were performed for pre-mining conditions for Barber Wash. Post-mining predictions are reported in Section 41.4.3.5.

The peak flows and sediment yields were predicted through the use of the SEDCAD+ computer program (Schwab and Warner, 1987) following the methodology and assumptions described in Section 18.1.2.1. Watershed subdivisions used for Barber Wash are provided on the SEDCAD+ Watershed map (Exhibit 18-3). Input parameters and output results for each subwatershed are provided in Appendix 18.C.

Sediment yields in Barber Wash were five and six times lower than those predicted for Hosteen. The lower sediment yields occur on Barber Wash because of lower curve numbers and runoff and lower slopes (less badlands area) as well as a slightly smaller drainage area. Sediment yields are predicted to increase from 447 tons for the 2-yr., 6-hr precipitation event to 4,240 tons for the 100-yr., 6-hr precipitation event. Peak suspended solids concentrations exceeded 23,000 mg/l for all events.

18.1.1.6 Neck Arroyo

Neck Arroyo is an ephemeral stream that flows only in response to runoff from precipitation events and is located south of the Area 3 shop complex just north of the Area 3 mining area (Lowe Pit). The drainage area extends from east of the permit boundary through the Permit Area towards the Chaco River to the west. Exhibit 18-2 shows the watershed area and the drainage configuration for this watershed. The Neck Arroyo watershed area is about 1.88 square miles. Approximately 14 percent of this drainage lies within the Permit Area.

Peak flows and sediment yields were predicted for the 6-hr. rainfall event on 2-, 10-, 25-, and 100-yr. frequencies. Predictions were performed for pre-mining conditions for Neck Arroyo. Postmining predictions are reported in Section 41.4.3.5, even though the relative area affected by life of mine operations is very small.

The peak flows and sediment yields were predicted through the use of the SEDCAD+ computer program (Schwab and Warner, 1987) following the methodology and assumptions described in Section 18.1.2.1.

Watershed subdivisions used for Neck Arroyo are provided on the SEDCAD+ Watershed Map (Exhibit 18-2) Input parameters and output results for each subwatershed are provided in Appendix 18.D.

Sediment yields predicted on Neck Arroyo were about twice the magnitude predicted for Barber Wash even though the Neck drainage area is less than 40 percent than that of Barber Wash drainage area. The higher sediment yields predicted for Neck Arroyo are due to higher curve numbers and runoff and higher slopes (more badlands area). Sediment yields are predicted to increase from 3,748 tons for the 2-yr., 6-hr precipitation event to 34,786 tons for the 100-yr., 6-hr precipitation event. Peak suspended solids concentrations were slightly higher than predicted for other drainages and exceeded 100,000 mg/l for all predicted events.

18.1.1.7 South Barber Drainage

The South Barber Drainage is an ephemeral stream that is a tributary to the Neck Arroyo. Exhibit 18-3 shows the watershed area and drainage configuration for the South Barber Drainage. The South Barber Drainage is about 0.82 square miles. Approximately 0.03 square miles (17 acres) of this drainage is disturbed by mining activities.

The Sedcad+ computer program was used to simulate the 2, 10, 25 and the 100 year-6 hour storm events following the methodology and assumptions outlined in Section 7.2. The watershed subdivisions used to model the South Barber Drainage is presented on Exhibit 18-3. The input parameters and output results for each subwatershed are provided in Appendix 18.E. The post-mining surface hydrology is presented in Section 41.4.3.4.

Results of the SEDCAD+ runs for pre-mining conditions show peak concentrations of suspended solids exceeding 34,000 mg/l for rainfall events of a 2-yr. frequency or larger. Sediment yields increase from 170 tons for a 2-yr., 6-hr rainfall to 1,449 tons for a 100-yr., 24-hr rainfall.

18.1.1.8 Lowe Arroyo

Lowe Arroyo lies in the middle of Area 3 and flows from NIIP, east of the Permit Area, through the Permit Area to Chaco River to the west. Lowe Arroyo is an ephemeral stream with flows occurring only in direct response to runoff from precipitation events. Exhibit 18-2 shows the watershed area and drainage configuration for Lowe Arroyo. Lowe Arroyo has a drainage area of about 11.25 square miles of which approximately 41 percent lies within the Permit Area.

Peak flows and sediment yields were predicted for the 6-hr. rainfall event on 2-, 10-, 25-, and 100-yr. frequencies. Predictions were performed for pre-mining conditions for Lowe Arroyo. Postmining predictions are reported in Section 41.4.3.5.

The peak flows and sediment yields were predicted through the use of the SEDCAD+ computer program following the methodology and assumptions described in Section 18.1.2.1. Watershed subdivisions used for Lowe Arroyo are provided on the SEDCAD+ Watershed Map (Exhibit 18-2). Input parameters and output results for each subwatershed are provided in Appendix 18.F.

The sediment yields on Lowe Arroyo were only slightly larger than that of Barber Wash although the Lowe Arroyo drainage area is about twice the size of the Barber Wash drainage area. Sediment yields are predicted to increase from 2,129 tons for the 2-yr., 6-hr precipitation event to 25,383 tons for the 100-yr., 6-hr precipitation event. Peak suspended solids concentrations were slightly lower than predicted for Barber Wash although it exceeded 100,000 mg/l for all events.

18.1.1.9 Cottonwood Arroyo

Cottonwood Arroyo is a major sand bed ephemeral drainage that passes through the southern portion of the Permit Area. Exhibit 18-2 show the watershed area and drainage configuration for Cottonwood Arroyo. The arroyo has a drainage area of about 79.83 square miles of which approximately six percent lies within the Permit Area. This drainage area includes approximately 12.4 square miles of the Chinde Wash drainage that is diverted by the NIIP Ojo Amarillo canal into the Cottonwood drainage. About 49 percent of this watershed is occupied by badlands that accounts for the high discharge, flow intensities and sediment load observed in this drainage.

Cottonwood Arroyo is characterized by a rapid increase in discharge from a dry channel to peak discharge, followed by a recession to a low discharge over several hours. These rapidly varying flows can transport large of amounts of sediment and cause extensive change in the shape of the channel, particularly noted at surface water station CNS-1. Total sediment and dissolved solids concentrations are similar to regional values and average 97,989 mg/l and 656 mg/l, respectively.

18.1.2 Surface Water Quality

Historically, seven surface water monitoring stations were established on ephemeral drainages that pass through the Navajo Mine. All of the monitoring stations except station CS-1 have been impacted by return flow irrigation activities derived from the Navajo Agricultural Products Industries (NAPI) project located to the east of the mine. CS-1 has been influenced by direct releases from unused waters in the NAPI canals. Average surface water quality data collected at the seven stations between 1986 and 2010 is summarized in Table 18-4. A geochemical analysis of historic surface water monitoring data is presented in Appendix 18.G.

The Navajo Nation Environmental Protection Agency (NNEPA) has designated uses; Fish Consumption (FC), Secondary Human Contact (ScHC), Aquatic and Wildlife Habitat (A&WHbt), and Livestock Watering (LW), for all Waters of the Navajo Nation (NNEPA WQP, 2008), which includes the drainages within the Navajo mine Permit Area. There are no other higher levels of designated use for surface water resources within the Navajo Mine Permit Area. During mining and reclamation activities, NTEC will conduct surface water monitoring (Section 42.1) and will demonstrate compliance with applicable surface water quality standards prior to bond release.

18.1.2.1 Methodologies and Assumptions

The peak flows and sediment yields were predicted through the use of the Sediment, Erosion, Discharge by Computer Aided Design (SEDCAD+) computer program by Schwab and Warner (1987). Hydrograph development and peak flow determination are based on user inputs of a design storm, i.e. rainfall amount and duration, selection of a rainfall distribution, and convolution increment. Hydrographs are developed on a subwatershed basis with the input of area, time of concentration, Soil Conservation Service (SCS) curve number, and selection of one of three dimensionless double triangle unit hydrograph shapes. Routing of hydrographs is accomplished by Muskingum's method (Schwab and Warner, 1987).

The sediment yield is also determined on a subwatershed basis. The program offers three options for generating sediment graphs, Modified Universal Soil Loss Equation (MUSLE), Soil Loss Routine (SLOSS) and Revised Universal Soil Loss Equation (RUSLE). The MUSLE option was used exclusively for sediment yield predictions at the Navajo Mine. This method uses USLE inputs for a representative slope in a given subwatershed and combines this with peak flow and runoff volume.

The drainage network and the mine plan were the major considerations involved in subdivision of the watersheds. Designated subwatersheds must drain to a particular channel reach or structure. Locations of all anticipated structures had to be incorporated in the subdivision of channel reaches and subwatersheds. Where possible, the subdivision of the drainage basin into relatively homogeneous subwatersheds helped facilitate determination of model parameters required by SEDCAD+.

Natural Resources Conservation Services (NRCS) Type II rainfall distribution was applied to all 6-hour storms. A medium hydrologic response class was applied to all subwatersheds. The hydrologic response class determines the shape of the unit hydrograph. The medium class is typical of agricultural and disturbed area conditions and was determined to be representative of both pre-mining and operational conditions.

Input parameters required to determine sediment yields using the SEDCAD+ program include the soil erodibility parameter (K), the representative slope and slope length, and the applicable control practice parameter (CP).

18.1.2.1.1 Curve Numbers

Refer to Section 26.3.5 for discussion on curve numbers for undisturbed and reclaimed lands.

The analysis was performed using AMC II based curve numbers. Channel loss reductions were not used for Chinde Wash due to the existence of NIIP and its associated irrigation return flows. Precipitation area reductions for other watersheds are based on "NOAA Atlas II", Volume 4, New Mexico (USDC, 1973).

18.1.2.1.2 Time of Concentration

For each watershed the drainage length from the highest to lowest elevation within the watershed were measured. The length and elevation differences with the appropriate type of flow path were input into the computer model for time of concentration computation.

18.1.2.1.3 Particle Size Distributions

A study performed at the Navajo Mine site by Simons, Li & Associates, Inc., (1981) was used to estimate particle size distributions. Four particle size distributions were used, two for pre-mining soils and two for postmining soils. Simons and Li analyzed two soil types. The first type was a badlands soil with predominantly clay-sized particles. The second type was a predominantly sandy soil. Since these were the only particle size data available for the mine site, all the soils were categorized into predominantly sandy or clayey and the appropriate particle size distribution was used in the SEDCAD+ model runs for each subwatershed.

18.1.2.1.4 Slope Length and Average Slope

Slope length is defined as: "representative of the typical slope length found on the subwatershed and the distance from the point of origin of overland flow until the point that the slope decreases such that significant deposition occurs or until the flow enters a defined channel" (Schwab and Warner, 1987). Average slope is the typical or representative slope for overland flow for each subwatershed. These definitions, although subjective, served as a basis for determining slope length and average slope in this study. In an effort to make the slope length and average slope determination more objective, the topography and the depicted watersheds were imported into Arc View to determine the average slope of each watershed. Then the slope length was selected from Table 18-15.

18.1.2.1.5 Soil Erodibility Factor (k)

The K-factors for the pre-mine watersheds were obtained from "Baseline Surface Water Hydrology and Erodibility – Navajo Mine", a report prepared by Metric Corporation; Albuquerque, New Mexico; 1989. The report gives K-factors for the NRCS soil mapping units. A weighted K-factor was computed for watersheds comprised of more than one soil mapping unit.

The K-factor for the post-mining watersheds is an estimated weighted value. A weighted K-factor was computed for each mining area (Area I, II, III, and IV) based on the volume of each soil type that is projected to be salvaged for topdressing. Refer to Table 18-5, Table 18-6, Table 18-7, and Table 18-8 for the weighted K-factors for each mining area.

18.1.2.1.6 Cover and Management Practice Factor (CP)

The P-factor or management practice factor is the measure of the effectiveness of any erosion control practices. For no practices the value is 1.0. The P-factor for both pre and post-mining was assigned a value of 1.0.

The C-factor is the measure of the vegetation, litter, and rock cover in the watershed area. The C-factors for the pre-mine watersheds were obtained from "Baseline Surface Water Hydrology and Erodibility – Navajo Mine", a report prepared by Metric Corporation; Albuquerque, New Mexico; 1989. The report gives C-factors for the NRCS soil mapping units. A weighted C-factor was computed for watersheds comprised of more than one soil mapping unit.

The C-factor for the post-mine watersheds are based on the vegetative cover surveys done on the reclaimed lands. The average cover on reclaimed lands is approximately 10.4%, interpolated from Table 6 in Technical Note 28 (USDA-NRCS, 1984) this corresponds to a C-factor of 0.315.

18.1.2.2 Surface Water Monitoring

Since 1990, Navajo Mine has been monitoring surface water flows and quality in Cottonwood Arroyo at three stations, CS-1 (south fork), CN-1 (north fork), and CNS-1 (main channel). Data collected during the ten years of monitoring has been submitted to OSM as part of the quarterly hydrologic reports and annual hydrologic reports. From 1990 through 1996, monitoring consisted of single stage sediment samplers in conjunction with crest gauges. From 1997 through 1999, monitoring consisted of automated samplers and ultrasonic water level sensors. This type of monitoring allows water quality samples to be related to flow measurements.

Monitoring has been discontinued in Cottonwood Arroyo and the following description details where the stations were located and type of equipment used to collect monitoring information. Station CN-1 was

located in an alluvial reach, which is relatively stable and confined. Stations CS-1 and CNS-1 were located in wide and unstable sand-bed washes.

Upper Cottonwood Arroyo, North Fork (CN-1):
Sample type: Automatic (ISCO Model 3700 sampler).
Sample frequency: 6 minutes (0.10 hour).
Sampling method/location: Fixed-position sampler intake 8 inches above thalweg in relatively stable channel section.
Sampling trigger stage: 12 inches, triggered by ultrasonic sensor.

Upper Cottonwood Arroyo, South Fork (CS-1):
Sample type: Automatic (ISCO Model 3700 sampler).
Sample frequency: 6 minutes (0.10 hour).
Sampling method/location: Variable-position sampler intake 8 or more inches above thalweg in unstable channel section.
Sampling trigger stage: 12 inches, triggered by ultrasonic sensor.

Lower Cottonwood Arroyo (CNS-1):
Sample type: Automatic (ISCO Model 3700 sampler).
Sample frequency: 6 minutes (0.10 hour)
Sampling method/location: Variable-position sampler intake 8 or more inches above thalweg in unstable channel section.
Sampling trigger stage: 12 inches, triggered by ultrasonic sensor.

Rating curves for the three Cottonwood Arroyo stations were developed from cross-sectional surveys and stage recorders using the slope-area method. The slope-area method is described in US Geological Survey Water-Supply Paper 2175 (1982). Discharges for incremental depths at the Cottonwood Arroyo stations were calculated by an in-house computer program for each surface water-monitoring site using the Mannings equation. The Mannings equation was developed for conditions of uniform flow where the cross-sectional area, hydraulic radius and depth remain constant throughout a reach. The Mannings equation is:

$$Q = A\frac{1.49}{n}\left(\frac{A}{WP}\right)^{2/3} S^{1/2}$$

Where: Q = Discharge rate (ft^3/s)

A = Cross-sectional area (ft^2)

n = Mannings coefficient of channel roughness

WP	=	Wetted perimeter (ft)
S	=	Slope (ft/ft)

The cross-sectional area (A) and wetted perimeter (WP) are functions of the depth of flow and the cross-section of the reach. The n value for each station is estimated using USGS Water Supply Paper No. 1849, "Roughness Characteristics of Natural Channels". The cross-section (A) and slope (S) of each reach are determined by field surveys and stage measurements.

The characterization of Cottonwood Arroyo presented below is based on data collected by the automated system over a three year period, 1997-1999. The characterization includes a comparison of channel cross-sections (See Exhibit 18-4) taken before and after large flow events that occurred during 1999.

18.1.2.3 Cottonwood Arroyo Water Quality

Samples collected by the automated sampler were analyzed for chemistry and total sediment. For each sample/flow event, only the first sample bottle collected is analyzed for chemistry from each station with the remaining samples analyzed for total sediment. A total of 314 water samples were collected between 1997-1999 from stations CN-1, CS-1, and CNS-1, with 255 of these samples analyzed for total sediment and 59 samples analyzed for chemistry.

Table 18-9 lists average values for total sediment concentration, texture and particle size distribution by station. Appendix 18.H contains the analytical data for each sample analyzed for total sediment concentration and sieve analysis by monitoring station. Total sediment concentration is the total amount of sediment being transported by flowing water and is supported by hydraulic forces rather than by the streambed.

Total sediment concentrations in Cottonwood Arroyo average 97,989 mg/l for all three stations with a range of 29,500 mg/l to 268,000, which are typical values of an arid ephemeral channel. Elevated concentrations of sediment determined from laboratory analyses in Cottonwood Arroyo water samples confirms visual observations made in the field, such as the color, turbidity, and sand waves.

Texturally, the sediment from the automated water samplers are clay, clay loam or a sandy loam, and are commonly dominated by the clay fraction with nearly one-third of the sample represented by sand (see Table 18-9). This texture reflects the source materials in the watershed, which has a high percentage of badlands with some dune areas in the upper portion of the watershed. Fine sand and very fine sand comprise a majority of the particle size distribution, which is similar to the particle size distribution of dune areas (regolith) within the upland portions of the Cottonwood Arroyo watershed.

Appendix 18.I contains graphs of total sediment verses flow, texture, and particle size distribution of water samples collected from Cottonwood Arroyo. The total sediment verses flow graphs show that only a weak correlation is possible between total sediment and discharge. In general, sediment concentrations vary independently of discharge. The texture and particle size distribution demonstrate the dominance of fine-grained materials within the water column, reflecting source areas and sampling method.

Total sediment data from station CN-1 is likely affected by extensive discharges from NIIP. Large erosion features in the upper portion of the watershed are evidence of these periodic flows. Large channels have developed within sandy materials up to 100 feet across with cutbanks up to 30 feet high.

Appendix 18.J contains statistical reports and a piper trilinear plot of the chemistry data collected from each station. The average total dissolved solids concentration (TDS) for CN-1 is 976 mg/l with a range of 420-2,780 mg/l. The average TDS concentration for CS-1 is 652 mg/l with a range of 340-910 and for CNS-1 the average TDS concentration is 639 mg/l with a range of 360-1,150 mg/l. These values indicate a slight decrease in TDS concentration from upstream to downstream. More importantly, these values are typical of regional TDS concentrations for surface water quality.

The piper trilinear plot indicates that for all three stations the dominant water type is a sodium sulfate. Station CN-1 has a slightly higher concentration of sulfate and TDS, which may reflect slightly different soil types in the watershed and possible Navajo Indian Irrigation Project (NIIP) impacts. Appendix 18.J also contains plots of time verses total suspended solids (TSS) and TDS for all three stations. The TDS and TSS graphs show that concentrations between stations are similar for individual storm events.

18.1.2.4 Cottonwood Arroyo Water and Sediment Quantity

Table 18-10 lists water and sediment yields for each station for several separate flow events during 1998 and 1999. Most of the flow events occurred during summer months as a result of high intensity, short duration thunderstorms. The exception is the storm event of April 22, 1999, which was due to a low-pressure system that produced low intensity precipitation.

Caution must be exercised when making upstream to downstream comparisons due to storm and watershed variability, however, it is still productive to compare and examine the data between stations. The hydrographs for several flow events (August 21, 1998, April 22, 1999, August 2, 1999, and August 3, 1999) for all three stations listed on Table 18-10 are located in Appendix 18.K. Water samples from each station were not collected for all of the flow events due to either equipment problems (plugged sample tubes) or flow stages below the minimum (1 foot) necessary to trigger the automated sampling device.

The flow and sediment data indicate that for most flow events, runoff volumes (acre/feet) decrease from upstream to downstream while sediment volumes (tons) increase. For example, the flow event on August 21, 1998 resulted in a net decrease of 121 acre/feet in the total runoff volume between stations CNS-1 and upstream stations CS-1 and CN-1. However, the two storm events in early August 1999 were in exception to this, in which runoff volumes increased from upstream to downstream .

The dominant condition of the loss of water from upstream to downstream may be the result of water infiltrating into the sand bed of the progressively widening channel downstream. The channel of the south fork and particularly the north fork, are incised and generally bedrock controlled. In contrast, the geomorphology of the main channel is broad, with a high width to depth ratio. In addition, the coarse alluvial materials that underlie the main channel are at least 22 feet thick, as evidenced by alluvial wells, such as Cottonwood alluvial well QACW- 1, which has a total depth of 22 feet into unconsolidated alluvial materials.

The two flow events in early August 1999 that show a slight net increase in the total runoff volume from upstream to downstream were preceded by several flow events in late July 1999. These frequent flow and precipitation events would produce high antecedent moisture within the channel bottom, which in turn may limit channel bed infiltration. MET II recorded 2.6 inches of precipitation in August 1999, (the average precipitation for August is 1.1 inches) which is 230% above normal. In contrast, 1998 was a drought year, with only 0.5 inches of precipitation recorded at MET II during the first seven months of the year. As a result of this lack of precipitation, no recorded flow events occurred between January 5, 1998 and August 21, 1998 in Cottonwood Arroyo.

The net sediment yield increased from upstream to downstream for three flow events. This is the result of increasing flow volume and/or total sediment concentration. Field observations of mechanisms for increasing the total sediment concentration include bank failure, redistribution of stored sediment due to higher peak flows downstream, and a progressively changing channel morphology (less bedrock control) downstream. Sediment sources between the upstream and downstream stations include main channel bed and banks, tributary channel bed and banks, and upland erosion.

The hydrograph shape for most of the events, particularly in the summer, is characterized by a very sharp rise or spike in the rising limb with a very short duration peak, followed by a gradual falling limb of the hydrograph. This hydrograph shape is characteristic of flashy flows in ephemeral channels due to high intensity thunderstorms. The shape of the hydrograph and the duration and timing for an individual flow event is similar between stations.

The storm of August 3, 1999 highlights the spatial variability of flows due to thunderstorm precipitation. Station CN-1 recorded a total volume of flow of 21 acre/feet (a/f) compared to 215 a/f at CS-1 and 254 a/f at CNS-1. The majority of precipitation from this storm fell on the watershed of the south fork of Cottonwood Arroyo, producing greater volumes of runoff and larger peak discharges. Due to erosional changes in the cross-sectional area from previous storms at station CNS-1 (see section 7.2.8.4), measured flow values may underestimate actual peak flow and runoff volume for the August 3, 1999 flow event.

18.1.2.5 Comparison of Channel Cross-Sections

Exhibit 18-4 shows channel cross sections from monitoring stations in Cottonwood Arroyo before and after the large flow events that occurred in July and August 1999. The cross-sections, taken in early June 1999 and again in January 2000, show the extreme amount of channel transformation due to large flow events, particularly at station CNS-1. At station CNS-1, the north bank (cut-bank) of the channel moved approximately 80 feet horizontally (See Exhibit 18-4, CNS-1 cross-sections 2 and 2A) over a six-month time frame. In addition to the loss of sediment on the cut-bank, some sediment is temporarily stored as evidenced by the formation of sand bars on the opposite bank and the sediment deposition on the flood plain for these out of bank flows.

The amount of horizontal and vertical change depicted in the cross-sections reinforces the dynamics of sediment movement within this ephemeral sand bed channel that is subjected to short duration high intensity flows.

18.1.2.6 Sediment and Hydrologic Predictions Compared with Surface Water Data

Predictions for the 6-hr. rainfall event on 2-, 10-, 25, and 100-yr. frequencies for pre-mining peak flows and sediment yields are listed on Table 18-11 (see Appendix 18.L for detailed results). Postmining predictions are reported in Section 41.4.32.

Sediment yields in Cottonwood Arroyo were higher than from the other drainages. The higher sediment yields predicted for Cottonwood Arroyo are due to the larger drainage area, nearly twice the size of Chinde Wash, the next largest drainage. Sediment yields in Cottonwood Arroyo were predicted to increase from 10,054 tons for the 2-yr., 6-hr precipitation event to 70,850 tons for the 100-yr., 6-hr precipitation event (see Table 18-11).

Peak suspended solids concentrations in Cottonwood Arroyo were similar to those predicted for Lowe Arroyo and lower than predicted for other drainages. Peak suspended sediment concentrations in Cottonwood Arroyo exceed 30,000 mg/l for all events.

Comparison of predicted sediment concentrations with measured sediment samples from storm runoff events on Cottonwood Arroyo shows total suspended sediment concentrations of the magnitude predicted by SEDCAD 4.0 for events of a magnitude similar to that predicted for a 10-yr., 6-hr storm or less. Table 18-11 lists the SEDCAD predictions for different design events. The results suggest that the SEDCAD 4.0 predictions for peak sediment concentration in Cottonwood Arroyo are reasonable compared to observed conditions.

The storm events of August 21, 1998 and August 3, 1999 may have been equivalent to a 25 year, 6 hour event or larger in portions of the watershed. Although the SEDCAD predictions for peak discharge, runoff volume and sediment yields are greater, the results compare reasonably to actual data for large flow events.

18.1.2.7 Pinabete Arroyo

Pinabete Arroyo flows east to west along through the NTEC lease area south of the existing Permit Area to the Chaco River. Pinabete Arroyo is a large ephemeral stream that flows only in direct response to precipitation events. The Pinabete Arroyo has a drainage basin of approximately 59.1 square miles of which approximately 2.9 percent lies within the Permit Area.

For the pre- mine, the hydrology modeling was done only on the subwatersheds or the tributaries to the Pinabete Arroyo that are projected to be disturbed by mining and reclamation support activities, not on the entire drainage basin. This should be appropriate since the stream channel will not be disturbed and only a small portion of the drainage basin (approximately 0.002 percent) will be disturbed by mining and reclamation support activities.

The peak flows and sediment yields were predicted using the SEDCAD+ computer program following the methodology and assumptions outlined in Section 18.1.2.1. The computer model was used to simulate the 2, 10, 25 and 100 year-6 hour storm events, the results are presented in Appendix 18.M. The watershed subdivisions used to model the hydrology are presented on Exhibit 18-2. The post-mining predictions and hydrologic impacts are reported in Section 42 – Probable Hydrologic Consequences.

The pre-mine sediment yields from the tributaries are predicted to increase from 3 tons for the 2 yr-6 hr precipitation event to 669 tons for the 100 yr- 6 hr precipitation event. Peak suspended solids concentrations are predicted to exceed 6,000 mg/l for all storm events.

18.2 Ground Water Resources

The Navajo Mine is located on the western flank of the San Juan Structural Basin in northwestern San Juan County approximately 15 miles west of Farmington, New Mexico. The geologic formation dips gently to the east toward the center of the basin at an angle of one to two degrees and steepens toward the outcrop

areas where a fairly abrupt monocline (Hogback) can be observed. A more thorough description of the regional and localized geology of Navajo Mine is provided in Section 17 – Geologic Information.

The Pictured Cliffs Sandstone was found to be water bearing throughout most of the Permit Area. Selected lenticular coal-bearing strata of the Fruitland Formation were also found to be marginally wet within the Permit Area; these strata include: 1) the No. 8 seam, 2) the No. 7 seam, 3) the No. 4-6 seam, and 4) the No. 2-3 seam. Groundwater was only observed in the quaternary alluvial deposits within the stream channels of Chinde and Cottonwood Arroyos.

18.2.1 Springs, Seeps, and Other Ground Water Discharges

As shown on Exhibit 18-5, springs and seeps occur along upper Chinde Wash, above the lease boundary. The springs and seeps are due to NAPI irrigation return flows. Because there are several springs along this reach of Chinde Wash, individual springs have not been identified. Instead, a broad reach of stream where the springs occur has been delineated on Exhibit 18-5.

The source of water for the transient springs and seeps appear to be extensive irrigation activities upgradient of Chinde Wash. It is unknown to what extent these springs will continue to flow in the future, as Navajo Mine has no effect on or control of the water source of the springs. The saturation of the regolith (eolian sand) and spring occurrence represents a distinct change from baseline conditions. No springs in the regolith would have been present prior to NAPI activities, and Chinde Wash would not have been a perennial stream.

The springs are the result of excess, unused irrigation water migrating downward through a spatially extensive and permeable eolian sand that underlies much of the irrigated fields. When this water encounters the less permeable siltstones and shales of the underlying Fruitland Formations, it migrates laterally along a stratigraphic contact of unconsolidated eolian sand and bedrock. As Chinde Wash progressively downcuts through the eolian sand and into the underlying bedrock, the water migrating along this stratigraphic contact discharges into the wash. The springs are limited to the area of this contact along the banks of the wash. Areas further away from the contact and downstream within the badland areas of the Chinde Wash no longer receives spring discharges.

The quantity and quality of the spring discharges into Chinde Wash has not been characterized. However, Navajo Mine does collect a monthly grab sample from Chinde Wash surface water in the area of the springs (station CD-1A). The surface water at station CD-1A is a sodium sulfate water type. TDS ranges from 170 to 2240 mg/l. No seasonal correlation in the data is discernable. More detailed information on station CD-1A is available in the quarterly and annual reports.

18.2.2 Wells

The mine and adjacent areas are underlain by the Pictured Cliffs Sandstone Formation, Fruitland-Kirtland Formation, and unconsolidated alluvial deposits in the valleys of the San Juan River, Chaco River, and the Chinde and Cottonwood Arroyos. A number of ground water monitoring wells have been completed (Exhibit 18-5, Appendix 18.N, Exhibit 6.G-1, and Exhibit 41-1) in the geologic formations on and near the Permit Area. The NTEC coal lease monitoring wells for Resources Areas 3, 4, and 5 are shown on Exhibit 6.G-1 and are described in Appendix 18.N. Additional baseline data were also obtained from monitoring wells and vibrating wire piezometers (VWPs) installed in the Fruitland coals and in the underlying Pictured Cliffs Sandstone Formation for baseline hydrogeology characterization of Area 4 and Area 5 of the NTEC coal lease. The data from these wells and VWPs are provided in Appendix 6.G along with a characterization of the groundwater aquifers within the Area 4 North resource area of the NTEC lease area. This Appendix also provides the baseline data that are used to support the development and calibration of multilayer, numerical, groundwater flow model of the hydrogeologic system of Areas 4 and 5 of the NTEC lease.

18.2.3 Aquifers and Other Ground Water Resources

No impacts on existing water supplies are anticipated because project interaction with ground and surface waters is limited. The amount of groundwater which will flow into the pits from the Fruitland Formation will be small. During mining operations, water will not flow from the active mining area into the Fruitland or Pictured Cliffs formations. For a more extensive discussion of operational groundwater flow quantities and characteristics, see Section 41 – Probable Hydrologic Consequences.

Surface water runoff will be diverted away from active mining operations or retained within the disturbed area. A water monitoring network (Section 42.2) and various water control measures (Section 41.3) will be implemented throughout the life of the mine to ensure that impacts to surface waters are minimized.

18.2.3.1 Alternate Water Supply

While the chance of impacts to water resources outside the mine area will be minimal, an alternate water supply source is available for development by NTEC should it become necessary. NTEC has water rights on the San Juan River, which can be used to offset any adverse impacts to the State of New Mexico and present users. These rights will be maintained throughout the mining operation and a period thereafter, for retirement, if required, to any affected San Juan Basin water users.

Should it become necessary, NTEC will develop water supplies of suitable quantity, quality and location, and provide an adequate distribution system to ensure that water supplies will be maintained at an equal or better condition.

Impacts on the hydrologic balance as a result of surface mining operations are discussed in more detail in Section 41 – Probable Hydrologic Consequences.

Table 18-12 lists wells adjacent to the Navajo Mine, which are not owned by NTEC. Limited information is available about these wells, particularly water quality data. However, some water quality data is available for well QACW–2B. The data indicate that the water in well QACW-2B is a sodium sulfate water type and that no seasonal quality fluctuations are discernible.

The likelihood of impacts to these wells from mining is minimal, due to their distance from active mining.

18.2.4 Ground Water Resources Information Collection and Analysis

To obtain hydrologic information, a piezometer installation program was conducted throughout the mine area to estimate the water-bearing potential of the above geologic formations. Information on the water-bearing zones within these formations was obtained during drilling by monitoring fluid return, air injection pressure, and lithology.

Aquifers were delineated using two different methods. The first approach treated the individual coal seams in the Fruitland Formation as separate aquifers. This resulted in the potentiometric surface maps for the major coal seams (Exhibit 18-6, Exhibit 18-7, Exhibit 18-8, and Exhibit 18-9). Since the coal seams are discontinuous through the formation, an alternate approach for delineation was considered which utilized United States Geological Survey (USGS) data and treated the coal seams and interbedded lithologic units of the Fruitland Formation as a single aquifer. The single aquifer approach was previously evaluated (Billings, 1987) A copy of the Billings (1987) report is located in Appendix 18.O. Information from the ground water studies was used to prepare the potentiometric maps found in Appendix 18.O, that were obtained from Appendix 18.P (Special Condition 4A). Even though there is very little water present and transmissivities are low, the individual seams will be treated as separate aquifers in the quantity and quality descriptions in this chapter.

18.2.5 Groundwater Quantity

In order to obtain representative baseline data, piezometers were completed using a rotary drilling rig. Piezometers were completed using air rotary drilling techniques and no drilling mud or additives were used which might have contaminated the well bore. Borings were completed by screening the single appropriate water-bearing zone. A gravel pack, gel seal, and 15-pound cement mixture were used to complete the well to reduce the possibility of cross contamination between water-bearing zones or bore hole leakage. Figure 18-2 provides a schematic of a typical piezometer completion.

Copies of the well completion records are found in Appendix 18.Q. Upon completion, each piezometer was purged using an air lift pump to remove drill cuttings and debris from the casing and gravel pack. Exhibit 18-10 shows the location of piezometers installed during the 1983/1984 hydrologic study program.

Following piezometer completion and development, water levels were measured in each piezometer. Static water levels were recorded over a period of time will continue to be taken as part of the ground water monitoring program as outlined in Section 42 – Monitoring, Maintenance, Inspections and Examinations .

Aquifer tests were conducted in 1984 on No. 8, No. 7, No. 4-6, and No. 2-3 Coal Seam piezometers and in 1998/1999 on the No. 3 Coals Seam piezometers. For the coal piezometers, two methods of testing were used to provide a representative transmissivity of each unit. The first method used was the Jacob Approximation of Theis (Jacob method) as presented by David and De Wiest (1966) for single bore hole recovery. The Jacob method is a semi-steady state analysis of recovery water levels versus dimension less time. Transmissivity is calculated based upon the relationship between residual drawdown time and the average discharge rate by:

$$T = \frac{2.3Q}{4\pi S}$$

where: T = transmissivity in ft^2/day

Q = Average discharge rate in ft^3/day

S = Residual drawdown over one log cycle in feet

The second method was an analysis of well recovery and discharge of the well bore as described by McWhorter (1980). This method is a modification of the standard recovery theory that accounts for the effects of afterflow after pumping has ceased. Transmissivity values calculated using the Jacob method could produce inconsistent and unreliable results due to this effect and result in errors in interpretation of the data plot. The McWhorter method avoids this problem by defining transmissivity as follows:

$$T = \frac{1}{4\pi \ x \ S_n} \ x \ Q_o \ x \ 1n\left\{\frac{t_n}{t_n - t_i}\right\} \ x \ n-1 \ x \ Q_1 \ x \ 1n\left\{\frac{t_n - t_i - 1}{t_n - t_i}\right\}$$

$$T = \frac{1}{4}; i = 1$$

where: T = Transmissivity in ft^2/day

S_n = Drawdown at final time

Q_o = Well discharged at ft^3/day

t_n = Time in minutes

t_o = Time at beginning of recovery

Q_i = Incremental discharge to well given by:

$$Q_i = r_o^2 \frac{(S_{i-1}-S_i)}{(t_i-t_{i-1})}$$

r_o = Diameter of well casing (feet)

s_i = Drawdown at (t_i) in feet

t_i = Time in minutes

18.2.5.1 Pictured Cliffs Sandstone

The Pictured Cliffs Sandstone was found to be nearly 120 feet thick in the mine and adjacent areas. The formation strikes generally north-south and dips to the east and southeast from one to two degrees. The sandstone is a well cemented marine sand and does not exhibit significant primary permeability, although secondary permeability is prevalent due to small scale fracturing. Aquifer tests performed on piezometers located in the Pictured Cliffs (Wells GM-30; T4-1) by Science Application, Inc. (SAI) (1979) yields an average transmissivity of 0.13 ft^2/day for both slug and recovery tests. Figure 18-3 and Figure 18-4 provide data analysis and results for each of these tests. The average permeability and storage coefficients for this formation were determined to be 0.0015 ft/day and 3.4 X 10^{-4}, respectively. These values are consistent with aquifer tests performed on the Pictured Cliffs at other locations near the Navajo Mine area (San Juan Coal Company, 1982; San Juan Coal Company, 1983).

18.2.5.2 Fruitland Coal Seams

Water Level elevations, vertical head difference, and the potentiometric surface maps for the four water-bearing coal seams were developed from field data and are presented in Figure 18-5, Figure 18-6, Figure 18-7, and Figure 18-8 and Exhibit 18-6, Exhibit 18-7, Exhibit 18-8, and Exhibit 18-9. When the coal seams are combined with the rest of the Fruitland formation and treated as a single aquifer, a potentiometric map can be drawn which more clearly shows the regional potentiometric surface.

As seen on Exhibit 18-6, Exhibit 18-7, Exhibit 18-8, and Exhibit 18-9, flow direction for the Fruitland Coal Seams is basically toward the east, with fluctuations near recharge/discharge areas (see Appendix 18.O for report). Information used to support Appendix 18.O are referenced in Appendix 18.P. Flow gradients range from 0.001 to 0.02 ft/ft with steeper gradients observed in apparent discharge areas, (e.g., San Juan River).

Potential recharge areas include outcrop locations to the north and south along the subcrop and outcrops in stream channels. Discharge occurs at the contact with the San Juan River alluvium. Since the entire area has been disturbed by mining activities, it is impossible to obtain pre-mining or undisturbed data. However, from the potentiometric surface maps, it can be deduced that the pre-miming condition in the disturbed area was similar to conditions of areas to the east.

The analysis of the aquifer testing conducted on the coal seams of the Fruitland Formation assumes that water flow to the well bore is horizontal and aquifer transmissivities are the same in all directions (isotropic conditions). Coal is not isotropic since there is preferential permeability due to fractures and flow often along vertical as well as horizontal streamlines. However, the assumption is not invalidated because the coal is consistently cleated and fractured. Therefore, the transmissivities calculated are indicative of the overall characteristics of the coal. Transmissivities, permeability and other discharge characteristics, along with piezometer information; are presented in Table 18-13.

Aquifer testing, as described previously, indicated extremely low transmissivity and permeability values. This situation is typical of other low yield systems in northwestern New Mexico. In some cases, the test well dewatered completely within a matter of minutes and recovery took place over several days, (e.g., KF84-22 (e)). Permeability and transmissivity values appear to be random over the Permit Area with no significant trends based on aquifer thickness or location.

18.2.5.3 No. 8 Coal Seam

For the No. 8 Seam, a mean transmissivity and permeability of 1.13 ft^2/day and 0.06 ft/day, respectively, were calculated for the mine area. Figure 18-9, Figure 18-10, and Figure 18-11 provide the method of calculation of the aquifer characteristics of the No. 8 Coal Seam. Exhibit 18-6 shows the potentiometric surface of the No. 8 Coal seam. Flow gradients range from 0.007ft/ft to 0.01ft/ft and flow velocities range from 1.12 x 10^{-2} ft/day. Flow is generally toward the east or downdip with discharge at the San Juan River and Cottonwood Arroyo subcrop areas.

18.2.5.4 No.7 Coal Seam

The No.7 Coal Seam has an average thickness of about five feet. The coal seam outcrops to the west of the Permit Area and extends from beyond Area III to the middle of Area II where it thins to less than one foot and eventually pinches out entirely. The No. 7 Coal Seam exhibits mean transmissivity and permeability values of 1.87 ft^2/day and 0.37 ft/day, respectively. Figure 18-12, Figure 18-13, and Figure 18-14 provide the method of calculation and analysis of the No. 7 seam. Exhibit 18-7 shows the potentiometric surface of the No. 7 Coal Seam and indicates that the water table within it is essentially flat with no observable flow gradient. North of Area III, the No. 7 Seam was found to be dry in all exploratory drill holes within the

Permit Area. The probable reason for this occurrence is that the No. 7 outcrop is above all potential recharge areas.

18.2.5.5 No. 4-6 Coal Seam

As was the case for the No. 7 Seam, the No. 4-6 Coal Seam extends from Area III to the south, and northward to just south of the North Area (Area I) where it thins out completely. Figure 18-15 shows the results of aquifer testing on the No. 4-6 Coal Seam. The No. 4-6 Coal Seam has an average thickness of seven feet and outcrops to the west of the Permit Area. No. 4-6 Coal Seam, as with the other coal strata, exhibits extremely low levels of transmissivity and permeability with values of 0.025 ft^2/day and 0.0037 ft/day, respectively. Exhibit 18-8 shows the potentiometric surface of the No. 4-6 Coal Seam. As observed, flow from the no. 4-6 Seam is both northeasterly and southwesterly toward the Cottonwood Arroyo discharge area. Flow gradients within the seam range from 0.0001 ft/ft to 0.001ft/ft and flow velocities range from 7.4×10^{-6} ft/day to 4.0×10^{-5} ft/day.

18.2.5.6 No. 2-3 Seam

The No. 2-3 Seam extends from Area III to the south, and northward to just above Area III, where the coal unit gradually thins and eventually disappears. The No. 2-3 Coal Seam an average thickness of 5 to 10 feet throughout Area III and outcrops to the west of the Permit Area. Secondary permeability predominates in the No. 2-3 Coal Seam with average transmissivity and permeability values of 0.16 ft^2/day and 0.00075 ft/day, respectively. Figure 18-16, Figure 18-17, and Figure 18-18 provide the results of aquifer testings. Exhibit 18-9 shows the potentiometric surface on this seam. Flow from the No. 2-3 seam within the Permit Area is generally toward its discharge area in the Cottonwood Arroyo. The flow gradient is relatively flat (0.0003 ft/ft) with only two foot decline over a 7000 foot distance. This low gradient and permeability translates into a flow velocity of only 4.5×10^{-5} ft/day (0.01 ft/year).

18.2.6 Quaternary Alluvium

Alluvial fill deposits occupying the valley bottoms of Chinde Arroyo, and the Cottonwood Arroyo, drainage have an average thickness of 10-15 feet. Chinde Arroyo has been mined through within the Permit Area and replaced with a temporary diversion structure (Section 26 – Drainage Control Plan). Cottonwood Arroyo, in Area IV North, contains alluvial deposits ranging from fine-grained wind blown sand to coarse-grained gravels. The Pinabete Arroyo, south of Area IV North and outside the permit boundary, is an ephemeral stream with a sandy channel bed. This is typical of ephemeral drainages of the southwest and it is estimated that transmissivity values will be similar to those found in other localities near the Navajo Mine (e.g., 218 ft^2/day, San Juan Coal Company, 1982). Generally, the direction of the flow gradient in the alluvial formations is towards the topograghic low areas in the adjacent washes. Groundwater may flow away from the washes during periods of peak flow. Water levels in the QA wells rise in the winter and spring during the period of low evapotranspiration and recharge from snow melt

runoff. The water levels in wells begin to decline with the increase of evaporation during the summer. The lowest levels occur during the fall when there is little to no precipitation. Short term increases of the water levels occur during peak runoff caused by precipitation related flows. An exception to geohydrology characteristics of the QA is irrigation fluctuations occurring in alluvial well QAC-1 within the Chinde Wash. Monitoring well QAC-1 has the highest water levels occurring during the NAPI irrigation season April through October. These fluctuations can be correlated to increases in water quantity discharged from NAPI canals into the Chinde Wash.

18.2.7 Groundwater Quality

As previously stated, groundwater exists within the Pictured Cliffs Sandstone, in selected lenticular coal strata of the Fruitland Formation, and in the Chinde Arroyo and Cottonwood Arroyo alluvial deposits. In order to obtain representative baseline water quality information from the deposits, the piezometers were purged at least twenty-four hours prior to sampling. The piezometers were sampled, preserved, shipped and analyzed in accordance with EPA guidelines (Guidelines Estimating Test Procedures for the Analysis of Pollutants 40 CFR Part 136). A summary of laboratory results for Fruitland Formation coal wells is provided in Table 18-14. Also, baseline water quality monitoring results for the Pictured Cliffs and Quaternary Alluvial Deposits are found in Appendix 18.N and Appendix 18.R. The results for each are briefly summarized below. The results presented in Table 18-14 are the median concentrations for the period of record, except for Baseline Fruitland Coals wells within the NTEC coal lease. The median baseline concentrations for the Fruitland Coals wells within coal lease are presented for the monitoring period only. For the coal monitoring wells within Areas 2 and 3 of the coal lease the baseline period was assumed to end at the end of year 2001 consistent with the period of record used for the calculation of reference criteria. Median concentrations were calculated based on all but rejected sample results including field splits and non-detected results Less than detection results were estimated at 1/2 the detection limit for calculating the median concentration. When the calculated median is found to be at one half the value of a detection limit, the detection limit is shown as the median in the table if it is lower than any detected result.

Based on the limited seasonal water quality data available, it is evident that analytical parameters do not fluctuate seasonally within the bedrock water-bearing units. The lack of seasonality is typical for aquifers with very low transmissivities and constant static water levels.

18.2.7.1 Pictured Cliffs Sandstone

Water within the Pictured Cliffs is of poor quality and is classified as a sodium sulfate water type with high concentrations of chloride and abundant hydrogen sulfide gas evident during sampling.

Generally, water quality improves near the outcrop or recharge areas and quickly declines down dip to near connate conditions. Since 1986, data has been submitted to the Office of Surface Mining (OSM) on a quarterly basis (see Appendix 18.R for copies of analyses from 1975 to 1985).

Within close proximity to the mine area, the water quality of the Pictured Cliffs varies significantly as indicated in Table 18-6.

Such large ranges in dissolved constituents are reflective of the low permeability and production rates of the Pictured Cliffs.

Water quality of the Pictured Cliffs Sandstone, as well as the Fruitland Formation discussed below, is poor, and does not meet standards and criteria for domestic and livestock use. Due to the low permeabilities, poor water quality and limited production, regional use is limited. Local use does occur in areas closer to the outcrop; however, it is restricted entirely to marginal livestock watering. For these reasons, the classification of the Pictured Cliffs and the Fruitland Formations as aquifers is questionable.

18.2.7.2 Fruitland Formation

Table 18-14 provides water quality summary for all the Fruitland Coal Seam piezometers. Water types vary between individual Coal Seams and are discussed separately in the following section.

18.2.7.3 No. 8 Coal Seam

The No. 8 Coal Seam water can be classified as a sodium bicarbonate – chloride type with high concentrations of fluoride and high concentrations of sulfate in shallow wells near the recharge area and low concentrations of sulfate in deeper wells and wells near groundwater discharge locations. Median concentrations of total dissolved solids (TDS) range from 3,460 mg/l to 50,010 mg/l and median pH ranges from 7.03 to 8.75. Generally, better water is observed closer to the mine area and extremely poor water is seen at potential discharge locations, e.g. San Juan River.

18.2.7.4 No. 7 Coal Seam

The No. 7 Coal Seam water is also classified as a sodium-bicarbonate-chloride type with high concentrations of carbonate and nitrates. Median concentrations of total dissolved solids range from 2,770 mg/l to 8,505 mg/l and pH ranges from 7.48 to 8.08.

18.2.7.5 No. 4-6 Coal Seam

The No. 4-6 Coal Seam water is classified as sodium – chloride type with high concentrations of iron and manganese. A median total dissolved solids concentration of 13,400 mg/l and median pH of 7.4 was observed in the analytical results for the No. 6 coal seam well KF84-18a.

18.2.7.6 No. 2-3 Coal Seam

The No. 2-3 Coal Seam is classified as sodium–chloride–bicarbonate type with high concentrations of carbonates. Median concentrations of total dissolved solids range from 3,130 mg/l to 8.610 mg/L and the median pH ranges from 7.9 to 7.98.

18.2.8 Quaternary Alluvium

As previously stated, within the Permit Area water occurs in the alluvial deposits of the Chinde Arroyo, Cottonwood Arroyo, drainages. Since 1986, data has been submitted to OSM on a quarterly basis (see Appendix 18.R for copies of data from 1975 to 1985). Water quality within these fill deposits can generally be described as poor with total dissolved solid (TDS) concentrations at well QAC-1 (Chinde alluvium) ranging from 7,700 to 17,200 mg/l, with a mean of 12,340 mg/l. The elevated TDS is the result of high concentrations of sodium, sulfate and chloride, (sodium chloride-sulfate water type) which is typical of these ephemeral wash alluvial aquifers. The concentrations for the major ions are: sulfate ranges form 500-5,520 with a mean of 4,150 mg/l; sodium ranges from 1,410-4,460 mg/l with a mean of 3,669 mg/l; chloride ranges from 1,200-4,900 mg/l with a mean of 3,397 mg/l.

Weak seasonal correlation is evident at well QAC-1 for static water levels, pH sulfate and manganese; however, it does not appear to fluctuate consistently from year to year, and in some years no seasonality is apparent. Seasonal fluctuations in the water quality are related to the changes in water quantity, as recorded by changing static water levels. Generally the water quantity increases in the winter and spring during the period of low evapotranspiration and greater recharge from snow melt runoff. In Chinde Wash, discharge rates by NAPI may dictate to a larger degree fluctuations in water chemistry than seasonality.

It is not possible to determine seasonal water quality fluctuations in Cottonwood Arroyo alluvium due to the insufficient number of samples caused by frequent dry well conditions. Data to support seasonal fluctuations can be found in the annual and quarterly hydrology reports. Median concentrations from baseline monitoring of Cottonwood alluvial wells are summarized in Appendix 18.N Table 6.G-1.

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Table 18-1

DRAINAGE BASIN CHARACTERISTICS SAN JUAN RIVER AT SHIPROCK, NM[1]

Drainage Area:	12,900 square miles.
Period of Record:	February 1927 to 1980.
Maximum Discharge:	80,000 cfs (03/11/29).
Minimum Discharge:	8 cfs (08/25/39).
Average Volume:	1,589,000 acre feet/year.
Specific Conductance: a. Minimum b. Maximum	 180 umhos/cm 4,360 umhos/cm
Sediment Concentration: a. Minimum b. Maximum	 2 mg/l 114,000 mg/l

[1]Source: U.S. Geological Survey. 1980. Water Resource Report. Publication No. USGS/WRD/HD-81/086.

Table 18-2 Drainage Basin Characteristics Chaco River Near Waterflow, NM[1]

Drainage Area:	4,350 square miles.
Period of Record:	1959 to 1969 and November 1975 to 1980.
Maximum Discharge:	7,300 cfs (09/69).
Minimum Discharge:	0.31 cfs (01/80)
Average Discharge:	Base flow from Four Corners Power Plant.
Specific Conductance:	Approximately 2,000 umhos/cm[2]
Sediment Concentrations:	
a. Maximum	140,000 mg/l
b. Minimum	15 mg/l

[1]Source: U.S. Geological Survey. 1980. Water Resource Report. Publication No. USGS/WRD/HD-81/086.

[2]Water year 1980 only.

Table 18-3 Precipitation Values (in inches) for Design Storms, Navajo Mine Drainage Basins

Drainage Basin Designation

Design Storm Frequency (6-hr.)	NOAA Atlas Point Values	Cottonwood Arroyo (79.8 $mi.^2$)	Chinde Wash (42.7 $mi.^2$)	Neck Arroyo (1.9 $mi.^2$)	Lowe Arroyo (11.3 $mi.^2$)	Barber Wash (5.3 $mi.^2$)	Hosteen Wash (9.1 $mi.^2$)
2-year	0.82	0.72	0.75	0.79	0.78	0.79	0.78
10-year	1.23	1.17	1.22	1.29	1.27	1.28	1.28
25-year	1.50	1.44	1.50	1.58	1.56	1.58	1.57
100-year	1.96	1.80	1.88	1.98	1.95	1.97	1.96

Sources: NOAA Atlas 14, Vol 1, Version 4 Point Precipitation Frequency Estimates. New Mexico. G.M. Bonnin, D. Martin, B. Lin, T. Parzybok, M. Yekta, and D. Riley. NOAA National Weather Service, Silver Spring, Maryland, 2006. Extracted Oct 2 2009 from hdsc.nws.**noaa**.gov.

Table 18-4 Summary of Surface Water Monitoring Data - Average Values

Parameter	NB-1	NB-2	CD-1	CD-2	CD-1A	CD-2A	CN-1	CS-1	CNS-1
Start Date	6/5/1986	7/21/1986	7/21/1986	4/17/1986	9/14/1996	8/6/1997	7/18/1990	7/18/1990	7/18/1990
End Date	5/22/1997	5/22/1997	5/23/1997	5/23/1997	9/21/2010	3/24/2010	9/2/1999	9/5/1999	8/3/1999
pH (S.U.)	8.14	8.1	7.7	7.7	8.23	8.26	7.8	8.4	8.16
Max # of Observations	96	123	289	168	85	51	96	92	104
Total Dissolved Solids (mg/l)	2271.5	2300.77	1301	1536	1139	1654	972	1047.8	1098.6
Total Suspended Solids (mg/l)	9172.02	<10270.51	5945	10290	169	78	131005	115803.9	95334.6
Total Settleable Solids (mg/l)	203.08	<229.3	69	96	0.3	0.2	327	247.3	<134.6
Conductivity (µ mhos/cm)	2912.63	3066.67	1696	2207	1650	2233	1151.4	1041.3	861.32
Arsenic(mg/L)	0.002	<0.002	0.002	0.002	0.003	NA	0.024	<0.0021	<0.0023
Boron (mg/l)	0.37	<0.39	0.19	0.21	0.37	0.26	0.17	<0.189	<0.17
Calcium (mg/l)	115.55	98.72	91.25	89.55	72	153	47.6	33.5	8.5
Cadmium (mg/L)	0.002	<0.0016	0.002	0.002	<0.0005	NA	<0.002	<0.002	<0.0019
Chloride (mg/l)	181.65	<168.53	44	217	55	80	<19.6	17.14	<14.07
Fluoride (mg/l)	1.28	<1.17	1.05		1.95	1.25	ND	ND	ND
Iron (mg/l)	0.38	<0.78	0.44	0.57	0.12	0.15	<2.48	<4.84	<4.11
Total Iron (mg/l)	73.42	<94.95	29.83	31.26	3.11	1.55	632.8	419.7	444.7
Lead	0.008	<0.0089	0.009	0.008	0.003		0.028	<0.03	<0.015
Magnesium (mg/l)	29.42	27.74	21.29	19.58	18	27	6.6	4.8	<4.68
Manganese (mg/l)		<0.23				0.03	<0.286	<0.52	<0.34
Total Manganese (mg/l)	1.29	<1.36	0.12	0.17	0.03	0.03	<12.5	8.88	<8.92
Mercury		ND	NA	NA	NA	NA		ND	ND
Nitrate as N (mg/L	9.4	8.9	11.67	15.25	4.20		<11.5	<18.91	<15.59
Potassium (mg/l)	6.7	7.3	5.5	6.8	2.3	6.8	6.5	5.98	5.4

Table 18-4 (Continued)

Parameter	NB-1	NB-2	CD-1	CD-2	CD-1A	CD-2A	CN-1	CS-1	CNS-1
Selenium (mg/l)	0.02	<0.016	0.004	0.003	0.009	0.010	<0.0035	<0.0026	<0.0025
Sulfate (mg/l)	1187	1139	729	697	519	891	451	317.3	292
Sodium (mg/l)	578	596	289	388	292	375	221	180.08	171
Bicarbonate as $CaCO_3$(mg/l)	167	186	153	255	290	255	169	170	152
Carbonate s $CaCO_3$(mg/l)	78.21	<56.75	0	9	13	9	<9.5	82	<65.93

*CD-1A & CD-2A are the remaining active sample points (3/04).

Dissolved unless stated otherwise

Table 18-5 Topdressing Type, Quantities and Curve Numbers for Area 1

Soil Mapping Unit Symbol	Soil Mapping Unit	Volume (cu yds)	Percent (%)	Hydrologic Group [2]	Curve Number [3]	Weighted Value
Bb [1]	Bacobi and	37,061	1.43%	C	86	1.23
-	Monierco soils	57,967	2.23%	D	91	2.03
Bc	Blancot	0	0.00%	B	78	0.00
Bh	Blancot, very hard	0	0.00%	B	78	0.00
Fa	Faro and Persayo Soils	8,024	0.31%	D/D	91	0.28
Gr	Grieta	0	0.00%	B	78	0.00
Jc	Jocity -Gilco	503,634	19.37%	B/B	78	15.11
Jh	Jocity, very hard	0	0.00%	B	78	0.00
Ma	Mack	0	0.00%	C	86	0.00
Mn	Mayqueen	295,981	11.39%	B	78	8.88
Ms	Mayqueen -Shiprock	421,971	16.23%	B	78	12.66
Mv	Mayqueen -Shiprock, very hard	85,805	3.30%	B	78	2.57
Na	Nakai	0	0.00%	B	78	0.00
Nt	Natrargids	0	0.00%	D	91	0.00
Nv	Natrargids, overblown	2,159	0.08%	D	91	0.08
Ra	Razito	599,753	23.07%	A	65	15.00
Rh	Razito. very hard	73,893	2.84%	A	65	1.85
Rl	Redlands Variant	19,683	0.76%	B	78	0.59
Rv	Redlands Variant, very hard	0	0.00%	B	78	0.00
Sc	Shiprock	192,636	7.41%	B	78	5.78
Sh	Shiprock, very hard	22,430	0.86%	B	78	0.67
Sl	Shiprock -Blancot	278,724	10.72%	B/B	78	8.36
Sv	Shiprock Variant	0	0.00%	B	78	0.00
Sz	Stumble	0	0.00%	A	65	0.00
Ta	Trail	0	0.00%	A	65	0.00
Th	Trail. very hard	0	0.00%	A	65	0.00
Totals		2,599,721	100.00%			75.09

(1) Undifferentiated groups and complex soil mapping units were delineated if the major components had contrasting hydrologic groups.

(2) Hydrologic groups were taken from SCS soil surveys, see Table 26-10 for the respective location and title of each survey.

(3) Curve number associated with the hydrological group classification was taken from Table 26-9 (reclaimed).

Table 18-6 Topdressing Type Quantities and Curve Numbers for Area 2

Soil Mapping Unit Symbol	Soil Mapping Unit	Volume (cu yds)	Percent (%)	Hydrologic Group (2)	Curve Number (3)	Weighted Value
Bb (1)	Bacobi and	20,523	1.05%	C	86	0.90
-	Monierco soils	32,101	1.64%	D	91	1.49
Bc	Blancot	0	0.00%	B	78	0.00
Bh	Blancot, very hard	0	0.00%	B	78	0.00
Fa	Faro and Persayo Soils	83,158	4.24%	D/D	91	3.85
Gr	Grieta	0	0.00%	B	78	0.00
Jc	Jocity -Gilco	183,596	9.35%	B/B	78	7.29
Jh	Jocity, very hard	0	0.00%	B	78	0.00
Ma	Mack	0	0.00%	C	86	0.00
Mn	Mayqueen	55,176	2.81%	B	78	2.19
Ms	Mayqueen -Shiprock	341,951	17.42%	B	78	13.59
Mv	Mayqueen -Shiprock, very hard	0	0.00%	B	78	0.00
Na	Nakai	0	0.00%	B	78	0.00
Nt	Natrargids	6,628	0.34%	D	91	0.31
Nv	Natrargids, overblown	82,861	4.22%	D	91	3.84
Ra	Razito	521,804	26.58%	A	65	17.28
Rh	Razito. very hard	0	0.00%	A	65	0.00
Rl	Redlands Variant	33,505	1.71%	B	78	1.33
Rv	Redlands Variant, very hard	0	0.00%	B	78	0.00
Sc	Shiprock	540,865	27.55%	B	78	21.49
Sh	Shiprock, very hard	21,812	1.11%	B	78	0.87
Sl	Shiprock -Blancot	0	0.00%	B/B	78	0.00
Sv	Shiprock Variant	0	0.00%	B	78	0.00
Sz	Stumble	0	0.00%	A	65	0.00
Ta	Trail	23,210	1.18%	A	65	0.77
Th	Trail. very hard	16,144	0.82%	A	65	0.53
Totals		1,963,334	100.00 %			75.72

(1) Undifferentiated groups and complex soil mapping units were delineated if the major components had contrasting hydrologic groups.

(2) Hydrologic groups were taken from SCS soil surveys, see Table 26-10 for the respective location and title of each survey .

(3) Curve number associated with the hydrological group classification was taken from Table 26-9 (reclaimed).

Table 18-7 Topdressing Type Quantities and Curve Numbers for Area 3

Soil Mapping Unit Symbol	Soil Mapping Unit	Volume (cu yds)	Percent (%)	Hydrologic Group [2]	Curve Number [3]	Weighted Value
Bb [1]	Bacobi and	201,579	2.80%	C	86	2.41
-	Monierco soils	315,290	4.38%	D	91	3.98
Bc	Blancot	664,484	9.23%	B	78	7.20
Bh	Blancot, very hard	307,680	4.27%	B	78	3.33
Fa	Faro and Persayo Soils	0	0.00%	D/D	91	0.00
Gr	Grieta	0	0.00%	B	78	0.00
Jc	Jocity -Gilco	481,270	6.68%	B/B	78	5.21
Jh	Jocity, very hard	103,722	1.44%	B	78	1.12
Ma	Mack	1,433,038	19.90%	C	86	17.11
Mn	Mayqueen	0	0.00%	B	78	0.00
Ms	Mayqueen -Shiprock	614,672	8.54%	B	78	6.66
Mv	Mayqueen -Shiprock, very hard	61,024	0.85%	B	78	0.66
Na	Nakai	0	0.00%	B	78	0.00
Nt	Natrargids	0	0.00%	D	91	0.00
Nv	Natrargids, overblown	97,028	1.35%	D	91	1.23
Ra	Razito	458,595	6.37%	A	65	4.14
Rh	Razito. very hard	21,089	0.29%	A	65	0.19
Rl	Redlands Variant	945,193	13.12%	B	78	10.24
Rv	Redlands Variant, very hard	105,452	1.46%	B	78	1.14
Sc	Shiprock	868,130	12.05%	B	78	9.40
Sh	Shiprock, very hard	67,523	0.94%	B	78	0.73
Sl	Shiprock -Blancot	23,813	0.33%	B/B	78	0.26
Sv	Shiprock Variant	416,510	5.78%	B	78	4.51
Sz	Stumble	15,596	0.22%	A	65	0.14
Ta	Trail	0	0.00%	A	65	0.00
Th	Trail. very hard	0	0.00%	A	65	0.00
Totals		7,201,688	100.00%			79.67

(1) Undifferentiated groups and complex soil mapping units were delineated if the major components had contrasting hydrologic groups.

(2) Hydrologic groups were taken from SCS soil surveys, see Table 26-10 for the respective location and title of each survey

(3) Curve number associated with the hydrological group classification was taken from Table 26-9 (reclaimed).

Table 18-8 Topdressing Type, Quantities and Curve Numbers for Area 4 North

Soil Mapping Unit Symbol	Soil Mapping Unit	Volume (cu yds)	Percent (%)	Hydrologic Group[2]	Curve Number[3]	Weighted Value
Bb[1]	Bacobi and	342,305	7.03%	C	86	6.04
-	Monierco soils	535,401	10.99%	D	91	10.00
Bc	Blancot	0	0.00%	B	78	0.00
Bh	Blancot, very hard	0	0.00%	B	78	0.00
Fa	Faro and Persayo Soils	161,922	3.32%	D/D	91	3.02
Gr	Grieta	69,104	1.42%	B	78	1.11
Jc	Jocity -Gilco	1,525,313	31.31%	B/B	78	24.42
Jh	Jocity, very hard	46,339	0.95%	B	78	0.74
Ma	Mack	176,992	3.63%	C	86	3.12
Mn	Mayqueen	23,851	0.49%	B	78	0.38
Ms	Mayqueen -Shiprock	333,565	6.85%	B	78	5.34
Mv	Mayqueen -Shiprock, very hard	0	0.00%	B	78	0.00
Na	Nakai	53,010	1.09%	B	78	0.85
Nt	Natrargids	0	0.00%	D	91	0.00
Nv	Natrargids, overblown	218,490	4.49%	D	91	4.08
Ra	Razito	311,260	6.39%	A	65	4.15
Rh	Razito. very hard	196,707	4.04%	A	65	2.62
Rl	Redlands Variant	331,678	6.81%	B	78	5.31
Rv	Redlands Variant, very hard	61,901	1.27%	B	78	0.99
Sc	Shiprock	160,006	3.28%	B	78	2.56
Sh	Shiprock, very hard	143,239	2.94%	B	78	2.29
Sl	Shiprock -Blancot	0	0.00%	B/B	78	0.00
Sv	Shiprock Variant	70,420	1.45%	B	78	1.13
Sz	Stumble	105,082	2.16%	A	65	1.40
Ta	Trail	0	0.00%	A	65	0.00
Th	Trail. very hard	4,538	0.09%	A	65	0.06
Totals		4,871,123	100.00%			79.65

[1]Undifferentiated groups and complex soil mapping units were delineated if the major components had contrasting hydrologic groups.

[2]Hydrologic groups were taken from SCS soil surveys, see Table 26-10 for the respective location and title of each survey.

[3]Curve number associated with the hydrological group classification was taken from Table 26-9 (reclaimed).

Table 18-9 Cottonwood Arroyo 1997-1999 Monitoring Data Average Values by Station

						Texture			Particle Size Distribution				
Station	Watershed Area	Number of Samples	Total Sediment	Maximum	Minimum	Sand	Silt	Clay	Very Coarse Sand	Coarse Sand	Medium Sand	Fine Sand	Very Fine Sand
	Acres		mg/L	mg/L	mg/L	%	%	%	%	%	%	%	%
CN-1	17,259	92	123,097	268,000	29,500	32	27	41	0	1	10	53	35
CS-1	29,385	40	79,420	143,200	44,500	21	29	50	0	1	5	46	48
CNS-1	49,221	123	85,247	193,800	29,800	29	28	43	0	1	5	49	44

Table 18-10 Cottonwood Arroyo 1997-1999 Surface Water Data from Automated Stations Hydrology and Sediment Upstream/Downstream Comparisons

FLOW EVENT	STATION	No. of Samples	Total Sediment conc. – ave. mg/l	Peak discharge cfs	Sediment yield Tons	Runoff volume Acre-feet	Difference in runoff volume Acre-feet	Difference in sediment yield Tons
7/24/1998	CN-1	NO FLOW		-	-	-		
	CS-1	-	-		-	1.3		
	CNS-1	-	-	14	-			NA
7/25/1998	CN-1	-	-	8	-	0.7	(0.6)	
	CS-1	-	-	33	-	0.5		
	CNS-1	-	-	25	-	1.3		NA
8/21/1998	CN-1	3	53,700	9	682	0.8	(1.0)	
	CS-1	10	80,609	877	13,904	190		
	CNS-1	18	140,543	1,120	23,515	202		11,076
4/22/1999	CN-1	-	-	142	48,495	272	(121)	
	CS-1	-	-	42	0	98		
	CNS-1	12	138,192	84	-	6		NA
7/15/1999	CN-1	-	-	101	0	19	(85)	
	CS-1	NO FLOW		-	-	5.2		
						-		

Table 18-10 (Continued)

		No. of Samples	Total Sediment conc. – ave.	Peak discharge	Sediment yield	Runoff volume	Difference in runoff volume	Difference in sediment yield
	CNS-1	-	-		-			NA
				37		2.4	(2.8)	
7/23/1999	CN-1	-	-		-			
				1,085		64.1		
	CS-1		89,500					
		4		281	4,376	40.0		
	CNS-1		63,500					NA
		3		1,118	8,999	104.2	0.2	
7/29/1999	CN-1		167,925					
		4		247	2,496	10.9		
	CS-1	-	-		-			
				10		0.6		
	CNS-1		129,450					NA
		4		71	1,215	6.9	(4.6)	
8/2/1999	CN-1		77,020					
		5		523	2,242	21		
	CS-1		52,600					
		4		1,018	3,022	42		
	CNS-1		62,867					609
		3		1,455	5,873	69	5	
8/3/1999	CN-1		85,325					
		4		272	2,483	21		
	CS-1		94,525					
		4		1,742	27,574	215		
	CNS-1		102,275					5,233
		4		1,415	35,290	254	18	

Note: Flow values at CNS-1for the August 3, 1999 flow event may not be accurate due to recent changes in the channel cross-section.

Table 18-11 Cottonwood SEDCAD Premine Results

	Peak sediment concentration	Peak discharge	Sediment yield	Runoff volume
Design event	mg/l	cfs	Tons	Acre-feet
2 Year - 6 Hour	32,208	1,055		
			10,054	495
10 Year - 6 Hour	34,186	2,841		
			30,644	1,512
25 Year - 6 Hour	35,872	4,120		
			46,506	2,285
100 Year - 6 Hour	36,850	5,976		
			70,805	3,444

Table 18-12 Non-Navajo Mine Wells Adjacent to the Lease Boundary (See Exhibit 18-5 or Appendix 41.A for locations)

Well Name	Owner	Distance from Coal Lease Boundary (mi)	Total Depth (ft)	Completion	Construction	Primary Use	Water Quality Data
#38	Navajo	4.01	1505	PCS	NA	Unknown	Available
#41	Unknown	1.96	60	Kirtland (Farmingt.)	NA	Unknown	NA
#44	Navajo	4.01	804	PCS	NA	Unknown	Available
45 (#34)	Navajo	1.38	8	Pinabete/Chaco Alluvium	NA	Unknown	NA
#46	Navajo	3.12	9	Alluvium	Dug Well	Unknown	Available
#51	Navajo	1.64	8	Alluvium	Dug Well	Unknown	NA
#57	Navajo	3.05	27	San Juan Alluvium	Drilled	Unknown	Available
#70	Navajo	(inside lease)	9	Alluvium	Dug Well	Unknown	Available
#90	Navajo	1.47	131	PCS	NA	Stock, Domestic	NA
#146	Unknown. Likely the same well as W-0593	0.66	9	San Juan Alluvium	NA	Unknown	Available
13-15-4 (#60)	Unknown	1.29	11	Chaco Alluvium	Concrete collar; wooden lid, bucket operated	Unknown	NA

Table 18-12 (Continued)

Well Name	Owner	Distance from Coal Lease Boundary (mi)	Total Depth (ft)	Completion	Construction	Primary Use	Water Quality Data
13-7-2	Unknown	1.53	Unknown	PCS	7" steel casing w/ windmill on 8'x8' concrete pad	Unknown	NA
13-7-4	Navajo Trust	1.01	Unknown	Unknown	Hand dug w/ hand pump	Unknown	NA
13-AW (13T-513, #58)	Unknown	1.49	530	Alluvium - Artesian	NA	OG well converted to Livestock	Available
46 (W-0618,13R-28, #35)	Navajo Trust	1.15	16	Cottonwood Alluvium	NA	Stock Water	NA
G5	Unknown	3.13	Unknown	Chaco Alluvium	NA	Unknown	Available
GM-22 (13R-38)	Unknown	1.84	47	Pinabete Alluvium	Dug well w/concrete pad & windmill	Monitoring/Livestock	NA
GM-32 (13-15-7)	Unknown. Likely the same well as W-0202	1.77	9	Chaco Alluvium	Block & Concrete dug well, formerly hand pump operated; 10'x10' concrete pad	Monitoring/Livestock	NA
GM-35	Unknown	1.23	Unknown	Unknown	Dug well w/concrete pad operated by portable hand pump	Unknown	NA
GM-36 (13-7-5)	Unknown	1.05	Unknown	Unknown	Dug well w concrete well head; bucket operated	Livestock & Monitoring	NA

Table 18-12 (Continued)

Well Name	Owner	Distance from Coal Lease Boundary (mi)	Total Depth (ft)	Completion	Construction	Primary Use	Water Quality Data
R.A. French (#150)	Unknown	2.43	37	San Juan Alluvium	NA	Unknown	Available
SJ 00248 (G7, #6)	Unknown	4.56	35	San Juan Alluvium	NA	DOM	Available
SJ 00264 (#7)	Unknown	4.13	35	San Juan Alluvium	NA	Stock Water	NA
W-0146	Navajo Trust	2.27	Unknown	Unknown	NA	Stock Water	NA
W-0147	Navajo Trust	1.51	Unknown	Unknown	NA	Stock Water	NA
W-0148	Navajo Trust	2.42	Unknown	Unknown	NA	Stock Water	NA
W-0202	Navajo Trust	1.73	7	Chaco Alluvium	NA	Stock Water	NA
W-0203 (13-15-5)	Navajo Trust	1.93	8	Chaco Alluvium	NA	Stock Water	NA
W-0204 (13-15-6)	Navajo Trust	1.85	14	Chaco Alluvium	Dug well; 8'x8' concrete pad; sides eroding into well	Stock Water	NA
W-0313	Navajo Trust	0.72	Unknown	Unknown	NA	Stock Water	NA
W-0342	Navajo Trust	2.16	Unknown	Unknown	NA	Stock Water	NA
W-0343 (13-5-1, Stevenson, 13-15-2)	Navajo Trust	(inside lease)	Unknown	Alluvium	5" steel casing; well cap welded shut	Stock Water	NA

Table 18-12 (Continued)

W-0344 (#93)	Navajo Trust	(inside lease)	9	Pinabete Alluvium	NA	Stock Water	Available
W-0345 (13R-48, 13-15-3)	Navajo Trust	(inside lease)	10	Pinabete Alluvium	Dug well; concrete well head; wooden cover	Stock Water	NA
W-0346 (13R-37, 13-8-4)	Navajo Trust	(inside lease)	8	Pinabete Alluvium	Dug well w/ concrete pad over well; hand pump operable	Stock Water, Use Unknown	NA
W-0348 (13-8-1)	Navajo Trust	0.55	13	Pinabete Alluvium	Open well; concrete well head	Stock Water	NA
W-0517	Navajo Trust	4.42	Unknown	Unknown	NA	Stock Water	NA
W-0519 (13R-31 #17, G4, 13-14-7)	Navajo Trust	1.59	16	Chaco Alluvium	NA	Stock Water	Available
W-0520 (G-3, #36)	Unknown	1.71	Unknown	Unknown	NA	Stock Water	Available
W-0593	Navajo Trust	0.70	Unknown	Unknown	Windmill	Stock Water	NA
W-0603	Navajo Trust	0.16	Unknown	Unknown	Windmill	Stock Water	NA
W-0606 (13-15-1)	Navajo Trust	(inside lease)	Unknown	Unknown	5" steel casing w/ 8' x 8' concrete pad; Windmill	Stock Water	NA
W-0607	Unknown	1.67	25	Alluvial	Windmill	Stock Water	NA

Table 18-12 (Continued)

Well Name	Owner	Distance from Coal Lease Boundary (mi)	Total Depth (ft)	Completion	Construction	Primary Use	Water Quality Data
W-0644 (13R-28A, QACW-2B, CWAP-1, #126)	BIA	0.18	11	Cottonwood Alluvium	Hand dug w/ hand pump	Stock Water	Available
W-0645 (13R-29, #61, 13-14-6)	Navajo Trust	1.68	16	Chaco Alluvium	NA	Stock Water	Available
W-0686	Navajo Trust	4.73	Unknown	Unknown	Windmill	Stock Water	NA
W-0691 (13-15-8)	Navajo Trust	1.86	Unknown	Chaco Alluvium	Dug well, 5'x5' concrete pad; equipped w/hand pump	Stock Water	NA
W-0695 (G-2)	Navajo Trust	3.81	Unknown	San Juan Alluvium	NA	Stock Water	Available
W-0768 (#10)	Navajo Trust	4.81	Unknown	Unknown	Windmill	Stock Water	NA
Wesleyan Navajo Mission (#147)	Unknown	0.85	19	San Juan Alluvium	NA	Unknown	Available

NA - Not Available; PCS - Pictured Cliffs Sandstone; OG - Oil & Gas

Table 18-13 Aquifer Discharge Characteristics

Well Name	Location	Casing I.D.	Total Depth Elev.	Dept	Type Test	Transmissivity	Permeability	Saturated Thickness	Formation*	Remarks
SJKF84#3	N	2.0 in.	4990.18	120	(1)	1.42 ft2/d	0.08 ft/d	18 ft.	No. 8	Q=1 gpm; VCW=18.06
	E				(2)	0.71 ft2/d	0.04 ft/d			Secondary Permeability
SJKF84#4	N	2.0 in.	5046.67	71	(1)	1.45 ft2/d	0.08 ft/d	18 ft.	No. 8	Q=0.3 gpm;
	E 333233.40				(2)	1.03 ft2/d	0.06 ft/d			Secondary Permeability
SJKF84#5	N	2.0 in.	5092.00	180	(1)	2.08 ft2/d	0.12 ft/d	18 ft.	No. 8	Q=0.1 gpm; VCW=5.52
	E 331410.00				(2)	0.07 ft2/d	0.004 ft/d			Secondary Permeability
KF8420(c)	N	2.0 in.	5213.92	190	(1)	1.28 ft2/d	0.26 ft/d	5 ft.	No. 7	Q=0.2 gpm; VCW=8.1
	E 304307.65				(2)	0.01 ft2/d	0.002 ft/d			Secondary Permeability
KF8420(a)	N	2.0 in.	5163.78	240	(1)	0.12 ft2/d	0.012 ft/d	10 ft.	No. 2	Q=0.2 gpm; VCW=13.9
	E 304306.50				(2)	0.009 ft2/d	0.001 ft/d			Secondary Permeability
KF8421(c)	N	2.0 in.	5219.66	75	(1)	9.08 ft2/d	1.82 ft/d	5 ft.	No. 7	Q=0.5 gpm; VCW=6.12
	E 302693.56				(2)	0.04 ft2/d	0.008 ft/d			Secondary Permeability
KF8422(b)	N	2.0 in.	5204.10	140	(1)	0.76 ft2/d	0.152 ft/d	5 ft.	No. 7	Q=0.13 gpm;
	E 307829.36				(2)	0.02 ft2/d	0.003 ft/d			Secondary Permeability
KF8422(c)	N	2.0 in.	5142.50	202	(1)	0.04 ft2/d	0.006 ft/d	7 ft.	No. 4-6	Q=0.03 gpm;
	E 307841.20				(2)	0.01 ft2/d	0.0014 ft/d			Secondary Permeability
KF8422(d)	N	2.0 in.	5124.20	220	(1)	0.71 ft2/d	0.14 ft/d	5 ft.	No. 3	Q=0.17 gpm;
	E 307832.96				(2)	0.01 ft2/d	0.002 ft/d			Secondary Permeability
KF8422(e)	N	2.0 in.	5107.80	237	(1)	0.15 ft2/d	0.015 ft/d	10 ft.	No. 2	Q=0.08 gpm;
	E 307820.38				(2)	0.01 ft2/d	0.001 ft/d			Secondary Permeability

* Fruitland (KF) Formation; (1) Standard Recovery; (2) Modified Recovery

Table 18-14 Groundwater Quality Summary

well category	Well	Monitoring Period*	pH (SU)		TDS -180° (mg/L)		Bicarbonate as HCO_3 (mg/L)		Carbonate as CO_3 (mg/L)		Chloride (mg/L)		Sulfate (mg/L)		Calcium (mg/L)		Magnesium (mg/L)		Potassium (mg/L)	
			n	median	n	median	n	median	n	median	n	median	n	median	n	median	n	median	n	median
Baseline Fruitland Coals within coal lease (median concentrations)	KF2007-01 (No. 8)	2007-2008	5	8.75	5	3460	5	1818	5	156	5	3385	6	740	5	3.2	5	1.7	6	17.9
	KF98-02 (No. 3)	1998 2007-2008	6	7.95	6	3130	6	1512	6	30	6	940	6	107	6	6.1	6	0.9	8	12.1
	KF84-21a (No 2)	1984-2001	30	7.9	30	8375	30	1197	17	<1	30	4445	30	63	30	13.3	30	14.9	30	13.3
	KF84-21c (No 7)	1984	1	8.08	1	8505	1	919	1	68.4	1	3980	1	184	1	14.6	1	14.9	1	15.0
	KF84-22a (No 8)	1984-2001	22	8.0	22	4650	22	1170	12	<1	22	290	22	2140	22	15.3	22	3.5	22	6.8
	KF84-22b (No 7)	1984-2001	26	7.4	26	6115	25	854	15	<1	25	3220	26	<10	26	45.0	26	13.4	26	11.9
	KF84-22d (No 3)	1984	1	7.94	1	8610	1	830	1	46.8	1	3420	1	<10	1	27.4	1	18.7	1	15.8
	KF84-22e (No 2)	1984	2	7.98	2	8155	2	814	2	52.8	2	4185	2	24.5	2	35.6	2	17.5	2	16.3
	KF84-20A (No 3)	1984-2001	26	7.93	26	7260	26	1090	23	<1	26	3715	26	<10	26	18.4	26	11.0	26	11.9
	KF84-20C (No 7)	1984-2001	23	7.9	23	2770	23	1562	21	<1	23	715	23	7	23	9.6	23	2.8	23	5.9
	KF84-18b (No 8)	1984-2001	25	7.1	25	9300	25	1030	13	<1	25	4900	25	<10	25	114.0	27	24.3	25	15.0
	KF84-18a (No. 6)	1984-2001	26	7.47	26	13400	26	450	14	<1	26	7900	26	5.5	26	157.0	26	50.6	26	22.5
Baseline Coal downgradient (median)	SJKF#2	1984	1	7.03	1	43035	1	944	1	<1	1	23800	1	<10	1	515	1	222	1	56
	SKJF#3	1984	1	7.29	1	50810	1	673	1	<1	1	28200	1	<10	1	700	1	278	1	61
	SJKF#4	1984	1	8.06	1	7370	1	3232	1	276	1	2210	1	<10	1	26.5	1	9.18	1	13.5
Potentially Affected Coal Wells (median)	Bitsui-2	1995-2010	26	8	26	5145	26	3233	18	2.75	26	1160	26	165	26	6.21	26	2.4	25	7
	Bitsui-3	1995-2009	21	7.6	17	7960	21	3123.2	12	<1	21	2820	21	317	21	22.4	21	9.4	20	11
	KF83-1	1983-2002	41	7.8	41	7100	40	3092.7	12	138	41	2255	41	340	41	19.4	41	6.9	40	9.35
	KF84	1985-2000	27	7.8	26	7760	27	1420	7	44.4	27	323	27	3860	27	47.5	27	25.9	27	8.6
	KF84-16	1985-2002	32	7.6	32	9955	32	2797.2	7	120	32	4551	32	15.5	32	38.2	32	14.95	32	16.3
	SJKF#5	1984	1	8.12	1	4470	1	3770	1	230	1	360	1	<10	1	5.57	1	2.27	1	11.1

*Monitoring period is period of record, except for Baseline Fruitland Coals wells within coal lease

Median calculation based on all but rejected sample results including field splits and non detected results

Rejected samples include: samples with no sampling or analysis date, samples with pH>11, samples that are clearly inconsistent with results of other samples

uncaracterized metals results included as dissolved metals in statistical summray

For less than detection limit, 1/2 the detection limit used for summary unles the median is a detection limit that is lower than any detected result

Table 18-15 Slope/Length Values

Average WS Slope (%)	Slope Length (ft)
0-2.0	400
>2.0-3.0	300
>3.0-4.0	200
>4.0-6.0	175
>6.0-8.0	150
>8.0-10.0	125
>10.0-12.0	100
>12	75

Table 18-6 Pictured Cliff Water Quality

	Range
Total Dissolved Solids	5200mg/l to 16960mg/l
Chloride	170 mg/l to 9000 mg/l
Sodium	1330 mg/l to 6100mg/l
Sulfate	1100 mg/l to 4750 mg/l
pH	6.8 to 9.1

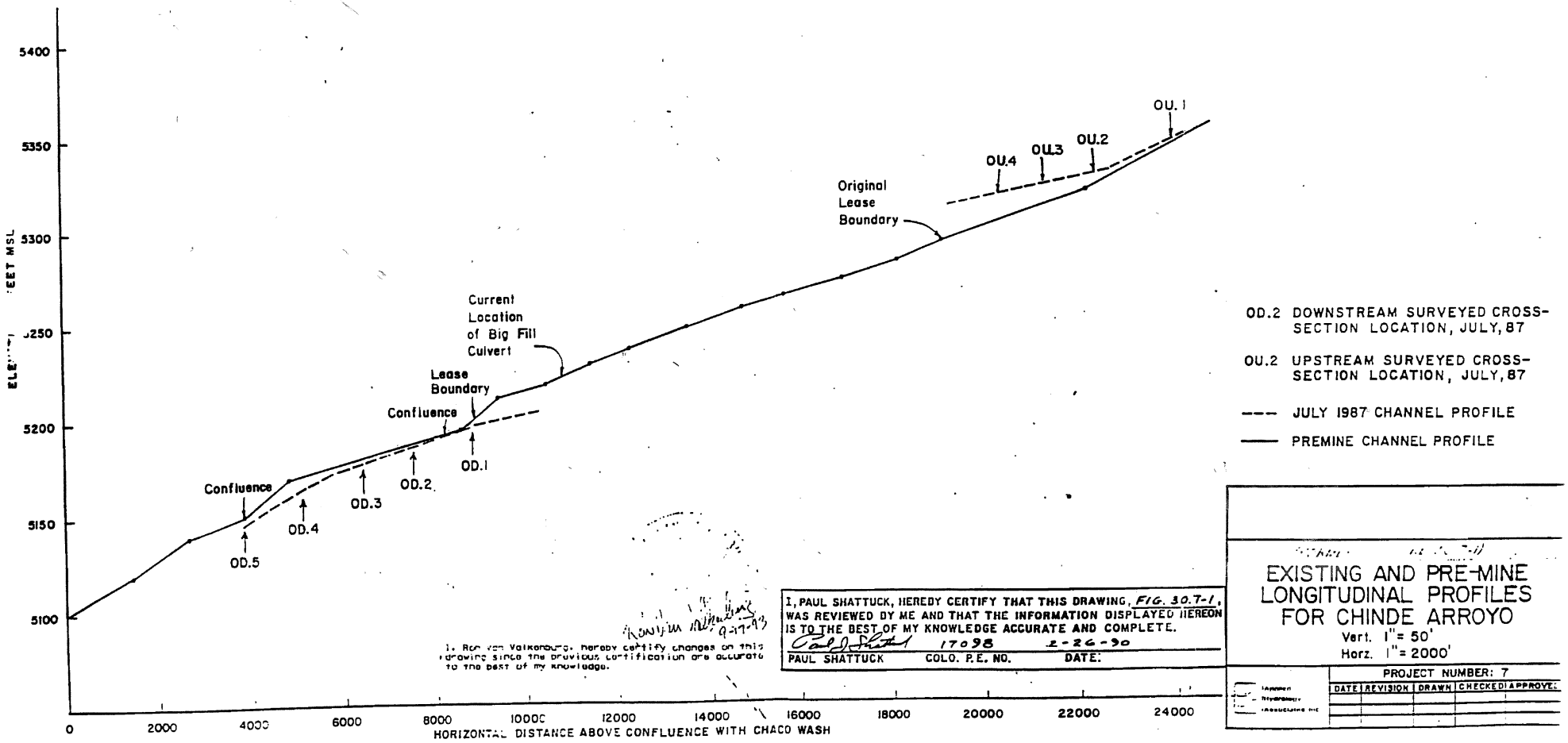
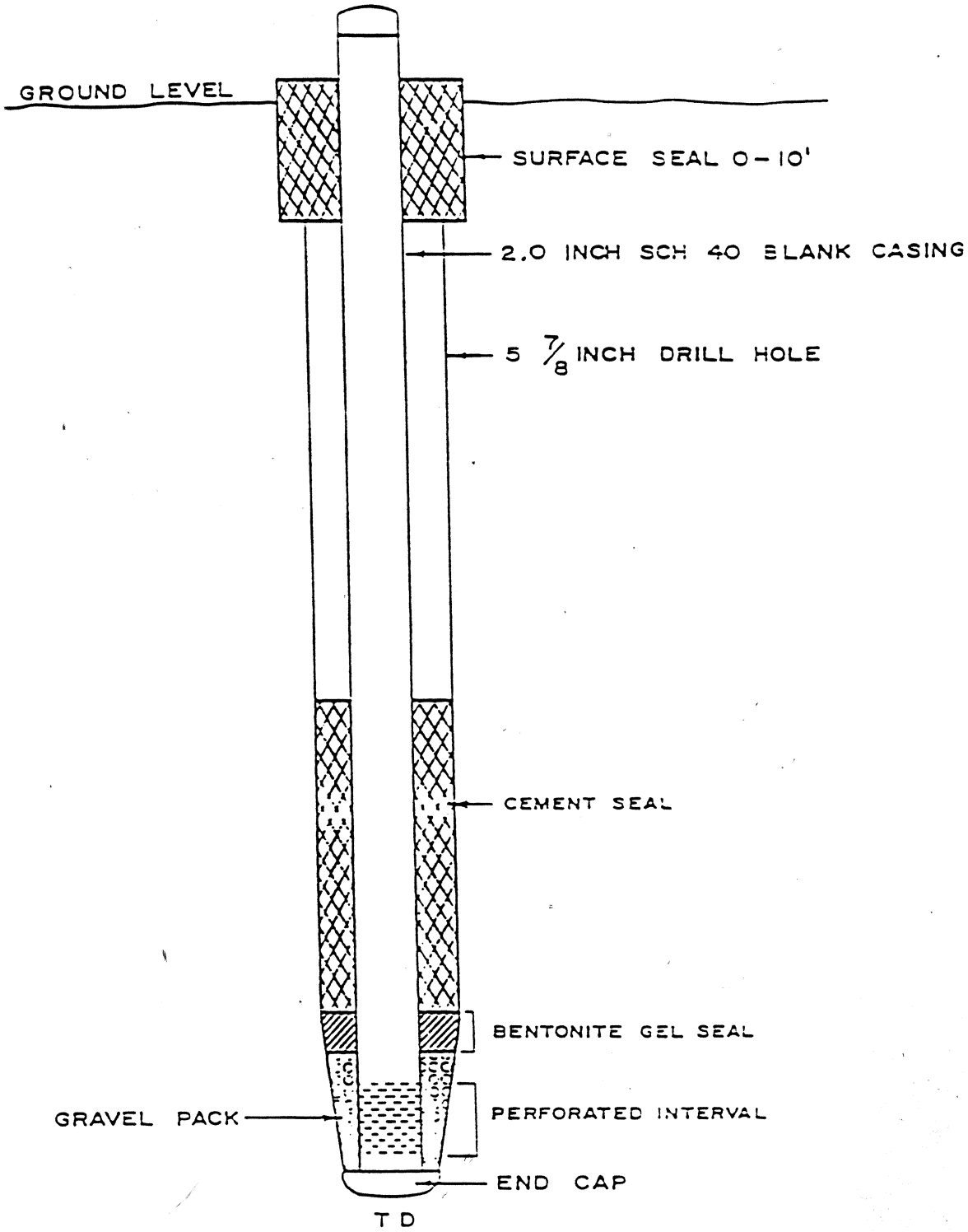

5400
5350
5300
5250
5200
5150
5100
FEET MSL
0
2000
4000
6000
8000
10000
12000
14000
16000
18000
20000
22000
24000
HORIZONTAL DISTANCE ABOVE CONFLUENCE WITH CHACO WASH
OU.1
OU.2
OU.3
OU.4
Original Lease Boundary
Current Location of Big Fill Culvert
Lease Boundary
Confluence
OD.1
OD.2
OD.3
OD.4
OD.5
Confluence
OD.2 DOWNSTREAM SURVEYED CROSS-SECTION LOCATION, JULY, 87
OU.2 UPSTREAM SURVEYED CROSS-SECTION LOCATION, JULY, 87
JULY 1987 CHANNEL PROFILE
PREMINE CHANNEL PROFILE
I, PAUL SHATTUCK, HEREBY CERTIFY THAT THIS DRAWING, FIG. 30.7-1, WAS REVIEWED BY ME AND THAT THE INFORMATION DISPLAYED HEREON IS TO THE BEST OF MY KNOWLEDGE ACCURATE AND COMPLETE.
PAUL SHATTUCK
COLO. P.E. NO. 17098
DATE: 2-26-90
I, Ron van Valkenburg, hereby certify changes on this drawing since the previous certification are accurate to the best of my knowledge.
EXISTING AND PRE-MINE LONGITUDINAL PROFILES FOR CHINDE ARROYO
Vert. 1" = 50'
Horz. 1" = 2000'
PROJECT NUMBER: 7
DATE
REVISION
DRAWN
CHECKED
APPROVED

Figure 18-1



COMPLETION DIAGRAM

Figure 18-2

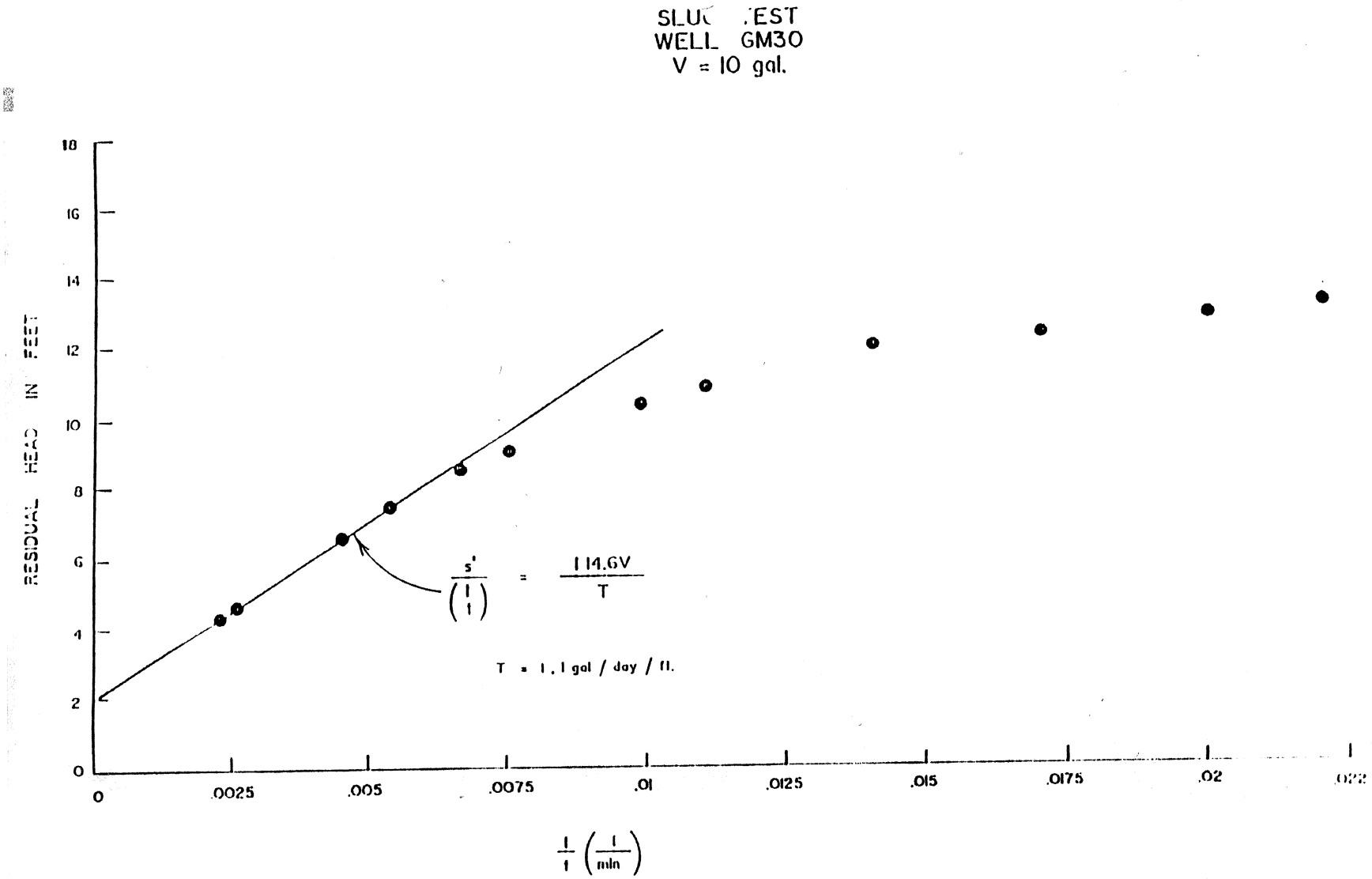

SLUG TEST
WELL GM30
V = 10 gal.
RESIDUAL HEAD IN FEET
18
16
14
12
10
8
6
4
2
0
0
.0025
.005
.0075
.01
.0125
.015
.0175
.02
$\frac{s'}{\left(\frac{1}{t}\right)} = \frac{114.6V}{T}$
T = 1.1 gal / day / ft.
$\frac{1}{t}\left(\frac{1}{min}\right)$

Figure 18-3

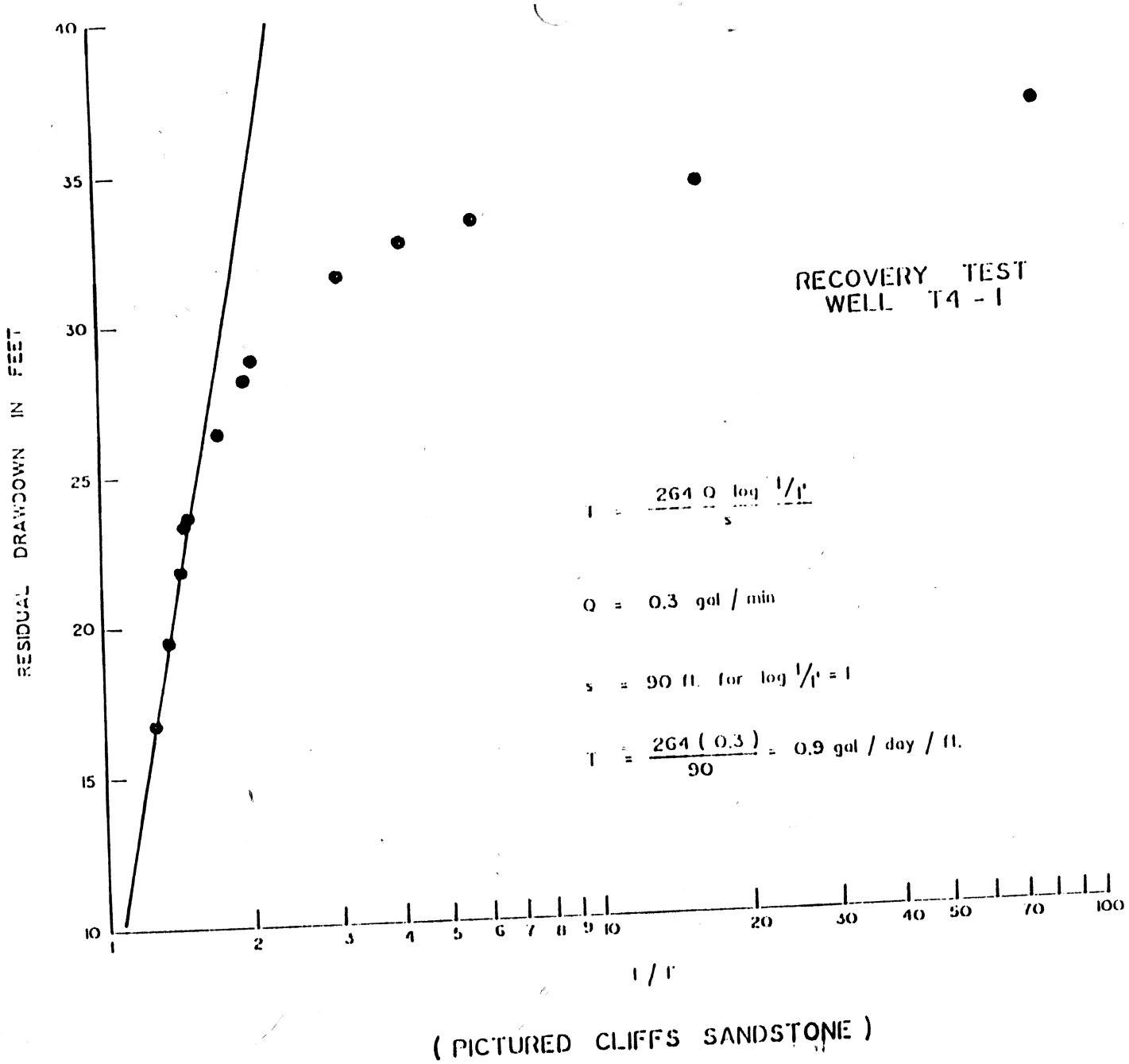

RECOVERY TEST
WELL T4 - 1
RESIDUAL DRAWDOWN IN FEET
40
35
30
25
20
15
10
1
2
3
4
5
6
7
8
9
10
20
30
40
50
70
100
t / t'
T = 264 Q log t/t' / s
Q = 0.3 gal / min
s = 90 ft. for log t/t' = 1
T = 264 (0.3) / 90 = 0.9 gal / day / ft.
(PICTURED CLIFFS SANDSTONE)

Figure 18-4

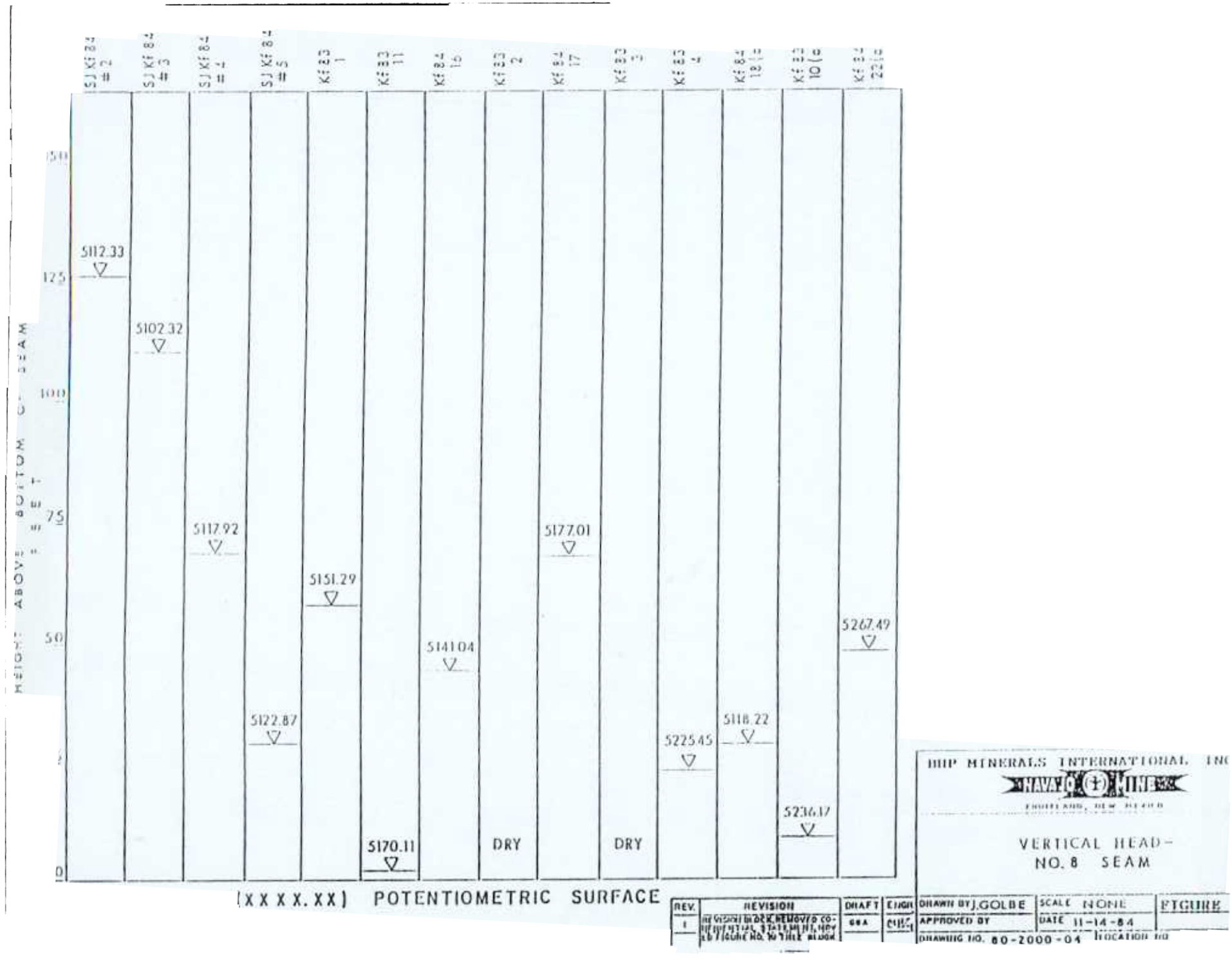
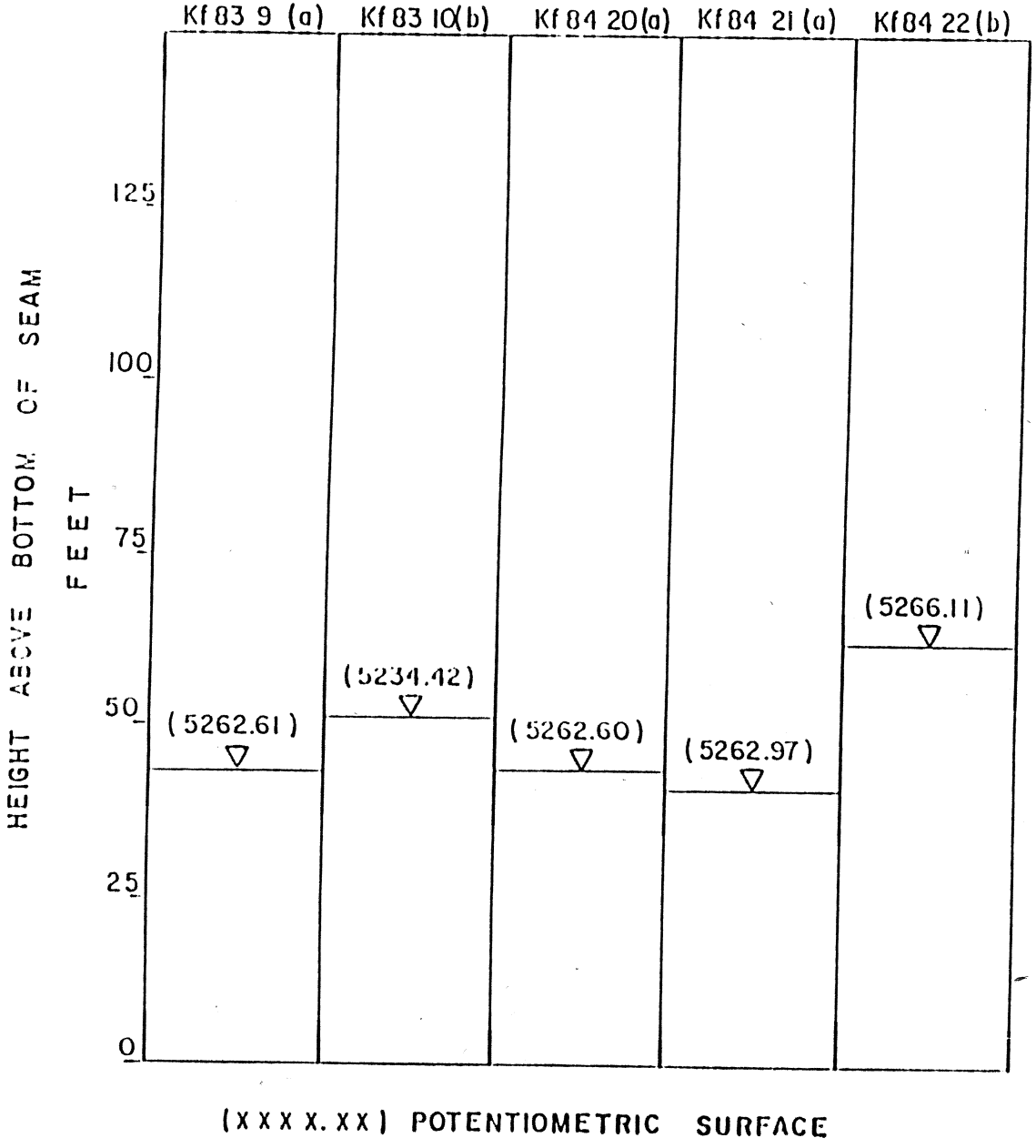

SJ KF 84 #2
SJ KF 84 #3
SJ KF 84 #4
SJ KF 84 #5
KF 83 1
KF 83 11
KF 84 16
KF 83 2
KF 84 17
KF 83 3
KF 85 4
KF 84 18(a)
KF 83 10(a)
KF 84 22(a)
HEIGHT ABOVE BOTTOM OF SEAM - FEET
150
125
100
75
50
25
0
5112.33
5102.32
5117.92
5122.87
5151.29
5170.11
5141.04
DRY
5177.01
DRY
5225.45
5118.22
5236.17
5267.49
(XXXX.XX) POTENTIOMETRIC SURFACE
BHP MINERALS INTERNATIONAL INC
VERTICAL HEAD - NO. 8 SEAM
REV.
REVISION
DRAFT
ENGR
DRAWN BY J.GOLBE
SCALE NONE
FIGURE
APPROVED BY
DATE 11-14-84
DRAWING NO. 80-2000-04
LOCATION NO

Figure 18-5



BHP MINERALS INTERNATIONAL INC.

NAVAJO MINE

FRUITLAND, NEW MEXICO

VERTICAL HEAD-
NO. 7 SEAM

REV.	DATE	REVISION	DRAFT	ENGR
1	6-4-8	REVISION BLOCK, REMOVED CONFIDENTIAL STATEMENT, MOVED FIGURE NO. TO TITLE BLOCK.	BBA	CBC

DRAWN BY J. GOLBE | SCALE NONE | FIGURE 6-
APPROVED BY | DATE 11-14-84
DRAWING NO. 80-2000-03 | LOCATION NO.

Figure 18-6

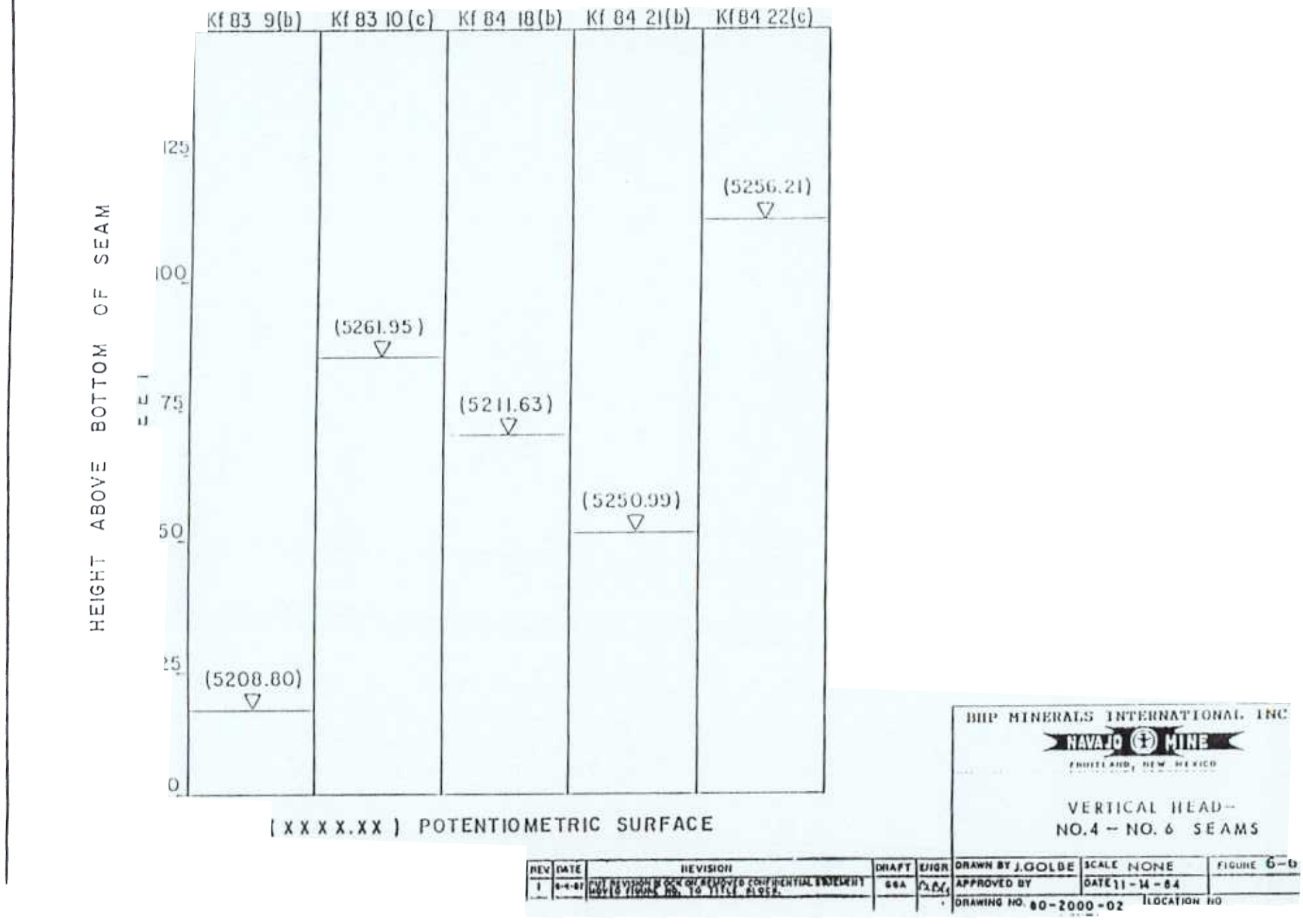

Kf 83 9(b)
Kf 83 10(c)
Kf 84 18(b)
Kf 84 21(b)
Kf 84 22(c)
HEIGHT ABOVE BOTTOM OF SEAM
FEET
125
100
75
50
25
0
(5208.80)
(5261.95)
(5211.63)
(5250.99)
(5256.21)
(XXXX.XX) POTENTIOMETRIC SURFACE
BHP MINERALS INTERNATIONAL INC
NAVAJO MINE
FRUITLAND, NEW MEXICO
VERTICAL HEAD-
NO.4 – NO. 6 SEAMS
REV
DATE
REVISION
DRAFT
DSGN
DRAWN BY J.GOLDE
SCALE NONE
FIGURE 6-b
APPROVED BY
DATE 11-14-84
DRAWING NO. 80-2000-02
LOCATION NO

Figure 18-7

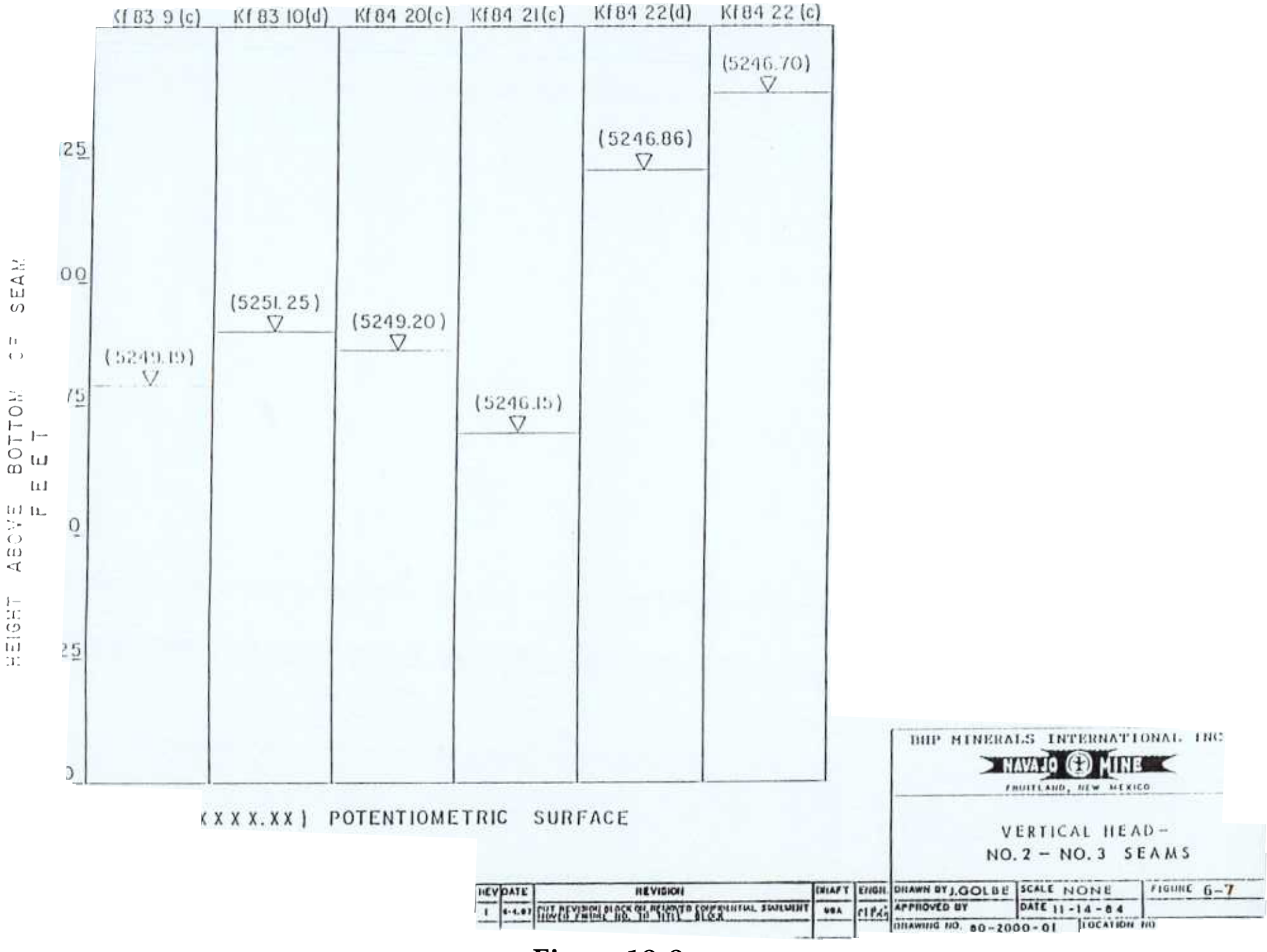

Kf 83 9 (c)
Kf 83 10(d)
Kf 84 20(c)
Kf 84 21(c)
Kf 84 22(d)
Kf 84 22 (c)
(5246.70)
(5246.86)
(5251.25)
(5249.20)
(5249.19)
(5246.15)
HEIGHT ABOVE BOTTOM OF SEAM
FEET
25
00
75
0
25
0
(XXXX.XX) POTENTIOMETRIC SURFACE
BHP MINERALS INTERNATIONAL INC
NAVAJO MINE
FRUITLAND, NEW MEXICO
VERTICAL HEAD -
NO. 2 - NO. 3 SEAMS
REV
DATE
REVISION
DRAFT
ENGR
DRAWN BY J.GOLBE
SCALE NONE
FIGURE 6-7
APPROVED BY
DATE 11-14-84
DRAWING NO. 80-2000-01
LOCATION NO

Figure 18-8

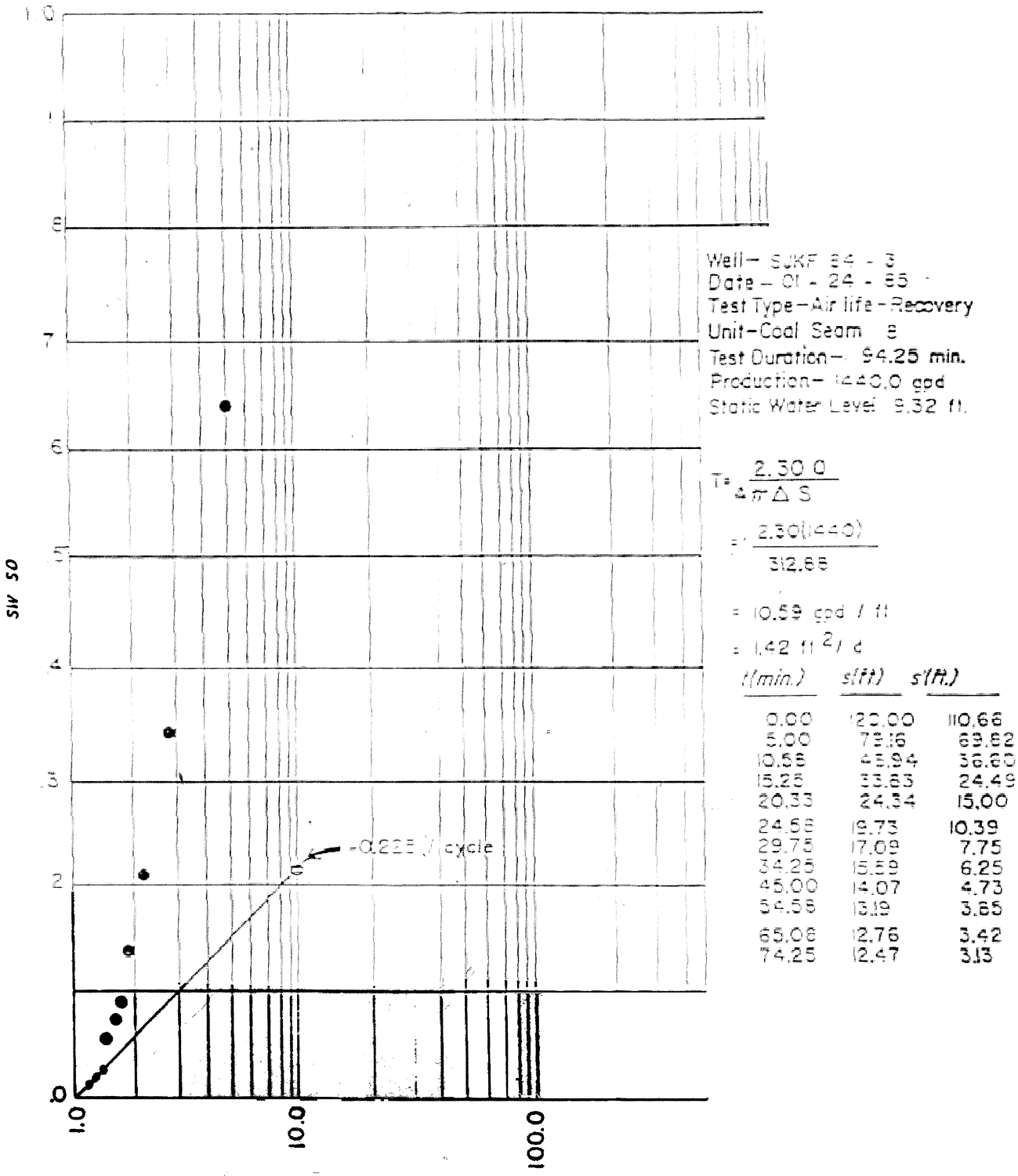

SW 50
1.0
8
7
6
5
4
3
2
0
1.0
10.0
100.0
-0.223) / cycle
Well- SJKF 84 - 3
Date - 01 - 24 - 85
Test Type-Air life-Recovery
Unit-Coal Seam 8
Test Duration- 94.25 min.
Production- 1440.0 gpd
Static Water Level 9.32 ft.
T = 2.30 Q / 4πΔS
= 2.30(1440) / 312.85
= 10.59 gpd / ft
= 1.42 ft^2 / d
t(min.) s(ft) s'(ft.)
0.00 120.00 110.66
5.00 78.16 69.82
10.58 45.94 36.60
15.28 33.83 24.49
20.33 24.34 15.00
24.58 19.73 10.39
29.75 17.09 7.75
34.25 15.59 6.25
45.00 14.07 4.73
54.58 13.19 3.85
65.08 12.76 3.42
74.25 12.47 3.13

Figure 18-9

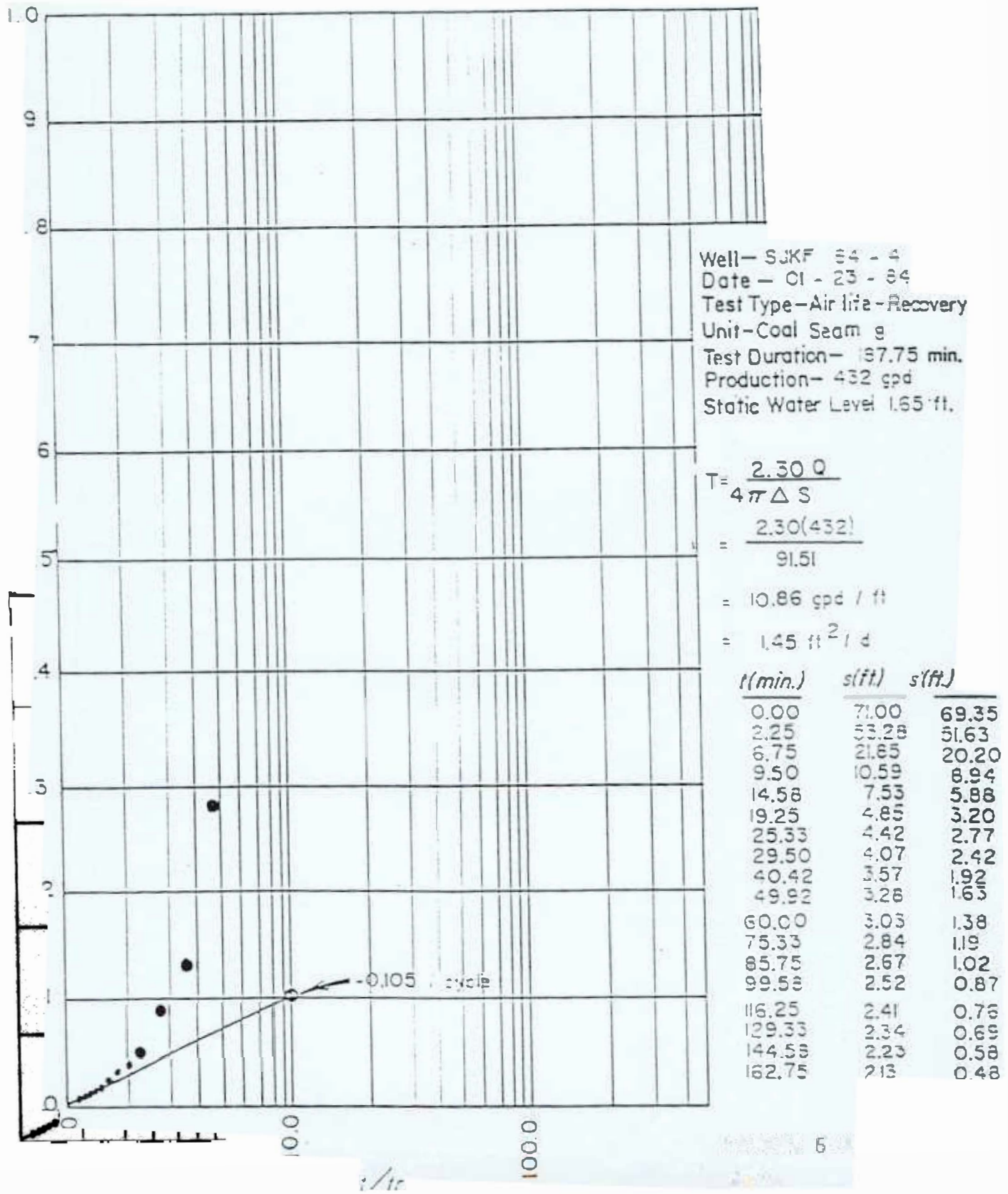

1.0
.9
.8
.7
.6
.5
.4
.3
.2
.1
0
SW SO
0.105
cycle
100.0
t/tr
Well— SJKF 84 - 4
Date — 01 - 23 - 84
Test Type—Air lift-Recovery
Unit—Coal Seam 9
Test Duration— 187.75 min.
Production— 432 gpd
Static Water Level 1.65 ft.
T = 2.30 Q / 4π Δ S
= 2.30(432) / 91.51
= 10.86 gpd / ft
= 1.45 ft² / d
t(min.) s(ft.) s'(ft.)
0.00 71.00 69.35
2.25 53.28 51.63
6.75 21.85 20.20
9.50 10.59 8.94
14.58 7.53 5.88
19.25 4.85 3.20
25.33 4.42 2.77
29.50 4.07 2.42
40.42 3.57 1.92
49.92 3.26 1.63
60.00 3.03 1.38
75.33 2.84 1.19
85.75 2.67 1.02
99.58 2.52 0.87
116.25 2.41 0.76
129.33 2.34 0.69
144.58 2.23 0.58
162.75 2.13 0.48

Figure 18-10

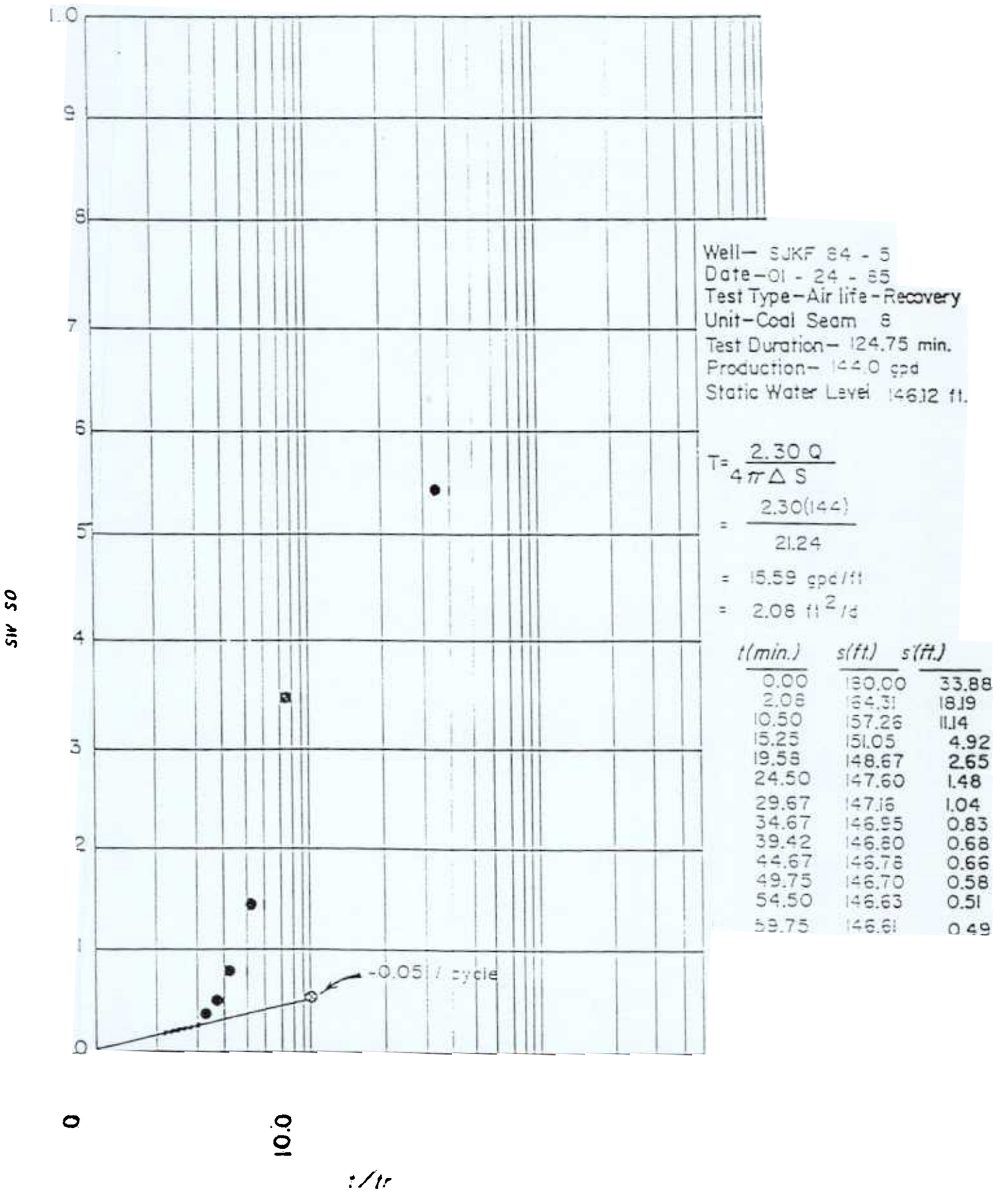

Well— SJKF 84 - 5
Date—01 - 24 - 85
Test Type—Air life-Recovery
Unit—Coal Seam 8
Test Duration— 124.75 min.
Production— 144.0 gpd
Static Water Level 146.12 ft.
T= 2.30 Q / 4πΔS
= 2.30(144) / 21.24
= 15.59 gpd/ft
= 2.08 ft²/d
t(min.) s(ft.) s'(ft.)
0.00 180.00 33.88
2.08 164.31 18.19
10.50 157.26 11.14
15.25 151.05 4.92
19.58 148.67 2.65
24.50 147.60 1.48
29.67 147.16 1.04
34.67 146.95 0.83
39.42 146.80 0.68
44.67 146.76 0.66
49.75 146.70 0.58
54.50 146.63 0.51
59.75 146.61 0.49
-0.05 / cycle
1.0
9
8
7
6
5
4
3
2
1
0
0
10.0
t/tr
SW SO

Figure 18-11

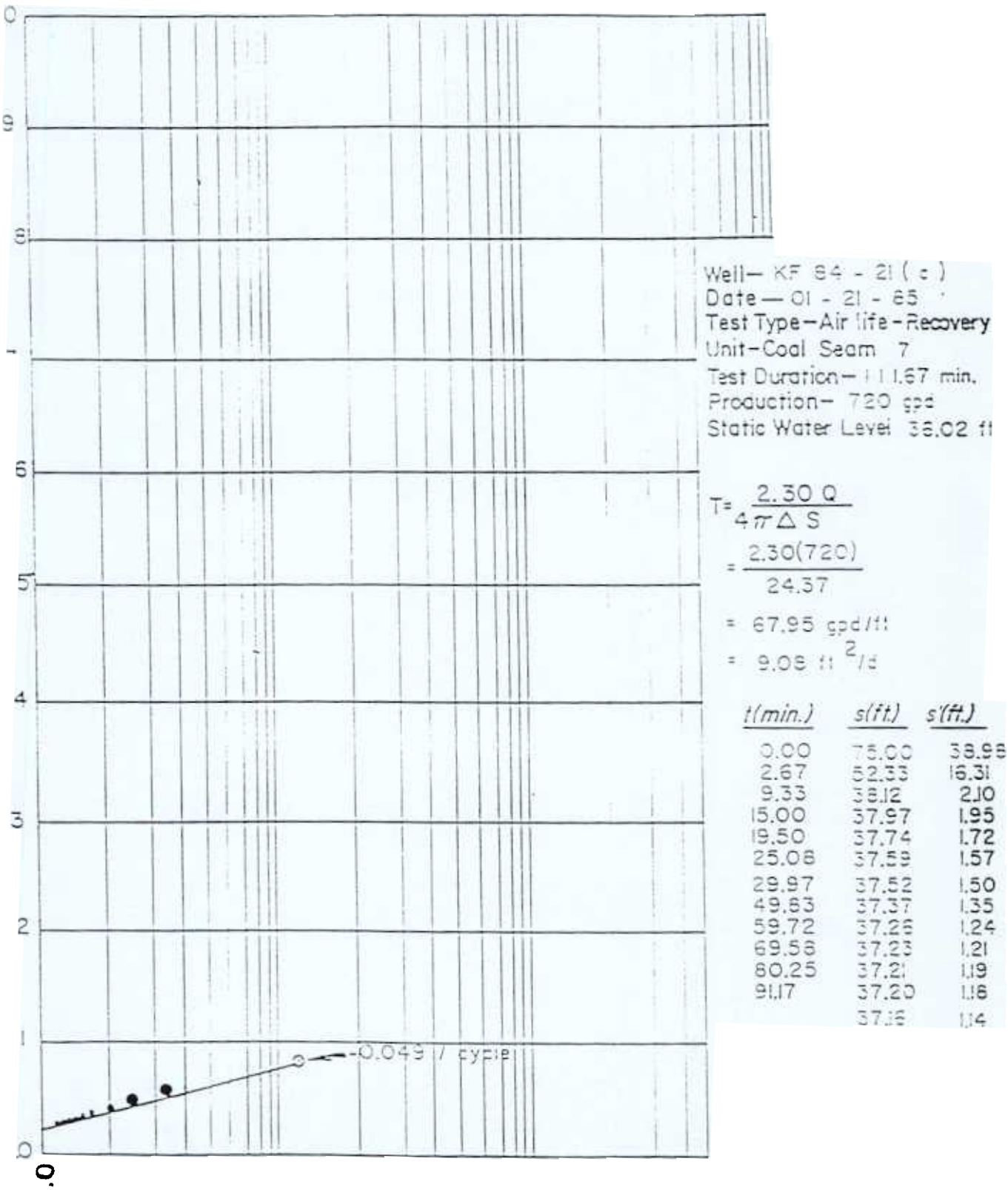

Well— KF 84 - 21 (c)
Date — 01 - 21 - 65
Test Type—Air life-Recovery
Unit—Coal Seam 7
Test Duration— 1 1.67 min.
Production— 720 gpd
Static Water Level 38.02 ft
T = 2.30 Q / 4π Δ S
= 2.30(720) / 24.37
= 67.95 gpd/ft
= 9.08 ft²/d
t(min.) s(ft.) s'(ft.)
0.00 76.00 38.98
2.67 52.33 16.31
9.33 38.12 2.10
15.00 37.97 1.95
19.50 37.74 1.72
25.08 37.59 1.57
29.97 37.52 1.50
49.83 37.37 1.35
59.72 37.26 1.24
69.58 37.23 1.21
80.25 37.21 1.19
91.17 37.20 1.18
37.16 1.14
-0.043 / cycle
0
1
2
3
4
5
6
8
9

Figure 18-12

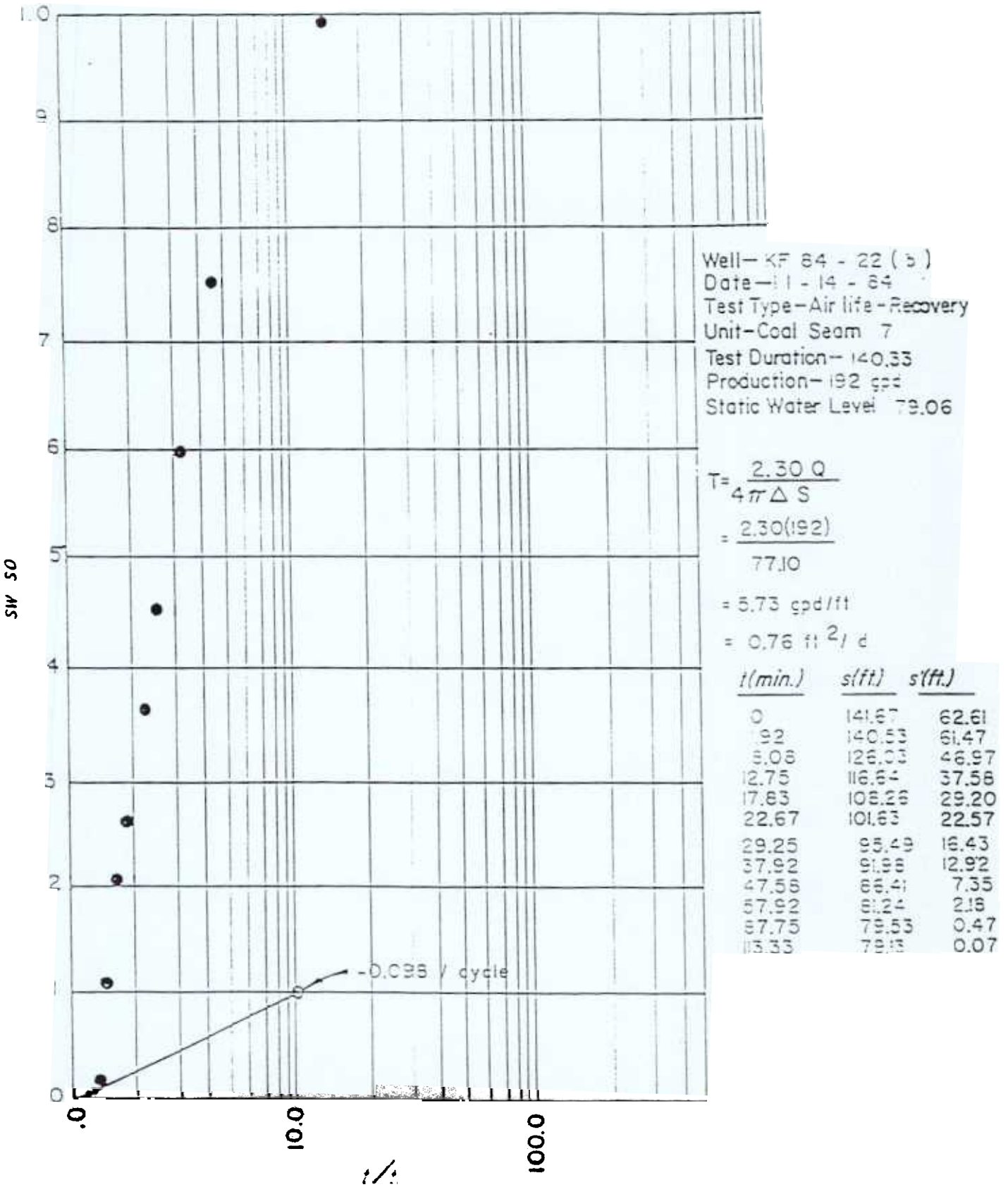

Well— KF 84 - 22 (b)
Date— 11 - 14 - 84
Test Type—Air lift - Recovery
Unit—Coal Seam 7
Test Duration— 140.33
Production— 192 gpd
Static Water Level 79.06
T= 2.30 Q / 4π Δ S
= 2.30(192) / 77.10
= 5.73 gpd/ft
= 0.76 ft²/d
t(min.) s(ft) s'(ft.)
0 141.67 62.61
.92 140.53 61.47
5.08 126.03 46.97
12.75 116.64 37.58
17.83 108.26 29.20
22.67 101.63 22.57
29.25 95.49 16.43
37.92 91.96 12.92
47.58 86.41 7.35
57.92 81.24 2.18
67.75 79.53 0.47
113.33 79.13 0.07
-0.035 / cycle
SW 50
1.0
9
8
7
6
5
4
3
2
1
0
.0
10.0
100.0
t/r²

Figure 18-13

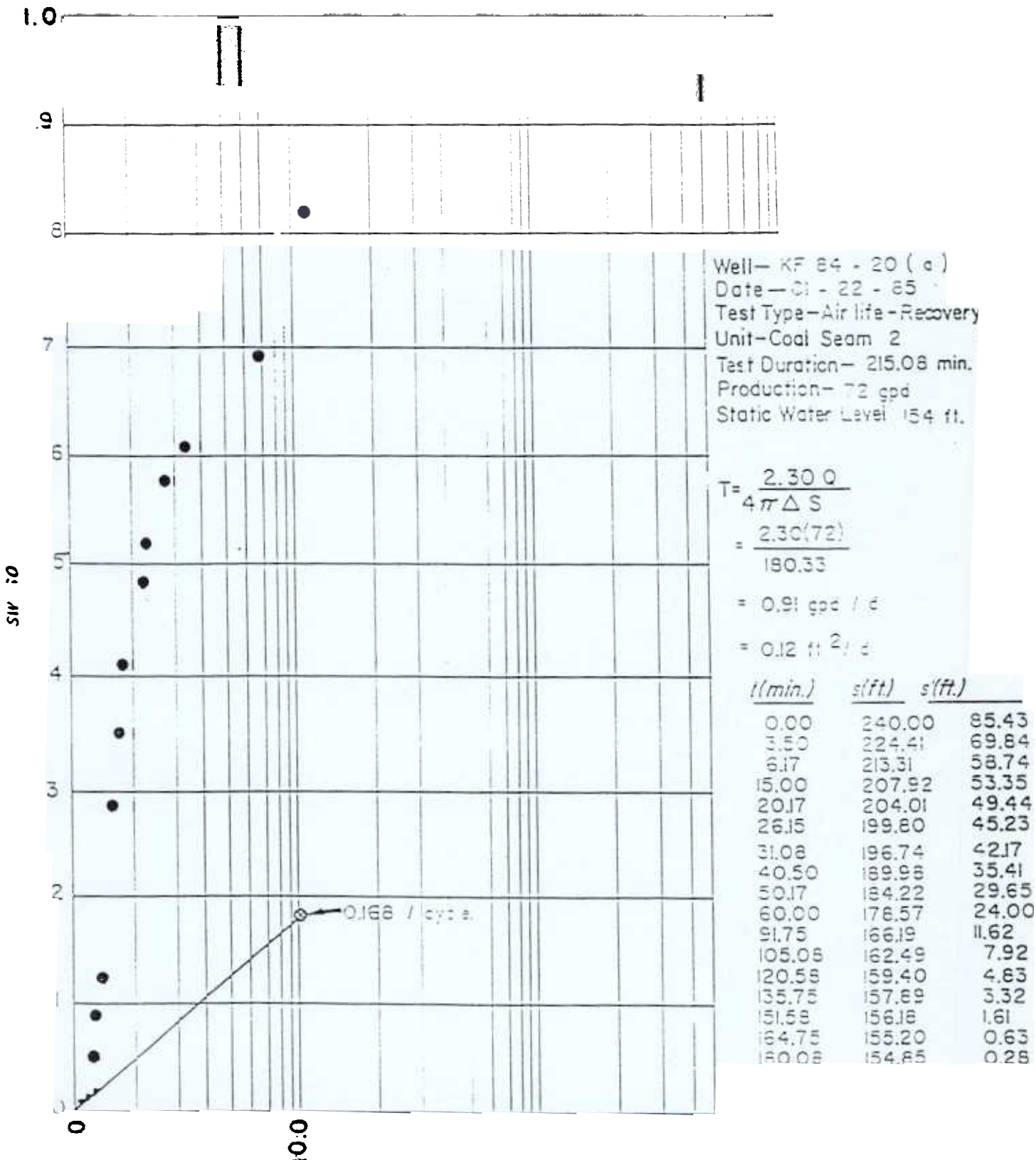
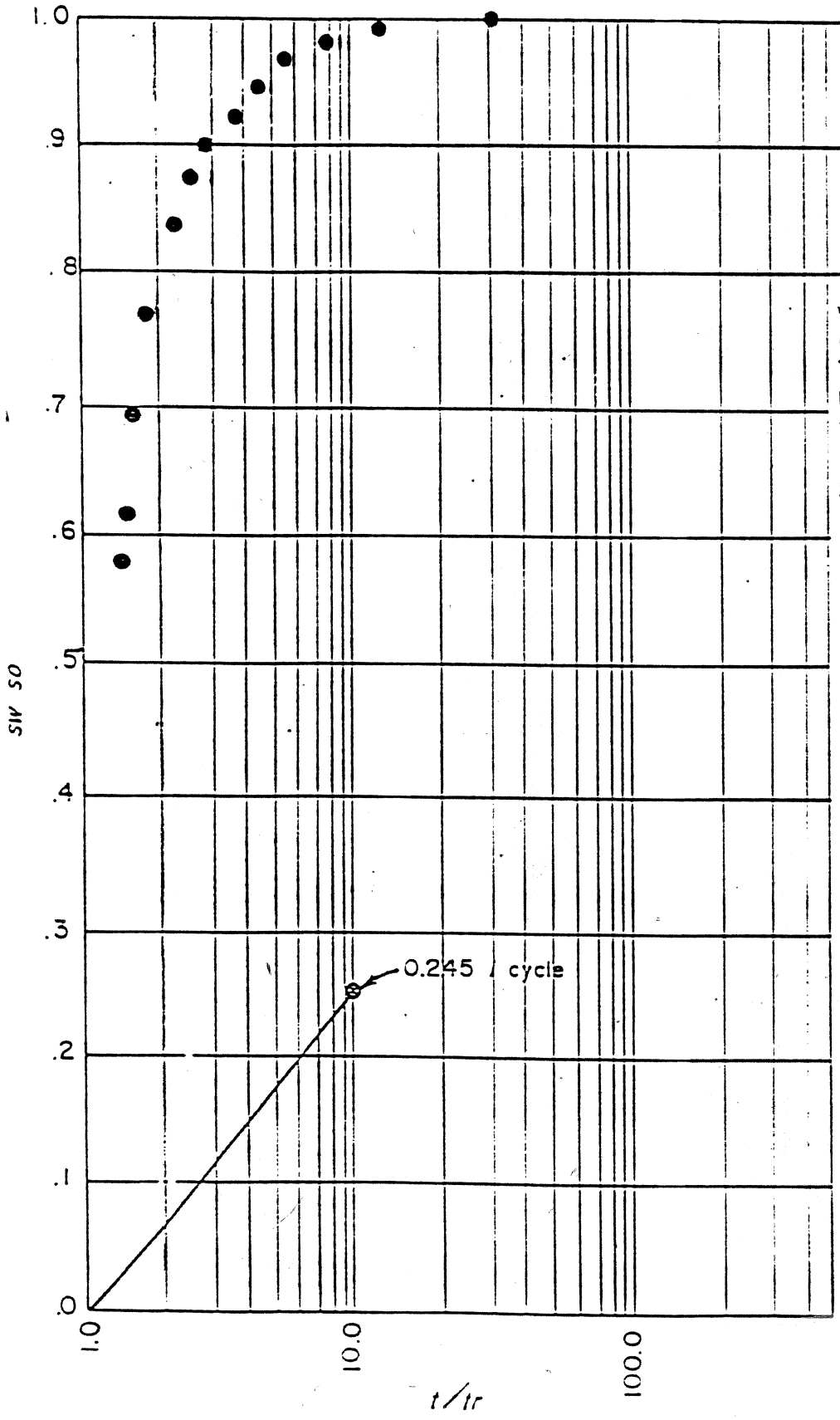

1.0
9
8
7
6
5
4
3
2
1
0
0
10.0
SW 10
Well— KF 84 - 20 (a)
Date — 01 - 22 - 85
Test Type—Air life-Recovery
Unit—Coal Seam 2
Test Duration— 215.08 min.
Production— 72 gpd
Static Water Level 154 ft.
T= 2.30 Q / 4πΔS
= 2.30(72) / 180.33
= 0.91 gpd / ft
= 0.12 ft²/d
0.168 / cycle
t(min.) s(ft.) s'(ft.)
0.00 240.00 85.43
3.50 224.41 69.84
6.17 213.31 58.74
15.00 207.92 53.35
20.17 204.01 49.44
26.15 199.80 45.23
31.08 196.74 42.17
40.50 189.98 35.41
50.17 184.22 29.65
60.00 176.57 24.00
91.75 166.19 11.62
105.05 162.49 7.92
120.58 159.40 4.83
135.75 157.89 3.32
151.58 156.18 1.61
164.75 155.20 0.63
180.08 154.85 0.28

Figure 18-14



Well– KF 84 - 22 (c)
Date– 11 - 14 - 84
Test Type–Air life - Recovery
Unit–Coal Seam 4
Test Duration– 1450.25 min.
Production– 48 gpd
Static Water Level 89.42 ft.

$$T = \frac{2.30 \cdot Q}{4\pi \Delta S}$$

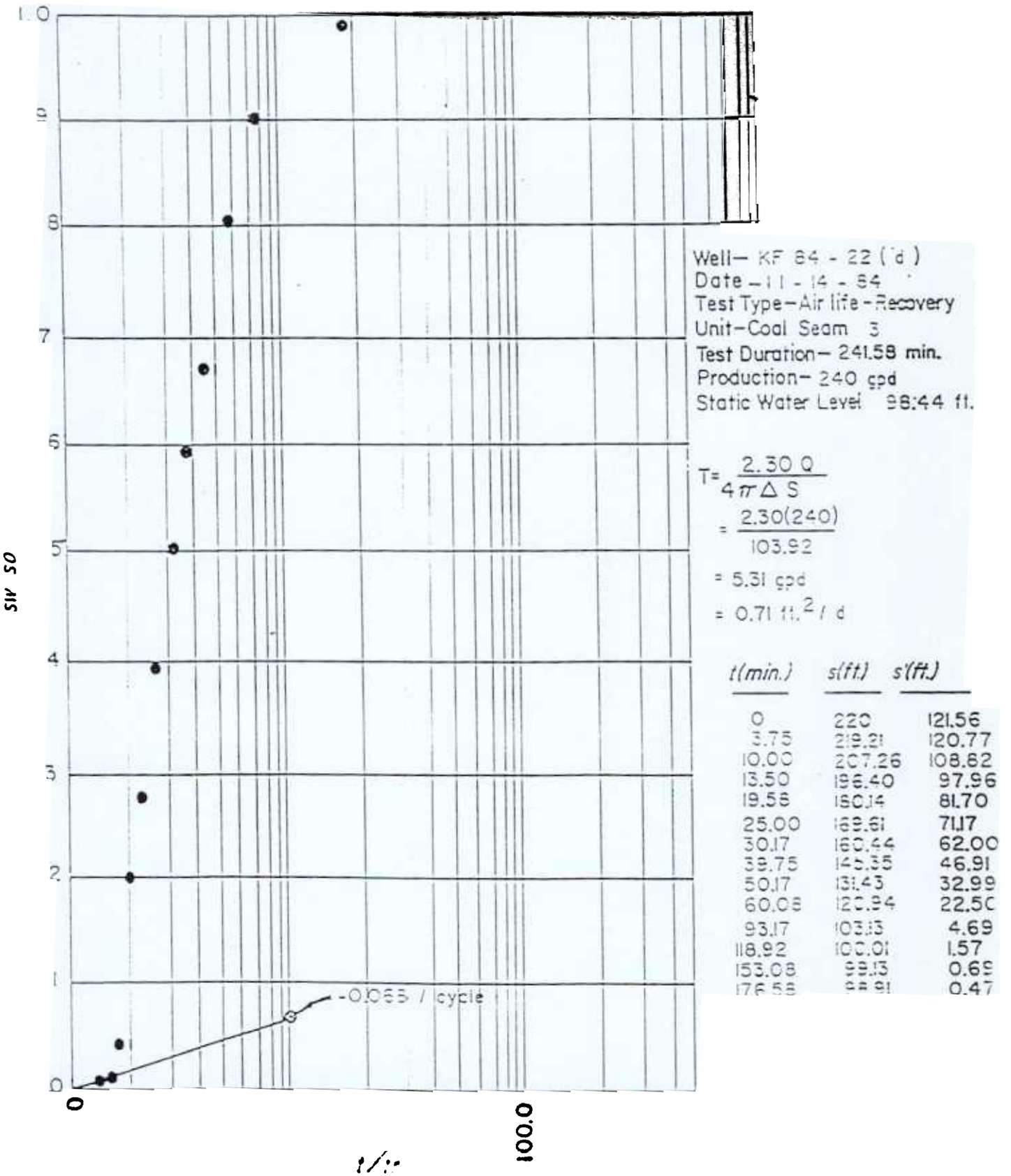
$$= \frac{2.30(48)}{961.51}$$

= 0.31 gpd / ft

= 0.04 ft^2/ d

t(min.)	s(ft.)	s'(ft.)
0	204.18	114.76
2.25	204.18	114.76
5.08	203.17	113.75
9.92	201.71	112.29
15.02	199.97	110.55
19.67	197.94	108.52
24.75	196.17	106.75
35.08	192.17	102.75
44.83	188.83	99.41
54.50	185.53	96.11
83.58	176.69	87.27
114.00	168.52	79.10
143.50	161.42	72.00
170.33	156.22	66.80
1145.17	93.64	4.22
1264.33	92.98	3.56
1385.24	92.35	2.93

Figure18-15



Well– KF 84 - 22 (d)
Date – 11 - 14 - 84
Test Type–Air life–Recovery
Unit–Coal Seam 3
Test Duration– 241.58 min.
Production– 240 gpd
Static Water Level 98.44 ft.

$$T = \frac{2.30\,Q}{4\pi\Delta S}$$

$$= \frac{2.30(240)}{103.92}$$

= 5.31 gpd

= 0.71 $ft.^2$ / d

t(min.)	s(ft.)	s'(ft.)
0	220	121.56
3.75	219.21	120.77
10.00	207.26	108.82
13.50	196.40	97.96
19.58	180.14	81.70
25.00	169.61	71.17
30.17	160.44	62.00
38.75	145.35	46.91
50.17	131.43	32.99
60.08	120.94	22.50
93.17	103.13	4.69
118.92	100.01	1.57
153.08	98.13	0.69
176.58	97.91	0.47

Figure 18-16

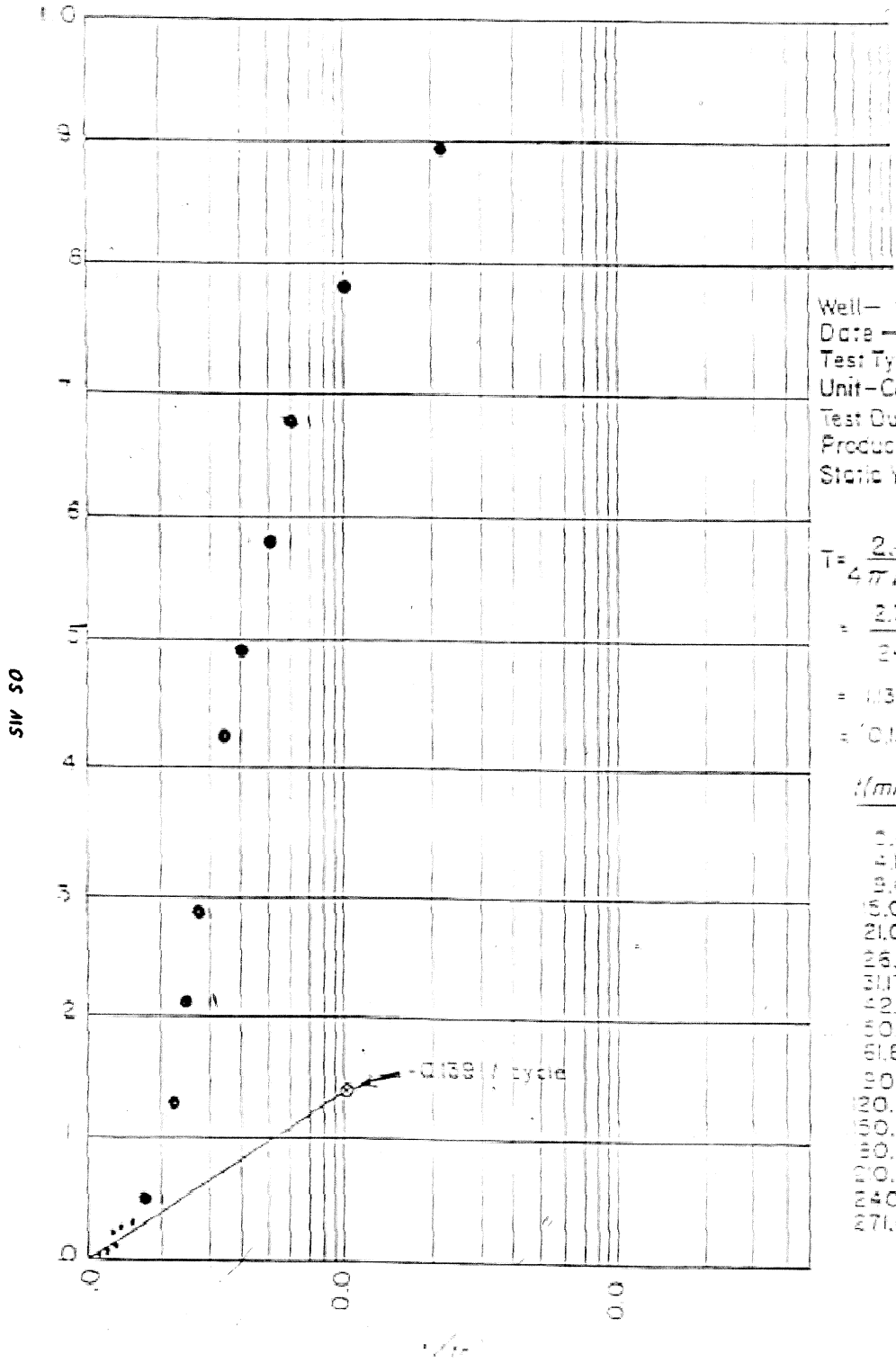
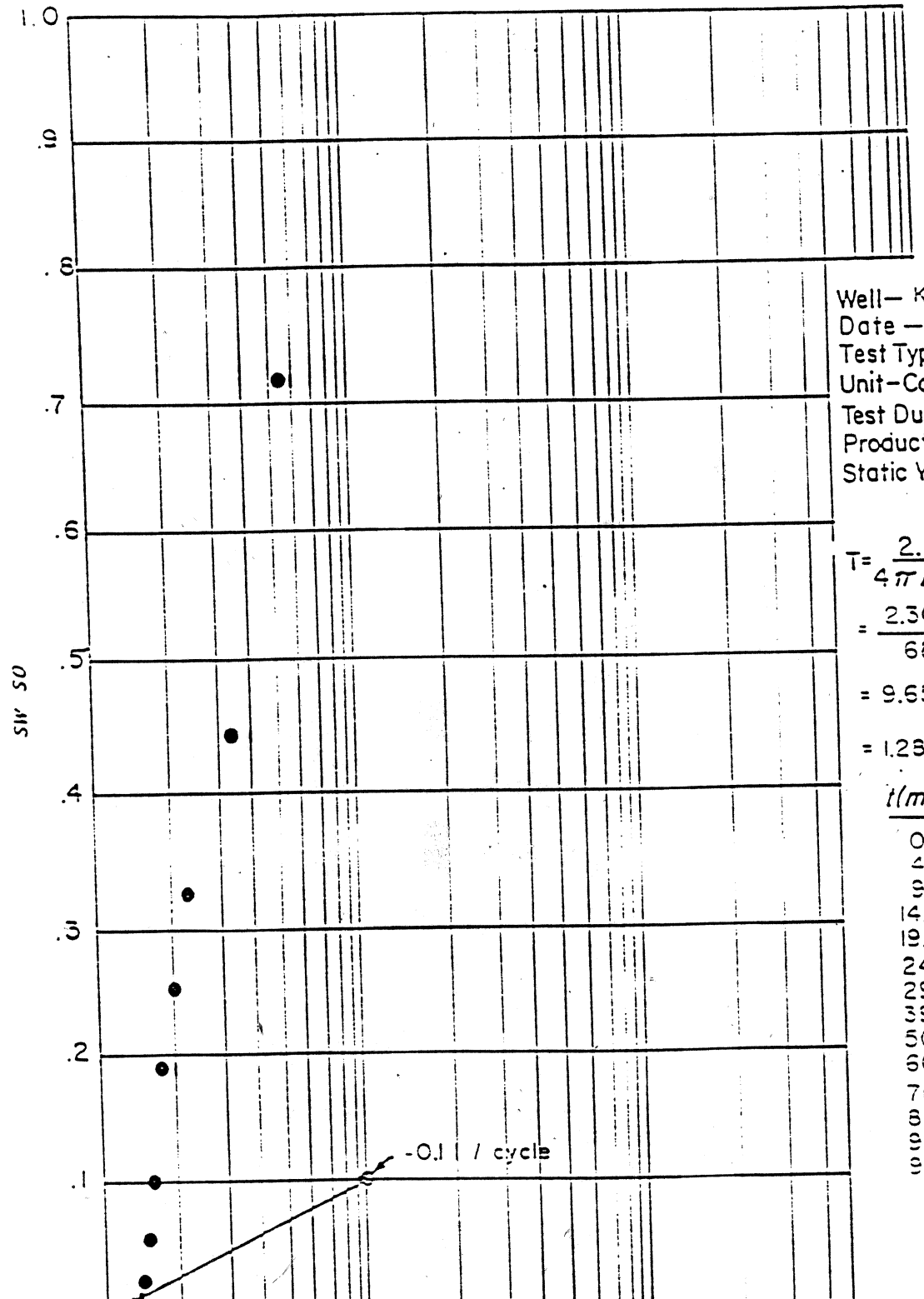

Well— [illegible] 22 (e)
Date — 11 - 13 - 84
Test Type—Air life-Recovery
Unit—Coal Seam 2
Test Duration— 361.42 min.
Production— 120 gpm
Static Water Level 9848 ft
T = 2.30 Q / 4πΔS
= 2.30(120) / 242.41
= .13 gpd
= 0.15 ft²/d
t(min.) s(ft.) s'(ft.)
5.00 337.0 138.62
7.10 222.46 124.30
9.05 207.41 109.23
15.00 192.16 94.00
21.00 177.20 79.02
26.25 166.56 68.38
31.17 158.1 59.92
42.33 139.55 41.37
50.92 127.43 29.25
61.83 116.33 18.15
90.12 104.42 6.24
120.67 103.43 5.25
150.00 102.37 4.19
180.25 101.37 3.19
210.33 100.44 2.26
240.17 100.13 1.95
271.42 99.79 1.61
-0.139 (cycle
SIN SO
0.0
0.0
0.0

Figure 18-17



Well— KF 84 - 20 d
Date —01 - 22 - 85
Test Type—Air life-Recovery
Unit—Coal Seam 7
Test Duration— 119.97 min.
Production— 288 gpd
Static Water Level 140.36 ft.

$$T = \frac{2.30\,Q}{4\pi\Delta S}$$

$$= \frac{2.30(288)}{68.61}$$

= 9.65 gpd / ft

= 1.28 ft^2 / d

t(min.)	s(ft.)	s'(ft.)
0.00	90.00	49.64
4.75	76.16	35.80
9.83	67.13	26.77
14.83	60.95	20.59
19.67	56.68	16.32
24.58	52.71	12.35
29.92	49.47	9.11
39.83	45.38	5.02
50.42	43.12	2.76
60.02	41.88	1.52
70.50	41.16	0.8
80.25	40.74	0.3
90.08	40.64	0.2
99.97	40.55	0.1

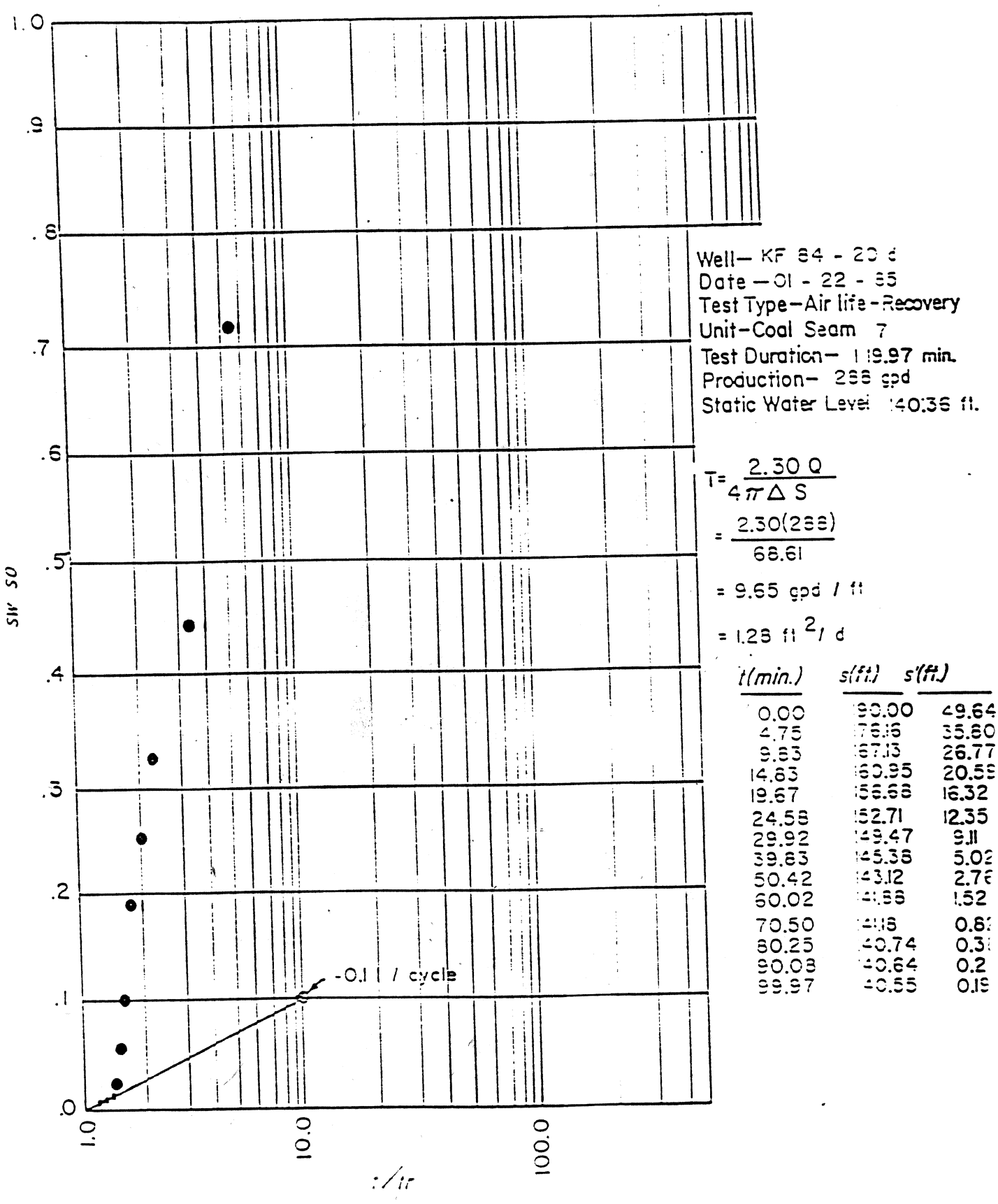
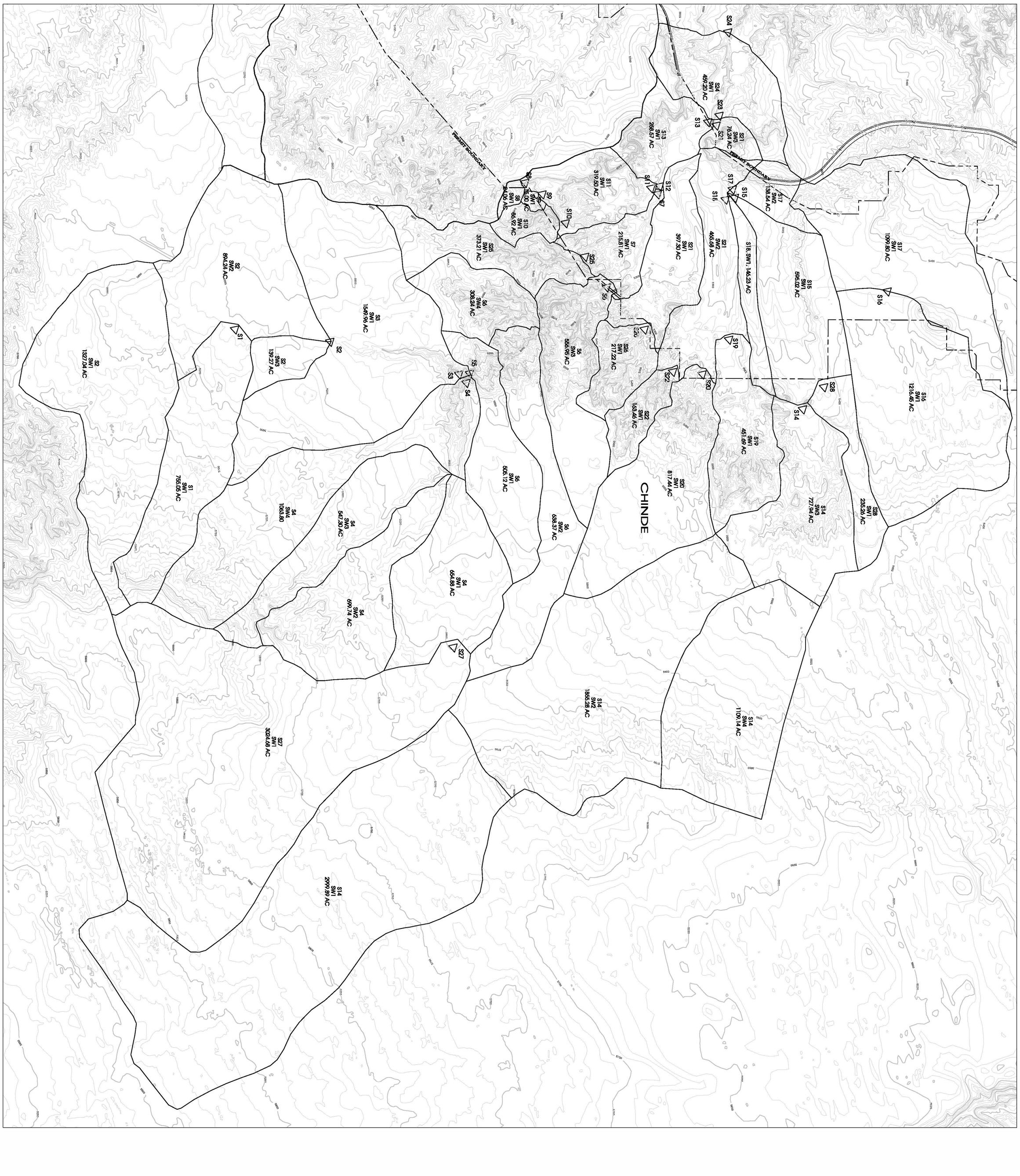

1.0
.9
.8
.7
.6
.5
.4
.3
.2
.1
.0
s/s' SO
1.0
10.0
100.0
t/tr
-0.1 l / cycle
Well— KF 84 - 20 d
Date — 01 - 22 - 85
Test Type—Air lift-Recovery
Unit—Coal Seam 7
Test Duration— 119.97 min.
Production— 288 gpd
Static Water Level 140.36 ft.
T = 2.30 Q / 4π Δ S
= 2.30(288) / 66.61
= 9.65 gpd / ft
= 1.28 ft 2/ d
t(min.) s(ft.) s'(ft.)
0.00 190.00 49.64
4.75 178.16 35.80
9.83 167.13 26.77
14.83 160.95 20.59
19.67 156.68 16.32
24.58 152.71 12.35
29.92 149.47 9.11
39.83 145.38 5.02
50.42 143.12 2.76
60.02 141.88 1.52
70.50 141.16 0.8
80.25 140.74 0.3
90.08 140.64 0.2
99.97 140.55 0.1

Figure 18-18



CERTIFICATION STATEMENT

I, Leonard Raymond, hereby certify that this drawing was reviewed by me and that the information shown is accurate and complete to the best of my knowledge.

LEONARD RAYMOND NEW MEXICO 5600 REGISTERED PROFESSIONAL ENGINEER

LEGEND

△ S1	STRUCTURE LOCATION AND DESIGNATION
SW1	SUBWATERSHED DESIGNATION
———	CHANNEL
—— – – ——	LEASE BOUNDARY

SCALE: 1" =2000

N

SHEET 0 OF

DRAWING

EXHIBIT 18-1
CHINDE ARROYO PRE–MINING SEDCAD DRAINAGE SUBDIVISION

LOCATION MAP

ACCOUNT: PERMITTING-N185A
DATE: SEPTEMBER 23, 1999
DESIGNED BY: AAYOUNG/LRAYMOND
DRAWN BY: PJFOSTER
CHECKED BY: LEONARD RAYMOND
APPROVED BY: LEONARD RAYMOND

BHP-NAVAJO COAL CO.
NAVAJO MINE
PO BOX 1717, FRUITLAND, NEW MEXICO, 87416

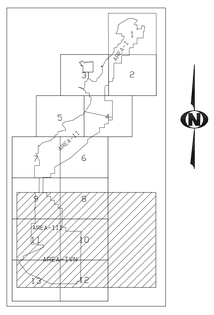
PROJECT MANAGER: DEREK J. RAWSON
ENGR. of RECORD: LEONARD RAYMOND
REG. NO: 5600
SRVYR of RECORD:
REG. NO:

	REVISION	DATE
1	Submitted to OSM for Approval	Oct.21,99
2	Updated exhibit and submitted to	Oct.13,04
3	OSM for Review.	
4		
5		

Project Desc.: Path: \\ENCNMCFMN-SRV02\Data\Departments\Gs\OSM_SUBM\PER_PROG\Ch_07-SURFACE WATER MONITORING\A2 FSC 2004\EXH 7-3_4C.pro Plot time: Tue Feb 13 10:19:52 2007

LEGEND

- PAVED ROAD
- DIRT ROAD
- HAUL ROAD
- TRAIL
- BUILDING
- FENCE
- IRRIGATION LINE
- CULVERT
- DAM
- DRAINAGE
- RAILROAD
- TREES
- POWERLINE
- × 5338.5 SPOT ELEVATION
- 5300 INDEX CONTOUR
- 5340 INTERMEDIATE CONTOUR
- 218 / 5422.45 HORIZ. & VERT. CONTROL
- L-30 LEASE CORNER
- PERMIT BOUNDARY



CERTIFICATION STATEMENT

I, Ron C. Van Valkenburg, hereby certify that this drawing has reviewed by me and that the information shown is complete and accurate to the best of my knowledge.

RON C. VAN VALKENBURG — NEW MEXICO — 9263 — REGISTERED PROFESSIONAL ENGINEER

REV. No.	DATE	DRAFT. BY	REVISION DESCRIPTION	ENGR	C.G.	P.E.	P.S.	CHIEF ENG.
11-A	FEB-2011	PJF	Area A North Revision Resubmittal to OSM for Review and Approval		MCV	SD	MCV	
10-A	7-12-09	PJF	ADDED TAN PORTION OF LOWE PIT AND SUBMITTED TO OSM FOR REVIEW		Brian Watch	YB	KAB	
B	11-15-04	PJF	ADDED TRIBUTARIES TO CHACO, PINABETE AND SUBMITTED TO OSM FOR REVIEW		LR	MC	LR	
A	5-10-01	PJF	UPDATE PERMIT EXHIBIT AND SUBMITTED TO OSM FOR REVIEW AND APPROVAL		LR	MC	LR	

APPROVALS

EXHIBIT 18-2

BHP NAVAJO COAL COMPANY

NAVAJO MINE

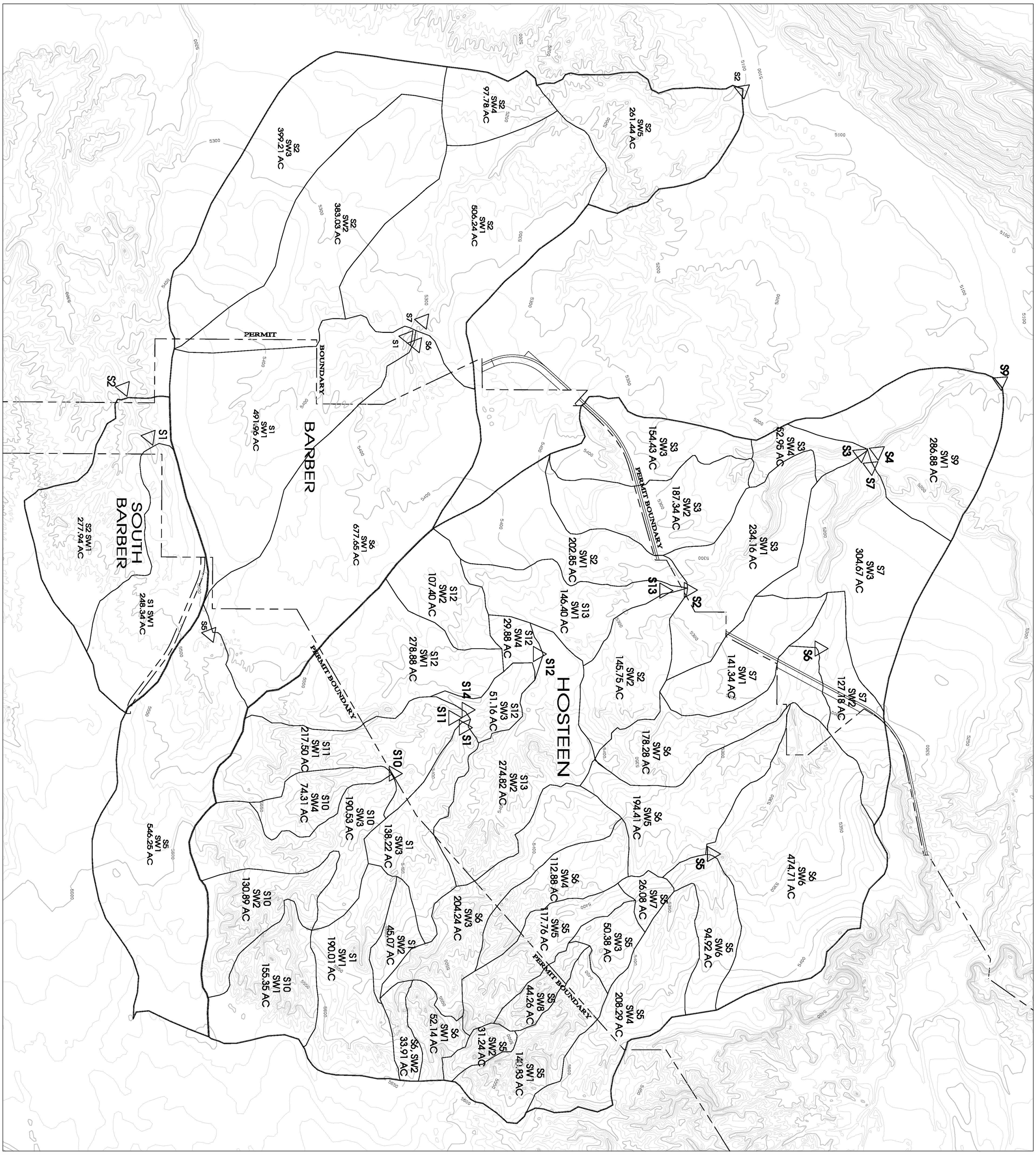
P.O. BOX 1717 FRUITLAND, NEW MEXICO 87416

LOWE, COTTONWOOD AND PINABETE ARROYO PRE-MINING SEDCAD DRAINAGE SUBDIVISIONS

PREPARED BY AAY/LR	DRAWN BY PJFOSTER	SCALE 1" = 2000'
APPROVED BY AAY/LR	DATE APRIL 27, 2001	

G:\GeNeral F\Ch 7\Exhibit 7-004\EXH 7-4_PER-MINE_ DATA.pro

Path:G:\GeNeral F\Ch 7\Exhibit 7-004\EXH 7-4_PER-MINE_ DATA.pro
Date/Time:Wed Feb 16 08:10:02 2011



CERTIFICATION STATEMENT

I, Leonard Raymond, hereby certify that this drawing was reviewed by me and that the information shown is accurate and complete to the best of my knowledge.

LEONARD RAYMOND NEW MEXICO 6600 REGISTERED PROFESSIONAL ENGINEER

NOTES :

1. THIS EXHIBIT SUPERCEDES EXHIBIT 7-4A FOR ONLY THE DATA RELATED TO THE HOSTEEN, BARBER AND SOUTH BARBER WATERSHEDS.

LEGEND

△ S1	STRUCTURE LOCATION AND DESIGNATION
SW1	SUBWATERSHED DESIGNATION
———	CHANNEL
——— – – ———	LEASE BOUNDARY

SCALE: 1"=2000

SHEET 0 OF DRAWING

EXHIBIT 18-3

HOSTEEN, BARBER AND SOUTH BARBER PRE-MINING SEDCAD DRAINAGE SUBDIVISION

LOCATION MAP

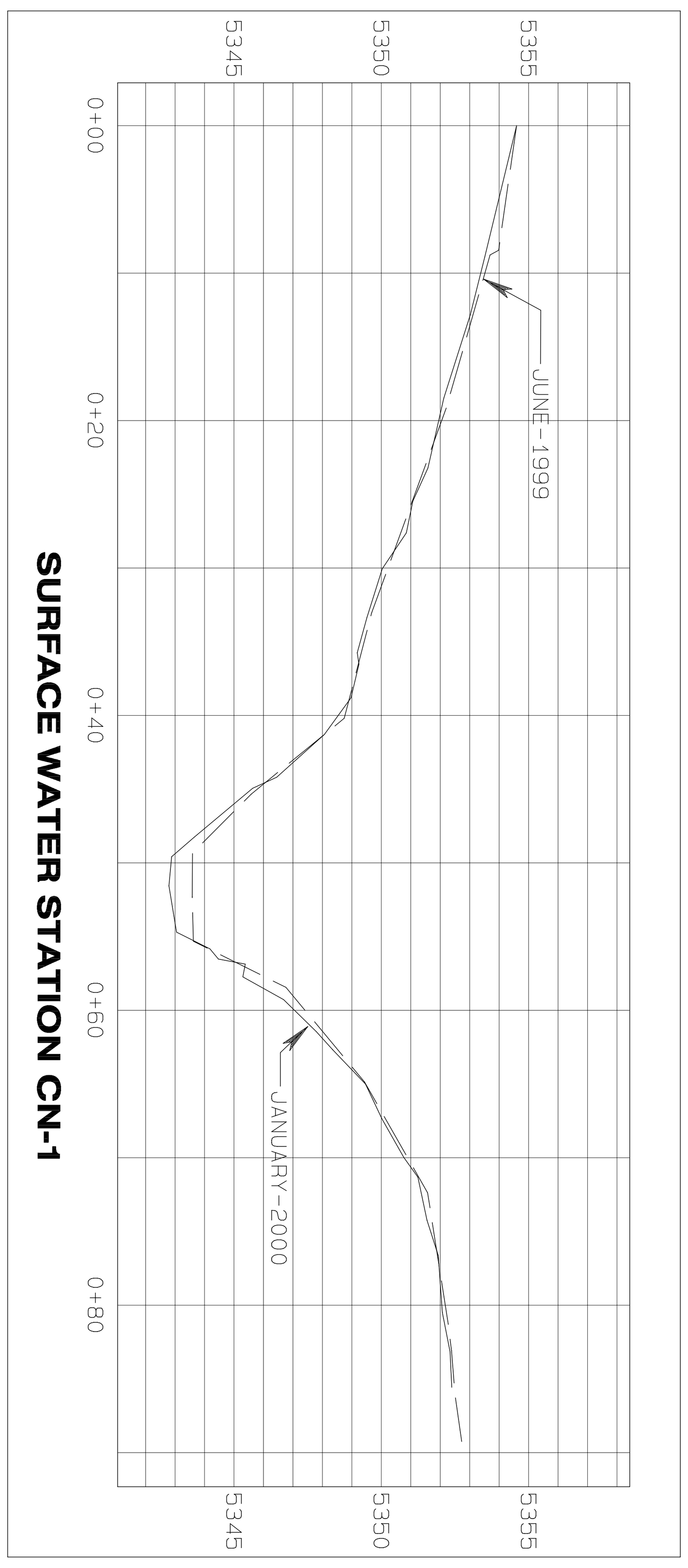
ACCOUNT: PERMITTING-N185A
DATE: SEPTEMBER 23, 1999
DESIGNED BY: AAYOUNG/LRAYMOND
DRAWN BY: PJFOSTER
CHECKED BY: LEONARD RAYMOND
APPROVED BY: LEONARD RAYMOND

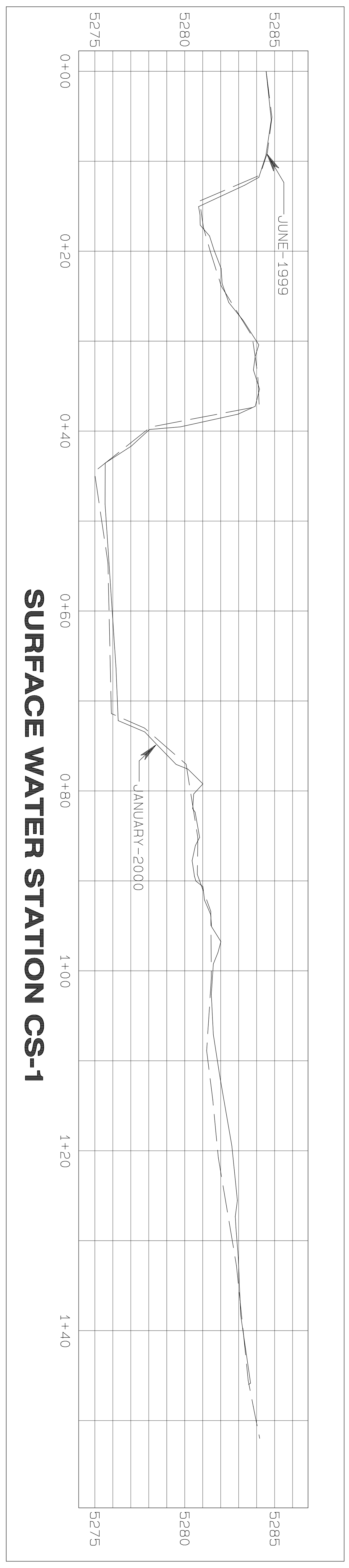
BHP-NAVAJO COAL CO.
NAVAJO MINE
PO BOX 1717, FRUITLAND, NEW MEXICO, 87416

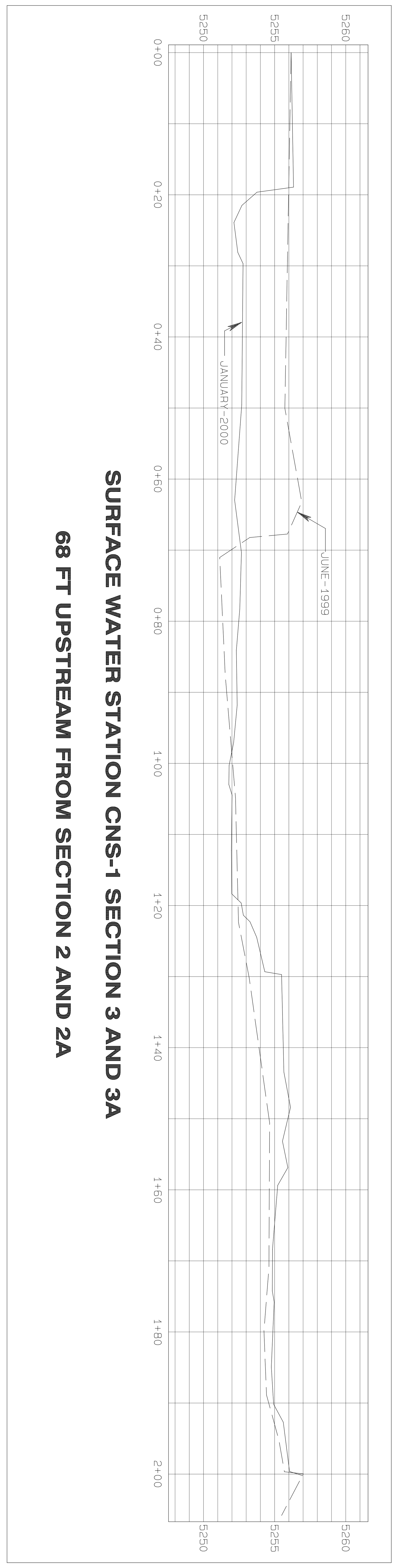
PROJECT MANAGER: DEREK J. RAWSON
ENGR. of RECORD: LEONARD RAYMOND
REG. NO: 6600
SAVYR of RECORD:
REG. NO:

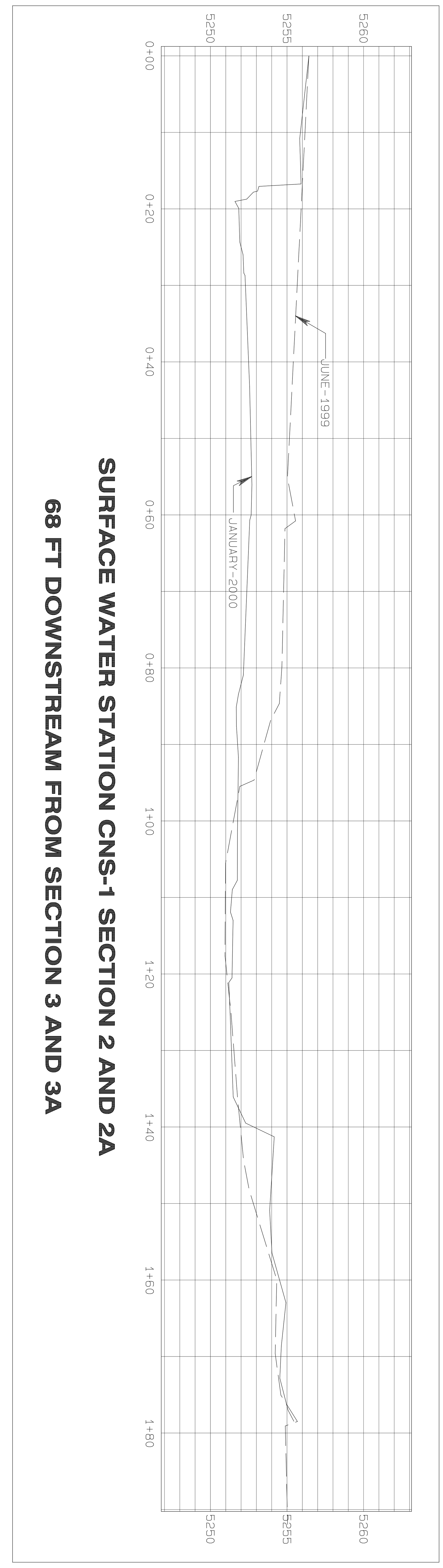
	REVISION	DATE
1	Submitted to OSM for Approval	Oct. 21, 99
2	Updated exhibit and submitted to OSM for Review.	Oct. 13, 04
3		
4		
5		

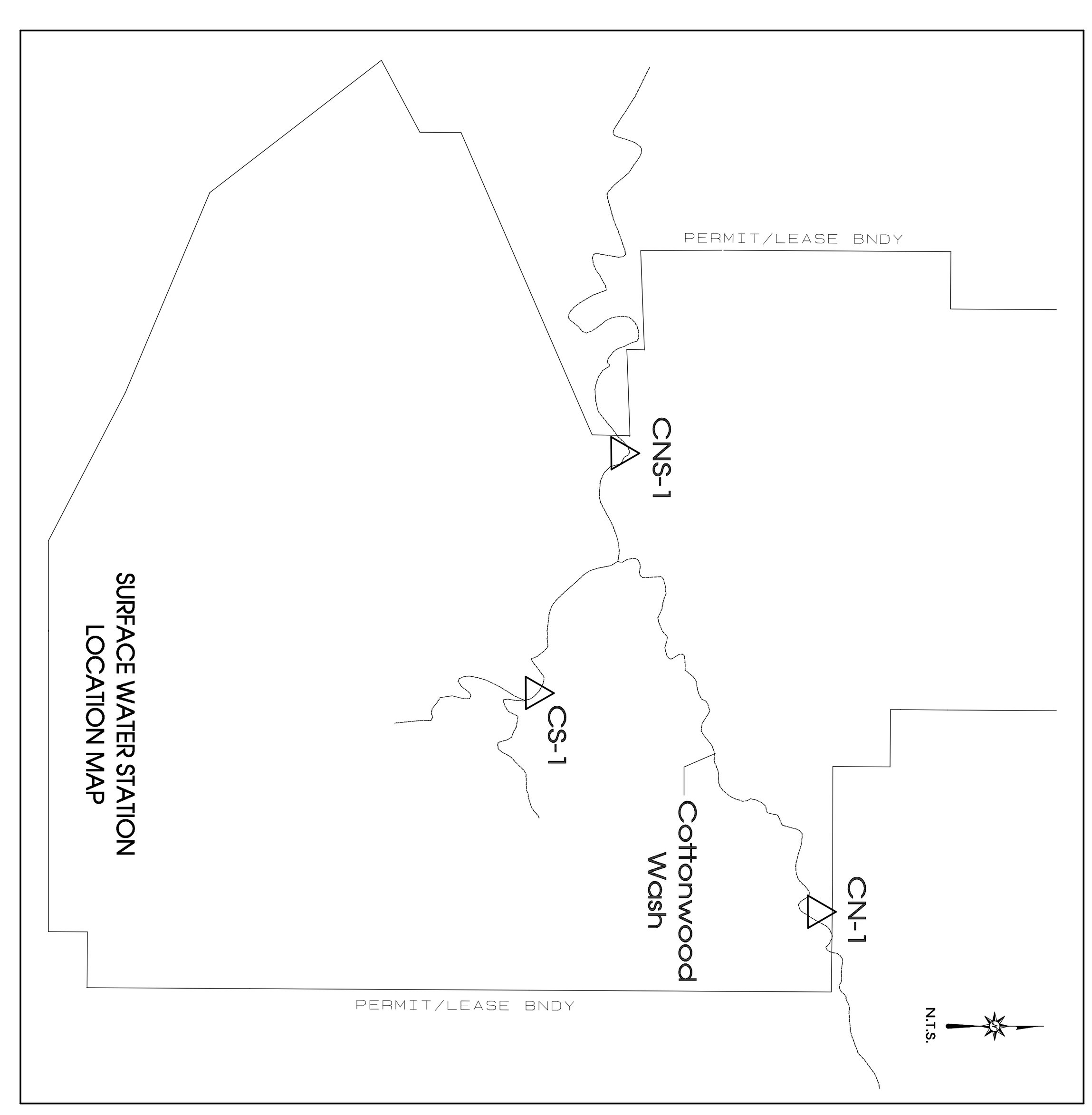
Project Desc.: Path: \\ENCNMCFMN-SRV02\Data\Departments\Gs\OSM_SUBM\PER_PROG\Ch_07-SURFACE WATER MONITORING\A2 FSC 2004\EXH 7-3_4C.pro Plot time: Tue Feb 13 10:16:47 2007











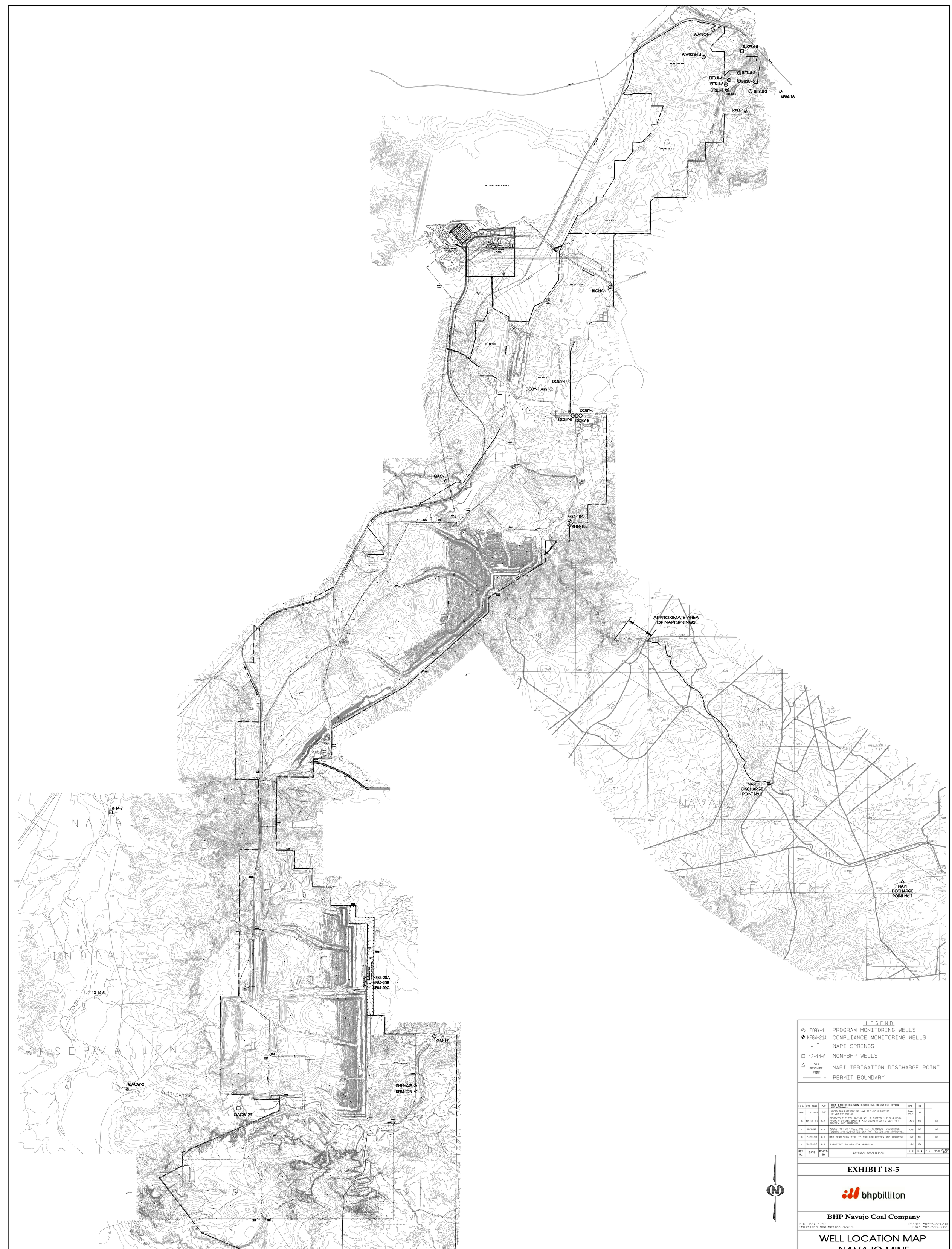
I, W. BENALLY, HEREBY CERTIFY THAT THE INFORMATION DISPLAYED ON THIS DRAWING EXHIBIT 7-6, IS COMPLETE AND ACCURATE TO THE BEST OF MY KNOWLEDGE.

SHEET OF 0	DRAWING	**EXHIBIT 18-4** CROSS-SECTIONS COTTONWOOD WASH	SURFACE WATER MONITORING STATIONS CN-1, CS-1, CNS-1 JUNE 1999 AND JANUARY 2000 SURFACES	ACCOUNT: PERMITTING-N185A DATE: JAN. 17, 2000 DESIGNED BY: AAYOUNG DRAWN BY: PJOSTER CHECKED BY: AAYOUNG APPROVED BY: AAYOUNG	**BHP-NAVAJO COAL CO.** NAVAJO MINE PO BOX 1717, FRUITLAND, NEW MEXICO, 87416

PROJECT MANAGER: CORY NELSON
ENGR. of RECORD: ANDY YOUNG
REG. NO:
SRVYR of RECORD: W. BENALLY
REG. NO: 11952

REV NO	DESCRIPTION	REV BY	DATE
1	SUBMITTED TO OSM	PJF	2-29-00
2			
3			
4			
5			

Project Desc.: Path: \\ENCNMCFMN-SRV02\Data\Departments\Gs\OSM_SUBM\PER_PROG\Ch_07-SURFACE WATER MONITORING\COTTONWOOD WASH\EXH 7-6-CTNWD WH.pro
Plot time: Tue Feb 13 10:01:04 2007



LEGEND

◎ DOBY-1	PROGRAM MONITORING WELLS
✤ KF84-21A	COMPLIANCE MONITORING WELLS
δ 9	NAPI SPRINGS
□ 13-14-6	NON-BHP WELLS
△ NAPI DISCHARGE POINT	NAPI IRRIGATION DISCHARGE POINT
———	PERMIT BOUNDARY

REV. No.	DATE	DRAFT. BY	REVISION DESCRIPTION	E.G.	E.G.	P.E.	RPLS	CHIEF ENG.
11-A	FEB-2011	PJF	AREA 4 NORTH REVISION RESUBMITTAL TO OSM FOR REVIEW AND APPROVAL.	MPQ	SD			
09-A	7-12-09	PJF	ADDED 100 EASTSIDE OF LOWE PIT AND SUBMITTED TO OSM FOR REVIEW.	Shawn Smith	YB			
D	12-10-01	PJF	REMOVED THE FOLLOWING WELLS CUSTER-1, 2, 3, 4, KF84, KF84, KF84-21A, QACW-1 AND SUBMITTED TO OSM FOR REVIEW AND APPROVAL.	AAY	MC		WB	
C	6-3-99	PJF	ADDED NON-BHP WELL AND NAPI SPRINGS, DISCHARGE POINTS AND SUBMITTED OSM FOR REVIEW AND APPROVAL.	AAY	MC		WB	
B	7-29-98	PJF	MID TERM SUBMITTAL TO OSM FOR REVIEW AND APPROVAL.	GW	MC		WB	
A	5-29-97	PJF	SUBMITTED TO OSM FOR APPROVAL.	GW	GW			

EXHIBIT 18-5

bhpbilliton

BHP Navajo Coal Company
P.O. Box 1717
Fruitland, New Mexico, 87416
Phone: 505-598-4200
Fax: 505-568-3361

WELL LOCATION MAP
NAVAJO MINE
MARCH, 1997

PREPARED BY GW/PJF	DRAWN BY PJF	SCALE 1" = 2000'
APPROVED BY	DATE MAR. 16, 1997	MYLAR LOC.

G:\Gs\Permit F\Ch 6\Exhibit 6-001\EXH 6-1.pro
Thu Feb 10 11:46:04 2011

Path: G:\Gs\Permit F\Ch 6\Exhibit 6-001\EXH 6-1.pro
PJFoster \Thu Feb 10 11:46:04 2011

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

FRUITLAND QUADRANGLE
NEW MEXICO - SAN JUAN CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)

NAVAJO RESERVATION BOUNDARY

MORGAN LAKE

A1

A2

A3

A4

UNSATURATED

SATURATED

5360
5340
5320
5300
5280
5260
5240
5220

Surface Use Permit Boundary

Southern Permit Boundary

N

LEGEND

- IMPROVED DIRT ROAD
- DIRT ROAD
- PAVED ROAD
- RAILROAD
- MINE SITES
- Drill Hole ○ DRILL HOLE
- WATER WELL
- PIPELINE
- 5450 CONTOUR ELEVATIONS
- x5356 ELEVATIONS
- DEPRESSION
- HIGH VOLTAGE POWER LINE
- TAILINGS PONDS
- BUILDINGS
- A.P.S. PROPERTY LINE
- Oil Well ○ OIL WELL
- RIVER
- HOME SITES
- PONDS
- AQUEDUCT

KF84 NO. 22 ⊙ PIEZOMETER
CONTOUR INTERVAL = 20 FT.
PERMIT BOUNDARY
BHP NAVAJO COAL COMPANY
LEASE BOUNDARY
⑤ AREA LOCATION
NAVAJO RESERVATION BOUNDARY

CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL

EXHIBIT18-6

bhpbilliton

NAVAJO COAL COMPANY
P.O. BOX 1717
FRUITLAND, NEW MEXICO 87418
PHONE (505) 598-5809
Fax (505) 598-3951

NO. 8 COAL SEAM POTENTIOMETRIC SURFACE

DRAWN BY J. GOLBE | SCALE: 1" = 2000'
APPROVED BY: JCH | DATE: AUG. 1985
DRAWING NO. | LOCATION NO.

REV. NO.	DATE	REVISIONS	APPROVALS: DRAFT BY:	ENGR.	CHIEF ENGR.	PROJECT MGR.
1	11 / 87	PUT REVISION BLOCK ON, CHANGED CO. NAME TO BHP-UI, REMOVED NUMBER IN TITLE BLOCK, CONFIDENTIAL STATEMENT ADDED SOUTHERN BOUNDARY	GG.			
2	9-11-93	ADDED NEW ESH. NO. FORMER NLK A,B,C & D BOUNDARY AND CHANGE CO. NAME.	PJF			
3	FEB-2011	AREA 4 NORTH REVISION RESUBMITTAL TO OSM FOR REVIEW AND APPROVAL	PJF	MPO		

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

FRUITLAND QUADRANGLE
NEW MEXICO - SAN JUAN CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)

A1

A2

A3

A4

A4

LEGEND

IMPROVED DIRT ROAD
DIRT ROAD
PAVED ROAD
RAILROAD
MINE SITES
Drill Hole DRILL HOLE
WATER WELL
PIPELINE
5450 CONTOUR ELEVATIONS
x5356 ELEVATIONS
DEPRESSION
HIGH VOLTAGE POWER LINE
TAILINGS PONDS
BUILDINGS
A.P.S. PROPERTY LINE
Oil Well OIL WELL
RIVER
HOME SITES
PONDS
AQUEDUCT

KF84 PIEZOMETER LOCATION
PERMIT BOUNDARY
BHP NAVAJO COAL COMPANY LEASE BOUNDARY
5 AREA LOCATION
NAVAJO RESERVATION BOUNDARY

EXHIBIT18-7

bhpbilliton

NAVAJO COAL COMPANY
P.O. BOX 1717, FRUITLAND, NEW MEXICO 87416
PHONE (505) 598-3000
FAX (505) 598-3361

NO. 7 COAL SEAM
POTENTIOMETRIC
SURFACE

DRAWN BY J. GOLBE | SCALE 1"= 6000'
APPROVED BY | DATE AUG. 1983
DRAWING NO. | LOCATION NO.

REV. NO.	DATE	REVISIONS	APPROVALS: DRAFT	ENGR.	CHIEF ENGR.	PROJECT MGR.
1	11/87	PUT REVISION BLOCK ON. CHANGED CO. NAME TO BHP-UI. REMOVED CONFIDENTIAL STATEMENT. PUT EXHIBIT NUMBER IN TITLE BL. OUT.	CG			
2	9-11-93	ADDED NEW EXH. NO. FORMER NUK A,B,C & D BOUNDARY AND CHANGE CO. NAME.	PJF			
3	FEB-2011	AREA 4 NORTH REVISION RESUBMITTAL TO OSM FOR REVIEW AND APPROVAL	PJF	MPO		

CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
FRUITLAND QUADRANGLE
NEW MEXICO—SAN JUAN CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)
NAVAJO RESERVATION BOUNDARY
MORGAN LAKE
A1
A2
A3
A4
LEGEND
IMPROVED DIRT ROAD
DIRT ROAD
PAVED ROAD
RAILROAD
MINE SITES
DRILL HOLE
WATER WELL
PIPELINE
CONTOUR ELEVATIONS
ELEVATIONS
DEPRESSION
HIGH VOLTAGE POWER LINE
TAILINGS PONDS
BUILDINGS
A.P.S. PROPERTY LINE
OIL WELL
RIVER
HOME SITES
PONDS
AQUEDUCT
KF84-20
PIEZOMETER
CONTOUR INTERVAL = 5 FT.
PERMIT BOUNDARY
BHP NAVAJO COAL COMPANY LEASE BOUNDARY
AREA LOCATION
NAVAJO RESERVATION BOUNDARY
EXHIBIT18-8
bhpbilliton
NAVAJO COAL COMPANY
P.O. BOX 1717
FRUITLAND, NEW MEXICO 87416
APPROVALS
DRAFT BY
ENGR.
CHIEF ENGR.
PROJECT MGR.
REVISIONS
GG
PJF
PJF
MPO
Nº4, & 6 COAL SEAM
POTENTIOMETRIC
SURFACE MAP
DRAWN BY J. GOLBE
SCALE 1" = 2000'
APPROVED BY
DATE AUG. 1983
DRAWING NO.
LOCATION NO.

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

FRUITLAND QUADRANGLE
NEW MEXICO - SAN JUAN CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)

NAVAJO RESERVATION BOUNDARY

MORGAN LAKE

A1

A2

A3

A4

Surface Use Permit Boundary

Southern Permit Boundary

KF84-20(c)

KF84-10(c)

KF84-21(c)

KF84-22(d)

KF84-22(c)

LEGEND

- IMPROVED DIRT ROAD
- DIRT ROAD
- PAVED ROAD
- RAILROAD
- MINE SITES
- Drill Hole — DRILL HOLE
- WATER WELL
- PIPELINE
- 5450 — CONTOUR ELEVATIONS
- x5356 ELEVATIONS
- DEPRESSION
- HIGH VOLTAGE POWER LINE
- TAILINGS PONDS
- BUILDINGS
- A.P.S. PROPERTY LINE
- Oil Well — OIL WELL
- RIVER
- HOME SITES
- PONDS
- AQUEDUCT
- KF84-22 — PIEZOMETER
- CONTOUR INTERVAL = 1 FT.
- PERMIT BOUNDARY
- BHP NAVAJO COAL COMPANY LEASE BOUNDARY
- ③ AREA LOCATION
- NAVAJO RESERVATION BOUNDARY

CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL

EXHIBIT18-9

bhpbilliton

NAVAJO COAL COMPANY
P.O. BOX 1717
FRUITLAND, NEW MEXICO 87416
PHONE (505) 598-3009
Fax (505) 598-3061

REV. NO.	DATE	REVISIONS	APPROVALS: DRAFT QT.	ENGR.	CHIEF ENGR.	PROJECT MGR.
1	11/87	PUT REVISION BLOCK ON, CHANGED CO. CHANGED TO BHP-UM, PUT EXHIBIT NUMBER IN TITLE BLOCK, REMOVED CONFIDENTIAL STATEMENT, ADDED SOUTHERN PERMIT BOUNDARY	CG			
2	9-11-93	ADDED NEW EXH. NO., FORMER NUX A,B,C & D BOUNDARY AND CHANGE CO. NAME.	PJF			
3	FEB-2011	AREA 4 NORTH REVISION RESUBMITTAL TO OSM FOR REVIEW AND APPROVAL	PJF	MPO		

N°2 & 3 COAL SEAM
POTENTIOMETRIC
SURFACE MAP

DRAWN BY J. GOLBE | SCALE 1" = 6000'
APPROVED BY [illegible] | DATE AUG 1983
DRAWING NO. | LOCATION NO.

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

FRUITLAND QUADRANGLE
NEW MEXICO - SAN JUAN CO.
7.5 MINUTE SERIES (TOPOGRAPHIC)

NAVAJO RESERVATION BOUNDARY

SJKF84-2
SJKF84-3
SJKF84-4
KF84-15
KF84-16
KF85-1
KF83-2 (Dry)
KF84-17 (Plugged)
CUSTER 5 (dry)
KF83-3 (Dry)
GM9
GM10
KF84-18
KF83
KF84-19
KF84-20
KF85-9(a)(b)(c)
KF84-20(a)(b)(c)(d)
KF85-10(a)(b)(c)(d)
GM17
KF84-22(a)(b)(c)(d)(e)
CWM-2
GM16
GM30
T4-1

MORGAN LAKE

Surface Use Permit Boundary

Coalmine Permit Boundary

CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL

LEGEND

- IMPROVED DIRT ROAD
- DIRT ROAD
- PAVED ROAD
- RAILROAD
- MINE SITES
- Drill Hole O DRILL HOLE
- WATER WELL
- PIPELINE
- 5450 CONTOUR ELEVATIONS
- x5356 ELEVATIONS
- DEPRESSION
- HIGH VOLTAGE POWER LINE
- TAILINGS PONDS
- BUILDINGS
- A.P.S. PROPERTY LINE
- Oil Well O OIL WELL
- RIVER
- HOME SITES
- PONDS
- AQUEDUCT
- ▲ GM AND T4 WELLS
- KF83-1 PIEZOMETER OR WELL LOCATION
- PERMIT BOUNDARY
- BHP NAVAJO COAL COMPANY LEASE BOUNDARY
- (5) AREA LOCATION
- NAVAJO RESERVATION BOUNDARY

REV NO	DATE	REVISIONS	APPROVALS: DRAFT BY	ENGR	CHIEF SURV	PROJECT MGR.
4	FEB-2011	AREA 4 NORTH REVISION RESUBMITTAL TO OSM FOR REVIEW AND APPROVAL	PJF	MPO		
3	9-11-93	ADDED NEW EXH. NO., FORMER BLK A,B,C & D BOUNDARY AND CHANGE CO. NAME	PJF			
1	11/87	PUT REVISION BLOCK ON, CHANGED CO. NAME TO BHP-UT, PUT PERMIT NUMBER IN TITLE BLOCK, CONFIDENTIAL STATEMENT ADDED SOUTHERN PERMIT BOUNDARY	GB			
2	1/89	ADDED NEW EXH. NO. FORMER BLK A,B,C & D BOUNDARY AND CHANGE CO., NAME.	JG	RHB		

EXHIBIT 18-10

bhpbilliton

NAVAJO COAL COMPANY
P.O. BOX 1717
FRUITLAND, NEW MEXICO 87416
PHONE (505) 598-3500
Fax (505) 598-3251

LOCATION OF WELL/ PIEZOMETER SITES

DRAWN BY J. GOLDE | SCALE 1" = 2000'
APPROVED BY [illegible] | DATE AUG. 1983
DRAWING NO | LOCATION NO

Appendix 18.A

Chide Arroyo Pre-Mine Hydrology & Sedimentology

(2 YR-6 HR, 10 YR-6 HR, 25 YR-6 HR & 100 YR-6 HR Storm Events)

Chinde Arroyo Pre-mine Hydrology and Sedimentology

The hydrology model and drainage subdivisions are presented on Exhibit 7-3.

LR

BHP Navajo Coal Company
Navajo Mine
PO Box 1717
Fruitland, NM 87415

Phone: 505-598-5861

General Information

Storm Information:

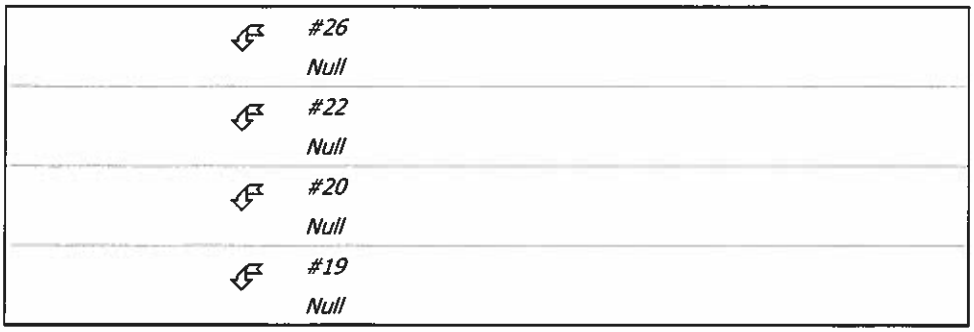
Storm Type:	NRCS Type II
Design Storm:	2 yr - 6 hr
Rainfall Depth:	0.800 inches

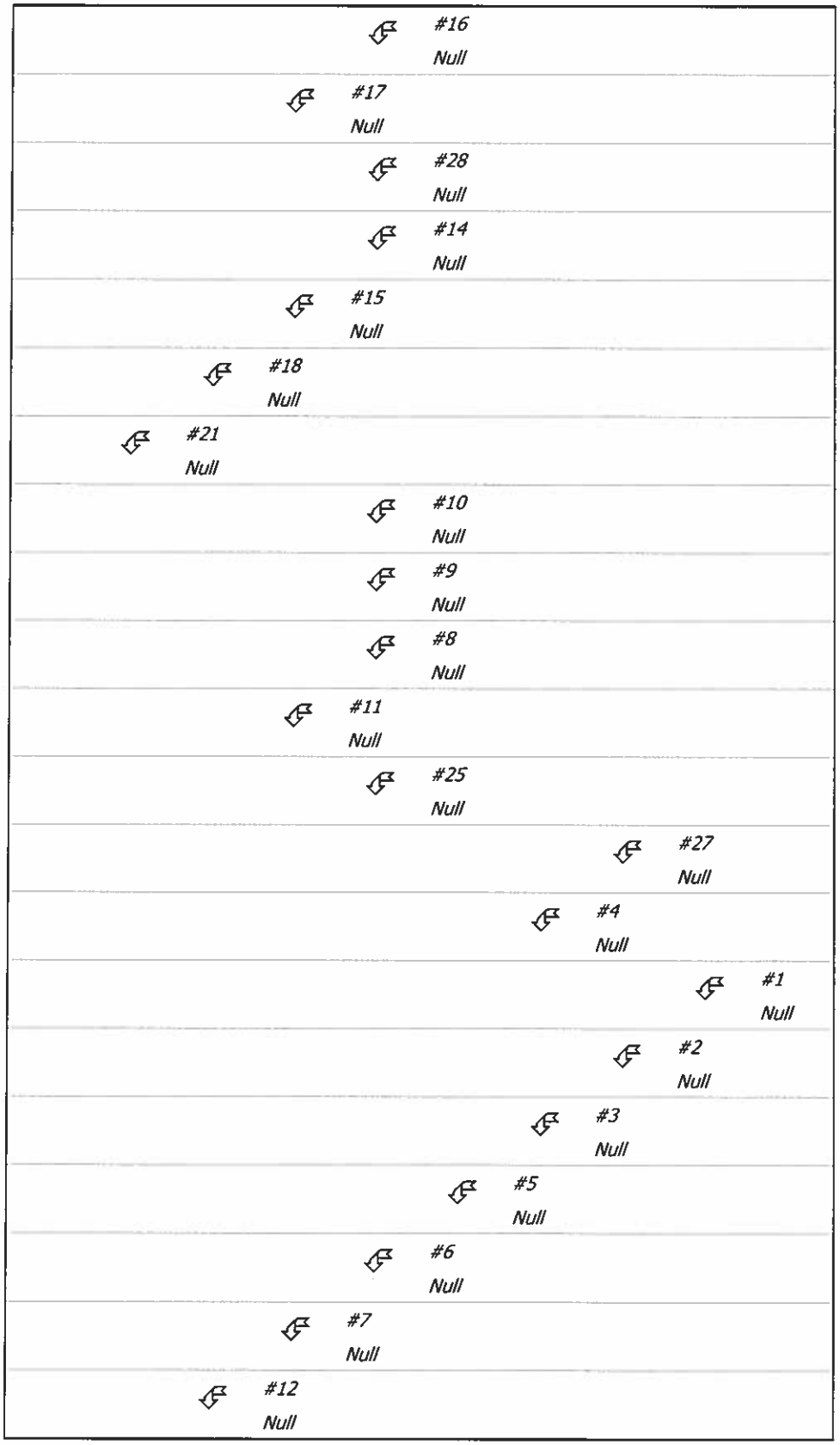
Particle Size Distribution:

Size (mm)	Badland Premining	Badland Postmining	LoamySand Premining	LoamySand Postmining
2.0000	100.000%	100.000%	100.000%	100.000%
0.1000	83.500%	75.900%	30.000%	26.500%
0.0500	77.000%	70.000%	17.000%	14.000%
0.0020	56.000%	47.000%	11.000%	11.000%
0.0010	0.000%	0.000%	0.000%	0.000%

Structure Networking:

Type	Stru #	(flows into)	Stru #	Musk. K (hrs)	Musk. X	Description
Null	#1	==>	#2	2.257	0.138	
Null	#2	==>	#3	0.484	0.354	
Null	#3	==>	#5	0.000	0.000	
Null	#4	==>	#5	0.000	0.000	
Null	#5	==>	#6	0.736	0.343	
Null	#6	==>	#7	0.505	0.313	
Null	#7	==>	#12	0.000	0.000	
Null	#8	==>	#11	0.421	0.362	
Null	#9	==>	#11	0.390	0.360	
Null	#10	==>	#11	0.378	0.343	
Null	#11	==>	#12	0.000	0.000	
Null	#12	==>	#13	0.378	0.332	
Null	#13	==>	#23	0.000	0.000	
Null	#14	==>	#15	0.821	0.337	
Null	#15	==>	#18	0.000	0.000	
Null	#16	==>	#17	1.675	0.310	
Null	#17	==>	#18	0.000	0.000	
Null	#18	==>	#21	0.314	0.334	
Null	#19	==>	#21	0.870	0.329	
Null	#20	==>	#21	1.002	0.331	
Null	#21	==>	#23	0.000	0.000	
Null	#22	==>	#21	0.988	0.335	
Null	#23	==>	#24	0.507	0.290	
Null	#24	==>	End	0.000	0.000	
Null	#25	==>	#7	0.420	0.337	
Null	#26	==>	#21	0.921	0.331	
Null	#27	==>	#4	1.069	0.340	
Null	#28	==>	#15	0.778	0.333	




#16
Null
#17
Null
#28
Null
#14
Null
#15
Null
#18
Null
#21
Null
#10
Null
#9
Null
#8
Null
#11
Null
#25
Null
#27
Null
#4
Null
#1
Null
#2
Null
#3
Null
#5
Null
#6
Null
#7
Null
#12
Null

	#13
	Null
#23	
Null	
#24	
Null	

Structure Routing Details:

Stru #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#1	5. Nearly bare and untilled, and alluvial valley fans	0.44	23.00	5,282.49	0.65	2.257
#1	**Muskingum K:**					**2.257**
#2	8. Large gullies, diversions, and low flowing streams	1.89	136.00	7,189.00	4.12	0.484
#2	**Muskingum K:**					**0.484**
#5	8. Large gullies, diversions, and low flowing streams	1.53	150.00	9,810.33	3.70	0.736
#5	**Muskingum K:**					**0.736**
#6	8. Large gullies, diversions, and low flowing streams	0.91	47.00	5,184.00	2.85	0.505
#6	**Muskingum K:**					**0.505**
#8	8. Large gullies, diversions, and low flowing streams	2.23	151.00	6,785.00	4.47	0.421
#8	**Muskingum K:**					**0.421**
#9	8. Large gullies, diversions, and low flowing streams	2.12	130.00	6,127.00	4.36	0.390
#9	**Muskingum K:**					**0.390**
#10	8. Large gullies, diversions, and low flowing streams	1.53	77.00	5,040.00	3.70	0.378
#10	**Muskingum K:**					**0.378**
#12	8. Large gullies, diversions, and low flowing streams	1.25	57.00	4,562.00	3.35	0.378
#12	**Muskingum K:**					**0.378**
#14	8. Large gullies, diversions, and low flowing streams	1.39	145.00	10,445.00	3.53	0.821
#14	**Muskingum K:**					**0.821**
#16	5. Nearly bare and untilled, and alluvial valley fans	0.80	33.00	4,101.41	0.89	1.280
	8. Large gullies, diversions, and low flowing streams	1.88	110.00	5,854.00	4.11	0.395
#16	**Muskingum K:**					**1.675**
#18	8. Large gullies, diversions, and low flowing streams	1.29	50.00	3,863.00	3.41	0.314
#18	**Muskingum K:**					**0.314**

Stru #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#19	8. Large gullies, diversions, and low flowing streams	1.19	122.00	10,247.00	3.27	0.870
#19	**Muskingum K:**					**0.870**
#20	8. Large gullies, diversions, and low flowing streams	1.23	147.00	11,977.51	3.32	1.002
#20	**Muskingum K:**					**1.002**
#22	8. Large gullies, diversions, and low flowing streams	1.33	163.00	12,276.00	3.45	0.988
#22	**Muskingum K:**					**0.988**
#23	8. Large gullies, diversions, and low flowing streams	0.61	26.00	4,271.00	2.34	0.507
#23	**Muskingum K:**					**0.507**
#25	8. Large gullies, diversions, and low flowing streams	1.37	73.00	5,314.00	3.51	0.420
#25	**Muskingum K:**					**0.420**
#26	8. Large gullies, diversions, and low flowing streams	1.25	138.00	11,075.00	3.34	0.921
#26	**Muskingum K:**					**0.921**
#27	8. Large gullies, diversions, and low flowing streams	1.44	200.00	13,863.00	3.60	1.069
#27	**Muskingum K:**					**1.069**
#28	8. Large gullies, diversions, and low flowing streams	1.29	123.00	9,531.18	3.40	0.778
#28	**Muskingum K:**					**0.778**

Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc. (ml/l)	24VW (ml/l)
#26	217.200	217.200	40.96	4.13	275.3	91,763	4.63	3.01
#22	163.500	163.500	23.86	2.81	140.5	67,654	1.31	0.87
#20	817.400	817.400	7.74	3.19	20.8	7,612	3.22	2.54
#19	451.700	451.700	18.34	4.37	106.1	29,219	0.00	0.00
#16	1,216.500	1,216.500	1.73	0.58	1.5	3,048	1.92	1.45
#17	1,238.300	2,454.800	7.58	4.98	32.8	19,524	8.32	2.71
#28	235.300	235.300	0.30	0.07	0.2	3,577	2.30	1.81
#14	6,692.200	6,692.200	20.25	15.13	100.3	16,047	1.51	0.55
#15	595.000	7,522.500	24.46	16.80	110.8	14,348	1.94	0.80
#18	146.200	10,123.500	28.72	22.03	145.5	17,272	3.57	1.24
#21	939.200	12,712.500	102.27	44.80	835.5	52,480	5.27	1.71
#10	86.900	86.900	19.01	1.65	135.0	115,081	8.72	5.52
#9	15.000	15.000	6.06	0.28	18.0	77,058	20.01	11.85
#8	24.100	24.100	9.74	0.46	25.6	68,327	17.74	10.50
#11	319.500	445.500	58.64	7.08	442.5	79,675	4.15	2.85
#25	373.200	373.200	23.37	4.23	152.5	45,283	0.00	0.00
#27	3,024.700	3,024.700	7.60	4.74	12.4	3,211	1.72	1.30
#4	2,965.700	5,990.400	23.19	12.51	48.4	4,876	2.52	1.78
#1	755.100	755.100	2.93	1.07	4.2	4,518	2.74	2.21
#2	2,360.500	3,115.600	10.59	7.15	18.4	2,959	1.29	0.97
#3	1,550.000	4,665.600	29.02	16.04	59.6	4,787	1.95	1.37
#5	0.000	10,656.000	49.85	28.56	108.0	4,762	2.17	1.55
#6	2,008.700	12,664.700	71.52	42.12	540.6	67,292	5.26	0.97
#7	215.800	13,253.700	82.23	50.40	868.5	58,345	3.18	0.89
#12	0.000	13,699.200	105.90	57.47	1,311.0	463,163	24.85	1.13
#13	258.600	13,957.800	109.38	60.02	1,354.6	64,614	1.94	0.63
#23	0.000	26,670.300	210.52	104.82	2,190.1	53,342	3.03	1.10
#24	459.200	27,129.500	215.45	109.05	2,252.1	50,262	2.05	0.78

Particle Size Distribution(s) at Each Structure

Structure #26:

Size (mm)	In/Out
2.0000	100.000%
0.1000	100.000%
0.0500	100.000%
0.0020	85.802%
0.0010	0.000%

Structure #22:

Size (mm)	In/Out
2.0000	100.000%
0.1000	100.000%
0.0500	100.000%
0.0020	94.560%
0.0010	0.000%

Structure #20:

Size (mm)	In/Out
2.0000	100.000%
0.1000	98.857%
0.0500	56.019%
0.0020	36.248%
0.0010	0.000%

Structure #19:

Size (mm)	In/Out
2.0000	100.000%
0.1000	100.000%
0.0500	100.000%

Size (mm)	In/Out
0.0020	100.000%
0.0010	0.000%

Structure #16:

Size (mm)	In/Out
2.0000	100.000%
0.1000	44.768%
0.0500	25.369%
0.0020	16.415%
0.0010	0.000%

Structure #17:

Size (mm)	In/Out
2.0000	100.000%
0.1000	82.513%
0.0500	55.432%
0.0020	36.017%
0.0010	0.000%

Structure #28:

Size (mm)	In/Out
2.0000	100.000%
0.1000	40.904%
0.0500	23.179%
0.0020	14.998%
0.0010	0.000%

Structure #14:

Size (mm)	In/Out
2.0000	100.000%
0.1000	95.865%
0.0500	89.926%
0.0020	86.160%
0.0010	0.000%

Structure #15:

Size (mm)	In/Out
2.0000	100.000%
0.1000	93.544%
0.0500	85.229%
0.0020	80.465%
0.0010	0.000%

Structure #18:

Size (mm)	In/Out
2.0000	100.000%
0.1000	90.450%
0.0500	77.749%
0.0020	69.623%
0.0010	0.000%

Structure #21:

Size (mm)	In/Out
2.0000	100.000%
0.1000	97.123%
0.0500	91.375%
0.0020	82.506%
0.0010	0.000%

Structure #10:

Size (mm)	In/Out
2.0000	100.000%
0.1000	100.000%
0.0500	100.000%
0.0020	78.968%
0.0010	0.000%

Structure #9:

Size (mm)	In/Out
2.0000	100.000%
0.1000	83.500%

Size (mm)	In/Out
0.0500	77.000%
0.0020	56.000%
0.0010	0.000%

Structure #8:

Size (mm)	In/Out
2.0000	100.000%
0.1000	83.500%
0.0500	77.000%
0.0020	56.000%
0.0010	0.000%

Structure #11:

Size (mm)	In/Out
2.0000	100.000%
0.1000	98.377%
0.0500	97.737%
0.0020	88.149%
0.0010	0.000%

Structure #25:

Size (mm)	In/Out
2.0000	100.000%
0.1000	100.000%
0.0500	100.000%
0.0020	100.000%
0.0010	0.000%

Structure #27:

Size (mm)	In/Out
2.0000	100.000%
0.1000	69.139%
0.0500	39.179%
0.0020	25.351%
0.0010	0.000%

Structure #4:

Size (mm)	In/Out
2.0000	100.000%
0.1000	74.076%
0.0500	41.976%
0.0020	27.161%
0.0010	0.000%

Structure #1:

Size (mm)	In/Out
2.0000	100.000%
0.1000	50.796%
0.0500	28.784%
0.0020	18.625%
0.0010	0.000%

Structure #2:

Size (mm)	In/Out
2.0000	100.000%
0.1000	89.195%
0.0500	53.972%
0.0020	34.923%
0.0010	0.000%

Structure #3:

Size (mm)	In/Out
2.0000	100.000%
0.1000	96.680%
0.0500	58.253%
0.0020	37.693%
0.0010	0.000%

Structure #5:

Size (mm)	In/Out
2.0000	100.000%
0.1000	86.551%

Size (mm)	In/Out
0.0500	50.959%
0.0020	32.974%
0.0010	0.000%

Structure #6:

Size (mm)	In/Out
2.0000	100.000%
0.1000	98.983%
0.0500	91.873%
0.0020	88.173%
0.0010	0.000%

Structure #7:

Size (mm)	In/Out
2.0000	100.000%
0.1000	99.379%
0.0500	94.953%
0.0020	90.994%
0.0010	0.000%

Structure #12:

Size (mm)	In/Out
2.0000	100.000%
0.1000	99.041%
0.0500	95.893%
0.0020	90.034%
0.0010	0.000%

Structure #13:

Size (mm)	In/Out
2.0000	100.000%
0.1000	100.000%
0.0500	98.885%
0.0020	92.958%
0.0010	0.000%

Structure #23:

Size (mm)	In/Out
2.0000	100.000%
0.1000	98.903%
0.0500	96.020%
0.0020	88.970%
0.0010	0.000%

Structure #24:

Size (mm)	In/Out
2.0000	100.000%
0.1000	100.000%
0.0500	97.951%
0.0020	91.095%
0.0010	0.000%

Subwatershed Hydrology Detail:

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
#26	1	217.200	0.309	0.000	0.000	91.000	M	40.96	4.125
	Σ	**217.200**						**40.96**	**4.125**
#22	1	163.500	0.421	0.000	0.000	90.300	M	23.86	2.812
	Σ	**163.500**						**23.86**	**2.812**
#20	1	817.400	2.464	0.000	0.000	81.600	M	7.74	3.187
	Σ	**817.400**						**7.74**	**3.187**
#19	1	451.700	1.091	0.000	0.000	86.500	M	18.34	4.373
	Σ	**451.700**						**18.34**	**4.373**
#16	1	1,216.500	2.442	0.000	0.000	75.200	M	1.73	0.581
	Σ	**1,216.500**						**1.73**	**0.581**
#17	1	1,099.800	4.518	0.612	0.218	80.600	M	6.03	3.413
	2	138.500	0.433	0.000	0.000	84.700	M	6.40	0.990
	Σ	**2,454.800**						**7.58**	**4.984**
#28	1	235.300	1.177	0.000	0.000	74.400	M	0.30	0.069
	Σ	**235.300**						**0.30**	**0.069**
#14	1	2,999.900	6.028	5.514	0.260	77.600	M	5.82	3.987
	2	1,855.300	3.849	1.483	0.319	78.800	M	7.17	3.593
	3	727.900	1.449	0.000	0.000	85.400	M	20.25	5.872
	4	1,109.100	2.160	1.449	0.311	78.000	M	4.46	1.683
	Σ	**6,692.200**						**20.25**	**15.134**
#15	1	595.000	1.000	0.000	0.000	80.000	M	5.21	1.594
	Σ	**7,522.500**						**24.46**	**16.797**
#18	1	146.200	0.733	0.000	0.000	78.400	M	0.81	0.251
	Σ	**10,123.500**						**28.72**	**22.033**
#21	1	397.300	1.532	0.102	0.358	86.700	M	13.75	3.973
	2	465.700	1.196	0.102	0.358	85.200	M	13.79	3.630
	3	76.200	0.242	0.000	0.000	85.900	M	6.34	0.669
	Σ	**12,712.500**						**102.27**	**44.801**
#10	1	86.900	0.209	0.000	0.000	91.000	M	19.01	1.650
	Σ	**86.900**						**19.01**	**1.650**
#9	1	15.000	0.044	0.000	0.000	91.000	M	6.06	0.285

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
	Σ	**15.000**						**6.06**	**0.285**
#8	1	24.100	0.118	0.000	0.000	91.000	M	9.74	0.458
	Σ	**24.100**						**9.74**	**0.458**
#11	1	319.500	0.430	0.000	0.000	89.200	M	38.09	4.685
	Σ	**445.500**						**58.64**	**7.078**
#25	1	373.200	0.745	0.000	0.000	87.500	M	23.37	4.234
	Σ	**373.200**						**23.37**	**4.234**
#27	1	3,024.700	5.305	0.000	0.000	78.100	M	7.60	4.738
	Σ	**3,024.700**						**7.60**	**4.738**
#4	1	654.900	1.236	0.425	0.345	79.900	M	5.22	1.710
	2	699.700	1.078	0.425	0.345	78.500	M	3.77	1.240
	3	547.300	0.992	0.425	0.345	78.100	M	2.63	0.857
	4	1,063.800	1.514	0.000	0.000	81.400	M	11.81	3.969
	Σ	**5,990.400**						**23.19**	**12.514**
#1	1	755.100	1.922	0.000	0.000	77.800	M	2.93	1.073
	Σ	**755.100**						**2.93**	**1.073**
#2	1	1,327.000	2.969	3.034	0.146	77.200	M	3.70	1.532
	2	894.200	3.538	0.000	0.000	82.100	M	7.94	3.879
	3	139.300	1.214	0.000	0.000	82.600	M	2.30	0.670
	Σ	**3,115.600**						**10.59**	**7.155**
#3	1	1,550.000	2.670	0.000	0.000	83.500	M	21.08	8.890
	Σ	**4,665.600**						**29.02**	**16.044**
#5	Σ	**10,656.000**						**49.85**	**28.559**
#6	1	505.100	2.318	0.538	0.343	76.200	M	1.12	0.392
	2	638.400	4.584	0.359	0.337	78.800	M	2.19	1.236
	3	557.000	2.148	0.000	0.000	88.100	M	20.08	6.929
	4	308.200	0.324	0.272	0.356	89.900	M	47.84	5.004
	Σ	**12,664.700**						**71.52**	**42.120**
#7	1	215.800	0.400	0.000	0.000	90.900	M	35.65	4.041
	Σ	**13,253.700**						**82.23**	**50.395**
#12	Σ	**13,699.200**						**105.90**	**57.473**
#13	1	258.600	0.301	0.000	0.000	86.600	M	22.46	2.545
	Σ	**13,957.800**						**109.38**	**60.018**

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
#23	**Σ**	**26,670.300**						**210.52**	**104.819**
#24	1	459.200	0.465	0.000	0.000	86.200	M	28.98	4.234
	Σ	**27,129.500**						**215.45**	**109.053**

Subwatershed Sedimentology Detail:

Stru #	SWS #	Soil K	L (ft)	S (%)	C	P	PS #	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc (ml/l)	24VW (ml/l)
#26	1	0.209	75.00	14.70	0.3940	1.0000	1	275.3	91,763	4.63	3.01
	Σ							**275.3**	**91,763**	**4.63**	**3.01**
#22	1	0.205	75.00	13.40	0.3870	1.0000	1	140.5	67,654	1.31	0.87
	Σ							**140.5**	**67,654**	**1.31**	**0.87**
#20	1	0.183	200.00	3.90	0.3520	1.0000	3	20.8	7,612	3.22	2.54
	Σ							**20.8**	**7,612**	**3.22**	**2.54**
#19	1	0.187	125.00	9.00	0.3940	1.0000	1	106.1	29,219	0.00	0.00
	Σ							**106.1**	**29,219**	**0.00**	**0.00**
#16	1	0.120	400.00	1.90	0.3520	1.0000	3	1.5	3,048	1.92	1.45
	Σ							**1.5**	**3,048**	**1.92**	**1.45**
#17	1	0.231	300.00	3.00	0.3440	1.0000	3	20.5	7,309	2.79	2.12
	2	0.192	150.00	6.70	0.2880	1.0000	3	14.8	19,524	11.05	7.74
	Σ							**32.8**	**19,524**	**8.32**	**2.71**
#28	1	0.109	300.00	2.90	0.3650	1.0000	3	0.2	3,577	2.30	1.81
	Σ							**0.2**	**3,577**	**2.30**	**1.81**
#14	1	0.175	400.00	1.40	0.3310	1.0000	3	8.9	2,762	1.45	1.11
	2	0.175	300.00	2.20	0.3170	1.0000	3	12.3	4,151	2.29	1.74
	3	0.189	175.00	5.30	0.3530	1.0000	1	79.5	16,047	0.00	0.00
	4	0.256	300.00	2.20	0.3050	1.0000	3	8.7	5,993	3.60	2.85
	Σ							**100.3**	**16,047**	**1.51**	**0.55**
#15	1	0.161	200.00	3.90	0.3660	1.0000	3	10.3	7,143	3.75	3.14
	Σ							**110.8**	**14,348**	**1.94**	**0.80**
#18	1	0.152	175.00	5.00	0.3930	1.0000	3	1.9	7,850	4.87	4.32
	Σ							**145.5**	**17,272**	**3.57**	**1.24**
#21	1	0.224	175.00	5.10	0.3800	1.0000	1	63.3	19,015	0.00	0.00

Stru #	SWS #	Soil K	L (ft)	S (%)	C	P	PS #	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc (ml/l)	24VW (ml/l)
	2	0.192	175.00	5.70	0.3820	1.0000	3	57.7	18,885	9.16	7.07
	3	0.241	75.00	15.30	0.2480	1.0000	1	26.7	56,482	1.55	0.98
	Σ							**835.5**	**52,480**	**5.27**	**1.71**
#10	1	0.210	75.00	17.50	0.3990	1.0000	1	135.0	115,081	8.72	5.52
	Σ							**135.0**	**115,081**	**8.72**	**5.52**
#9	1	0.210	75.00	12.80	0.3990	1.0000	1	18.0	77,058	20.01	11.85
	Σ							**18.0**	**77,058**	**20.01**	**11.85**
#8	1	0.210	125.00	9.40	0.3990	1.0000	1	25.6	68,327	17.74	10.50
	Σ							**25.6**	**68,327**	**17.74**	**10.50**
#11	1	0.222	100.00	11.70	0.3910	1.0000	1	263.9	75,708	0.50	0.33
	Σ							**442.5**	**79,675**	**4.15**	**2.85**
#25	1	0.187	100.00	11.59	0.3780	1.0000	1	152.5	45,283	0.00	0.00
	Σ							**152.5**	**45,283**	**0.00**	**0.00**
#27	1	0.150	300.00	2.10	0.3220	1.0000	3	12.4	3,211	1.72	1.30
	Σ							**12.4**	**3,211**	**1.72**	**1.30**
#4	1	0.160	300.00	2.10	0.3320	1.0000	3	6.2	4,037	2.10	1.75
	2	0.130	200.00	3.80	0.3070	1.0000	3	5.0	4,277	2.62	2.26
	3	0.147	200.00	3.90	0.2900	1.0000	3	3.6	4,436	2.73	2.39
	4	0.121	175.00	4.50	0.2900	1.0000	3	21.3	6,107	2.85	2.31
	Σ							**48.4**	**4,876**	**2.52**	**1.78**
#1	1	0.144	300.00	3.00	0.3260	1.0000	3	4.2	4,518	2.74	2.21
	Σ							**4.2**	**4,518**	**2.74**	**2.21**
#2	1	0.142	300.00	2.30	0.3360	1.0000	3	4.7	3,714	2.23	1.70
	2	0.167	400.00	1.30	0.3480	1.0000	3	9.9	3,049	1.15	0.88
	3	0.180	400.00	1.60	0.3370	1.0000	3	2.3	3,966	1.89	1.50
	Σ							**18.4**	**2,959**	**1.29**	**0.97**
#3	1	0.179	300.00	2.20	0.3420	1.0000	3	41.2	5,456	2.16	1.69
	Σ							**59.6**	**4,787**	**1.95**	**1.37**
#5	**Σ**							**108.0**	**4,762**	**2.17**	**1.55**
#6	1	0.170	200.00	3.70	0.3350	1.0000	3	1.8	5,608	3.57	2.74
	2	0.176	175.00	4.10	0.3370	1.0000	3	6.7	6,586	3.52	2.66
	3	0.196	100.00	11.80	0.3770	1.0000	1	197.7	33,891	0.00	0.00
	4	0.203	100.00	11.60	0.3800	1.0000	1	273.3	74,350	2.93	1.94

Stru #	SWS #	Soil K	L (ft)	S (%)	C	P	PS #	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc (ml/l)	24VW (ml/l)
	Σ							**540.6**	**67,292**	**5.26**	**0.97**
#7	1	0.210	125.00	9.34	0.3950	1.0000	1	175.5	59,279	1.72	1.14
	Σ							**868.5**	**58,345**	**3.18**	**0.89**
#12	Σ							**1,311.0**	**463,163**	**24.85**	**1.13**
#13	1	0.230	75.00	12.00	0.2560	1.0000	1	82.4	45,369	0.68	0.44
	Σ							**1,354.6**	**64,614**	**1.94**	**0.63**
#23	Σ							**2,190.1**	**53,342**	**3.03**	**1.10**
#24	1	0.233	125.00	8.70	0.2550	1.0000	1	103.0	32,211	0.00	0.00
	Σ							**2,252.1**	**50,262**	**2.05**	**0.78**

Subwatershed Time of Concentration Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#1	1	5. Nearly bare and untilled, and alluvial valley fans	5.19	120.00	2,312.00	2.270	0.282
		8. Large gullies, diversions, and low flowing streams	1.85	100.00	5,414.00	4.070	0.369
		5. Nearly bare and untilled, and alluvial valley fans	1.65	97.00	5,861.00	1.280	1.271
#1	**1**	**Time of Concentration:**					**1.922**
#2	1	5. Nearly bare and untilled, and alluvial valley fans	4.27	115.00	2,694.00	2.060	0.363
		8. Large gullies, diversions, and low flowing streams	2.37	100.00	4,211.00	4.620	0.253
		5. Nearly bare and untilled, and alluvial valley fans	1.10	97.00	8,811.00	1.040	2.353
#2	**1**	**Time of Concentration:**					**2.969**
#2	2	5. Nearly bare and untilled, and alluvial valley fans	0.63	63.00	10,064.00	0.790	3.538
#2	**2**	**Time of Concentration:**					**3.538**
#2	3	5. Nearly bare and untilled, and alluvial valley fans	1.24	60.00	4,853.00	1.110	1.214
#2	**3**	**Time of Concentration:**					**1.214**
#3	1	5. Nearly bare and untilled, and alluvial valley fans	1.32	140.00	10,633.45	1.140	2.590
		8. Large gullies, diversions, and low flowing streams	5.53	113.00	2,042.03	7.050	0.080
#3	**1**	**Time of Concentration:**					**2.670**

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#4	1	5. Nearly bare and untilled, and alluvial valley fans	1.72	60.00	3,483.00	1.310	0.738
		8. Large gullies, diversions, and low flowing streams	1.45	94.00	6,477.00	3.610	0.498
#4	**1**	**Time of Concentration:**					**1.236**
#4	2	5. Nearly bare and untilled, and alluvial valley fans	6.55	122.00	1,863.00	2.550	0.202
		8. Large gullies, diversions, and low flowing streams	1.44	164.00	11,361.00	3.600	0.876
#4	**2**	**Time of Concentration:**					**1.078**
#4	3	5. Nearly bare and untilled, and alluvial valley fans	5.52	95.00	1,722.00	2.340	0.204
		8. Large gullies, diversions, and low flowing streams	2.05	249.00	12,174.00	4.290	0.788
#4	**3**	**Time of Concentration:**					**0.992**
#4	4	5. Nearly bare and untilled, and alluvial valley fans	6.83	145.00	2,123.00	2.610	0.225
		8. Large gullies, diversions, and low flowing streams	1.80	336.00	18,657.00	4.020	1.289
#4	**4**	**Time of Concentration:**					**1.514**
#6	1	5. Nearly bare and untilled, and alluvial valley fans	1.39	128.00	9,201.00	1.170	2.184
		8. Large gullies, diversions, and low flowing streams	3.50	95.00	2,715.00	5.610	0.134
#6	**1**	**Time of Concentration:**					**2.318**
#6	2	5. Nearly bare and untilled, and alluvial valley fans	0.88	130.00	14,812.00	0.930	4.424
		8. Large gullies, diversions, and low flowing streams	4.79	182.00	3,801.00	6.560	0.160
#6	**2**	**Time of Concentration:**					**4.584**
#6	3	5. Nearly bare and untilled, and alluvial valley fans	0.74	37.00	5,027.00	0.850	1.642
		8. Large gullies, diversions, and low flowing streams	2.80	256.00	9,143.00	5.010	0.506
#6	**3**	**Time of Concentration:**					**2.148**
#6	4	8. Large gullies, diversions, and low flowing streams	5.14	90.00	1,752.00	6.790	0.071
		8. Large gullies, diversions, and low flowing streams	3.43	174.00	5,073.00	5.550	0.253
#6	**4**	**Time of Concentration:**					**0.324**
#7	1	5. Nearly bare and untilled, and alluvial valley fans	12.45	63.00	506.00	3.520	0.039
		8. Large gullies, diversions, and low flowing streams	1.91	103.00	5,392.00	4.140	0.361
#7	**1**	**Time of Concentration:**					**0.400**
#8	1	5. Nearly bare and untilled, and alluvial valley fans	2.65	15.00	565.00	1.620	0.096
		9. Small streams flowing bankfull	5.06	82.00	1,620.00	20.240	0.022

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#8	**1**	**Time of Concentration:**					**0.118**
#9	1	5. Nearly bare and untilled, and alluvial valley fans	6.06	12.00	198.00	2.460	0.022
		8. Large gullies, diversions, and low flowing streams	8.78	62.00	706.00	8.890	0.022
#9	**1**	**Time of Concentration:**					**0.044**
#10	1	5. Nearly bare and untilled, and alluvial valley fans	8.40	63.00	750.00	2.890	0.072
		8. Large gullies, diversions, and low flowing streams	4.59	146.00	3,184.00	6.420	0.137
#10	**1**	**Time of Concentration:**					**0.209**
#11	1	5. Nearly bare and untilled, and alluvial valley fans	14.84	38.00	256.00	3.850	0.018
		8. Large gullies, diversions, and low flowing streams	2.21	146.00	6,606.00	4.450	0.412
#11	**1**	**Time of Concentration:**					**0.430**
#13	1	5. Nearly bare and untilled, and alluvial valley fans	19.00	53.00	279.00	4.350	0.017
		8. Large gullies, diversions, and low flowing streams	3.60	210.00	5,831.00	5.690	0.284
#13	**1**	**Time of Concentration:**					**0.301**
#14	1	5. Nearly bare and untilled, and alluvial valley fans	0.99	213.00	21,485.00	0.990	6.028
#14	**1**	**Time of Concentration:**					**6.028**
#14	2	5. Nearly bare and untilled, and alluvial valley fans	1.44	240.00	16,629.00	1.200	3.849
#14	**2**	**Time of Concentration:**					**3.849**
#14	3	5. Nearly bare and untilled, and alluvial valley fans	2.29	45.00	1,966.00	1.510	0.361
		8. Large gullies, diversions, and low flowing streams	1.60	105.00	6,562.00	3.790	0.480
		5. Nearly bare and untilled, and alluvial valley fans	0.94	20.00	2,124.00	0.970	0.608
#14	**3**	**Time of Concentration:**					**1.449**
#14	4	5. Nearly bare and untilled, and alluvial valley fans	1.79	185.00	10,345.00	1.330	2.160
#14	**4**	**Time of Concentration:**					**2.160**
#15	1	5. Nearly bare and untilled, and alluvial valley fans	3.28	65.00	1,983.00	1.810	0.304
		8. Large gullies, diversions, and low flowing streams	1.29	110.00	8,530.00	3.400	0.696
#15	**1**	**Time of Concentration:**					**1.000**
#16	1	5. Nearly bare and untilled, and alluvial valley fans	1.18	112.00	9,497.00	1.080	2.442
#16	**1**	**Time of Concentration:**					**2.442**
#17	1	5. Nearly bare and untilled, and alluvial valley fans	0.64	80.00	12,462.00	0.800	4.327

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
		8. Large gullies, diversions, and low flowing streams	2.04	60.00	2,946.00	4.280	0.191
#17	**1**	**Time of Concentration:**					**4.518**
#17	2	5. Nearly bare and untilled, and alluvial valley fans	4.83	165.00	3,419.00	2.190	0.433
#17	**2**	**Time of Concentration:**					**0.433**
#18	1	5. Nearly bare and untilled, and alluvial valley fans	10.99	80.00	728.00	3.310	0.061
		8. Large gullies, diversions, and low flowing streams	1.48	130.00	8,808.00	3.640	0.672
#18	**1**	**Time of Concentration:**					**0.733**
#19	1	5. Nearly bare and untilled, and alluvial valley fans	6.02	55.00	914.00	2.450	0.103
		8. Large gullies, diversions, and low flowing streams	2.59	160.00	6,167.00	4.830	0.354
		5. Nearly bare and untilled, and alluvial valley fans	1.41	38.00	2,695.00	1.180	0.634
#19	**1**	**Time of Concentration:**					**1.091**
#20	1	5. Nearly bare and untilled, and alluvial valley fans	1.12	93.00	8,290.00	1.050	2.193
		8. Large gullies, diversions, and low flowing streams	3.40	184.00	5,404.00	5.530	0.271
#20	**1**	**Time of Concentration:**					**2.464**
#21	1	8. Large gullies, diversions, and low flowing streams	7.18	125.00	1,741.00	8.030	0.060
		5. Nearly bare and untilled, and alluvial valley fans	1.02	40.00	3,904.00	1.010	1.073
		8. Large gullies, diversions, and low flowing streams	1.06	47.00	4,430.00	3.080	0.399
#21	**1**	**Time of Concentration:**					**1.532**
#21	2	5. Nearly bare and untilled, and alluvial valley fans	3.87	124.00	3,207.00	1.960	0.454
		8. Large gullies, diversions, and low flowing streams	1.03	84.00	8,127.00	3.040	0.742
#21	**2**	**Time of Concentration:**					**1.196**
#21	3	5. Nearly bare and untilled, and alluvial valley fans	4.80	62.00	1,291.00	2.190	0.163
		8. Large gullies, diversions, and low flowing streams	6.45	140.00	2,172.00	7.610	0.079
#21	**3**	**Time of Concentration:**					**0.242**
#22	1	5. Nearly bare and untilled, and alluvial valley fans	4.23	55.00	1,300.00	2.050	0.176
		8. Large gullies, diversions, and low flowing streams	3.29	158.00	4,808.00	5.430	0.245
#22	**1**	**Time of Concentration:**					**0.421**
#24	1	5. Nearly bare and untilled, and alluvial valley fans	4.21	45.00	1,070.00	2.050	0.144

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
		8. Large gullies, diversions, and low flowing streams	3.18	196.00	6,172.00	5.340	0.321
#24	**1**	**Time of Concentration:**					**0.465**
#25	1	5. Nearly bare and untilled, and alluvial valley fans	3.15	52.00	1,653.05	1.770	0.259
		8. Large gullies, diversions, and low flowing streams	3.05	280.00	9,168.00	5.240	0.486
#25	**1**	**Time of Concentration:**					**0.745**
#26	1	5. Nearly bare and untilled, and alluvial valley fans	9.72	75.00	772.00	3.110	0.068
		8. Large gullies, diversions, and low flowing streams	3.52	172.00	4,892.00	5.620	0.241
#26	**1**	**Time of Concentration:**					**0.309**
#27	1	5. Nearly bare and untilled, and alluvial valley fans	1.17	241.00	20,629.00	1.080	5.305
#27	**1**	**Time of Concentration:**					**5.305**
#28	1	5. Nearly bare and untilled, and alluvial valley fans	1.66	62.00	3,744.00	1.280	0.812
		8. Large gullies, diversions, and low flowing streams	1.92	105.00	5,466.00	4.150	0.365
#28	**1**	**Time of Concentration:**					**1.177**

Subwatershed Muskingum Routing Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#2	1	5. Nearly bare and untilled, and alluvial valley fans	0.50	38.00	7,646.00	0.700	3.034
#2	**1**	**Muskingum K:**					**3.034**
#4	1	8. Large gullies, diversions, and low flowing streams	1.59	92.00	5,787.00	3.780	0.425
#4	**1**	**Muskingum K:**					**0.425**
#4	2	8. Large gullies, diversions, and low flowing streams	1.59	92.00	5,787.00	3.780	0.425
#4	**2**	**Muskingum K:**					**0.425**
#4	3	8. Large gullies, diversions, and low flowing streams	1.59	92.00	5,787.00	3.780	0.425
#4	**3**	**Muskingum K:**					**0.425**
#6	1	8. Large gullies, diversions, and low flowing streams	1.54	111.00	7,218.00	3.720	0.538
#6	**1**	**Muskingum K:**					**0.538**
#6	2	8. Large gullies, diversions, and low flowing streams	1.37	62.00	4,531.00	3.500	0.359
#6	**2**	**Muskingum K:**					**0.359**
#14	1	5. Nearly bare and untilled, and alluvial valley fans	0.97	143.00	14,748.00	0.980	4.180

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
		5. Nearly bare and untilled, and alluvial valley fans	1.34	10.00	747.00	1.150	0.180
		8. Large gullies, diversions, and low flowing streams	1.65	125.00	7,592.00	3.840	0.549
		5. Nearly bare and untilled, and alluvial valley fans	0.95	20.00	2,116.00	0.970	0.605
#14	**1**	**Muskingum K:**					**5.514**
#14	2	5. Nearly bare and untilled, and alluvial valley fans	1.34	10.00	747.04	1.150	0.180
		8. Large gullies, diversions, and low flowing streams	1.65	125.00	7,592.00	3.840	0.549
		5. Nearly bare and untilled, and alluvial valley fans	0.82	20.00	2,446.00	0.900	0.754
#14	**2**	**Muskingum K:**					**1.483**
#14	4	5. Nearly bare and untilled, and alluvial valley fans	2.29	45.00	1,966.00	1.510	0.361
		8. Large gullies, diversions, and low flowing streams	1.60	105.00	6,562.00	3.790	0.480
		5. Nearly bare and untilled, and alluvial valley fans	0.94	20.00	2,124.00	0.970	0.608
#14	**4**	**Muskingum K:**					**1.449**
#17	1	5. Nearly bare and untilled, and alluvial valley fans	1.73	50.00	2,887.00	1.310	0.612
#17	**1**	**Muskingum K:**					**0.612**
#21	1	8. Large gullies, diversions, and low flowing streams	2.03	32.00	1,575.00	4.270	0.102
#21	**1**	**Muskingum K:**					**0.102**
#21	2	8. Large gullies, diversions, and low flowing streams	2.03	32.00	1,575.11	4.270	0.102
#21	**2**	**Muskingum K:**					**0.102**

General Information

Storm Information:

Storm Type:	NRCS Type II
Design Storm:	10 yr - 6 hr
Rainfall Depth:	1.300 inches

Particle Size Distribution:

Size (mm)	Badland Premining	Badland Postmining	LoamySand Premining	LoamySand Postmining
2.0000	100.000%	100.000%	100.000%	100.000%
0.1000	83.500%	75.900%	30.000%	26.500%
0.0500	77.000%	70.000%	17.000%	14.000%
0.0020	56.000%	47.000%	11.000%	11.000%
0.0010	0.000%	0.000%	0.000%	0.000%

Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc. (ml/l)	24VW (ml/l)
#26	217.200	217.200	108.07	10.51	800.4	102,305	7.46	4.95
#22	163.500	163.500	67.11	7.43	432.1	77,791	3.74	2.51
#20	817.400	817.400	41.80	15.82	131.2	9,921	4.15	3.20
#19	451.700	451.700	70.66	14.41	440.5	38,200	0.00	0.00
#16	1,216.500	1,216.500	26.11	10.56	33.8	3,753	1.53	1.20
#17	1,238.300	2,454.800	60.08	33.30	241.1	27,582	11.14	2.68
#28	235.300	235.300	6.29	1.81	7.2	4,581	2.20	1.75
#14	6,692.200	6,692.200	103.52	97.12	574.0	20,962	1.45	0.41
#15	595.000	7,522.500	109.88	108.55	633.2	16,412	1.65	0.58
#18	146.200	10,123.500	168.88	143.80	898.5	19,535	3.78	1.17
#21	939.200	12,712.500	379.30	220.29	3,336.6	49,801	6.77	1.91
#10	86.900	86.900	48.55	4.21	385.5	124,001	11.44	7.49
#9	15.000	15.000	14.02	0.73	48.6	75,590	19.63	12.54
#8	24.100	24.100	22.52	1.17	69.0	67,021	17.40	11.11
#11	319.500	445.500	171.53	19.23	1,380.1	89,066	6.48	4.56
#25	373.200	373.200	83.14	13.10	584.3	57,323	0.00	0.00
#27	3,024.700	3,024.700	61.09	38.87	129.3	4,060	1.16	0.89
#4	2,965.700	5,990.400	181.03	85.95	431.1	7,229	3.08	1.91
#1	755.100	755.100	27.28	9.34	49.7	6,285	2.73	2.13
#2	2,360.500	3,115.600	73.72	45.81	164.1	3,933	1.43	1.16
#3	1,550.000	4,665.600	129.93	82.51	358.2	5,967	2.24	1.48
#5	0.000	10,656.000	290.73	168.46	789.3	6,589	2.66	1.70
#6	2,008.700	12,664.700	376.89	216.65	2,418.8	74,907	12.19	1.65
#7	215.800	13,253.700	405.11	240.10	3,520.6	64,972	7.78	1.59
#12	0.000	13,699.200	423.38	259.33	4,900.7	76,781	8.17	1.82
#13	258.600	13,957.800	429.95	267.67	5,079.8	70,467	5.76	1.40
#23	0.000	26,670.300	702.12	487.95	8,416.4	53,357	5.51	1.63
#24	459.200	27,129.500	714.58	502.19	8,656.9	50,387	4.16	1.30

General Information

Storm Information:

Storm Type:	NRCS Type II
Design Storm:	25 yr - 6 hr
Rainfall Depth:	1.600 inches

Particle Size Distribution:

Size (mm)	Badland Premining	Badland Postmining	LoamySand Premining	LoamySand Postmining
2.0000	100.000%	100.000%	100.000%	100.000%
0.1000	83.500%	75.900%	30.000%	26.500%
0.0500	77.000%	70.000%	17.000%	14.000%
0.0020	56.000%	47.000%	11.000%	11.000%
0.0010	0.000%	0.000%	0.000%	0.000%

Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc. (ml/l)	24VW (ml/l)
#26	217.200	217.200	153.43	14.88	1,183.1	106,078	8.49	5.66
#22	163.500	163.500	97.22	10.63	649.8	81,426	4.65	3.14
#20	817.400	817.400	71.98	26.42	237.1	10,819	4.68	3.57
#19	451.700	451.700	111.15	21.92	717.8	41,110	0.00	0.00
#16	1,216.500	1,216.500	54.52	21.15	75.3	4,231	1.73	1.34
#17	1,238.300	2,454.800	112.96	59.50	451.2	29,638	12.28	2.85
#28	235.300	235.300	14.41	3.75	17.1	5,465	2.66	2.05
#14	6,692.200	6,692.200	184.03	171.42	1,034.6	22,771	1.93	0.51
#15	595.000	7,522.500	193.46	191.83	1,147.4	17,283	1.99	0.68
#18	146.200	10,123.500	304.51	254.85	1,648.8	20,265	4.26	1.31
#21	939.200	12,712.500	598.22	372.17	5,480.0	49,641	7.54	2.08
#10	86.900	86.900	68.66	5.95	568.5	128,056	12.62	8.33
#9	15.000	15.000	19.08	1.03	70.2	75,205	19.53	12.77
#8	24.100	24.100	30.65	1.65	99.6	66,678	17.31	11.32
#11	319.500	445.500	250.69	27.75	2,087.8	92,416	7.40	5.26
#25	373.200	373.200	128.36	19.59	933.5	61,317	0.00	0.00
#27	3,024.700	3,024.700	112.14	70.82	254.2	4,389	1.29	0.98
#4	2,965.700	5,990.400	336.67	152.63	836.5	8,131	3.58	2.14
#1	755.100	755.100	52.74	17.17	101.0	7,055	3.16	2.43
#2	2,360.500	3,115.600	133.45	80.70	313.3	4,340	1.61	1.27
#3	1,550.000	4,665.600	213.31	139.64	633.1	6,422	2.42	1.54
#5	0.000	10,656.000	512.13	292.27	1,469.7	7,365	3.04	1.86
#6	2,008.700	12,664.700	651.03	368.09	4,015.7	77,431	14.35	1.83
#7	215.800	13,253.700	690.79	402.35	5,717.5	68,279	9.46	1.78
#12	0.000	13,699.200	715.89	430.10	7,805.3	80,011	9.83	2.01
#13	258.600	13,957.800	724.14	442.74	8,110.8	73,508	7.31	1.64
#23	0.000	26,670.300	1,148.02	814.92	13,590.8	54,734	6.60	1.84
#24	459.200	27,129.500	1,154.68	836.68	13,925.8	52,850	5.12	1.48

General Information

Storm Information:

Storm Type:	NRCS Type II
Design Storm:	100 yr - 6 hr
Rainfall Depth:	2.000 inches

Particle Size Distribution:

Size (mm)	Badland Premining	Badland Postmining	LoamySand Premining	LoamySand Postmining
2.0000	100.000%	100.000%	100.000%	100.000%
0.1000	83.500%	75.900%	30.000%	26.500%
0.0500	77.000%	70.000%	17.000%	14.000%
0.0020	56.000%	47.000%	11.000%	11.000%
0.0010	0.000%	0.000%	0.000%	0.000%

Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc. (ml/l)	24VW (ml/l)
#26	217.200	217.200	216.50	21.06	1,742.7	109,754	9.48	6.35
#22	163.500	163.500	139.61	15.19	971.8	84,928	5.53	3.73
#20	817.400	817.400	120.48	42.97	415.4	11,743	5.26	3.98
#19	451.700	451.700	172.44	33.01	1,154.6	44,050	0.00	0.00
#16	1,216.500	1,216.500	105.20	39.27	153.9	4,707	1.99	1.53
#17	1,238.300	2,454.800	203.45	102.11	815.1	31,546	13.51	3.08
#28	235.300	235.300	29.91	7.10	36.8	6,368	3.22	2.42
#14	6,692.200	6,692.200	314.68	291.29	1,816.1	24,473	2.48	0.62
#15	595.000	7,522.500	330.71	326.28	2,030.3	18,199	2.38	0.79
#18	146.200	10,123.500	527.55	434.47	2,941.8	21,058	4.79	1.47
#21	939.200	12,712.500	930.98	612.73	8,915.9	49,473	8.27	2.26
#10	86.900	86.900	96.52	8.43	835.7	131,991	14.46	9.60
#9	15.000	15.000	25.92	1.45	101.2	74,997	19.47	13.01
#8	24.100	24.100	41.65	2.34	143.7	66,493	17.26	11.53
#11	319.500	445.500	364.52	39.93	3,138.1	95,694	8.43	6.04
#25	373.200	373.200	194.63	29.08	1,470.6	64,958	0.00	0.00
#27	3,024.700	3,024.700	196.66	123.04	474.3	4,726	1.45	1.11
#4	2,965.700	5,990.400	595.82	260.25	1,547.2	8,999	4.10	2.40
#1	755.100	755.100	96.46	30.02	193.7	7,830	3.64	2.76
#2	2,360.500	3,115.600	231.44	136.89	583.6	4,782	1.87	1.43
#3	1,550.000	4,665.600	343.82	229.79	1,100.6	6,877	2.65	1.65
#5	0.000	10,656.000	872.77	490.04	2,647.8	8,139	3.47	2.05
#6	2,008.700	12,664.700	1,093.67	608.13	6,651.1	79,534	16.84	2.08
#7	215.800	13,253.700	1,148.58	658.01	9,258.1	71,513	11.48	2.03
#12	0.000	13,699.200	1,182.70	697.94	12,396.2	82,918	11.78	2.27
#13	258.600	13,957.800	1,192.93	716.96	12,902.9	76,114	9.10	1.94
#23	0.000	26,670.300	1,876.55	1,329.69	21,818.8	54,912	7.63	2.08
#24	459.200	27,129.500	1,885.94	1,362.60	22,398.4	52,542	6.13	1.75

Appendix 18.B

Hosteen Wash Pre-Mine Hydrology & Sedimentology

(2 YR-6 HR, 10 YR-6 HR, 25 YR-6 HR & 100 YR-6 HR Storm Events)

Hosteen Wash Pre-mine Hydrology and Sedimentology

The hydrology model and drainage subdivisions are presented on Exhibit 7-4C. The pre-mine channel alignment and profiles are presented on Exhibit 11-76F thru 11-76H.

LR

BHP Navajo Coal Company
Navajo Mine
PO Box 1717
Fruitland, NM 87415

Phone: 505-598-5861

General Information

Storm Information:

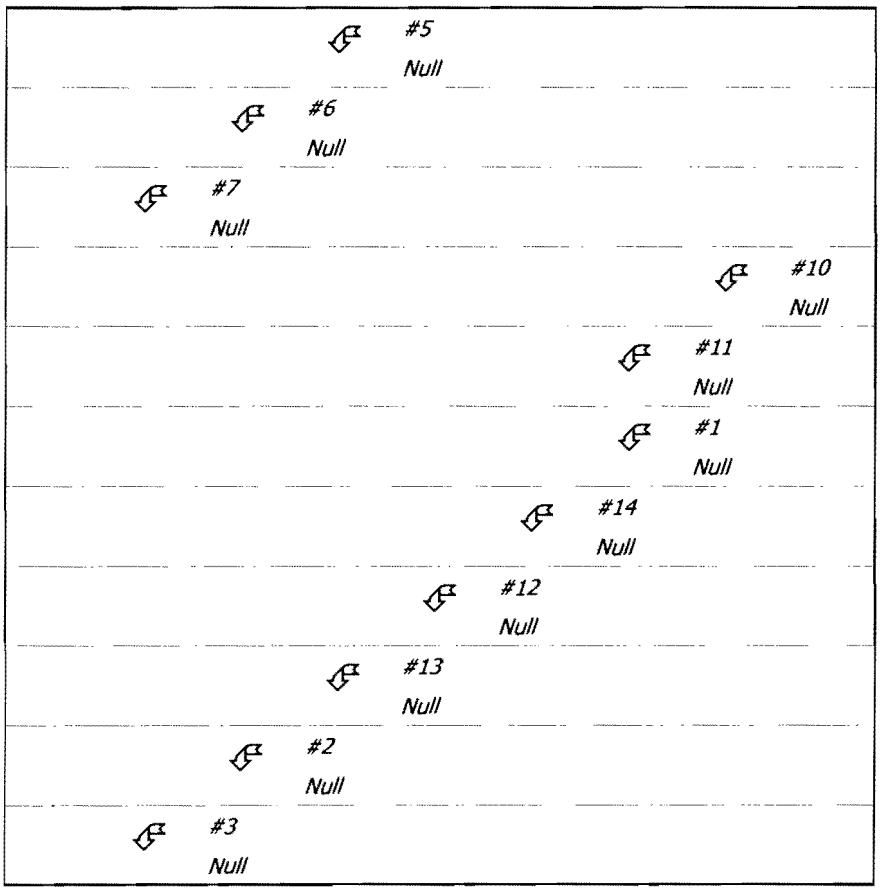
Storm Type:	NRCS Type II-60
Design Storm:	2 yr - 6 hr
Rainfall Depth:	0.800 inches

Particle Size Distribution:

Size (mm)	Badland Premining	Badland Postmining	LoamySand Premining	LoamySand Postmining
2.0000	100.000%	100.000%	100.000%	100.000%
0.1000	83.500%	75.900%	30.000%	26.500%
0.0500	77.000%	70.000%	17.000%	14.000%
0.0020	56.000%	47.000%	11.000%	11.000%
0.0010	0.000%	0.000%	0.000%	0.000%

Structure Networking:

Type	Stru #	(flows into)	Stru #	Musk. K (hrs)	Musk. X	Description
Null	#1	==>	#14	0.000	0.000	Hosteen branch 1, S1
Null	#2	==>	#3	0.447	0.361	Hosteen branch 1, S2
Null	#3	==>	#4	0.000	0.000	Hosteen branch 1, S3
Null	#4	==>	#9	0.433	0.304	Hosteen branch 1 & 2 junction
Null	#5	==>	#6	0.503	0.338	Hosteen branch 2, S1
Null	#6	==>	#7	0.346	0.362	Hosteen branch 2, S2
Null	#7	==>	#4	0.000	0.000	Hosteen branch 2, S3
Null	#9	==>	End	0.000	0.000	Hosteen branch 1, J2
Null	#10	==>	#11	0.183	0.348	Hosteen branch 1
Null	#11	==>	#14	0.000	0.000	Hosteen branch 1
Null	#12	==>	#13	0.287	0.350	Hosteen branch 1
Null	#13	==>	#2	0.000	0.000	Hosteen branch 1
Null	#14	==>	#12	0.222	0.334	Hosteen branch 1



#4	
Null	
#9	
Null	

Structure Routing Details:

Stru #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#2	8. Large gullies, diversions, and low flowing streams	2.17	154.00	7,099.06	4.41	0.447
#2	**Muskingum K:**					**0.447**
#4	8. Large gullies, diversions, and low flowing streams	0.78	32.00	4,124.00	2.64	0.433
#4	**Muskingum K:**					**0.433**
#5	8. Large gullies, diversions, and low flowing streams	1.41	91.00	6,457.00	3.56	0.503
#5	**Muskingum K:**					**0.503**
#6	8. Large gullies, diversions, and low flowing streams	2.22	124.00	5,583.00	4.47	0.346
#6	**Muskingum K:**					**0.346**
#10	8. Large gullies, diversions, and low flowing streams	1.68	43.00	2,560.00	3.88	0.183
#10	**Muskingum K:**					**0.183**
#12	8. Large gullies, diversions, and low flowing streams	1.75	72.00	4,104.00	3.97	0.287
#12	**Muskingum K:**					**0.287**
#14	8. Large gullies, diversions, and low flowing streams	1.31	36.00	2,750.19	3.43	0.222
#14	**Muskingum K:**					**0.222**

Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc. (ml/l)	24VW (ml/l)
#5	713.800	713.800	133.11	12.69	592.3	62,425	3.93	2.64
#6	1,250.500	1,964.300	238.38	31.61	1,209.2	51,753	2.04	1.37
#7	573.200	2,537.500	259.08	38.37	1,324.5	49,591	1.78	1.15
#10	551.100	551.100	62.06	7.73	295.2	46,631	0.70	0.52
#11	217.500	768.600	88.20	11.41	414.4	44,062	0.47	0.35
#1	373.300	373.300	46.34	5.99	187.4	39,872	0.42	0.31
#14	0.000	1,141.900	134.54	17.41	601.8	42,604	0.45	0.34
#12	467.400	1,609.300	179.79	25.89	828.2	38,229	0.49	0.37
#13	421.200	2,030.500	210.52	33.26	1,064.4	36,821	0.38	0.30
#2	348.700	2,379.200	225.59	36.98	1,162.0	35,837	0.52	0.42
#3	628.900	3,008.100	250.38	46.75	1,464.6	43,740	0.17	0.11
#4	0.000	5,545.600	509.44	85.12	2,789.2	41,701	0.79	0.56
#9	286.900	5,832.500	503.37	90.57	2,804.6	40,483	0.19	0.13

Particle Size Distribution(s) at Each Structure

Structure #5 (Hosteen branch 2, S1):

Size (mm)	In/Out
2.0000	100.000%
0.1000	98.200%
0.0500	97.489%
0.0020	85.430%
0.0010	0.000%

Structure #6 (Hosteen branch 2, S2):

Size (mm)	In/Out
2.0000	100.000%
0.1000	99.128%
0.0500	98.780%
0.0020	90.446%
0.0010	0.000%

Structure #7 (Hosteen branch 2, S3):

Size (mm)	In/Out
2.0000	100.000%
0.1000	99.216%
0.0500	98.898%
0.0020	91.290%
0.0010	0.000%

Structure #10 (Hosteen branch 1):

Size (mm)	In/Out
2.0000	100.000%
0.1000	100.000%
0.0500	100.000%

Size (mm)	In/Out
0.0020	95.783%
0.0010	0.000%

Structure #11 (Hosteen branch 1):

Size (mm)	In/Out
2.0000	100.000%
0.1000	100.000%
0.0500	100.000%
0.0020	97.000%
0.0010	0.000%

Structure #1 (Hosteen branch 1, S1):

Size (mm)	In/Out
2.0000	100.000%
0.1000	100.000%
0.0500	100.000%
0.0020	97.011%
0.0010	0.000%

Structure #14 (Hosteen branch 1):

Size (mm)	In/Out
2.0000	100.000%
0.1000	100.000%
0.0500	100.000%
0.0020	97.003%
0.0010	0.000%

Structure #12 (Hosteen branch 1):

Size (mm)	In/Out
2.0000	100.000%
0.1000	100.000%
0.0500	100.000%
0.0020	96.384%
0.0010	0.000%

Structure #13 (Hosteen branch 1):

Size (mm)	In/Out
2.0000	100.000%
0.1000	100.000%
0.0500	100.000%
0.0020	97.089%
0.0010	0.000%

Structure #2 (Hosteen branch 1, S2):

Size (mm)	In/Out
2.0000	100.000%
0.1000	100.000%
0.0500	99.649%
0.0020	96.313%
0.0010	0.000%

Structure #3 (Hosteen branch 1, S3):

Size (mm)	In/Out
2.0000	100.000%
0.1000	100.000%
0.0500	100.000%
0.0020	98.901%
0.0010	0.000%

Structure #4 (Hosteen branch 1 & 2 junction):

Size (mm)	In/Out
2.0000	100.000%
0.1000	99.627%
0.0500	99.477%
0.0020	95.286%
0.0010	0.000%

Structure #9:

Size (mm)	In/Out
2.0000	100.000%

Size (mm)	In/Out
0.1000	100.000%
0.0500	100.000%
0.0020	98.648%
0.0010	0.000%

Subwatershed Hydrology Detail:

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
#5	1	140.800	0.349	0.314	0.343	90.600	M	28.94	2.527
	2	31.200	0.082	0.521	0.356	91.000	M	15.99	0.593
	3	50.400	0.209	0.209	0.330	91.000	M	13.62	0.957
	4	208.300	0.431	0.145	0.309	90.500	M	37.65	3.686
	5	117.800	0.290	0.209	0.330	91.000	M	27.97	2.237
	6	94.900	0.308	0.000	0.000	89.000	M	16.14	1.351
	7	26.100	0.136	0.145	0.309	91.000	M	7.68	0.496
	8	44.300	0.153	0.314	0.343	91.000	M	13.03	0.841
	Σ	**713.800**						**133.11**	**12.688**
#6	1	52.100	0.168	0.961	0.354	89.500	M	12.34	0.798
	2	33.900	0.162	0.961	0.354	89.300	M	7.81	0.504
	3	204.200	0.455	0.522	0.346	91.000	M	38.67	3.878
	4	112.900	0.347	0.522	0.346	91.000	M	24.71	2.144
	5	194.400	0.515	0.134	0.325	91.000	M	34.24	3.692
	6	474.700	0.818	0.134	0.325	86.400	M	28.06	4.522
	7	178.300	0.556	0.000	0.000	91.000	M	29.96	3.386
	Σ	**1,964.300**						**238.38**	**31.613**
#7	1	141.300	0.418	0.235	0.370	87.800	M	16.42	1.679
	2	127.200	0.684	0.235	0.370	85.900	M	7.61	1.116
	3	304.700	1.045	0.000	0.000	88.400	M	22.18	3.967
	Σ	**2,537.500**						**259.08**	**38.375**
#10	1	155.400	0.402	0.326	0.346	87.700	M	18.15	1.818
	2	130.900	0.335	0.176	0.352	89.000	M	21.32	1.864
	3	190.500	0.448	0.000	0.000	88.800	M	25.39	2.633
	4	74.300	0.302	0.000	0.000	91.000	M	17.34	1.411
	Σ	**551.100**						**62.06**	**7.726**
#11	1	217.500	0.494	0.000	0.000	90.200	M	34.57	3.687
	Σ	**768.600**						**88.20**	**11.413**
#1	1	190.000	0.460	0.320	0.351	88.500	M	23.62	2.511
	2	45.100	0.207	0.320	0.351	91.000	M	12.23	0.857
	3	138.200	0.479	0.000	0.000	91.000	M	25.41	2.625
	Σ	**373.300**						**46.34**	**5.992**
#14	**Σ**	**1,141.900**						**134.54**	**17.405**
#12	1	278.900	0.410	0.101	0.315	90.800	M	54.33	5.149

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
	2	107.400	0.463	0.101	0.315	90.100	M	17.45	1.795
	3	51.200	0.280	0.000	0.000	91.000	M	12.35	0.972
	4	29.900	0.229	0.000	0.000	91.000	M	7.83	0.568
	Σ	**1,609.300**						**179.79**	**25.889**
#13	1	146.400	0.618	0.000	0.000	89.200	M	17.10	2.147
	2	274.800	0.401	0.243	0.353	91.000	M	55.86	5.219
	Σ	**2,030.500**						**210.52**	**33.255**
#2	1	202.900	1.004	0.000	0.000	82.500	M	4.55	0.956
	2	145.800	0.385	0.000	0.000	91.000	M	30.27	2.769
	Σ	**2,379.200**						**225.59**	**36.980**
#3	1	234.200	0.565	0.110	0.338	90.500	M	35.97	4.144
	2	187.300	0.585	0.191	0.362	88.600	M	20.46	2.513
	3	154.400	0.473	0.191	0.362	88.700	M	19.56	2.102
	4	53.000	0.249	0.000	0.000	91.000	M	13.43	1.007
	Σ	**3,008.100**						**250.38**	**46.746**
#4	**Σ**	**5,545.600**						**509.44**	**85.121**
#9	1	286.900	0.322	0.000	0.000	91.000	M	65.02	5.449
	Σ	**5,832.500**						**503.37**	**90.569**

Subwatershed Sedimentology Detail:

Stru #	SWS #	Soil K	L (ft)	S (%)	C	P	PS #	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc (ml/l)	24VW (ml/l)
#5	1	0.205	75.00	12.70	0.3960	1.0000	1	140.7	73,843	2.32	1.57
	2	0.203	75.00	17.20	0.3950	1.0000	1	64.7	118,767	30.84	20.14
	3	0.210	175.00	5.50	0.3990	1.0000	1	30.0	43,381	3.10	2.03
	4	0.207	150.00	7.20	0.3970	1.0000	1	132.4	47,793	0.45	0.31
	5	0.210	100.00	10.10	0.3990	1.0000	1	115.3	69,522	3.42	2.29
	6	0.224	175.00	5.00	0.3950	1.0000	1	38.6	39,840	1.20	0.78
	7	0.210	150.00	6.30	0.3990	1.0000	1	15.9	43,651	3.74	2.44
	8	0.210	75.00	13.60	0.3990	1.0000	1	54.9	86,903	7.44	4.91
	Σ							**592.3**	**62,425**	**3.93**	**2.64**
#6	1	0.211	75.00	15.40	0.3870	1.0000	1	58.9	95,230	7.37	5.02
	2	0.211	100.00	10.90	0.3770	1.0000	1	25.9	67,164	5.16	3.50
	3	0.210	125.00	8.70	0.3990	1.0000	1	162.5	54,809	0.43	0.30

Stru #	SWS #	Soil K	L (ft)	S (%)	C	P	PS #	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc (ml/l)	24VW (ml/l)
	4	0.210	150.00	7.10	0.3990	1.0000	1	77.7	48,027	1.68	1.14
	5	0.210	175.00	4.70	0.3990	1.0000	1	92.2	33,018	0.00	0.00
	6	0.242	175.00	4.80	0.3900	1.0000	1	106.2	29,638	0.00	0.00
	7	0.201	175.00	5.80	0.3920	1.0000	1	93.6	36,545	0.00	0.00
	Σ							**1,209.2**	**51,753**	**2.04**	**1.37**
#7	1	0.223	200.00	3.60	0.3840	1.0000	1	27.3	21,947	0.00	0.00
	2	0.235	200.00	4.00	0.3780	1.0000	1	17.9	20,527	0.00	0.00
	3	0.194	150.00	6.50	0.3200	1.0000	1	70.3	22,395	0.00	0.00
	Σ							**1,324.5**	**49,591**	**1.78**	**1.15**
#10	1	0.204	100.00	10.50	0.3710	1.0000	1	76.9	56,148	0.00	0.00
	2	0.196	100.00	10.70	0.3810	1.0000	1	86.5	62,576	1.40	0.94
	3	0.182	150.00	7.50	0.3850	1.0000	1	78.0	39,950	0.00	0.00
	4	0.210	150.00	7.60	0.3990	1.0000	1	53.8	52,381	2.42	1.60
	Σ							**295.2**	**46,631**	**0.70**	**0.52**
#11	1	0.205	150.00	6.90	0.3940	1.0000	1	119.2	43,061	0.00	0.00
	Σ							**414.4**	**44,062**	**0.47**	**0.35**
#1	1	0.208	150.00	7.40	0.3830	1.0000	1	81.9	43,194	0.00	0.00
	2	0.210	150.00	8.00	0.3990	1.0000	1	35.2	56,162	4.04	2.67
	3	0.210	150.00	6.10	0.3990	1.0000	1	76.5	38,933	0.08	0.06
	Σ							**187.4**	**39,872**	**0.42**	**0.31**
#14	Σ							**601.8**	**42,604**	**0.45**	**0.34**
#12	1	0.209	175.00	5.40	0.3990	1.0000	1	163.3	42,619	0.74	0.50
	2	0.206	200.00	3.50	0.3990	1.0000	1	27.4	20,600	0.00	0.00
	3	0.210	175.00	5.60	0.3990	1.0000	1	29.1	41,471	2.15	1.41
	4	0.210	200.00	3.20	0.3990	1.0000	1	8.6	21,350	1.41	0.91
	Σ							**828.2**	**38,229**	**0.49**	**0.37**
#13	1	0.202	175.00	5.40	0.3980	1.0000	1	50.5	30,826	0.00	0.00
	2	0.210	150.00	6.90	0.3990	1.0000	1	196.4	50,061	1.07	0.73
	Σ							**1,064.4**	**36,821**	**0.38**	**0.30**
#2	1	0.171	200.00	3.80	0.3950	1.0000	3	8.1	10,332	4.82	3.62
	2	0.210	150.00	6.30	0.3990	1.0000	1	89.6	44,028	1.11	0.74
	Σ							**1,162.0**	**35,837**	**0.52**	**0.42**
#3	1	0.205	75.00	12.90	0.3160	1.0000	1	170.7	53,768	0.00	0.00
	2	0.198	150.00	6.50	0.3850	1.0000	1	63.9	33,151	0.00	0.00
	3	0.198	150.00	6.60	0.3860	1.0000	1	57.3	36,271	0.00	0.00

Stru #	SWS #	Soil K	L (ft)	S (%)	C	P	PS #	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc (ml/l)	24VW (ml/l)
	4	0.174	75.00	18.60	0.2570	1.0000	1	48.3	65,947	3.99	2.60
	Σ							**1,464.6**	**43,740**	**0.17**	**0.11**
#4	Σ							**2,789.2**	**41,701**	**0.79**	**0.56**
#9	1	0.156	175.00	5.90	0.3250	1.0000	1	123.3	31,253	1.28	0.85
	Σ							**2,804.6**	**40,483**	**0.19**	**0.13**

Subwatershed Time of Concentration Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#1	1	5. Nearly bare and untilled, and alluvial valley fans	4.44	73.00	1,643.00	2.100	0.217
		8. Large gullies, diversions, and low flowing streams	2.89	129.00	4,465.00	5.090	0.243
#1	**1**	**Time of Concentration:**					**0.460**
#1	2	5. Nearly bare and untilled, and alluvial valley fans	7.48	62.00	829.00	2.730	0.084
		8. Large gullies, diversions, and low flowing streams	3.36	82.00	2,442.00	5.490	0.123
#1	**2**	**Time of Concentration:**					**0.207**
#1	3	5. Nearly bare and untilled, and alluvial valley fans	5.97	70.00	1,173.00	2.440	0.133
		8. Large gullies, diversions, and low flowing streams	2.11	115.00	5,440.18	4.360	0.346
#1	**3**	**Time of Concentration:**					**0.479**
#2	1	5. Nearly bare and untilled, and alluvial valley fans	1.12	33.00	2,939.00	1.050	0.777
		8. Large gullies, diversions, and low flowing streams	2.59	102.00	3,941.00	4.820	0.227
#2	**1**	**Time of Concentration:**					**1.004**
#2	2	5. Nearly bare and untilled, and alluvial valley fans	6.18	50.00	809.00	2.480	0.090
		8. Large gullies, diversions, and low flowing streams	2.21	105.00	4,746.00	4.460	0.295
#2	**2**	**Time of Concentration:**					**0.385**
#3	1	5. Nearly bare and untilled, and alluvial valley fans	4.42	82.00	1,857.00	2.100	0.245
		8. Large gullies, diversions, and low flowing streams	2.98	178.00	5,969.00	5.180	0.320
#3	**1**	**Time of Concentration:**					**0.565**
#3	2	5. Nearly bare and untilled, and alluvial valley fans	3.69	50.00	1,356.00	1.920	0.196

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
		8. Large gullies, diversions, and low flowing streams	1.66	90.00	5,419.00	3.860	0.389
#3	**2**	**Time of Concentration:**					**0.585**
#3	3	5. Nearly bare and untilled, and alluvial valley fans	4.62	120.00	2,595.00	2.150	0.335
		8. Large gullies, diversions, and low flowing streams	4.01	120.00	2,994.00	6.000	0.138
#3	**3**	**Time of Concentration:**					**0.473**
#3	4	5. Nearly bare and untilled, and alluvial valley fans	23.01	110.00	478.00	4.790	0.027
		8. Large gullies, diversions, and low flowing streams	1.36	38.00	2,801.00	3.490	0.222
#3	**4**	**Time of Concentration:**					**0.249**
#5	1	5. Nearly bare and untilled, and alluvial valley fans	4.59	35.00	763.00	2.140	0.099
		8. Large gullies, diversions, and low flowing streams	3.24	158.00	4,869.00	5.400	0.250
#5	**1**	**Time of Concentration:**					**0.349**
#5	2	5. Nearly bare and untilled, and alluvial valley fans	15.41	55.00	357.00	3.920	0.025
		8. Large gullies, diversions, and low flowing streams	6.97	115.00	1,650.00	7.920	0.057
#5	**2**	**Time of Concentration:**					**0.082**
#5	3	5. Nearly bare and untilled, and alluvial valley fans	6.44	43.00	668.00	2.530	0.073
		8. Large gullies, diversions, and low flowing streams	2.29	51.00	2,225.00	4.540	0.136
#5	**3**	**Time of Concentration:**					**0.209**
#5	4	5. Nearly bare and untilled, and alluvial valley fans	12.85	55.00	428.00	3.580	0.033
		8. Large gullies, diversions, and low flowing streams	2.70	191.00	7,069.00	4.930	0.398
#5	**4**	**Time of Concentration:**					**0.431**
#5	5	5. Nearly bare and untilled, and alluvial valley fans	41.67	115.00	276.00	6.450	0.011
		8. Large gullies, diversions, and low flowing streams	3.54	201.00	5,680.00	5.640	0.279
#5	**5**	**Time of Concentration:**					**0.290**
#5	6	5. Nearly bare and untilled, and alluvial valley fans	3.21	25.00	779.00	1.790	0.120
		8. Large gullies, diversions, and low flowing streams	2.72	91.00	3,351.00	4.940	0.188
#5	**6**	**Time of Concentration:**					**0.308**
#5	7	5. Nearly bare and untilled, and alluvial valley fans	6.79	47.00	692.00	2.600	0.073
		8. Large gullies, diversions, and low flowing streams	1.53	13.00	852.00	3.700	0.063
#5	**7**	**Time of Concentration:**					**0.136**

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#5	8	5. Nearly bare and untilled, and alluvial valley fans	22.82	115.00	504.00	4.770	0.029
		8. Large gullies, diversions, and low flowing streams	4.01	108.00	2,693.00	6.000	0.124
#5	**8**	**Time of Concentration:**					**0.153**
#6	1	5. Nearly bare and untilled, and alluvial valley fans	8.05	33.00	410.00	2.830	0.040
		8. Large gullies, diversions, and low flowing streams	3.87	106.00	2,738.00	5.900	0.128
#6	**1**	**Time of Concentration:**					**0.168**
#6	2	5. Nearly bare and untilled, and alluvial valley fans	11.18	104.00	930.00	3.340	0.077
		8. Large gullies, diversions, and low flowing streams	4.86	99.00	2,035.00	6.610	0.085
#6	**2**	**Time of Concentration:**					**0.162**
#6	3	5. Nearly bare and untilled, and alluvial valley fans	23.16	135.00	583.00	4.810	0.033
		8. Large gullies, diversions, and low flowing streams	2.56	186.00	7,279.00	4.790	0.422
#6	**3**	**Time of Concentration:**					**0.455**
#6	4	5. Nearly bare and untilled, and alluvial valley fans	6.44	25.00	388.00	2.530	0.042
		8. Large gullies, diversions, and low flowing streams	2.70	146.00	5,416.00	4.920	0.305
#6	**4**	**Time of Concentration:**					**0.347**
#6	5	5. Nearly bare and untilled, and alluvial valley fans	4.42	55.00	1,245.00	2.100	0.164
		8. Large gullies, diversions, and low flowing streams	1.91	100.00	5,238.00	4.140	0.351
#6	**5**	**Time of Concentration:**					**0.515**
#6	6	5. Nearly bare and untilled, and alluvial valley fans	2.87	75.00	2,614.00	1.690	0.429
		8. Large gullies, diversions, and low flowing streams	1.96	115.00	5,879.00	4.190	0.389
#6	**6**	**Time of Concentration:**					**0.818**
#6	7	5. Nearly bare and untilled, and alluvial valley fans	5.13	65.00	1,268.00	2.260	0.155
		8. Large gullies, diversions, and low flowing streams	1.88	112.00	5,943.00	4.110	0.401
#6	**7**	**Time of Concentration:**					**0.556**
#7	1	5. Nearly bare and untilled, and alluvial valley fans	2.71	25.00	922.00	1.640	0.156
		8. Large gullies, diversions, and low flowing streams	2.50	112.00	4,479.00	4.740	0.262
#7	**1**	**Time of Concentration:**					**0.418**
#7	2	5. Nearly bare and untilled, and alluvial valley fans	3.68	130.00	3,533.00	1.910	0.513

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
		8. Large gullies, diversions, and low flowing streams	2.48	72.00	2,906.00	4.720	0.171
#7	**2**	**Time of Concentration:**					**0.684**
#7	3	5. Nearly bare and untilled, and alluvial valley fans	1.87	81.00	4,340.13	1.360	0.886
		8. Large gullies, diversions, and low flowing streams	3.65	120.00	3,286.05	5.730	0.159
#7	**3**	**Time of Concentration:**					**1.045**
#9	1	5. Nearly bare and untilled, and alluvial valley fans	3.83	20.00	522.00	1.950	0.074
		8. Large gullies, diversions, and low flowing streams	3.29	160.00	4,861.00	5.440	0.248
#9	**1**	**Time of Concentration:**					**0.322**
#10	1	5. Nearly bare and untilled, and alluvial valley fans	1.36	15.00	1,102.00	1.160	0.263
		8. Large gullies, diversions, and low flowing streams	4.84	160.00	3,303.00	6.600	0.139
#10	**1**	**Time of Concentration:**					**0.402**
#10	2	5. Nearly bare and untilled, and alluvial valley fans	3.37	15.00	445.00	1.830	0.067
		8. Large gullies, diversions, and low flowing streams	3.33	176.00	5,291.00	5.470	0.268
#10	**2**	**Time of Concentration:**					**0.335**
#10	3	5. Nearly bare and untilled, and alluvial valley fans	2.31	15.00	649.00	1.520	0.118
		8. Large gullies, diversions, and low flowing streams	3.19	203.00	6,373.00	5.350	0.330
#10	**3**	**Time of Concentration:**					**0.448**
#10	4	5. Nearly bare and untilled, and alluvial valley fans	6.48	70.00	1,081.00	2.540	0.118
		8. Large gullies, diversions, and low flowing streams	2.59	83.00	3,204.00	4.820	0.184
#10	**4**	**Time of Concentration:**					**0.302**
#11	1	5. Nearly bare and untilled, and alluvial valley fans	6.01	45.00	749.00	2.450	0.084
		8. Large gullies, diversions, and low flowing streams	2.56	181.00	7,074.00	4.790	0.410
#11	**1**	**Time of Concentration:**					**0.494**
#12	1	5. Nearly bare and untilled, and alluvial valley fans	8.58	35.00	408.00	2.920	0.038
		8. Large gullies, diversions, and low flowing streams	2.74	182.00	6,650.10	4.960	0.372
#12	**1**	**Time of Concentration:**					**0.410**
#12	2	5. Nearly bare and untilled, and alluvial valley fans	2.38	47.00	1,974.00	1.540	0.356
		8. Large gullies, diversions, and low flowing streams	3.06	62.00	2,024.00	5.250	0.107
#12	**2**	**Time of Concentration:**					**0.463**

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#12	3	5. Nearly bare and untilled, and alluvial valley fans	7.91	55.00	695.00	2.810	0.068
		8. Large gullies, diversions, and low flowing streams	1.25	32.00	2,560.00	3.350	0.212
#12	**3**	**Time of Concentration:**					**0.280**
#12	4	5. Nearly bare and untilled, and alluvial valley fans	4.04	55.00	1,363.00	2.000	0.189
		8. Large gullies, diversions, and low flowing streams	1.09	5.00	458.00	3.130	0.040
#12	**4**	**Time of Concentration:**					**0.229**
#13	1	5. Nearly bare and untilled, and alluvial valley fans	3.63	85.00	2,341.01	1.900	0.342
		8. Large gullies, diversions, and low flowing streams	1.99	84.00	4,214.00	4.230	0.276
#13	**1**	**Time of Concentration:**					**0.618**
#13	2	5. Nearly bare and untilled, and alluvial valley fans	10.44	55.00	527.00	3.230	0.045
		8. Large gullies, diversions, and low flowing streams	2.94	194.00	6,604.00	5.140	0.356
#13	**2**	**Time of Concentration:**					**0.401**

Subwatershed Muskingum Routing Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#1	1	8. Large gullies, diversions, and low flowing streams	1.79	83.00	4,633.00	4.010	0.320
#1	**1**	**Muskingum K:**					**0.320**
#1	2	8. Large gullies, diversions, and low flowing streams	1.79	83.00	4,633.00	4.010	0.320
#1	**2**	**Muskingum K:**					**0.320**
#3	1	8. Large gullies, diversions, and low flowing streams	1.41	20.00	1,419.00	3.560	0.110
#3	**1**	**Muskingum K:**					**0.110**
#3	2	8. Large gullies, diversions, and low flowing streams	2.22	68.00	3,067.00	4.460	0.191
#3	**2**	**Muskingum K:**					**0.191**
#3	3	8. Large gullies, diversions, and low flowing streams	2.22	68.00	3,067.00	4.460	0.191
#3	**3**	**Muskingum K:**					**0.191**
#5	1	8. Large gullies, diversions, and low flowing streams	1.53	64.00	4,186.00	3.700	0.314
#5	**1**	**Muskingum K:**					**0.314**
#5	2	8. Large gullies, diversions, and low flowing streams	1.97	156.00	7,900.00	4.210	0.521
#5	**2**	**Muskingum K:**					**0.521**

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#5	3	8. Large gullies, diversions, and low flowing streams	1.21	30.00	2,480.00	3.290	0.209
#5	**3**	**Muskingum K:**					**0.209**
#5	4	8. Large gullies, diversions, and low flowing streams	0.84	12.00	1,432.00	2.740	0.145
#5	**4**	**Muskingum K:**					**0.145**
#5	5	8. Large gullies, diversions, and low flowing streams	1.21	30.00	2,480.00	3.290	0.209
#5	**5**	**Muskingum K:**					**0.209**
#5	7	8. Large gullies, diversions, and low flowing streams	0.84	12.00	1,432.15	2.740	0.145
#5	**7**	**Muskingum K:**					**0.145**
#5	8	8. Large gullies, diversions, and low flowing streams	1.53	64.00	4,186.00	3.700	0.314
#5	**8**	**Muskingum K:**					**0.314**
#6	1	8. Large gullies, diversions, and low flowing streams	1.91	273.00	14,327.00	4.140	0.961
#6	**1**	**Muskingum K:**					**0.961**
#6	2	8. Large gullies, diversions, and low flowing streams	1.91	273.00	14,327.00	4.140	0.961
#6	**2**	**Muskingum K:**					**0.961**
#6	3	8. Large gullies, diversions, and low flowing streams	1.62	116.00	7,170.00	3.810	0.522
#6	**3**	**Muskingum K:**					**0.522**
#6	4	8. Large gullies, diversions, and low flowing streams	1.62	116.00	7,170.00	3.810	0.522
#6	**4**	**Muskingum K:**					**0.522**
#6	5	8. Large gullies, diversions, and low flowing streams	1.11	17.00	1,530.00	3.160	0.134
#6	**5**	**Muskingum K:**					**0.134**
#6	6	8. Large gullies, diversions, and low flowing streams	1.11	17.00	1,530.00	3.160	0.134
#6	**6**	**Muskingum K:**					**0.134**
#7	1	8. Large gullies, diversions, and low flowing streams	2.59	106.00	4,093.00	4.820	0.235
#7	**1**	**Muskingum K:**					**0.235**
#7	2	8. Large gullies, diversions, and low flowing streams	2.59	106.00	4,093.00	4.820	0.235
#7	**2**	**Muskingum K:**					**0.235**
#10	1	8. Large gullies, diversions, and low flowing streams	1.62	73.00	4,495.07	3.820	0.326
#10	**1**	**Muskingum K:**					**0.326**
#10	2	8. Large gullies, diversions, and low flowing streams	1.83	47.00	2,573.00	4.050	0.176
#10	**2**	**Muskingum K:**					**0.176**
#12	1	8. Large gullies, diversions, and low flowing streams	0.94	10.00	1,064.00	2.900	0.101

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#12	**1**	**Muskingum K:**					**0.101**
#12	2	8. Large gullies, diversions, and low flowing streams	0.94	10.00	1,064.00	2.900	0.101
#12	**2**	**Muskingum K:**					**0.101**
#13	2	8. Large gullies, diversions, and low flowing streams	1.85	66.00	3,574.00	4.070	0.243
#13	**2**	**Muskingum K:**					**0.243**

General Information

Storm Information:

Storm Type:	NRCS Type II-60
Design Storm:	10 yr - 6 hr
Rainfall Depth:	1.300 inches

Particle Size Distribution:

Size (mm)	Badland Premining	Badland Postmining	LoamySand Premining	LoamySand Postmining
2.0000	100.000%	100.000%	100.000%	100.000%
0.1000	83.500%	75.900%	30.000%	26.500%
0.0500	77.000%	70.000%	17.000%	14.000%
0.0020	56.000%	47.000%	11.000%	11.000%
0.0010	0.000%	0.000%	0.000%	0.000%

Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc. (ml/l)	24VW (ml/l)
#5	713.800	713.800	358.36	33.10	1,722.2	67,582	5.53	3.75
#6	1,250.500	1,964.300	667.85	85.11	3,654.5	56,483	3.18	2.15
#7	573.200	2,537.500	732.77	105.67	4,073.7	53,878	2.75	1.75
#10	551.100	551.100	192.35	21.98	980.4	53,800	2.18	1.62
#11	217.500	768.600	261.74	31.78	1,344.9	50,469	1.80	1.36
#1	373.300	373.300	134.11	16.20	598.8	44,970	1.48	1.10
#14	0.000	1,141.900	395.16	47.97	1,943.8	48,605	1.69	1.28
#12	467.400	1,609.300	511.13	69.95	2,608.3	43,920	1.64	1.26
#13	421.200	2,030.500	590.96	89.28	3,309.5	42,035	1.43	1.14
#2	348.700	2,379.200	640.42	100.66	3,617.2	40,430	1.68	1.36
#3	628.900	3,008.100	705.52	127.41	4,542.3	43,935	1.06	0.78
#4	0.000	5,545.600	1,436.82	233.08	8,616.0	45,624	1.68	1.22
#9	286.900	5,832.500	1,417.39	246.97	8,657.6	45,433	1.11	0.77

General Information

Storm Information:

Storm Type:	NRCS Type II-60
Design Storm:	25 yr - 6 hr
Rainfall Depth:	1.600 inches

Particle Size Distribution:

Size (mm)	Badland Premining	Badland Postmining	LoamySand Premining	LoamySand Postmining
2.0000	100.000%	100.000%	100.000%	100.000%
0.1000	83.500%	75.900%	30.000%	26.500%
0.0500	77.000%	70.000%	17.000%	14.000%
0.0020	56.000%	47.000%	11.000%	11.000%
0.0010	0.000%	0.000%	0.000%	0.000%

Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc. (ml/l)	24VW (ml/l)
#5	713.800	713.800	512.95	47.19	2,551.8	69,456	6.20	4.25
#6	1,250.500	1,964.300	969.37	122.54	455.9	33,367	0.79	0.51
#7	573.200	2,537.500	1,070.88	153.15	1,118.1	31,285	0.47	0.31
#10	551.100	551.100	286.43	32.14	1,508.1	56,419	2.84	2.12
#11	217.500	768.600	387.22	46.17	2,057.7	52,866	2.43	1.85
#1	373.300	373.300	196.36	23.33	906.0	47,101	2.00	1.50
#14	0.000	1,141.900	582.61	69.50	2,963.7	50,919	2.29	1.73
#12	467.400	1,609.300	747.93	100.77	3,951.7	46,147	2.18	1.67
#13	421.200	2,030.500	860.02	128.35	4,997.0	44,117	1.91	1.53
#2	348.700	2,379.200	937.47	145.43	5,466.5	42,313	2.21	1.78
#3	628.900	3,008.100	1,029.04	184.11	6,856.7	45,268	1.50	1.12
#4	0.000	5,545.600	2,093.35	337.27	7,974.8	37,244	1.14	0.86
#9	286.900	5,832.500	2,068.43	356.93	8,223.4	35,092	0.79	0.60

General Information

Storm Information:

Storm Type:	NRCS Type II-60
Design Storm:	100 yr - 6 hr
Rainfall Depth:	2.000 inches

Particle Size Distribution:

Size (mm)	Badland Premining	Badland Postmining	LoamySand Premining	LoamySand Postmining
2.0000	100.000%	100.000%	100.000%	100.000%
0.1000	83.500%	75.900%	30.000%	26.500%
0.0500	77.000%	70.000%	17.000%	14.000%
0.0020	56.000%	47.000%	11.000%	11.000%
0.0010	0.000%	0.000%	0.000%	0.000%

Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc. (ml/l)	24VW (ml/l)
#5	713.800	713.800	729.89	67.20	3,768.5	71,238	6.84	4.74
#6	1,250.500	1,964.300	1,404.93	176.12	8,197.2	60,100	4.14	2.85
#7	573.200	2,537.500	1,554.22	221.42	9,231.3	57,149	3.56	2.32
#10	551.100	551.100	422.67	46.80	2,305.9	58,998	3.52	2.64
#11	217.500	768.600	568.61	66.87	3,130.0	55,245	3.07	2.34
#1	373.300	373.300	285.75	33.55	1,365.9	49,304	2.55	1.91
#14	0.000	1,141.900	854.34	100.42	4,496.0	53,238	2.90	2.20
#12	467.400	1,609.300	1,088.84	144.85	5,959.6	48,362	2.72	2.09
#13	421.200	2,030.500	1,248.36	184.20	7,513.3	46,203	2.42	1.93
#2	348.700	2,379.200	1,366.20	209.69	8,226.7	44,200	2.75	2.21
#3	628.900	3,008.100	1,496.71	265.48	10,317.1	46,863	2.00	1.50
#4	0.000	5,545.600	3,044.53	486.90	19,548.4	48,667	2.53	1.88
#9	286.900	5,832.500	3,002.48	514.72	19,645.7	47,755	1.91	1.38

Appendix 18.C

Barber Wash Pre-Mine Hydrology & Sedimentology

(2 YR-6 HR, 10 YR-6 HR, 25 YR-6 HR & 100 YR-6 HR Storm Events)

Barber Wash Pre-mine Hydrology and Sedimentology

The hydrology model and drainage subdivisions are presented on Exhibit 7-4C. The pre-mine channel alignment and profiles are presented on Exhibit 11-76F thru 11-76H.

AY/LR

BHP Navajo Coal Company
Navajo Mine
PO Box 1717
Fruitland, NM 87415

Phone: 505-598-5861

General Information

Storm Information:

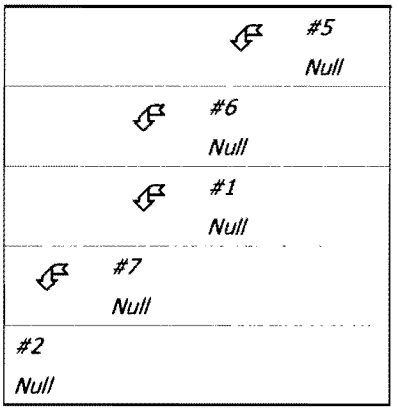
Storm Type:	NRCS Type II-60
Design Storm:	2 yr - 6 hr
Rainfall Depth:	0.800 inches

Particle Size Distribution:

Size (mm)	Badland Premining	Badland Postmining	LoamySand Premining	LoamySand Postmining
2.0000	100.000%	100.000%	100.000%	100.000%
0.1000	83.500%	75.900%	30.000%	26.500%
0.0500	77.000%	70.000%	17.000%	14.000%
0.0020	56.000%	47.000%	11.000%	11.000%
0.0010	0.000%	0.000%	0.000%	0.000%

Structure Networking:

Type	Stru #	(flows into)	Stru #	Musk. K (hrs)	Musk. X	Description
Null	#1	==>	#7	0.000	0.000	Barber branch 1, S1
Null	#2	==>	End	0.000	0.000	Barber branch 1, S2
Null	#5	==>	#6	0.678	0.353	
Null	#6	==>	#7	0.000	0.000	
Null	#7	==>	#2	1.115	0.335	



Structure Routing Details:

Stru #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#5	8. Large gullies, diversions, and low flowing streams	1.87	187.00	10,008.00	4.10	0.678
#5	**Muskingum K:**					**0.678**
#7	8. Large gullies, diversions, and low flowing streams	1.33	185.00	13,888.88	3.46	1.115
#7	**Muskingum K:**					**1.115**

Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc. (ml/l)	24VW (ml/l)
#5	546.300	546.300	6.65	2.22	11.1	6,018	2.24	1.71
#6	677.700	1,224.000	59.59	12.46	165.7	19,253	0.42	0.27
#1	492.000	492.000	32.20	5.00	68.4	17,552	0.00	0.00
#7	0.000	1,716.000	90.24	17.46	234.1	18,532	0.29	0.19
#2	1,647.600	3,363.600	120.60	31.06	447.0	23,314	0.00	0.00

Particle Size Distribution(s) at Each Structure

Structure #5:

Size (mm)	In/Out
2.0000	100.000%
0.1000	100.000%
0.0500	63.714%
0.0020	41.227%
0.0010	0.000%

Structure #6:

Size (mm)	In/Out
2.0000	100.000%
0.1000	100.000%
0.0500	97.937%
0.0020	96.429%
0.0010	0.000%

Structure #1 (Barber branch 1, S1):

Size (mm)	In/Out
2.0000	100.000%
0.1000	100.000%
0.0500	100.000%
0.0020	100.000%
0.0010	0.000%

Structure #7:

Size (mm)	In/Out
2.0000	100.000%
0.1000	100.000%
0.0500	98.540%

Size (mm)	In/Out
0.0020	97.473%
0.0010	0.000%

Structure #2:

Size (mm)	In/Out
2.0000	100.000%
0.1000	100.000%
0.0500	100.000%
0.0020	100.000%
0.0010	0.000%

Subwatershed Hydrology Detail:

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
#5	1	546.300	2.139	0.000	0.000	81.800	M	6.65	2.224
	Σ	**546.300**						**6.65**	**2.224**
#6	1	677.700	1.018	0.000	0.000	89.400	M	59.52	10.233
	Σ	**1,224.000**						**59.59**	**12.457**
#1	1	492.000	0.787	0.000	0.000	86.800	M	32.20	4.999
	Σ	**492.000**						**32.20**	**4.999**
#7	Σ	**1,716.000**						**90.24**	**17.455**
#2	1	506.200	0.749	0.473	0.336	87.900	M	41.93	6.108
	2	383.000	0.948	0.697	0.338	79.700	M	4.16	0.950
	3	399.200	1.072	0.697	0.338	78.200	M	2.48	0.645
	4	97.800	0.364	0.473	0.336	86.900	M	10.40	1.010
	5	261.400	0.579	0.000	0.000	90.900	M	42.17	4.895
	Σ	**3,363.600**						**120.60**	**31.063**

Subwatershed Sedimentology Detail:

Stru #	SWS #	Soil K	L (ft)	S (%)	C	P	PS #	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc (ml/l)	24VW (ml/l)
#5	1	0.159	300.00	2.70	0.3580	1.0000	3	11.1	6,018	2.24	1.71
	Σ							**11.1**	**6,018**	**2.24**	**1.71**
#6	1	0.209	200.00	3.80	0.3910	1.0000	1	155.2	19,272	0.00	0.00
	Σ							**165.7**	**19,253**	**0.42**	**0.27**
#1	1	0.191	200.00	3.90	0.3880	1.0000	1	68.4	17,552	0.00	0.00
	Σ							**68.4**	**17,552**	**0.00**	**0.00**
#7	Σ							**234.1**	**18,532**	**0.29**	**0.19**
#2	1	0.186	150.00	7.19	0.3000	1.0000	1	126.6	26,447	0.00	0.00
	2	0.157	175.00	5.00	0.3820	1.0000	3	10.1	12,665	6.08	4.67
	3	0.151	300.00	2.45	0.3930	1.0000	3	3.1	5,520	2.92	2.30
	4	0.177	75.00	13.90	0.2560	1.0000	1	29.8	39,363	0.00	0.00
	5	0.190	125.00	9.00	0.1940	1.0000	1	90.1	24,359	0.00	0.00

Stru #	SWS #	Soil K	L (ft)	S (%)	C	P	PS #	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc (ml/l)	24VW (ml/l)
	Σ							**447.0**	**23,314**	**0.00**	**0.00**

Subwatershed Time of Concentration Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#1	1	5. Nearly bare and untilled, and alluvial valley fans	2.65	45.00	1,698.00	1.620	0.291
		8. Large gullies, diversions, and low flowing streams	2.03	155.00	7,633.00	4.270	0.496
#1	**1**	**Time of Concentration:**					**0.787**
#2	1	5. Nearly bare and untilled, and alluvial valley fans	4.37	40.00	916.00	2.080	0.122
		8. Large gullies, diversions, and low flowing streams	1.74	155.00	8,920.00	3.950	0.627
#2	**1**	**Time of Concentration:**					**0.749**
#2	2	5. Nearly bare and untilled, and alluvial valley fans	3.55	102.00	2,872.00	1.880	0.424
		8. Large gullies, diversions, and low flowing streams	1.67	122.00	7,308.00	3.870	0.524
#2	**2**	**Time of Concentration:**					**0.948**
#2	3	5. Nearly bare and untilled, and alluvial valley fans	3.55	122.00	3,440.00	1.880	0.508
		8. Large gullies, diversions, and low flowing streams	1.50	112.00	7,452.00	3.670	0.564
#2	**3**	**Time of Concentration:**					**1.072**
#2	4	5. Nearly bare and untilled, and alluvial valley fans	3.83	45.00	1,176.00	1.950	0.167
		8. Large gullies, diversions, and low flowing streams	1.28	31.00	2,416.00	3.390	0.197
#2	**4**	**Time of Concentration:**					**0.364**
#2	5	5. Nearly bare and untilled, and alluvial valley fans	5.87	56.00	954.00	2.420	0.109
		8. Large gullies, diversions, and low flowing streams	1.30	75.00	5,772.00	3.410	0.470
#2	**5**	**Time of Concentration:**					**0.579**
#5	1	8. Large gullies, diversions, and low flowing streams	1.28	45.00	3,519.00	3.390	0.288
		5. Nearly bare and untilled, and alluvial valley fans	1.62	137.00	8,464.00	1.270	1.851
#5	**1**	**Time of Concentration:**					**2.139**
#6	1	5. Nearly bare and untilled, and alluvial valley fans	3.04	90.00	2,962.00	1.740	0.472
		8. Large gullies, diversions, and low flowing streams	1.99	165.00	8,308.00	4.220	0.546

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#6	**1**	**Time of Concentration:**					**1.018**

Subwatershed Muskingum Routing Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#2	1	8. Large gullies, diversions, and low flowing streams	1.35	80.00	5,933.00	3.480	0.473
#2	**1**	**Muskingum K:**					**0.473**
#2	2	8. Large gullies, diversions, and low flowing streams	1.40	125.00	8,915.00	3.550	0.697
#2	**2**	**Muskingum K:**					**0.697**
#2	3	8. Large gullies, diversions, and low flowing streams	1.40	125.00	8,915.00	3.550	0.697
#2	**3**	**Muskingum K:**					**0.697**
#2	4	8. Large gullies, diversions, and low flowing streams	1.35	80.00	5,933.00	3.480	0.473
#2	**4**	**Muskingum K:**					**0.473**

General Information

Storm Information:

Storm Type:	NRCS Type II-60
Design Storm:	10 yr - 6 hr
Rainfall Depth:	1.300 inches

Particle Size Distribution:

Size (mm)	Badland Premining	Badland Postmining	LoamySand Premining	LoamySand Postmining
2.0000	100.000%	100.000%	100.000%	100.000%
0.1000	83.500%	75.900%	30.000%	26.500%
0.0500	77.000%	70.000%	17.000%	14.000%
0.0020	56.000%	47.000%	11.000%	11.000%
0.0010	0.000%	0.000%	0.000%	0.000%

Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc. (ml/l)	24VW (ml/l)
#5	546.300	546.300	35.85	10.81	69.2	7,872	3.23	2.42
#6	677.700	1,224.000	176.28	39.18	561.7	22,504	0.79	0.46
#1	492.000	492.000	115.29	16.16	269.6	21,568	0.00	0.00
#7	0.000	1,716.000	284.66	55.34	831.3	21,916	0.52	0.33
#2	1,647.600	3,363.600	404.08	100.74	1,672.0	27,241	0.36	0.21

General Information

Storm Information:

Storm Type:	NRCS Type II-60
Design Storm:	25 yr - 6 hr
Rainfall Depth:	1.600 inches

Particle Size Distribution:

Size (mm)	Badland Premining	Badland Postmining	LoamySand Premining	LoamySand Postmining
2.0000	100.000%	100.000%	100.000%	100.000%
0.1000	83.500%	75.900%	30.000%	26.500%
0.0500	77.000%	70.000%	17.000%	14.000%
0.0020	56.000%	47.000%	11.000%	11.000%
0.0010	0.000%	0.000%	0.000%	0.000%

Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc. (ml/l)	24VW (ml/l)
#5	546.300	546.300	61.47	17.97	124.4	8,570	3.68	2.74
#6	677.700	1,224.000	260.69	59.13	872.9	23,679	0.97	0.56
#1	492.000	492.000	178.78	24.44	434.6	22,986	0.00	0.00
#7	0.000	1,716.000	427.91	83.57	1,307.5	23,157	0.63	0.39
#2	1,647.600	3,363.600	621.73	153.52	2,674.9	28,540	0.77	0.44

General Information

Storm Information:

Storm Type:	NRCS Type II-60
Design Storm:	100 yr - 6 hr
Rainfall Depth:	2.000 inches

Particle Size Distribution:

Size (mm)	Badland Premining	Badland Postmining	LoamySand Premining	LoamySand Postmining
2.0000	100.000%	100.000%	100.000%	100.000%
0.1000	83.500%	75.900%	30.000%	26.500%
0.0500	77.000%	70.000%	17.000%	14.000%
0.0020	56.000%	47.000%	11.000%	11.000%
0.0010	0.000%	0.000%	0.000%	0.000%

Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc. (ml/l)	24VW (ml/l)
#5	546.300	546.300	102.19	29.12	216.6	9,259	4.14	3.06
#6	677.700	1,224.000	383.05	88.65	1,347.5	24,832	1.16	0.65
#1	492.000	492.000	272.80	36.66	691.0	24,319	0.00	0.00
#7	0.000	1,716.000	639.12	125.30	2,038.4	24,417	0.76	0.46
#2	1,647.600	3,363.600	949.46	232.22	4,239.9	29,848	1.24	0.71

Appendix 18.D

Neck Arroyo Pre-Mine Hydrology & Sedimentology

SEDCAD + Files

(2 YR-6 HR, 10 YR-6 HR, 25 YR-6 HR & 100 YR-6 HR)

SEDCAD+(TM)
Sediment, Erosion, Discharge by Computer Aided Design

by

Pamela J. Schwab
Civil Software Design
P.O. Box 11092
Lexington, Kentucky 40572

Version No. 2.15 (6/20/88)

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SEDCAD+(TM) Serial No. 101 has been Authorized and Released to:

Applied Hydrology Associates
1325 S. Colorado Blvd.
Denver, CO 80222
(303) 782-0164

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File Created By:	Pam Tarquin	
File Currently Being Printed:	b:neck2	

WATERSHED IDENTIFICATION

Premining Peak Flows for Neck Arroyo - 2 year 6 hour

STORM INPUT

Storm Type	SCS TYPE 2
Rainfall Depth	0.8 inches
Storm Duration	6.0 hours

--- Applied Hydrology Associates ---

WATERSHED NETWORK

JUNCTIONS	BRANCHES	STRUCTURES
1	1	1
		2

SEDIMENTOLOGY INPUTS

Specific Gravity =	2.5
Submerged Bulk Specific Gravity =	1.25

PERCENT FINER DISTRIBUTIONS:

NO.	PARTICLE SIZE, (mm)	NO. 1	NO. 2	NO. 3	NO. 4
1	2.0000	100.00	100.00	100.00	100.00
2	0.1000	83.30	75.90	30.00	26.80
3	0.0500	77.00	70.00	17.00	14.00
4	0.0020	56.00	47.00	11.00	11.00
5	0.0010	0.00	0.00	0.00	0.00

BETWEEN STRUCTURE ROUTING PARAMETERS

J	B		TRAVEL TIME (hours)	MUSK. K (hours)	MUSK. X
1	1	Prior J or S to Structure 1	0.000	0.000	0.000
1	1	Prior J or S to Structure 2	0.673	0.673	0.348

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****
****
**
** JUNCTION 1 , BRANCH 1 , STRUCTURE 1 **
** NULL STRUCTURE **
** J1 B1 S1 **
**
****
****

SUBWATERSHED INFORMATION

HYDRAULIC INPUT VALUES

WATER SHED	AREA (acre)	CURVE NUMBER	TC (hr)	TT (hr)	ROUTING COEF'S K-(hr)	X	UNIT HYDRO RESPONSE
1	251.61	81.99	0.741	0.049	0.049	0.367	MED
2	85.40	89.00	0.357	0.172	0.172	0.361	MED
3	153.35	89.00	0.544	0.049	0.049	0.367	MED
4	97.34	89.00	0.193	0.000	0.000	0.000	MED
5	89.99	84.00	0.151	0.000	0.000	0.000	MED

SEDIMENT INPUT VALUES

WATER SHED	SEG NUM	SOIL K	LENGTH (feet)	SLOPE (%)	CP VALUE	PART OPT	
1	1	0.32	800.0	5.0	0.450	1	(MUSLE)
2	1	0.37	200.0	10.0	0.450	1	(MUSLE)
3	1	0.37	400.0	10.0	0.450	1	(MUSLE)
4	1	0.37	400.0	10.0	0.450	1	(MUSLE)
5	1	0.32	400.0	10.0	0.450	1	(MUSLE)

COMPUTED VALUES FOR INDIVIDUAL WATERSHEDS

WATERSHED	PEAK FLOW (cfs)	RUNOFF (inches)	SEDIMENT (tons)	D50 (mm)
1	4.668	0.048	49.24	0.001
2	11.717	0.166	133.51	0.001
3	16.490	0.166	317.33	0.001
4	17.805	0.166	256.81	0.002
5	6.153	0.072	73.70	0.002

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RESULTS TO J1 B1 S1

Total Drainage Area to This Point = 677.686 acres

	RUNOFF VOLUME (ac-ft)	PEAK DISCHARGE (cfs)	PEAK SEDIMENT CONCENTRATION (mg/l)	PEAK SETTLEABLE CONCENTRATION (ml/l)	SEDIMENT YIELD (tons)
IN/OUT	6,194	43.144	154e56.00	5.955	830.57

	TIME OF SIGNIFICANT CONCENTRATION (hrs)	AVERAGE SETTLEABLE CONCENTRATION: VOLUME WEIGHTED DURING TIME OF SIGN. CONC. (ml/l)	VOLUME WEIGHTED DURING PEAK 24 HOUR (ml/l)	ARITHMETIC DURING TIME OF SIGN. CONC. (ml/l)	ARITHMETIC DURING PEAK 24 HOUR (ml/l)
IN/OUT	6.40	3.62	3.62	2.05	0.55

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****
**
** JUNCTION 1 , BRANCH 1 , STRUCTURE 2 **
** NULL STRUCTURE **
** J1 B1 S2 **
**
****
****

SUBWATERSHED INFORMATION

HYDRAULIC INPUT VALUES

WATER SHED	AREA (acre)	CURVE NUMBER	TC (hr)	TT (hr)	ROUTING COEF'S K-(hr)	X	UNIT HYDRO RESPONSE
1	359.96	89.00	0.602	0.233	0.233	0.337	MED
2	162.04	84.00	0.427	0.000	0.000	0.000	MED

SEDIMENT INPUT VALUES

WATER SHED	SED NUM	SOIL K	LENGTH (feet)	SLOPE (%)	CP VALUE	PART OPT	
1	1	0.36	800.0	15.0	0.450	1	(MUSLE)
2	1	0.32	600.0	16.0	0.450	1	(MUSLE)

COMPUTED VALUES FOR INDIVIDUAL WATERSHEDS

WATERSHED	PEAK FLOW (cfs)	RUNOFF (inches)	SEDIMENT (tons)	D50 (mm)
1	36.472	0.166	2637.74	0.001
2	6.828	0.072	352.21	0.001

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RESULTS TO J1 B1 S2

Total Drainage Area to This Point = 1105.693 acres
Drainage Area Between Previous Structure and This One = 528.007 acres

	RUNOFF VOLUME (ac-ft)	PEAK DISCHARGE (cfs)	PEAK SEDIMENT CONCENTRATION (mg/l)	PEAK SETTLEABLE CONCENTRATION (ml/l)	SEDIMENT YIELD (tons)
IN/OUT	12.175	71.833	354957.31	2.965	5820.08

	TIME OF SIGNIFICANT CONCENTRATION (hrs)	AVERAGE SETTLEABLE CONCENTRATION: VOLUME WEIGHTED DURING TIME OF SIGN. CONC. (ml/l)	VOLUME WEIGHTED DURING PEAK 24 HOUR (ml/l)	ARITHMETIC DURING TIME OF SIGN. CONC. (ml/l)	ARITHMETIC DURING PEAK 24 HOUR (ml/l)
IN/OUT	6.30	1.74	1.74	1.10	0.29

*** RUN COMPLETED ***

SEDCAD+(TM)
Sediment, Erosion, Discharge by Computer Aided Design

by

Pamela J. Schwab
Civil Software Design
P.O. Box 11092
Lexington, Kentucky 40572

Version No. 2.15 (6/20/10)

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Current Date and Time:	01-05-1988	17:18:27
Computed Date and Time:	01-05-1988	17:13:05
File Created By:	Pam Tarquin	
File Currently Being Printed:	b:neck10	

WATERSHED IDENTIFICATION

Premining Peak Flows for Neck Arroyo - 10 year 6 hour

STORM INPUT

Storm Type	SCS TYPE 2
Rainfall Depth	1.3 inches
Storm Duration	6.0 hours

WATERSHED NETWORK

JUNCTIONS	BRANCHES	STRUCTURES
1	1	1
		2

SEDIMENTOLOGY INPUTS

Specific Gravity =	2.5
Submerged Bulk Specific Gravity =	1.25

PERCENT FINER DISTRIBUTIONS:

NO.	PARTICLE SIZE, (mm)	NO. 1	NO. 2	NO. 3	NO. 4
1	2.0000	100.00	100.00	100.00	100.00
2	0.1000	83.50	75.90	30.00	26.50
3	0.0500	77.00	70.00	17.00	14.00
4	0.0020	56.00	47.00	11.00	11.30
5	0.0010	0.00	0.00	0.00	0.00

BETWEEN STRUCTURE ROUTING PARAMETERS

J	B		TRAVEL TIME (hours)	MUSK. K (hours)	MUSK. X
1	1	Prior J or S to Structure 1	0.000	0.000	0.000
1	1	Prior J or S to Structure 2	0.673	0.673	0.348

<<< SEDCAD+ >>>
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****
**
** JUNCTION 1 . BRANCH 1 , STRUCTURE 1 **
** NULL STRUCTURE **
** J1 B1 S1 **
**
****
****

SUBWATERSHED INFORMATION

HYDRAULIC INPUT VALUES

WATER SHED	AREA (acre)	CURVE NUMBER	TC (hr)	TT (hr)	ROUTING COEF'S K-(hr)	X	UNIT HYDRO RESPONSE
1	251.61	81.99	0.741	0.049	0.049	0.367	MED
2	85.40	89.00	0.357	0.172	0.172	0.361	MED
3	153.35	89.00	0.544	0.049	0.049	0.367	MED
4	97.34	89.00	0.193	0.000	0.000	0.000	MED
5	89.99	84.00	0.151	0.000	0.000	0.000	MED

SEDIMENT INPUT VALUES

WATER SHED	SEG NUM	SOIL K	LENGTH (feet)	SLOPE (%)	CP VALUE	PART OPT	
1	1	0.32	800.0	5.0	0.450	1	(MUSLE)
2	1	0.37	200.0	10.0	0.450	1	(MUSLE)
3	1	0.37	400.0	10.0	0.450	1	(MUSLE)
4	1	0.37	400.0	10.0	0.450	1	(MUSLE)
5	1	0.32	400.0	10.0	0.450	1	(MUSLE)

COMPUTED VALUES FOR INDIVIDUAL WATERSHEDS

WATERSHED	PEAK FLOW (cfs)	RUNOFF (inches)	SEDIMENT (tons)	D50 (mm)
1	31.179	0.237	348.00	0.001
2	36.619	0.477	457.08	0.002
3	52.918	0.477	1102.60	0.001
4	53.993	0.477	864.49	0.002
5	31.382	0.294	402.34	0.002

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RESULTS TO J1 B1 S1

Total Drainage Area to This Point = 677.686 acres

	RUNOFF VOLUME (ac-ft)	PEAK DISCHARGE (cfs)	PEAK SEDIMENT CONCENTRATION (mg/l)	PEAK SETTLEABLE CONCENTRATION (ml/l)	SEDIMENT YIELD (tons)
IN/OUT	20.547	161.763	176633.41	12.551	3174.44

	TIME OF SIGNIFICANT CONCENTRATION (hrs)	AVERAGE SETTLEABLE CONCENTRATION: VOLUME WEIGHTED DURING TIME OF SIGN. CONC. (ml/l)	VOLUME WEIGHTED DURING PEAK 24 HOUR (ml/l)	ARITHMETIC DURING TIME OF SIGN. CONC. (ml/l)	ARITHMETIC DURING PEAK 24 HOUR (ml/l)
IN/OUT	6.50	7.63	7.63	4.04	1.10

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JUNCTION 1 , BRANCH 1 , STRUCTURE 2
NULL STRUCTURE
J1 B1 S2

SUBWATERSHED INFORMATION

HYDRAULIC INPUT VALUES

WATER SHED	AREA (acre)	CURVE NUMBER	TC (hr)	TT (hr)	ROUTING COEF'S K-(hr)	X	UNIT HYDRO RESPONSE
1	359.96	89.00	0.602	0.233	0.233	0.337	MED
2	168.04	84.00	0.427	0.000	0.000	0.000	MED

SEDIMENT INPUT VALUES

WATER SHED	SEG NUM	SOIL K	LENGTH (feet)	SLOPE (%)	CP VALUE	PART OPT	
1	1	0.36	800.0	15.0	0.450	1	(MUSLE)
2	1	0.32	600.0	16.0	0.450	1	(MUSLE)

COMPUTED VALUES FOR INDIVIDUAL WATERSHEDS

WATERSHED	PEAK FLOW (cfs)	RUNOFF (inches)	SEDIMENT (tons)	D50 (mm)
1	117.129	0.477	9169.08	0.001
2	37.674	0.294	2009.29	0.001

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RESULTS TO J1 B1 S2

Total Drainage Area to This Point = 1205.693 acres
Drainage Area Between Previous Structure and This One = 525.007 acres

	RUNOFF VOLUME (ac-ft)	PEAK DISCHARGE (cfs)	PEAK SEDIMENT CONCENTRATION (mg/l)	PEAK SETTLEABLE CONCENTRATION (ml/l)	SEDIMENT YIELD (tons)
IN/OUT	33.97%	247.374	426430.31	14.660	14351.13

	TIME OF SIGNIFICANT CONCENTRATION (hrs)	AVERAGE SETTLEABLE CONCENTRATION: VOLUME WEIGHTED DURING TIME OF SIGN. CONC. (ml/l)	VOLUME WEIGHTED DURING PEAK 24 HOUR (ml/l)	ARITHMETIC DURING TIME OF SIGN. CONC. (ml/l)	ARITHMETIC DURING PEAK 24 HOUR (ml/l)
IN/OUT	6.50	8.22	8.12	4.97	1.35

*** RUN COMPLETED ***

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**********************************************************************
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*                          Civil Software Design                     *
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*    Current Date and Time:            01-05-1988   17:19:13       *
*    Computed Date and Time:           01-05-1988   17:13:31       *
*    File Created By:                  Pam Tarquin                 *
*    File Currently Being Printed:     b:neck25                    *
*                                                                    *
**********************************************************************

************************* WATERSHED IDENTIFICATION *********************
*                                                                    *
* Premining Peak Flows for Neck Arroyo - 25 year 6 hour              *
*                                                                    *
**********************************************************************

********************************* STORM INPUT **************************
*                                                                    *
*                  Storm Type          SCS TYPE 2                    *
*                  Rainfall Depth       1.6 inches                   *
*                  Storm Duration       6.0 hours                    *
*                                                                    *
**********************************************************************
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<<< SEDCAD+ >>>

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WATERSHED NETWORK

JUNCTIONS	BRANCHES	STRUCTURES
1	1	1
		2

SEDIMENTOLOGY INPUTS

Specific Gravity =	2.5
Submerged Bulk Specific Gravity =	1.25

PERCENT FINER DISTRIBUTIONS:

NO.	PARTICLE SIZE, (mm)	NO. 1	NO. 2	NO. 3	NO. 4
1	2.0000	100.00	100.00	100.00	100.00
2	0.1000	83.50	75.90	30.00	26.50
3	0.0500	77.00	70.00	17.00	14.00
4	0.0020	56.00	47.00	11.00	11.00
5	0.0010	0.00	0.00	0.00	0.00

BETWEEN STRUCTURE ROUTING PARAMETERS

J	S		TRAVEL TIME (hours)	MUSK. K (hours)	MUSK. X
1	1	Prior J or S to Structure 1	0.000	0.000	0.000
1	1	Prior J or S to Structure 2	0.673	0.673	0.348

(((SEDCAD+)))
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**
** JUNCTION 1 , BRANCH 1 , STRUCTURE 1 **
** NULL STRUCTURE **
** J1 B1 S1 **
**
****
****

SUBWATERSHED INFORMATION

HYDRAULIC INPUT VALUES

WATER SHED	AREA (acre)	CURVE NUMBER	TC (hr)	TT (hr)	ROUTING COEF'S K-(hr)	X	UNIT HYDRO RESPONSE
1	251.61	81.99	0.741	0.049	0.049	0.367	MED
2	85.40	89.00	0.337	0.172	0.172	0.361	MED
3	153.35	89.00	0.544	0.049	0.049	0.367	MED
4	97.34	89.00	0.193	0.000	0.000	0.000	MED
5	89.99	84.00	0.151	0.000	0.000	0.000	MED

SEDIMENT INPUT VALUES

WATER SHED	SEG NUM	SOIL K	LENGTH (feet)	SLOPE (%)	CP VALUE	PART OPT	
1	1	0.32	200.0	5.0	0.450	1	(MUSLE)
2	1	0.37	200.0	10.0	0.450	1	(MUSLE)
3	1	0.37	400.0	10.0	0.450	1	(MUSLE)
4	1	0.37	400.0	10.0	0.450	1	(MUSLE)
5	1	0.32	400.0	10.0	0.450	1	(MUSLE)

COMPUTED VALUES FOR INDIVIDUAL WATERSHEDS

WATERSHED	PEAK FLOW (cfs)	RUNOFF (inches)	SEDIMENT (tons)	D50 (mm)
1	54.743	0.390	629.59	0.001
2	53.950	0.692	698.95	0.002
3	78.199	0.692	1688.93	0.001
4	78.423	0.692	1311.46	0.002
5	50.758	0.463	679.76	0.002

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RESULTS TO J1 B1 S1

Total Drainage Area to This Point = 677.686 acres

	RUNOFF VOLUME (ac-ft)	PEAK DISCHARGE (cfs)	PEAK SEDIMENT CONCENTRATION (mg/l)	PEAK SETTLEABLE CONCENTRATION (ml/l)	SEDIMENT YIELD (tons)
IN/OUT	31.016	256.658	181642.70	14.937	5008.61

	TIME OF SIGNIFICANT CONCENTRATION (hrs)	AVERAGE SETTLEABLE CONCENTRATION: VOLUME WEIGHTED DURING TIME OF SIGN. CONC. (ml/l)	VOLUME WEIGHTED DURING PEAK 24 HOUR (ml/l)	ARITHMETIC DURING TIME OF SIGN. CONC. (ml/l)	ARITHMETIC DURING PEAK 24 HOUR (ml/l)
IN/OUT	6.70	9.25	9.25	4.70	1.31

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****
****
**
** JUNCTION 1 , BRANCH 1 , STRUCTURE 2 **
** NULL STRUCTURE **
** J1 B1 S2 **
**
****
****

SUBWATERSHED INFORMATION

HYDRAULIC INPUT VALUES

WATER SHED	AREA (acre)	CURVE NUMBER	TC (hr)	TT (hr)	ROUTING K-(hr)	COEF'S X	UNIT HYDRO RESPONSE
1	359.96	69.00	0.602	0.233	0.233	0.337	MED
2	168.04	84.00	0.427	0.000	0.000	0.000	MED

SEDIMENT INPUT VALUES

WATER SHED	SEG NUM	SOIL K	LENGTH (feet)	SLOPE (%)	CP VALUE	PART OPT	
1	1	0.36	800.0	15.0	0.450	1	(MUSLE)
2	1	0.32	600.0	16.0	0.450	1	(MUSLE)

COMPUTED VALUES FOR INDIVIDUAL WATERSHEDS

WATERSHED	PEAK FLOW (cfs)	RUNOFF (inches)	SEDIMENT (tons)	D50 (mm)
1	173.463	0.692	14062.02	0.001
2	62.329	0.463	3438.01	0.001

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RESULTS TO J1 B1 S2

Total Drainage Area to This Point = 1205.693 acres
Drainage Area Between Previous Structure and This One = 529.007 acres

	RUNOFF VOLUME (ac-ft)	PEAK DISCHARGE (cfs)	PEAK SEDIMENT CONCENTRATION (mg/l)	PEAK SETTLEABLE CONCENTRATION (ml/l)	SEDIMENT YIELD (tons)
IN/OUT	32.247	302.490	445158.00	20.767	22506.06

	TIME OF SIGNIFICANT CONCENTRATION (hrs)	AVERAGE SETTLEABLE CONCENTRATION: VOLUME WEIGHTED DURING TIME OF SIGN. CONC. (ml/l)	VOLUME WEIGHTED DURING PEAK 24 HOUR (ml/l)	ARITHMETIC DURING TIME OF SIGN. CONC. (ml/l)	ARITHMETIC DURING PEAK 24 HOUR (ml/l)
IN/OUT	6.70	11.64	11.64	6.79	1.90

*** RUN COMPLETED ***

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*    Current Date and Time:              01-05-1988   17:20:25                *
*    Computed Date and Time:             01-05-1988   17:13:56                *
*    File Created By:                    Pam Tarquin                          *
*    File Currently Being Printed:       b:neck100                            *
*                                                                             *
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************************** WATERSHED IDENTIFICATION ***************************
*                                                                             *
* Premining Peak Flows for Neck Arroyo - 100 year 6 hour                      *
*                                                                             *
*******************************************************************************

********************************** STORM INPUT ********************************
*                                                                             *
*                    Storm Type           SCS TYPE 2                          *
*                    Rainfall Depth        2.0 inches                         *
*                    Storm Duration        6.0 hours                          *
*                                                                             *
*******************************************************************************
```

WATERSHED NETWORK

JUNCTIONS	BRANCHES	STRUCTURES
1	1	1 2

SEDIMENTOLOGY INPUTS

Specific Gravity =	2.5
Submerged Bulk Specific Gravity =	1.25

		PERCENT FINER DISTRIBUTIONS:			
NO.	PARTICLE SIZE, (mm)	NO. 1	NO. 2	NO. 3	NO. 4
1	2.0000	100.00	100.00	100.00	100.00
2	0.1000	83.50	75.90	30.00	26.50
3	0.0500	77.00	70.00	17.00	14.00
4	0.0020	56.00	47.00	11.00	11.00
5	0.0010	0.00	0.00	0.00	0.00

BETWEEN STRUCTURE ROUTING PARAMETERS

J	B		TRAVEL TIME (hours)	MUSK. K (hours)	MUSK. X
1	1	Prior J or S to Structure 1	0.000	0.000	0.000
1	1	Prior J or S to Structure 2	0.673	0.673	0.348

<<< SEDCAD+ >>>
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****
****
**
** JUNCTION 1 , BRANCH 1 , STRUCTURE 1 **
** NULL STRUCTURE **
** J1 B1 S1 **
**
****
****

SUBWATERSHED INFORMATION

HYDRAULIC INPUT VALUES

WATER SHED	AREA (acre)	CURVE NUMBER	TC (hr)	TT (hr)	ROUTING K-(hr)	COEF'S X	UNIT HYDRO RESPONSE
1	251.61	81.99	0.741	0.049	0.049	0.367	MED
2	85.40	89.00	0.357	0.172	0.172	0.361	MED
3	153.35	89.00	0.544	0.049	0.049	0.367	MED
4	97.34	89.00	0.193	0.000	0.000	0.000	MED
5	89.99	84.00	0.151	0.000	0.000	0.000	MED

SEDIMENT INPUT VALUES

WATER SHED	SEG NUM	SOIL K	LENGTH (feet)	SLOPE (%)	CP VALUE	PART OPT	
1	1	0.32	800.0	5.0	0.450	1	(MUSLE)
2	1	0.37	200.0	10.0	0.450	1	(MUSLE)
3	1	0.37	400.0	10.0	0.450	1	(MUSLE)
4	1	0.37	400.0	10.0	0.450	1	(MUSLE)
5	1	0.32	400.0	10.0	0.450	1	(MUSLE)

COMPUTED VALUES FOR INDIVIDUAL WATERSHEDS

WATERSHED	PEAK FLOW (cfs)	RUNOFF (inches)	SEDIMENT (tons)	D50 (mm)
1	93.496	0.635	1116.66	0.001
2	79.854	1.011	1077.17	0.002
3	116.454	1.011	2611.74	0.002
4	114.193	1.011	2002.68	0.002
5	80.852	0.730	1137.96	0.002

<<< SEDCAD+ >>>
--- Applied Hydrology Associates ---

RESULTS TO J1 E1 S1

Total Drainage Area to This Point = 677.686 acres

	RUNOFF VOLUME (ac-ft)	PEAK DISCHARGE (cfs)	PEAK SEDIMENT CONCENTRATION (mg/l)	PEAK SETTLEABLE CONCENTRATION (ml/l)	SEDIMENT YIELD (tons)
IN/OUT	47.117	401.347	182306.00	16.908	7946.06

	TIME OF SIGNIFICANT CONCENTRATION (hrs)	AVERAGE SETTLEABLE CONCENTRATION: VOLUME WEIGHTED DURING TIME OF SIGN. CONC. (ml/l)	VOLUME WEIGHTED DURING PEAK 24 HOUR (ml/l)	ARITHMETIC DURING TIME OF SIGN. CONC. (ml/l)	ARITHMETIC DURING PEAK 24 HOUR (ml/l)
IN/OUT	7.00	10.83	10.83	5.30	1.55

<<< SEDCAD+ >>>
--- Applied Hydrology Associates ---

****
****
**
** JUNCTION 1 , BRANCH 1 , STRUCTURE 2 **
** NULL STRUCTURE **
** J1 B1 S2 **
**
****
****

SUBWATERSHED INFORMATION

HYDRAULIC INPUT VALUES

WATER SHED	AREA (acre)	CURVE NUMBER	TC (hr)	TT (hr)	ROUTING K-(hr)	COEF'S X	UNIT HYDRO RESPONSE
1	359.96	89.00	0.602	0.233	0.233	0.337	MED
2	163.04	84.00	0.427	0.000	0.000	0.000	MED

SEDIMENT INPUT VALUES

WATER SHED	SEG NUM	SOIL K	LENGTH (feet)	SLOPE (%)	CP VALUE	PART OPT	
1	1	0.36	800.0	15.0	0.450	1	(MUSLE)
2	1	0.32	600.0	16.0	0.450	1	(MUSLE)

COMPUTED VALUES FOR INDIVIDUAL WATERSHEDS

WATERSHED	PEAK FLOW (cfs)	RUNOFF (inches)	SEDIMENT (tons)	D50 (mm)
1	257.944	1.011	21727.51	0.001
2	101.028	0.730	5811.84	0.002

<<< SEDCAD+ >>>

--- Applied Hydrology Associates ---

RESULTS TO J1 B1 S2

Total Drainage Area to This Point = 1205.693 acres
Drainage Area Between Previous Structure and This One = 528.007 acres

	RUNOFF VOLUME (ac-ft)	PEAK DISCHARGE (cfs)	PEAK SEDIMENT CONCENTRATION (mg/l)	PEAK SETTLEABLE CONCENTRATION (ml/l)	SEDIMENT YIELD (tons)
IN/OUT	87.673	590.777	44.3232.50	25.621	35481.36

	TIME OF SIGNIFICANT CONCENTRATION (hrs)	AVERAGE SETTLEABLE CONCENTRATION: VOLUME WEIGHTED DURING TIME OF SIGN. CONC. (ml/l)	VOLUME WEIGHTED DURING PEAK 24 HOUR (ml/l)	ARITHMETIC DURING TIME OF SIGN. CONC. (ml/l)	ARITHMETIC DURING PEAK 24 HOUR (ml/l)
IN/OUT	6.90	15.03	15.03	8.59	2.47

*** RUN COMPLETED ***

Appendix 18.E

South Barber Channel Pre-Mine Hydrology & Sedimentology

(2 YR-6 HR, 10 YR-6 HR, 25 YR-6 HR & 100 YR-6 HR Storm Events)

South Barber Channel Pre-mine Hydrology and Sedimentology

The hydrology model and drainage subdivisions are presented on Exhibit 7-3. The pre-mine channel alignment and profiles are presented on Exhibit 11-76F thru 11-76H.

LR

BHP Navajo Coal Company
Navajo Mine
PO Box 1717
Fruitland, NM 87415

Phone: 505-598-5861

General Information

Storm Information:

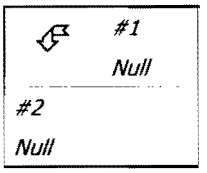
Storm Type:	NRCS Type II-60
Design Storm:	2 yr - 6 hr
Rainfall Depth:	0.800 inches

Particle Size Distribution:

Size (mm)	PostMine-LoamySand	PreMine-LoamySand	PreMine-Badlands	LoamySand Postmining
2.0000	100.000%	100.000%	100.000%	0.000%
0.1000	26.500%	30.000%	83.500%	0.000%
0.0500	14.000%	17.000%	77.000%	0.000%
0.0020	11.000%	11.000%	56.000%	0.000%
0.0010	0.000%	0.000%	0.000%	0.000%

Structure Networking:

Type	Stru #	(flows into)	Stru #	Musk. K (hrs)	Musk. X	Description
Null	#1	==>	#2	0.088	0.367	
Null	#2	==>	End	0.000	0.000	



Structure Routing Details:

Stru #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#1	8. Large gullies, diversions, and low flowing streams	2.47	37.00	1,497.00	4.71	0.088
#1	**Muskingum K:**					**0.088**

Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc. (ml/l)	24VW (ml/l)
#1	248.300	248.300	21.80	2.82	51.6	24,035	0.00	0.00
#2	277.900	526.200	51.15	6.54	169.6	34,473	0.00	0.00

Particle Size Distribution(s) at Each Structure

Structure #1:

Size (mm)	In/Out
2.0000	100.000%
0.1000	100.000%
0.0500	100.000%
0.0020	100.000%
0.0010	0.000%

Structure #2:

Size (mm)	In/Out
2.0000	100.000%
0.1000	100.000%
0.0500	100.000%
0.0020	100.000%
0.0010	0.000%

Subwatershed Hydrology Detail:

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
#1	1	248.300	0.608	0.000	0.000	87.500	M	21.80	2.817
	Σ	**248.300**						**21.80**	**2.817**
#2	1	277.900	0.573	0.000	0.000	88.600	M	30.74	3.728
	Σ	**526.200**						**51.15**	**6.545**

Subwatershed Sedimentology Detail:

Stru #	SWS #	Soil K	L (ft)	S (%)	C	P	PS #	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc (ml/l)	24VW (ml/l)
#1	1	0.188	175.00	4.50	0.3890	1.0000	3	51.6	24,035	0.00	0.00
	Σ							**51.6**	**24,035**	**0.00**	**0.00**
#2	1	0.197	150.00	7.60	0.3930	1.0000	3	118.0	41,550	0.00	0.00
	Σ							**169.6**	**34,473**	**0.00**	**0.00**

Subwatershed Time of Concentration Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#1	1	5. Nearly bare and untilled, and alluvial valley fans	2.73	43.00	1,575.00	1.650	0.265
		8. Large gullies, diversions, and low flowing streams	2.28	128.00	5,604.20	4.530	0.343
#1	**1**	**Time of Concentration:**					**0.608**
#2	1	5. Nearly bare and untilled, and alluvial valley fans	1.30	15.00	1,152.00	1.140	0.280
		8. Large gullies, diversions, and low flowing streams	3.22	183.00	5,676.00	5.380	0.293
#2	**1**	**Time of Concentration:**					**0.573**

General Information

Storm Information:

Storm Type:	NRCS Type II-60
Design Storm:	10 yr - 6 hr
Rainfall Depth:	1.300 inches

Particle Size Distribution:

Size (mm)	PostMine-LoamySand	PreMine-LoamySand	PreMine-Badlands	LoamySand Postmining
2.0000	100.000%	100.000%	100.000%	0.000%
0.1000	26.500%	30.000%	83.500%	0.000%
0.0500	14.000%	17.000%	77.000%	0.000%
0.0020	11.000%	11.000%	56.000%	0.000%
0.0010	0.000%	0.000%	0.000%	0.000%

Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc. (ml/l)	24VW (ml/l)
#1	248.300	248.300	74.04	8.71	192.5	29,038	0.00	0.00
#2	277.900	526.200	166.13	19.52	598.5	40,564	0.00	0.00

General Information

Storm Information:

Storm Type:	NRCS Type II-60
Design Storm:	25 yr - 6 hr
Rainfall Depth:	1.600 inches

Particle Size Distribution:

Size (mm)	PostMine-LoamySand	PreMine-LoamySand	PreMine-Badlands	LoamySand Postmining
2.0000	100.000%	100.000%	100.000%	0.000%
0.1000	26.500%	30.000%	83.500%	0.000%
0.0500	14.000%	17.000%	77.000%	0.000%
0.0020	11.000%	11.000%	56.000%	0.000%
0.0010	0.000%	0.000%	0.000%	0.000%

Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc. (ml/l)	24VW (ml/l)
#1	248.300	248.300	112.78	13.03	305.2	30,686	0.00	0.00
#2	277.900	526.200	250.79	28.91	934.3	42,542	0.27	0.18

General Information

Storm Information:

Storm Type:	NRCS Type II-60
Design Storm:	100 yr - 6 hr
Rainfall Depth:	2.000 inches

Particle Size Distribution:

Size (mm)	PostMine-LoamySand	PreMine-LoamySand	PreMine-Badlands	LoamySand Postmining
2.0000	100.000%	100.000%	100.000%	0.000%
0.1000	26.500%	30.000%	83.500%	0.000%
0.0500	14.000%	17.000%	77.000%	0.000%
0.0020	11.000%	11.000%	56.000%	0.000%
0.0010	0.000%	0.000%	0.000%	0.000%

Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc. (ml/l)	24VW (ml/l)
#1	248.300	248.300	169.53	19.35	478.5	32,242	0.29	0.20
#2	277.900	526.200	375.20	42.56	1,448.6	44,575	0.77	0.54

Appendix 18.F

Lowe Arroyo Pre-Mine Hydrology & Sedimentology

(2 YR-6 HR, 10 YR-6 HR, 25 YR-6 HR & 100 YR-6 HR Storm Events)

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Civil Software Design

Lowe Arroyo Pre-mining Hydrology and Sedimentology

The drainage subdivisions used to model the hydrology is shown on Exhibit 7-4.

LR

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Civil Software Design

Lowe Arroyo Pre-mine Hydrology and Sedimentology

LR

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Navajo Mine
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Phone: 505-598-5861

General Information

Storm Information:

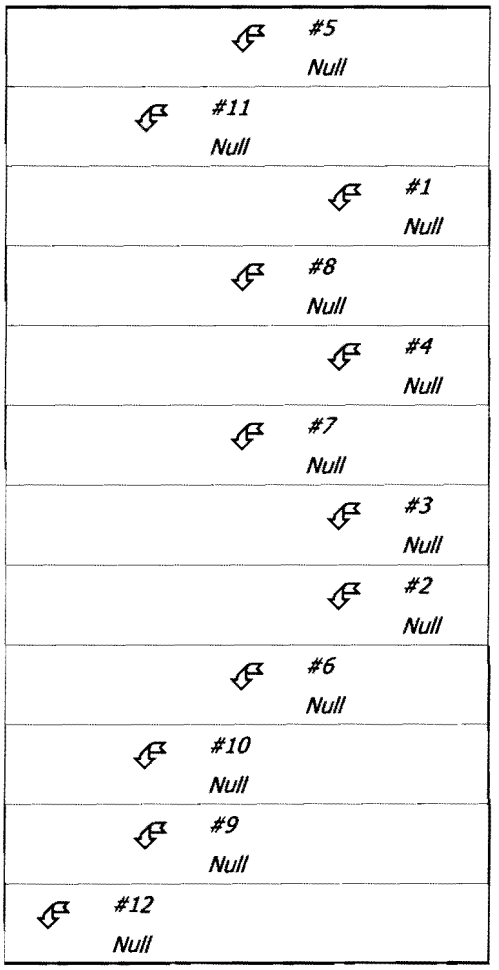
Storm Type:	NRCS Type II-60
Design Storm:	10 yr - 6 hr
Rainfall Depth:	1.300 inches

Particle Size Distribution:

Size (mm)	PostMine-LoamySand	PreMine-LoamySand	PreMine-Badlands	LoamySand Postmining
2.0000	100.000%	100.000%	100.000%	0.000%
0.1000	26.500%	30.000%	83.500%	0.000%
0.0500	14.000%	17.000%	77.000%	0.000%
0.0020	11.000%	11.000%	56.000%	0.000%
0.0010	0.000%	0.000%	0.000%	0.000%

Structure Networking:

Type	Stru #	(flows into)	Stru #	Musk. K (hrs)	Musk. X	Description
Null	#1	==>	#8	0.419	0.337	
Null	#2	==>	#6	0.434	0.325	
Null	#3	==>	#6	0.396	0.322	
Null	#4	==>	#7	0.517	0.328	
Null	#5	==>	#11	5.868	0.239	
Null	#6	==>	#10	0.469	0.325	
Null	#7	==>	#10	0.469	0.325	
Null	#8	==>	#10	0.274	0.337	
Null	#9	==>	#12	0.000	0.000	
Null	#10	==>	#12	0.000	0.000	
Null	#11	==>	#12	0.000	0.000	
Null	#12	==>	#13	1.302	0.306	
Null	#13	==>	End	0.000	0.000	



#13
Null

Structure Routing Details:

Stru #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#1	8. Large gullies, diversions, and low flowing streams	1.38	73.00	5,307.00	3.51	0.419
#1	**Muskingum K:**					**0.419**
#2	8. Large gullies, diversions, and low flowing streams	1.11	55.00	4,948.00	3.16	0.434
#2	**Muskingum K:**					**0.434**
#3	8. Large gullies, diversions, and low flowing streams	1.05	46.00	4,378.00	3.07	0.396
#3	**Muskingum K:**					**0.396**
#4	8. Large gullies, diversions, and low flowing streams	1.16	70.00	6,012.00	3.23	0.517
#4	**Muskingum K:**					**0.517**
#5	5. Nearly bare and untilled, and alluvial valley fans	0.33	38.00	11,449.23	0.57	5.579
	8. Large gullies, diversions, and low flowing streams	1.92	83.00	4,330.00	4.15	0.289
#5	**Muskingum K:**					**5.868**
#6	8. Large gullies, diversions, and low flowing streams	1.12	60.00	5,360.01	3.17	0.469
#6	**Muskingum K:**					**0.469**
#7	8. Large gullies, diversions, and low flowing streams	1.12	60.00	5,360.00	3.17	0.469
#7	**Muskingum K:**					**0.469**
#8	8. Large gullies, diversions, and low flowing streams	1.38	48.00	3,479.00	3.52	0.274
#8	**Muskingum K:**					**0.274**
#12	8. Large gullies, diversions, and low flowing streams	0.81	102.00	12,617.00	2.69	1.302
#12	**Muskingum K:**					**1.302**

Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc. (ml/l)	24VW (ml/l)
#5	386.400	386.400	55.42	11.29	75.7	9,732	1.93	1.25
#11	1,459.300	1,845.700	128.96	55.22	246.0	9,727	3.67	1.59
#1	384.000	384.000	56.15	9.43	121.9	30,006	4.92	1.94
#8	224.900	608.900	96.48	15.66	166.0	20,180	5.50	2.62
#4	1,417.400	1,417.400	289.92	52.21	965.8	30,956	2.37	1.28
#7	669.200	2,086.600	382.04	73.97	1,131.9	25,049	3.17	1.75
#3	825.600	825.600	223.61	31.54	681.9	31,071	3.50	2.18
#2	798.200	798.200	100.05	19.62	290.5	33,737	2.28	0.91
#6	131.700	1,755.500	302.76	53.94	1,001.0	29,377	3.32	1.89
#10	208.400	4,659.400	735.39	154.05	2,430.9	25,143	3.12	1.77
#9	541.300	541.300	241.08	28.26	1,005.3	46,299	1.49	1.03
#12	0.000	7,046.400	925.58	237.53	3,682.2	33,793	3.91	1.63
#13	808.700	7,855.101	918.77	272.46	3,951.1	27,433	1.49	0.73

Particle Size Distribution(s) at Each Structure

Structure #5:

Size (mm)	In/Out
2.0000	100.000%
0.1000	93.533%
0.0500	78.288%
0.0020	71.252%
0.0010	0.000%

Structure #11:

Size (mm)	In/Out
2.0000	100.000%
0.1000	85.499%
0.0500	58.887%
0.0020	45.248%
0.0010	0.000%

Structure #1:

Size (mm)	In/Out
2.0000	100.000%
0.1000	97.042%
0.0500	88.202%
0.0020	68.787%
0.0010	0.000%

Structure #8:

Size (mm)	In/Out
2.0000	100.000%
0.1000	87.022%
0.0500	73.709%

Size (mm)	In/Out
0.0020	56.300%
0.0010	0.000%

Structure #4:

Size (mm)	In/Out
2.0000	100.000%
0.1000	97.885%
0.0500	96.065%
0.0020	83.357%
0.0010	0.000%

Structure #7:

Size (mm)	In/Out
2.0000	100.000%
0.1000	95.283%
0.0500	89.950%
0.0020	76.975%
0.0010	0.000%

Structure #3:

Size (mm)	In/Out
2.0000	100.000%
0.1000	98.357%
0.0500	94.288%
0.0020	75.564%
0.0010	0.000%

Structure #2:

Size (mm)	In/Out
2.0000	100.000%
0.1000	100.000%
0.0500	97.590%
0.0020	84.027%
0.0010	0.000%

Structure #6:

Size (mm)	In/Out
2.0000	100.000%
0.1000	97.610%
0.0500	93.451%
0.0020	76.441%
0.0010	0.000%

Structure #10:

Size (mm)	In/Out
2.0000	100.000%
0.1000	96.025%
0.0500	90.920%
0.0020	76.457%
0.0010	0.000%

Structure #9:

Size (mm)	In/Out
2.0000	100.000%
0.1000	100.000%
0.0500	100.000%
0.0020	90.954%
0.0010	0.000%

Structure #12:

Size (mm)	In/Out
2.0000	100.000%
0.1000	96.407%
0.0500	91.259%
0.0020	78.330%
0.0010	0.000%

Structure #13:

Size (mm)	In/Out
2.0000	100.000%
0.1000	100.000%

Size (mm)	In/Out
0.0500	98.743%
0.0020	86.239%
0.0010	0.000%

Subwatershed Hydrology Detail:

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
#5	1	87.500	0.590	1.287	0.200	91.500	M	39.54	4.431
	2	298.900	1.434	0.000	0.000	83.200	M	31.04	6.861
	Σ	**386.400**						**55.42**	**11.292**
#11	1	412.100	2.888	0.734	0.325	84.300	M	28.67	10.590
	2	221.700	1.474	0.639	0.330	88.400	M	39.74	8.464
	3	446.000	1.668	0.377	0.347	84.900	M	50.35	12.171
	4	379.500	1.000	0.000	0.000	87.000	M	77.60	12.702
	Σ	**1,845.700**						**128.96**	**55.219**
#1	1	293.800	1.413	0.000	0.000	81.200	M	24.10	5.441
	2	90.200	0.263	0.000	0.000	90.000	M	51.85	3.989
	Σ	**384.000**						**56.15**	**9.430**
#8	1	87.100	0.557	0.211	0.323	83.200	M	16.90	1.999
	2	120.200	0.725	0.000	0.000	86.100	M	27.54	3.690
	3	17.600	0.228	0.673	0.330	86.100	M	7.47	0.540
	Σ	**608.900**						**96.48**	**15.660**
#4	1	470.600	1.256	0.387	0.350	87.000	M	82.04	15.752
	2	166.700	1.396	0.534	0.354	81.100	M	13.62	3.053
	3	66.500	0.818	0.534	0.354	82.600	M	9.45	1.433
	4	96.300	0.766	0.389	0.341	90.200	M	32.64	4.337
	5	54.100	0.199	0.389	0.341	93.000	M	43.64	3.132
	6	112.200	0.398	0.332	0.342	92.700	M	70.13	6.324
	7	56.900	0.238	0.183	0.333	93.000	M	44.03	3.294
	8	89.500	0.413	0.183	0.333	91.900	M	51.12	4.697
	9	226.200	0.610	0.000	0.000	87.500	M	67.31	7.938
	10	78.400	0.397	0.000	0.000	85.400	M	24.03	2.248
	Σ	**1,417.400**						**289.92**	**52.207**
#7	1	388.800	1.318	0.089	0.330	86.100	M	59.50	11.937
	2	207.300	1.094	0.089	0.330	86.900	M	39.43	6.873
	3	73.100	0.360	0.000	0.000	89.000	M	33.71	2.950
	Σ	**2,086.600**						**382.04**	**73.967**
#3	1	256.900	2.055	0.510	0.336	83.500	M	21.18	6.084
	2	138.800	0.315	0.510	0.336	89.900	M	74.01	6.083
	3	54.800	0.221	0.510	0.336	93.000	M	43.24	3.172
	4	98.200	0.277	0.176	0.362	89.900	M	54.97	4.303

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
	5	111.900	0.466	0.176	0.362	92.700	M	64.83	6.307
	6	37.900	0.159	0.418	0.309	93.000	M	32.25	2.194
	7	127.100	0.386	0.000	0.000	84.700	M	36.63	3.400
	Σ	**825.600**						**223.61**	**31.542**
#2	1	549.100	2.696	0.436	0.369	80.300	M	25.37	9.187
	2	191.400	0.472	0.000	0.000	88.300	M	71.94	7.240
	3	57.700	0.205	0.000	0.000	92.500	M	44.34	3.195
	Σ	**798.200**						**100.05**	**19.621**
#6	1	131.700	0.434	0.000	0.000	82.400	M	27.02	2.779
	Σ	**1,755.500**						**302.76**	**53.942**
#10	1	179.300	0.676	0.000	0.000	91.200	M	72.49	8.838
	2	29.100	0.311	0.000	0.000	92.700	M	20.09	1.640
	Σ	**4,659.400**						**735.39**	**154.046**
#9	1	274.600	0.559	0.179	0.345	90.600	M	117.31	12.823
	2	266.700	0.484	0.000	0.000	93.000	M	155.83	15.438
	Σ	**541.300**						**241.08**	**28.260**
#12	**Σ**	**7,046.400**						**925.58**	**237.526**
#13	1	130.600	0.245	1.141	0.305	91.800	M	90.42	6.793
	2	101.000	0.160	1.048	0.302	92.300	M	81.48	5.493
	3	133.900	0.165	0.948	0.300	90.500	M	93.64	6.196
	4	443.200	1.345	0.000	0.000	88.100	M	82.41	16.454
	Σ	**7,855.101**						**918.77**	**272.463**

Subwatershed Sedimentology Detail:

Stru #	SWS #	Soil K	L (ft)	S (%)	C	P	PS #	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc (ml/l)	24VW (ml/l)
#5	1	0.198	300.00	2.62	0.3180	1.0000	3	47.7	13,650	0.17	0.12
	2	0.171	400.00	1.47	0.3320	1.0000	2	31.5	5,755	2.75	2.02
	Σ							**75.7**	**9,732**	**1.93**	**1.25**
#11	1	0.198	400.00	0.90	0.3290	1.0000	2	29.7	3,451	1.30	0.97
	2	0.190	400.00	0.82	0.3130	1.0000	2	26.7	3,966	2.00	1.47
	3	0.231	400.00	0.67	0.3450	1.0000	2	43.2	4,428	2.07	1.53
	4	0.200	400.00	1.96	0.3340	1.0000	2	112.1	11,292	6.09	4.38

Stru #	SWS #	Soil K	L (ft)	S (%)	C	P	PS #	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc (ml/l)	24VW (ml/l)
	Σ							**246.0**	**9,727**	**3.67**	**1.59**
#1	1	0.146	300.00	2.28	0.3430	1.0000	2	28.5	6,517	3.04	2.25
	2	0.181	175.00	4.95	0.3390	1.0000	3	93.4	31,853	2.29	1.53
	Σ							**121.9**	**30,006**	**4.92**	**1.94**
#8	1	0.118	300.00	2.87	0.3400	1.0000	2	13.1	8,707	4.98	3.46
	2	0.141	200.00	3.15	0.3220	1.0000	2	26.6	9,408	5.31	3.74
	3	0.141	200.00	3.15	0.3220	1.0000	2	4.4	10,851	6.87	4.66
	Σ							**166.0**	**20,180**	**5.50**	**2.62**
#4	1	0.185	200.00	3.05	0.2970	1.0000	3	129.7	10,379	0.00	0.00
	2	0.184	300.00	2.66	0.3150	1.0000	2	19.9	8,104	3.79	2.81
	3	0.217	200.00	3.33	0.2980	1.0000	2	12.9	11,500	6.17	4.44
	4	0.207	150.00	6.22	0.3420	1.0000	3	100.3	29,619	0.00	0.00
	5	0.209	150.00	6.14	0.3920	1.0000	3	112.4	46,980	4.60	3.18
	6	0.205	150.00	7.39	0.3680	1.0000	3	238.9	49,209	2.86	1.99
	7	0.210	175.00	5.44	0.3990	1.0000	3	114.4	45,465	4.14	2.85
	8	0.198	175.00	4.66	0.3870	1.0000	3	119.8	33,648	1.70	1.18
	9	0.172	200.00	3.03	0.3630	1.0000	3	89.4	14,879	0.00	0.00
	10	0.176	200.00	3.36	0.3680	1.0000	2	28.3	17,238	10.44	6.97
	Σ							**965.8**	**30,956**	**2.37**	**1.28**
#7	1	0.180	300.00	2.29	0.3130	1.0000	2	82.9	8,738	4.41	3.23
	2	0.192	400.00	1.80	0.3380	1.0000	2	49.1	9,074	4.81	3.48
	3	0.185	200.00	3.64	0.2810	1.0000	3	34.4	15,848	0.72	0.48
	Σ							**1,131.9**	**25,049**	**3.17**	**1.75**
#3	1	0.215	300.00	2.93	0.3350	1.0000	2	50.9	10,327	4.42	3.30
	2	0.202	175.00	4.54	0.3220	1.0000	3	141.1	30,697	1.85	1.27
	3	0.208	175.00	5.72	0.3740	1.0000	3	108.0	44,184	4.17	2.90
	4	0.180	175.00	5.53	0.3450	1.0000	3	113.3	35,491	2.43	1.64
	5	0.205	175.00	4.67	0.3930	1.0000	3	170.1	35,379	1.59	1.11
	6	0.210	150.00	6.04	0.3990	1.0000	3	78.3	45,725	5.28	3.67
	7	0.100	300.00	2.77	0.3090	1.0000	2	20.4	8,293	5.02	3.33
	Σ							**681.9**	**31,071**	**3.50**	**2.18**
#2	1	0.150	400.00	1.06	0.3310	1.0000	2	22.2	2,954	1.07	0.81
	2	0.175	175.00	5.69	0.3280	1.0000	3	167.3	30,892	0.52	0.36
	3	0.201	175.00	5.48	0.3730	1.0000	3	101.7	42,684	4.04	2.74
	Σ							**290.5**	**33,737**	**2.28**	**0.91**
#6	1	0.155	200.00	3.21	0.3700	1.0000	2	28.8	14,163	8.32	5.59

Stru #	SWS #	Soil K	L (ft)	S (%)	C	P	PS #	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc (ml/l)	24VW (ml/l)
	Σ							**1,001.0**	**29,377**	**3.32**	**1.89**
#10	1	0.189	175.00	4.10	0.2370	1.0000	3	107.6	15,889	0.00	0.00
	2	0.190	150.00	6.90	0.2030	1.0000	3	26.7	21,813	1.64	1.11
	Σ							**2,430.9**	**25,143**	**3.12**	**1.77**
#9	1	0.186	175.00	5.87	0.3630	1.0000	3	367.2	37,441	0.46	0.32
	2	0.209	150.00	7.17	0.3850	1.0000	3	638.1	53,961	2.35	1.63
	Σ							**1,005.3**	**46,299**	**1.49**	**1.03**
#12	Σ							**3,682.2**	**33,793**	**3.91**	**1.63**
#13	1	0.194	150.00	7.45	0.2660	1.0000	3	197.6	37,036	3.12	2.22
	2	0.190	150.00	6.64	0.2120	1.0000	3	115.7	26,701	2.95	2.09
	3	0.183	150.00	7.16	0.2340	1.0000	3	152.9	31,544	3.12	2.19
	4	0.175	175.00	4.23	0.2690	1.0000	3	177.2	13,592	0.00	0.00
	Σ							**3,951.1**	**27,433**	**1.49**	**0.73**

Subwatershed Time of Concentration Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#1	1	5. Nearly bare and untilled, and alluvial valley fans	1.14	50.00	4,385.00	1.060	1.149
		8. Large gullies, diversions, and low flowing streams	3.18	162.00	5,088.00	5.350	0.264
#1	**1**	**Time of Concentration:**					**1.413**
#1	2	5. Nearly bare and untilled, and alluvial valley fans	2.30	10.00	434.00	1.510	0.079
		8. Large gullies, diversions, and low flowing streams	3.70	142.00	3,834.00	5.770	0.184
#1	**2**	**Time of Concentration:**					**0.263**
#2	1	5. Nearly bare and untilled, and alluvial valley fans	0.77	60.00	7,840.00	0.870	2.503
		8. Large gullies, diversions, and low flowing streams	1.22	28.00	2,301.00	3.300	0.193
#2	**1**	**Time of Concentration:**					**2.696**
#2	2	5. Nearly bare and untilled, and alluvial valley fans	3.97	23.00	580.00	1.990	0.080
		8. Large gullies, diversions, and low flowing streams	2.60	178.00	6,838.00	4.840	0.392
#2	**2**	**Time of Concentration:**					**0.472**
#2	3	5. Nearly bare and untilled, and alluvial valley fans	13.68	45.00	329.00	3.690	0.024

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
		8. Large gullies, diversions, and low flowing streams	3.12	108.00	3,466.00	5.290	0.181
#2	**3**	**Time of Concentration:**					**0.205**
#3	1	5. Nearly bare and untilled, and alluvial valley fans	0.79	46.00	5,799.00	0.890	1.809
		8. Large gullies, diversions, and low flowing streams	3.31	160.00	4,837.00	5.450	0.246
#3	**1**	**Time of Concentration:**					**2.055**
#3	2	5. Nearly bare and untilled, and alluvial valley fans	4.93	75.00	1,521.00	2.220	0.190
		8. Large gullies, diversions, and low flowing streams	2.98	70.00	2,345.00	5.180	0.125
#3	**2**	**Time of Concentration:**					**0.315**
#3	3	5. Nearly bare and untilled, and alluvial valley fans	6.42	83.00	1,293.00	2.530	0.141
		8. Large gullies, diversions, and low flowing streams	3.21	50.00	1,559.00	5.370	0.080
#3	**3**	**Time of Concentration:**					**0.221**
#3	4	5. Nearly bare and untilled, and alluvial valley fans	8.98	60.00	668.00	2.990	0.062
		8. Large gullies, diversions, and low flowing streams	2.82	110.00	3,900.00	5.030	0.215
#3	**4**	**Time of Concentration:**					**0.277**
#3	5	5. Nearly bare and untilled, and alluvial valley fans	4.11	50.00	1,216.00	2.020	0.167
		8. Large gullies, diversions, and low flowing streams	1.86	82.00	4,404.00	4.090	0.299
#3	**5**	**Time of Concentration:**					**0.466**
#3	6	5. Nearly bare and untilled, and alluvial valley fans	9.01	53.00	588.00	3.000	0.054
		8. Large gullies, diversions, and low flowing streams	1.64	24.00	1,463.00	3.840	0.105
#3	**6**	**Time of Concentration:**					**0.159**
#3	7	5. Nearly bare and untilled, and alluvial valley fans	3.83	50.00	1,304.00	1.950	0.185
		8. Large gullies, diversions, and low flowing streams	1.42	37.00	2,598.00	3.580	0.201
#3	**7**	**Time of Concentration:**					**0.386**
#4	1	5. Nearly bare and untilled, and alluvial valley fans	1.08	35.00	3,237.00	1.030	0.872
		8. Large gullies, diversions, and low flowing streams	2.41	155.00	6,442.00	4.650	0.384
#4	**1**	**Time of Concentration:**					**1.256**
#4	2	5. Nearly bare and untilled, and alluvial valley fans	0.86	37.00	4,286.00	0.920	1.294
		8. Large gullies, diversions, and low flowing streams	4.10	92.00	2,243.00	6.070	0.102
#4	**2**	**Time of Concentration:**					**1.396**

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#4	3	5. Nearly bare and untilled, and alluvial valley fans	0.93	23.00	2,478.00	0.960	0.717
		8. Large gullies, diversions, and low flowing streams	3.83	82.00	2,141.00	5.870	0.101
#4	**3**	**Time of Concentration:**					**0.818**
#4	4	5. Nearly bare and untilled, and alluvial valley fans	0.63	10.00	1,582.00	0.790	0.556
		8. Large gullies, diversions, and low flowing streams	3.62	157.00	4,332.00	5.710	0.210
#4	**4**	**Time of Concentration:**					**0.766**
#4	5	5. Nearly bare and untilled, and alluvial valley fans	8.38	73.00	871.00	2.890	0.083
		8. Large gullies, diversions, and low flowing streams	2.64	54.00	2,043.00	4.870	0.116
#4	**5**	**Time of Concentration:**					**0.199**
#4	6	5. Nearly bare and untilled, and alluvial valley fans	4.90	80.00	1,632.02	2.210	0.205
		8. Large gullies, diversions, and low flowing streams	2.57	86.00	3,346.04	4.800	0.193
#4	**6**	**Time of Concentration:**					**0.398**
#4	7	5. Nearly bare and untilled, and alluvial valley fans	12.89	70.00	543.00	3.590	0.042
		8. Large gullies, diversions, and low flowing streams	1.40	35.00	2,508.00	3.540	0.196
#4	**7**	**Time of Concentration:**					**0.238**
#4	8	5. Nearly bare and untilled, and alluvial valley fans	3.98	30.00	754.00	1.990	0.105
		8. Large gullies, diversions, and low flowing streams	1.87	85.00	4,548.00	4.100	0.308
#4	**8**	**Time of Concentration:**					**0.413**
#4	9	5. Nearly bare and untilled, and alluvial valley fans	2.53	40.00	1,584.00	1.580	0.278
		8. Large gullies, diversions, and low flowing streams	1.61	73.00	4,546.00	3.800	0.332
#4	**9**	**Time of Concentration:**					**0.610**
#4	10	5. Nearly bare and untilled, and alluvial valley fans	3.26	50.00	1,536.00	1.800	0.237
		8. Large gullies, diversions, and low flowing streams	1.21	23.00	1,901.00	3.290	0.160
#4	**10**	**Time of Concentration:**					**0.397**
#5	1	5. Nearly bare and untilled, and alluvial valley fans	2.32	75.00	3,231.00	1.520	0.590
#5	**1**	**Time of Concentration:**					**0.590**
#5	2	5. Nearly bare and untilled, and alluvial valley fans	1.37	83.00	6,044.00	1.170	1.434
#5	**2**	**Time of Concentration:**					**1.434**
#6	1	5. Nearly bare and untilled, and alluvial valley fans	2.93	22.00	752.00	1.710	0.122

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
		8. Large gullies, diversions, and low flowing streams	1.52	63.00	4,146.00	3.690	0.312
#6	**1**	**Time of Concentration:**					**0.434**
#7	1	5. Nearly bare and untilled, and alluvial valley fans	1.93	102.00	5,288.00	1.380	1.064
		8. Large gullies, diversions, and low flowing streams	1.09	31.00	2,857.00	3.120	0.254
#7	**1**	**Time of Concentration:**					**1.318**
#7	2	5. Nearly bare and untilled, and alluvial valley fans	1.54	55.00	3,561.00	1.240	0.797
		8. Large gullies, diversions, and low flowing streams	1.40	53.00	3,788.00	3.540	0.297
#7	**2**	**Time of Concentration:**					**1.094**
#7	3	5. Nearly bare and untilled, and alluvial valley fans	3.26	60.00	1,842.00	1.800	0.284
		8. Large gullies, diversions, and low flowing streams	0.98	8.00	817.00	2.960	0.076
#7	**3**	**Time of Concentration:**					**0.360**
#8	1	5. Nearly bare and untilled, and alluvial valley fans	3.08	75.00	2,436.00	1.750	0.386
		8. Large gullies, diversions, and low flowing streams	1.53	35.00	2,291.00	3.700	0.171
#8	**1**	**Time of Concentration:**					**0.557**
#8	2	5. Nearly bare and untilled, and alluvial valley fans	3.67	37.00	1,008.00	1.910	0.146
		8. Large gullies, diversions, and low flowing streams	0.96	59.00	6,130.00	2.940	0.579
#8	**2**	**Time of Concentration:**					**0.725**
#8	3	5. Nearly bare and untilled, and alluvial valley fans	4.25	72.00	1,695.00	2.060	0.228
#8	**3**	**Time of Concentration:**					**0.228**
#9	1	5. Nearly bare and untilled, and alluvial valley fans	5.25	130.00	2,477.00	2.290	0.300
		8. Large gullies, diversions, and low flowing streams	2.40	104.00	4,333.00	4.640	0.259
#9	**1**	**Time of Concentration:**					**0.559**
#9	2	5. Nearly bare and untilled, and alluvial valley fans	7.24	80.00	1,105.00	2.690	0.114
		8. Large gullies, diversions, and low flowing streams	2.34	143.00	6,113.00	4.580	0.370
#9	**2**	**Time of Concentration:**					**0.484**
#10	1	5. Nearly bare and untilled, and alluvial valley fans	3.67	68.00	1,855.00	1.910	0.269
		8. Large gullies, diversions, and low flowing streams	1.16	55.00	4,740.00	3.230	0.407
#10	**1**	**Time of Concentration:**					**0.676**
#10	2	5. Nearly bare and untilled, and alluvial valley fans	4.40	103.00	2,342.00	2.090	0.311

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#10	**2**	**Time of Concentration:**					**0.311**
#11	1	5. Nearly bare and untilled, and alluvial valley fans	0.70	60.00	8,630.00	0.830	2.888
#11	**1**	**Time of Concentration:**					**2.888**
#11	2	5. Nearly bare and untilled, and alluvial valley fans	1.08	59.00	5,468.00	1.030	1.474
#11	**2**	**Time of Concentration:**					**1.474**
#11	3	5. Nearly bare and untilled, and alluvial valley fans	0.89	50.00	5,647.00	0.940	1.668
#11	**3**	**Time of Concentration:**					**1.668**
#11	4	5. Nearly bare and untilled, and alluvial valley fans	1.48	47.00	3,181.00	1.210	0.730
		8. Large gullies, diversions, and low flowing streams	1.98	81.00	4,100.00	4.210	0.270
#11	**4**	**Time of Concentration:**					**1.000**
#13	1	5. Nearly bare and untilled, and alluvial valley fans	3.21	25.00	778.00	1.790	0.120
		8. Large gullies, diversions, and low flowing streams	3.74	98.00	2,620.00	5.800	0.125
#13	**1**	**Time of Concentration:**					**0.245**
#13	2	5. Nearly bare and untilled, and alluvial valley fans	9.77	50.00	512.00	3.120	0.045
		8. Large gullies, diversions, and low flowing streams	3.65	87.00	2,386.00	5.720	0.115
#13	**2**	**Time of Concentration:**					**0.160**
#13	3	5. Nearly bare and untilled, and alluvial valley fans	19.02	85.00	447.00	4.360	0.028
		8. Large gullies, diversions, and low flowing streams	3.12	82.00	2,627.00	5.300	0.137
#13	**3**	**Time of Concentration:**					**0.165**
#13	4	5. Nearly bare and untilled, and alluvial valley fans	3.51	105.00	2,995.00	1.870	0.444
		8. Large gullies, diversions, and low flowing streams	0.72	60.00	8,278.00	2.550	0.901
#13	**4**	**Time of Concentration:**					**1.345**

Subwatershed Muskingum Routing Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#3	1	8. Large gullies, diversions, and low flowing streams	1.36	87.00	6,414.00	3.490	0.510
#3	**1**	**Muskingum K:**					**0.510**
#3	2	8. Large gullies, diversions, and low flowing streams	1.36	87.00	6,414.00	3.490	0.510
#3	**2**	**Muskingum K:**					**0.510**

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#3	3	8. Large gullies, diversions, and low flowing streams	1.36	87.00	6,414.03	3.490	0.510
#3	**3**	**Muskingum K:**					**0.510**
#3	4	8. Large gullies, diversions, and low flowing streams	2.20	62.00	2,822.00	4.440	0.176
#3	**4**	**Muskingum K:**					**0.176**
#3	5	8. Large gullies, diversions, and low flowing streams	2.20	62.00	2,822.00	4.440	0.176
#3	**5**	**Muskingum K:**					**0.176**
#3	6	8. Large gullies, diversions, and low flowing streams	0.84	35.00	4,143.48	2.750	0.418
#3	**6**	**Muskingum K:**					**0.418**
#4	1	8. Large gullies, diversions, and low flowing streams	1.76	98.00	5,553.00	3.980	0.387
#4	**1**	**Muskingum K:**					**0.387**
#4	2	8. Large gullies, diversions, and low flowing streams	1.90	151.00	7,950.00	4.130	0.534
#4	**2**	**Muskingum K:**					**0.534**
#4	3	8. Large gullies, diversions, and low flowing streams	1.90	151.00	7,950.00	4.130	0.534
#4	**3**	**Muskingum K:**					**0.534**
#4	4	8. Large gullies, diversions, and low flowing streams	1.49	76.00	5,117.00	3.650	0.389
#4	**4**	**Muskingum K:**					**0.389**
#4	5	8. Large gullies, diversions, and low flowing streams	1.49	76.00	5,117.00	3.650	0.389
#4	**5**	**Muskingum K:**					**0.389**
#4	6	8. Large gullies, diversions, and low flowing streams	1.50	66.00	4,388.00	3.670	0.332
#4	**6**	**Muskingum K:**					**0.332**
#4	7	8. Large gullies, diversions, and low flowing streams	1.29	29.00	2,252.00	3.400	0.183
#4	**7**	**Muskingum K:**					**0.183**
#4	8	8. Large gullies, diversions, and low flowing streams	1.29	29.00	2,252.00	3.400	0.183
#4	**8**	**Muskingum K:**					**0.183**
#5	1	5. Nearly bare and untilled, and alluvial valley fans	1.30	68.00	5,236.00	1.130	1.287
#5	**1**	**Muskingum K:**					**1.287**
#7	1	8. Large gullies, diversions, and low flowing streams	1.22	13.00	1,067.00	3.310	0.089
#7	**1**	**Muskingum K:**					**0.089**
#7	2	8. Large gullies, diversions, and low flowing streams	1.22	13.00	1,067.00	3.310	0.089
#7	**2**	**Muskingum K:**					**0.089**
#8	1	8. Large gullies, diversions, and low flowing streams	1.06	25.00	2,356.04	3.090	0.211

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#8	**1**	**Muskingum K:**					**0.211**
#8	3	8. Large gullies, diversions, and low flowing streams	1.21	97.00	8,001.00	3.300	0.673
#8	**3**	**Muskingum K:**					**0.673**
#9	1	8. Large gullies, diversions, and low flowing streams	1.59	39.00	2,446.00	3.780	0.179
#9	**1**	**Muskingum K:**					**0.179**
#11	1	8. Large gullies, diversions, and low flowing streams	1.11	93.00	8,350.00	3.160	0.734
#11	**1**	**Muskingum K:**					**0.734**
#11	2	8. Large gullies, diversions, and low flowing streams	1.22	93.00	7,626.00	3.310	0.639
#11	**2**	**Muskingum K:**					**0.639**
#11	3	8. Large gullies, diversions, and low flowing streams	1.67	88.00	5,265.04	3.870	0.377
#11	**3**	**Muskingum K:**					**0.377**
#13	1	8. Large gullies, diversions, and low flowing streams	0.79	87.00	10,974.00	2.670	1.141
#13	**1**	**Muskingum K:**					**1.141**
#13	2	8. Large gullies, diversions, and low flowing streams	0.75	73.00	9,772.00	2.590	1.048
#13	**2**	**Muskingum K:**					**1.048**
#13	3	8. Large gullies, diversions, and low flowing streams	0.72	63.00	8,709.00	2.550	0.948
#13	**3**	**Muskingum K:**					**0.948**

General Information

Storm Information:

Storm Type:	NRCS Type II-60
Design Storm:	2 yr - 6 hr
Rainfall Depth:	0.800 inches

Particle Size Distribution:

Size (mm)	PostMine-LoamySand	PreMine-LoamySand	PreMine-Badlands	LoamySand Postmining
2.0000	100.000%	100.000%	100.000%	0.000%
0.1000	26.500%	30.000%	83.500%	0.000%
0.0500	14.000%	17.000%	77.000%	0.000%
0.0020	11.000%	11.000%	56.000%	0.000%
0.0010	0.000%	0.000%	0.000%	0.000%

Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc. (ml/l)	24VW (ml/l)
#5	386.400	386.400	17.95	3.40	22.3	9,239	1.04	0.66
#11	1,459.300	1,845.700	36.98	16.31	63.0	8,152	2.78	1.24
#1	384.000	384.000	19.63	2.53	35.0	28,788	2.73	1.20
#8	224.900	608.900	27.62	4.26	44.7	20,968	3.99	1.82
#4	1,417.400	1,417.400	105.48	18.08	325.7	30,260	1.60	0.86
#7	669.200	2,086.600	130.23	24.78	368.7	25,084	2.22	1.19
#3	825.600	825.600	84.06	11.25	235.8	29,484	2.13	1.36
#2	798.200	798.200	33.66	5.39	89.9	32,611	1.46	0.68
#6	131.700	1,755.500	108.32	17.24	330.1	27,846	1.97	1.23
#10	208.400	4,659.400	252.75	50.49	790.4	24,804	2.03	1.16
#9	541.300	541.300	94.75	11.61	368.5	42,487	0.54	0.36
#12	0.000	7,046.400	315.21	78.41	1,221.9	32,533	2.42	1.05
#13	808.700	7,855.101	313.68	91.37	1,307.1	26,156	0.59	0.30

General Information

Storm Information:

Storm Type:	NRCS Type II-60
Design Storm:	25 yr - 6 hr
Rainfall Depth:	1.600 inches

Particle Size Distribution:

Size (mm)	PostMine-LoamySand	PreMine-LoamySand	PreMine-Badlands	LoamySand Postmining
2.0000	100.000%	100.000%	100.000%	0.000%
0.1000	26.500%	30.000%	83.500%	0.000%
0.0500	14.000%	17.000%	77.000%	0.000%
0.0020	11.000%	11.000%	56.000%	0.000%
0.0010	0.000%	0.000%	0.000%	0.000%

Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc. (ml/l)	24VW (ml/l)
#5	386.400	386.400	83.16	17.31	117.6	9,972	2.30	1.49
#11	1,459.300	1,845.700	199.75	84.72	394.2	10,287	4.01	1.73
#1	384.000	384.000	82.66	14.90	192.6	30,241	5.74	2.25
#8	224.900	608.900	149.37	24.61	266.1	63,299	18.89	2.93
#4	1,417.400	1,417.400	420.23	76.93	1,445.3	31,344	2.67	1.44
#7	669.200	2,086.600	564.56	109.89	1,711.7	25,157	3.50	1.96
#3	825.600	825.600	320.72	46.13	1,012.9	31,706	4.05	2.50
#2	798.200	798.200	147.88	30.91	445.8	34,689	2.81	1.07
#6	131.700	1,755.500	442.66	81.60	1,509.9	30,015	3.89	2.16
#10	208.400	4,659.400	1,086.64	230.83	3,681.4	25,250	3.53	2.01
#9	541.300	541.300	340.11	39.46	1,461.7	47,786	1.96	1.37
#12	0.000	7,046.400	1,369.85	355.02	5,537.2	34,205	4.49	1.86
#13	808.700	7,855.101	1,359.63	405.34	5,949.0	27,971	1.99	0.97

General Information

Storm Information:

Storm Type:	NRCS Type II-60
Design Storm:	100 yr - 6 hr
Rainfall Depth:	2.000 inches

Particle Size Distribution:

Size (mm)	PostMine-LoamySand	PreMine-LoamySand	PreMine-Badlands	LoamySand Postmining
2.0000	100.000%	100.000%	100.000%	0.000%
0.1000	26.500%	30.000%	83.500%	0.000%
0.0500	14.000%	17.000%	77.000%	0.000%
0.0020	11.000%	11.000%	56.000%	0.000%
0.0010	0.000%	0.000%	0.000%	0.000%

Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc. (ml/l)	24VW (ml/l)
#5	386.400	386.400	124.17	26.30	182.0	10,210	2.65	1.74
#11	1,459.300	1,845.700	305.69	128.65	624.5	10,829	4.36	1.87
#1	384.000	384.000	121.54	23.24	302.0	30,311	6.47	2.54
#8	224.900	608.900	228.49	38.16	422.1	20,132	6.46	3.22
#4	1,417.400	1,417.400	609.14	112.97	2,160.7	31,731	3.00	1.63
#7	669.200	2,086.600	829.58	162.46	2,583.4	25,312	3.85	2.18
#3	825.600	825.600	460.83	67.32	1,502.8	32,415	4.62	2.84
#2	798.200	798.200	217.13	48.13	680.3	35,831	3.39	1.22
#6	131.700	1,755.500	643.48	122.77	2,271.3	30,703	4.49	2.43
#10	208.400	4,659.400	1,596.63	344.13	5,560.6	25,485	3.96	2.26
#9	541.300	541.300	478.94	55.19	2,125.0	49,328	2.42	1.71
#12	0.000	7,046.400	2,017.42	527.97	8,310.0	34,564	5.07	2.10
#13	808.700	7,855.101	2,001.72	600.34	8,936.1	28,482	2.48	1.20

Appendix 18.G

Geochemical Signature Summary

GEOCHEMICAL SIGNATURE SUMMARY

A geochemical analysis was completed in 1993 using eight (8) years of surface water monitoring data (1985-1992) to characterize the geochemical signature of the precipitation and irrigation water (NAPI wasteflow) which flow through Bitsui, Chinde, and Cottonwood Washes.

According to the surface water monitoring data base, all but one (1) monitoring station (CS-1) has received irrigation wastewater, and the data for Station CN-1 includes only one (1) irrigation wastewater flow.

The surface water monitoring data base indicates whether each sample is predominately irrigation wastewater (I), precipitation event (P), or a mixture (P/I). At the stations which normally receive irrigation wastewater flows, the precipitation flows would generally contain some contribution of irrigation wastewater.

A geochemical analysis was performed on the data from each gaging station using trilinear (Piper) diagrams. The data was first separated into three (3) groups: irrigation, precipitation event water or, a mixture. The mean concentration for each major anion and cation was converted from mg/l to meq/l and then into percent of total anions or cations (in meq/l) as shown in TABLES 1 through 7. The percentages of total anions (or cations) were then plotted on trilinear diagrams to allow possible differentiation between the irrigation wastewater and precipitation event water.

Trilinear diagrams for each surface water monitoring station are presented as FIGURES 1 through 7. While the diagrams show that the three (3) waters are distinguishable, they also show that at any given station, they are not substantially different types. FIGURES 1 through 4 show that the flows (irrigation and precipitation) from the Bitsui (Stations NB-1 and NB-2) and Chinde (Stations CD-1 and CD-2) watersheds are of the sodium sulfate type while the flows from the Cottonwood watershed (CN-1, CS-1 and CNS-1) are of sodium sulfate/sodium bicarbonate type. This difference might be explained by different salts being present in the soils of the different watersheds.

Mean total dissolved solids (TDS) values were calculated for all three (3) waters at each station to determine if any difference exists between the waters in absolute salt concentrations. TABLE 8 shows that there is no significant difference in TDS values between the irrigation and precipitation flows.

In conclusion, the available surface water monitoring data and the geochemical analyses indicate that while the irrigation and precipitation flows are geochemically distinguishable, they are not significantly different. It is believed that the three (3) waters are similar because they initially contain very little dissolved solids (salts) and have reached an equilibrium with the salts in the soils in the watersheds and the sediments in the watercourses. The source of the NAPI irrigation water is the Navajo Reservoir which has TDS levels of no more than a few hundred mg/l while rain water has virtually no dissolved solids.

TABLE 1
Station NB-1 Surface Water Data

Water Type[1]	Parameter	# of Observations	Mg/L	Mean MEQ/L	% of Total
P	Na	12	474.13	20.62	
P	K	12	7.26	0.19	
P	Na + K			20.81	75.85
P	Mg	12	19.76	1.63	5.93
P	Ca	12	100.12	5.00	18.21
			Total	27.43	
P	HCO3	12	163.67	2.68	
P	CO3	11	0.00	0.00	
P	HCO3 + CO3			2.68	9.57
P	Cl	12	147.25	4.15	14.82
P	SO4	12	1017.17	21.19	75.61
			Total	28.03	
I	Na	1	127.00	5.52	
I	K	2	7.15	0.18	
I	Na + K			5.71	61.41
I	Mg	2	6.25	0.51	5.54
I	Ca	2	61.55	3.07	33.05
			Total	9.29	
I	HCO3	2	163.67	2.68	
I	CO3	2	0.00	0.00	
I	HCO3 + CO3			2.68	18.88
I	Cl	2	55.00	1.55	10.92
I	SO4	2	479.00	9.98	70.21
			Total	14.21	
P/I	Na	6	558.83	24.31	
P/I	K	6	9.68	0.23	
P/I	Na + K			24.54	73.65
P/I	Mg	6	29.68	2.44	7.32
P/I	Ca	6	127.15	6.34	19.03
			Total	33.32	
P/I	HCO3	6	171.83	2.82	
P/I	CO3	6	0.00	0.00	
P/I	HCO3 + CO3			2.82	9.79
P/I	Cl	6	151.83	4.28	14.86
P/I	SO4	6	1042.00	21.71	75.36
			Total	28.81	

[1] P = Sample from precipitation.
I = Sample from irrigation.
P/I = Samples are precipitation and irrigation combined.

TABLE 2
Station NB-2 Surface Water Data

Water Type[1]	Parameter	# of Observations	Mg/L	Mean MEQ/L	% of Total
P	Na	18	361.61	14.42	
P	K	18	8.47	0.22	
P	Na + K			14.64	81.94
P	Mg	18	10.18	0.84	4.69
P	Ca	18	47.88	2.39	13.37
			Total	17.87	
P	HCO3	18	157.11	2.58	
P	CO3	18	0.67	0.02	
P	HCO3 + CO3			2.60	15.34
P	Cl	18	54.50	1.54	9.08
P	SO4	18	614.44	12.80	75.58
			Total	16.94	
I	Na	3	297.67	12.95	
I	K	3	6.13	0.16	
I	Na + K			13.10	80.74
I	Mg	3	9.47	0.78	4.81
I	Ca	3	47.03	2.35	14.46
			Total	16.23	
I	HCO3	3	184.00	3.02	
I	CO3	3	8.00	0.27	
I	HCO3 + CO3			3.28	20.23
I	Cl	3	65.00	1.83	11.30
I	SO4	3	533.33	11.11	68.47
			Total	16.23	
P/I	Na	8	853.88	37.15	
P/I	K	8	10.41	0.27	
P/I	Na + K			37.42	74.63
P/I	Mg	8	41.95	3.46	6.90
P/I	Ca	8	185.59	9.26	18.47
			Total	50.14	
P/I	HCO3	8	222.75	3.65	
P/I	CO3	8	0.00	0.00	
P/I	HCO3 + CO3			3.65	8.43
P/I	Cl	8	294.00	8.29	19.15
P/I	SO4	8	1505.13	31.36	72.42
			Total	43.3	

[1] P = Sample from precipitation.
I = Sample from irrigation.
P/I = Samples are precipitation and irrigation combined.

TABLE 3
Station CD-1 Surface Water Data

Water Type[1]	Parameter	# of Observations	Mg/L	Mean MEQ/L	% of Total
P	Na		256.64	11.16	
P	K	44	5.27	0.13	
P	Na + K			11.30	68.43
P	Mg	44	17.38	1.43	8.67
P	Ca	43	75.77	3.78	22.90
			Total	16.51	
P	HCO3	44	125.16	2.05	
P	CO3	46	0.00	0.00	
P	HCO3 + CO3			2.05	12.24
P	Cl	43	34.47	0.97	5.80
P	SO4	44	659.18	13.73	81.95
			Total	16.76	
I	Na		255.75	11.12	
I	K	59	4.23	0.11	
I	Na + K			11.23	65.81
I	Mg	58	19.28	1.59	9.31
I	Ca	59	85.10	4.25	24.88
			Total	17.07	
I	HCO3	59	124.90	2.05	
I	CO3	59	1.32	0.04	
I	HCO3 + CO3			2.09	11.87
I	Cl	60	33.95	0.96	5.44
I	SO4	57	699.35	14.57	82.69
			Total	17.62	
P/I	Na	22	382.5	16.64	
P/I	K	22	6.90	0.18	
P/I	Na + K			16.82	60.63
P/I	Mg	22	35.73	2.94	10.60
P/I	Ca	22	159.92	7.98	28.77
			Total	27.72	
P/I	HCO3	22	130.45	2.14	
P/I	CO3	22	0.00	0.00	
P/I	HCO3 + CO3			2.14	7.94
P/I	Cl	22	56.91	1.61	5.97
P/I	SO4	22	1113.41	23.20	86.09
			Total	26.95	

[1] P = Sample from precipitation.
I = Sample from irrigation.
P/I = Samples are precipitation and irrigation combined.

TABLE 4
Station CD-2 Surface Water Data

Water Type[1]	Parameter	# of Observations	Mg/L	Mean MEQ/L	% of Total
P	Na	25	250.76	10.91	
P	K	25	7.60	0.19	
P	Na + K			11.10	68.60
P	Mg	25	15.07	1.24	7.67
P	Ca	26	76.98	3.84	23.73
			Total	16.18	
P	HCO3	25	136.56	2.24	
P	CO3	25	0.00	0.00	
P	HCO3 + CO3			2.24	13.72
P	Cl	25	71.80	2.03	12.41
P	SO4	25	578.80	12.06	73.88
			Total	16.32	
I	Na	20	196.90	8.56	
I	K	20	5.92	0.15	
I	Na + K			8.72	61.67
I	Mg	20	15.72	1.29	9.16
I	Ca	20	82.63	4.12	29.17
			Total	14.13	
I	HCO3	20	123.30	2.02	
I	CO3	20	0.60	0.02	
I	HCO3 + CO3			2.04	14.13
I	Cl	20	43.50	1.23	8.49
I	SO4	18	536.67	11.18	77.38
			Total	14.45	
P/I	Na	11	349.36	15.20	
P/I	K	11	7.86	0.20	
P/I	Na + K			15.40	60.63
P/I	Mg	11	25.32	2.09	8.23
P/I	Ca	11	158.48	7.91	31.14
			Total	25.40	
P/I	HCO3	11	135.73	2.23	
P/I	CO3	11	0.00	0.00	
P/I	HCO3 + CO3			2.23	10.55
P/I	Cl	11	90.73	2.56	12.12
P/I	SO4	11	784.18	16.34	77.33
			Total	21.13	

[1] P = Sample from precipitation.
I = Sample from irrigation.
P/I = Samples are precipitation and irrigation combined.

TABLE 5

Station CN-1 Surface Water Data

Water Type[1]	Parameter	# of Observations	Mg/L	Mean MEQ/L	% of Total
P	Na	19	214.03	9.31	
P	K	19	8.31	0.21	
P	Na + K			9.52	77.04
P	Mg	18	7.90	0.65	5.27
P	Ca	19	43.82	2.19	17.69
			Total	12.36	
P	HCO3	19	162.26	2.66	
P	CO3	19	1.05	0.04	
P	HCO3 + CO3			2.70	22.21
P	Cl	19	11.84	0.33	2.75
P	SO4	19	436.95	9.10	75.03
			Total	12.13	
I	Na	1	70.10	3.05	
I	K	1	1.20	0.03	
I	Na + K			3.08	69.53
I	Mg	1	3.30	0.27	6.14
I	Ca	1	21.60	1.08	24.33
			Total	4.43	
I	HCO3	1	98.00	1.61	
I	CO3	1	0.00	0.00	
I	HCO3 + CO3			1.61	40.19
I	Cl	1	5.00	0.14	3.53
I	SO4	1	108.00	2.25	56.28
			Total	4.00	

[1] P = Sample from precipitation.
I = Sample from irrigation.

TABLE 6

Station CS-1 Surface Water Data

Water Type[1]	Parameter	# of Observations	Mg/L	Mean MEQ/L	% of Total
P	Na	24	176.10	7.66	
P	K	24	173.13	4.43	
P	Na + K			12.09	84.87
P	Mg	24	5.01	0.41	2.90
P	Ca	24	34.93	1.74	12.24
			Total	14.24	
P	HCO3		173.13	2.84	
P	CO3		1.33	0.04	
P	HCO3 + CO3			2.88	28.98
P	Cl	24	12.42	0.35	3.52
P	SO4	24	322.25	6.71	67.50
			Total	9.95	
I	Na	0	0.00	0.00	
I	K	0	0.00	0.00	
I	Na + K			0.00	
I	Mg	0	0.00	0.00	
I	Ca	0	0.00	0.00	
			Total	0.00	
I	HCO3	0	0.00	0.00	
I	CO3	0	0.00	0.00	
I	HCO3 + CO3			0.00	
I	Cl	0	0.00	0.00	
I	SO4	0	0.00	0.00	
			Total	0.00	

[1] P = Sample from precipitation.
I = Sample from irrigation.

TABLE 7

Station CNS-1 Surface Water Data

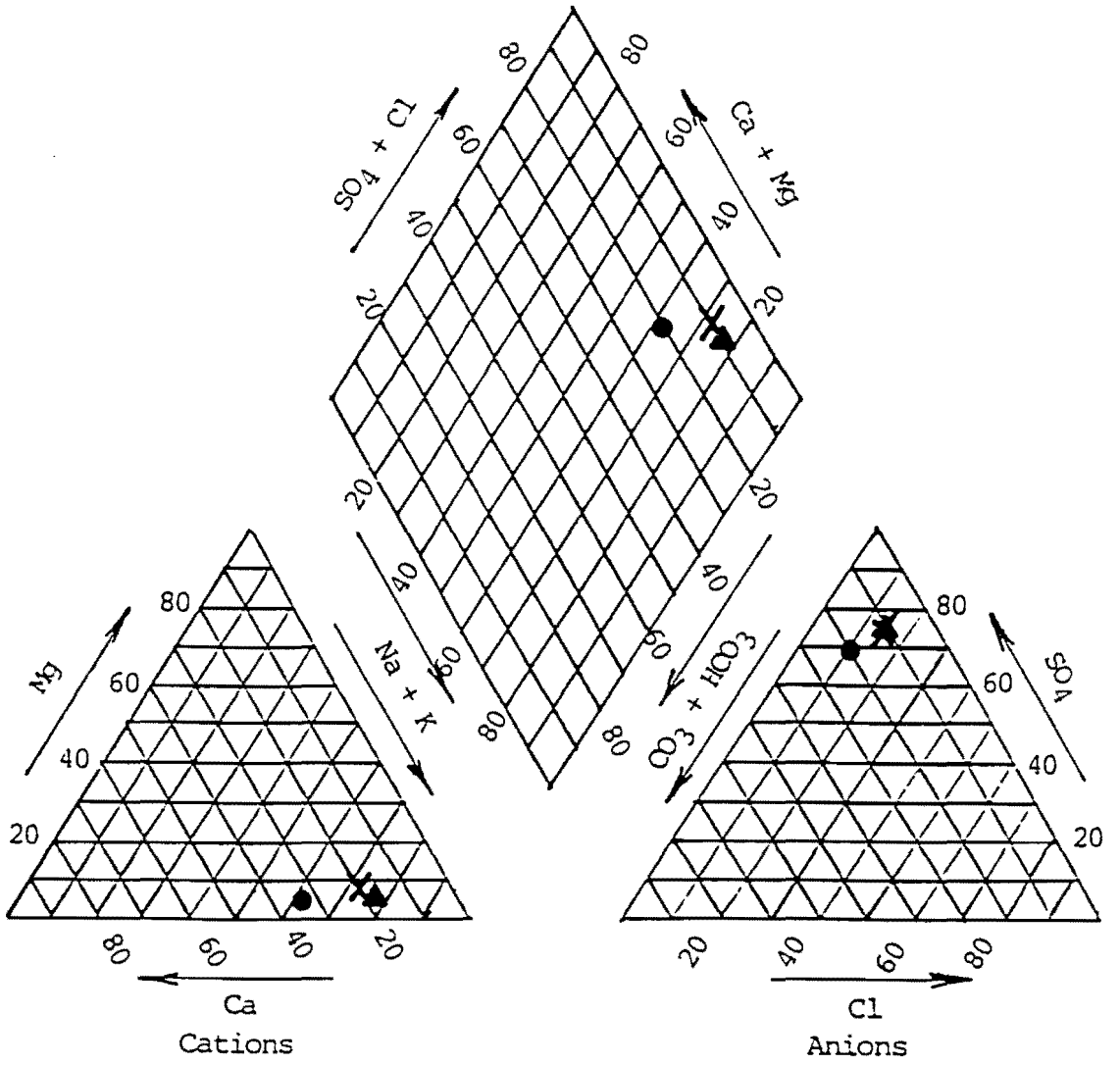
Water Type[1]	Parameter	# of Observations	Mg/L	Mean MEQ/L	% of Total
P	Na	18	176.15	7.66	
P	K	18	6.60	0.17	
P	Na + K			7.83	75.13
P	Mg	18	4.98	0.41	3.94
P	Ca	18	43.72	2.18	20.93
			Total	10.42	
P	HCO3	18	161.22	2.64	
P	CO3	18	0.67	0.02	
P	HCO3 + CO3			2.67	25.73
P	Cl	18	12.94	0.37	3.52
P	SO4	18	351.78	7.33	70.75
			Total	10.36	
I	Na	2	154.75	6.73	
I	K	2	3.20	0.08	
I	Na + K			6.81	77.87
I	Mg	2	3.85	0.32	3.62
I	Ca	2	32.45	1.62	18.51
			Total	8.75	
I	HCO3	2	144.50	2.37	
I	CO3	2	0.00	0.00	
I	HCO3 + CO3			2.37	27.47
I	Cl	2	13.50	0.38	4.42
I	SO4	2	282.00	5.88	68.12
			Total	8.62	

[1] P = Sample from precipitation.
I = Sample from irrigation.

TABLE 8

Total Dissolved Solids Data
(mg/l)

Station	# of Obs.	Precip.	# of Obs.	Irrig.	# of Obs.	Precip./Irrig.
NB-1	12	1935.83	2	1030.00	6	2315.00
NB-2	17	1296.18	1	1940.00	8	3255.00
CD-1	42	1171.95	59	1201.86	22	1827.27
CD-2	24	1119.88	20	1004.50	11	1562.27
CN-1	17	935.00	1	290.00	0	NA
CS-1	19	693.89	0	NA	0	NA
CNS-1	12	794.58	2	612.50	0	NA



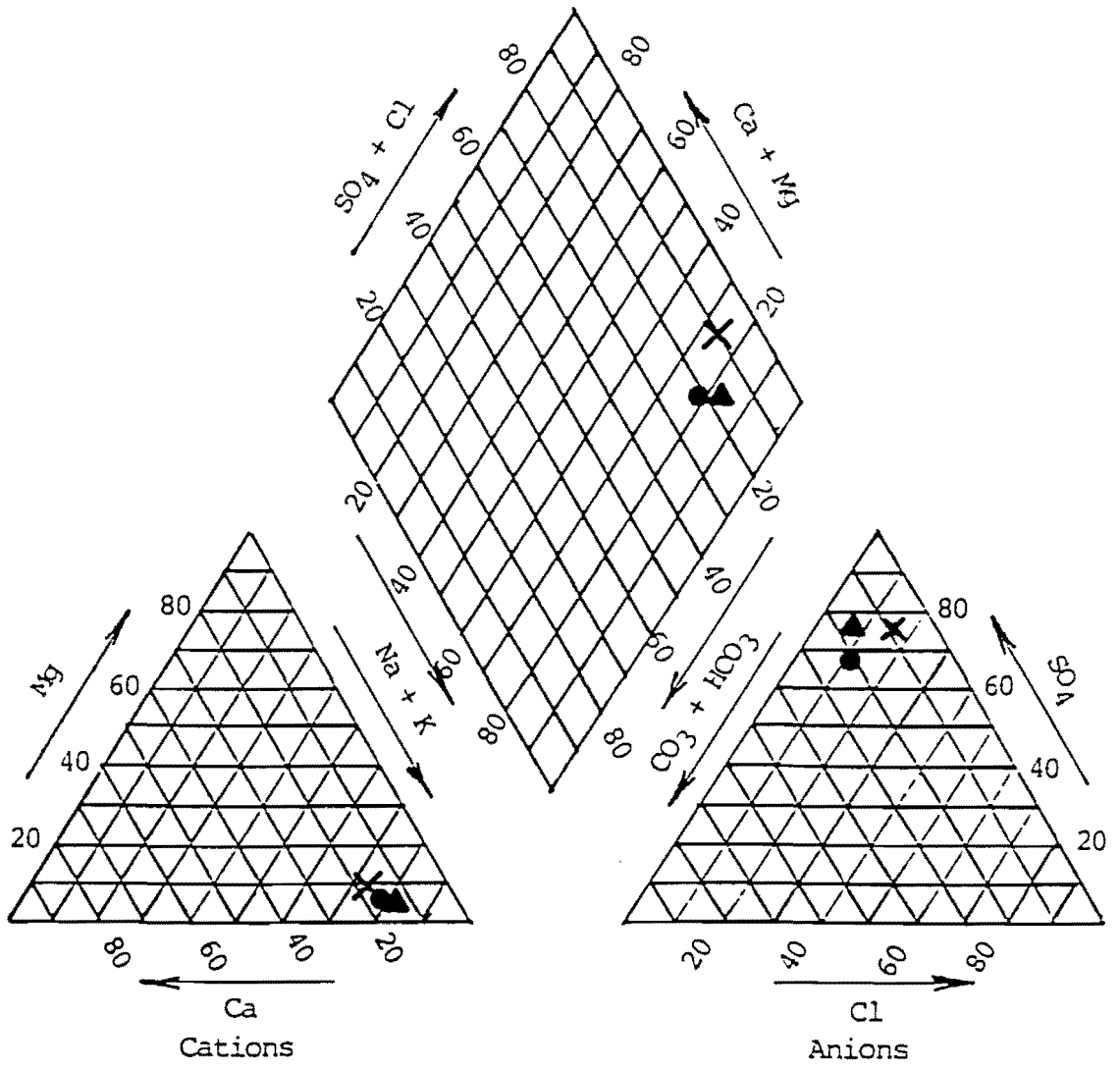
▲ Precipitation

● Irrigation

✕ P/I

FIGURE 1

Geochemical Analysis of
Station NB-1 Surface Water Data



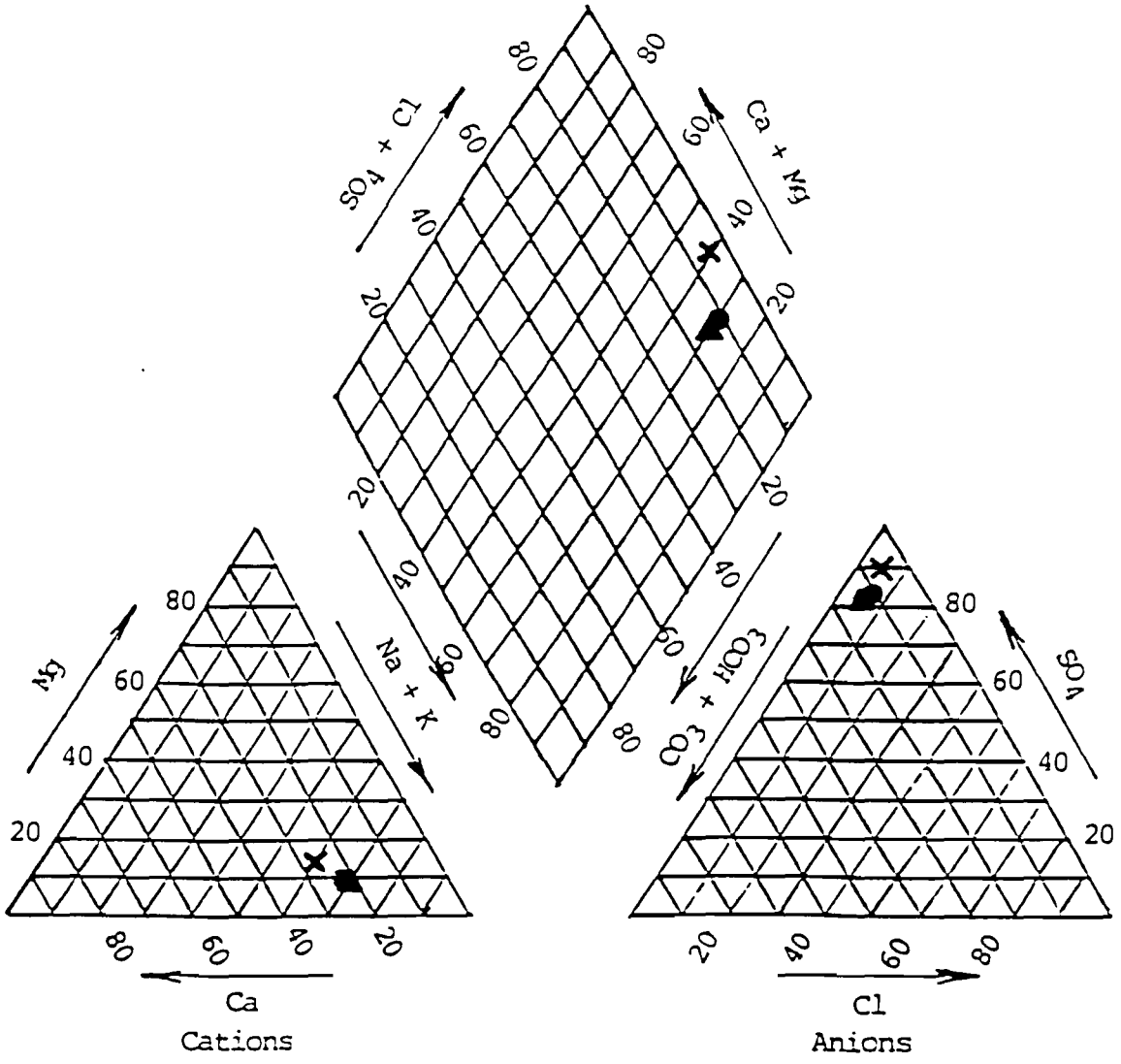
▲ Precipitation

● Irrigation

× P/I

FIGURE 2

Geochemical Analysis of
Station NB-2 Surface Water Data



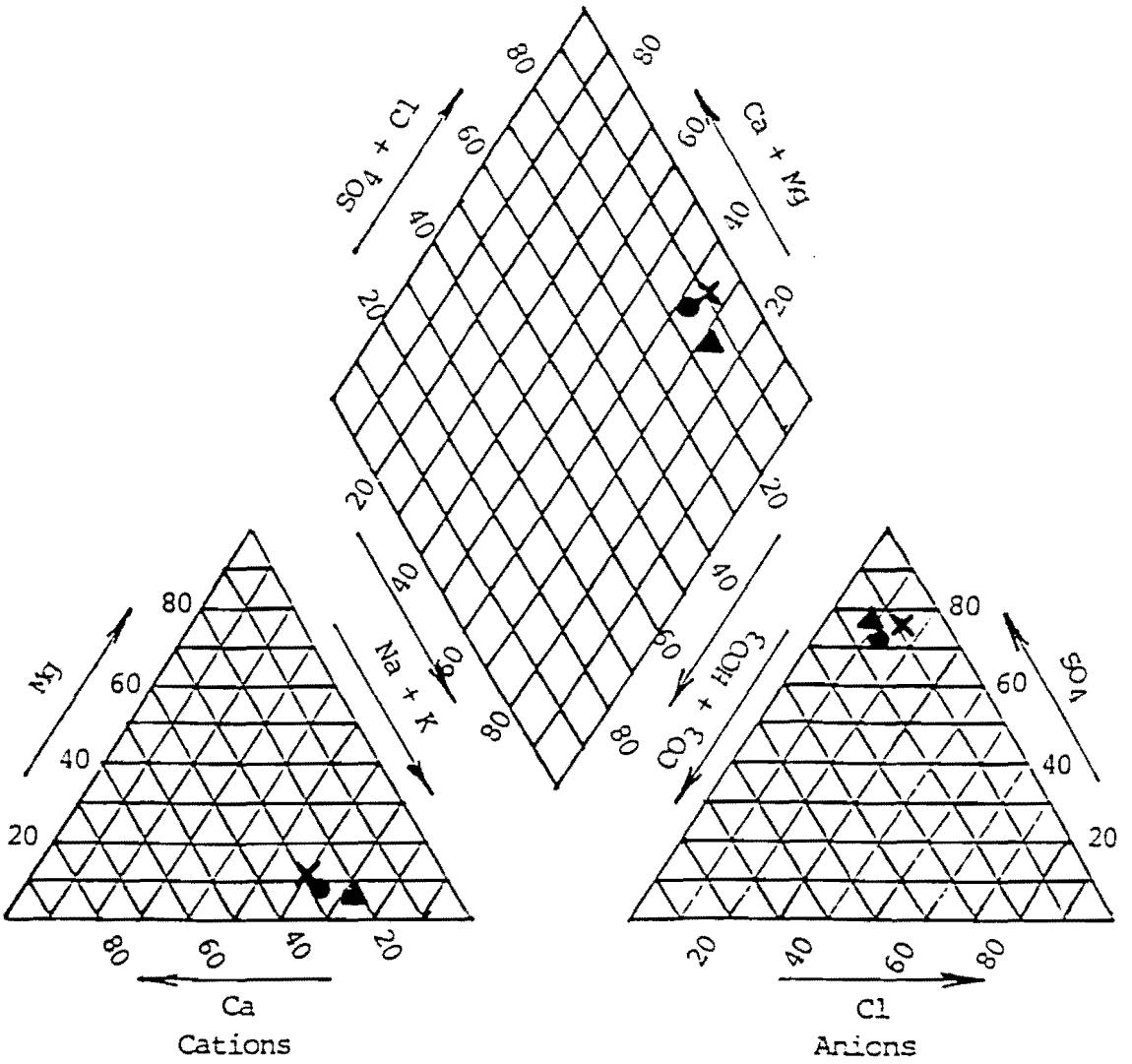
▲ Precipitation

● Irrigation

✕ P/I

FIGURE 3

Geochemical Analysis of
Station CD-1 Surface Water Data



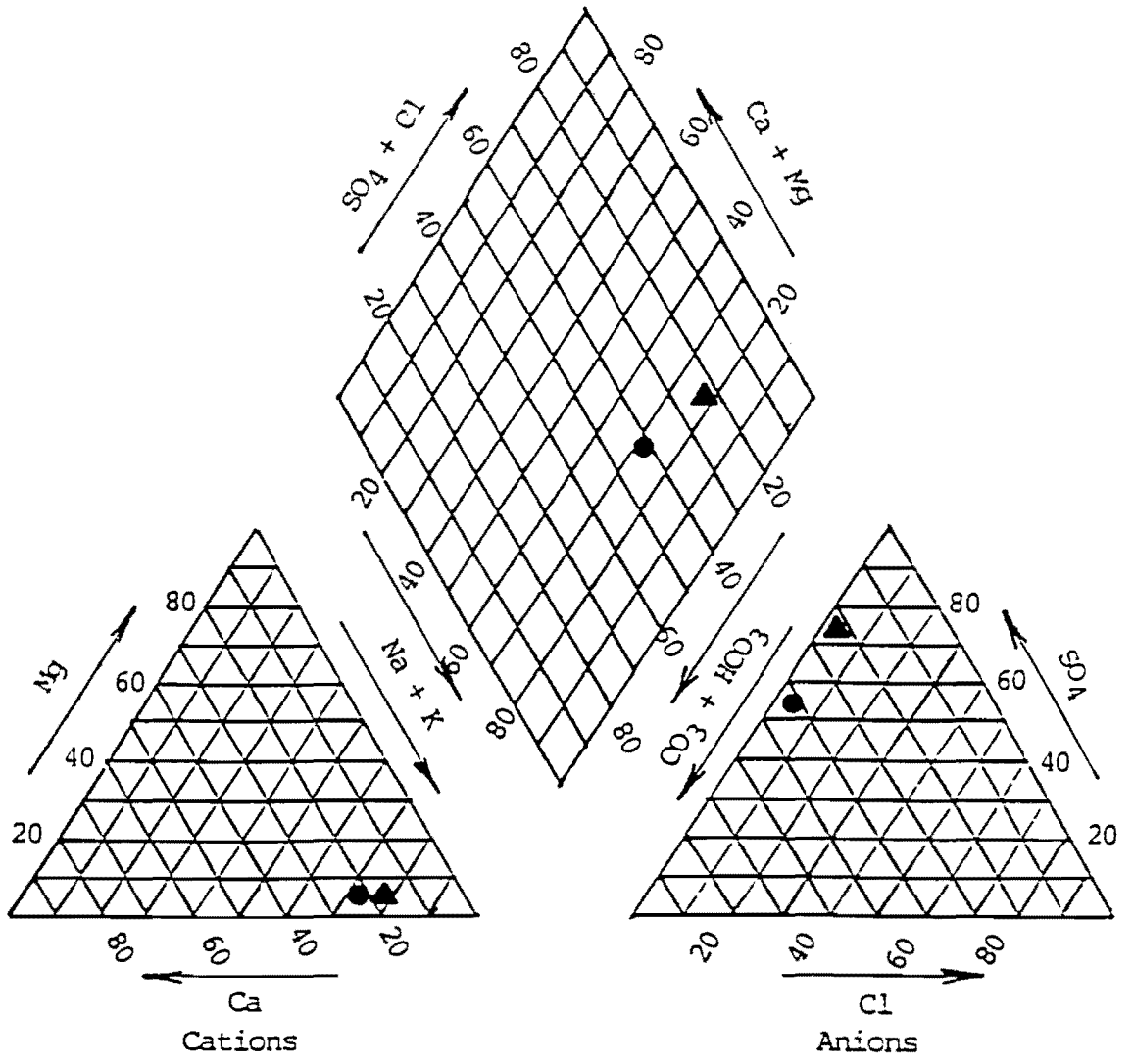
▲ Precipitation

● Irrigation

✕ P/I

FIGURE 4

Geochemical Analysis of
Station CD-2 Surface Water Data

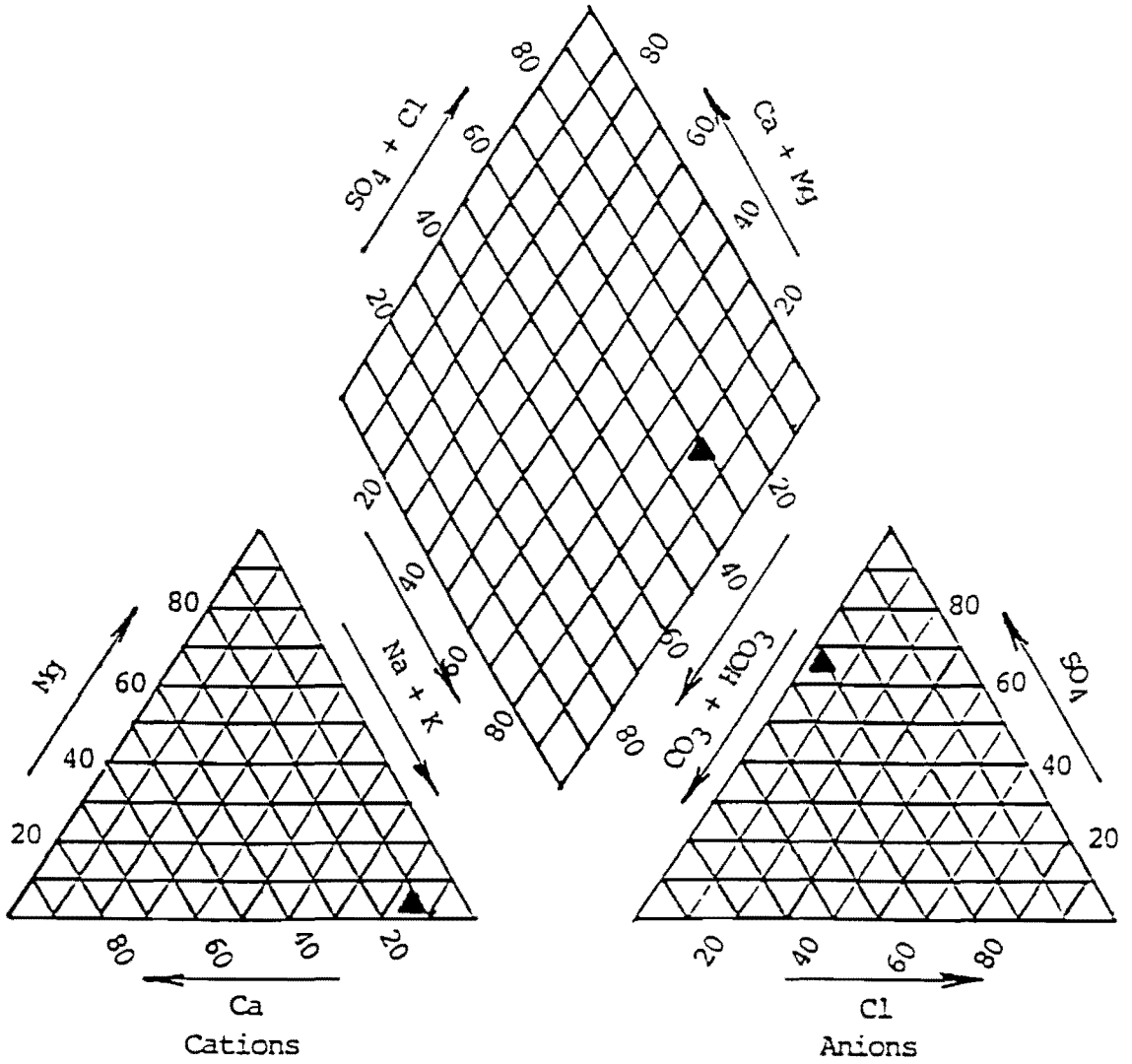


▲ Precipitation

● Irrigation

FIGURE 5

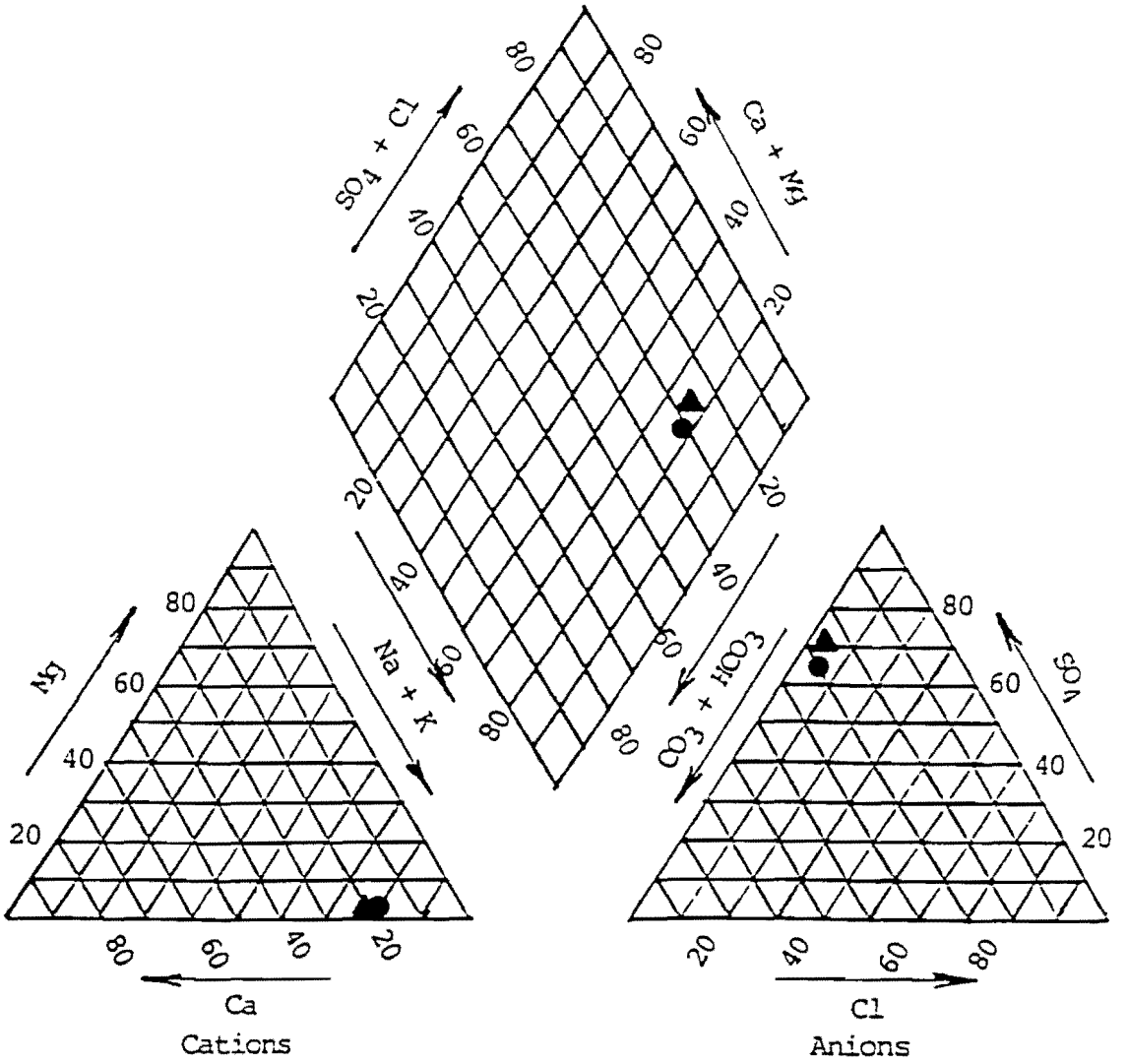
Geochemical Analysis of
Station CN-1 Surface Water Data



▲ Precipitation

FIGURE 6

Geochemical Analysis of
Station CS-1 Surface Water Data



▲ Precipitation

● Irrigation

FIGURE 7

Geochemical Analysis of
Station CNS-1 Surface Water Data

Appendix 18.H

Cottonwood Arroyo

Automated Samplers

Total Sediment Laboratory Data

Stations CN-1, CNS-1 and CS-1

1997-1999

COTTONWOOD ARROYO

CN-1 SEDIMENT DATA 1997-1999

Lab ID	Sample ID	Date Sampled	Time Sampled	Flow	Total Sediment	Sand	Silt	Clay	Texture	very coarse sand	coarse sand	medium sand	fine sand	very fine sand
				cfs	mg/L	%	%	%	%	%	%	%	%	%
0397W0160	cn-1-02	7/23/97		12	168,400									
0397W0160	cn-1-03	7/23/97		10	147,300									
0397W0160	cn-1-04	7/23/97		15	162,600									
0397W0166	CN-1 02	8/3/97		86	268,000									
0397W0166	CN-1 03	8/3/97		100	95,700									
0397W0200	CN-1 #3	9/13/97		71	128,000									
0397W0201	CN-1 #5	9/13/97		109	115,000									
0397W0201	CN-1 #6	9/13/97		80	129,000									
0397W0201	CN-1 #12	9/13/97		137	256,000									
0397W0201	CN-1 #18	9/13/97		115	208,000									
0397W0201	CN-1 #15	9/13/97		405	226,000									
0397W0204	CN-1 #5	9/15/97		34	106,000									
0397W0204	CN-1 #8	9/15/97		42	69,900									
0397W0204	CN-1 #11	9/15/97		24	69,700									
0397W0214	CN-1 #13	9/21/97		33	87,300									
0397W0214	CN-1 #14	9/21/97		33	85,800									
0397W0270	CN-1 #4	11/12/97		43	31,700									
0397W0270	CN-1 #5	11/12/97		59	29,500									
0397W0270	CN-1 #7	11/12/97		73	32,200									
W04782	CN-1 #2	8/20/98	1708	80	142,200	22	26	52	C	0	0.3	1.8	40	58
W04783	CN-1 #3	8/20/98	1712	50	121,000	22	24	54	C	0	0.2	1.1	54	45
W04784	CN-1 #5	8/20/98	0106	50	53,720	20	27	53	C	0.3	0.3	0.3	31	68
W04785	CN-1 #6	8/20/98	0110	50	53,210	20	22	58	C	0	0	1.0	21	78
W04786	CN-1 #7	8/20/98	0118	50	54,170	24	23	53	C	0	0	1.4	30	68
W04853	CN-1 #2	8/21/98	1654	350	97,100	38	27	35	CL	0	0.1	2.2	65	33
W04854	CN-1 #3	8/21/98	1658	525	91,780	36	25	39	CL	0	0	4.4	88	8
W04855	CN-1 #4	8/21/98	1704	850	115,100	36	25	39	CL	0	0.3	7.6	57	35

COTTONWOOD ARROYO

CN-1 SEDIMENT DATA 1997-1999

Lab ID	Sample ID	Date Sampled	Time Sampled	Flow	Total Sediment	Sand	Silt	Clay	Texture	very coarse sand	coarse sand	medium sand	fine sand	very fine sand
				cfs	mg/L	%	%	%	%	%	%	%	%	%
W04856	CN-1 #5	8/21/98	1710	1,000	149,400	32	25	43	C	0	1.2	8.5	52	38
W05786	CN-1	09/30/98	1540	210	117,000	43	20	37	CL	0	1.5	45	37	16
W05787	CN-1	09/29/98	1546	380	118,000	34	24	42	C	0.02	4.4	19	70	6.1
W05788	CN-1	09/29/98	1552	601	131,000	32	23	45	C	0.03	4.3	14	56	25
W05789	CN-1	09/29/98	1558	550	137,000	34	22	44	C	1.2	11	16	50	22
W05790	CN-1	09/29/98	1604	500	148,000	27	25	48	C	0.85	6.4	13	61	19
S06273	CN-1 #2	10/25/98	2026	45	39,900	18	35	47	C	0	0.71	9.2	28	62
S06274	CN-1 #3	10/25/98	2030	53	40,100	10	36	54	C	0.89	0.44	3.6	23	72
S06275	CN-1 #4	10/25/98	2036	73	45,600	15	30	55	C	0	0.17	5.9	30	64
S06276	CN-1 #5	10/25/98	2044	89	45,200	12	32	56	C	0	0.42	5.0	30	65
S06277	CN-1 #6	10/25/98	2050	76	46,600	15	29	56	C	0.20	1.6	6.4	32	60
S06278	CN-1 #7	10/25/98	2056	78	46,600	15	27	58	C	0	0.27	2.7	25	72
S06279	CN-1 #8	10/25/98	2102	58	44,800									
W03418	CN-1#4	07/03/99	1418	41	108,000	34	24	42	C	0	0.16	3.2	64	33
W03419	CN-1#11	07/03/99	1500	16	200,400	33	27	40	C	0	0.07	3.4	67	29
W03420	CN-1#16	07/03/99	1530	10	210,900	38	28	34	CL	0	0.03	4.0	73	23
W03421	CN-1#20	07/03/99	1554	3	152,200	28	33	39	CL	0	0	3.7	54	42
W03602	CN-1 #3	07/15/99	1352	62	201,600	28	30	42	C	0	0.21	4.4	51	44
W03603	CN-1 #5	07/15/99	1404	98	223,800	36	28	36	CL	0	0.34	6.8	74	19
W03604	CN-1 #7	07/15/99	1416	63	231,500	42	26	32	CL	0	0.18	6.2	61	32
W03605	CN-1 #8	07/15/99	1422	44	213,400	38	29	33	CL	0	0.06	8.0	69	23
W03967	CN-1 #4	07/29/99	0128	27	38,500	15	27	58	C	20	0	13	47	20

COTTONWOOD ARROYO

CN-1 SEDIMENT DATA 1997-1999

Lab ID	Sample ID	Date Sampled	Time Sampled	Flow	Total Sediment	Sand	Silt	Clay	Texture	very coarse sand	coarse sand	medium sand	fine sand	very fine sand
				cfs	mg/L	%	%	%	%	%	%	%	%	%
W03968	CN-1 #6	07/29/99	0220	247	225,800	30	34	36	CL	0.13	1.6	9.8	60	28
W03969	CN-1 #9	07/29/99	0238	90	206,000	28	40	32	CL	0.05	0.66	5.2	62	32
W03970	CN-1 #12	07/29/99	0256	22	201,400	33	34	33	CL	0.03	0.74	5.6	61	33
W03994	CN-1 #1	08/02/99	1540	155	112,400	43	22	35	CL	0.17	2.1	10	57	31
W04000	CN-1 #3	08/02/99	1550*	525	81,900	36	23	41	C	0.73	3.3	10	59	27
W04001	CN-1 #5	08/02/99	1602	325	73,600	32	23	45	C	0.90	8.6	14	46	30
W04002	CN-1 #9	08/02/99	1626	80	50,900	30	18	52	C	0	0.66	6.7	63	29
W04003	CN-1 #14	08/02/99	1656	20	66,300	24	23	53	C	0	0.22	7.8	65	27
W04031	CN-1 #5	8/3/99	1356*	160	175,800	33	32	35	CL	0	1.10	7.4	58	34
W04032	CN-1 #12	8/3/99	1654	105	53,800	35	24	41	C	0	0.49	9.2	53	37
W04033	CN-1 #14	8/3/99	1706*	270	59,000	41	20	39	CL	0	2.10	13.0	57	28
W04034	CN-1 #18	8/3/99	1730	65	52,700	37	22	41	C	0	0.22	7.6	56	36
W04130	CN-1 #5	08/05/99	1744	610	108,000	36	27	37	CL	0.32	2.1	13	54	30
W04131	CN-1 #9	08/05/99	1808*	1,320	142,500	42	25	33	CL	0.33	6.2	29	51	13
W04132	CN-1 #18	08/05/99	1902	865	169,500	40	25	35	CL	0	0.62	10	62	28
W04133	CN-1 #23	08/05/99	1932	500	164,100	46	25	29	SCL	0	0.38	9.9	72	18
W04247	CN-1 #2	08/08/99	2036*	150	187,000	28	30	42	C	0.03	6.8	38	24	31
W04248	CN-1 #3	08/08/99	2042	134	175,600	26	32	42	C	0	3.1	35	32	30
W04249	CN-1 #4	08/08/99	2048	95	175,200	22	34	44	C	0.06	4.4	19	45	31
W04250	CN-1 #5	08/08/99	2054	57	200,600	30	30	40	C	0.10	3.1	30	39	28
W04287	CN-1 #6	08/15/99	0310	54	46,100	29	23	48	C	0	0.46	4.6	50	45
W04288	CN-1 #11	08/15/99	0340*	135	130,300	22	34	44	C	0.05	0.59	4.2	45	50

COTTONWOOD ARROYO

CN-1 SEDIMENT DATA 1997-1999

Lab ID	Sample ID	Date Sampled	Time Sampled	Flow	Total Sediment	Sand	Silt	Clay	Texture	very coarse sand	coarse sand	medium sand	fine sand	very fine sand
				cfs	mg/L	%	%	%	%	%	%	%	%	%
W04289	CN-1 #14	08/15/99	0358	76	144,500	21	37	42	C	0	0.53	4.7	40	55
W04290	CN-1 #17	08/15/99	0416	47	123,200	24	34	42	C	0	0.52	6.5	48	45
W04452	CN-1 #7	08/24/99	1938	320	68,000	32	25	43	C	0.14	1.1	8.6	54	37
W04453	CN-1 #9	08/24/99	1950*	710	142,300	48	22	30	SCL	0.10	0.91	13	62	24
W04454	CN-1 #18	08/24/99	2044*	380	139,100	46	24	30	SCL	0.23	3.8	13	56	26
W04455	CN-1 #24	08/24/99	2120	150	134,000	44	27	29	CL	0.05	0.14	4.5	69	26
W04496	CN-1 #3	08/26/99	1936	125	59,400	43	21	36	CL	0	0.14	4.4	62	34
W04497	CN-1 #8	08/26/99	2016*	590	215,000	50	21	29	SCL	0.04	0.45	17	62	21
W04498	CN-1 #13	08/26/99	2046	160	136,000	42	26	32	CL	0.02	0.05	0.90	63	36
W04499	CN-1 #21	08/26/99	2134	30	108,400	40	28	32	CL	0.03	0.06	1.6	54	44
W04515	CN-1 #5	08/27/99	1552*	435	119,100	46	20	34	SCL	0	0.29	7.4	67	26
W04516	CN-1 #7	08/27/99	1604	287	109,400	40	22	38	CL	0	0.34	7.2	67	26
W04517	CN-1 #10	08/27/99	1622*	465	169,300	40	26	34	CL	0.02	0.84	17	60	22
W04518	CN-1 #14	08/27/99	1646	155	144,000	34	31	35	CL	0	0.14	2.9	60	37
W04519	CN-1 #2	08/29/99	1242*	265	152,600	36	26	38	CL	0.08	5.8	37	35	22
W04520	CN-1 #9	08/29/99	0124*	155	113,200	32	32	36	CL	0	0.29	5.4	56	38
W04521	CN-1 #13	08/29/99	0148	120	122,200	40	27	33	CL	0	0.18	5.2	60	35
W04522	CN-1 #19	08/29/99	0224	40	98,400	38	26	36	CL	0	0.08	4.2	61	35
W04598	CN-1 #2	09/02/99	1402*	28	108,000	36	28	36	CL	0	0.25	5.0	60	35
W04599	CN-1 #3	09/02/99	1408	29	116,300	36	30	34	CL	0	0.18	6.5	62	32
W04600	CN-1 #4	09/02/99	1414	24	110,100	34	32	34	CL	0	0.23	6.7	63	30
				Ave.	123,097	32	27	41		0	1	10	53	35

COTTONWOOD ARROYO

CS-1 1997-1999 Sediment Data

Lab ID	Sample ID	Date Sampled	Time Sampled	Flow	Total Sediment	Sand	Silt	Clay	Texture	very coarse sand	coarse sand	medium sand	fine sand	very fine sand
				cfs	mg/L	%	%	%	%	%	%	%	%	%
0397W0169	CS-1 #5	8/2/97		1350	61,400									
0397W0169	CS-1 #9	8/2/97		2910	95,400									
0397W0169	CS-1 #10	8/2/97		2575	99,400									
0397W0189	CS-1 #7	8/31/97		75	46,200									
0397W0189	CS-1 #9	8/31/97		47	46,500									
W04788	CS-1	8/21/98	0916	240	79,000	16	25	59	C	0	0.6	2.4	43	54
W04789	CS-1	8/21/98	0924	860	76,290	16	21	63	C	0	0	0.8	27	73
W04790	CS-1	8/21/98	0934	640	70,190	12	21	67	C	0	0	3.3	30	67
W04791	CS-1	8/21/98	0944	560	135,700	18	25	57	C	0	0.2	1.4	45	53
W04792	CS-1	8/21/98	0954	340	68,060	12	21	67	C	0	0	3.2	32	65
W04793	CS-1	8/21/98	1004	480	67,810	12	21	67	C	0	0	4.3	87	9
W04794	CS-1	8/21/98	1014	600	77,210	14	21	65	C	0	0	11	22	67
W04795	CS-1	8/21/98	1024	340	78,420	14	19	67	C	0	5.6	5.6	33	56
W04796	CS-1	8/21/98	1034	350	74,630	12	19	69	C	0	0	14	29	57
W04797	CS-1	8/21/98	1044	320	78,780	14	21	65	C	0	0	1.0	35	64
W02597	CS-1#2	05/23/99	1540	90	122,900	16	34	50	C	0	0.37	0.46	42	57
W02598	CS-1#3	05/23/99	1546*	195	140,300	25	31	44	C	0	1.1	11	53	35
W02599	CS-1#4	05/23/99	1552	162	73,100	21	39	40	C	0	0.30	3.6	48	48
W02600	CS-1#5	05/23/99	1558	125	58,700	21	38	41	C	0	0.27	1.5	40	58
W02601	CS-1#6	05/23/99	1604	125	55,100	19	39	42	C	0	0.42	1.5	42	56
W02602	CS-1#7	05/23/99	1610	90	55,900	20	38	42	C	0	0.63	2.1	43	54
W02603	CS-1#8	05/23/99	1616	65	62,700	22	36	42	C	0	0.32	1.8	45	53
W02604	CS-1#9	05/23/99	1622	55	52,100	18	34	48	C	0	0	1.4	40	58

COTTONWOOD ARROYO
CS-1 1997-1999 Sediment Data

Lab ID	Sample ID	Date Sampled	Time Sampled	Flow	Total Sediment	Sand	Silt	Clay	Texture	very coarse sand	coarse sand	medium sand	fine sand	very fine sand
				cfs	mg/L	%	%	%	%	%	%	%	%	%
W02605	CS-1#10	05/23/99	1632	35	55,100	20	32	48	C	0	0.16	2.1	44	54
W03754	CS-1 #13	7/23/99	2120*	260	54,100	22	33	45	C	0	0.39	1.7	46	52
W03755	CS-1 #17	7/23/99	2144	130	62,300	19	31	50	C	0	0	2.4	41	57
W03756	CS-1 #21	7/23/99	2208	175	114,200	18	34	48	C	0	0.32	3.0	55	41
W03757	CS-1 #24	7/23/99	2226	65	126,000	20	35	45	C	0	0.14	2.4	50	47
W03996	CS-1 #3	08/02/99	1604	815	63,500	36	29	35	CL	1.9	8.2	12	42	36
W03997	CS-1 #5	08/02/99	1616*	1115	51,700	30	27	43	C	2.1	6.9	12	47	31
W03998	CS-1 #7	08/02/99	1628	540	44,600	33	23	44	C	0.17	2.1	12	51	34
W03999	CS-1 #10	08/02/99	1646	60	50,600	25	28	47	C	0.31	1.4	4.3	47	47
W04035	CS-1 #3	08/03/99	1502	35	143,200	34	36	30	CL	0	0.14	1.7	67	31
W04036	CS-1 #9	08/03/99	1700	625	58,800	36	29	35	CL	2.9	6.3	10	49	31
W04037	CS-1 #13	08/03/99	1724*	1750	48,200	29	31	40	C	0.46	2.0	5.2	51	40
W04038	CS-1 #23	08/03/99	1824	1120	127,900	26	29	45	C	0	0	3.3	58	38
W04134	CS-1 #7	08/05/99	1812	3100	74,500	32	26	42	C	0	0.24	4.9	61	34
W04135	CS-1 #13	08/05/99	1848	3500	97,600	22	29	49	C	0	0	3.5	51	46
W04136	CS-1 #17	08/05/99	1912	3400	112,100	20	31	49	C	0	0.26	5.1	46	49
W04137	CS-1 #23	08/05/99	1948	3300	116,600	26	33	41	C	0	0.09	4.3	57	39
				Ave.	79,420	21	29	50		0	1	5	46	48

COTTONWOOD ARROYO

CNS-1 1997-1999 Sediment Data

Lab ID	Sample ID	Date Sampled	Time Sampled	Flow	Total Sediment	Sand 29	Silt 28	Clay 43	Texture	very coarse sand	coarse sand	medium sand	fine sand	very fine sand
				cfs	mg/L	%	%	%	%	%	%	%	%	%
0397W01895	CNS-1 #4	8/31/97		52	68,100									
0397W01896	CNS-1 #7	8/31/97		118	74,100									
0397W01897	CNS-1 #15	8/31/97		66	78,700									
0397W02044	CNS-1 #2	9/15/97		65	57,000									
0397W02045	CNS-1 #3	9/15/97		79	61,700									
0397W02046	CNS-1 #19	9/15/97		53	61,700									
0397W02140	CNS-1 #5	9/21/97		86	59,900									
0397W02141	CNS-1 #8	9/21/97		112	93,600									
0397W02142	CNS-1 #10	9/21/97		82	86,500									
0397W02713	CNS-1 #8	11/12/97		186	47,200									
0397W02714	CNS-1 #11	11/12/97		137	33,200									
0397W02715	CNS-1 #14	11/12/97		152	29,800									
W04763	CNS-1 #3	8/21/98	0136	630	175,400	21	29	50	C	0.1	0.4	3.0	53	44
W04764	CNS-1 #4	8/21/98	0142	860	193,800	23	28	49	C	0.1	0.5	7.5	65	27
W04765	CNS-1 #5	8/21/98	0148	585	176,500	21	28	51	C	0.1	0.3	6.4	55	39
W04767	CNS-1 #7	8/21/98	0200	740	162,500	21	28	51	C	0	0.1	5.4	60	34
W04768	CNS-1 #8	8/21/98	0206	600	161,500	23	28	49	C	0.1	0.3	3.6	52	44
W04769	CNS-1 #9	8/21/98	0212	540	146,900	21	30	49	C	0.1	0.2	2.2	52	45
W04770	CNS-1 #10	8/21/98	0218	560	139,500	21	28	51	C	0.1	0.3	1.7	44	54
W04771	CNS-1 #11	8/21/98	0224	450	131,200	20	29	51	C	0.1	0.1	1.6	42	56
W04772	CNS-1 #12	8/21/98	0230	400	120,800	19	28	53	C	0.7	0.4	2.2	44	53
W04773	CNS-1 #13	8/21/98	0236	405	96,570	15	26	59	C	0	2.9	8.8	35	53
W04774	CNS-1 #14	8/21/98	0242	440	107,300	17	32	51	C	0.5	0.5	1.0	26	72
W04775	CNS-1 #15	8/21/98	0248	510	119,600	13	38	49	C	0.1	0.7	6.8	51	41

COTTONWOOD ARROYO

CNS-1 1997-1999 Sediment Data

Lab ID	Sample ID	Date Sampled	Time Sampled	Flow	Total Sediment	Sand 29	Silt 28	Clay 43	Texture	very coarse sand	coarse sand	medium sand	fine sand	very fine sand
				cfs	mg/L	%	%	%	%	%	%	%	%	%
W04776	CNS-1 #16	8/21/98	0254	640	117,800	21	28	51	C	0.2	0.4	4.3	44	51
W04777	CNS-1 #17	8/21/98	0300	850	133,100	27	25	48	C	1.5	4.7	13	52	29
W04778	CNS-1 #18	8/21/98	0306	605	140,500	28	26	46	C	1.9	4.4	14	48	31
W04779	CNS-1 #19	8/21/98	0312	525	145,600	24	26	50	C	1.8	5.2	16	47	29
W04780	CNS-1 #20	8/21/98	0318	900	130,000	22	27	51	C	1.3	2.6	6.9	44	45
W04781	CNS-1 #21	8/21/98	0324	730	131,200	26	26	48	C	0.7	2.2	9.5	51	36
W04840	CNS-1 #2	8/21/98	1628	300	83,160	30	30	40	CL	0	0.6	10	73	16
W04841	CNS-1 #3	8/21/98	1634	465	76,600	26	32	42	C	0.3	1.1	3.0	39	57
W04842	CNS-1 #4	8/21/98	1640	650	91,860	36	25	39	CL	0.6	3.8	11	44	40
W04843	CNS-1 #12	8/21/98	1728	300	82,390	19	29	52	C	0.3	0.6	4.1	48	47
W04844	CNS-1 #13	8/21/98	1734	290	99,500	26	26	48	C	0	0	4.5	49	47
W04845	CNS-1 #14	8/21/98	1740	240	93,800	24	27	49	C	0	0.6	3.6	47	49
W04846	CNS-1 #15	8/21/98	1746	165	83,880	22	28	50	C	0	0	2.3	45	52
W04847	CNS-1 #16	8/21/98	1752	115	79,030	20	27	53	C	0	0	1.1	30	69
W04848	CNS-1 #17	8/21/98	1758	105	71,320	16	29	55	C	0	0	0	26	73
W04849	CNS-1 #18	8/21/98	1804	85	67,540	16	29	55	C	0	0	0.7	15	84
W04850	CNS-1 #19	8/21/98	1810	45	67,690	16	29	55	C	0	0	0	18	81
W04851	CNS-1 #20	8/21/98	1816	40	66,680	14	30	56	C	0	0.1	0	23	76
W04852	CNS-1 #21	8/21/98	1822	40	64,020	16	27	57	C	0	0.3	0.9	31	68
W05770	CNS-1	09/30/98	1454	220	55,300	33	32	35	SIC	0.20	1.4	5.7	43	49
W05771	CNS-1	09/30/98	1500	260	47,100	27	34	39	CL	0	0.49	2.7	46	51
W05772	CNS-1	09/30/98	1506	320	53,700	25	33	42	C	0	0.52	3.6	45	50
W05773	CNS-1	09/30/98	1512	370	52,600	21	34	45	C	0.43	0.85	4.7	44	50
W05774	CNS-1	09/30/98	1518	440	60,400	19	34	47	C	0.32	0.16	3.0	45	50

COTTONWOOD ARROYO

CNS-1 1997-1999 Sediment Data

Lab ID	Sample ID	Date Sampled	Time Sampled	Flow	Total Sediment	Sand 29	Silt 28	Clay 43	Texture	very coarse sand	coarse sand	medium sand	fine sand	very fine sand
				cfs	mg/L	%	%	%	%	%	%	%	%	%
W05775	CNS-1	09/30/98	1524	530	57,000	19	33	48	C	0.15	0.46	1.7	38	60
W05776	CNS-1	09/30/98	1530	320	61,500	19	31	50	C	0.60	0.40	1.6	43	55
W05777	CNS-1	09/30/98	1536	370	69,600	17	31	52	C	0.43	0.58	3.2	42	53
W05778	CNS-1	09/30/98	1542	420	68,000	18	28	54	C	0.19	0.38	2.5	42	54
W05779	CNS-1	09/30/98	1548	520	63,500	16	30	54	C	0.55	0.55	3.0	32	64
W05780	CNS-1	09/30/98	1554	440	61,000	15	31	54	C	0.34	0.34	3.4	30	66
W05781	CNS-1	09/30/98	1600	510	60,300	16	29	55	C	0	0.08	2.3	38	59
W05782	CNS-1	09/30/98	1606	350	61,200	18	27	55	C	0	0	4.6	51	44
W05783	CNS-1	09/30/98	1612	260	58,700	17	28	55	C	0	0.02	1.8	39	59
W05784	CNS-1	09/30/98	1618	160	60,800	16	29	55	C	0	0.37	3.1	40	56
W05785	CNS-1	09/30/98	1624	170	57,700	16	28	56	C	0	0.20	3.1	41	56
S06255	CNS-1 #2	10/25/98	2004	75	43,800									
S06256	CNS-1 #3	10/25/98	2010	90	49,800									
S06257	CNS-1 #4	10/25/98	2016	105	51,000									
S06258	CNS-1 #5	10/25/98	2222	120	58,400									
S06259	CNS-1 #6	10/25/98	2028	130	57,900									
S06260	CNS-1 #7	10/25/98	2034	135	55,500									
S06261	CNS-1 #8	10/25/98	2040	135	54,400									
S06262	CNS-1 #9	10/25/98	2046	130	54,400									
S06263	CNS-1 #10	10/25/98	2052	125	56,900									
S06264	CNS-1 #11	10/25/98	2058	140	56,100									
S06265	CNS-1 #12	10/25/98	2104	125	53,400									
S06266	CNS-1 #13	10/25/98	2110	145	56,100									
S06267	CNS-1 #14	10/25/98	2116	140	53,400									

COTTONWOOD ARROYO

CNS-1 1997-1999 Sediment Data

Lab ID	Sample ID	Date Sampled	Time Sampled	Flow	Total Sediment	Sand 29	Silt 28	Clay 43	Texture	very coarse sand	coarse sand	medium sand	fine sand	very fine sand
				cfs	mg/L	%	%	%	%	%	%	%	%	%
S06268	CNS-1 #15	10/25/98	2122	150	58,700									
S06269	CNS-1 #16	10/25/98	2128	180	63,000									
S06270	CNS-1 #17	10/25/98	2134	160	66,900									
S06271	CNS-1 #18	10/25/98	2140	190	68,300									
S06272	CNS-1 #19	10/25/98	2146	160	68,000									
W06621	CNS-1	11/9/98	0306	31	35,000	21	40	38	CL	0.09	1.8	10	41	47
W06622	CNS-1	11/9/98	0312	40	38,800	29	31	39	CL	0.52	3.1	14	48	35
W06623	CNS-1	11/9/98	0320	42	39,000	28	33	39	CL	0	1.4	10	55	34
W06624	CNS-1	11/9/98	0324	60	39,100	28	32	40	C	0.06	2.5	11	46	40
W06625	CNS-1	11/9/98	0330	57	40,400	29	30	40	C	0.29	1.2	7.7	49	42
W06626	CNS-1	11/9/98	0336	93	42,600	31	28	41	C	0.04	2.0	11	48	38
W06627	CNS-1	11/9/98	0342	95	43,000	29	29	42	C	0.17	1.0	6.4	54	39
W06628	CNS-1	11/9/98	0348	100	44,300	31	27	42	C	0.04	1.6	9.2	52	37
W06629	CNS-1	11/9/98	0354	77	45,700	35	22	42	C	0.14	1.5	8.6	50	39
W06630	CNS-1	11/9/98	0400	125	46,600	31	23	45	C	0.22	1.7	6.2	52	40
W06631	CNS-1	11/9/98	0406	120	47,000	35	23	42	C	0.47	1.8	8.3	52	37
W06632	CNS-1	11/9/98	0412	134	51,700	36	21	43	C	0.03	2.0	7.4	52	38
W06633	CNS-1	11/9/98	0418	157	56,900	37	21	42	C	0.05	1.5	7.7	58	33
W06634	CNS-1	11/9/98	0424	164	61,900	40	18	42	C	0.66	3.6	12	55	29
W06635	CNS-1	11/9/98	0430	157	67,900	41	18	41	C	0.38	2.7	12	54	31
W06636	CNS-1	11/9/98	0436	142	67,000	37	19	44	C	0.14	2.1	13	56	29
W02143	CNS-2	4/22/99	1506	37	142,500	48	22	30	SCL	0	0.01	1.3	78	21
W02144	CNS-3	4/22/99	1512	47	150,400	52	20	28	SCL	0	0.03	1.7	79	19
W02145	CNS-4	4/22/99	1516	65	129,700	48	22	30	SCL	0	0.03	2.1	81	17

COTTONWOOD ARROYO

CNS-1 1997-1999 Sediment Data

Lab ID	Sample ID	Date Sampled	Time Sampled	Flow	Total Sediment	Sand 29	Silt 28	Clay 43	Texture	very coarse sand	coarse sand	medium sand	fine sand	very fine sand
				cfs	mg/L	%	%	%	%	%	%	%	%	%
W02146	CNS-5	4/22/99	1522	75	143,200	54	20	26	SCL	0	0.03	8.6	69	22
W02147	CNS-6	4/22/99	1528	76	149,000	58	16	26	SCL	0	0.01	1.5	74	25
W02148	CNS-7	4/22/99	1534	53	132,100	48	18	34	SCL	0	0.03	1.5	72	27
W02149	CNS-8	4/22/99	1540	76	131,400	52	18	30	SCL	0	0.00	2.0	72	26
W02150	CNS-9	4/22/99	1546	58	124,900	52	18	30	SCL	0	0.03	1.7	65	33
W02151	CNS-10	4/22/99	1552	61	130,300	54	18	28	SCL	0	0.05	2.9	79	18
W02152	CNS-11	4/22/99	1558	74	146,700	59	16	25	SCL	0	0.11	5.5	75	19
W02153	CNS-12	4/22/99	1604	54	133,800	56	18	26	SCL	0	0.06	3.0	72	25
W02154	CNS-13	4/22/99	1610	60	144,300	58	14	28	SCL	0	0.12	9.5	70	21
W03422	CNS-1#3	07/03/99	1440	305	126,900	52	26	22	SCL	0	0.27	1.8	63	35
W03423	CNS-1#5	07/03/99	1452	340	150,900	46	26	28	SCL	0	0.74	2.9	59	38
W03424	CNS-1#7	07/03/99	1504	295	87,600	39	27	34	CL	0	0.69	4.3	58	37
W03425	CNS-1#24	07/03/99	1646	230	105,700	16	36	48	C	0	0	0.32	39	60
W03758	CNS-1 #2	7/23/99	2014	120	52,200	34	35	31	CL	0.83	0.50	2.0	35	62
W03759	CNS-1 #3	7/23/99	2018	310	69,800	44	28	28	CL	2.0	3.7	7.9	44	42
W03760	CNS-1 #4	7/23/99	2024	500	68,500	40	28	32	CL	3.2	5.0	6.0	43	35
W03971	CNS-1 #2	07/29/99	0256	51	56,400	24	32	44	C	0.47	2.8	7.8	26	63
W03972	CNS-1 #3	07/29/99	0300	64	130,900	28	31	41	C	0.91	2.1	2.6	39	56
W03973	CNS-1 #4	07/29/99	0306	57	182,800	30	35	35	CL	0.19	0.61	1.6	54	44
W03974	CNS-1 #6	07/29/99	0318	32	147,700	24	38	38	CL	0.07	0.41	1.4	44	55
W03995	CNS-1 #1	08/02/99	1610	650	106,300	38	25	37	CL	0.31	0.80	2.9	52	44
W04004	CNS-1 #2	08/02/99	1616	1,150	40,300	23	27	50	C	0.13	0.27	1.3	35	64
W04005	CNS-1 #3	08/02/99	1620	1,230	42,000	23	28	49	C	0.02	0.49	2.5	39	58
W04039	CNS-1 #7	08/03/99	1458	65	134,300	24	34	42	C	0	0.21	2.1	51	46
W04040	CNS-1 #12	08/03/99	1528	60	126,600	30	35	35	CL	0.09	0.75	5.3	58	36
W04041	CNS-1 #18	08/03/99	1604	35	91,600	26	35	39	CL	0.23	2.3	7.9	44	46
W04042	CNS-1 #23	08/03/99	1654	640	56,600	42	24	34	CL	1.9	7.8	15	44	30
			Ave.		85,247	29	28	43		• 0	1	5	49	44

Appendix 18.I

Cottonwood Arroyo

Automated Samplers

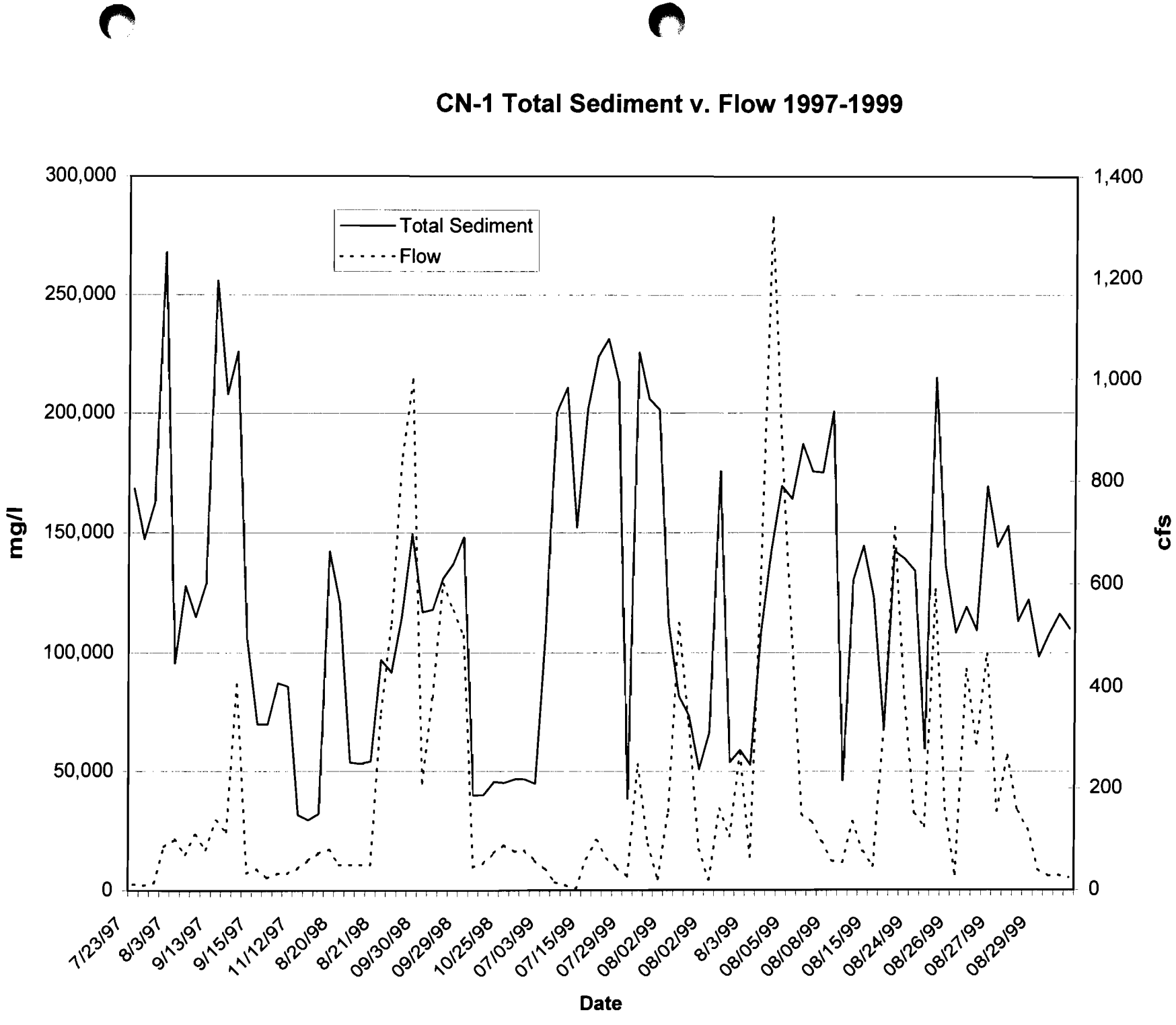
Total Sediment Graphs

Particle Size Distribution Graphs

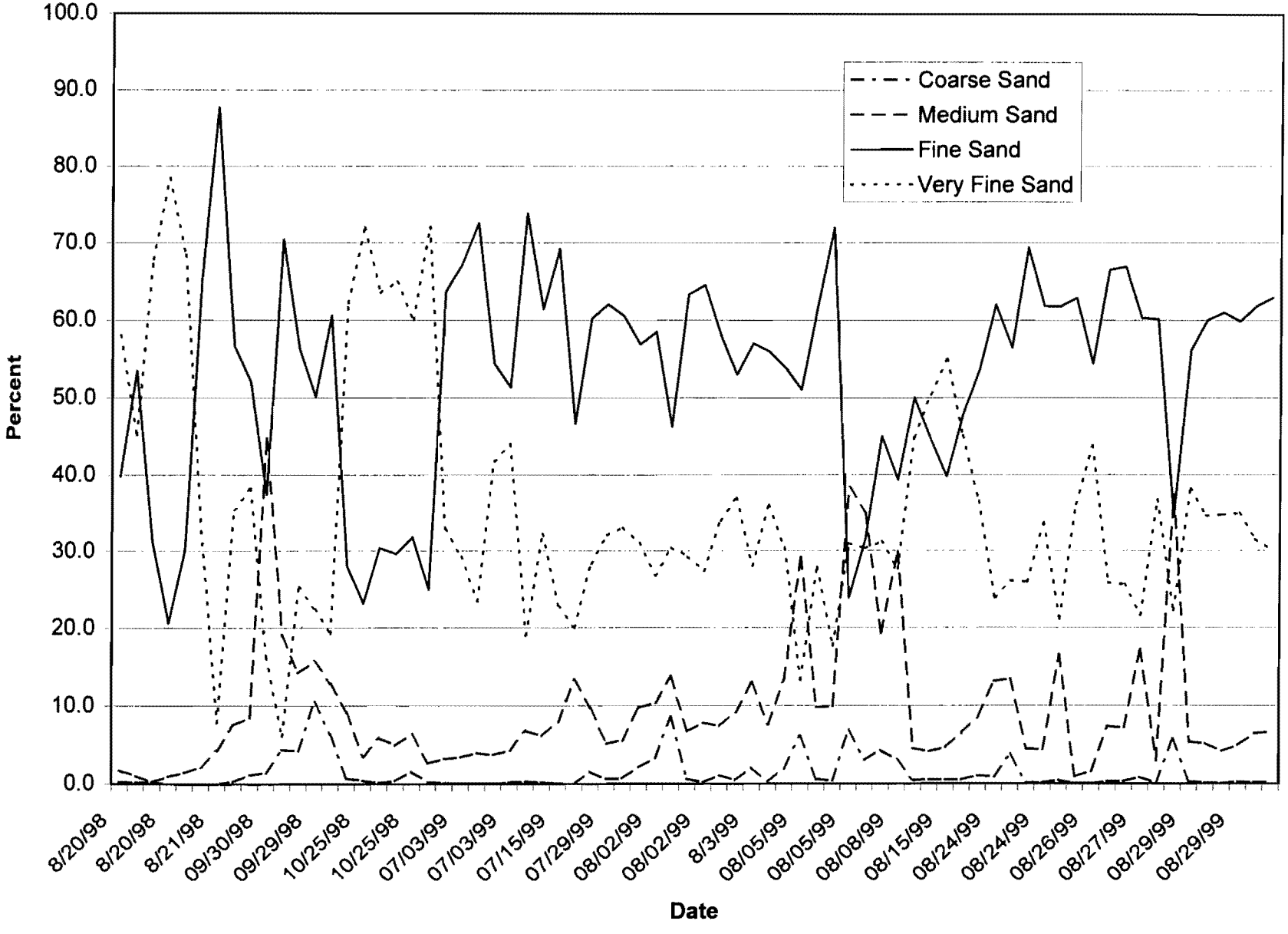
Texture Graphs

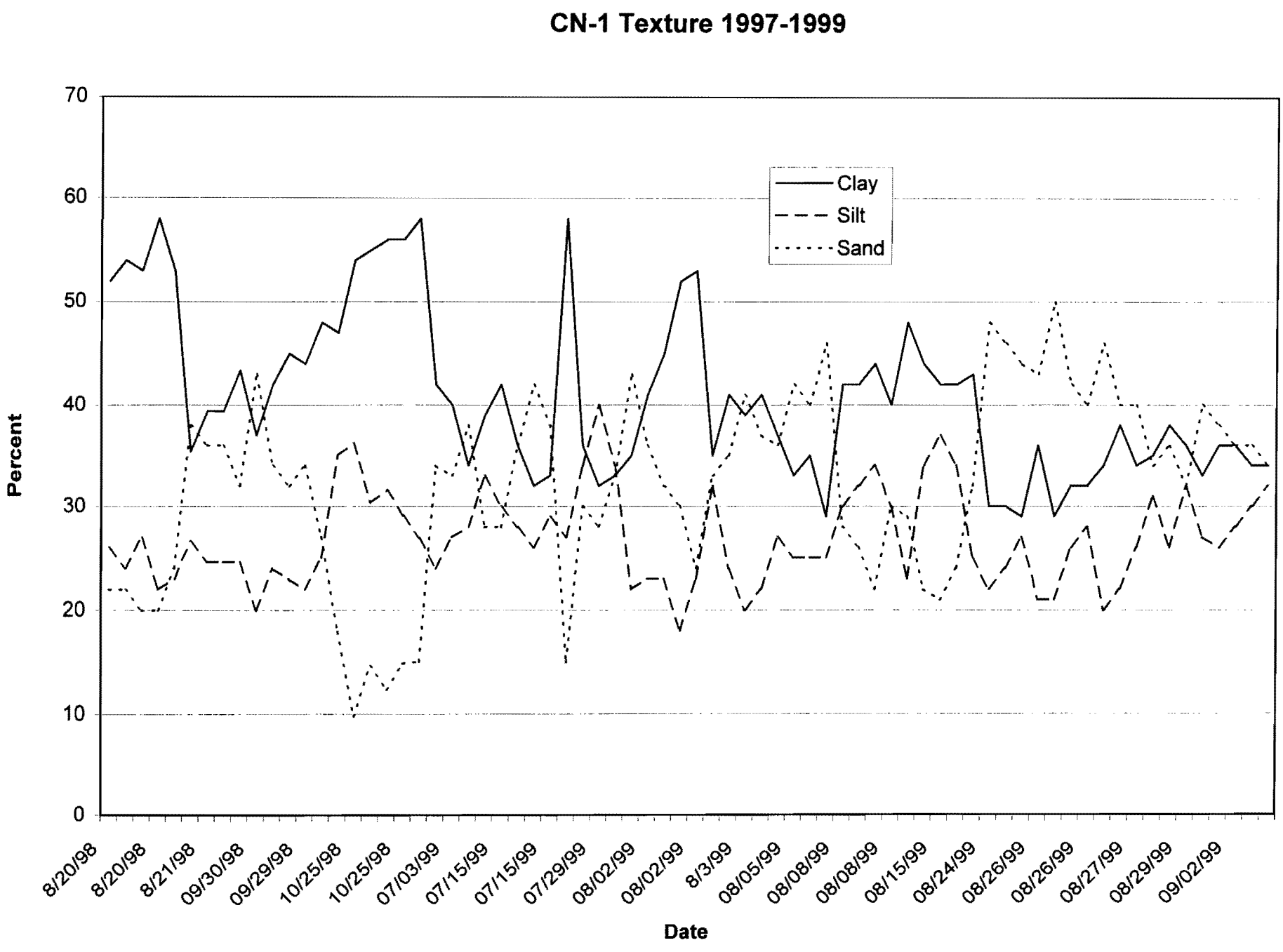
Stations CN-1, CNS-1 and CS-1

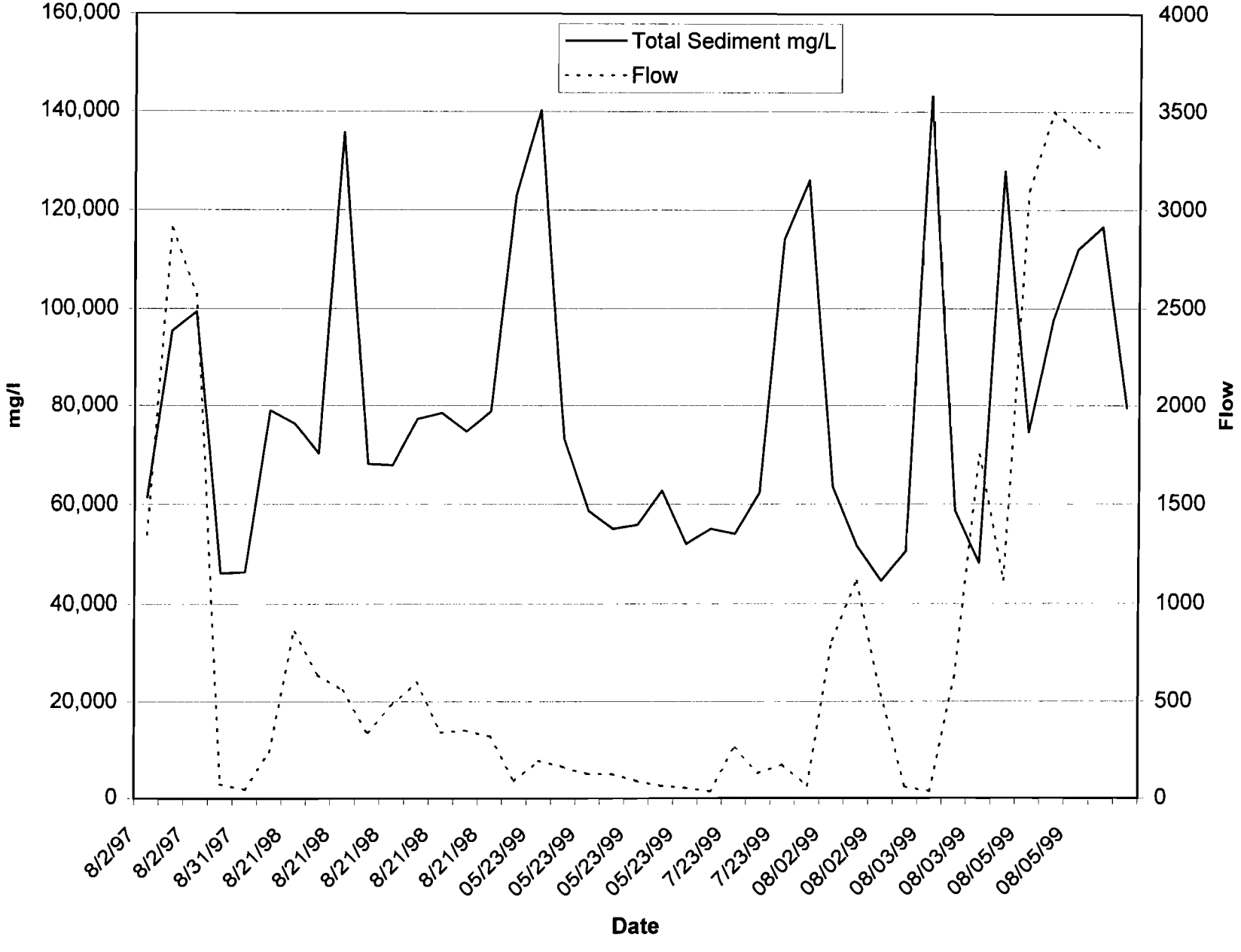
1997-1999


CN-1 Total Sediment v. Flow 1997-1999
Total Sediment
Flow
mg/l
cfs
300,000
250,000
200,000
150,000
100,000
50,000
0
1,400
1,200
1,000
800
600
400
200
0
7/23/97
8/3/97
9/13/97
9/15/97
11/12/97
8/20/98
8/21/98
09/30/98
09/29/98
10/25/98
07/03/99
07/15/99
07/29/99
08/02/99
08/02/99
8/3/99
08/05/99
08/08/99
08/15/99
08/24/99
08/26/99
08/27/99
08/29/99
Date

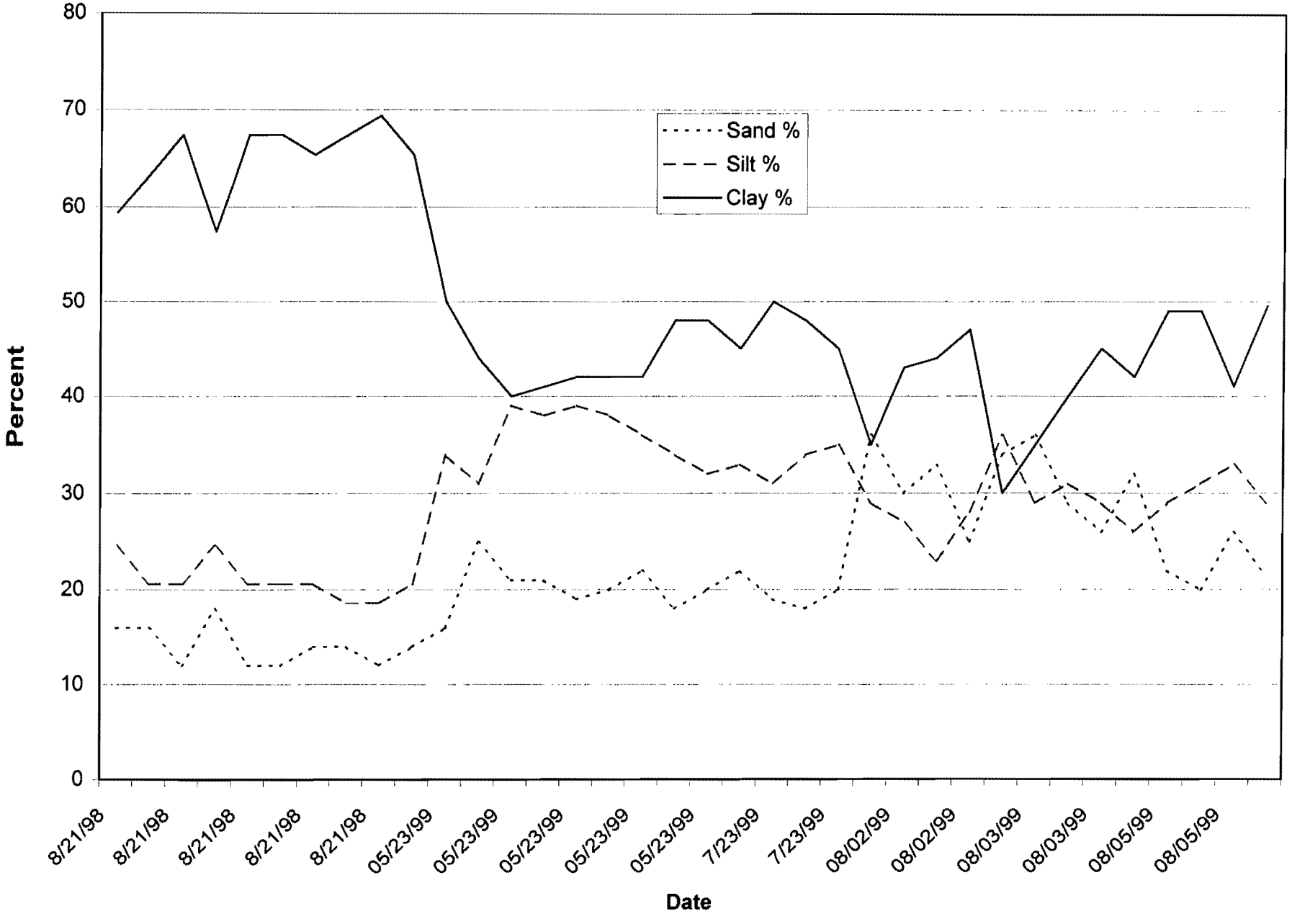
CN-1 Particle Size Distribution 1997-1999

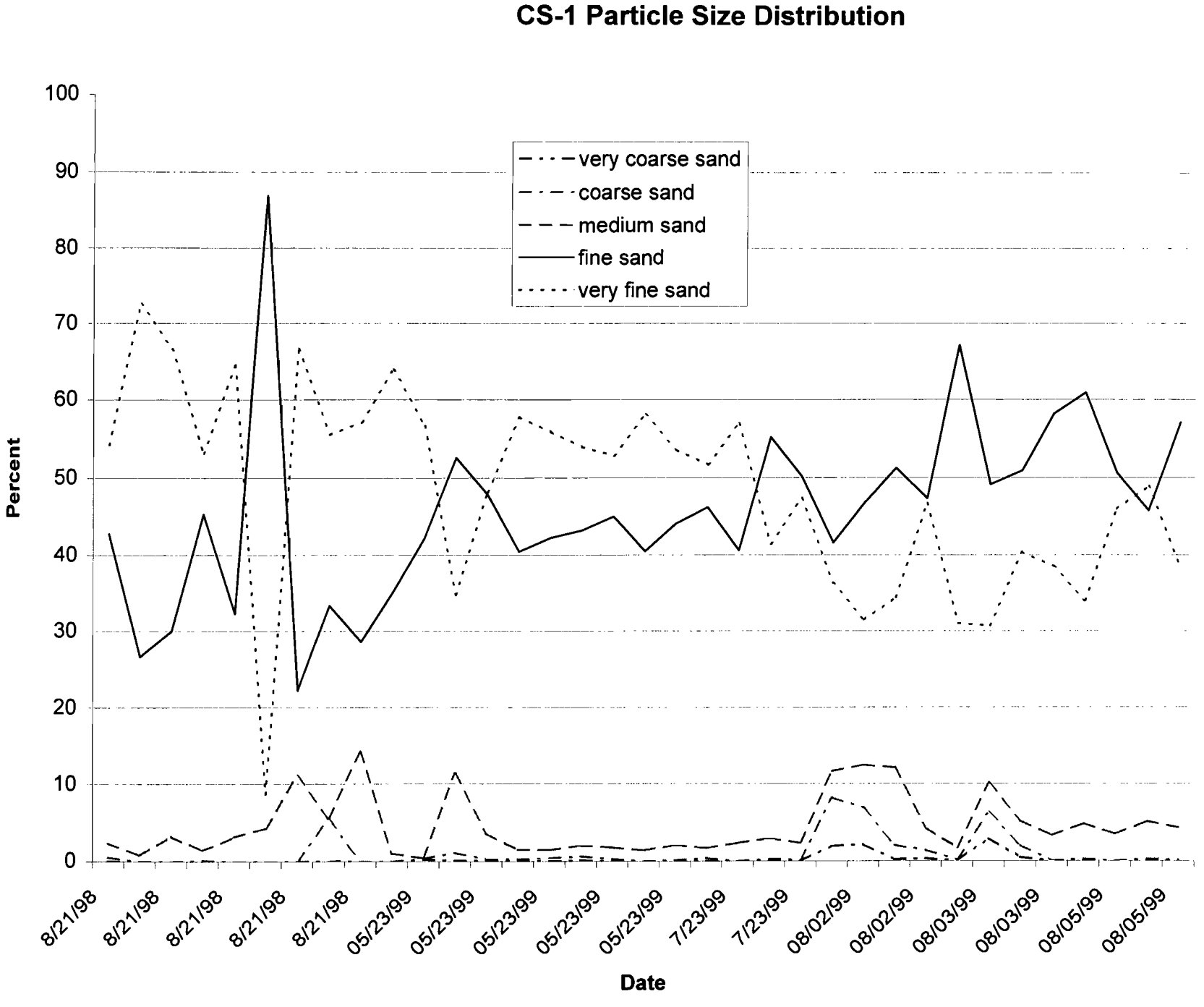



CN-1 Texture 1997-1999
Clay
Silt
Sand
Percent
70
60
50
40
30
20
10
0
8/20/98
8/20/98
8/21/98
09/30/98
09/29/98
10/25/98
10/25/98
07/03/99
07/15/99
07/15/99
07/29/99
08/02/99
08/02/99
8/3/99
08/05/99
08/08/99
08/08/99
08/15/99
08/24/99
08/26/99
08/26/99
08/27/99
08/29/99
09/02/99
Date

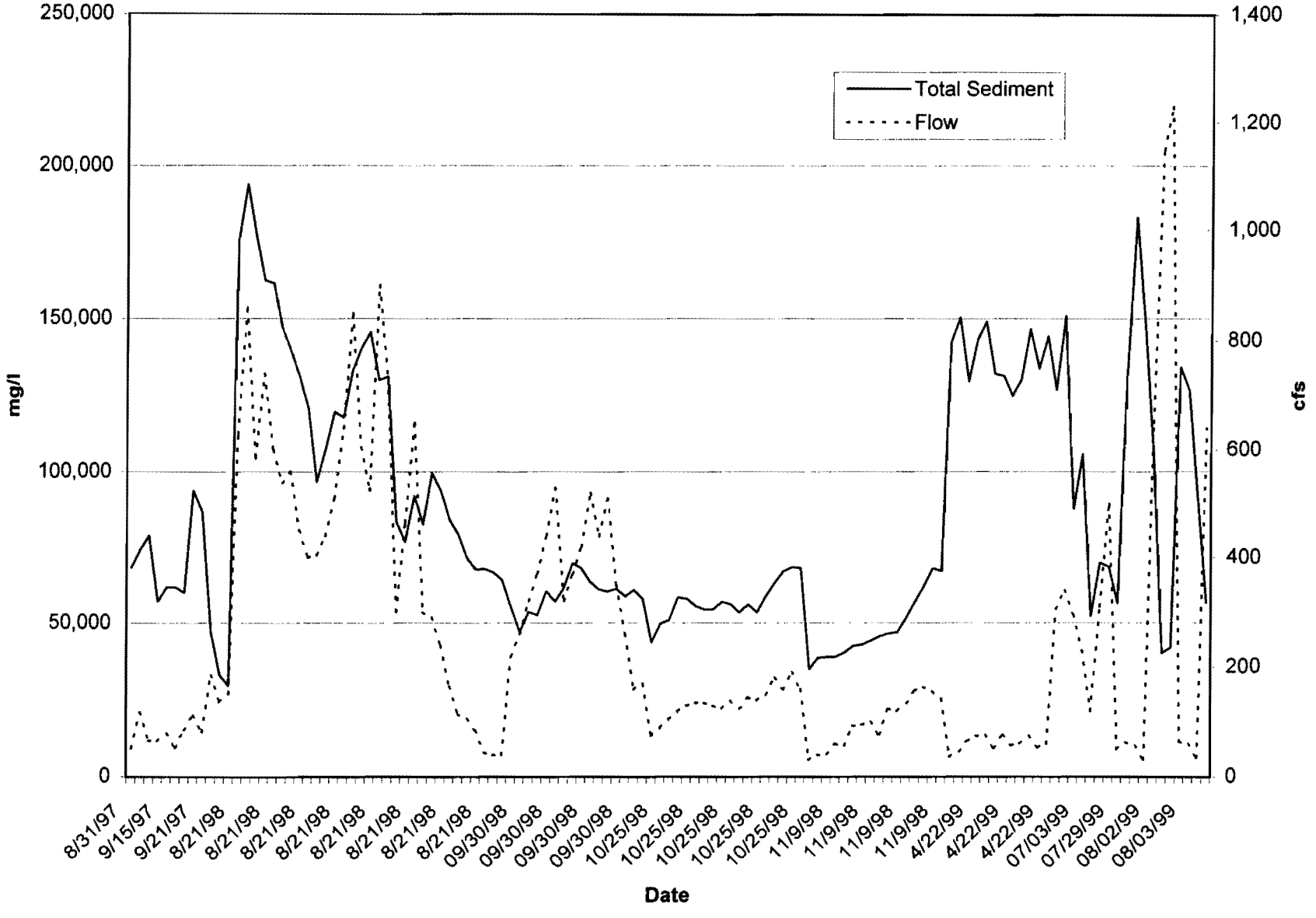

CS-1 Flow v. Total Sediment 1997-1999
Total Sediment mg/L
Flow
mg/l
Flow
Date
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
4000
3500
3000
2500
2000
1500
1000
500
0
8/2/97
8/2/97
8/31/97
8/21/98
8/21/98
8/21/98
8/21/98
8/21/98
05/23/99
05/23/99
05/23/99
05/23/99
7/23/99
7/23/99
08/02/99
08/02/99
08/03/99
08/03/99
08/05/99
08/05/99

CS-1 Texture 1997-1999

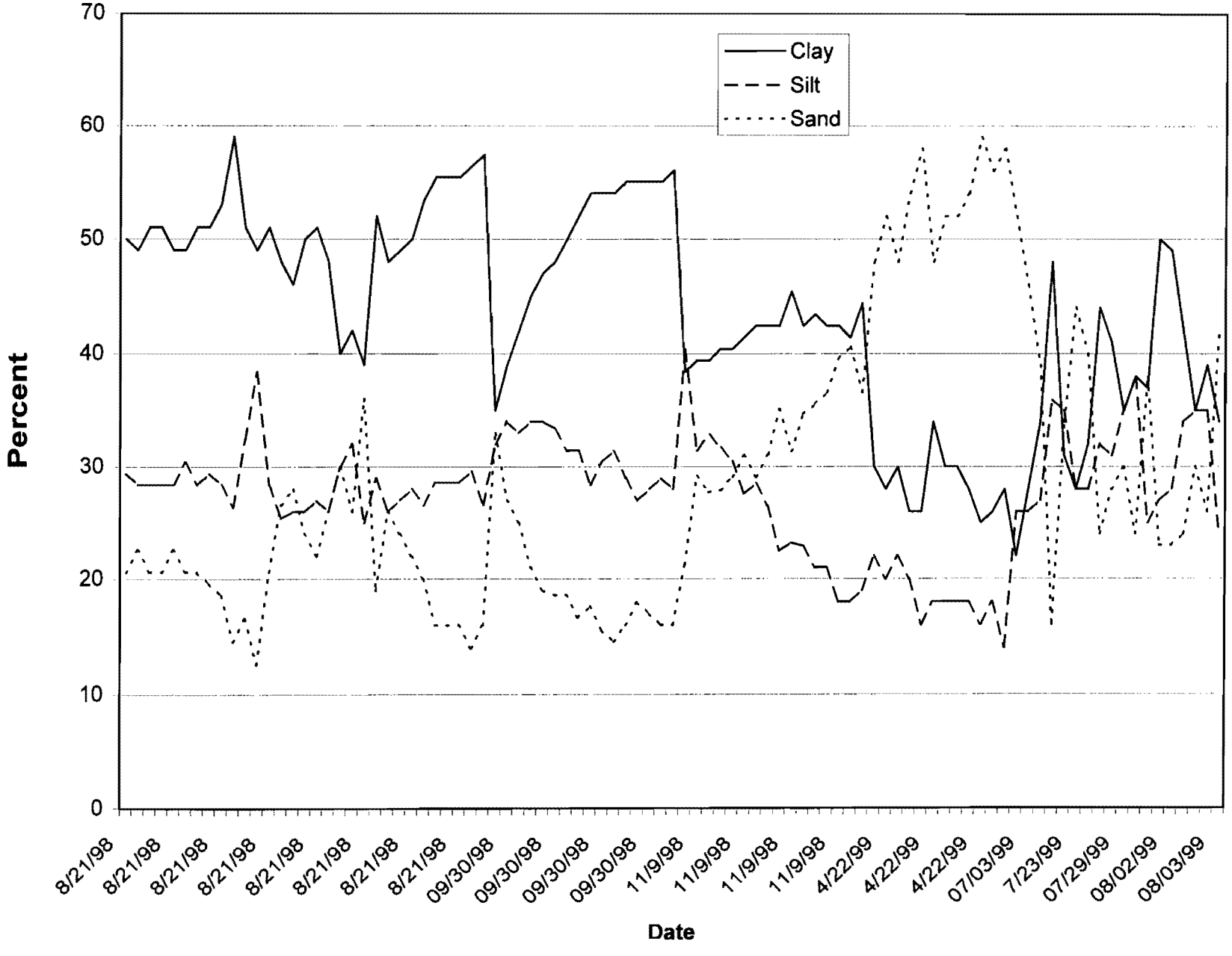


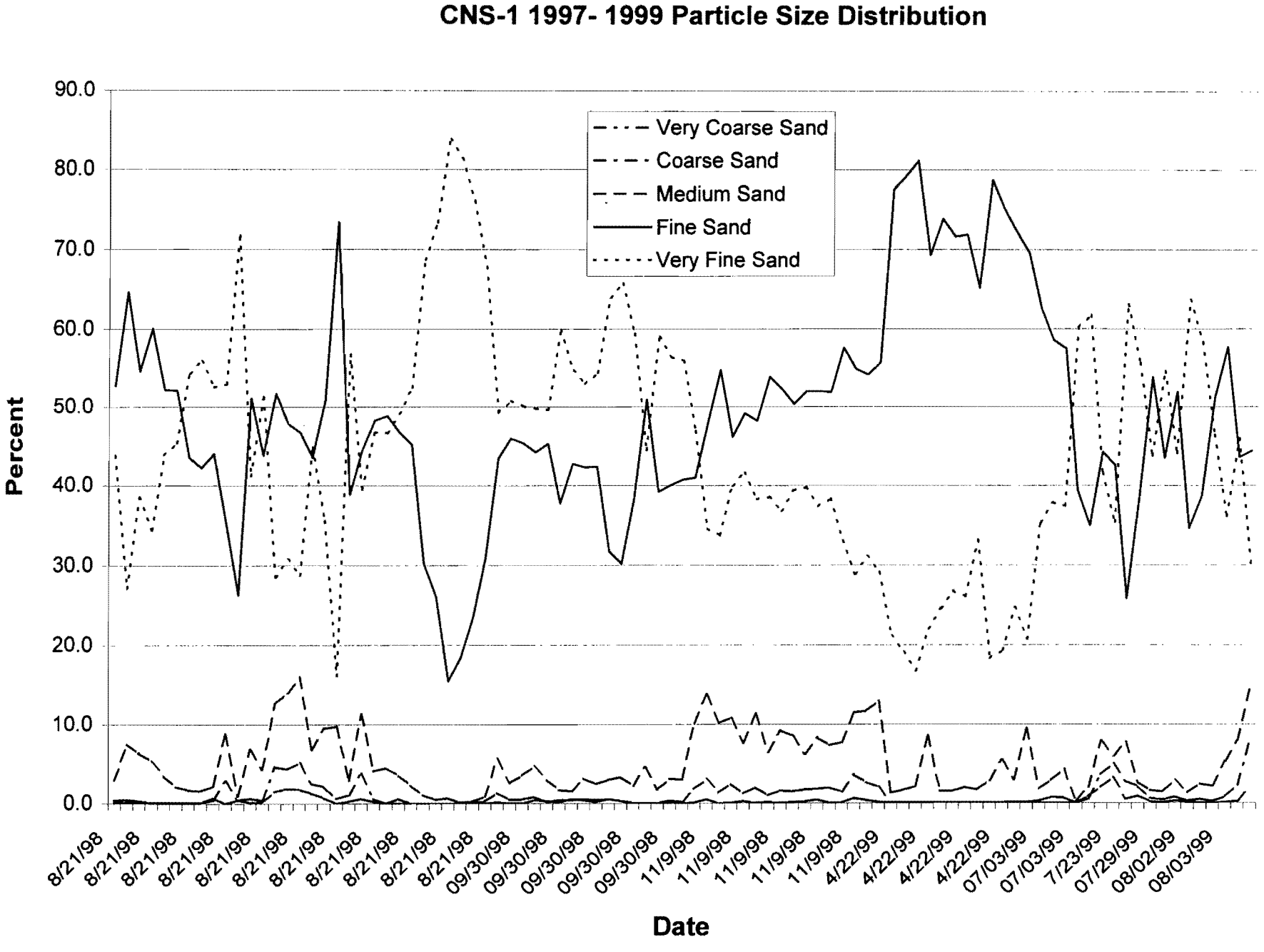

CS-1 Particle Size Distribution
very coarse sand
coarse sand
medium sand
fine sand
very fine sand
Percent
100
90
80
70
60
50
40
30
20
10
0
8/21/98
8/21/98
8/21/98
8/21/98
8/21/98
05/23/99
05/23/99
05/23/99
05/23/99
05/23/99
7/23/99
7/23/99
08/02/99
08/02/99
08/03/99
08/03/99
08/05/99
08/05/99
Date

CNS-1 Flow v. Total Sediment 1997-1999



CNS-1 Texture 1997-1999




CNS-1 1997- 1999 Particle Size Distribution
Very Coarse Sand
Coarse Sand
Medium Sand
Fine Sand
Very Fine Sand
Percent
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
8/21/98
09/30/98
11/9/98
4/22/99
07/03/99
7/23/99
07/29/99
08/02/99
08/03/99
Date

Appendix 18.J

Cottonwood Arroyo

Automated Samplers

Chemistry Data

Statistical Report

Trilinear Graph

Total Dissolved Solids Graph

Total Suspended Solids Graph

Stations CN-1, CNS-1 and CS-1

1997-1999

Quality Statistics for Stream Stations

Station: CN-1

		Mean	Std Dev	Coef Var	Range	Maximum Value	Minimum Value	Max Value Found	Min Value Found	# of Samp
Field pH	(S.U.)	8.49				8.60	8.40	11/12/97	09/01/97	2
Field Temperature	(deg C)	16.5	12.0	73	17.0	25.0	8.0	09/01/97	11/12/97	2
Field Conductivity	(umho/cm)	1	0	0	0	1	1	09/01/97	09/01/97	2
pH (Lab)	(S.U.)	7.99				8.70	7.50	08/02/99	07/15/99	28
Conductivity (Lab)	(umho/cm)	1298	770	59	2780	3350	570	08/29/99	08/03/97	28
TDS (180 deg C)	(mg/l)	976	624	64	2360	2780	420	08/29/99	07/23/97	27
Total Suspended Solids	(mg/l)	114919.2	77695.7	68	371600.0	386000.0	14400.0	07/15/99	05/23/99	26
Total Alk. as CaCO3	(mg/l)	137.89	80.71	59	453.00	475.00	22.00	08/15/99	08/08/99	27
Total Hardness as CaCO3	(mg/l)	175.65	134.88	77	491.00	542.00	51.00	08/29/99	09/15/97	27
Boron	(mg/l)	0.07	0.05	62	0.22	0.24	0.03	10/25/98	09/13/97	27
Fluoride	(mg/l)	0.83	0.32	38	1.23	1.66	0.43	09/01/97	05/23/99	27
SAR		11.00			0.00	11.00	11.00	09/01/97	09/01/97	1
Total Phosphorus	(mg/l)	96.80			0.00	96.80	96.80	09/01/97	09/01/97	1
Bicarbonate as HCO3	(mg/l)	167.70	98.69	59	554.00	580.00	26.00	08/15/99	08/08/99	27
Carbonate as CO3	(mg/l)	0.65	0.55	85	2.50	3.00	0.50	09/30/98	07/23/97	27
Hydroxide as OH	(mg/l)	0.50	0.00	0	0.00	0.50	0.50	07/23/97	07/23/97	26
Chloride	(mg/l)	29.37	18.18	62	69.00	77.00	8.00	09/02/99	09/13/97	27
Sulfate	(mg/l)	515.15	428.38	83	1710.00	1760.00	50.00	08/29/99	08/15/99	27
Calcium	(mg/l)	57.73	46.66	81	163.40	179.00	15.60	08/29/99	09/15/97	27
Magnesium	(mg/l)	7.61	8.33	109	29.10	30.40	1.30	08/26/99	09/02/99	27
Total Potassium	(mg/l)									0
Sodium	(mg/l)	239.74	145.79	61	547.00	649.00	102.00	08/29/99	07/23/97	27
Major Cations	(meq/l)	14.08	8.68	62	32.84	39.25	6.41	08/29/99	07/23/97	27
Major Anions	(meq/l)	14.31	8.71	61	33.13	39.52	6.39	08/29/99	07/23/97	27
Charge Balance	(percent)	2.14	2.63	123	13.59	13.68	0.09	09/01/97	08/15/99	27
Lab Determined Anions	(meq/l)	14.37	8.82	61	33.06	39.43	6.37	08/29/99	07/23/97	27
Lab Determined Ion Balance	(percent)	2.14	2.67	125	13.56	13.60	0.04	09/01/97	08/15/99	26
Arsenic	(mg/l)	0.003			0.000	0.003	0.003	09/01/97	09/01/97	1
Barium	(mg/l)	0.030			0.000	0.030	0.030	09/01/97	09/01/97	1
Cadmium	(mg/l)	0.0005			0.0000	0.0005	0.0005	09/01/97	09/01/97	1
Chromium	(mg/l)	0.0050			0.0000	0.0050	0.0050	09/01/97	09/01/97	1
Iron	(mg/l)	3.586	8.387	234	37.190	37.200	0.010	08/03/97	11/09/98	28
Lead	(mg/l)	0.003			0.000	0.003	0.003	09/01/97	09/01/97	1
Manganese	(mg/l)	0.168	0.304	182	1.165	1.170	0.005	08/03/97	09/01/97	27
Selenium	(mg/l)	0.006	0.008	127	0.030	0.032	0.003	08/27/99	07/23/97	28
Silver	(mg/l)	0.005			0.000	0.005	0.005	09/01/97	09/01/97	1
Zinc	(mg/l)	0.013			0.000	0.013	0.013	09/01/97	09/01/97	1
Total Iron	(mg/l)	669.57	1072.57	160	4349.99	4350.00	0.01	08/08/99	09/21/97	27
Total Manganese	(mg/l)	14.48	20.22	140	86.82	86.90	0.08	08/08/99	07/29/99	27

Below detection: calculate using half of detection limit.

Quality Statistics for Stream Stations

Station: CS-1

		Mean	Std Dev	Coef Var	Range	Maximum Value	Minimum Value	Max Value Found	Min Value Found	# of Samp
Field pH	(S.U.)	8.68				9.00	8.50	11/12/97	09/01/97	2
Field Temperature	(deg C)	12.5	6.4	51	9.0	17.0	8.0	09/01/97	11/12/97	2
Field Conductivity	(umho/cm)	1	0	0	0	1	1	09/01/97	09/01/97	2
pH (Lab)	(S.U.)	8.14				8.80	7.80	08/02/99	05/23/99	11
Conductivity (Lab)	(umho/cm)	1728	3187	184	11559	11809	250	08/05/99	08/21/98	12
TDS (180 deg C)	(mg/l)	652	190	29	570	910	340	05/23/99	08/02/99	12
Total Suspended Solids	(mg/l)	74009.1	57440.1	78	199900.0	216000.0	16100.0	08/03/99	05/23/99	11
Total Alk. as CaCO3	(mg/l)	156.42	69.34	44	216.00	265.00	49.00	09/01/97	11/09/98	12
Total Hardness as CaCO3	(mg/l)	131.13	62.23	47	191.50	237.00	45.50	04/22/99	08/02/99	12
Boron	(mg/l)	0.14	0.29	202	1.03	1.05	0.03	10/26/98	11/12/97	12
Fluoride	(mg/l)	0.68	0.35	51	1.21	1.23	0.03	11/09/98	04/22/99	12
SAR										0
Total Phosphorus	(mg/l)									0
Bicarbonate as HCO3	(mg/l)	189.25	85.16	45	269.00	323.00	54.00	09/01/97	11/09/98	12
Carbonate as CO3	(mg/l)	1.13	1.13	101	2.50	3.00	0.50	10/26/98	08/02/97	12
Hydroxide as OH	(mg/l)	0.50	0.00	0	0.00	0.50	0.50	08/02/97	08/02/97	11
Chloride	(mg/l)	21.25	11.82	56	30.00	40.00	10.00	05/23/99	10/26/98	12
Sulfate	(mg/l)	279.92	117.63	42	361.00	464.00	103.00	05/23/99	08/02/99	12
Calcium	(mg/l)	43.40	24.27	56	69.90	84.80	14.90	07/23/99	11/09/98	12
Magnesium	(mg/l)	5.46	3.24	59	10.00	11.00	1.00	10/26/98	11/12/97	12
Total Potassium	(mg/l)									0
Sodium	(mg/l)	166.18	52.42	32	161.80	258.00	96.20	08/21/98	08/02/99	12
Major Cations	(meq/l)	10.02	2.84	28	8.86	14.04	5.18	08/21/98	08/02/99	12
Major Anions	(meq/l)	9.56	2.77	29	8.17	12.87	4.70	08/21/98	08/02/99	12
Charge Balance	(percent)	2.96	2.29	77	5.87	5.95	0.08	09/01/97	08/03/99	12
Lab Determined Anions	(meq/l)	9.55	2.78	29	8.21	12.90	4.69	08/21/98	08/02/99	12
Lab Determined Ion Balance	(percent)	2.99	2.34	78	5.93	6.01	0.08	09/01/97	08/03/99	12
Arsenic	(mg/l)									0
Barium	(mg/l)									0
Cadmium	(mg/l)									0
Chromium	(mg/l)									0
Iron	(mg/l)	7.538	12.983	172	41.690	41.700	0.010	08/02/97	07/23/99	12
Lead	(mg/l)									0
Manganese	(mg/l)	0.436	0.801	184	2.815	2.820	0.005	08/02/97	11/09/98	12
Selenium	(mg/l)	0.003	0.001	27	0.003	0.005	0.003	07/23/99	08/02/97	12
Silver	(mg/l)									0
Zinc	(mg/l)									0
Total Iron	(mg/l)	540.17	795.53	147	2186.23	2190.00	3.77	08/05/99	07/23/99	12
Total Manganese	(mg/l)	11.01	13.94	127	40.19	40.30	0.11	08/05/99	07/23/99	11

Below detection: calculate using half of detection limit.

Quality Statistics for Stream Stations

Station: CNS-1

		Mean	Std Dev	Coef Var	Range	Maximum Value	Minimum Value	Max Value Found	Min Value Found	# of Samp
Field pH	(S.U.)	8.25				8.90	8.00	11/12/97	08/31/97	2
Field Temperature	(deg C)	12.5	7.8	62	11.0	18.0	7.0	08/31/97	11/12/97	2
Field Conductivity	(umho/cm)	1	0	0	0	1	1	08/31/97	08/31/97	2
pH (Lab)	(S.U.)	8.17				8.60	7.80	11/12/97	07/03/99	19
Conductivity (Lab)	(umho/cm)	861	269	31	1000	1590	590	08/21/98	07/23/99	19
TDS (180 deg C)	(mg/l)	639	189	30	790	1150	360	08/21/98	07/23/99	19
Total Suspended Solids	(mg/l)	97282.4	35178.2	36	120200.0	169000.0	48800.0	08/02/97	11/09/98	17
Total Alk. as CaCO3	(mg/l)	164.84	56.07	34	192.00	282.00	90.00	09/13/97	07/29/99	19
Total Hardness as CaCO3	(mg/l)	114.82	51.11	45	202.00	245.00	43.00	08/21/98	11/12/97	19
Boron	(mg/l)	0.08	0.08	98	0.37	0.39	0.03	10/25/98	09/13/97	18
Fluoride	(mg/l)	0.74	0.22	29	0.96	0.98	0.03	08/21/98	04/22/99	19
SAR										0
Total Phosphorus	(mg/l)									0
Bicarbonate as HCO3	(mg/l)	191.66	82.53	43	342.50	343.00	0.50	09/13/97	09/13/97	19
Carbonate as CO3	(mg/l)	6.84	22.95	335	99.50	100.00	0.50	08/03/99	08/02/97	19
Hydroxide as OH	(mg/l)	7.94	24.36	307	99.50	100.00	0.50	08/03/99	08/02/97	18
Chloride	(mg/l)	16.89	10.54	62	41.00	47.00	6.00	08/21/98	09/30/98	19
Sulfate	(mg/l)	276.74	157.33	57	668.00	718.00	50.00	08/21/98	09/30/98	19
Calcium	(mg/l)	38.92	17.80	46	68.70	83.30	14.60	08/21/98	11/12/97	19
Magnesium	(mg/l)	4.22	2.05	48	7.40	8.80	1.40	08/21/98	11/12/97	19
Total Potassium	(mg/l)									0
Sodium	(mg/l)	169.37	58.88	35	244.00	332.00	88.00	08/21/98	07/23/99	19
Major Cations	(meq/l)	9.79	3.23	33	12.74	19.50	6.76	08/21/98	11/12/97	19
Major Anions	(meq/l)	9.53	3.37	35	13.73	20.08	6.35	08/21/98	11/12/97	19
Charge Balance	(percent)	3.57	2.89	81	11.95	12.04	0.09	08/31/97	07/23/99	19
Lab Determined Anions	(meq/l)	9.53	3.37	35	13.73	20.10	6.37	08/21/98	11/12/97	19
Lab Determined Ion Balance	(percent)	3.57	2.89	81	11.93	12.00	0.07	08/31/97	07/23/99	19
Arsenic	(mg/l)									0
Barium	(mg/l)									0
Cadmium	(mg/l)									0
Chromium	(mg/l)									0
Iron	(mg/l)	6.651	8.565	129	34.290	34.300	0.010	08/31/97	07/03/99	18
Lead	(mg/l)									0
Manganese	(mg/l)	0.337	0.430	128	1.345	1.350	0.005	08/21/98	11/09/98	19
Selenium	(mg/l)	0.003	0.001	22	0.003	0.005	0.003	10/31/98	08/02/97	19
Silver	(mg/l)									0
Zinc	(mg/l)									0
Total Iron	(mg/l)	181.55	381.42	210	1569.93	1570.00	0.07	08/02/99	07/23/99	19
Total Manganese	(mg/l)	5.84	6.21	106	22.04	22.10	0.06	08/02/99	07/23/99	19

Below detection: calculate using half of detection limit.

TDS (180 deg C)

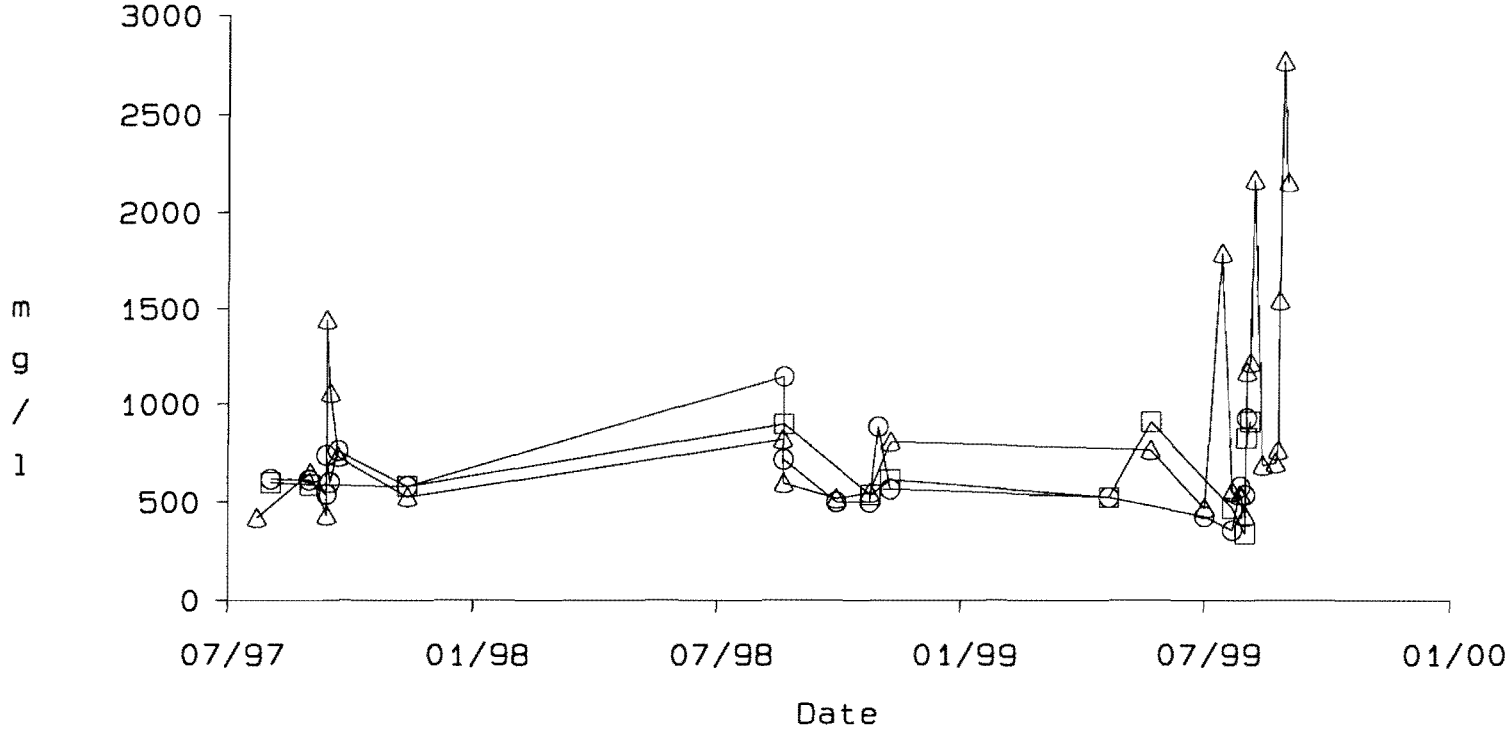
COTTONWOOD WASH 1997-1999

NAVAJO MINE AUTOMATED SAMPLER

○ CNS-1 MAIN CHANEL

□ CS-1 SOUTH FORK

△ CN-1 NORTH FORK



TOTAL SUSPENDED SOLIDS

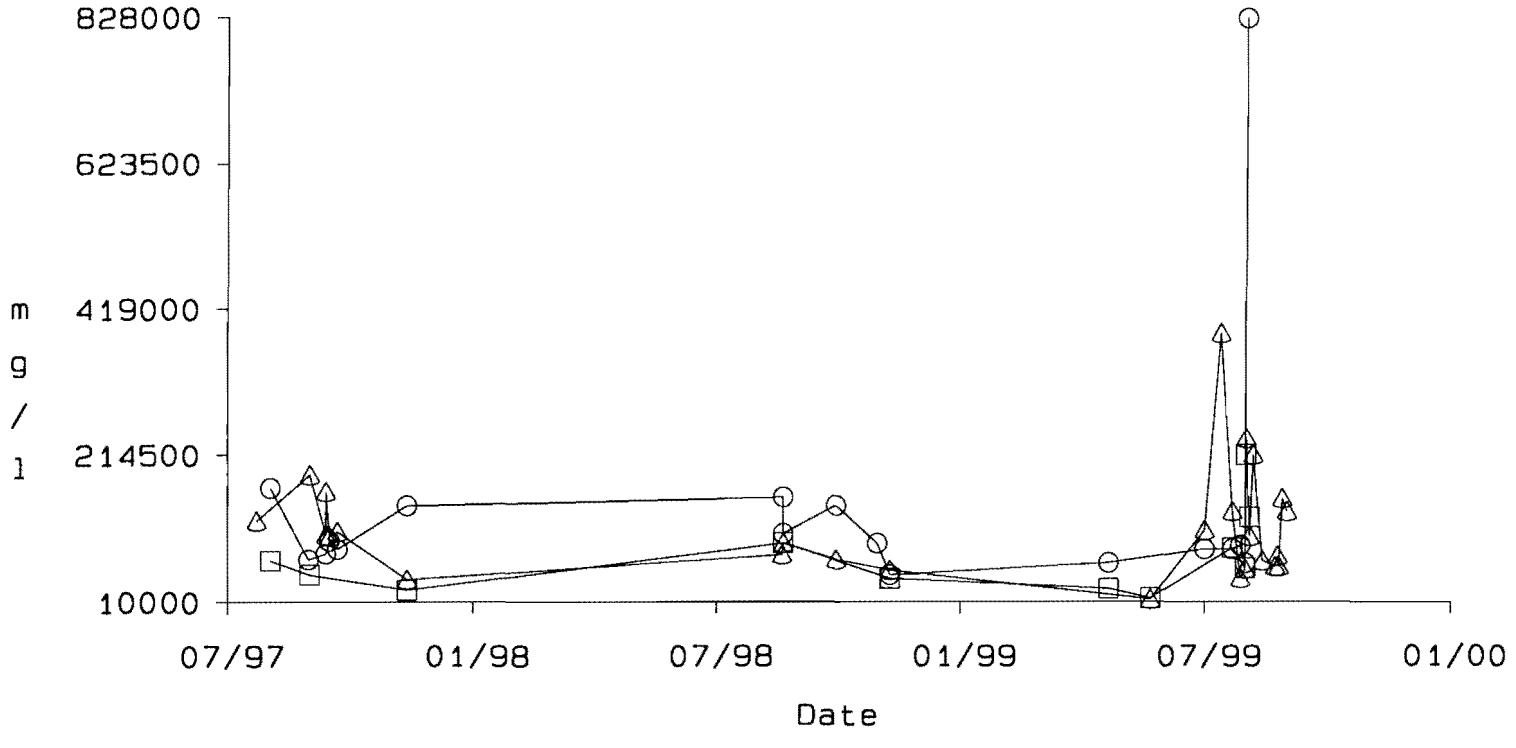
COTTONWOOD WASH 1997-1999

NAVAJO MINE AUTOMATED SAMPLER

○ CNS-1 MAIN CHANNEL

□ CS-1 SOUTH FORK

△ CN-1 NORTH FORK



PIPER TRILINEAR DIAGRAM

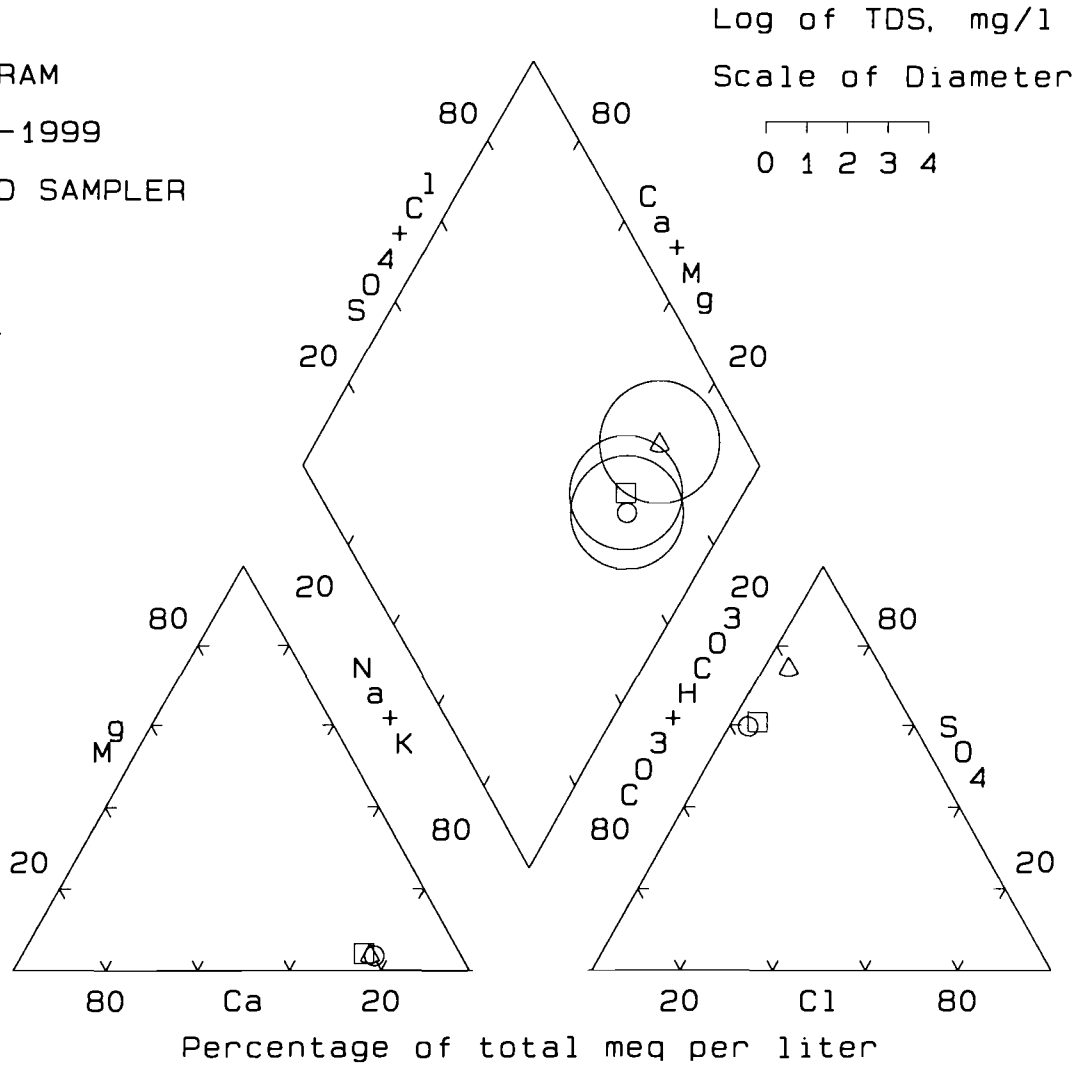
COTTONWOOD WASH 1997-1999

NAVAJO MINE AUTOMATED SAMPLER

○ CNS-1 MAIN CHANNEL

□ CS-1 SOUTH FORK

△ CN-1 NORTH FORK



Appendix 18.K

Cottonwood Arroyo

Storm Hydrographs

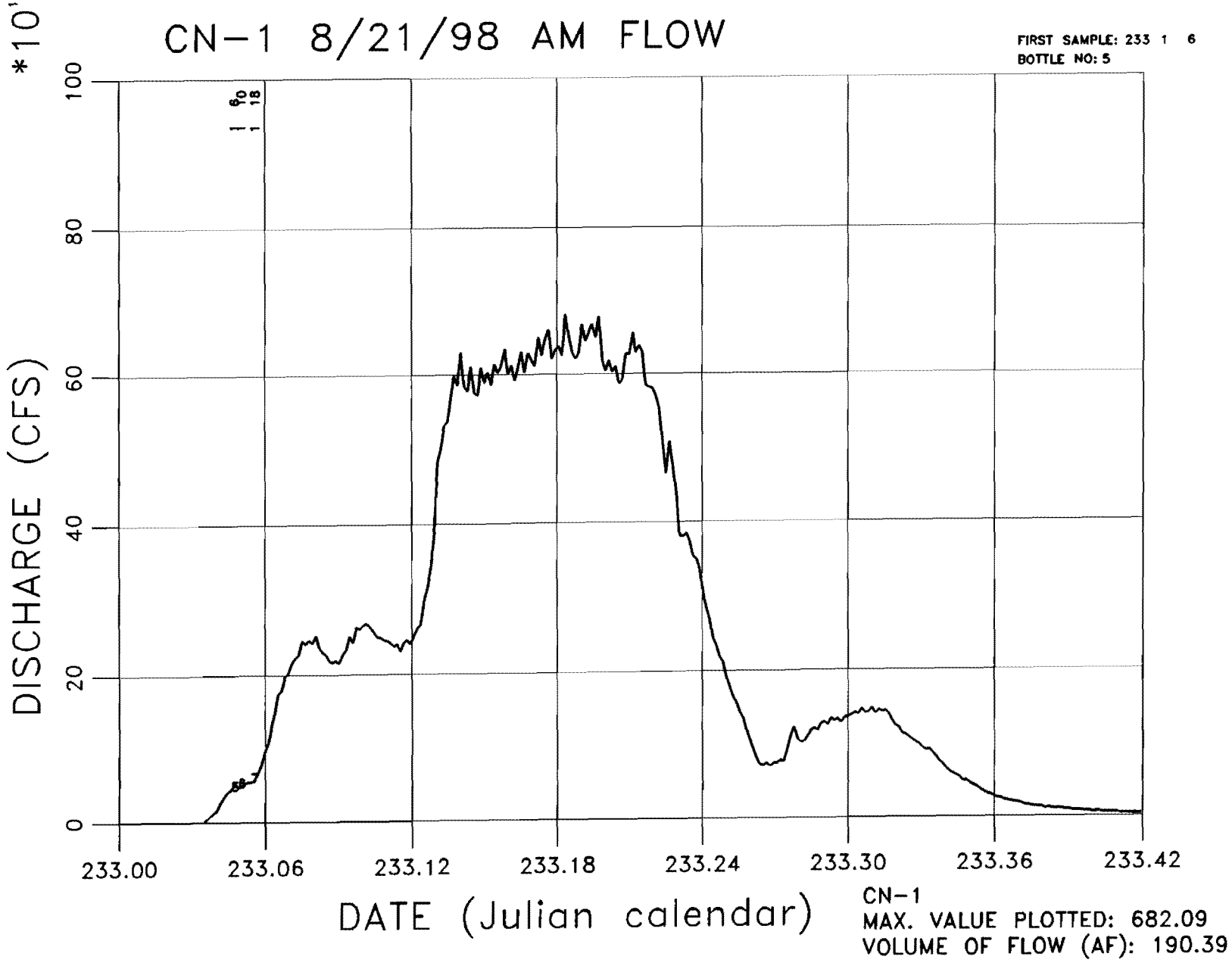
August 21, 1998

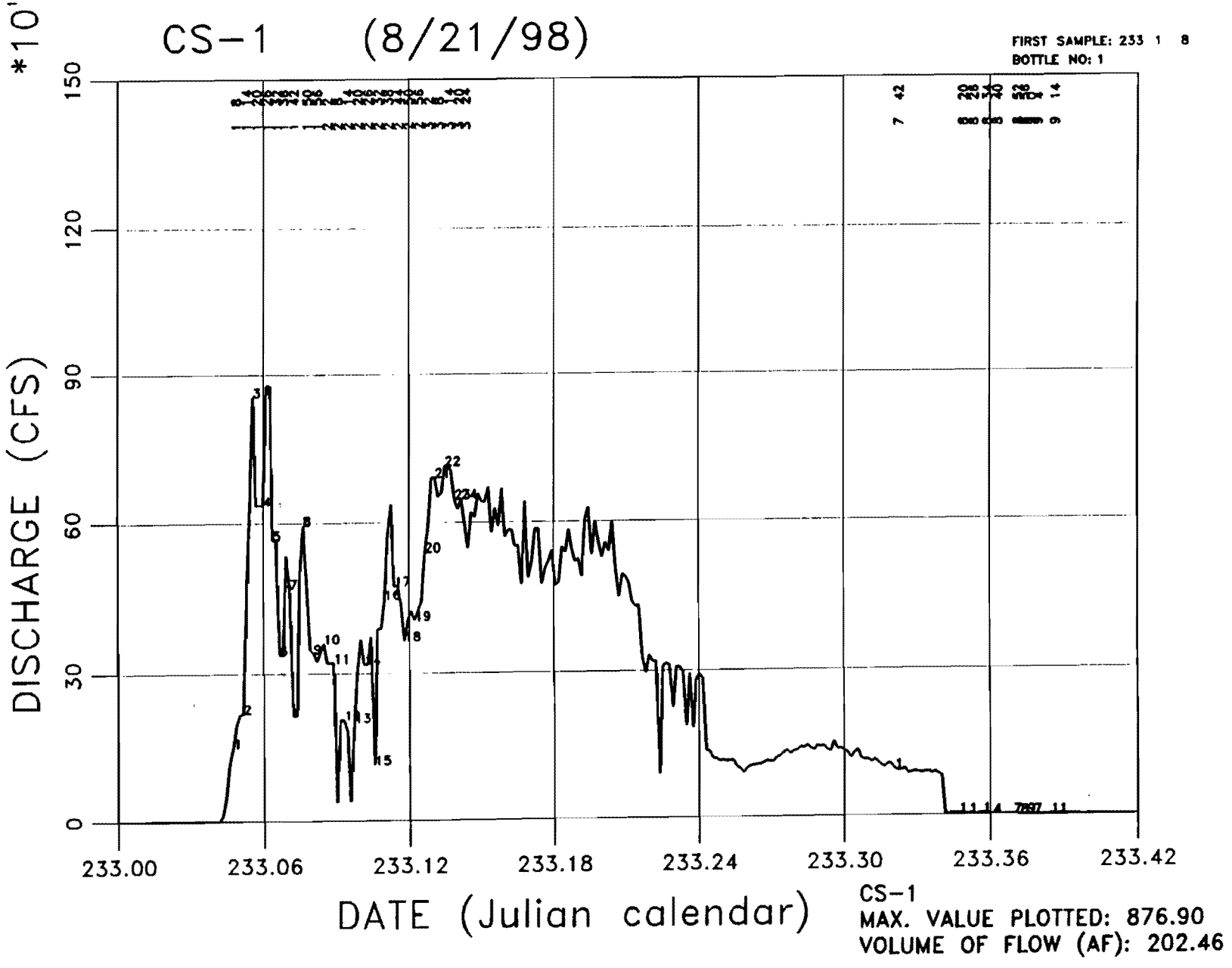
April 22, 1998

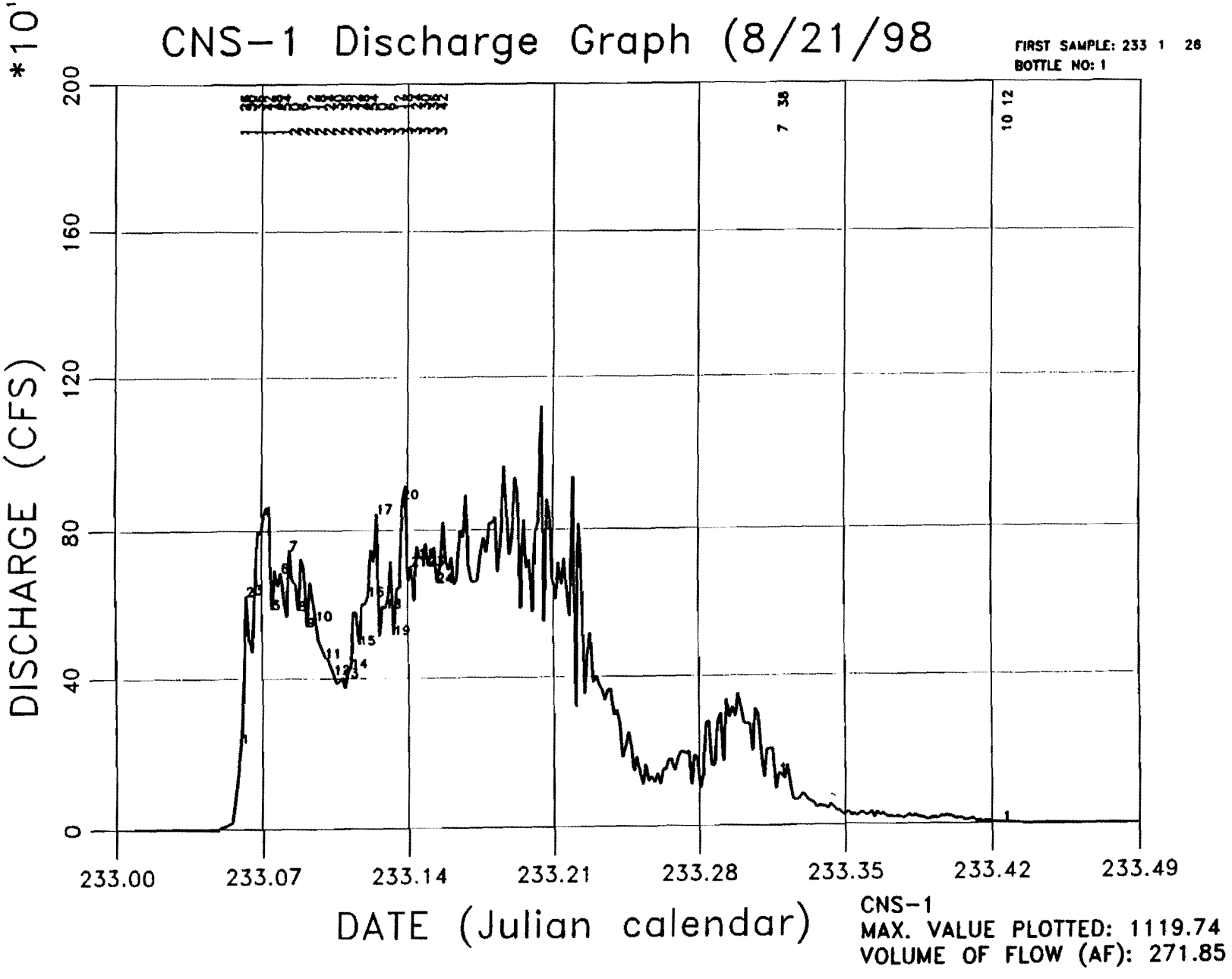
August 2, 1999

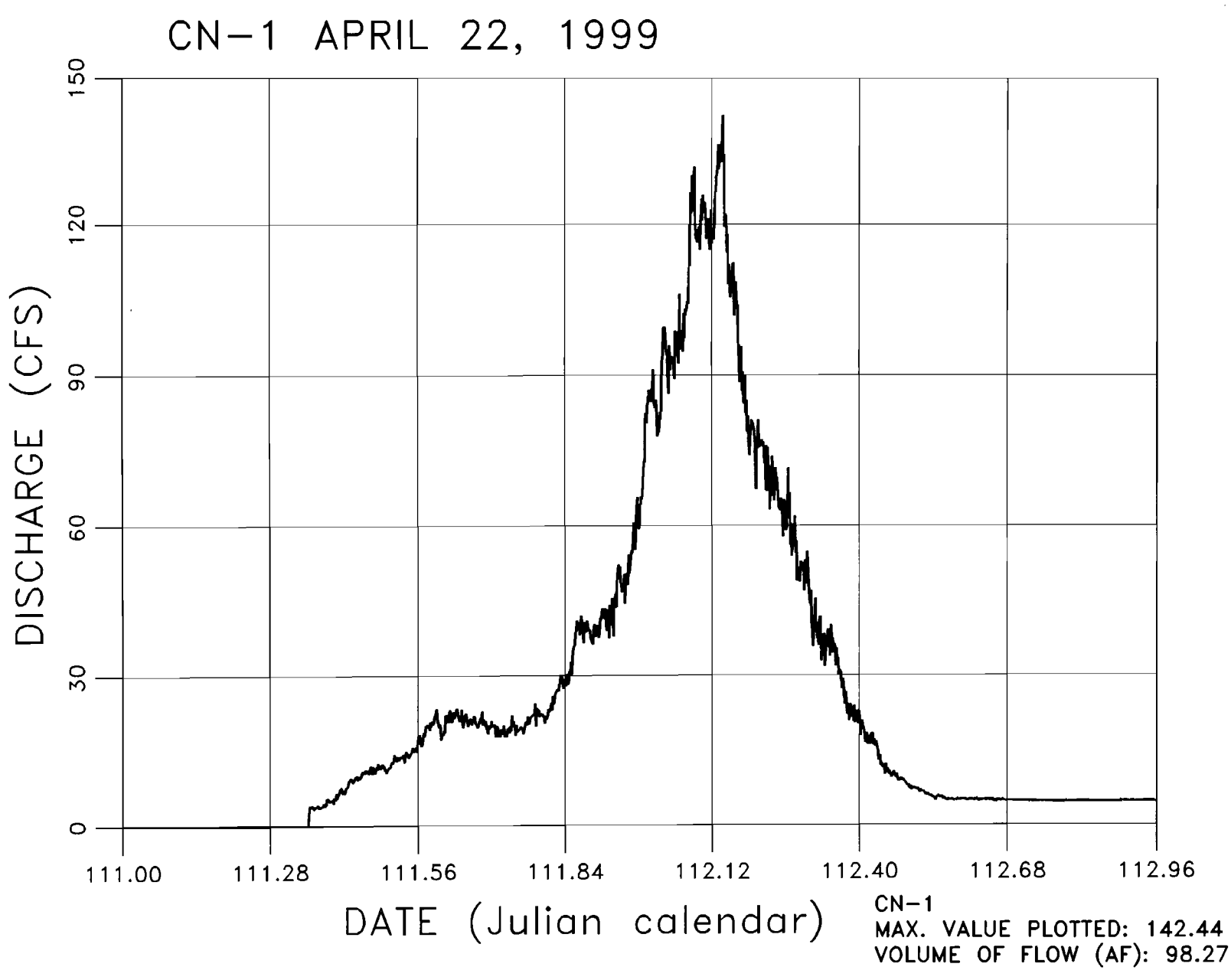
August 3, 1999

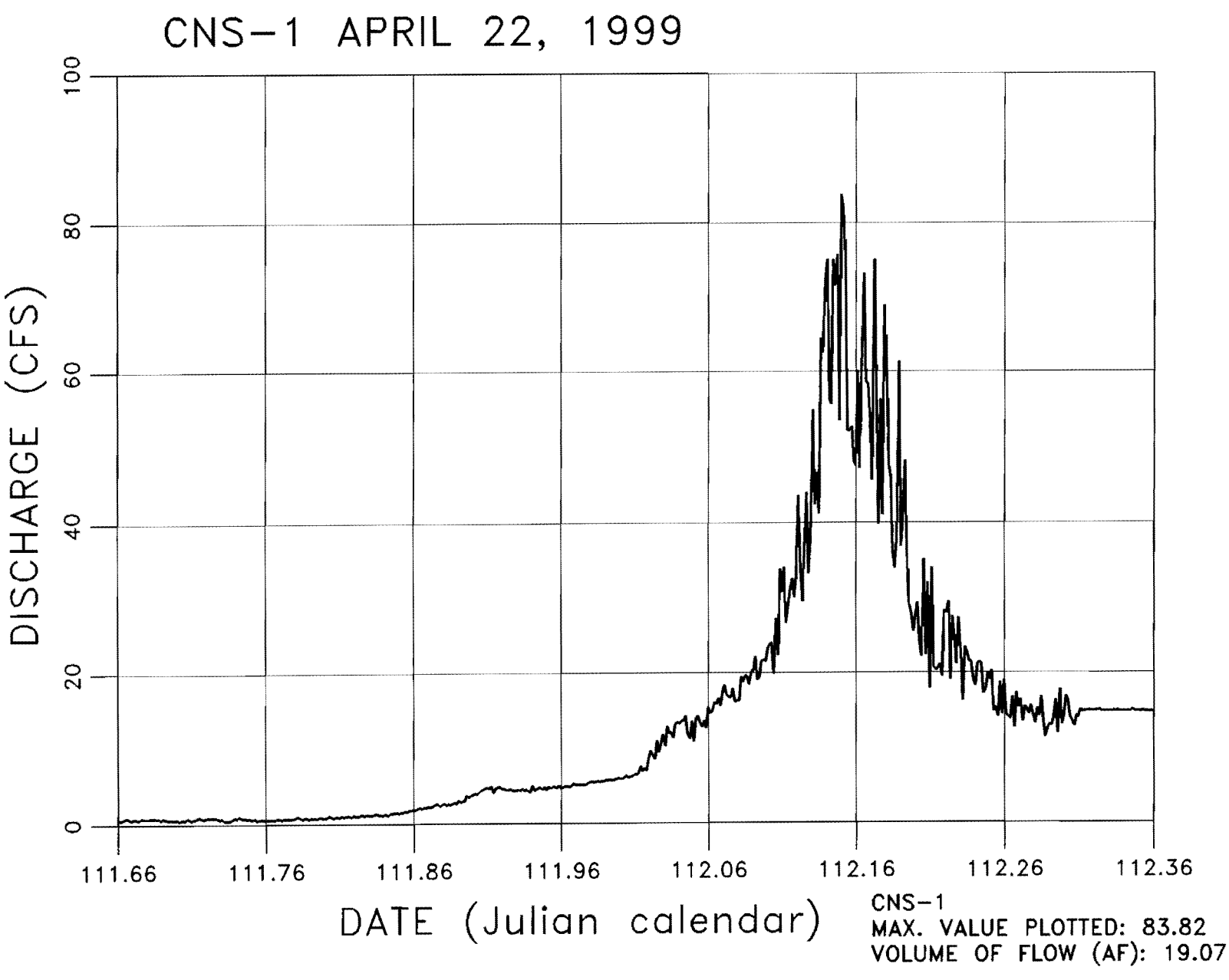
Stations CN-1, CNS-1 and CS-1

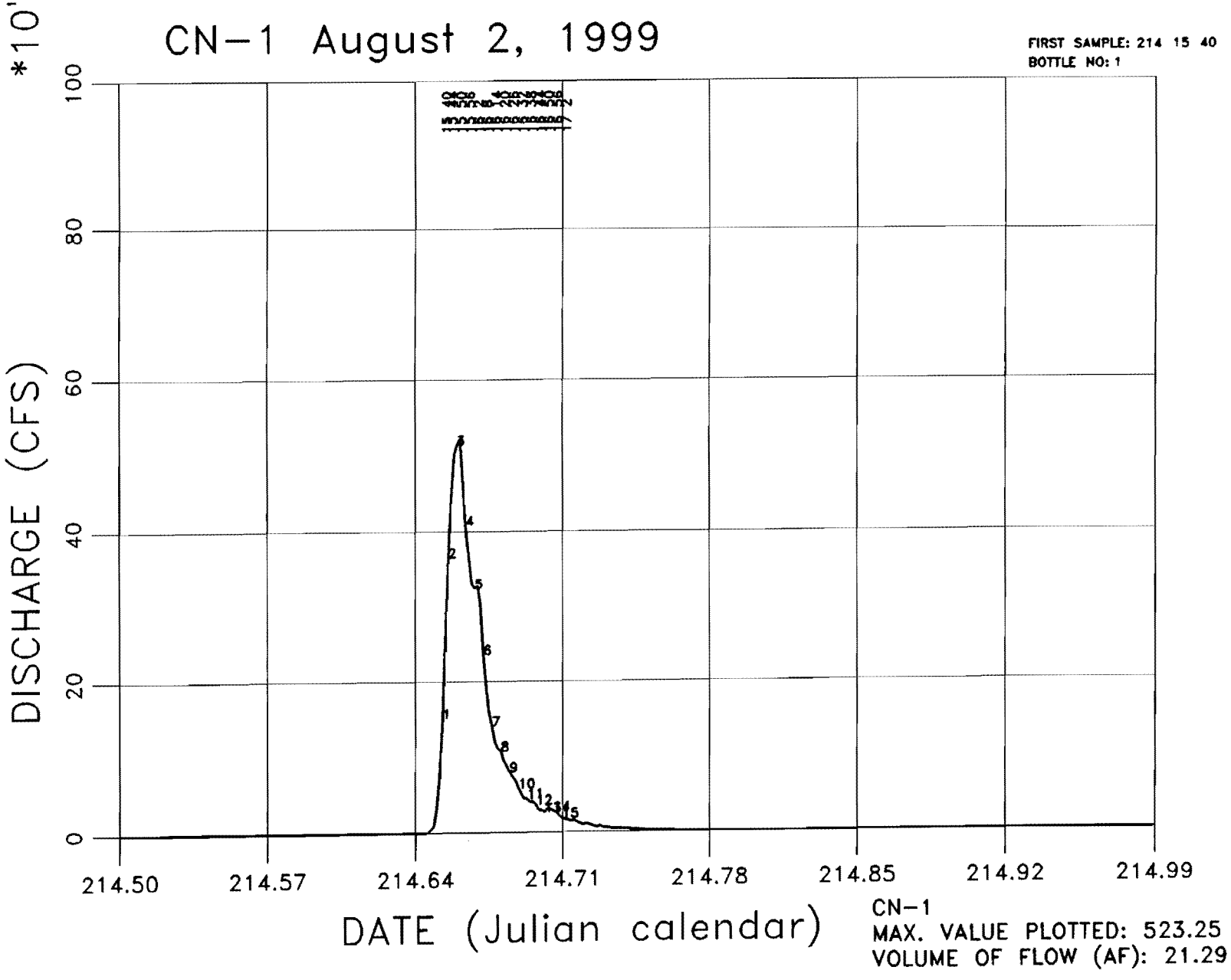

CN-1 8/21/98 AM FLOW
FIRST SAMPLE: 233 1 6
BOTTLE NO: 5
*10'
DISCHARGE (CFS)
0
20
40
60
80
100
233.00
233.06
233.12
233.18
233.24
233.30
233.36
233.42
DATE (Julian calendar)
CN-1
MAX. VALUE PLOTTED: 682.09
VOLUME OF FLOW (AF): 190.39

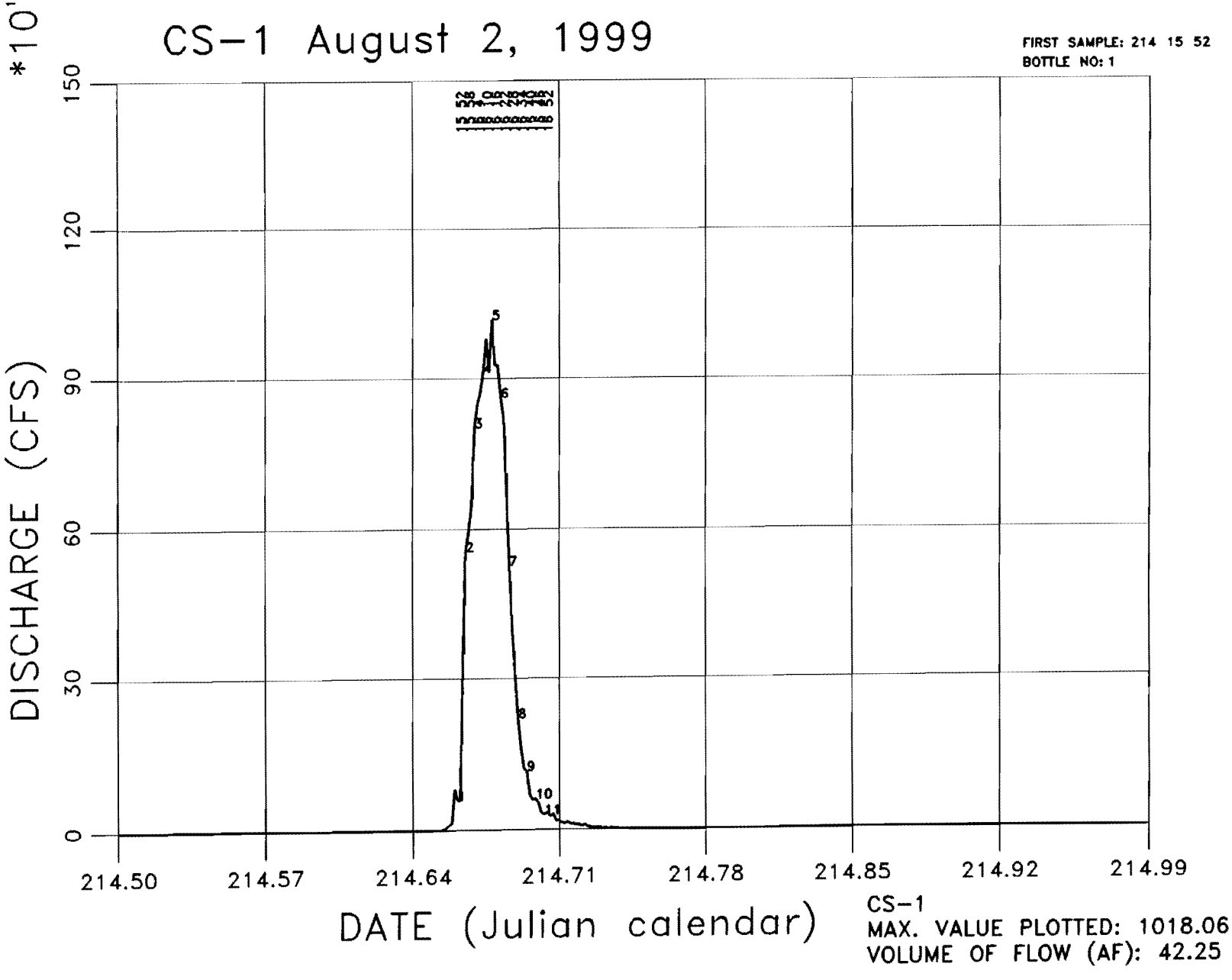

CS-1 (8/21/98)
FIRST SAMPLE: 233 1 8
BOTTLE NO: 1
*10'
DISCHARGE (CFS)
0
30
60
90
120
150
233.00
233.06
233.12
233.18
233.24
233.30
233.36
233.42
DATE (Julian calendar)
CS-1
MAX. VALUE PLOTTED: 876.90
VOLUME OF FLOW (AF): 202.46

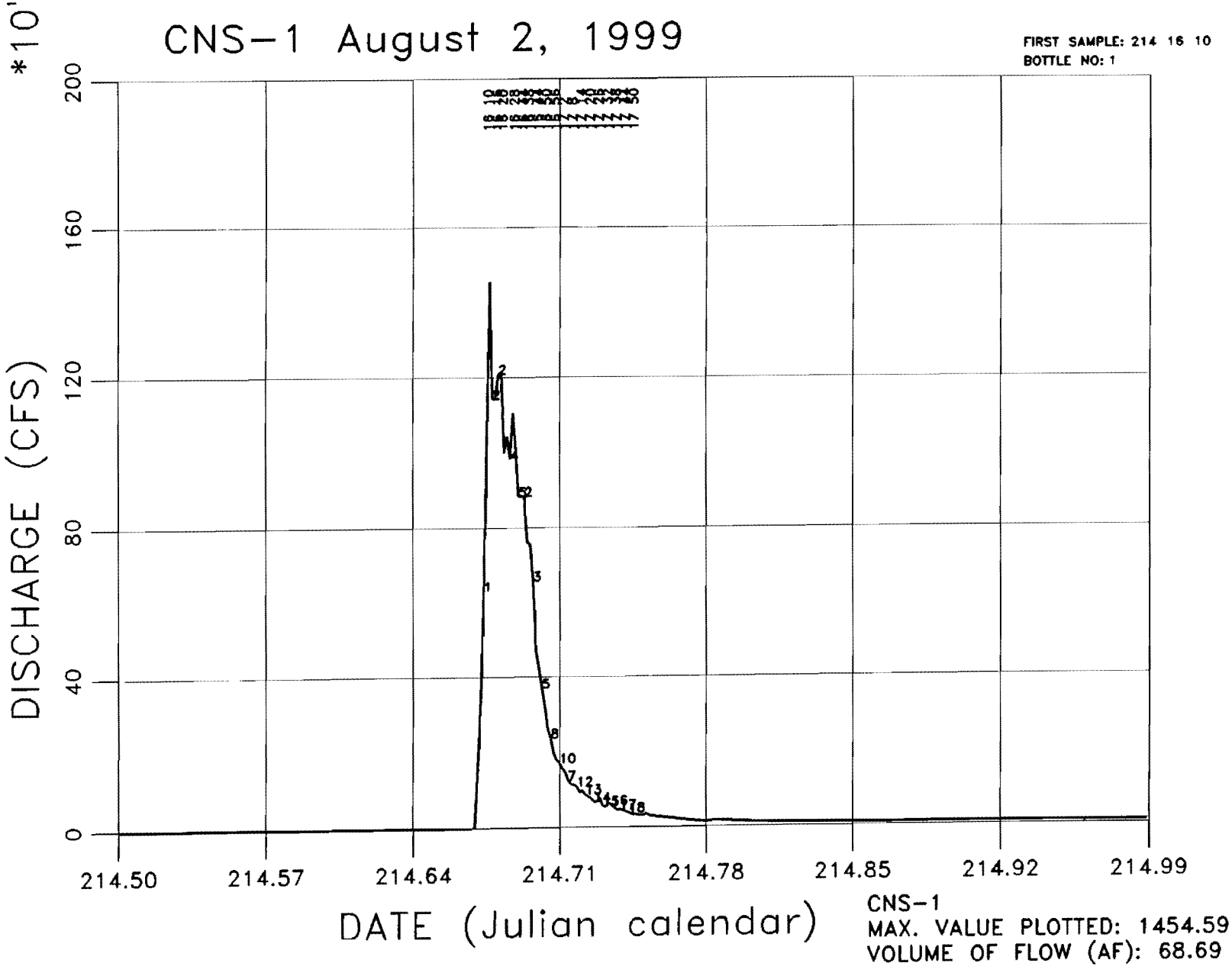

CNS-1 Discharge Graph (8/21/98
FIRST SAMPLE: 233 1 26
BOTTLE NO: 1
*10'
DISCHARGE (CFS)
0
40
80
120
160
200
233.00
233.07
233.14
233.21
233.28
233.35
233.42
233.49
DATE (Julian calendar)
CNS-1
MAX. VALUE PLOTTED: 1119.74
VOLUME OF FLOW (AF): 271.85

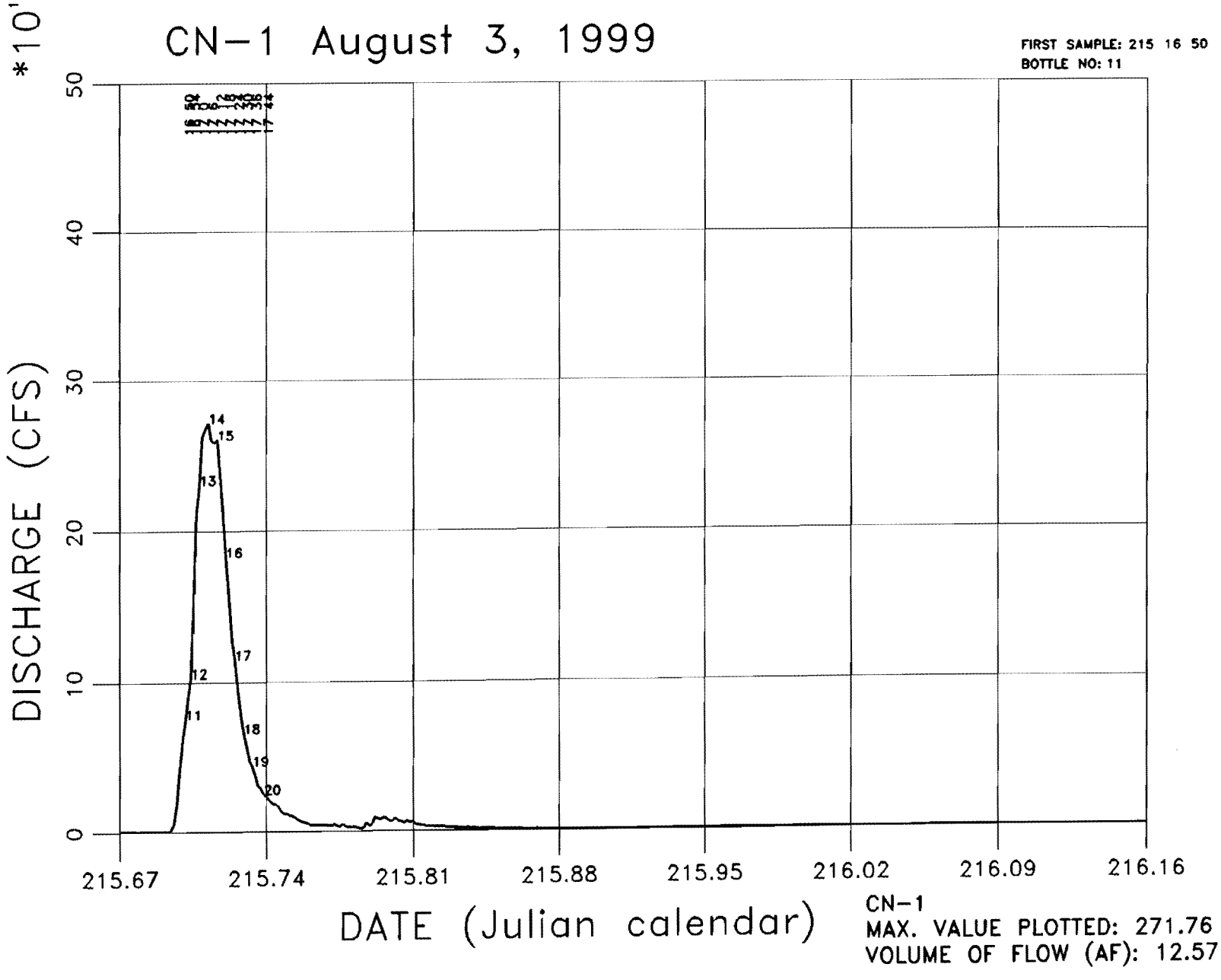

CN-1 APRIL 22, 1999
DISCHARGE (CFS)
0
30
60
90
120
150
111.00
111.28
111.56
111.84
112.12
112.40
112.68
112.96
DATE (Julian calendar)
CN-1
MAX. VALUE PLOTTED: 142.44
VOLUME OF FLOW (AF): 98.27

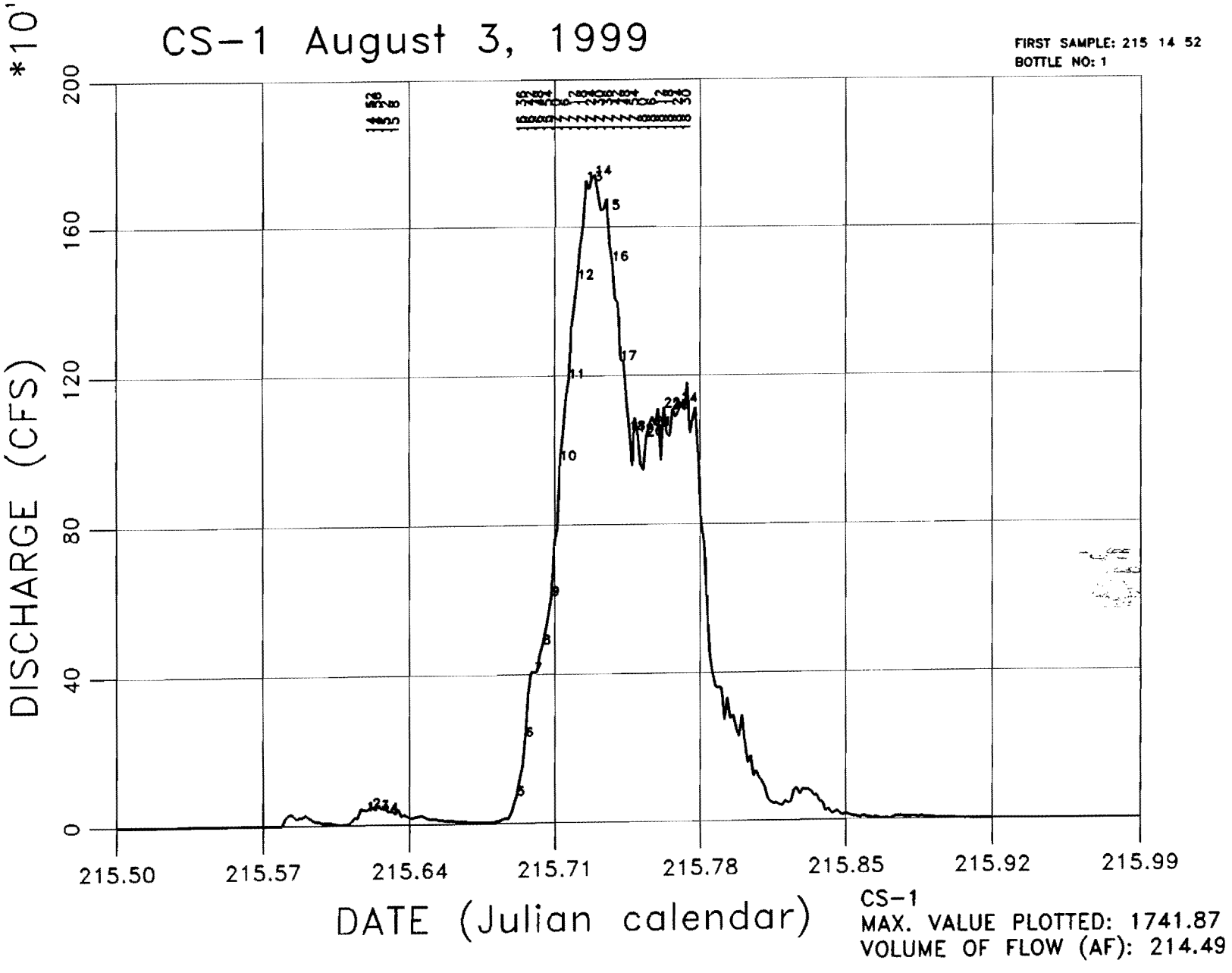

CNS-1 APRIL 22, 1999
DISCHARGE (CFS)
0
20
40
60
80
100
111.66
111.76
111.86
111.96
112.06
112.16
112.26
112.36
DATE (Julian calendar)
CNS-1
MAX. VALUE PLOTTED: 83.82
VOLUME OF FLOW (AF): 19.07

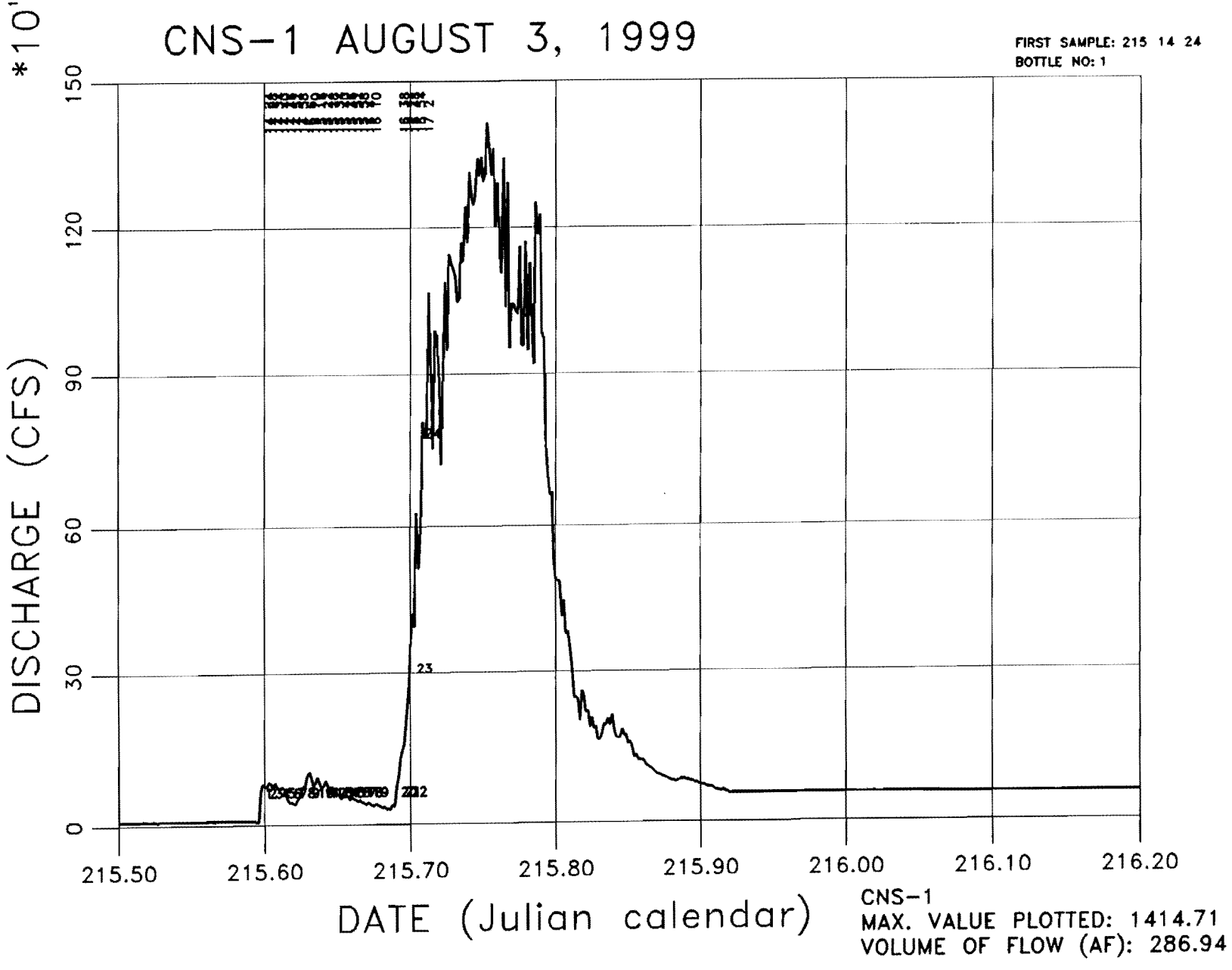

CN-1 August 2, 1999
FIRST SAMPLE: 214 15 40
BOTTLE NO: 1
*10'
DISCHARGE (CFS)
0
20
40
60
80
100
214.50
214.57
214.64
214.71
214.78
214.85
214.92
214.99
DATE (Julian calendar)
CN-1
MAX. VALUE PLOTTED: 523.25
VOLUME OF FLOW (AF): 21.29


CS-1 August 2, 1999
FIRST SAMPLE: 214 15 52
BOTTLE NO: 1
*10'
DISCHARGE (CFS)
0
30
60
90
120
150
214.50
214.57
214.64
214.71
214.78
214.85
214.92
214.99
DATE (Julian calendar)
CS-1
MAX. VALUE PLOTTED: 1018.06
VOLUME OF FLOW (AF): 42.25


CNS−1 August 2, 1999
FIRST SAMPLE: 214 16 10
BOTTLE NO: 1
*10'
DISCHARGE (CFS)
0
40
80
120
160
200
214.50
214.57
214.64
214.71
214.78
214.85
214.92
214.99
DATE (Julian calendar)
CNS−1
MAX. VALUE PLOTTED: 1454.59
VOLUME OF FLOW (AF): 68.69


CN–1 August 3, 1999
FIRST SAMPLE: 215 16 50
BOTTLE NO: 11
*10'
DISCHARGE (CFS)
0
10
20
30
40
50
215.67
215.74
215.81
215.88
215.95
216.02
216.09
216.16
DATE (Julian calendar)
11
12
13
14
15
16
17
18
19
20
CN–1
MAX. VALUE PLOTTED: 271.76
VOLUME OF FLOW (AF): 12.57


CS-1 August 3, 1999
FIRST SAMPLE: 215 14 52
BOTTLE NO: 1
*10'
DISCHARGE (CFS)
0
40
80
120
160
200
215.50
215.57
215.64
215.71
215.78
215.85
215.92
215.99
DATE (Julian calendar)
CS-1
MAX. VALUE PLOTTED: 1741.87
VOLUME OF FLOW (AF): 214.49


CNS-1 AUGUST 3, 1999
FIRST SAMPLE: 215 14 24
BOTTLE NO: 1
*10'
DISCHARGE (CFS)
0
30
60
90
120
150
215.50
215.60
215.70
215.80
215.90
216.00
216.10
216.20
DATE (Julian calendar)
CNS-1
MAX. VALUE PLOTTED: 1414.71
VOLUME OF FLOW (AF): 286.94

Appendix 18.L

Cottonwood Arroyo Pre-mine Hydrology and Sedimentology

SEDCAD + Files

(2 YR-6 HR, 10 YR-6 HR and 100 YR-6 HR Storm Events)

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Cottonwood Arroyo Pre-mine Hydrology and Sedimentology

The drainage subdivisions used to model the hydrology is shown on Exhibit 7-4.

Revised Febuary 2011

AAY/LR/RY

BHP Billiton
Navajo Mine
PO Box 1717
Fruitland, NM 87416

Phone: 505 598 2007

General Information

Storm Information:

Storm Type:	Type II-60
Design Storm:	2 yr - 6 hr
Rainfall Depth:	0.800 inches

Particle Size Distribution:

Size (mm)	PostMine-LoamySand	PreMine-LoamySand	PreMine-Badlands	LoamySand Postmining
2.0000	100.000%	100.000%	100.000%	0.000%
0.1000	26.500%	30.000%	83.500%	0.000%
0.0500	14.000%	17.000%	77.000%	0.000%
0.0020	11.000%	11.000%	56.000%	0.000%
0.0010	0.000%	0.000%	0.000%	0.000%

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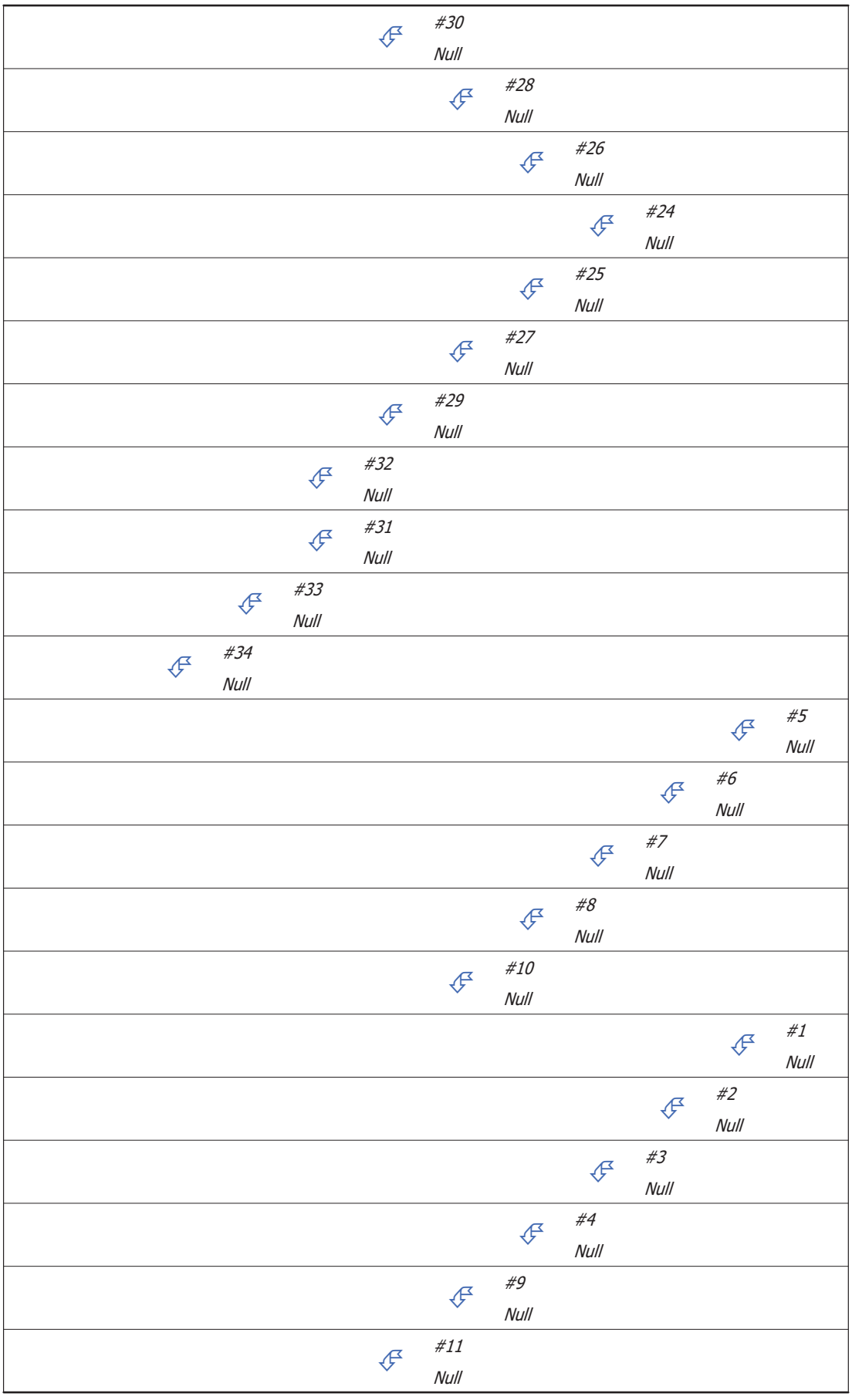
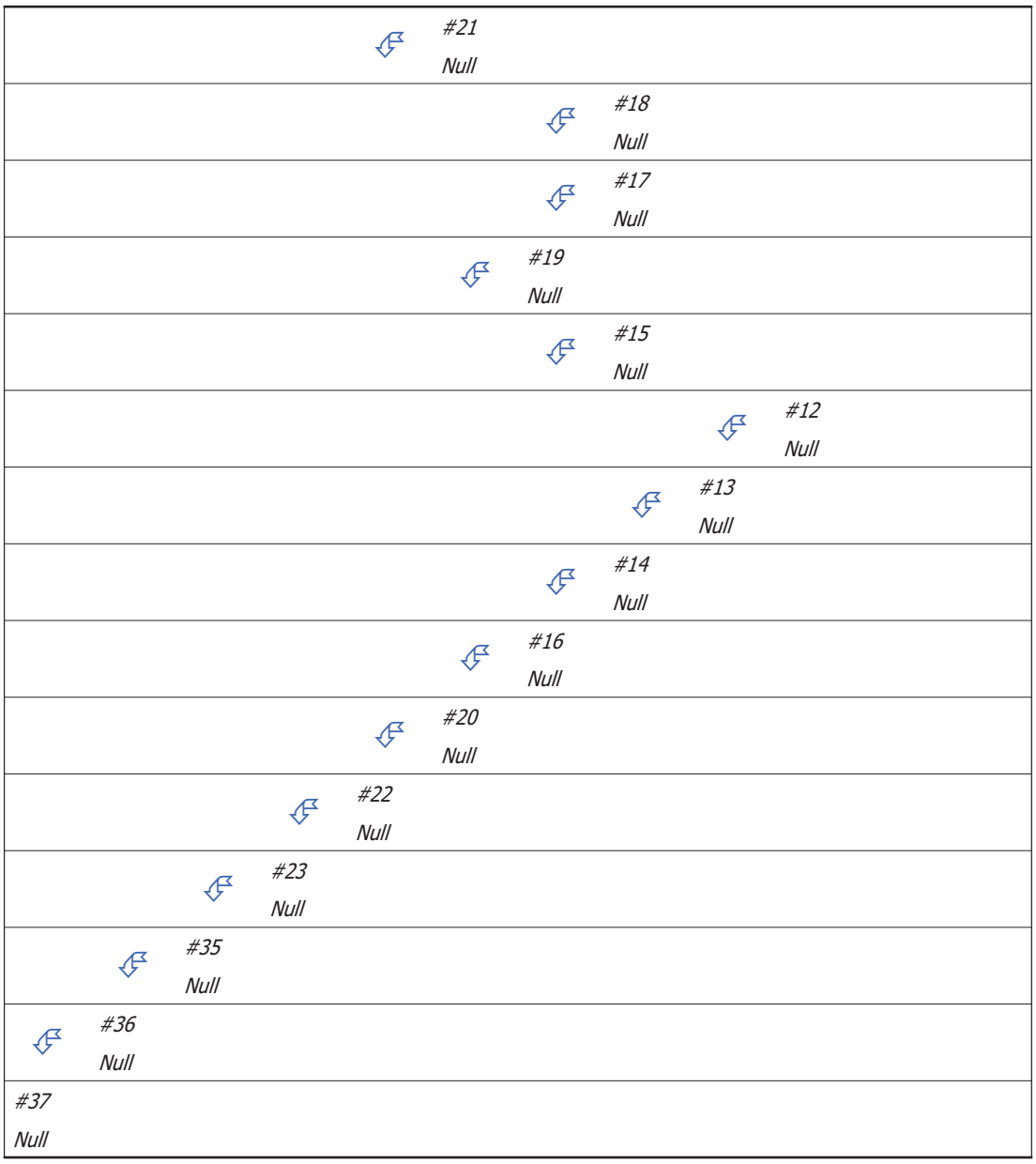
Structure Networking:

Type	Stru #	(flows into)	Stru #	Musk. K (hrs)	Musk. X	Description
Null	#1	==>	#2	0.961	0.307	
Null	#2	==>	#3	0.068	0.331	
Null	#3	==>	#4	0.000	0.000	
Null	#4	==>	#9	0.718	0.281	
Null	#5	==>	#6	1.205	0.328	
Null	#6	==>	#7	0.189	0.304	
Null	#7	==>	#8	0.000	0.000	
Null	#8	==>	#10	0.989	0.300	
Null	#9	==>	#11	0.000	0.000	
Null	#10	==>	#11	0.000	0.000	
Null	#11	==>	#21	0.495	0.453	
Null	#12	==>	#13	0.076	0.330	
Null	#13	==>	#14	3.790	0.314	
Null	#14	==>	#16	1.198	0.286	
Null	#15	==>	#16	1.198	0.286	
Null	#16	==>	#20	0.911	0.280	
Null	#17	==>	#19	0.000	0.000	
Null	#18	==>	#19	0.000	0.000	
Null	#19	==>	#20	0.915	0.252	
Null	#20	==>	#22	0.000	0.000	
Null	#21	==>	#22	0.000	0.000	
Null	#22	==>	#23	0.811	0.247	
Null	#23	==>	#35	0.000	0.000	
Null	#24	==>	#25	0.964	0.340	
Null	#25	==>	#27	1.454	0.333	
Null	#26	==>	#27	1.454	0.333	
Null	#27	==>	#29	0.800	0.323	
Null	#28	==>	#29	0.800	0.323	
Null	#29	==>	#32	0.479	0.298	
Null	#30	==>	#32	0.479	0.298	
Null	#31	==>	#33	0.000	0.000	
Null	#32	==>	#33	0.000	0.000	
Null	#33	==>	#34	1.372	0.293	Inlet to North Fork Diversion
Null	#34	==>	#35	0.000	0.000	
Null	#35	==>	#36	0.735	0.251	
Null	#36	==>	#37	3.388	0.246	
Null	#37	==>	End	0.000	0.000	


#30
Null
#28
Null
#26
Null
#24
Null
#25
Null
#27
Null
#29
Null
#32
Null
#31
Null
#33
Null
#34
Null
#5
Null
#6
Null
#7
Null
#8
Null
#10
Null
#1
Null
#2
Null
#3
Null
#4
Null
#9
Null
#11
Null



Structure Routing Details:

Stru #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#1	8. Large gullies, diversions, and low flowing streams	0.81	76.00	9,347.00	2.70	0.961
#1	**Muskingum K:**					**0.961**
#2	8. Large gullies, diversions, and low flowing streams	1.23	10.00	814.00	3.32	0.068
#2	**Muskingum K:**					**0.068**
#3	8. Large gullies, diversions, and low flowing streams	0.00	0.00	0.00	0.00	0.000

Stru #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#3	**Muskingum K:**					**0.000**
#4	8. Large gullies, diversions, and low flowing streams	0.53	30.00	5,637.00	2.18	0.718
#4	**Muskingum K:**					**0.718**
#5	8. Large gullies, diversions, and low flowing streams	1.17	165.00	14,065.00	3.24	1.205
#5	**Muskingum K:**					**1.205**
#6	8. Large gullies, diversions, and low flowing streams	0.78	14.00	1,799.25	2.64	0.189
#6	**Muskingum K:**					**0.189**
#8	8. Large gullies, diversions, and low flowing streams	0.72	65.00	9,046.00	2.54	0.989
#8	**Muskingum K:**					**0.989**
#11	8. Large gullies, diversions, and low flowing streams	30.00	8,801.00	29,336.66	16.43	0.495
#11	**Muskingum K:**					**0.495**
#12	8. Large gullies, diversions, and low flowing streams	1.21	11.00	906.00	3.30	0.076
#12	**Muskingum K:**					**0.076**
#13	8. Large gullies, diversions, and low flowing streams	0.92	363.00	39,301.00	2.88	3.790
#13	**Muskingum K:**					**3.790**
#14	8. Large gullies, diversions, and low flowing streams	0.58	57.00	9,834.00	2.28	1.198
#14	**Muskingum K:**					**1.198**
#15	8. Large gullies, diversions, and low flowing streams	0.58	57.00	9,834.00	2.28	1.198
#15	**Muskingum K:**					**1.198**
#16	8. Large gullies, diversions, and low flowing streams	0.52	37.00	7,084.00	2.16	0.911
#16	**Muskingum K:**					**0.911**
#19	8. Large gullies, diversions, and low flowing streams	0.33	19.00	5,699.00	1.73	0.915
#19	**Muskingum K:**					**0.915**
#22	8. Large gullies, diversions, and low flowing streams	0.31	15.00	4,852.00	1.66	0.811
#22	**Muskingum K:**					**0.811**
#24	8. Large gullies, diversions, and low flowing streams	1.46	184.00	12,568.00	3.62	0.964
#24	**Muskingum K:**					**0.964**
#25	8. Large gullies, diversions, and low flowing streams	1.28	228.00	17,755.00	3.39	1.454
#25	**Muskingum K:**					**1.454**
#26	8. Large gullies, diversions, and low flowing streams	1.28	228.00	17,755.62	3.39	1.454
#26	**Muskingum K:**					**1.454**
#27	8. Large gullies, diversions, and low flowing streams	1.07	96.00	8,938.00	3.10	0.800

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Stru #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#27	**Muskingum K:**					**0.800**
#28	8. Large gullies, diversions, and low flowing streams	1.07	96.00	8,938.00	3.10	0.800
#28	**Muskingum K:**					**0.800**
#29	8. Large gullies, diversions, and low flowing streams	0.70	30.00	4,313.00	2.50	0.479
#29	**Muskingum K:**					**0.479**
#30	8. Large gullies, diversions, and low flowing streams	0.70	30.00	4,313.00	2.50	0.479
#30	**Muskingum K:**					**0.479**
#33	8. Large gullies, diversions, and low flowing streams	0.65	77.00	11,910.00	2.41	1.372
#33	**Muskingum K:**					**1.372**
#35	8. Large gullies, diversions, and low flowing streams	0.33	15.00	4,554.00	1.72	0.735
#35	**Muskingum K:**					**0.735**
#36	8. Large gullies, diversions, and low flowing streams	0.30	60.00	20,005.00	1.64	3.388
#36	**Muskingum K:**					**3.388**

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Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc. (ml/l)	24VW (ml/l)
#30	476.400	476.400	0.20	0.03	0.1	3,489	2.23	1.76
#28	1,217.900	1,217.900	127.50	16.94	739.9	45,906	0.00	0.00
#26	2,486.400	2,486.400	5.44	1.83	8.0	4,125	2.21	1.71
#24	8,061.800	8,061.800	6.64	3.90	9.6	3,240	1.51	0.84
#25	1,015.700	9,077.500	25.38	7.24	39.4	12,153	6.31	2.07
#27	1,783.700	13,347.600	51.42	14.78	134.0	17,591	8.96	3.39
#29	966.000	15,531.500	173.24	44.74	1,587.3	54,538	2.41	1.14
#32	293.700	16,301.600	178.81	50.64	1,694.8	49,619	0.00	0.00
#31	957.100	957.100	135.01	17.47	610.8	34,117	0.32	0.24
#33	0.000	17,258.700	243.60	68.11	2,305.6	39,263	0.10	0.06
#34	932.500	18,191.200	256.20	80.12	2,205.4	32,513	0.05	0.03
#5	2,023.000	2,023.000	171.21	20.33	462.4	32,307	2.05	1.05
#6	1,743.200	3,766.200	212.42	40.43	934.0	28,405	0.14	0.08
#7	2,395.300	6,161.500	387.09	85.94	2,914.9	36,696	0.00	0.00
#8	0.000	6,161.500	387.09	85.94	2,914.9	36,696	0.00	0.00
#10	1,053.200	7,214.700	408.03	101.32	2,888.5	33,288	0.04	0.03
#1	2,411.100	2,411.100	102.40	16.59	452.6	29,702	2.57	1.72
#2	1,497.000	3,908.100	165.97	41.66	776.1	20,475	0.10	0.07
#3	862.700	4,770.800	217.82	52.22	899.7	17,142	0.03	0.02
#4	0.000	4,770.800	217.82	52.22	899.7	17,142	0.03	0.02
#9	425.500	5,196.300	225.97	58.39	914.0	14,897	0.00	0.00
#11	0.000	12,411.000	567.35	159.72	3,802.5	27,497	0.01	0.01
#21	1,080.800	13,491.800	591.22	170.38	3,862.9	26,737	0.00	0.00
#18	848.500	848.500	63.40	10.11	89.4	9,383	0.00	0.00
#17	182.200	182.200	46.10	3.64	42.5	12,532	0.29	0.20
#19	0.000	1,030.700	106.20	13.75	132.0	8,986	0.07	0.05
#15	1,992.700	1,992.700	132.09	21.29	666.2	35,689	0.30	0.19
#12	3,494.500	3,494.500	29.47	6.13	64.8	10,798	5.21	3.74
#13	2,720.700	6,215.200	61.66	11.51	150.5	14,172	7.19	4.86
#14	5,096.800	11,312.000	166.07	56.22	1,310.1	62,956	0.45	0.12
#16	876.500	14,181.200	302.67	94.57	2,485.3	41,640	0.46	0.21
#20	681.900	15,893.800	327.56	120.97	2,763.2	31,815	0.24	0.12
#22	0.000	29,385.600	870.59	291.35	6,626.1	27,392	0.08	0.05
#23	752.900	30,138.500	867.57	297.93	6,609.5	26,955	0.00	0.00
#35	0.000	48,329.700	1,063.48	378.05	8,814.9	25,656	0.01	0.01
#36	730.590	49,060.290	1,061.94	382.05	8,845.9	29,111	0.00	0.00
#37	2,208.500	51,268.790	1,055.02	394.73	8,889.8	26,564	0.12	0.07

Particle Size Distribution(s) at Each Structure

Structure #30:

Size (mm)	In/Out
2.0000	100.000%
0.1000	42.445%
0.0500	24.052%
0.0020	15.563%
0.0010	0.000%

Structure #28:

Size (mm)	In/Out
2.0000	100.000%
0.1000	100.000%
0.0500	100.000%
0.0020	100.000%
0.0010	0.000%

Structure #26:

Size (mm)	In/Out
2.0000	100.000%
0.1000	69.288%
0.0500	39.263%
0.0020	25.406%
0.0010	0.000%

Structure #24:

Size (mm)	In/Out
2.0000	100.000%
0.1000	84.148%
0.0500	49.683%
0.0020	32.148%

Size (mm)	In/Out
0.0010	0.000%

Structure #25:

Size (mm)	In/Out
2.0000	100.000%
0.1000	71.787%
0.0500	41.659%
0.0020	26.956%
0.0010	0.000%

Structure #27:

Size (mm)	In/Out
2.0000	100.000%
0.1000	75.596%
0.0500	43.126%
0.0020	27.905%
0.0010	0.000%

Structure #29:

Size (mm)	In/Out
2.0000	100.000%
0.1000	97.956%
0.0500	95.215%
0.0020	93.528%
0.0010	0.000%

Structure #32:

Size (mm)	In/Out
2.0000	100.000%
0.1000	100.000%
0.0500	100.000%
0.0020	100.000%
0.0010	0.000%

Structure #31:

Size (mm)	In/Out
2.0000	100.000%
0.1000	100.000%
0.0500	100.000%
0.0020	97.356%
0.0010	0.000%

Structure #33 (Inlet to North Fork Diversion):

Size (mm)	In/Out
2.0000	100.000%
0.1000	100.000%
0.0500	100.000%
0.0020	99.300%
0.0010	0.000%

Structure #34:

Size (mm)	In/Out
2.0000	100.000%
0.1000	100.000%
0.0500	100.000%
0.0020	99.556%
0.0010	0.000%

Structure #5:

Size (mm)	In/Out
2.0000	100.000%
0.1000	100.000%
0.0500	93.482%
0.0020	90.338%
0.0010	0.000%

Structure #6:

Size (mm)	In/Out
2.0000	100.000%
0.1000	100.000%
0.0500	100.000%
0.0020	98.640%

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Size (mm)	In/Out
0.0010	0.000%

Structure #7:

Size (mm)	In/Out
2.0000	100.000%
0.1000	100.000%
0.0500	100.000%
0.0020	100.000%
0.0010	0.000%

Structure #8:

Size (mm)	In/Out
2.0000	100.000%
0.1000	100.000%
0.0500	100.000%
0.0020	100.000%
0.0010	0.000%

Structure #10:

Size (mm)	In/Out
2.0000	100.000%
0.1000	100.000%
0.0500	99.878%
0.0020	99.809%
0.0010	0.000%

Structure #1:

Size (mm)	In/Out
2.0000	100.000%
0.1000	97.983%
0.0500	90.770%
0.0020	87.230%
0.0010	0.000%

Structure #2:

Size (mm)	In/Out
2.0000	100.000%
0.1000	100.000%
0.0500	100.000%
0.0020	98.573%
0.0010	0.000%

Structure #3:

Size (mm)	In/Out
2.0000	100.000%
0.1000	100.000%
0.0500	100.000%
0.0020	99.513%
0.0010	0.000%

Structure #4:

Size (mm)	In/Out
2.0000	100.000%
0.1000	100.000%
0.0500	100.000%
0.0020	99.513%
0.0010	0.000%

Structure #9:

Size (mm)	In/Out
2.0000	100.000%
0.1000	100.000%
0.0500	100.000%
0.0020	100.000%
0.0010	0.000%

Structure #11:

Size (mm)	In/Out
2.0000	100.000%
0.1000	100.000%
0.0500	100.000%
0.0020	99.855%

Size (mm)	In/Out
0.0010	0.000%

Structure #21:

Size (mm)	In/Out
2.0000	100.000%
0.1000	100.000%
0.0500	100.000%
0.0020	100.000%
0.0010	0.000%

Structure #18:

Size (mm)	In/Out
2.0000	100.000%
0.1000	100.000%
0.0500	100.000%
0.0020	100.000%
0.0010	0.000%

Structure #17:

Size (mm)	In/Out
2.0000	100.000%
0.1000	100.000%
0.0500	100.000%
0.0020	93.383%
0.0010	0.000%

Structure #19:

Size (mm)	In/Out
2.0000	100.000%
0.1000	100.000%
0.0500	100.000%
0.0020	97.868%
0.0010	0.000%

Structure #15:

Size (mm)	In/Out
2.0000	100.000%
0.1000	100.000%
0.0500	100.000%
0.0020	97.622%
0.0010	0.000%

Structure #12:

Size (mm)	In/Out
2.0000	100.000%
0.1000	83.060%
0.0500	47.068%
0.0020	30.456%
0.0010	0.000%

Structure #13:

Size (mm)	In/Out
2.0000	100.000%
0.1000	76.526%
0.0500	43.365%
0.0020	28.060%
0.0010	0.000%

Structure #14:

Size (mm)	In/Out
2.0000	100.000%
0.1000	100.000%
0.0500	100.000%
0.0020	97.990%
0.0010	0.000%

Structure #16:

Size (mm)	In/Out
2.0000	100.000%
0.1000	100.000%
0.0500	100.000%
0.0020	96.912%

Size (mm)	In/Out
0.0010	0.000%

Structure #20:

Size (mm)	In/Out
2.0000	100.000%
0.1000	100.000%
0.0500	100.000%
0.0020	97.911%
0.0010	0.000%

Structure #22:

Size (mm)	In/Out
2.0000	100.000%
0.1000	100.000%
0.0500	100.000%
0.0020	99.129%
0.0010	0.000%

Structure #23:

Size (mm)	In/Out
2.0000	100.000%
0.1000	100.000%
0.0500	100.000%
0.0020	100.000%
0.0010	0.000%

Structure #35:

Size (mm)	In/Out
2.0000	100.000%
0.1000	100.000%
0.0500	100.000%
0.0020	99.889%
0.0010	0.000%

Structure #36:

Size (mm)	In/Out
2.0000	100.000%
0.1000	100.000%
0.0500	100.000%
0.0020	100.000%
0.0010	0.000%

Structure #37:

Size (mm)	In/Out
2.0000	100.000%
0.1000	100.000%
0.0500	99.531%
0.0020	99.309%
0.0010	0.000%

Structure Detail:

Structure #30 (Null)

Structure #28 (Null)

Structure #26 (Null)

Structure #24 (Null)

Structure #25 (Null)

Structure #27 (Null)

Structure #29 (Null)

Structure #32 (Null)

Structure #31 (Null)

Structure #33 (Null)

Inlet to North Fork Diversion

Structure #34 (Null)

Structure #5 (Null)

Structure #6 (Null)

Structure #7 (Null)

Structure #8 (Null)

Structure #10 (Null)

Structure #1 (Null)

Structure #2 (Null)

Structure #3 (Null)

Structure #4 (Null)

Structure #9 (Null)

Structure #11 (Null)

Structure #21 (Null)

Structure #18 (Null)

Structure #17 (Null)

Structure #19 (Null)

Structure #15 (Null)

Structure #12 (Null)

Structure #13 (Null)

Structure #14 (Null)

Structure #16 (Null)

Structure #20 (Null)

Structure #22 (Null)

Structure #23 (Null)

Structure #35 (Null)

Structure #36 (Null)

Structure #37 (Null)

Subwatershed Hydrology Detail:

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
#30	1	476.400	1.131	0.000	0.000	73.100	M	0.20	0.034
	Σ	**476.400**						**0.20**	**0.034**
#28	1	772.300	0.657	0.523	0.334	90.400	M	106.00	10.740
	2	445.600	0.587	0.000	0.000	90.400	M	65.74	6.199
	Σ	**1,217.900**						**127.50**	**16.939**
#26	1	447.600	2.192	0.000	0.000	74.200	M	0.34	0.091
	2	2,038.800	3.000	0.000	0.000	77.000	M	5.10	1.740
	Σ	**2,486.400**						**5.44**	**1.831**
#24	1	2,607.500	5.367	2.377	0.305	75.200	M	2.02	0.992
	2	2,331.900	4.813	2.431	0.304	74.700	M	1.48	0.662
	3	1,758.500	2.231	1.788	0.297	76.200	M	3.66	1.087
	4	1,363.900	2.618	0.000	0.000	77.000	M	3.63	1.164
	Σ	**8,061.800**						**6.64**	**3.905**
#25	1	515.200	0.990	0.342	0.357	78.200	M	3.32	0.663
	2	130.500	0.787	0.342	0.357	78.100	M	0.89	0.163
	3	370.000	0.516	0.000	0.000	85.700	M	25.34	2.504
	Σ	**9,077.500**						**25.38**	**7.235**
#27	1	354.400	0.612	1.233	0.337	83.100	M	11.81	1.500
	2	305.200	0.529	1.054	0.328	84.000	M	14.02	1.532
	3	289.800	0.692	0.551	0.328	75.500	M	0.59	0.129
	4	253.000	0.361	0.551	0.328	79.400	M	3.26	0.463
	5	581.300	0.980	0.000	0.000	82.300	M	12.58	2.093
	Σ	**13,347.600**						**51.42**	**14.783**
#29	1	508.800	0.409	0.416	0.312	89.500	M	80.63	6.230
	2	233.200	0.521	0.291	0.312	91.600	M	44.78	3.842
	3	224.000	0.467	0.000	0.000	90.000	M	35.63	2.942
	Σ	**15,531.500**						**173.24**	**44.736**
#32	1	293.700	0.576	0.000	0.000	93.000	M	65.60	5.870
	Σ	**16,301.600**						**178.81**	**50.641**
#31	1	431.100	0.588	0.450	0.336	91.500	M	75.71	7.004
	2	325.800	0.432	0.149	0.327	93.000	M	85.40	6.520
	3	200.200	0.373	0.000	0.000	92.900	M	55.57	3.945
	Σ	**957.100**						**135.01**	**17.469**

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
#33	**∑**	**17,258.700**						**243.60**	**68.110**
#34	1	91.700	0.244	0.965	0.300	92.300	M	28.02	1.678
	2	105.200	0.256	0.965	0.300	93.000	M	34.57	2.114
	3	735.600	0.885	0.000	0.000	88.900	M	65.22	8.216
	∑	**18,191.200**						**256.20**	**80.118**
#5	1	503.600	0.618	0.000	0.000	87.600	M	44.56	4.621
	2	406.500	0.388	0.501	0.350	84.800	M	27.28	2.356
	3	439.600	0.342	0.681	0.347	87.800	M	57.48	4.181
	4	162.600	0.280	0.681	0.347	86.000	M	16.74	1.161
	5	294.100	0.375	1.021	0.348	92.000	M	71.65	5.116
	6	216.600	0.272	1.018	0.348	90.100	M	46.35	2.899
	∑	**2,023.000**						**171.21**	**20.334**
#6	1	149.100	0.331	0.000	0.000	92.600	M	41.87	2.831
	2	245.000	0.529	0.192	0.328	88.100	M	26.07	2.430
	3	276.200	0.450	0.461	0.319	89.500	M	41.36	3.372
	4	158.400	0.380	1.385	0.185	93.000	M	44.23	3.163
	5	206.200	0.402	0.796	0.320	89.400	M	32.46	2.488
	6	414.000	0.430	1.066	0.323	87.200	M	42.38	3.578
	7	294.300	0.535	1.066	0.323	86.400	M	22.70	2.235
	∑	**3,766.200**						**212.42**	**40.431**
#7	1	731.700	1.274	0.000	0.000	93.000	M	96.39	14.602
	2	445.800	1.043	0.000	0.000	93.000	M	67.76	8.894
	3	270.800	0.804	0.000	0.000	93.000	M	49.02	5.404
	4	78.900	0.267	1.035	0.328	93.000	M	25.53	1.584
	5	154.900	0.310	1.071	0.326	93.000	M	47.40	3.105
	6	101.400	0.288	1.164	0.328	92.900	M	31.46	2.004
	7	117.700	0.298	1.344	0.329	92.200	M	32.72	2.112
	8	494.100	0.518	1.344	0.329	91.300	M	90.89	7.807
	∑	**6,161.500**						**387.09**	**85.942**
#8	1	0.000	0.000	0.000	0.000	1.000	0.00	0.000	
	∑	**6,161.500**						**387.09**	**85.942**
#10	1	355.500	1.286	0.000	0.000	93.000	M	46.51	7.093
	2	307.100	1.282	0.668	0.305	83.200	M	7.05	1.324
	3	147.300	1.245	0.517	0.303	90.600	M	13.65	2.105
	4	126.400	0.585	0.517	0.303	93.000	M	27.97	2.527
	5	116.900	1.179	0.621	0.305	93.000	M	16.29	2.333
	∑	**7,214.700**						**408.03**	**101.324**
#1	1	557.400	0.941	0.000	0.000	83.600	M	16.72	2.594

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
	2	169.600	1.616	0.677	0.333	93.000	M	18.75	3.384
	3	636.400	1.842	0.729	0.333	81.000	M	6.98	1.726
	4	223.400	0.846	1.005	0.336	84.100	M	7.97	1.141
	5	77.700	0.330	1.392	0.341	81.400	M	2.25	0.232
	6	746.600	0.678	1.392	0.341	88.200	M	69.45	7.514
	Σ	**2,411.100**						**102.40**	**16.592**
#2	1	257.000	0.423	0.000	0.000	93.000	M	68.09	5.147
	2	180.500	0.562	0.478	0.281	91.800	M	34.14	3.055
	3	200.700	0.687	0.574	0.283	93.000	M	40.21	4.007
	4	438.600	0.811	0.574	0.283	93.000	M	78.94	8.755
	5	420.200	1.247	0.801	0.293	88.000	M	25.21	4.099
	Σ	**3,908.100**						**165.97**	**41.656**
#3	1	172.600	0.443	0.000	0.000	93.000	M	44.66	3.448
	2	311.200	0.890	0.000	0.000	88.900	M	27.49	3.477
	3	378.900	0.632	0.209	0.314	87.900	M	34.90	3.641
	Σ	**4,770.800**						**217.82**	**52.221**
#4	**Σ**	**4,770.800**						**217.82**	**52.221**
#9	1	425.500	0.830	0.000	0.000	90.700	M	52.76	6.171
	Σ	**5,196.300**						**225.97**	**58.392**
#11	**Σ**	**12,411.000**						**567.35**	**159.716**
#21	1	272.800	0.819	0.000	0.000	86.900	M	17.75	2.243
	2	230.500	0.388	0.694	0.266	89.200	M	35.79	2.694
	3	181.100	0.289	0.877	0.256	91.300	M	44.96	2.866
	4	396.400	0.939	0.877	0.256	86.100	M	20.22	2.863
	Σ	**13,491.800**						**591.22**	**170.383**
#18	1	301.700	0.652	0.000	0.000	93.000	M	62.47	6.029
	2	546.800	0.768	0.561	0.320	86.300	M	32.97	4.083
	Σ	**848.500**						**63.40**	**10.112**
#17	1	182.200	0.462	0.000	0.000	93.000	M	46.10	3.640
	Σ	**182.200**						**46.10**	**3.640**
#19	**Σ**	**1,030.700**						**106.20**	**13.753**
#15	1	437.400	0.803	0.000	0.000	91.300	M	60.86	6.898
	2	549.000	0.637	0.654	0.327	91.300	M	88.81	8.663
	3	1,006.300	1.023	0.768	0.331	84.700	M	36.49	5.725
	Σ	**1,992.700**						**132.09**	**21.286**
#12	1	517.800	0.791	0.000	0.000	81.900	M	11.30	1.714

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
	2	229.000	0.571	0.043	0.418	80.100	M	3.43	0.501
	3	592.700	0.706	0.044	0.417	81.500	M	12.26	1.800
	4	1,806.900	1.542	0.487	0.362	76.700	M	5.34	1.374
	5	348.100	0.618	0.487	0.362	80.000	4.94	0.743	
	Σ	**3,494.500**						**29.47**	**6.132**
#13	1	411.600	0.725	0.000	0.000	79.700	M	5.01	0.813
	2	636.400	0.774	0.322	0.336	80.700	M	10.16	1.611
	3	319.000	0.575	0.685	0.318	85.500	M	19.58	2.087
	4	231.700	0.314	0.923	0.328	80.400	M	4.67	0.548
	5	1,122.000	1.308	0.923	0.328	74.700	M	1.29	0.319
	Σ	**6,215.200**						**61.66**	**11.510**
#14	1	405.900	0.384	0.000	0.000	90.800	M	81.84	5.970
	2	411.100	0.452	0.707	0.308	90.700	M	74.57	5.964
	3	787.400	0.658	0.975	0.307	91.400	M	126.78	12.610
	4	144.200	0.341	1.716	0.310	86.200	M	13.94	1.064
	5	343.800	0.289	1.970	0.312	86.500	M	38.50	2.659
	6	392.800	0.806	2.107	0.316	81.900	M	8.49	1.301
	7	528.200	0.518	2.544	0.316	87.200	M	48.43	4.560
	8	890.900	1.253	2.544	0.316	83.500	M	22.13	4.068
	9	741.400	1.076	3.047	0.316	84.800	M	26.61	4.293
	10	451.100	0.916	3.354	0.316	83.900	M	14.69	2.221
	Σ	**11,312.000**						**166.07**	**56.222**
#16	1	329.600	0.641	0.000	0.000	93.000	M	68.96	6.584
	2	348.400	0.542	0.509	0.286	92.500	M	74.85	6.493
	3	198.500	0.266	0.943	0.279	93.000	M	64.31	3.984
	Σ	**14,181.200**						**302.67**	**94.568**
#20	1	296.300	0.667	0.000	0.000	91.700	M	49.57	4.948
	2	385.600	0.713	0.476	0.440	93.000	M	75.43	7.699
	Σ	**15,893.800**						**327.56**	**120.968**
#22	**Σ**	**29,385.600**						**870.59**	**291.351**
#23	1	442.400	0.960	0.000	0.000	85.300	M	18.91	2.793
	2	310.500	0.538	0.559	0.291	89.500	M	41.66	3.791
	Σ	**30,138.500**						**867.57**	**297.934**
#35	**Σ**	**48,329.700**						**1,063.48**	**378.052**
#36	1	298.200	0.987	0.000	0.000	85.000	M	11.77	1.788
	2	196.800	0.441	0.000	0.000	87.900	M	22.54	1.893
	3	235.590	0.885	0.166	0.372	78.300	M	1.65	0.313

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
	Σ	**49,060.290**						**1,061.94**	**382.046**
#37	1	744.000	1.756	0.000	0.000	84.800	M	19.52	4.306
	2	296.000	0.439	1.780	0.243	87.800	M	33.37	2.805
	3	237.700	0.333	1.649	0.246	85.500	M	20.26	1.561
	4	561.400	1.502	1.780	0.243	84.100	M	14.17	2.866
	5	369.400	0.817	2.236	0.284	81.600	M	7.35	1.147
	Σ	**51,268.790**						**1,055.02**	**394.731**

Subwatershed Sedimentology Detail:

Stru #	SWS #	Soil K	L (ft)	S (%)	C	P	PS #	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc (ml/l)	24VW (ml/l)
#30	1	0.095	200.00	3.80	0.3720	1.0000	2	0.1	3,489	2.23	1.76
	Σ							**0.1**	**3,489**	**2.23**	**1.76**
#28	1	0.187	100.00	10.10	0.3750	1.0000	3	555.9	52,723	0.00	0.00
	2	0.196	100.00	10.20	0.3930	1.0000	3	348.4	58,373	0.00	0.00
	Σ							**739.9**	**45,906**	**0.00**	**0.00**
#26	1	0.155	400.00	1.40	0.3480	1.0000	2	0.2	2,448	1.53	1.18
	2	0.155	300.00	2.40	0.3340	1.0000	2	7.8	4,238	2.26	1.74
	Σ							**8.0**	**4,125**	**2.21**	**1.71**
#24	1	0.128	300.00	2.30	0.3360	1.0000	2	2.7	2,661	1.33	1.00
	2	0.136	300.00	2.70	0.3440	1.0000	2	2.3	3,360	1.86	1.39
	3	0.107	300.00	2.30	0.3330	1.0000	2	3.3	2,811	1.56	1.23
	4	0.163	400.00	1.60	0.3210	1.0000	2	3.9	3,194	1.73	1.35
	Σ							**9.6**	**3,240**	**1.51**	**0.84**
#25	1	0.125	400.00	1.90	0.3440	1.0000	2	2.6	3,677	1.96	1.55
	2	0.124	300.00	2.60	0.3280	1.0000	2	0.7	3,754	2.08	1.63
	3	0.122	175.00	4.90	0.2660	1.0000	2	28.7	12,170	6.76	4.66
	Σ							**39.4**	**12,153**	**6.31**	**2.07**
#27	1	0.127	175.00	5.90	0.3160	1.0000	2	20.7	13,801	7.09	5.20
	2	0.122	150.00	7.50	0.2920	1.0000	2	23.8	15,793	8.49	6.12
	3	0.070	125.00	8.40	0.3270	1.0000	2	0.7	4,438	2.66	2.32
	4	0.097	125.00	9.60	0.3170	1.0000	2	6.0	12,370	6.54	5.00
	5	0.126	125.00	8.90	0.3290	1.0000	2	35.7	16,624	7.78	5.85
	Σ							**134.0**	**17,591**	**8.96**	**3.39**

Stru #	SWS #	Soil K	L (ft)	S (%)	C	P	PS #	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc (ml/l)	24VW (ml/l)
#29	1	0.190	125.00	9.80	0.3930	1.0000	3	387.3	64,968	0.38	0.26
	2	0.203	125.00	8.90	0.3940	1.0000	3	197.0	53,216	0.00	0.00
	3	0.193	125.00	8.40	0.3940	1.0000	3	129.6	47,000	0.00	0.00
	Σ							**1,587.3**	**54,538**	**2.41**	**1.14**
#32	1	0.210	150.00	7.70	0.3990	1.0000	3	289.6	51,320	0.00	0.00
	Σ							**1,694.8**	**49,619**	**0.00**	**0.00**
#31	1	0.204	125.00	8.70	0.3620	1.0000	3	329.8	48,526	0.00	0.00
	2	0.210	150.00	7.30	0.3990	1.0000	3	338.0	54,451	1.63	1.12
	3	0.210	175.00	4.50	0.3980	1.0000	3	136.5	37,227	1.56	1.06
	Σ							**610.8**	**34,117**	**0.32**	**0.24**
#33	Σ							**2,305.6**	**39,263**	**0.10**	**0.06**
#34	1	0.189	175.00	4.60	0.2250	1.0000	3	29.8	18,628	1.29	0.90
	2	0.206	175.00	5.10	0.3620	1.0000	3	73.8	36,250	2.51	1.76
	3	0.176	175.00	4.20	0.2510	1.0000	3	111.6	13,883	0.00	0.00
	Σ							**2,205.4**	**32,513**	**0.05**	**0.03**
#5	1	0.149	75.00	12.50	0.3230	1.0000	3	165.7	37,263	0.00	0.00
	2	0.133	75.00	15.80	0.3190	1.0000	2	102.5	45,635	26.07	18.02
	3	0.103	100.00	11.00	0.2030	1.0000	3	78.2	20,017	0.17	0.12
	4	0.093	75.00	13.80	0.2130	1.0000	2	20.6	19,161	11.51	7.80
	5	0.123	100.00	11.00	0.1370	1.0000	3	80.0	16,445	0.58	0.40
	6	0.149	75.00	14.70	0.1990	1.0000	3	98.7	35,948	1.74	1.20
	Σ							**462.4**	**32,307**	**2.05**	**1.05**
#6	1	0.208	175.00	4.30	0.3980	1.0000	3	91.6	35,102	1.73	1.16
	2	0.183	175.00	5.40	0.3910	1.0000	3	69.3	29,853	0.00	0.00
	3	0.188	150.00	7.60	0.3900	1.0000	3	141.7	44,004	0.00	0.00
	4	0.210	150.00	6.30	0.3990	1.0000	3	135.6	42,816	1.77	1.28
	5	0.185	125.00	8.10	0.3860	1.0000	3	99.0	41,472	0.28	0.20
	6	0.104	100.00	11.30	0.2240	1.0000	3	69.9	20,288	0.00	0.00
	7	0.164	100.00	11.20	0.3740	1.0000	3	98.6	44,820	0.00	0.00
	Σ							**934.0**	**28,405**	**0.14**	**0.08**
#7	1	0.208	150.00	7.80	0.3780	1.0000	3	568.9	38,847	0.00	0.00
	2	0.209	100.00	10.20	0.3940	1.0000	3	464.2	52,246	0.00	0.00
	3	0.210	150.00	6.70	0.3990	1.0000	3	205.7	38,872	0.00	0.00
	4	0.210	100.00	11.50	0.3990	1.0000	3	122.7	79,219	5.29	3.71
	5	0.210	150.00	7.10	0.3990	1.0000	3	156.1	51,819	2.96	2.08
	6	0.209	150.00	7.90	0.3990	1.0000	3	107.1	54,958	3.37	2.37
	7	0.206	75.00	15.50	0.3990	1.0000	3	201.7	96,052	5.25	3.72

Stru #	SWS #	Soil K	L (ft)	S (%)	C	P	PS #	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc (ml/l)	24VW (ml/l)
	8	0.202	75.00	14.50	0.3980	1.0000	3	669.7	85,902	0.00	0.00
	Σ							**2,914.9**	**36,696**	**0.00**	**0.00**
#8	1	0.000	0.00	0.00	0.0000	1.0000	0	0.0	1	0.00	0.00
	Σ							**2,914.9**	**36,696**	**0.00**	**0.00**
#10	1	0.190	300.00	2.70	0.1930	1.0000	3	46.3	6,587	0.00	0.00
	2	0.153	200.00	3.50	0.3610	1.0000	2	10.6	7,825	3.48	2.62
	3	0.189	200.00	3.70	0.3190	1.0000	3	22.9	10,906	0.00	0.00
	4	0.190	300.00	2.10	0.1940	1.0000	3	15.6	6,459	0.00	0.00
	5	0.201	300.00	2.00	0.3030	1.0000	3	17.5	7,554	0.00	0.00
	Σ							**2,888.5**	**33,288**	**0.04**	**0.03**
#1	1	0.157	150.00	6.80	0.3830	1.0000	2	54.3	20,582	9.89	7.35
	2	0.210	150.00	6.60	0.3990	1.0000	3	91.1	26,615	0.00	0.00
	3	0.149	200.00	3.90	0.3870	1.0000	2	14.2	7,833	3.10	2.38
	4	0.169	175.00	4.70	0.3950	1.0000	2	19.1	16,624	8.23	6.06
	5	0.157	100.00	10.10	0.3940	1.0000	2	6.6	28,074	15.42	11.39
	6	0.175	75.00	12.60	0.2840	1.0000	3	290.9	39,015	0.00	0.00
	Σ							**452.6**	**29,702**	**2.57**	**1.72**
#2	1	0.190	150.00	7.90	0.1930	1.0000	3	123.1	25,644	0.82	0.56
	2	0.184	175.00	4.80	0.2010	1.0000	3	42.3	14,436	0.00	0.00
	3	0.202	200.00	3.90	0.3220	1.0000	3	68.3	17,482	0.00	0.00
	4	0.203	150.00	7.40	0.3220	1.0000	3	301.9	34,875	0.00	0.00
	5	0.181	175.00	5.10	0.3710	1.0000	3	81.0	19,571	0.00	0.00
	Σ							**776.1**	**20,475**	**0.10**	**0.07**
#3	1	0.190	175.00	5.20	0.1930	1.0000	3	56.3	17,538	0.48	0.33
	2	0.177	175.00	4.20	0.2560	1.0000	3	43.6	12,816	0.00	0.00
	3	0.166	175.00	4.30	0.2290	1.0000	3	43.8	12,524	0.00	0.00
	Σ							**899.7**	**17,142**	**0.03**	**0.02**
#4	Σ							**899.7**	**17,142**	**0.03**	**0.02**
#9	1	0.189	175.00	4.44	0.1970	1.0000	3	74.9	12,497	0.00	0.00
	Σ							**914.0**	**14,897**	**0.00**	**0.00**
#11	Σ							**3,802.5**	**27,497**	**0.01**	**0.01**
#21	1	0.177	175.00	4.44	0.2560	1.0000	3	28.1	12,793	0.00	0.00
	2	0.184	175.00	5.81	0.2210	1.0000	3	53.4	20,771	0.18	0.13
	3	0.185	300.00	2.70	0.2180	1.0000	3	30.0	10,952	0.56	0.39
	4	0.175	300.00	2.66	0.2690	1.0000	3	22.1	7,715	0.00	0.00
	Σ							**3,862.9**	**26,737**	**0.00**	**0.00**

Stru #	SWS #	Soil K	L (ft)	S (%)	C	P	PS #	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc (ml/l)	24VW (ml/l)
#18	1	0.193	300.00	2.80	0.2200	1.0000	3	59.6	10,362	0.00	0.00
	2	0.173	175.00	4.70	0.3880	1.0000	3	86.9	21,485	0.00	0.00
	Σ							**89.4**	**9,383**	**0.00**	**0.00**
#17	1	0.196	300.00	2.60	0.2600	1.0000	3	42.5	12,532	0.29	0.20
	Σ							**42.5**	**12,532**	**0.29**	**0.20**
#19	Σ							**132.0**	**8,986**	**0.07**	**0.05**
#15	1	0.201	125.00	8.20	0.3960	1.0000	3	284.0	41,954	0.00	0.00
	2	0.161	100.00	11.40	0.3060	1.0000	3	372.2	43,886	0.00	0.00
	3	0.118	100.00	10.20	0.2850	1.0000	2	104.7	18,046	8.67	6.42
	Σ							**666.2**	**35,689**	**0.30**	**0.19**
#12	1	0.124	150.00	6.30	0.3070	1.0000	2	20.4	11,661	5.67	4.23
	2	0.132	200.00	3.60	0.3500	1.0000	2	3.5	6,903	3.51	2.63
	3	0.136	175.00	5.00	0.3330	1.0000	2	22.6	12,336	6.09	4.54
	4	0.188	200.00	3.40	0.3570	1.0000	2	11.0	7,280	4.16	3.35
	5	0.228	175.00	4.10	0.3640	1.0000	2	12.6	16,394	8.29	6.26
	Σ							**64.8**	**10,798**	**5.21**	**3.74**
#13	1	0.128	150.00	6.90	0.3390	1.0000	2	10.6	12,556	6.27	4.76
	2	0.130	175.00	5.70	0.3300	1.0000	2	20.5	12,360	6.02	4.53
	3	0.191	175.00	6.00	0.2890	1.0000	2	46.2	22,620	12.32	8.80
	4	0.122	175.00	5.10	0.3460	1.0000	2	6.4	11,408	6.15	4.62
	5	0.137	175.00	4.20	0.3530	1.0000	2	2.2	6,078	3.78	3.16
	Σ							**150.5**	**14,172**	**7.19**	**4.86**
#14	1	0.196	100.00	10.20	0.3980	1.0000	3	390.8	70,290	1.68	1.13
	2	0.193	150.00	6.70	0.4020	1.0000	3	254.4	44,287	0.26	0.18
	3	0.169	75.00	13.80	0.3240	1.0000	3	675.2	54,052	0.00	0.00
	4	0.114	100.00	11.00	0.2980	1.0000	3	26.7	25,596	0.00	0.00
	5	0.078	100.00	10.10	0.1830	1.0000	3	29.3	11,302	0.14	0.10
	6	0.084	150.00	7.10	0.2700	1.0000	2	9.9	7,446	3.61	2.71
	7	0.087	100.00	10.00	0.1840	1.0000	3	48.3	10,687	0.00	0.00
	8	0.126	150.00	6.70	0.2740	1.0000	2	46.3	11,063	4.96	3.74
	9	0.117	150.00	7.30	0.2600	1.0000	2	50.6	11,548	5.49	4.11
	10	0.115	125.00	8.50	0.2610	1.0000	2	27.1	11,936	5.79	4.34
	Σ							**1,310.1**	**62,956**	**0.45**	**0.12**
#16	1	0.200	200.00	3.30	0.3000	1.0000	3	96.3	15,320	0.00	0.00
	2	0.204	150.00	6.00	0.3630	1.0000	3	229.8	36,609	0.07	0.05
	3	0.210	150.00	6.10	0.3990	1.0000	3	184.0	47,468	3.18	2.24
	Σ							**2,485.3**	**41,640**	**0.46**	**0.21**

Stru #	SWS #	Soil K	L (ft)	S (%)	C	P	PS #	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc (ml/l)	24VW (ml/l)
#20	1	0.186	175.00	4.80	0.2130	1.0000	3	73.2	15,471	0.00	0.00
	2	0.194	200.00	3.80	0.2330	1.0000	3	94.9	12,766	0.00	0.00
	Σ							**2,763.2**	**31,815**	**0.24**	**0.12**
#22	Σ							**6,626.1**	**27,392**	**0.08**	**0.05**
#23	1	0.172	175.00	4.20	0.2810	1.0000	3	33.4	11,905	0.00	0.00
	2	0.185	150.00	6.00	0.2160	1.0000	3	66.0	18,149	0.00	0.00
	Σ							**6,609.5**	**26,955**	**0.00**	**0.00**
#35	Σ							**8,814.9**	**25,656**	**0.01**	**0.01**
#36	1	0.190	175.00	5.94	0.2830	1.0000	3	30.8	17,048	0.00	0.00
	2	0.180	125.00	9.92	0.2410	1.0000	3	57.7	32,827	0.00	0.00
	3	0.151	300.00	2.63	0.3890	1.0000	2	1.9	5,825	3.11	2.43
	Σ							**8,845.9**	**29,111**	**0.00**	**0.00**
#37	1	0.196	200.00	3.80	0.3980	1.0000	2	55.5	12,520	5.18	3.91
	2	0.193	175.00	5.40	0.4020	1.0000	3	93.4	33,384	0.00	0.00
	3	0.173	150.00	7.11	0.2770	1.0000	3	37.8	24,351	0.00	0.00
	4	0.171	150.00	6.52	0.2990	1.0000	2	42.8	14,476	6.23	4.70
	5	0.078	400.00	1.20	0.1830	1.0000	2	1.2	1,055	0.51	0.39
	Σ							**8,889.8**	**26,564**	**0.12**	**0.07**

Subwatershed Time of Concentration Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#1	1	5. Nearly bare and untilled, and alluvial valley fans	3.65	50.00	1,369.00	1.910	0.199
		8. Large gullies, diversions, and low flowing streams	1.57	157.00	10,030.00	3.750	0.742
#1	**1**	**Time of Concentration:**					**0.941**
#1	2	5. Nearly bare and untilled, and alluvial valley fans	6.63	70.00	1,056.00	2.570	0.114
		5. Nearly bare and untilled, and alluvial valley fans	1.98	150.00	7,573.00	1.400	1.502
#1	**2**	**Time of Concentration:**					**1.616**
#1	3	5. Nearly bare and untilled, and alluvial valley fans	1.65	117.00	7,070.00	1.280	1.534
		8. Large gullies, diversions, and low flowing streams	2.43	126.00	5,188.00	4.670	0.308
#1	**3**	**Time of Concentration:**					**1.842**
#1	4	5. Nearly bare and untilled, and alluvial valley fans	5.77	260.00	4,506.00	2.400	0.521

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
		8. Large gullies, diversions, and low flowing streams	2.84	168.00	5,924.00	5.050	0.325
#1	**4**	**Time of Concentration:**					**0.846**
#1	5	5. Nearly bare and untilled, and alluvial valley fans	19.93	180.00	903.00	4.460	0.056
		8. Large gullies, diversions, and low flowing streams	3.30	178.00	5,393.00	5.450	0.274
#1	**5**	**Time of Concentration:**					**0.330**
#1	6	5. Nearly bare and untilled, and alluvial valley fans	13.43	105.00	782.00	3.660	0.059
		8. Large gullies, diversions, and low flowing streams	2.62	283.00	10,822.00	4.850	0.619
#1	**6**	**Time of Concentration:**					**0.678**
#2	1	5. Nearly bare and untilled, and alluvial valley fans	6.84	70.00	1,024.00	2.610	0.108
		8. Large gullies, diversions, and low flowing streams	1.62	70.00	4,325.00	3.810	0.315
#2	**1**	**Time of Concentration:**					**0.423**
#2	2	5. Nearly bare and untilled, and alluvial valley fans	5.56	45.00	810.00	2.350	0.095
		8. Large gullies, diversions, and low flowing streams	0.86	40.00	4,663.00	2.770	0.467
#2	**2**	**Time of Concentration:**					**0.562**
#2	3	5. Nearly bare and untilled, and alluvial valley fans	5.89	50.00	849.00	2.420	0.097
		8. Large gullies, diversions, and low flowing streams	1.17	80.00	6,862.00	3.230	0.590
#2	**3**	**Time of Concentration:**					**0.687**
#2	4	5. Nearly bare and untilled, and alluvial valley fans	12.63	95.00	752.00	3.550	0.058
		8. Large gullies, diversions, and low flowing streams	1.40	135.00	9,630.00	3.550	0.753
#2	**4**	**Time of Concentration:**					**0.811**
#2	5	5. Nearly bare and untilled, and alluvial valley fans	11.02	70.00	635.00	3.320	0.053
		8. Large gullies, diversions, and low flowing streams	0.46	40.00	8,732.00	2.030	1.194
#2	**5**	**Time of Concentration:**					**1.247**
#3	1	5. Nearly bare and untilled, and alluvial valley fans	1.24	10.00	805.00	1.110	0.201
		8. Large gullies, diversions, and low flowing streams	1.33	40.00	3,017.00	3.450	0.242
#3	**1**	**Time of Concentration:**					**0.443**
#3	2	5. Nearly bare and untilled, and alluvial valley fans	0.68	10.00	1,478.00	0.820	0.500
		8. Large gullies, diversions, and low flowing streams	1.78	100.00	5,622.00	4.000	0.390
#3	**2**	**Time of Concentration:**					**0.890**

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#3	3	5. Nearly bare and untilled, and alluvial valley fans	4.66	70.00	1,501.00	2.150	0.193
		8. Large gullies, diversions, and low flowing streams	1.17	60.00	5,126.00	3.240	0.439
#3	**3**	**Time of Concentration:**					**0.632**
#5	1	5. Nearly bare and untilled, and alluvial valley fans	19.06	285.00	1,495.00	4.360	0.095
		8. Large gullies, diversions, and low flowing streams	2.64	242.00	9,174.00	4.870	0.523
#5	**1**	**Time of Concentration:**					**0.618**
#5	2	5. Nearly bare and untilled, and alluvial valley fans	14.27	105.00	736.00	3.770	0.054
		8. Large gullies, diversions, and low flowing streams	4.08	297.00	7,279.00	6.050	0.334
#5	**2**	**Time of Concentration:**					**0.388**
#5	3	5. Nearly bare and untilled, and alluvial valley fans	8.27	35.00	423.00	2.870	0.040
		8. Large gullies, diversions, and low flowing streams	3.44	208.00	6,049.00	5.560	0.302
#5	**3**	**Time of Concentration:**					**0.342**
#5	4	5. Nearly bare and untilled, and alluvial valley fans	14.58	85.00	583.00	3.810	0.042
		8. Large gullies, diversions, and low flowing streams	4.53	248.00	5,473.00	6.380	0.238
#5	**4**	**Time of Concentration:**					**0.280**
#5	5	5. Nearly bare and untilled, and alluvial valley fans	5.07	70.00	1,382.00	2.250	0.170
		8. Large gullies, diversions, and low flowing streams	3.89	170.00	4,375.00	5.910	0.205
#5	**5**	**Time of Concentration:**					**0.375**
#5	6	5. Nearly bare and untilled, and alluvial valley fans	12.48	90.00	721.00	3.530	0.056
		8. Large gullies, diversions, and low flowing streams	5.16	274.00	5,308.02	6.810	0.216
#5	**6**	**Time of Concentration:**					**0.272**
#6	1	5. Nearly bare and untilled, and alluvial valley fans	5.36	75.00	1,399.00	2.310	0.168
		8. Large gullies, diversions, and low flowing streams	2.41	66.00	2,742.00	4.650	0.163
#6	**1**	**Time of Concentration:**					**0.331**
#6	2	5. Nearly bare and untilled, and alluvial valley fans	3.39	80.00	2,359.00	1.840	0.356
		8. Large gullies, diversions, and low flowing streams	2.63	80.00	3,039.00	4.860	0.173
#6	**2**	**Time of Concentration:**					**0.529**
#6	3	5. Nearly bare and untilled, and alluvial valley fans	4.60	34.00	739.00	2.140	0.095
		8. Large gullies, diversions, and low flowing streams	2.33	136.00	5,845.00	4.570	0.355

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#6	**3**	**Time of Concentration:**					**0.450**
#6	4	5. Nearly bare and untilled, and alluvial valley fans	6.06	85.00	1,402.00	2.460	0.158
		8. Large gullies, diversions, and low flowing streams	2.52	96.00	3,810.00	4.760	0.222
#6	**4**	**Time of Concentration:**					**0.380**
#6	5	5. Nearly bare and untilled, and alluvial valley fans	7.24	70.00	967.00	2.690	0.099
		8. Large gullies, diversions, and low flowing streams	2.34	117.00	5,003.00	4.580	0.303
#6	**5**	**Time of Concentration:**					**0.402**
#6	6	5. Nearly bare and untilled, and alluvial valley fans	31.83	183.00	575.00	5.640	0.028
		8. Large gullies, diversions, and low flowing streams	3.38	270.00	7,990.00	5.510	0.402
#6	**6**	**Time of Concentration:**					**0.430**
#6	7	5. Nearly bare and untilled, and alluvial valley fans	23.08	325.00	1,408.00	4.800	0.081
		8. Large gullies, diversions, and low flowing streams	2.88	240.00	8,327.00	5.090	0.454
#6	**7**	**Time of Concentration:**					**0.535**
#7	1	5. Nearly bare and untilled, and alluvial valley fans	11.42	90.00	788.00	3.370	0.064
		8. Large gullies, diversions, and low flowing streams	1.46	230.00	15,769.00	3.620	1.210
#7	**1**	**Time of Concentration:**					**1.274**
#7	2	5. Nearly bare and untilled, and alluvial valley fans	10.97	60.00	547.00	3.310	0.045
		8. Large gullies, diversions, and low flowing streams	1.61	220.00	13,660.00	3.800	0.998
#7	**2**	**Time of Concentration:**					**1.043**
#7	3	5. Nearly bare and untilled, and alluvial valley fans	6.40	60.00	938.00	2.520	0.103
		8. Large gullies, diversions, and low flowing streams	1.72	171.00	9,931.00	3.930	0.701
#7	**3**	**Time of Concentration:**					**0.804**
#7	4	5. Nearly bare and untilled, and alluvial valley fans	19.23	80.00	416.00	4.380	0.026
		8. Large gullies, diversions, and low flowing streams	2.45	100.00	4,083.00	4.690	0.241
#7	**4**	**Time of Concentration:**					**0.267**
#7	5	5. Nearly bare and untilled, and alluvial valley fans	6.09	67.00	1,101.00	2.460	0.124
		8. Large gullies, diversions, and low flowing streams	2.51	80.00	3,184.00	4.750	0.186
#7	**5**	**Time of Concentration:**					**0.310**
#7	6	5. Nearly bare and untilled, and alluvial valley fans	5.93	63.00	1,062.00	2.430	0.121

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
		8. Large gullies, diversions, and low flowing streams	2.74	82.00	2,993.00	4.960	0.167
#7	**6**	**Time of Concentration:**					**0.288**
#7	7	5. Nearly bare and untilled, and alluvial valley fans	7.97	65.00	816.00	2.820	0.080
		8. Large gullies, diversions, and low flowing streams	3.48	153.00	4,400.00	5.590	0.218
#7	**7**	**Time of Concentration:**					**0.298**
#7	8	5. Nearly bare and untilled, and alluvial valley fans	6.60	50.00	758.00	2.560	0.082
		8. Large gullies, diversions, and low flowing streams	4.66	473.00	10,157.00	6.470	0.436
#7	**8**	**Time of Concentration:**					**0.518**
#9	1	5. Nearly bare and untilled, and alluvial valley fans	3.35	90.00	2,687.00	1.830	0.407
		8. Large gullies, diversions, and low flowing streams	0.58	20.00	3,463.00	2.270	0.423
#9	**1**	**Time of Concentration:**					**0.830**
#10	1	5. Nearly bare and untilled, and alluvial valley fans	1.24	41.00	3,317.00	1.110	0.830
		8. Large gullies, diversions, and low flowing streams	0.70	29.00	4,125.00	2.510	0.456
#10	**1**	**Time of Concentration:**					**1.286**
#10	2	5. Nearly bare and untilled, and alluvial valley fans	2.25	125.00	5,554.00	1.500	1.028
		8. Large gullies, diversions, and low flowing streams	2.13	85.00	3,997.00	4.370	0.254
#10	**2**	**Time of Concentration:**					**1.282**
#10	3	5. Nearly bare and untilled, and alluvial valley fans	1.39	68.00	4,904.00	1.170	1.164
		8. Large gullies, diversions, and low flowing streams	4.73	90.00	1,904.00	6.520	0.081
#10	**3**	**Time of Concentration:**					**1.245**
#10	4	5. Nearly bare and untilled, and alluvial valley fans	3.76	51.00	1,357.00	1.930	0.195
		8. Large gullies, diversions, and low flowing streams	0.65	22.00	3,385.00	2.410	0.390
#10	**4**	**Time of Concentration:**					**0.585**
#10	5	5. Nearly bare and untilled, and alluvial valley fans	1.63	88.00	5,391.16	1.270	1.179
#10	**5**	**Time of Concentration:**					**1.179**
#12	1	5. Nearly bare and untilled, and alluvial valley fans	4.50	75.00	1,667.00	2.120	0.218
		8. Large gullies, diversions, and low flowing streams	1.85	155.00	8,400.00	4.070	0.573
#12	**1**	**Time of Concentration:**					**0.791**
#12	2	5. Nearly bare and untilled, and alluvial valley fans	2.99	50.00	1,674.03	1.720	0.270

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
		8. Large gullies, diversions, and low flowing streams	1.67	70.00	4,201.17	3.870	0.301
#12	**2**	**Time of Concentration:**					**0.571**
#12	3	5. Nearly bare and untilled, and alluvial valley fans	4.04	57.00	1,411.00	2.000	0.195
		8. Large gullies, diversions, and low flowing streams	1.55	107.00	6,884.00	3.740	0.511
#12	**3**	**Time of Concentration:**					**0.706**
#12	4	5. Nearly bare and untilled, and alluvial valley fans	2.23	84.00	3,771.04	1.490	0.703
		8. Large gullies, diversions, and low flowing streams	1.62	186.00	11,515.60	3.810	0.839
#12	**4**	**Time of Concentration:**					**1.542**
#12	5	5. Nearly bare and untilled, and alluvial valley fans	3.68	53.00	1,442.00	1.910	0.209
		8. Large gullies, diversions, and low flowing streams	1.95	120.00	6,155.00	4.180	0.409
#12	**5**	**Time of Concentration:**					**0.618**
#13	1	5. Nearly bare and untilled, and alluvial valley fans	4.62	62.00	1,342.00	2.140	0.174
		8. Large gullies, diversions, and low flowing streams	1.91	157.00	8,225.00	4.140	0.551
#13	**1**	**Time of Concentration:**					**0.725**
#13	2	5. Nearly bare and untilled, and alluvial valley fans	2.91	50.00	1,717.00	1.700	0.280
		8. Large gullies, diversions, and low flowing streams	2.28	183.00	8,039.00	4.520	0.494
#13	**2**	**Time of Concentration:**					**0.774**
#13	3	5. Nearly bare and untilled, and alluvial valley fans	6.18	95.00	1,537.00	2.480	0.172
		8. Large gullies, diversions, and low flowing streams	2.13	135.00	6,347.00	4.370	0.403
#13	**3**	**Time of Concentration:**					**0.575**
#13	4	5. Nearly bare and untilled, and alluvial valley fans	3.17	10.00	315.00	1.780	0.049
		8. Large gullies, diversions, and low flowing streams	2.30	100.00	4,344.00	4.550	0.265
#13	**4**	**Time of Concentration:**					**0.314**
#13	5	5. Nearly bare and untilled, and alluvial valley fans	3.10	70.00	2,255.00	1.760	0.355
		8. Large gullies, diversions, and low flowing streams	1.23	140.00	11,392.00	3.320	0.953
#13	**5**	**Time of Concentration:**					**1.308**
#14	1	5. Nearly bare and untilled, and alluvial valley fans	10.59	63.00	595.00	3.250	0.050
		8. Large gullies, diversions, and low flowing streams	2.60	151.00	5,808.00	4.830	0.334
#14	**1**	**Time of Concentration:**					**0.384**

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#14	2	5. Nearly bare and untilled, and alluvial valley fans	7.28	67.00	920.00	2.690	0.095
		8. Large gullies, diversions, and low flowing streams	2.17	123.00	5,670.00	4.410	0.357
#14	**2**	**Time of Concentration:**					**0.452**
#14	3	5. Nearly bare and untilled, and alluvial valley fans	21.46	150.00	699.00	4.630	0.041
		8. Large gullies, diversions, and low flowing streams	3.10	364.00	11,728.00	5.280	0.617
#14	**3**	**Time of Concentration:**					**0.658**
#14	4	5. Nearly bare and untilled, and alluvial valley fans	3.39	35.00	1,032.00	1.840	0.155
		8. Large gullies, diversions, and low flowing streams	2.97	103.00	3,470.00	5.160	0.186
#14	**4**	**Time of Concentration:**					**0.341**
#14	5	5. Nearly bare and untilled, and alluvial valley fans	28.15	125.00	444.00	5.300	0.023
		8. Large gullies, diversions, and low flowing streams	4.18	246.00	5,886.00	6.130	0.266
#14	**5**	**Time of Concentration:**					**0.289**
#14	6	5. Nearly bare and untilled, and alluvial valley fans	3.18	40.00	1,257.00	1.780	0.196
		8. Large gullies, diversions, and low flowing streams	2.29	228.00	9,963.00	4.530	0.610
#14	**6**	**Time of Concentration:**					**0.806**
#14	7	5. Nearly bare and untilled, and alluvial valley fans	16.72	100.00	598.00	4.080	0.040
		8. Large gullies, diversions, and low flowing streams	2.81	243.00	8,649.00	5.020	0.478
#14	**7**	**Time of Concentration:**					**0.518**
#14	8	5. Nearly bare and untilled, and alluvial valley fans	1.70	47.00	2,765.00	1.300	0.590
		8. Large gullies, diversions, and low flowing streams	2.44	274.00	11,208.00	4.690	0.663
#14	**8**	**Time of Concentration:**					**1.253**
#14	9	5. Nearly bare and untilled, and alluvial valley fans	2.87	105.00	3,657.00	1.690	0.601
		8. Large gullies, diversions, and low flowing streams	2.43	194.00	7,991.00	4.670	0.475
#14	**9**	**Time of Concentration:**					**1.076**
#14	10	5. Nearly bare and untilled, and alluvial valley fans	2.75	80.00	2,907.00	1.650	0.489
		8. Large gullies, diversions, and low flowing streams	2.41	172.00	7,149.00	4.650	0.427
#14	**10**	**Time of Concentration:**					**0.916**
#15	1	5. Nearly bare and untilled, and alluvial valley fans	12.80	54.00	422.00	3.570	0.032
		8. Large gullies, diversions, and low flowing streams	1.68	181.00	10,781.00	3.880	0.771

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#15	**1**	**Time of Concentration:**					**0.803**
#15	2	5. Nearly bare and untilled, and alluvial valley fans	44.22	260.00	588.00	6.640	0.024
		8. Large gullies, diversions, and low flowing streams	2.45	254.00	10,354.00	4.690	0.613
#15	**2**	**Time of Concentration:**					**0.637**
#15	3	5. Nearly bare and untilled, and alluvial valley fans	10.04	85.00	847.00	3.160	0.074
		8. Large gullies, diversions, and low flowing streams	2.34	366.00	15,663.00	4.580	0.949
#15	**3**	**Time of Concentration:**					**1.023**
#16	1	5. Nearly bare and untilled, and alluvial valley fans	4.17	15.00	360.00	2.040	0.049
		8. Large gullies, diversions, and low flowing streams	1.42	108.00	7,618.00	3.570	0.592
#16	**1**	**Time of Concentration:**					**0.641**
#16	2	5. Nearly bare and untilled, and alluvial valley fans	8.70	62.00	713.00	2.940	0.067
		8. Large gullies, diversions, and low flowing streams	1.99	144.00	7,241.00	4.230	0.475
#16	**2**	**Time of Concentration:**					**0.542**
#16	3	5. Nearly bare and untilled, and alluvial valley fans	6.88	32.00	465.00	2.620	0.049
		8. Large gullies, diversions, and low flowing streams	2.29	81.00	3,543.00	4.530	0.217
#16	**3**	**Time of Concentration:**					**0.266**
#17	1	5. Nearly bare and untilled, and alluvial valley fans	9.37	65.00	694.00	3.060	0.062
		8. Large gullies, diversions, and low flowing streams	1.19	56.00	4,712.00	3.270	0.400
#17	**1**	**Time of Concentration:**					**0.462**
#18	1	5. Nearly bare and untilled, and alluvial valley fans	9.00	60.00	667.00	2.990	0.061
		8. Large gullies, diversions, and low flowing streams	0.97	61.00	6,287.00	2.950	0.591
#18	**1**	**Time of Concentration:**					**0.652**
#18	2	5. Nearly bare and untilled, and alluvial valley fans	2.47	33.00	1,336.00	1.570	0.236
		8. Large gullies, diversions, and low flowing streams	2.01	164.00	8,154.00	4.250	0.532
#18	**2**	**Time of Concentration:**					**0.768**
#20	1	5. Nearly bare and untilled, and alluvial valley fans	11.87	45.00	379.00	3.440	0.030
		8. Large gullies, diversions, and low flowing streams	0.75	45.00	5,969.00	2.600	0.637
#20	**1**	**Time of Concentration:**					**0.667**
#20	2	5. Nearly bare and untilled, and alluvial valley fans	5.40	45.00	833.00	2.320	0.099

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
		8. Large gullies, diversions, and low flowing streams	1.30	98.00	7,547.00	3.410	0.614
#20	**2**	**Time of Concentration:**					**0.713**
#21	1	5. Nearly bare and untilled, and alluvial valley fans	4.09	60.00	1,467.00	2.020	0.201
		8. Large gullies, diversions, and low flowing streams	0.93	60.00	6,433.00	2.890	0.618
#21	**1**	**Time of Concentration:**					**0.819**
#21	2	5. Nearly bare and untilled, and alluvial valley fans	3.50	50.00	1,430.00	1.860	0.213
		8. Large gullies, diversions, and low flowing streams	2.15	60.00	2,785.00	4.400	0.175
#21	**2**	**Time of Concentration:**					**0.388**
#21	3	5. Nearly bare and untilled, and alluvial valley fans	1.70	15.00	881.00	1.300	0.188
		9. Small streams flowing bankfull	1.49	60.00	4,014.00	11.000	0.101
#21	**3**	**Time of Concentration:**					**0.289**
#21	4	5. Nearly bare and untilled, and alluvial valley fans	2.21	40.00	1,811.02	1.480	0.339
		8. Large gullies, diversions, and low flowing streams	0.84	50.00	5,949.54	2.750	0.600
#21	**4**	**Time of Concentration:**					**0.939**
#23	1	5. Nearly bare and untilled, and alluvial valley fans	2.44	65.00	2,660.01	1.560	0.473
		8. Large gullies, diversions, and low flowing streams	0.33	10.00	3,017.50	1.720	0.487
#23	**1**	**Time of Concentration:**					**0.960**
#23	2	5. Nearly bare and untilled, and alluvial valley fans	3.49	60.00	1,718.01	1.860	0.256
		8. Large gullies, diversions, and low flowing streams	1.66	65.00	3,926.06	3.860	0.282
#23	**2**	**Time of Concentration:**					**0.538**
#24	1	5. Nearly bare and untilled, and alluvial valley fans	1.71	430.00	25,118.00	1.300	5.367
#24	**1**	**Time of Concentration:**					**5.367**
#24	2	5. Nearly bare and untilled, and alluvial valley fans	1.84	430.00	23,393.00	1.350	4.813
#24	**2**	**Time of Concentration:**					**4.813**
#24	3	5. Nearly bare and untilled, and alluvial valley fans	1.82	155.00	8,498.00	1.350	1.748
		8. Large gullies, diversions, and low flowing streams	0.84	40.00	4,771.00	2.740	0.483
#24	**3**	**Time of Concentration:**					**2.231**
#24	4	5. Nearly bare and untilled, and alluvial valley fans	1.24	50.00	4,042.00	1.110	1.011
		8. Large gullies, diversions, and low flowing streams	0.49	60.00	12,150.00	2.100	1.607
#24	**4**	**Time of Concentration:**					**2.618**

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#25	1	5. Nearly bare and untilled, and alluvial valley fans	0.51	10.00	1,950.00	0.710	0.762
		8. Large gullies, diversions, and low flowing streams	1.81	60.00	3,322.00	4.030	0.228
#25	**1**	**Time of Concentration:**					**0.990**
#25	2	5. Nearly bare and untilled, and alluvial valley fans	1.11	25.00	2,254.00	1.050	0.596
		8. Large gullies, diversions, and low flowing streams	2.36	75.00	3,178.00	4.600	0.191
#25	**2**	**Time of Concentration:**					**0.787**
#25	3	5. Nearly bare and untilled, and alluvial valley fans	3.23	30.00	929.00	1.790	0.144
		8. Large gullies, diversions, and low flowing streams	2.45	154.00	6,297.00	4.690	0.372
#25	**3**	**Time of Concentration:**					**0.516**
#26	1	5. Nearly bare and untilled, and alluvial valley fans	1.20	103.00	8,602.00	1.090	2.192
#26	**1**	**Time of Concentration:**					**2.192**
#26	2	5. Nearly bare and untilled, and alluvial valley fans	1.23	120.00	9,780.00	1.100	2.469
		8. Large gullies, diversions, and low flowing streams	2.18	184.00	8,454.00	4.420	0.531
#26	**2**	**Time of Concentration:**					**3.000**
#27	1	5. Nearly bare and untilled, and alluvial valley fans	4.32	50.00	1,158.02	2.070	0.155
		8. Large gullies, diversions, and low flowing streams	2.53	198.00	7,838.16	4.760	0.457
#27	**1**	**Time of Concentration:**					**0.612**
#27	2	5. Nearly bare and untilled, and alluvial valley fans	5.26	30.00	570.00	2.290	0.069
		8. Large gullies, diversions, and low flowing streams	3.15	278.00	8,822.00	5.320	0.460
#27	**2**	**Time of Concentration:**					**0.529**
#27	3	5. Nearly bare and untilled, and alluvial valley fans	16.33	80.00	490.00	4.040	0.033
		8. Large gullies, diversions, and low flowing streams	2.15	225.00	10,443.00	4.400	0.659
#27	**3**	**Time of Concentration:**					**0.692**
#27	4	5. Nearly bare and untilled, and alluvial valley fans	12.43	65.00	523.00	3.520	0.041
		8. Large gullies, diversions, and low flowing streams	3.49	225.00	6,454.00	5.600	0.320
#27	**4**	**Time of Concentration:**					**0.361**
#27	5	5. Nearly bare and untilled, and alluvial valley fans	9.40	25.00	266.00	3.060	0.024
		8. Large gullies, diversions, and low flowing streams	2.32	364.00	15,700.00	4.560	0.956
#27	**5**	**Time of Concentration:**					**0.980**

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#28	1	5. Nearly bare and untilled, and alluvial valley fans	5.25	40.00	762.00	2.290	0.092
		8. Large gullies, diversions, and low flowing streams	2.96	310.00	10,479.34	5.150	0.565
#28	**1**	**Time of Concentration:**					**0.657**
#28	2	5. Nearly bare and untilled, and alluvial valley fans	25.86	105.00	406.00	5.080	0.022
		8. Large gullies, diversions, and low flowing streams	2.96	310.00	10,479.34	5.150	0.565
#28	**2**	**Time of Concentration:**					**0.587**
#29	1	5. Nearly bare and untilled, and alluvial valley fans	11.58	30.00	259.00	3.400	0.021
		8. Large gullies, diversions, and low flowing streams	3.61	288.00	7,976.00	5.700	0.388
#29	**1**	**Time of Concentration:**					**0.409**
#29	2	5. Nearly bare and untilled, and alluvial valley fans	8.06	40.00	496.00	2.830	0.048
		8. Large gullies, diversions, and low flowing streams	2.90	252.00	8,693.55	5.100	0.473
#29	**2**	**Time of Concentration:**					**0.521**
#29	3	5. Nearly bare and untilled, and alluvial valley fans	7.25	25.00	345.00	2.690	0.035
		8. Large gullies, diversions, and low flowing streams	2.26	158.00	7,001.00	4.500	0.432
#29	**3**	**Time of Concentration:**					**0.467**
#30	1	5. Nearly bare and untilled, and alluvial valley fans	4.93	35.00	710.00	2.220	0.088
		8. Large gullies, diversions, and low flowing streams	1.67	243.00	14,540.00	3.870	1.043
#30	**1**	**Time of Concentration:**					**1.131**
#31	1	5. Nearly bare and untilled, and alluvial valley fans	2.91	15.00	515.00	1.700	0.084
		8. Large gullies, diversions, and low flowing streams	2.74	247.00	9,006.00	4.960	0.504
#31	**1**	**Time of Concentration:**					**0.588**
#31	2	5. Nearly bare and untilled, and alluvial valley fans	7.46	25.00	335.00	2.730	0.034
		8. Large gullies, diversions, and low flowing streams	2.18	138.00	6,335.00	4.420	0.398
#31	**2**	**Time of Concentration:**					**0.432**
#31	3	5. Nearly bare and untilled, and alluvial valley fans	3.84	20.00	521.00	1.950	0.074
		8. Large gullies, diversions, and low flowing streams	2.24	108.00	4,826.00	4.480	0.299
#31	**3**	**Time of Concentration:**					**0.373**
#32	1	5. Nearly bare and untilled, and alluvial valley fans	3.48	22.00	632.00	1.860	0.094
		8. Large gullies, diversions, and low flowing streams	1.56	101.00	6,494.00	3.740	0.482

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#32	**1**	**Time of Concentration:**					**0.576**
#34	1	5. Nearly bare and untilled, and alluvial valley fans	3.21	25.00	779.00	1.790	0.120
		8. Large gullies, diversions, and low flowing streams	2.80	63.00	2,251.00	5.010	0.124
#34	**1**	**Time of Concentration:**					**0.244**
#34	2	5. Nearly bare and untilled, and alluvial valley fans	5.75	40.00	696.00	2.390	0.080
		8. Large gullies, diversions, and low flowing streams	23.00	2,100.00	9,130.43	14.380	0.176
#34	**2**	**Time of Concentration:**					**0.256**
#34	3	5. Nearly bare and untilled, and alluvial valley fans	2.67	40.00	1,500.00	1.630	0.255
		8. Large gullies, diversions, and low flowing streams	1.28	98.00	7,675.00	3.380	0.630
#34	**3**	**Time of Concentration:**					**0.885**
#36	1	5. Nearly bare and untilled, and alluvial valley fans	3.21	105.00	3,274.00	1.790	0.508
		8. Large gullies, diversions, and low flowing streams	0.21	5.00	2,367.00	1.370	0.479
#36	**1**	**Time of Concentration:**					**0.987**
#36	2	5. Nearly bare and untilled, and alluvial valley fans	5.50	140.00	2,547.00	2.340	0.302
		8. Large gullies, diversions, and low flowing streams	1.58	30.00	1,897.00	3.770	0.139
#36	**2**	**Time of Concentration:**					**0.441**
#36	3	5. Nearly bare and untilled, and alluvial valley fans	2.03	80.00	3,938.62	1.420	0.770
		8. Large gullies, diversions, and low flowing streams	2.52	50.00	1,981.86	4.760	0.115
#36	**3**	**Time of Concentration:**					**0.885**
#37	1	5. Nearly bare and untilled, and alluvial valley fans	4.68	129.00	2,754.05	2.160	0.354
		8. Large gullies, diversions, and low flowing streams	0.16	10.00	6,108.73	1.210	1.402
#37	**1**	**Time of Concentration:**					**1.756**
#37	2	5. Nearly bare and untilled, and alluvial valley fans	7.32	90.00	1,229.00	2.700	0.126
		8. Large gullies, diversions, and low flowing streams	1.62	70.00	4,309.01	3.820	0.313
#37	**2**	**Time of Concentration:**					**0.439**
#37	3	5. Nearly bare and untilled, and alluvial valley fans	8.10	100.00	1,234.00	2.840	0.120
		8. Large gullies, diversions, and low flowing streams	2.66	100.00	3,763.21	4.890	0.213
#37	**3**	**Time of Concentration:**					**0.333**
#37	4	5. Nearly bare and untilled, and alluvial valley fans	5.09	90.00	1,768.03	2.250	0.218

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
		8. Large gullies, diversions, and low flowing streams	0.36	30.00	8,326.39	1.800	1.284
#37	**4**	**Time of Concentration:**					**1.502**
#37	5	5. Nearly bare and untilled, and alluvial valley fans	0.81	20.00	2,466.09	0.900	0.761
		8. Large gullies, diversions, and low flowing streams	4.06	50.00	1,231.01	6.040	0.056
#37	**5**	**Time of Concentration:**					**0.817**

Subwatershed Muskingum Routing Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#1	2	8. Large gullies, diversions, and low flowing streams	1.29	107.00	8,294.00	3.400	0.677
#1	**2**	**Muskingum K:**					**0.677**
#1	3	8. Large gullies, diversions, and low flowing streams	1.27	113.00	8,880.00	3.380	0.729
#1	**3**	**Muskingum K:**					**0.729**
#1	4	8. Large gullies, diversions, and low flowing streams	1.35	171.00	12,634.00	3.490	1.005
#1	**4**	**Muskingum K:**					**1.005**
#1	5	8. Large gullies, diversions, and low flowing streams	1.49	274.00	18,349.00	3.660	1.392
#1	**5**	**Muskingum K:**					**1.392**
#1	6	8. Large gullies, diversions, and low flowing streams	1.49	274.00	18,349.00	3.660	1.392
#1	**6**	**Muskingum K:**					**1.392**
#2	2	8. Large gullies, diversions, and low flowing streams	0.53	20.00	3,756.00	2.180	0.478
#2	**2**	**Muskingum K:**					**0.478**
#2	3	8. Large gullies, diversions, and low flowing streams	0.55	25.00	4,570.00	2.210	0.574
#2	**3**	**Muskingum K:**					**0.574**
#2	4	8. Large gullies, diversions, and low flowing streams	0.55	25.00	4,570.00	2.210	0.574
#2	**4**	**Muskingum K:**					**0.574**
#2	5	8. Large gullies, diversions, and low flowing streams	0.65	45.00	6,955.00	2.410	0.801
#2	**5**	**Muskingum K:**					**0.801**
#3	3	8. Large gullies, diversions, and low flowing streams	0.92	20.00	2,168.00	2.880	0.209
#3	**3**	**Muskingum K:**					**0.209**
#5	1	8. Large gullies, diversions, and low flowing streams	0.00	0.00	0.00	0.000	0.000
#5	**1**	**Muskingum K:**					**0.000**

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#5	2	8. Large gullies, diversions, and low flowing streams	1.75	125.00	7,149.00	3.960	0.501
#5	**2**	**Muskingum K:**					**0.501**
#5	3	8. Large gullies, diversions, and low flowing streams	1.65	155.00	9,418.00	3.840	0.681
#5	**3**	**Muskingum K:**					**0.681**
#5	4	8. Large gullies, diversions, and low flowing streams	1.65	155.00	9,418.00	3.840	0.681
#5	**4**	**Muskingum K:**					**0.681**
#5	5	8. Large gullies, diversions, and low flowing streams	1.67	239.00	14,273.00	3.880	1.021
#5	**5**	**Muskingum K:**					**1.021**
#5	6	8. Large gullies, diversions, and low flowing streams	1.68	239.00	14,223.00	3.880	1.018
#5	**6**	**Muskingum K:**					**1.018**
#6	2	8. Large gullies, diversions, and low flowing streams	1.16	26.00	2,241.00	3.230	0.192
#6	**2**	**Muskingum K:**					**0.192**
#6	3	8. Large gullies, diversions, and low flowing streams	1.00	50.00	4,987.00	3.000	0.461
#6	**3**	**Muskingum K:**					**0.461**
#6	4	5. Nearly bare and untilled, and alluvial valley fans	1.00	50.00	4,987.00	1.000	1.385
#6	**4**	**Muskingum K:**					**1.385**
#6	5	8. Large gullies, diversions, and low flowing streams	1.02	89.00	8,685.00	3.030	0.796
#6	**5**	**Muskingum K:**					**0.796**
#6	6	8. Large gullies, diversions, and low flowing streams	1.06	126.00	11,860.00	3.090	1.066
#6	**6**	**Muskingum K:**					**1.066**
#6	7	8. Large gullies, diversions, and low flowing streams	1.06	126.00	11,860.00	3.090	1.066
#6	**7**	**Muskingum K:**					**1.066**
#7	1	8. Large gullies, diversions, and low flowing streams	0.00	0.00	0.00	0.000	0.000
#7	**1**	**Muskingum K:**					**0.000**
#7	2	8. Large gullies, diversions, and low flowing streams	0.00	0.00	0.00	0.000	0.000
#7	**2**	**Muskingum K:**					**0.000**
#7	4	8. Large gullies, diversions, and low flowing streams	1.16	140.00	12,037.00	3.230	1.035
#7	**4**	**Muskingum K:**					**1.035**
#7	5	8. Large gullies, diversions, and low flowing streams	1.14	140.00	12,307.69	3.190	1.071
#7	**5**	**Muskingum K:**					**1.071**
#7	6	8. Large gullies, diversions, and low flowing streams	1.17	158.00	13,546.00	3.230	1.164
#7	**6**	**Muskingum K:**					**1.164**

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#7	7	8. Large gullies, diversions, and low flowing streams	1.18	187.00	15,784.00	3.260	1.344
#7	**7**	**Muskingum K:**					**1.344**
#7	8	8. Large gullies, diversions, and low flowing streams	1.18	187.00	15,784.00	3.260	1.344
#7	**8**	**Muskingum K:**					**1.344**
#10	3	8. Large gullies, diversions, and low flowing streams	0.76	37.00	4,861.00	2.610	0.517
#10	**3**	**Muskingum K:**					**0.517**
#10	4	8. Large gullies, diversions, and low flowing streams	0.76	37.00	4,861.00	2.610	0.517
#10	**4**	**Muskingum K:**					**0.517**
#10	5	8. Large gullies, diversions, and low flowing streams	0.79	47.00	5,956.00	2.660	0.621
#10	**5**	**Muskingum K:**					**0.621**
#12	2	8. Large gullies, diversions, and low flowing streams	8.24	111.00	1,347.00	8.610	0.043
#12	**2**	**Muskingum K:**					**0.043**
#12	3	8. Large gullies, diversions, and low flowing streams	8.01	109.00	1,360.00	8.490	0.044
#12	**3**	**Muskingum K:**					**0.044**
#12	4	8. Large gullies, diversions, and low flowing streams	2.24	176.00	7,866.00	4.480	0.487
#12	**4**	**Muskingum K:**					**0.487**
#12	5	8. Large gullies, diversions, and low flowing streams	2.24	176.00	7,866.00	4.480	0.487
#12	**5**	**Muskingum K:**					**0.487**
#13	2	8. Large gullies, diversions, and low flowing streams	1.34	54.00	4,025.00	3.470	0.322
#13	**2**	**Muskingum K:**					**0.322**
#13	3	8. Large gullies, diversions, and low flowing streams	0.98	72.00	7,333.00	2.970	0.685
#13	**3**	**Muskingum K:**					**0.685**
#13	4	8. Large gullies, diversions, and low flowing streams	1.18	127.00	10,806.00	3.250	0.923
#13	**4**	**Muskingum K:**					**0.923**
#13	5	8. Large gullies, diversions, and low flowing streams	1.18	127.00	10,806.00	3.250	0.923
#13	**5**	**Muskingum K:**					**0.923**
#14	1	8. Large gullies, diversions, and low flowing streams	0.00	0.00	0.00	0.000	0.000
#14	**1**	**Muskingum K:**					**0.000**
#14	2	8. Large gullies, diversions, and low flowing streams	0.83	58.00	6,957.00	2.730	0.707
#14	**2**	**Muskingum K:**					**0.707**
#14	3	8. Large gullies, diversions, and low flowing streams	0.81	77.00	9,480.00	2.700	0.975
#14	**3**	**Muskingum K:**					**0.975**

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#14	4	8. Large gullies, diversions, and low flowing streams	0.86	147.00	17,117.00	2.770	1.716
#14	**4**	**Muskingum K:**					**1.716**
#14	5	8. Large gullies, diversions, and low flowing streams	0.88	175.00	19,934.00	2.810	1.970
#14	**5**	**Muskingum K:**					**1.970**
#14	6	8. Large gullies, diversions, and low flowing streams	0.95	211.00	22,155.00	2.920	2.107
#14	**6**	**Muskingum K:**					**2.107**
#14	7	8. Large gullies, diversions, and low flowing streams	0.96	257.00	26,835.00	2.930	2.544
#14	**7**	**Muskingum K:**					**2.544**
#14	8	8. Large gullies, diversions, and low flowing streams	0.96	257.00	26,835.00	2.930	2.544
#14	**8**	**Muskingum K:**					**2.544**
#14	9	8. Large gullies, diversions, and low flowing streams	0.95	307.00	32,146.59	2.930	3.047
#14	**9**	**Muskingum K:**					**3.047**
#14	10	8. Large gullies, diversions, and low flowing streams	0.96	339.00	35,382.00	2.930	3.354
#14	**10**	**Muskingum K:**					**3.354**
#15	1	8. Large gullies, diversions, and low flowing streams	0.00	0.00	0.00	0.000	0.000
#15	**1**	**Muskingum K:**					**0.000**
#15	2	8. Large gullies, diversions, and low flowing streams	1.14	86.00	7,535.00	3.200	0.654
#15	**2**	**Muskingum K:**					**0.654**
#15	3	8. Large gullies, diversions, and low flowing streams	1.25	115.00	9,236.00	3.340	0.768
#15	**3**	**Muskingum K:**					**0.768**
#16	2	8. Large gullies, diversions, and low flowing streams	0.58	24.00	4,161.00	2.270	0.509
#16	**2**	**Muskingum K:**					**0.509**
#16	3	8. Large gullies, diversions, and low flowing streams	0.51	37.00	7,269.00	2.140	0.943
#16	**3**	**Muskingum K:**					**0.943**
#17	1	8. Large gullies, diversions, and low flowing streams	0.00	0.00	0.00	0.000	0.000
#17	**1**	**Muskingum K:**					**0.000**
#18	1	8. Large gullies, diversions, and low flowing streams	0.00	0.00	0.00	0.000	0.000
#18	**1**	**Muskingum K:**					**0.000**
#18	2	8. Large gullies, diversions, and low flowing streams	1.02	62.00	6,103.00	3.020	0.561
#18	**2**	**Muskingum K:**					**0.561**
#20	2	8. Large gullies, diversions, and low flowing streams	17.00	3,605.00	21,205.88	12.360	0.476
#20	**2**	**Muskingum K:**					**0.476**

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#21	1	8. Large gullies, diversions, and low flowing streams	0.00	0.00	0.00	0.000	0.000
#21	**1**	**Muskingum K:**					**0.000**
#21	2	8. Large gullies, diversions, and low flowing streams	0.41	20.00	4,824.00	1.930	0.694
#21	**2**	**Muskingum K:**					**0.694**
#21	3	8. Large gullies, diversions, and low flowing streams	0.36	20.00	5,626.00	1.780	0.877
#21	**3**	**Muskingum K:**					**0.877**
#21	4	8. Large gullies, diversions, and low flowing streams	0.36	20.00	5,626.00	1.780	0.877
#21	**4**	**Muskingum K:**					**0.877**
#23	1	8. Large gullies, diversions, and low flowing streams	0.00	0.00	0.00	0.000	0.000
#23	**1**	**Muskingum K:**					**0.000**
#23	2	8. Large gullies, diversions, and low flowing streams	0.63	30.00	4,771.75	2.370	0.559
#23	**2**	**Muskingum K:**					**0.559**
#24	1	8. Large gullies, diversions, and low flowing streams	0.79	180.00	22,769.00	2.660	2.377
#24	**1**	**Muskingum K:**					**2.377**
#24	2	8. Large gullies, diversions, and low flowing streams	0.78	180.00	23,111.00	2.640	2.431
#24	**2**	**Muskingum K:**					**2.431**
#24	4	8. Large gullies, diversions, and low flowing streams	0.00	0.00	0.00	0.000	0.000
#24	**4**	**Muskingum K:**					**0.000**
#25	1	8. Large gullies, diversions, and low flowing streams	1.99	104.00	5,220.00	4.230	0.342
#25	**1**	**Muskingum K:**					**0.342**
#25	2	8. Large gullies, diversions, and low flowing streams	1.99	104.00	5,220.00	4.230	0.342
#25	**2**	**Muskingum K:**					**0.342**
#25	3	8. Large gullies, diversions, and low flowing streams	0.00	0.00	0.00	0.000	0.000
#25	**3**	**Muskingum K:**					**0.000**
#27	1	8. Large gullies, diversions, and low flowing streams	1.38	216.00	15,629.00	3.520	1.233
#27	**1**	**Muskingum K:**					**1.233**
#27	2	8. Large gullies, diversions, and low flowing streams	1.17	144.00	12,301.00	3.240	1.054
#27	**2**	**Muskingum K:**					**1.054**
#27	3	8. Large gullies, diversions, and low flowing streams	1.18	76.00	6,454.00	3.250	0.551
#27	**3**	**Muskingum K:**					**0.551**
#27	4	8. Large gullies, diversions, and low flowing streams	1.18	76.00	6,454.00	3.250	0.551
#27	**4**	**Muskingum K:**					**0.551**

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#28	1	8. Large gullies, diversions, and low flowing streams	1.30	84.00	6,445.17	3.420	0.523
#28	**1**	**Muskingum K:**					**0.523**
#29	1	8. Large gullies, diversions, and low flowing streams	0.88	37.00	4,210.00	2.810	0.416
#29	**1**	**Muskingum K:**					**0.416**
#29	2	8. Large gullies, diversions, and low flowing streams	0.88	26.00	2,949.00	2.810	0.291
#29	**2**	**Muskingum K:**					**0.291**
#31	1	8. Large gullies, diversions, and low flowing streams	1.35	76.00	5,639.00	3.480	0.450
#31	**1**	**Muskingum K:**					**0.450**
#31	2	8. Large gullies, diversions, and low flowing streams	1.15	20.00	1,734.00	3.220	0.149
#31	**2**	**Muskingum K:**					**0.149**
#34	1	8. Large gullies, diversions, and low flowing streams	0.73	65.00	8,900.00	2.560	0.965
#34	**1**	**Muskingum K:**					**0.965**
#34	2	8. Large gullies, diversions, and low flowing streams	0.73	65.00	8,900.00	2.560	0.965
#34	**2**	**Muskingum K:**					**0.965**
#36	3	8. Large gullies, diversions, and low flowing streams	2.71	80.00	2,957.00	4.930	0.166
#36	**3**	**Muskingum K:**					**0.166**
#37	2	8. Large gullies, diversions, and low flowing streams	0.29	30.00	10,319.91	1.610	1.780
#37	**2**	**Muskingum K:**					**1.780**
#37	3	8. Large gullies, diversions, and low flowing streams	0.31	30.00	9,800.71	1.650	1.649
#37	**3**	**Muskingum K:**					**1.649**
#37	4	8. Large gullies, diversions, and low flowing streams	0.29	30.00	10,319.91	1.610	1.780
#37	**4**	**Muskingum K:**					**1.780**
#37	5	8. Large gullies, diversions, and low flowing streams	0.56	100.00	17,956.54	2.230	2.236
#37	**5**	**Muskingum K:**					**2.236**

General Information

Storm Information:

Storm Type:	Type II-60
Design Storm:	10 yr - 6 hr
Rainfall Depth:	1.300 inches

Particle Size Distribution:

Size (mm)	PostMine-LoamySand	PreMine-LoamySand	PreMine-Badlands	LoamySand Postmining
2.0000	100.000%	100.000%	100.000%	0.000%
0.1000	26.500%	30.000%	83.500%	0.000%
0.0500	14.000%	17.000%	77.000%	0.000%
0.0020	11.000%	11.000%	56.000%	0.000%
0.0010	0.000%	0.000%	0.000%	0.000%

Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc. (ml/l)	24VW (ml/l)
#30	476.400	476.400	12.85	2.37	14.2	5,823	2.63	1.99
#28	1,217.900	1,217.900	348.89	44.53	2,235.4	51,499	0.14	0.10
#26	2,486.400	2,486.400	65.87	20.75	120.8	5,583	1.83	1.40
#24	8,061.800	8,061.800	94.58	59.06	203.0	3,780	0.64	0.43
#25	1,015.700	9,077.500	103.41	74.45	286.7	13,375	3.76	0.80
#27	1,783.700	13,347.600	236.67	122.48	960.5	24,353	10.74	2.54
#29	966.000	15,531.500	535.73	201.59	5,382.3	61,965	5.75	1.80
#32	293.700	16,301.600	553.89	217.52	5,815.1	55,468	2.48	0.87
#31	957.100	957.100	333.75	41.62	1,654.1	37,577	0.51	0.39
#33	0.000	17,258.700	646.50	259.13	7,469.2	47,241	1.78	0.79
#34	932.500	18,191.200	673.81	291.44	7,139.8	39,505	0.08	0.03
#5	2,023.000	2,023.000	506.93	59.77	1,630.2	37,031	3.51	1.88
#6	1,743.200	3,766.200	630.69	115.88	3,138.3	32,912	0.18	0.11
#7	2,395.300	6,161.500	1,047.30	222.75	8,489.7	41,428	0.00	0.00
#8	0.000	6,161.500	1,047.30	222.75	8,489.7	41,428	0.00	0.00
#10	1,053.200	7,214.700	1,090.14	261.44	8,415.3	37,733	0.09	0.06
#1	2,411.100	2,411.100	349.94	55.56	1,695.8	33,350	4.70	3.13
#2	1,497.000	3,908.100	424.36	116.70	2,361.2	21,959	0.16	0.11
#3	862.700	4,770.800	559.86	145.57	2,728.8	17,946	0.05	0.04
#4	0.000	4,770.800	559.86	145.57	2,728.8	17,946	0.05	0.04
#9	425.500	5,196.300	582.11	161.54	2,763.7	15,917	0.00	0.00
#11	0.000	12,411.000	1,509.13	422.98	11,178.9	31,017	0.06	0.04
#21	1,080.800	13,491.800	1,551.27	454.62	11,229.3	30,029	0.02	0.01
#18	848.500	848.500	169.02	27.56	312.0	12,741	0.08	0.05
#17	182.200	182.200	108.99	8.41	110.0	13,892	0.66	0.46
#19	0.000	1,030.700	255.08	35.96	422.0	11,926	0.20	0.14
#15	1,992.700	1,992.700	386.36	60.50	2,083.2	40,738	1.65	1.01
#12	3,494.500	3,494.500	193.05	40.14	518.1	13,885	6.21	4.23
#13	2,720.700	6,215.200	371.99	71.83	1,125.3	16,885	8.41	5.71
#14	5,096.800	11,312.000	509.48	208.73	4,412.1	73,888	1.32	0.27
#16	876.500	14,181.200	826.28	308.99	7,823.8	48,939	1.39	0.52
#20	681.900	15,893.800	880.92	374.91	8,627.8	37,115	0.74	0.33
#22	0.000	29,385.600	2,341.22	829.53	19,857.1	31,245	0.28	0.16
#23	752.900	30,138.500	2,329.13	849.99	19,615.8	30,259	0.00	0.00
#35	0.000	48,329.700	2,891.62	1,141.43	26,755.6	28,682	0.01	0.01
#36	730.590	49,060.290	2,879.45	1,156.16	26,828.2	32,691	0.01	0.01
#37	2,208.500	51,268.790	2,841.60	1,203.14	26,816.0	28,166	0.22	0.13

General Information

Storm Information:

Storm Type:	Type II-60
Design Storm:	25 yr - 6 hr
Rainfall Depth:	1.600 inches

Particle Size Distribution:

Size (mm)	PostMine-LoamySand	PreMine-LoamySand	PreMine-Badlands	LoamySand Postmining
2.0000	100.000%	100.000%	100.000%	0.000%
0.1000	26.500%	30.000%	83.500%	0.000%
0.0500	14.000%	17.000%	77.000%	0.000%
0.0020	11.000%	11.000%	56.000%	0.000%
0.0010	0.000%	0.000%	0.000%	0.000%

Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc. (ml/l)	24VW (ml/l)
#30	476.400	476.400	30.89	5.19	36.1	6,848	3.20	2.38
#28	1,217.900	1,217.900	503.94	63.61	3,353.7	53,603	0.44	0.31
#26	2,486.400	2,486.400	129.71	39.61	252.2	6,132	2.13	1.63
#24	8,061.800	8,061.800	187.84	116.49	438.7	4,231	0.75	0.49
#25	1,015.700	9,077.500	192.60	142.05	565.2	13,913	3.62	0.76
#27	1,783.700	13,347.600	390.94	227.10	1,814.3	26,321	11.54	2.57
#29	966.000	15,531.500	811.81	340.27	8,464.1	64,471	7.33	2.05
#32	293.700	16,301.600	841.49	364.08	9,178.5	57,790	4.40	1.40
#31	957.100	957.100	468.62	57.72	2,405.5	38,963	0.70	0.54
#33	0.000	17,258.700	933.80	421.80	11,584.0	49,667	3.18	1.28
#34	932.500	18,191.200	970.74	468.31	11,094.0	41,995	0.16	0.06
#5	2,023.000	2,023.000	759.22	88.30	2,575.9	39,084	4.33	2.35
#6	1,743.200	3,766.200	937.84	170.00	4,873.0	34,451	0.20	0.12
#7	2,395.300	6,161.500	1,511.91	317.58	12,625.5	43,159	0.00	0.00
#8	0.000	6,161.500	1,511.91	317.58	12,625.5	43,159	0.00	0.00
#10	1,053.200	7,214.700	1,570.05	372.35	12,524.8	39,453	0.12	0.07
#1	2,411.100	2,411.100	539.70	85.33	2,707.2	34,591	5.44	3.63
#2	1,497.000	3,908.100	639.70	170.84	3,692.2	22,950	0.17	0.12
#3	862.700	4,770.800	796.58	212.60	4,101.8	17,905	0.05	0.04
#4	0.000	4,770.800	796.58	212.60	4,101.8	17,905	0.05	0.04
#9	425.500	5,196.300	828.60	235.31	4,152.0	16,461	0.00	0.00
#11	0.000	12,411.000	2,176.63	607.66	16,676.8	32,376	0.07	0.05
#21	1,080.800	13,491.800	2,235.06	654.51	16,746.8	31,156	0.03	0.02
#18	848.500	848.500	254.46	39.93	510.1	14,524	0.14	0.09
#17	182.200	182.200	150.01	11.54	157.1	14,384	0.80	0.55
#19	0.000	1,030.700	355.05	51.47	667.3	13,576	0.27	0.19
#15	1,992.700	1,992.700	573.85	88.69	3,170.2	42,664	2.31	1.40
#12	3,494.500	3,494.500	342.58	71.01	983.8	14,979	6.87	4.65
#13	2,720.700	6,215.200	652.52	126.55	2,108.3	17,849	9.04	6.17
#14	5,096.800	11,312.000	855.51	331.51	7,120.7	78,733	2.33	0.46
#16	876.500	14,181.200	1,197.97	474.97	12,195.1	52,354	2.06	0.73
#20	681.900	15,893.800	1,271.46	567.91	13,409.7	39,944	1.24	0.53
#22	0.000	29,385.600	3,381.04	1,222.43	30,156.4	32,772	0.47	0.26
#23	752.900	30,138.500	3,362.72	1,253.09	29,810.4	31,775	0.08	0.05
#35	0.000	48,329.700	4,201.38	1,721.40	40,904.4	29,996	0.09	0.05
#36	730.590	49,060.290	4,182.58	1,744.59	41,011.3	33,567	0.02	0.01
#37	2,208.500	51,268.790	4,121.09	1,818.24	40,933.4	30,075	0.28	0.15

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General Information

Storm Information:

Storm Type:	Type II-60
Design Storm:	100 yr - 6 hr
Rainfall Depth:	2.000 inches

Particle Size Distribution:

Size (mm)	PostMine-LoamySand	PreMine-LoamySand	PreMine-Badlands	LoamySand Postmining
2.0000	100.000%	100.000%	100.000%	0.000%
0.1000	26.500%	30.000%	83.500%	0.000%
0.0500	14.000%	17.000%	77.000%	0.000%
0.0020	11.000%	11.000%	56.000%	0.000%
0.0010	0.000%	0.000%	0.000%	0.000%

Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc. (ml/l)	24VW (ml/l)
#30	476.400	476.400	65.84	10.21	80.6	7,897	3.88	2.84
#28	1,217.900	1,217.900	724.22	90.75	5,014.7	55,579	0.74	0.53
#26	2,486.400	2,486.400	239.85	71.16	491.1	6,676	2.47	1.87
#24	8,061.800	8,061.800	347.67	214.00	875.6	4,680	0.88	0.57
#25	1,015.700	9,077.500	355.36	255.52	1,084.6	14,498	3.70	0.80
#27	1,783.700	13,347.600	632.57	400.49	3,310.4	27,999	12.29	2.66
#29	966.000	15,531.500	1,224.41	562.17	13,267.6	67,394	9.00	2.29
#32	293.700	16,301.600	1,271.84	598.03	14,429.8	60,085	6.29	1.84
#31	957.100	957.100	658.11	80.24	3,502.4	40,447	0.93	0.73
#33	0.000	17,258.700	1,380.10	678.27	17,932.2	51,948	4.61	1.71
#34	932.500	18,191.200	1,400.95	745.11	17,024.5	43,308	0.74	0.29
#5	2,023.000	2,023.000	1,134.33	129.85	4,047.1	40,903	5.32	2.95
#6	1,743.200	3,766.200	1,388.71	248.47	7,527.5	36,069	0.30	0.18
#7	2,395.300	6,161.500	2,178.26	452.80	18,760.6	44,925	0.00	0.00
#8	0.000	6,161.500	2,178.26	452.80	18,760.6	44,925	0.00	0.00
#10	1,053.200	7,214.700	2,258.75	530.48	18,793.8	41,539	0.16	0.10
#1	2,411.100	2,411.100	823.47	129.88	4,276.8	35,752	6.14	4.11
#2	1,497.000	3,908.100	957.23	249.69	5,734.6	23,757	0.18	0.13
#3	862.700	4,770.800	1,132.66	309.97	6,206.0	18,918	0.06	0.05
#4	0.000	4,770.800	1,132.66	309.97	6,206.0	18,918	0.06	0.05
#9	425.500	5,196.300	1,179.29	342.25	6,277.3	17,458	0.00	0.00
#11	0.000	12,411.000	3,137.48	872.73	25,071.1	34,011	0.10	0.06
#21	1,080.800	13,491.800	3,219.23	941.73	25,165.8	32,434	0.03	0.02
#18	848.500	848.500	380.92	57.77	823.4	16,272	0.19	0.12
#17	182.200	182.200	206.29	15.91	224.8	14,878	0.93	0.64
#19	0.000	1,030.700	494.85	73.68	1,048.2	15,219	0.34	0.23
#15	1,992.700	1,992.700	849.14	129.64	4,812.3	44,608	3.06	1.85
#12	3,494.500	3,494.500	584.36	120.82	1,787.9	16,061	7.55	5.09
#13	2,720.700	6,215.200	1,103.87	214.86	3,780.1	18,686	9.62	6.62
#14	5,096.800	11,312.000	1,402.27	519.98	11,403.3	82,900	4.66	0.89
#16	876.500	14,181.200	1,733.22	725.28	18,947.3	55,490	3.31	1.13
#20	681.900	15,893.800	1,832.17	856.51	20,783.5	42,612	2.15	0.89
#22	0.000	29,385.600	4,878.63	1,798.24	45,949.4	34,369	0.80	0.44
#23	752.900	30,138.500	4,851.70	1,843.91	45,442.9	33,353	0.32	0.17
#35	0.000	48,329.700	6,100.87	2,589.01	62,467.4	31,240	0.36	0.21
#36	730.590	49,060.290	6,071.91	2,625.03	62,622.7	34,666	0.27	0.13
#37	2,208.500	51,268.790	5,977.12	2,738.89	62,441.9	31,125	0.32	0.17

Appendix 18.M

Chaco and Pinabete Tributaries Pre-mine Hydrology and Sedimentology

SEDCAD + Files

(2 YR-6 HR, 10 YR-6 HR and 100 YR-6 HR Storm Events)

Tributary A to the Chaco Wash

Pre-mine Hydrology and Sedimentology

The drainage subdivisions used to model the hydrology is presented on Exhibit 7-4.

Revised Feb2011

LR / RY

BHP Billiton
Navajo Mine
PO Box 1717
Fruitland, NM 87416

Phone: 505 598 2007

Structure Networking:

Type	Stru #	(flows into)	Stru #	Musk. K (hrs)	Musk. X	Description
Null	#1	==>	End	0.000	0.000	Tributary A to Chaco

Particle Size Distribution(s) at Each Structure

Structure #1:

Size (mm)	In/Out
2.0000	100.000%
0.1000	82.737%
0.0500	46.884%
0.0020	30.337%
0.0010	0.000%

Subwatershed Hydrology Detail:

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
#1	1	456.280	1.570	0.000	0.000	78.400	M	2.53	0.625
	Σ	**456.280**						**2.53**	**0.625**

Subwatershed Sedimentology Detail:

Stru #	SWS #	Soil K	L (ft)	S (%)	C	P	PS #	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc (ml/l)	24VW (ml/l)
#1	1	0.151	200.00	3.48	0.3870	1.0000	2	4.1	6,170	2.99	2.35
	Σ							**4.1**	**6,170**	**2.99**	**2.35**

Subwatershed Time of Concentration Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#1	1	5. Nearly bare and untilled, and alluvial valley fans	1.33	80.00	6,028.18	1.150	1.456
		8. Large gullies, diversions, and low flowing streams	2.00	35.00	1,752.01	4.240	0.114
#1	**1**	**Time of Concentration:**					**1.570**

Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc. (ml/l)	24VW (ml/l)
#1	456.280	456.280	24.01	4.85	46.0	9,274	4.03	3.03

Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc. (ml/l)	24VW (ml/l)
#1	456.280	456.280	45.58	8.76	91.7	10,334	4.71	3.50

Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc. (ml/l)	24VW (ml/l)
#1	456.280	456.280	82.07	15.12	173.0	11,391	5.41	3.98

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Tributary B to the Pinabete Arroyo

Pre-mine Hydrology and Sedimentology

The drainage subdivisions used to model the hydrology is presented on Exhibit 7-4.

LR

BHP Navajo Coal Company
PO Box 1717
Fruitland, NM 87416

Phone: 505-598-5861

General Information

Storm Information:

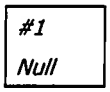
Storm Type:	NRCS Type II - 60
Design Storm:	2 yr - 6 hr
Rainfall Depth:	0.800 inches

Particle Size Distribution:

Size (mm)	PostMine-LoamySand	PreMine-LoamySand	PreMine-Badlands	LoamySand Postmining
2.0000	100.000%	100.000%	100.000%	0.000%
0.1000	26.500%	30.000%	83.500%	0.000%
0.0500	14.000%	17.000%	77.000%	0.000%
0.0020	11.000%	11.000%	56.000%	0.000%
0.0010	0.000%	0.000%	0.000%	0.000%

Structure Networking:

Type	Stru #	(flows into)	Stru #	Musk. K (hrs)	Musk. X	Description
Null	#1	==>	End	0.000	0.000	Tributary B to Pinabete



Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc. (ml/l)	24VW (ml/l)
#1	475.900	475.900	38.39	5.40	72.0	17,346	0.00	0.00

Particle Size Distribution(s) at Each Structure

Structure #1:

Size (mm)	In/Out
2.0000	100.000%
0.1000	100.000%
0.0500	100.000%
0.0020	100.000%
0.0010	0.000%

Subwatershed Hydrology Detail:

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
#1	1	475.900	0.696	0.000	0.000	87.500	M	38.39	5.399
	Σ	**475.900**						**38.39**	**5.399**

Subwatershed Sedimentology Detail:

Stru #	SWS #	Soil K	L (ft)	S (%)	C	P	PS #	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc (ml/l)	24VW (ml/l)
#1	1	0.179	175.00	5.33	0.2460	1.0000	3	72.0	17,346	0.00	0.00
	Σ							**72.0**	**17,346**	**0.00**	**0.00**

Subwatershed Time of Concentration Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#1	1	5. Nearly bare and untilled, and alluvial valley fans	5.18	65.00	1,255.02	2.270	0.153
		8. Large gullies, diversions, and low flowing streams	1.13	70.00	6,219.45	3.180	0.543
#1	**1**	**Time of Concentration:**					**0.696**

General Information

Storm Information:

Storm Type:	NRCS Type II - 60
Design Storm:	10 yr - 6 hr
Rainfall Depth:	1.300 inches

Particle Size Distribution:

Size (mm)	PostMine-LoamySand	PreMine-LoamySand	PreMine-Badlands	LoamySand Postmining
2.0000	100.000%	100.000%	100.000%	0.000%
0.1000	26.500%	30.000%	83.500%	0.000%
0.0500	14.000%	17.000%	77.000%	0.000%
0.0020	11.000%	11.000%	56.000%	0.000%
0.0010	0.000%	0.000%	0.000%	0.000%

Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc. (ml/l)	24VW (ml/l)
#1	475.900	475.900	130.23	16.70	268.6	20,996	0.00	0.00

General Information

Storm Information:

Storm Type:	NRCS Type II - 60
Design Storm:	25 yr - 6 hr
Rainfall Depth:	1.600 inches

Particle Size Distribution:

Size (mm)	PostMine-LoamySand	PreMine-LoamySand	PreMine-Badlands	LoamySand Postmining
2.0000	100.000%	100.000%	100.000%	0.000%
0.1000	26.500%	30.000%	83.500%	0.000%
0.0500	14.000%	17.000%	77.000%	0.000%
0.0020	11.000%	11.000%	56.000%	0.000%
0.0010	0.000%	0.000%	0.000%	0.000%

Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc. (ml/l)	24VW (ml/l)
#1	475.900	475.900	198.79	24.98	426.5	22,253	0.00	0.00

General Information

Storm Information:

Storm Type:	NRCS Type II - 60
Design Storm:	100 yr - 6 hr
Rainfall Depth:	2.000 inches

Particle Size Distribution:

Size (mm)	PostMine-LoamySand	PreMine-LoamySand	PreMine-Badlands	LoamySand Postmining
2.0000	100.000%	100.000%	100.000%	0.000%
0.1000	26.500%	30.000%	83.500%	0.000%
0.0500	14.000%	17.000%	77.000%	0.000%
0.0020	11.000%	11.000%	56.000%	0.000%
0.0010	0.000%	0.000%	0.000%	0.000%

Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc. (ml/l)	24VW (ml/l)
#1	475.900	475.900	299.25	37.08	669.1	23,430	0.00	0.00

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Tributary C to the Pinabete Arroyo

Pre-mine Hydrology and Sedimentology

The drainage subdivisions used to model the hydrology is presented on Exhibit 7-4.

LR

BHP Navajo Coal Company
PO Box 1717
Fruitland, NM 87416

Phone: 505-598-5861

General Information

Storm Information:

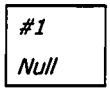
Storm Type:	NRCS Type II - 60
Design Storm:	2 yr - 6 hr
Rainfall Depth:	0.800 inches

Particle Size Distribution:

Size (mm)	PostMine-LoamySand	PreMine-LoamySand	PreMine-Badlands	LoamySand Postmining
2.0000	100.000%	100.000%	100.000%	0.000%
0.1000	26.500%	30.000%	83.500%	0.000%
0.0500	14.000%	17.000%	77.000%	0.000%
0.0020	11.000%	11.000%	56.000%	0.000%
0.0010	0.000%	0.000%	0.000%	0.000%

Structure Networking:

Type	Stru #	(flows into)	Stru #	Musk. K (hrs)	Musk. X	Description
Null	#1	==>	End	0.000	0.000	Tributary C to Pinabete



Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc. (ml/l)	24VW (ml/l)
#1	142.200	142.200	11.30	1.07	25.6	33,477	0.00	0.00

Particle Size Distribution(s) at Each Structure

Structure #1:

Size (mm)	In/Out
2.0000	100.000%
0.1000	100.000%
0.0500	100.000%
0.0020	100.000%
0.0010	0.000%

Subwatershed Hydrology Detail:

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
#1	1	142.200	0.313	0.000	0.000	85.000	M	11.30	1.071
	Σ	**142.200**						**11.30**	**1.071**

Subwatershed Sedimentology Detail:

Stru #	SWS #	Soil K	L (ft)	S (%)	C	P	PS #	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc (ml/l)	24VW (ml/l)
#1	1	0.172	125.00	9.27	0.2850	1.0000	3	25.6	33,477	0.00	0.00
	Σ							**25.6**	**33,477**	**0.00**	**0.00**

Subwatershed Time of Concentration Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#1	1	5. Nearly bare and untilled, and alluvial valley fans	3.87	23.00	594.00	1.960	0.084
		8. Large gullies, diversions, and low flowing streams	2.65	107.00	4,030.13	4.880	0.229
#1	**1**	**Time of Concentration:**					**0.313**

General Information

Storm Information:

Storm Type:	NRCS Type II - 60
Design Storm:	10 yr - 6 hr
Rainfall Depth:	1.300 inches

Particle Size Distribution:

Size (mm)	PostMine-LoamySand	PreMine-LoamySand	PreMine-Badlands	LoamySand Postmining
2.0000	100.000%	100.000%	100.000%	0.000%
0.1000	26.500%	30.000%	83.500%	0.000%
0.0500	14.000%	17.000%	77.000%	0.000%
0.0020	11.000%	11.000%	56.000%	0.000%
0.0010	0.000%	0.000%	0.000%	0.000%

Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc. (ml/l)	24VW (ml/l)
#1	142.200	142.200	47.14	3.92	117.9	41,628	1.58	1.04

General Information

Storm Information:

Storm Type:	NRCS Type II - 60
Design Storm:	25 yr - 6 hr
Rainfall Depth:	1.600 inches

Particle Size Distribution:

Size (mm)	PostMine-LoamySand	PreMine-LoamySand	PreMine-Badlands	LoamySand Postmining
2.0000	100.000%	100.000%	100.000%	0.000%
0.1000	26.500%	30.000%	83.500%	0.000%
0.0500	14.000%	17.000%	77.000%	0.000%
0.0020	11.000%	11.000%	56.000%	0.000%
0.0010	0.000%	0.000%	0.000%	0.000%

Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc. (ml/l)	24VW (ml/l)
#1	142.200	142.200	74.18	6.12	195.0	43,508	2.14	1.42

General Information

Storm Information:

Storm Type:	NRCS Type II - 60
Design Storm:	100 yr - 6 hr
Rainfall Depth:	2.000 inches

Particle Size Distribution:

Size (mm)	PostMine-LoamySand	PreMine-LoamySand	PreMine-Badlands	LoamySand Postmining
2.0000	100.000%	100.000%	100.000%	0.000%
0.1000	26.500%	30.000%	83.500%	0.000%
0.0500	14.000%	17.000%	77.000%	0.000%
0.0020	11.000%	11.000%	56.000%	0.000%
0.0010	0.000%	0.000%	0.000%	0.000%

Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc. (ml/l)	24VW (ml/l)
#1	142.200	142.200	114.87	9.42	317.2	45,429	2.71	1.82

Appendix 18.N

Baseline Groundwater Update for

Navajo Mine Area 4 North

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6.G-1 Introduction

This Appendix has been prepared to summarize and interpret the additional baseline data obtained from monitoring wells and vibrating wire piezometers (VWPs) that were installed in the Fruitland coals and in the underlying Pictured Cliffs Sandstone (PCS) for baseline hydrogeology characterization of Area IV and Area V of the BHP Navajo Coal Company (BNCC) coal lease. Completion diagrams and lithologic logs for these monitoring wells and VWPs are provided in Attachment 6.G-1. The data from these wells and VWPs locations provide additional information on groundwater levels, aquifer characteristics, and groundwater quality within and adjacent to the Navajo Mine permit area. Geologic information as well as data from monitoring wells installed in Area III of the BNCC lease are also included in this Appendix to support the hydrogeologic interpretations. This Appendix also provides the baseline data that are used to support the development and calibration of the multilayer, numerical, groundwater flow model of the hydrogeologic system of Areas IV and V of the BNCC coal lease.

The hydrogeologic units within and adjacent to Navajo Mine Area IV North include:

- The alluvial groundwater of the Chaco River, Pinabete Arroyo, and Cottonwood arroyo
- The coal seams of the Fruitland Formation
- The Pictured Cliffs Sandstone (PCS), located below the Fruitland Formation

The location of baseline monitoring wells and VWPs completed within or adjacent to Areas III, IV and V of the BNCC coal lease are shown in Exhibit 6.G-1. This exhibit also provides hydrogeologic sections, depicting the various coal seams of the Fruitland Formation and the top of the PCS. Water level elevations measured in the monitored coal units and in the underlying PCS are plotted in the hydrogeologic sections in Exhibit 6.G-5 to depict both horizontal and vertical gradients.

6.G-2 Alluvial Groundwater

Alluvial fill deposits occur in the valley bottom of Cottonwood Arroyo within the permit area and along the Chaco River and Pinabete Arroyo, to the west and south of the permit area. However, these deposits are not considered Alluvial Valley Floors (AVF). Refer to of Chapter 6.5 for information on the negative determination for AVF within and adjacent to the permit area. The Chaco River alluvium is saturated and provides limited stock water supply at several dug wells. Likewise, portions of the alluvium of Cottonwood and Pinabete Arroyos are saturated and will yield water to wells, as evidenced by the dug wells completed in the alluvium of both Cottonwood and Pinabete Arroyos as indicated in Appendix 6.E.

Baseline monitoring of the alluvium of Cottonwood Arroyo was conducted at four alluvial well monitoring locations shown on Exhibit 6.G-1. Baseline water quality information obtained prior to year 1983 from the monitoring wells GM-17 and QACQ-2 (GM-18) are included in Appendix 6-C. Well GM-17 is completed

in the alluvium of North Fork of Cottonwood Arroyo. A dug well, GM-18, completed in the alluvium of Cottonwood Arroyo west of the permit area, was converted for use as a monitoring well and is designated as QACW-2 in Exhibit 6.G-1. This well was included in the Navajo Mine quarterly monitoring program. However, the well is usually dry and relatively few samples have been obtained during baseline monitoring. Water quality samples could not be obtained from alluvial monitoring well QACW-1 because it was dry or had insufficient water for sampling during baseline monitoring from 1987 through 1998. The well was subsequently removed by the advance of mining operations in Area III. BNCC has also performed baseline monitoring of well QACW–2B completed in the alluvium of Cottonwood Arroyo west of the permit area as shown in Exhibit 6.G-1. This well is a dug well that has been used for stock water supply and is not owned by BNCC.

The baseline water quality monitoring results for these Cottonwood alluvial wells are summarized in Table 6.G-1. These results show the water quality of the alluvium of Cottonwood Arroyo to be a sodium-sulfate type with variable TDS concentrations. TDS, sulfate, fluoride, iron, and manganese concentrations in the groundwater within the Cottonwood alluvium exceed the relevant groundwater use criteria listed Table 6.G-2. The use criteria in Table 6.G.2 are not enforceable standards with respect to groundwater and are included only as a reference for the suitability of the groundwater quality for domestic water supply and for livestock use. These use criteria are mostly derived from the Navajo Nation surface water quality criteria for domestic water supply and for livestock watering use. Lardy, G., C. Stoltenow, and R. Johnson (2008) provide relevant livestock watering criteria for TDS, sulfate, and fluoride but do not provide a livestock use criterion for chloride. Based on these relevant use criteria, the water in the alluvium of the mainstem of Cottonwood is a poor source of supply for livestock watering use. Fluoride, sulfate, and TDS concentrations often exceed relevant criteria for livestock use (Table 6.G-2). Also, the alluvium is variably saturated and often will not yield sufficient water for sampling.

Two alluvial monitoring wells, PA-1 and PA-2, were installed in 1998 within the alluvium of Pinabete Arroyo at the locations shown in Exhibit 6.G-1. Table 6.G-3 summarizes the baseline water level readings and aquifer test results are summarized in Table 6.G-4. The estimated hydraulic conductivities for the Pinabete Arroyo alluvium of 51.3 ft per day (ft/day) (1.8×10^{-2} cm per second (cm/sec)) and 10.7 ft/day (3.8×10^{-3} cm/sec) are within the range expected for clean sand and are considerably higher than the bedrock values in the area. Well yields from the alluvium, however, are limited by a very low saturated thickness of about 5 ft or less.

Water quality analytical results from the baseline sampling of alluvial wells PA-1 and PA-2 are provided in Table 6.G-5 and Table 6.G-6, respectively. These results show the water quality to be a sodium-sulfate type with TDS concentrations ranging from 1,500 to 4,310 mg/L. Water within the alluvium is unsuitable for drinking water use due to TDS, sulfate, fluoride, iron, and manganese concentrations above drinking

water criteria. The water is also a poor source of supply for livestock watering use. TDS, sulfate, and fluoride concentrations usually exceed relevant criteria for livestock use (Table 6.G-2).

Some information on the baseline water quality in the Chaco River Alluvium is provided in the well inventory included in Appendix 6-E-Addendum 12-D-A of the PAP. The available water quality information from this well inventory show TDS concentrations ranging from 1,950 mg/l to 3,110 mg/l and sulfate concentrations ranging from 1,100 to 1,790 mg/l at wells located west of Areas II, III and IV at the Navajo Mine. Limited groundwater quality baseline data are also provided by Thorn (1993) for the Chaco River alluvium. The results show considerable variability in the alluvial water quality with TDS concentrations ranging from 742 to 11,900 mg/L, sulfate concentrations from 350 to 6,600 mg/L, and fluoride concentrations ranging from 0.4 to 1.7 mg/L.

6.G-3 Fruitland Coal Seams

Groundwater is also found in the coal units of the Fruitland Formation and in the PCS, which underlies the Fruitland Formation at the Navajo Mine site. The geologic strata within the permit and adjacent area dip gently to the east toward the center of the San Juan Basin at an angle of 1 to 2 degrees as depicted in the cross sections provided in Exhibit 6.G-1. Based on both regional and site-specific information, the Fruitland Formation and associated coal units, and the PCS are unsaturated or partially saturated near the outcrop of these units on the western side of the Navajo Mine permit area but become saturated to the east and down dip of the outcrop. The pre-mine groundwater in the Fruitland Formation throughout most of the BNCC coal lease will not support beneficial use because of the very low well yields and poor water quality. There are no known water supply wells completed in the Fruitland Formation within or adjacent to the BNCC coal lease.

Based on baseline information obtained from water level elevations measured in the wells and piezometers, the general groundwater flow directions in the Fruitland Formation within Areas III, IV and V of the BNCC coal lease are vertically downward through the interbedded shale and coal units of the Fruitland Formation and into the PCS and laterally within individual coal seams toward the north-northeast with some localized flow toward the topographic lows along Cottonwood and Pinabete Arroyos. Direct recharge rates measured by chloride mass balance methods on undisturbed areas at the Navajo Mine ranged from 0.002 to 0.09 in/yr (Stone 1987). The highest recharge rate of 0.09 in/yr was for valley terraces while the lowest recharge rate of 0.002 in/yr was for badland areas. Recharge from upland flats averaged 0.03 in/yr. Recharge is expected to be higher from saturated alluvium and surface impoundments. Although Stone's research (1986 and 1987) did not include recharge estimates for surface impoundments, it does provide an estimate of an average recharge rate of 0.16 in/yr from depressions within reclaimed mine areas at the Navajo Mine.

Based on the previous mining experience at the Navajo Mine, the coals, the overburden, and the interburden in the Fruitland Formation are not expected to yield much water during mining. The mine pit has remained dry except on rare occasions when surface flows are captured. Groundwater seeps are rarely observed along the highwall as any groundwater in the Fruitland overburden and coals is consumed by evaporation along the highwall. The few seeps that have been observed during mining were at locations within Area I where the highwall was near Navajo Agricultural Products Industry (NAPI) irrigation plots. NAPI irrigation plots do not occur within the drainages associated with proposed Area IV mining, although Cottonwood Arroyo does receive direct discharges of water from irrigation canals. The direct discharges occur when an over supply of water in the canal is released directly to the stream channel. Direct discharge is highly variable, occurs quickly, and can last up to 12 hours. However, usually there is no flow in Cottonwood Arroyo and it retains the characteristics of an ephemeral stream

One conceptualization of the hydrogeology of the Navajo Mine site is to consider the Fruitland Formation as a single hydrogeologic unit. The single hydrogeologic unit approach was previously proposed by Billings and Associates (Appendix 6.D) for modeling groundwater at the Navajo Mine because of the complexity of the individual coal seams, which often split or pinch out. This conceptualization has been used for predicting steady-state post mining flow in the Fruitland Formation from the Navajo Mine to the discharge locations along the subcrop with the San Juan River alluvium. This conceptualization may be best for regional modeling and is the appropriate conceptualization when baseline hydrogeologic information does not exist to calibrate a more complex hydrogeologic model.

However, given the extensive baseline hydrogologic information that was available within areas IV and V of the BNCC lease, a conceptual hydrogeologic model and the numerical groundwater model that delineates the coal beds as distinct hydrogeologic units was developed to assess the baseline hydrogeologic conditions and to simulate the effects of mining within Area IV North. This conceptualization supports the calibration of a numerical model because the potentiometric information is developed from monitoring wells and piezometers completed in specific coal units. This conceptualization is also better for evaluating local influences and the potential changes in vertical and horizontal groundwater flows that may occur as a result of mining and reclamation.

The potentiometric elevations in the specific coal units decline with depth within Areas III, IV and V of the BNCC lease as shown in Exhibit 6.G-1, indicating a vertical downward component of flow through the Fruitland Formation. One of the primary hydrogeologic changes to occur as a result of mining is the removal of the coals, interbedded shales, and sandstone strata, thus resulting in more homogeneous and isotropic conditions within the mine backfill. This change is expected to result in a steady-state post-mining water table that is lower than pre-mining but steady-state potentiometric elevations at the base of the mine backfill that are higher than the potentiometric elevations that occurred in the lowest coal seam

prior to mining. The result of this change would be an increase in vertical flow from the mine backfill into the PCS under steady-state post-mining conditions relative to the vertical flow from the Fruitland Formation to the PCS prior to mining.

However, these changes would not be expected within Area I. The pre-mine vertical downward gradient may not have occurred in the Fruitland Formation within Area I because of its closer proximity to the San Juan River, a location for regional groundwater discharge where upward gradients would be expected. Also, Morgan Lake has increased potentiometric elevations in the PCS, which further limits the potential for downward flow into the PCS from the Fruitland Formation.

The PCS, the first hydrogeologic unit below the Fruitland Formation, has been included in the groundwater flow model. The top of the Lewis Shale, the first hydrogeologic unit below the PCS, has been included as the base of the model domain. The delineation of these hydrogeologic units within the model domain was created from the extensive geologic and groundwater information developed for Areas IV and V. Information was also obtained from a variety of sources to help delineate the hydrogeologic units and define groundwater conditions for the portions of the model domain that are beyond the limits of Areas IV and V. Norwest Corporation (2011) provides a description of the hydrogeologic model that was developed to characterize the baseline hydrogeology and to support the probable hydrologic consequences assessment.

Baseline potentiometric elevations measured in the wells and in the VWPs completed in specific coal seams within Areas IV and V are summarized in Table 6.G-7. The potentiometric surface for the No. 3 coal seam is provided in Exhibit 6.G-2. This potentiometric surface was constructed from the baseline potentiometric elevations for the No. 3 coal seam presented in Table 6.G-7 and the July 1989 baseline potentiometric elevations measured in the No. 3 coal wells located within Area III. The modeled baseline potentiometric surface for the No. 3 coal in Figure 6.G-2 was also used to estimate the potentiometric contours beyond the limits of the monitoring data. The potentiometric gradient in the No. 3 coal indicates groundwater flow components toward the north-northeast with local gradients toward Pinabete Arroyo and Cottonwood Arroyo. The lower coal seams pinch out and do not extend north of Area III. The groundwater moving along the potentiometric gradients to the northeast flows through the undifferentiated Fruitland Formation into either the upper coal units or into the underlying PCS.

Potentiometric gradients in the other coal seams within Areas III, IV, and V of the BNCC coal lease are expected to be generally toward the northeast, similar to the gradients shown for No. 3 coal. However, the upper coal seams (No. 6, No. 7, and No. 8) outcrop to a greater extent within the valleys of Pinabete Arroyo, No Name Arroyo, and Cottonwood Arroyo within the BNCC coal lease. The groundwater associated with these upper coal seams is expected to show greater local influence from the topographic lower elevations along the arroyos. The baseline hydrogeologic model generated to support the probable

hydrologic consequences assessment simulated local potentiometric gradients toward the topographic lows along Pinabete Arroyo, No Name Arroyo, and Cottonwood Arroyo in all of the Fruitland coal units. The local influence of topography on potentiometric gradients was greatest for the shallowest coal, the No. 8 seam (Norwest Corporation, 2011). Field observations of salt deposits and enhanced vegetation production also indicate that local discharge may occur from the No. 8 coal at the coal outcrop along Pinabete Arroyo. Baseline groundwater model simulations in Figure 6.G-3 and potentiometric elevations at wells KF-2007-01, KF84-22A, and KF83-10A were used to prepare the potentiometric surface of the No. 8 coal seam that is provided in Exhibit 6.G-3.

A displacement (slug) test was performed at well KF-98-02 and bailed recovery tests were conducted at wells KF-98-03 and KF-98-04 to determine transmissivity and hydraulic conductivity in the No. 3 coal seam within Area IV South. The test results are summarized in Table 6.G-8 and show very low hydraulic conductivity values for the No. 3 coal consistent with the low hydraulic conductivity values reported in Table 6-1 for the No. 2, No. 3, and No. 4-6 coal seam wells located within Area IV North. A pumping test of the No. 8 coal seam well KF2007-01 was also performed and interpreted using the Papadopulos-Cooper method as shown in Table 6.G-8. The higher hydraulic conductivity for the No. 8 coal seam relative to the No. 3 seam is consistent with the results in Table 6-1, which show higher hydraulic conductivities for the No. 7 and No. 8 coal units relative to the lower coal units.

In a separate set of tests, the transmissivity and hydraulic conductivity values calculated from the observation well response during a pumping test of the No. 8 coal seam well, G-20, located at the San Juan Mine were 0.017 ft^2/day and 0.001 ft/day (3.5×10^{-7} cm/sec), respectively (San Juan Coal Company, 2009). These results for the hydraulic conductivity from G-20 are lower than the values from well tests at Navajo Mine. However, the observation well response from well G-20 pumping test is useful because it provides a reliable estimate for the storage coefficient (4.2×10^{-4}) associated with the No. 8 coal seam.

Water quality monitoring data from Fruitland Formation coal wells at the Navajo Mine and BNCC coal lease monitoring locations show that baseline groundwater in the coals is very saline. Table 6.G-9 provides a summary of the baseline water quality obtained from coal wells located within Areas II, III, and IV at the BNCC coal lease. This table provides median baseline concentrations measured at the coal wells along with the number of baseline analyses obtained for each constituent at each well. Given the variability in some of the analytical results, the median provides a good representation of baseline water quality at each well location. The median, unlike the mean, is not biased by an anomalous value resulting from analytical or transcription errors or by a sample that may not be representative due to sampling method or impact by drilling fluids or annular grout seal.

The TDS concentrations in Table 6.G-9 for the coal water at the Navajo Mine monitoring locations exceed relevant criteria for both drinking water and livestock use (Table 6.G-2). The chloride concentrations also exceed the drinking water use criterions in most of the wells. Fluoride concentrations are quite variable but the median values in several of the wells exceed the relevant criteria for both drinking water and livestock uses. Sulfate is also quite variable among coal wells with concentrations above relevant drinking water and livestock use criteria in the shallow coal wells near the outcrop but very low sulfate concentrations in the coal water in the deeper coal units and down dip of the outcrop. The low sulfate in these deeper coals is due to apparent sulfate reduction in the groundwater.

Groundwater monitoring results in Table 6.G-9 show that sodium is the dominant cation in the coal water and that bicarbonate and chloride are typically the dominant anions except for the relatively high sulfate in the shallow coals near the outcrop. The TDS concentrations in the coal units at the Navajo Mine typically increase from south to north and from shallow to deep. Furthermore, baseline TDS concentrations in excess of 40,000 mg/L have been reported in Table 6-2 of Navajo Mine Permit Application for the Fruitland coal monitoring wells SJKF84#2 and SJKF84#3 installed in the No. 8 coal northeast of the Navajo Mine as shown in Exhibit 6-6 of the Navajo Mine Permit Application.

Groundwater chemistry can change or evolve along its flow path from the recharge area to the discharge area. Precipitation is low in TDS, is naturally weakly acidic, and contains bicarbonate due to the solution of carbon dioxide in the air. In this portion of the San Juan Basin, the precipitation reaching the ground is immediately neutralized and acquires sodium, sulfate, and other ions. Water that has only a short residence time in the ground is still typically high in TDS concentrations, with sodium, sulfate, and bicarbonate the dominant ions as indicated by both the surface water and alluvial groundwater samples. Calcium is also present due to dissolution of calcium carbonate, but at concentrations that are considerably lower than sodium. Chloride concentrations in precipitation are low. Chloride concentrations in groundwater increase due to evapotranspiration and are typically lower in groundwater in the alluvium and in shallow bedrock near recharge areas. As groundwater migrates through the saturated zones it is no longer in contact with atmospheric carbon dioxide and its capacity to dissolve carbonates diminishes. The chemistry of the groundwater continues to evolve as other soluble minerals dissolve and cation exchange processes reduce the proportion of calcium and increase the proportion of sodium in solution. Sulfate reduction also appears to occur when groundwater transitions from oxidizing to reducing conditions, particularly within the coal units.

6.G-4 Pictured Cliffs Sandstone

The PCS is a well-cemented, low-permeability, marine sand and is the first water-bearing unit below the Fruitland Formation. Based on the geologic information presented in Section 5 of the Navajo Mine Permit, the PCS is approximately 110 to 120 ft thick and follows the structure of the Fruitland Formation, dipping

to the east at approximately 2 degrees, although the structure varies locally. The PCS conformably overlies the Lewis Shale, with the contact marked by a zone of interbedded sandstones and mudstones in the lower part of the PCS (Stone et al. 1983). It outcrops just west of the mine lease and east of the Chaco River. The PCS is a marginal water resource due to low permeability, poor water quality, gas production, and low yields (Stone et al. 1983). The PCS is also a natural gas reservoir in the San Juan Basin. Stone et al. (1983) state that the PCS cannot be considered a major aquifer and it is important only because it is the water-bearing horizon immediately underlying the coals in the Fruitland Formation.

Well KPC-98-01 was installed in 1998 near the PCS outcrop at the location shown in Exhibit 6.G-1. In 2007, wells KPC2007-01, KPC2007-02, and KPC2007-03 were completed in the PCS at locations around the perimeter of Area IV South (Exhibit 6.G-1). VWPs were installed in the PCS at four of the five VWP locations as shown on Exhibit 6.G-1. A VWP was not installed in the PCS at the VWP2007-03 location because monitoring well KPC2007-02 was installed in the PCS at this location. Potentiometric elevations measured at the PCS wells and the VWPs are summarized in Table 6.G-10.

The water levels measured in the PCS well KPC2007-01 at the VWP2007-01 location show elevations in the PCS monitoring well that are consistently about 6 feet lower than the potentiometric elevation measured in the PCS at the VWP. The VWP in the PCS at this location is installed at the top of the PCS, while the well screen and filter pack extends through about 75 ft of the PCS. The difference between the two measurements suggests that hydrostatic heads are higher at the top of the PCS at this location and decline with depth. Thus, downward gradients are believed to continue through the PCS at this location.

Historical water level data are also available for six PCS wells that were completed within or adjacent to BNCC lease Areas IV and V during the mid-1970s. Data from these well are included in a report by Science Application, Inc. (1979) that was prepared for a proposed coal gasification project. These PCS monitoring wells are designated as the GM wells with water elevations shown on Exhibit 6.G-4. These PCS monitoring wells and piezometers were plugged and abandoned in 1994.

The modeled baseline potentiometric surface for the PCS in Figure 6.G-1 together with the baseline potentiometric elevations from the PCS wells and VWPs were used to prepare the PCS potentiometric surface provided in Exhibit 6.G-4. The measurements of the baseline potentiometric elevations for the abandoned GM wells were obtained in June 1989. The potentiometric surface for the PCS shows overall gradients to the north. The highest potentiometric elevations for the PCS shown in Exhibit 6.G-4 correspond with a structural high in the PCS located within the southeast portion of Area V of the BNCC coal lease. There are also local gradients toward the topographic lows along No Name Arroyo, Pinabete Arroyo and Cottonwood Arroyo.

Water yields are quite low from these PCS monitoring wells completed around BNCC lease Area IV South. Two of the PCS wells were quickly pumped or bailed dry during conventional sampling. The yield from one of the PCS wells was sufficient to sustain a rate of about 0.4 gallons per minute (gpm) during a constant rate pumping test. The fourth PCS monitoring well was pumped dry after about 140 minutes during a constant-rate pumping test at a rate of about 1 gpm.

An aquifer test was also conducted in 1975 at well T4-1 installed in the PCS near the western side of the Navajo Mine lease boundary as shown in Exhibit 6.G-4. The drawdown and recovery measurements were recorded at the pumped well and at observation well GM30A, located 55.8 ft from the pumping well, and at observation well T4-2 located 12.5 ft from the pumping well (Science Application Inc. 1979). The results of this aquifer test and those performed at the PCS monitoring wells installed within or adjacent to Area IV South are summarized on Table 6.G-11.

Water quality analytical results from the baseline sampling of KPC-98-01 are provided in Table 6.G-12. The initial sample collected from this well in 1998 showed some influence from drilling fluids based on elevated pH and nitrate in the well sample results (Table 6.G-12). It is suspected that the well was not fully developed due to low permeability and limited saturation. Sampling results starting in 2007 are more consistent and representative of baseline conditions within the PCS at this location. Based on the recent samples, the PCS groundwater at this location is a sodium-sulfate type with TDS concentrations slightly above 6,000 mg/L.

The baseline water quality results from PCS well KPC2007-01 are summarized in Table 6.G-13. The PCS groundwater at this location is similar to the groundwater at well KPC-98-01 with TDS concentrations slightly below 6,000 mg/l. Baseline water quality information was also collected during the mid-1970s from PCS wells GM-19, GM-20, GM-30A and GM21 located within or in close proximity to the BNCC coal lease as shown in Exhibit 6.G-1. Water quality data from these wells are summarized in Tables 6.G-14 through 6.G-17. Baseline water quality data for these PCS monitoring wells indicate a sodium-sulfate type with TDS concentrations between 5,000 and 9,000 mg/l. The water quality results are consistent with the results from wells KPC-98-01 and KPC2007-01, although the initial well samples from a number of the PCS wells is suspect due to either poor ion balance or insufficient well development.

In summary, groundwater quality data from monitoring wells located within and adjacent to the Navajo Mine indicate that the groundwater in the PCS has high TDS concentrations, ranging from 5,000 mg/L to over 9,000 mg/L. Sulfate is the dominant anion, although the concentrations of chloride and bicarbonate are also relatively high. Sodium is the dominant cation. Magnesium and calcium concentrations are quite low and are typically less than the potassium concentrations. Generally, water quality changes are observed in the first few samples obtained from PCS monitoring wells, apparently due to the difficulty in

developing these low-yield wells. Thus, samples obtained after the initial two samples are believed to provide a better representation of baseline conditions.

The groundwater in the PCS groundwater within Areas IV and V of the BNCC coal lease is unsuitable for either domestic or livestock use. The concentrations of TDS, sulfate, chloride, and boron in the PCS wells are considerably higher than the domestic use criteria provided in Table 6.G-2. The TDS and sulfate concentrations in the PCS are also considerably higher than the livestock use criteria provided in Table 6.G-2. The low permeability and low yield of the PCS also limits the potential for groundwater use from the PCS. There are no known water supply wells completed in the PCS within or adjacent to Navajo Mine Permit Area.

6.G-5 Hydrologic Model

Conceptual and numerical groundwater models are useful to support the interpretation of baseline hydrogeologic information. Furthermore, conceptual or numerical groundwater models are required for the predictive evaluations needed to prepare a probable hydrologic consequence (PHC) assessment of proposed mining and reclamation activities. Groundwater models used for a PHC assessment can range from conceptual depictions, to simple empirical equations, to complex numerical computer simulations of groundwater flow and chemistry.

Site-specific data or data representative of the site conditions are needed to apply groundwater models. Numerical groundwater flow models can help develop a better understanding of the hydrogeologic system, including the groundwater flow relationships between hydrogeologic units and between surface water and groundwater. Extrapolation of data from adjacent or nearby areas or using typical values for parameters from similar hydrogeologic environments is often used in developing numerical flow models. Model calibration can also serve to revise the conceptual model of the groundwater system and provide a better assessment of the properties of hydrogeologic units on a regional scale that cannot be obtained solely from local pumping testing results.

The first step in developing a groundwater model is to establish the objectives of the study. The primary objectives for the development of a groundwater model for Area IV North mine permit revision application:

- To provide a better understanding of the baseline groundwater flow systems within and adjacent to the proposed mine area.
- To provide a better understanding of the likely groundwater changes that are expected during and after mining.

Potentiometric elevations in the monitored coal units and in the underlying PCS are plotted in the hydrogeologic sections in Exhibit 6.G-1, to depict vertical gradients. Quarterly monitoring performed on many of these wells and VWPs show no seasonal changes but occasional fluctuation in some wells due to slow recovery following bailing, purging and sampling. Results show downward potentiometric gradients through the Fruitland formation. Generally the gradients are downward from the Fruitland to the PCS except at locations VWP2007-02 and VWP2007-05. The slightly higher potentiometric elevation in the PCS at these locations indicates a slight upward gradient from the PCS to the No. 2 and 3 coal units of the Fruitland Formation.

6.G-6 Numerical Groundwater Model

A multilayer, numerical, groundwater flow model has been developed to model the groundwater flow systems within and adjacent to Navajo Mine Area IV. Norwest Corporation (2011) provides a detailed description of the numerical groundwater flow model. This numerical model is based on the conceptual model of the hydrogeology of the Fruitland coals, the PCS and the alluvial groundwater systems within and adjacent to Navajo Mine Area IV. A conceptual groundwater model is a complex hypothesis of the characteristics and functions of a hydrogeologic system, including recharge and discharge relationships, groundwater flow within and between hydrogeologic units, and the expected properties of these hydrogeologic units. An essential part of both the conceptual and numerical models is a graphical representation of the horizontal and vertical boundaries of the hydrogeologic system (the model domain) and the delineation of the hydrogeologic units within the model domain that are believed to have the primary controlling influence on groundwater flows. Another element of the conceptual model is to define, to the extent possible, the properties of these hydrogeologic units, including the thickness, hydraulic conductivities, and storage characteristics across the model domain. The conceptual model also includes the hydrogeologist's understanding of spatial relationships between and approximate rates of recharge and discharge, including the groundwater inflows and outflows from the model domain.

The delineation of the hydrogeologic units within and adjacent to Navajo Mine Area IV was based on the extensive geologic and groundwater information obtained from a variety of sources, including the baseline information presented in this Appendix. The multilayer groundwater model was calibrated to obtain a good match with potentiometric surfaces and water levels established from the baseline groundwater information while maintaining consistency with the site-specific recharge estimates from Stone (1986) and the range of hydraulic conductivities associated with each hydrogeologic unit. During model calibration, hydraulic conductivities were applied only for the entire hydrogeologic unit and not spatially within a unit. Without a consistent geologic basis, spatial adjustments in hydrologic conductivities would lead to over-parameterization of the model to match modeled potentiometric levels with observed values. Although some of the differences between the modeled and observed potentiometric levels may be associated with spatial variation in hydrogeologic properties within a hydrogeologic unit, the chosen method for model

calibration allows for the overall groundwater flow within each hydrogeologic unit and between units to be represented by the calibrated groundwater model.

Generally, a shale zone such as the Lewis Shale would be considered as an impermeable boundary. However, given the low recharge rates at the Navajo Mine site, the overall low permeability of the Fruitland Formation shales and coals, and the relatively low permeability of the PCS, the flow conditions at the boundary between the PCS and Lewis Shale were found to be significant for calibrating the groundwater flow model. Providing for downward flow from the PCS into the Lewis Shale was required in order to reach an adequate calibration with recharge rates consistent with the measurements from Stone (1987). Downward flow and downward gradients are also indicated by hydrogeologic studies and tests of the Lewis Shale and the PCS immediately west of Area V of the Navajo Mine lease (Science Application, Inc. 1979). Also, as discussed in Section 6.G-4, the water levels measured in the PCS well KPC2007-01 and in the PCS VWP2007-01 at the same location show that downward gradients continue through the PCS at this location.

Table 6.G-18 shows the relationship between the modeled recharge rates and the measurements by Stone (1987). Outside of the alluvial valleys, recharge rates were adjusted by slope within the range of estimates from Stone (1987) for badland areas and for upland flats. The modeled potentiometric surface for the PCS, the No. 3 coal seam, and the No. 8 coal seam are provided in Figure 6.G-1, Figure 6.G-2, and Figure 6.G-3, respectively. These results are consistent with the baseline potentiometric elevations obtained from monitoring wells completed in these hydrogeologic units. However, the modeled potentiometric surfaces extend beyond the limits that could be depicted from well measurements. These potentiometric surfaces and flow patterns are consistent with the conceptual model and all the geologic and hydrogeologic information and the specified boundary conditions.

The results in Figure 6.G-1 show a component of groundwater flow from the PCS to the topographic lows along the west side of the model domain in the valleys of Brimhall Wash, No Name Arroyo, Pinabete Arroyo, and Cottonwood Arroyo. The results for the No. 3 coal seam in Figure 6.G-2 also show a component of groundwater flow to the topographic lows along the west side of the model domain in the valleys of No Name Arroyo, Pinabete Arroyo, and Cottonwood Arroyo. The No. 3 coal seam is not present over a portion of the Brimhall Wash drainage or along the western portion of the model domain. Also, the No 3 coal seam is unsaturated in areas along the western outcrop and remains unsaturated in the modeled potentiometric surface as indicated in Figure 6.G-2. A similar pattern is observed in Figure 6.G-3 for the No. 8 coal seam, although this coal is not present over a large portion of the Brimhall drainage or within a large portion of the No Name, Pinabete, and Cottonwood valleys within the BNCC coal lease. In addition to the flow toward the topographic lows, there is a component of flow down dip to the northeast. Portions of the No. 8 coal seam near the western outcrop are unsaturated. Not shown in these figures for individual hydrogeologic units are the overall downward gradients and downward flow between units. In

fact, the model predicts perched groundwater conditions in the shallower coals along the western portion of the lease area as depicted by the north-south section in Figure 6.G-4.

The calibrated numerical model helps confirm the conceptual model. The numerical model is well constrained and consistent with the recharge rates measured by Stone (1987) and with the hydraulic conductivities and heads measured within the various hydrogeologic units in the model domain.

6.G-7 References

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Appendix 6.G Figures

Figure 6.G-1. Modeled Potentiometric Surface for the PCS

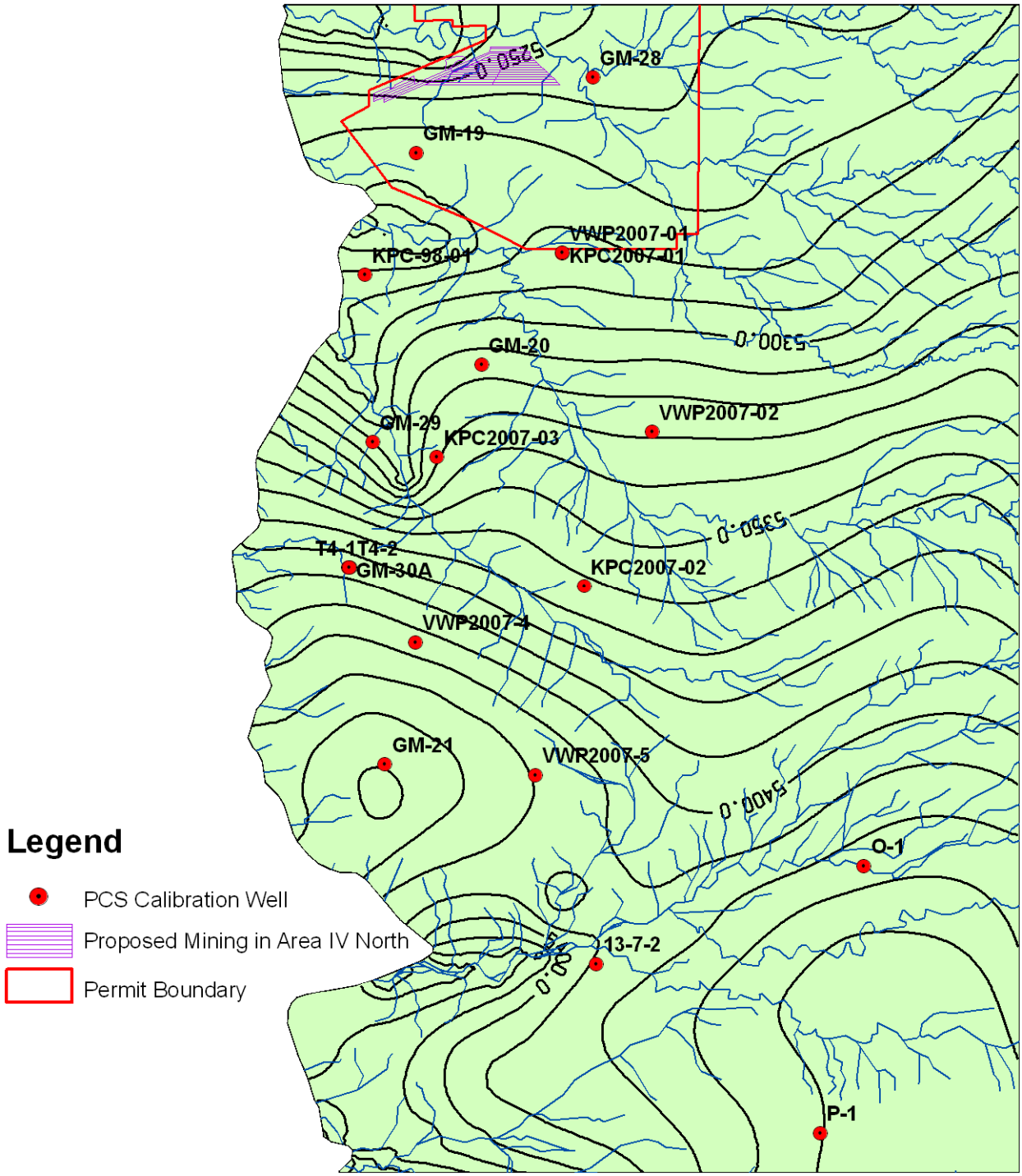


Figure 6.G-2. Modeled Potentiometric Surface for the No.3 Coal

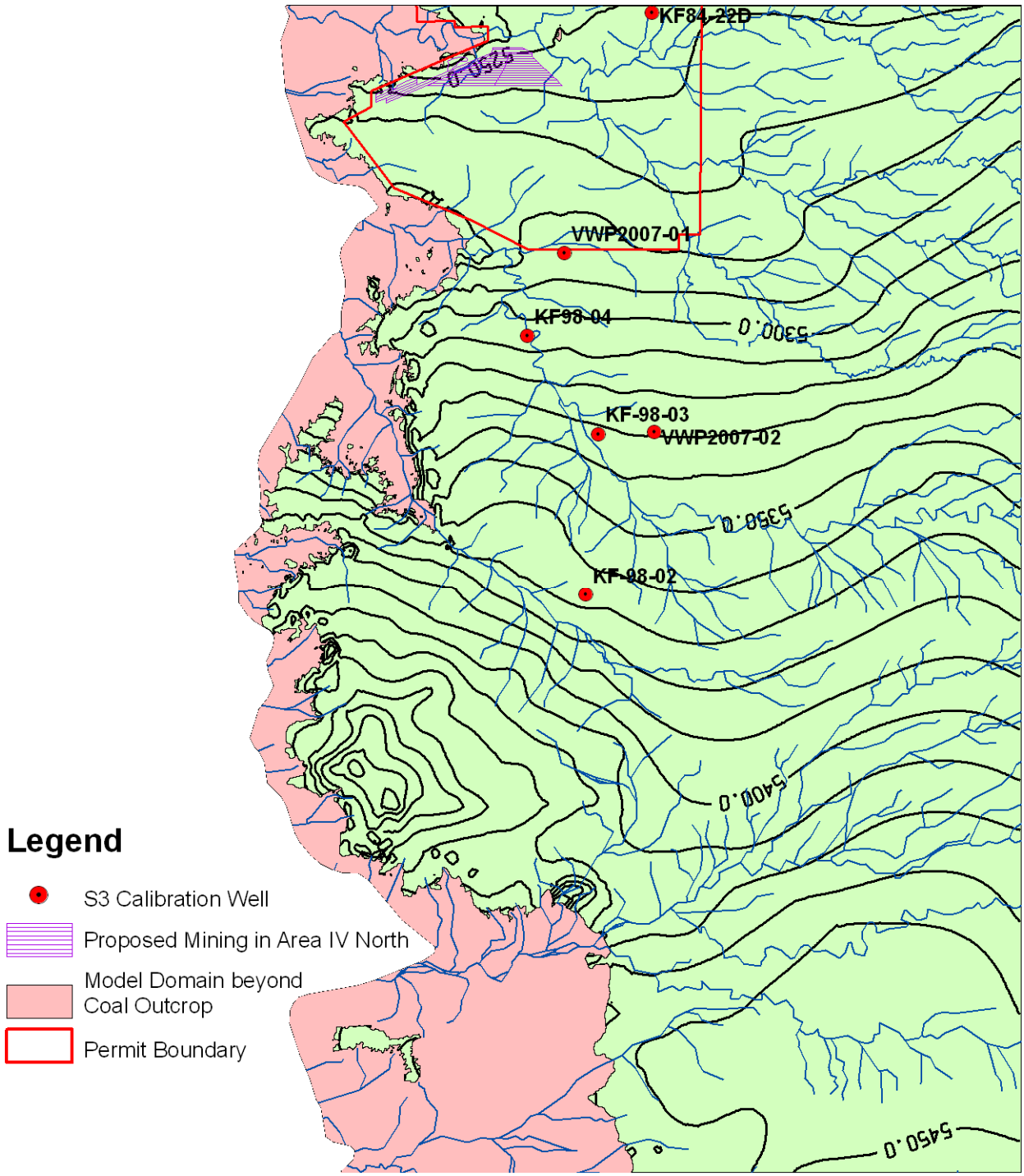


Figure 6.G-3. Modeled Potentiometric Surface for the No. 8 Coal

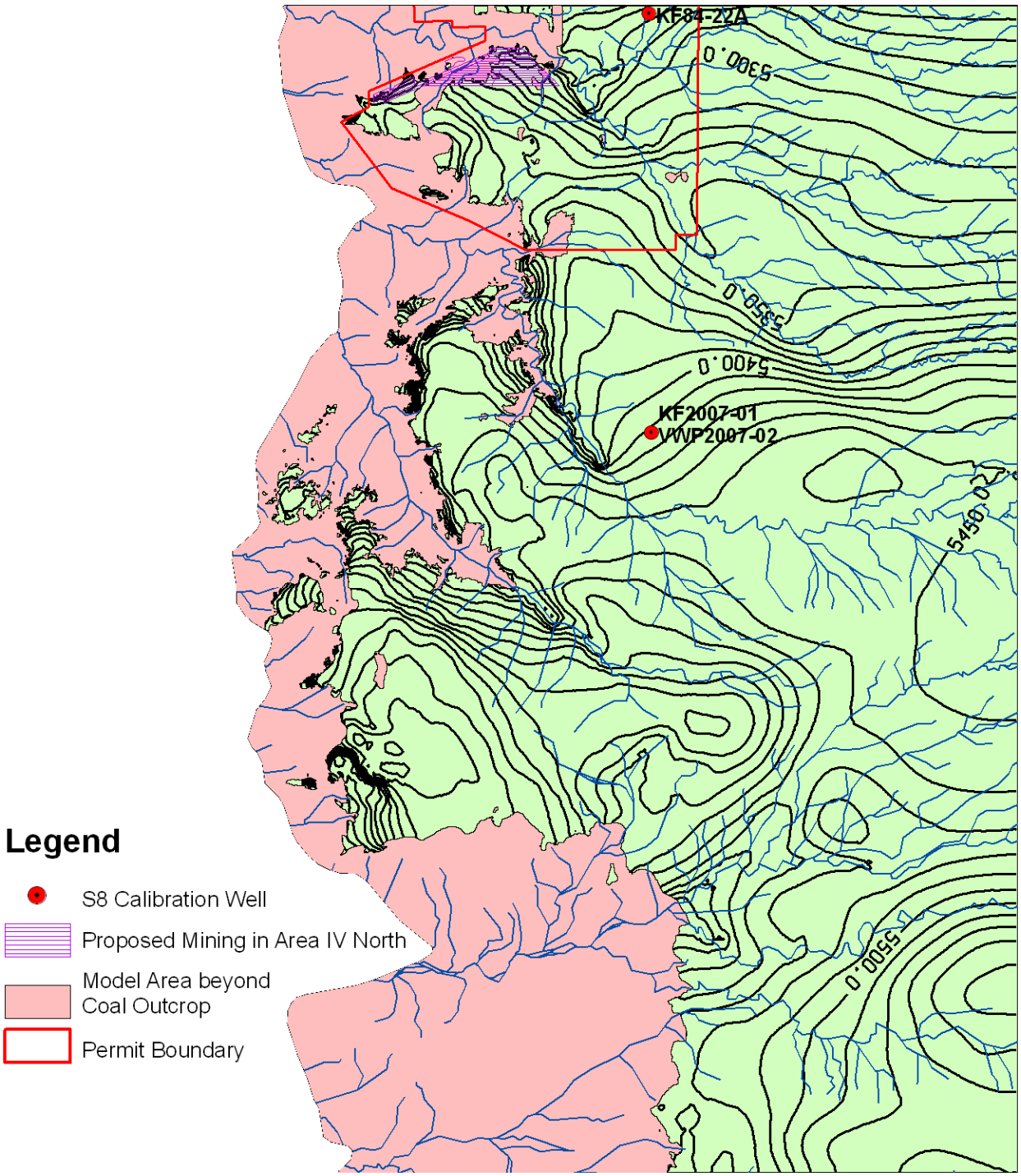
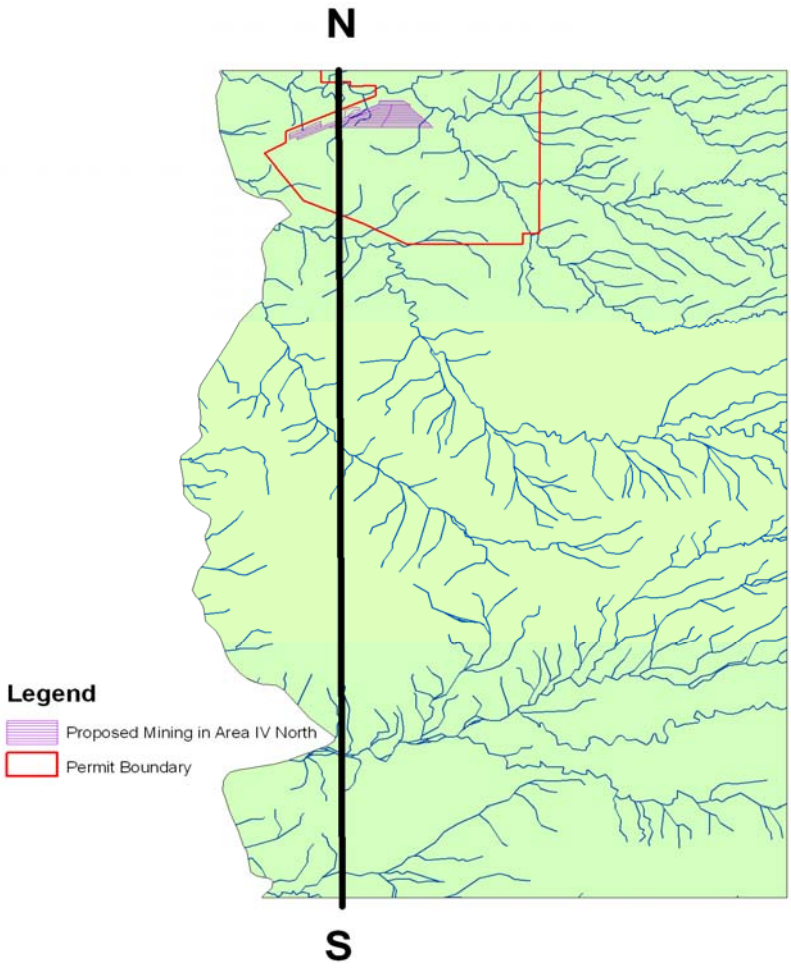
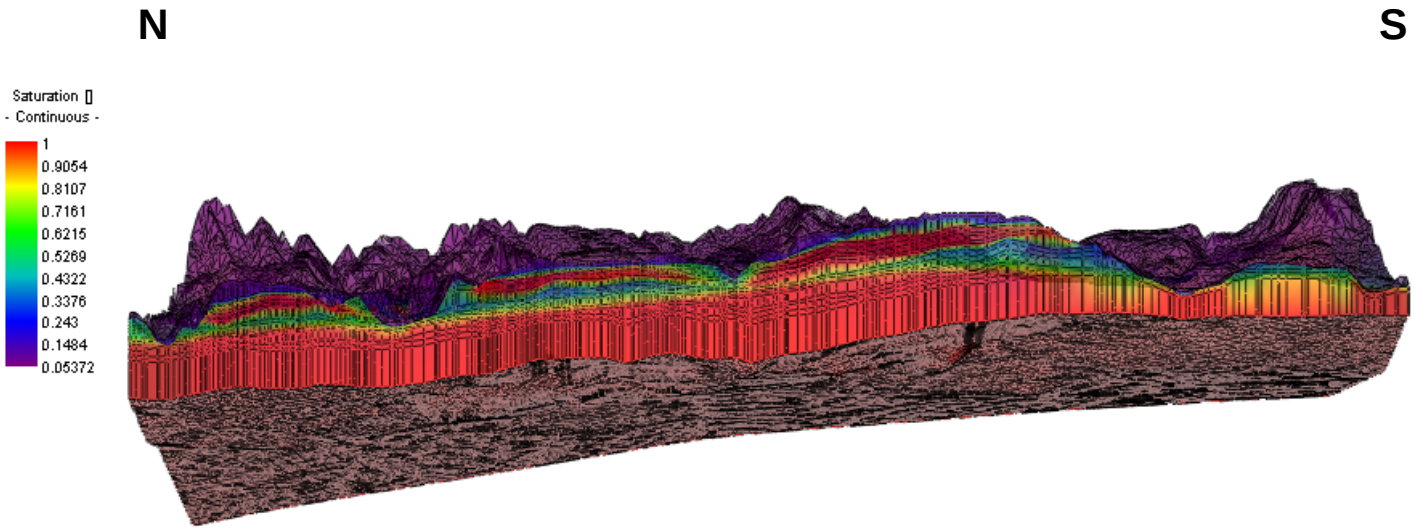


Figure 6.G-4. Modeled Saturation for a N-S Section





Appendix 6.G Tables

Table 6.G-1 Baseline Water Quality at Cottonwood Arroyo Alluvial Wells

		Cottonwood Alluvial Well		
Parameter		QACW-2	QACW-2B	GM-17
Baseline Monitoring Period		1974 - 2008	1986 - 1999	1975 - 1982
pH (SU)[1]	n	9	33	7
	median	7.9	7.8	6.9
TDS -180° (mg/L)	n	14	32	11
	median	2,305	3,015	15,210
Bicarbonate (as HCO3 mg/L)	n	9	32	2
	median	310	375.2	767
Carbonate (as CaCO3 mg/L)	n	2	15	0
	median	24	0.5	NA
Chloride (mg/L)	n	14	33	11
	median	28.2	138	113
Sulfate (mg/L)	n	14	32	11
	median	1,227	1,605	9,308
Calcium (mg/L)	n	9	33	8
	median	113	154	375
Magnesium (mg/L)	n	11	33	10
	median	16.2	22.7	145.0
Potassium (mg/L)	n	5	32	6
	median	2.0	6.5	25.5
Sodium (mg/L)	n	9	33	8
	median	451	778	4,510
Fluoride (mg/L)	n	14	33	11
	median	2.35	1.38	0.30
Nitrate as N (mg/L)	n	7	7	11
	median	0.18	0.09	1.03
Boron (mg/L)	n	13	32	11
	median	0.11	0.13	0.28
Iron, total (mg/L)	n	4	16	9
	median	0.03	1.04	0.62
Iron, diss.(mg/L)	n	14	33	11
	median	0.18	0.10	0.09
Manganese, total (mg/L)	n	3	16	8
	median	0.02	0.37	1.765
Manganese, diss. (mg/L)	n	14	33	11
	median	0.10	0.11	1.02
Selenium. (mg/L)	n	9	33	11
	median	0.0030	0.0025	0.0004

[1]Lab pH included in summary only when no field pH data are available for the well
QACW-2 include 1974 through 1979 samples from GM-18

Table 6.G-2. Relevant Groundwater Quality Use Criteria

Parameter (units)	Livestock Watering Criteria [1]	Domestic Water Supply Criteria for Surface Water by 2007 Navajo Nation Standards	EPA Secondary Drinking Water Standards[2]
Arsenic (mg/L)	0.2	0.01	
Barium (mg/L)		1	
Boron (mg/L)	5	0.63	
Cadmium (mg/L)	0.05	0.005	
Chloride (mg/L)			250
Chromium (mg/L)	1	0.1	
Copper (mg/L)	0.5(D)	1.3	1
Fluoride (mg/L)	2*	4	2
Total iron (mg/L)	-		0.3
Lead (mg/L)	0.1	0.015	
Total manganese (mg/L)	-		0.05
Mercury (mg/L)	0.01	0.002	
Nitrate (mg/L-N)	0.132	10	
pH (su)	6.5-9.0	5.0-9.0	6.5-8.5
Potassium (mg/L)			
Radium-226 (pCi/L)	30**	5**	
Radium-228 (pCi/L)	30**	5**	
Selenium (mg/L)	0.05	0.05	
Silver (mg/L)		0.035	0.1
Sulfate (mg/L)	1000*		250
Total dissolved solids (TDS) (mg/L)	3000*		500
Uranium (mg/L)		0.03	
Zinc (mg/L)	25	2.1	5

[1] Based on Navajo Nation Environmental Protection Agency Water Quality Program, 2008, Navajo Nation Surface Water Quality Standards 2007, passed by Navajo Nation Resources Committee on May 13, 2008 and on other cirteria for livestock use as noted

[2] http://water.epa.gov/drink/contaminants/secondarystandards.cfm

* Although there are no Navajo Nation livestock watering criteria for TDS, sulfate and fluoride, TDS concentrations above 3,000 may adversely affect growing/young livestock and waters with sulfate concentrations above 1,000 mg/l and fluoride concentrations above 2 mg/l are not recommended for livestock use (Lardy, G., C. Stoltenow, and R.

** 30 pCi/L criteria for Ra-226 + Ra-228

mg/L - milligram per liter

Table 6.G-3 Water Levels in Pinabete Alluvial Monitoring Wells

Well Name	PA-1		PA-2	
Measuring point elevation (ft msl)	5352.9		5431.43	
Date	Water level (ft)	Elevation (ft msl)	Water level (ft)	Elevation (ft msl)
3/26/1998	-	-	7.61	5423.82
3/29/1998	11.35	5341.55	7.69	5423.74
4/30/1998	11.42	5341.48	-	-
5/12/1998	11.46	5341.44	7.94	5423.49
6/11/1998	11.63	5341.27	8.16	5423.27
7/21/1998	12.04	5340.86	8.38	5423.05
8/20/1998	11.87	5341.03	8.24	5423.19
9/30/1998	11.7	5341.20	8.09	5423.34
11/8/1998	11.4	5341.50	7.88	5423.55
12/17/1998	11.18	5341.72	7.63	5423.8
8/22/2007	11.85	5341.05	8.78	5422.65
9/4/2007	11.95	5340.95	8.76	5422.67
10/4/2007	12.1	5340.80	NA	-
11/5/2007	12.14	5340.76	-	-
11/15/2007	-	-	8.76	5422.67
12/3/2007	12.09	5340.81	-	-
12/5/2007	-	-	8.7	5422.73
1/17/2008	12.0	5340.90	8.6	5422.83
2/19/2008	-	-	8.6	5422.83
2/21/2008	11.7	5341.20	-	-
3/20/2008	11.6	5341.30	8.3	5423.18
4/24/2008	11.5	5341.40	5.5	5425.93
5/27/2008	11.0	5341.90	5.0	5426.43
6/24/2008	12.0	5340.90	8.2	5423.23
7/24/2008	12.2	5340.70	9.0	5422.43
8/19/2008	-	-	9.2	5422.23
8/20/2008	11.2	5341.70	-	-
9/30/2008	11.0	5341.90	9.0	5422.4

ft msl - feet above mean sea level
(-) no measurement taken

Table 6.G-4 Alluvial Monitoring Well Summary and Aquifer Test Results

Well	Location (ft)		ID (in)	Elevation (ft)	Well depth (ft)	Test type	Transmissivity (ft^2/day)	Hydraulic conductivity		Saturated thickness (feet)
	Northing	Easting						(ft/day)	(cm/sec)	
PA-1	1990260.34	300409.2	2.1	5351.2	15.2	2.0 gpm pumping test	230.7	51.3	1.8E-02	4.5
PA-2	1980956.93	306702.8	2.1	5429.6	9.6	0.75 gpm pumping test	53.6	10.7	3.8E-03	5

ft^2/day - square feet per day
cm/sec - centimeter per second
NA - information not available
ID - inside well casing diameter

Table 6.G-5 Water Quality at Pinabete Arroyo Alluvial Well PA-1

Parameter (units)	3/29/1998	5/15/1998	8/20/1998	11/8/1998	6/15/2004	11/5/2007	2/21/2008	5/27/2008	8/20/2008	11/21/2008
Total Alkalinity as $CaCO_3$ (mg/L)	300	297	282	301	302	304	314	310	224	344
Arsenic (mg/L)	<0.005	<0.005	<0.005	<0.005	-	0.0008	<0.0005	0.0007	<0.0005	0.0008
Barium (mg/L)	0.05	0.03	0.9	0.03	-	0.0161	0.0144	0.0262	0.0164	0.0174
Bicarbonate as HCO_3 (mg/L)	365	362	344	367	368	371	383	378.2	216	344
Boron (mg/L)	0.17	0.2	0.2	0.22	-	0.787	0.2	0.2	0.2	0.2
Ion balance (%)	6.77	0.89	3.88	2.38	-	5.99	1.06	1.78	0.85	1.64
Cadmium (mg/L)	<0.001	<0.001	<0.001	<0.001	-	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Calcium (mg/L)	85.4	68.5	103	90.6	102	110	116	137	139	101
Carbonate (mg/L)	<1	<1	<1	<1	<10	<10	<10	<10	<10	<10
Chloride (mg/L)	25	22	29	16	14	14	17	36	25	18
Chromium (mg/L)	0.03* (total)	<0.01	<0.01	<0.01	-	0.005	0.004	0.004	<0.001	<0.001
Electrical conductivity (EC) (uS/cm)	2540	2410	2310	2150	2480	2380	2380	2680	3050	2520
Copper (mg/L)	<0.01	<0.01	<0.01	<0.01	-	0.0106	0.0151	0.0101	0.0094	0.0079
Fluoride (mg/L)	2.49	2.36	2.39	2.53	-	2.2	2.2	2.1	2.2	3
Hydroxide (mg/L)	<1	<1	<1	<1	<10	<10	<10	<10	<10	<10
Iron (mg/L)	0.99	0.06	<0.02	<0.02	-	<0.05	<0.05	<0.05	<0.05	<0.05
Total iron (mg/L)	41.9	3.07	4.43	0.25	-	16.7	17.5	53.2	1.39	3.88
Lead (mg/L)	<0.005	<0.005	<0.005	<0.005	-	<0.0001	<0.0001	0.0002	0.0002	0.0003
Magnesium (mg/L)	15.4	13.4	16.5	13.8	15.8	16.3	17.9	22.3	22.3	16.4
Manganese, D (mg/L)	0.138	0.005	0.017	<0.01	-	0.118	0.057	0.488	0.218	0.087
Manganese, T (mg/L)	1.31	0.843	0.37	0.03	-	0.487	0.302	3.56	0.350	0.142
Mercury (mg/L)	<0.001	<0.001	<0.001	<0.001	-	<0.0002	<0.0002	0.0002	<0.0002	<0.0002
Nitrate (mg/L-N)	0.66	0.72	<0.05	NM	-	0.05	0.03	0.04	0.10	0.05
pH (su)	7.6	7.5	7.5	7.7	7.67	7.61	7.54	7.53	7.48	7.78

Table 6.G-5 Water Quality at Pinabete Arroyo Alluvial Well PA-1

Parameter (units)	3/29/1998	5/15/1998	8/20/1998	11/8/1998	6/15/2004	11/5/2007	2/21/2008	5/27/2008	8/20/2008	11/21/2008
Potassium (mg/L)	9.8	1.8	1.7	2.9	1.4	1.4	1.3	2.7	1.7	1.7
Radium-226 (pCi/L)	<1.69	5.78	NM	0.91	-	2.9 ± 0.9	0.42 ± 0.34	1.3 ± 0.4	0.6 ± 0.42	0.10 ± 0.22
Radium-228 (pCi/L)	<1.9	5.77	NM	11.74	-	1.5 ± 0.7	0.60 ± 0.40	1.1 ± 0.6	0.53 ± 0.49	0.48 ± 0.38
Selenium (mg/L)	0.005	0.005	<0.005	<0.005	0.014	0.006	0.004	0.006	0.003	0.006
Silver (mg/L)	<0.01	<0.01	<0.01	<0.01	-	<0.00005	<0.00005	0.00006	<0.00005	<0.00005
Sodium (mg/L)	375	458	374	377	464	418	457	511	503	445
Sulfate (mg/L)	893	833	875	805	920	1040	1060	1140	1280	980
Total dissolved solids (TDS) (mg/L)	1610	1640	1730	1500	1660	1680	4310	1950	2030	1750
Uranium (mg/L)	-	-	-	-	-	0.01010	0.01080	0.01350	0.01620	0.01230
Zinc (mg/L)	0.053	0.037	<0.025	0.043	-	0.007	0.002	0.002	0.002	0.007

(-) s no analysis performed

mg/L - milligram per liter

µS/cm - microsiemens per centimeter

su - standard units

pCi/L - picocuries per liter

Table 6.G-6 Water Quality at Pinabete Arroyo Alluvial Well PA-2

Parameter (units)	3/30/1998	5/15/1998	8/20/1998	11/11/1998	6/15/2004	11/15/2007	2/21/2008	5/27/2008	8/19/2008	11/20/2008
Total alkalinity as $CaCO_3$ (mg/L)	293	281	315	327	286	410	308	328	405	430
Arsenic (mg/L)	<0.005	<0.005	<0.005	<0.005	-	0.0012	0.0007	0.0018	0.0008	0.0027
Barium (mg/L)	0.04	0.02	<0.2	0.02	-	0.0107	0.0129	0.0195	0.0143	0.0119
Bicarbonate as HCO_3 (mg/L)	357	342	384	398	349	451	376	400	405	430
Boron (mg/L)	0.19	0.2	0.22	0.31	-	0.2	2.1	0.2	0.3	0.2
Ion balance (%)	4.27	2.64	1.65	3.2	-	16	6.5	5.57	0.61	8.18
Cadmium (mg/L)	<0.001	<0.001	<0.001	<0.001	-	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Calcium (mg/L)	56.8	61	101	95	87.5	95	96.0	96.8	90.8	92.3
Carbonate (mg/L)	<1	<1	<1	<1	<10	24	<10	<10	<10	<10
Chloride (mg/L)	22	65	51	35	22	38	30	32	42	45
Chromium (mg/L)	0.03* (total)	<0.01	<0.01	<0.01	-	0.006	0.004	0.003	<0.001	0.009
Electrical conductivity (EC) (uS/cm)	4390	4510	4530	4520	4040	4600	4410	4110	5010	4860
Copper (mg/L)	<0.01	<0.01	<0.01	<0.01	-	0.0508	0.0116	0.0225	0.0226	0.0220
Fluoride (mg/L)	2.47	2.81	3.06	2.91	-	2.8	2.4	2.5	3.1	3.3
Hydroxide (mg/L)	<1	<1	<1	<1	<10	<10	<10	<10	<10	<10
Iron (mg/L)	0.11	<0.02	<0.02	0.04	-	<0.05	<0.05	<0.05	<0.05	<0.05
Total iron (mg/L)	63.9	2.88	6.55	0.13	-	1.86	5.61	3.03	1.86	3.19
Lead (mg/L)	<0.005	<0.005	<0.005	<0.005	-	<0.0001	<0.0001	0.0001	0.0002	0.0001
Magnesium (mg/L)	12	11	16	15	13.2	0.0277	15.5	16.7	15.5	16.7
Manganese (mg/L)	1.33	0.456	0.22	0.11	-	0.0277	0.090	0.141	0.128	0.135
Total manganese (mg/L)	3.71	0.525	0.88	0.24	-	0.552	1.27	0.599	0.551	0.748
Mercury (mg/L)	<0.001	<0.001	<0.001	<0.001	-	<0.0002	<0.0002	0.0002	<0.0002	<0.0002
Nitrate (mg/L-N)	0.27	0.32	<0.05	NM	-	0.06	0.08	0.08	0.11	0.05
pH (su)	7.9	7.4	7.3	7.5	7.62	7.19	7.41	7.5	7.21	7.31

Table 6.G-6 Water Quality at Pinabete Arroyo Alluvial Well PA-2

Parameter (units)	3/30/1998	5/15/1998	8/20/1998	11/11/1998	6/15/2004	11/15/2007	2/21/2008	5/27/2008	8/19/2008	11/20/2008
Potassium (mg/L)	5	2	3	5.4	1.8	2.1	2.0	2.4	3.3	3.2
Radium-226 (pCi/L)	<1.69	27.9	-	0.48	-	0.67 ± 0.43	0.40 ± 0.39	0.45 ± 0.34	0.60 ± 0.40	2.5 ± 0.7
Radium-228 (pCi/L)	<1.9	1.74	-	9.02	-	0.62 ± 0.48	1.4 ± 0.6	0.19 ± 0.56	1.2 ± 0.5	0.55 ± 0.37
Selenium (mg/L)	0.0007	0.006	<0.005	<0.005	0.012	0.012	0.009	0.014	0.010	0.018
Silver (mg/L)	<0.01	<0.01	<0.01	<0.01	-	<0.00005	<0.00005	0.00009	<0.00005	<0.00005
Sodium (mg/L)	781	981	872	891	839	809	850	907	966	1000
Sulfate (mg/L)	1670	1760	1690	1940	1550	2200	2100	2150	1950	2400
Total Dissolved Solids (TDS) (mg/L)	2990	3150	3600	3420	2780	3500	3070	3030	3540	3580
Uranium (mg/L)	-	-	-	-	-	0.01230	0.01120	0.01350	0.01160	0.01170
Zinc (mg/L)	0.051	0.025	<0.025	0.18	-	0.003	0.008	0.009	0.004	0.008

(-) no analysis performed
mg/L - milligram per liter
µS/cm - microsiemens per centimeter
su - standard units
pCi/L - picocuries per liter

Table 6.G-7. Potentiometric Elevations in Coal Monitoring Wells and Piezometers

Well/VWP Name	KF-98-02	KF-98-03	KF-98-04	KF2007-01	VWP 2007-01 (yellow)	VWP 2007-01 (green)	VWP 2007-01 S6 (white)	VWP 2007-02 (yellow)	VWP 2007-02 (white)	VWP 2007-02 (blue)	VWP 2007-02 (green)	VWP 2007-03 (yellow)	VWP 2007-03 (red)	VWP 2007-05 S2 (blue)
Coal Unit	S3	S3	S3	S8	S2a/S2b	S3	S6	S2	S3	S7	S8	S3	S2	S2
Date	Potentiometric Elevation (ft msl)													
4/30/1998	5325.75	5294.77	5289.62	-	-	-	-	-	-	-	-	-	-	-
5/12/1998	5331.00	5294.95	5289.59	-	-	-	-	-	-	-	-	-	-	-
6/11/1998	5340.83	5292.87	5289.03	-	-	-	-	-	-	-	-	-	-	-
7/21/1998	5349.56	5293.74	5289.07	-	-	-	-	-	-	-	-	-	-	-
11/8/1998		5293.78	5288.83	-	-	-	-	-	-	-	-	-	-	-
12/17/1998	5315.64	5292.75	5288.85	-	-	-	-	-	-	-	-	-	-	-
8/22/2007	-	5292.21	-	5392.33	5275.44	5278.48	5331.54	5292.06	5288.98	5372.05	5394.32	5366.22	5360.25	-
9/4/2007	5352.12	5292.37	-	5392.60	5273.72	5278.78	5331.85	5291.73	5288.58	5371.69	5394.47	5367.05	5357.72	-
10/4/2007	5354.47	-	5288.48	-	-	-	-	-	-	-	-	-	-	-
10/9/2007	-	-	-	5392.81	5273.44	5278.79	5330.39	5291.30	5287.63	5371.25	5393.71	5367.63	5357.26	-
11/5/2007	5356.16	-	-	-	-	-	-	-	-	-	-	5367.88	5357.23	5410.91
11/15/2007	-	-	-	5392.86	5273.37	5278.69	5329.97	5290.94	5288.21	5370.93	5393.77	-	-	-
12/3/2007	-	-	-	-	-	-	-	-	-	-	-	5367.74	5357.60	-
12/5/2007	5323.44	5291.94	-	5392.01	-	5278.56	5329.88	5291.09	5287.85	5370.81	5393.67	-	-	5410.61
1/17/2008	5329.14	5292.73	-	5393.06	-	-	-	-	-	-	-	-	-	-
1/31/2008	-	-	-	-	5273.42	5278.79	5329.84	5291.91	5288.15	5370.74	5393.81	5368.04	5357.83	5410.71
2/19/2008	5332.94	5291.73	-	5393.36	5273.05	5278.62	5330.05	5289.57	5287.20	5370.63	5393.56	5368.70	5357.74	-
3/20/2008	5328.04	5292.13	-	5392.96	5273.15	5278.39	5330.09	5289.18	5286.96	5370.63	5393.71	5366.44	5385.30	-
4/24/2008	5331.34	5292.83	-	5393.26	5273.23	5278.30	5330.11	5289.12	5286.86	5370.60	5393.67	5366.52	5385.50	5410.22
5/27/2008	-	-	-	5393.06	-	-	-	-	-	-	-	-	-	-
5/28/2008	5332.54	-	-	-	5273.42	5286.86	5330.11	5289.70	5286.86	5370.54	5390.11	5365.97	5385.40	5410.27
6/24/2008	5299.04	5291.73	-	5393.06	5273.47	5278.62	5330.15	5287.02	5287.02	5370.59	5390.11	5365.97	5385.40	5410.33
7/24/2008	5303.84	5293.43	-	5365.96	5273.30	5278.76	5330.17	5289.63	5286.89	5370.51	5390.05	5366.05	5385.50	5410.33
8/19/2008	5305.84	-	-	5392.96	5273.42	5278.56	5330.17	5286.99	5287.51	5370.45	5393.48	5366.19	5358.26	5410.33
8/20/2008	-	5293.03	-	-	-	-	-	-	-	-	-	-	-	-
9/30/2008	5300.24	5292.73	-	5392.76	5273.45	5278.53	5330.42	5287.63	5287.42	5370.51	5393.36	5366.14	5358.11	5410.39

ft msl - feet above mean sea level
VWP - vibrating wire piezometer
(-) no measurement taken

Table 6.G-8. Coal Monitoring Well Summary and Aquifer Test Results

Well	Location (ft)[1]		Coal seam	Ground Elevation (ft)	Well depth (ft)	Test type	Transmissivity (ft^2/day)	Hydraulic conductivity		Saturated thickness (feet)
	Northing	Easting						(ft/day)	(cm/sec)	
Kf-98-02	1974601.45	2526796.60	#3	5505.9	216.5	Displacement Test	0.0010	0.0001	4.6E-08	7.5
Kf-98-03	1984332.35	2527508.40	#3	5423.5	133.9	Bailed Recovery Test	0.010	0.002	7.1E-07	5
Kf-98-04	1990225.42	2523277.83	#3	5351.8	64.8	Bailed Recovery Test	0.010	0.001	3.5E-07	10
Kf2007-01	1995163.61	2525504.37	#8	5557.2	118	Papadopulos-Cooper Pumping Test	1.398	0.056	2.0E-05	25

ft^2/day - square feet per day

cm/sec - centimeter per second

[1] Coordinate system - State Plane New Mexico West, NAD 1983

Table 6.G-9. Baseline Water Quality in the Fruitland Coals at the BNCC Coal Lease

Well	Well Depth (feet)	Baseline Monitoring Period	pH (SU)		TDS -180° (mg/L)		Bicarbonate as HCO_3 (mg/L)		Carbonate as CO_3 (mg/L)		Chloride (mg/L)		Sulfate (mg/L)		Calcium (mg/L)		Magnesium (mg/L)		Potassium (mg/L)	
			n	median	n	median	n	median	n	median	n	median	n	median	n	median	n	median	n	median
KF2007-01 (No. 8)	118	2007-2008	5	8.75	5	3460	5	1818	5	156	5	3385	6	740	5	3.2	5	1.7	6	17.9
KF98-02 (No. 3)	216.5	1998 2007-2008	6	7.95	6	3130	6	1512	6	30	6	940	6	107	6	6.1	6	0.9	8	12.1
KF84-21a (No 2)	118	1984-2001	30	7.9	30	8375	30	1197	17	<1	30	4445	30	63	30	13.3	30	14.9	30	13.3
KF84-21c (No 7)	75	1984	1	8.08	1	8505	1	919	1	68.4	1	3980	1	184	1	14.6	1	14.9	1	15.0
KF84-22a (No 8)	125	1984-2001	22	8.0	22	4650	22	1170	12	<1	22	290	22	2140	22	15.3	22	3.5	22	6.8
KF84-22b (No 7)	140	1984-2001	26	7.4	26	6115	25	854	15	<1	25	3220	26	<10	26	45.0	26	13.4	26	11.9
KF84-22d (No 3)	220	1984	1	7.94	1	8610	1	830	1	46.8	1	3420	1	<10	1	27.4	1	18.7	1	15.8
KF84-22e (No 2)	237	1984	2	7.98	2	8155	2	814	2	52.8	2	4185	2	24.5	2	35.6	2	17.5	2	16.3
KF84-20A (No 3)	190	1984-2001	26	7.93	26	7260	26	1090	23	<1	26	3715	26	<10	26	18.4	26	11.0	26	11.9
KF84-20C (No 7)	240	1984-2001	23	7.9	23	2770	23	1562	21	<1	23	715	23	7	23	9.6	23	2.8	23	5.9
KF84-18b (No 8)	133	1984-2001	25	7.1	25	9300	25	1030	13	<1	25	4900	25	<10	25	114.0	27	24.3	25	15.0
KF84-18a (No. 6)	181	1984-2001	26	7.47	26	13400	26	450	14	<1	26	7900	26	5.5	26	157.0	26	50.6	26	22.5

Well	Well Depth (feet)	Baseline Monitoring Period	Sodium (mg/L)		Fluoride (mg/L)		Nitrate as N (mg/L)		Boron (mg/L)		Iron, total (mg/L)		Iron, diss.(mg/L)		Manganese, total (mg/L)		Manganese, diss. (mg/L)		Selenium, diss. (mg/L)	
			n	median	n	median	n	median	n	median	n	median	n	median	n	median	n	median	n	median
KF2007-01 (No. 8)	118	2007-2008	5	1180	5	2.70	5	0.25	5	0.33	5	0.290	5	<0.05	5	0.017	5	0.008	5	0.005
KF98-02 (No. 3)	216.5	1998 2007-2008	6	1210.0	6	1.65	6	0.03	8	0.4	6	0.530	6	0.038	8	0.018	6	0.018	6	0.008
KF84-21a (No 2)	118	1984-2001	30	3080	30	1.56	5	0.1	30	0.61	21	0.100	30	0.100	21	0.020	30	0.0255	29	<0.005
KF84-21c (No 7)	75	1984	1	2858	1	1.79	1	394	1	0.63	1	-	1	0.015	1	-	1	0.3800	1	<0.001
KF84-22a (No 8)	125	1984-2001	22	1600	22	2.19	3	0.53	22	0.27	19	0.420	22	0.080	19	0.020	22	0.0143	22	<0.005
KF84-22b (No 7)	140	1984-2001	26	2210	25	0.89	1	0.08	25	0.39	23	1.130	26	0.195	23	0.300	26	0.300	26	<0.005
KF84-22d (No 3)	220	1984	1	2866	1	1.28	1	-	1	0.5	1	-	1	0.006	1	-	1	0.016	1	<0.001
KF84-22e (No 2)	237	1984	2	2803	2	1.23	2	-	2	0.51	2	-	2	0.005	2	-	2	0.140	2	<0.001
KF84-20A (No 3)	190	1984-2001	26	2690	26	1.39	2	0.115	26	0.55	17	2.730	26	0.235	17	0.180	26	0.100	26	<0.005
KF84-20C (No 7)	240	1984-2001	23	1040	23	1.74	2	0.18	21	0.42	16	0.640	23	0.180	16	0.075	23	0.082	23	<0.005
KF84-18b (No 8)	133	1984-2001	25	3380	25	0.44	3	0.1	25	0.73	17	11.900	25	<0.5	16	0.380	25	0.380	25	<0.005
KF84-18a (No. 6)	181	1984-2001	26	4640	26	0.66	2	0.1	26	0.72	17	3.80	26	0.25	17	1.33	26	1.32	19	<0.005

Median calculation based on all but rejected sample results including field splits and non detected results

Rejected samples include: samples with no sampling or analysis date, samples with pH>11, samples that are clearly inconsistent with results of other damples

For less than detection limit, 1/2 the detection limit used for summary unles the median is a detection limit that is lower than any detected result

uncaracterized metals results included as dissolved metals in statistical summray

Table 6.G-10 Water Depths and Potentiometric Elevations in the Pictured Cliffs Sandstone Monitoring Wells and Piezometers

	Well or Piezometer Name											
Measuring point elevation (ft msl)	KPC-98-01		KPC2007-01		KPC2007-02		KPC2007-03		VWP 2007-01 Kpc (blue)	VWP 2007-02 Kpc (red)	VWP 2007-04 Kpc	VWP 2007-05 Kpc (red)
	5366.46		5355.71		5515.06		5470.23					
Date	Water depth (ft)	Elevation (ft msl)	Water depth (ft)	Elevation (ft msl)	Water depth (ft)	Elevation (ft msl)	Water depth (ft)	Elevation (ft msl)	Potentiometric elev (ft msl)	Potentiometric elev (ft- msl)	Potentiometric Elev. (ft- msl)	Potentiometric Elev. (ft- msl)
3/29/1998	91.31*	5275.15	-	-	-	-	-	-	-	-	-	-
4/30/1998	86.62	5279.84	-	-	-	-	-	-	-	-	-	-
5/12/1998	84.84	5281.62	-	-	-	-	-	-	-	-	-	-
6/11/1998	106.37	5260.09	-	-	-	-	-	-	-	-	-	-
7/21/1998	97.27	5269.19	-	-	-	-	-	-	-	-	-	-
11/8/1998	80.30	5286.16	-	-	-	-	-	-	-	-	-	-
12/17/1998	89.81	5276.65	-	-	-	-	-	-	-	-	-	-
8/22/2007	-	-	93.61	5262.10	217.55	5297.51	-	-	5270.44	-	-	-
8/23/2007	75.09	5291.37	-	-	-	-	128.66	5341.57	-	5298.44	-	-
9/4/2007	79.35	5287.11	93.68	5262.03	169.11	5345.95	128.03	5342.20	5268.35	5297.90	-	-
10/4/2007	77.56	5288.90	93.65	5262.06	-	-	-	-	-	5297.37	-	-
10/9/2007	-	-	-	-	-	-	-	-	5267.89	-	-	-
11/5/2007	76.51	5289.95	93.78	5261.93	183.30	5331.76	130.67	5339.56	-	-	5393.83	5411.60
11/15/2007	-	-	-	-	-	-	-	-	5268.14	-		
12/5/2007	78.15	5288.31	93.71	5262.00	163.16	5351.90	133.71	5336.52	5268.26	5296.81	5397.48	5411.26
1/31/2008	-	-	-	-	-	-	-	-	5268.09	5297.32	5393.68	5411.54
2/19/2008	-	-	-	-	-	-	-	-	5268.91	-	-	-
2/21/2008	-	-	-	-	-	-	-	-	-	5296.42	-	-
3/20/2008	89.80	5276.66	96.80	5258.91	158.80	5356.26	128.30	5341.93	5268.95	5296.48	5401.50	5410.79
4/24/2008	85.00	5281.46	94.10	5261.61	156.40	5358.66	123.50	5346.73	5268.78	5296.42	5401.82	5410.76
5/27/2008	81.50	5284.96	98.50	5257.21	155.90	5359.16	126.50	5343.73	-	-	-	-
5/28/2008	-	-	-	-	-	-	-	-	5269.01	5296.28	5402.20	5410.82
6/24/2008	79.90	5286.56	94.10	5261.61	157.10	5357.96	127.10	5343.13	5269.04	5296.48	5402.40	5410.88
7/24/2008	79.20	5287.26	94.00	5261.71	156.30	5358.76	126.70	5343.53	5268.76	5296.39	5402.86	5410.85
8/19/2008	-	-	-	-	157.80	5357.26	-	-	5268.83	5296.14	5402.95	5410.85
8/20/2008	78.40	5288.06	94.10	5261.61	-	-	126.70	5343.53	-	-	-	-
9/30/2008	77.70	5288.76	94.40	5261.31	155.20	5359.86	126.80	5343.43	5268.66	5296.25	5403.30	5410.94

ft msl - feet above mean sea level

*1 day after well development

(-) no measurement taken

Table 6.G-11 Pictured Cliffs Sandstone Monitoring Well Summary and Aquifer Test Results

Well	Location (ft)[1]		Elevation (ft)	Well Depth (ft)	Test type	Transmissivity (ft^2/day)	Hydraulic conductivity		Saturated thickness (ft)	Storage coefficient
	Northing	Easting					(ft/day)	(cm/sec)		
KPC-98-01	1993802	290787	5366.46	125.7	0.4 gpm pumping test	0.79	0.020	7.1E-06	39	NA
KPC2007-01	1995103	302596	5355.71	208.84	NA	0.576	0.0074	2.6E-06	78	NA
KPC2007-02	1975119	303891	5515.06	320.98	NA	NA	0.0001	3.5E-08	NA	NA
KPC2007-03	1982885	295091	5470.23	138.4	NA	NA	0.0040	1.4E-06	NA	NA
Pumping test well T4-1	1976250	289850	5520	228	0.15 gpm pumping	0.1203	0.0014	4.9E-07	84	0.00032
Recovery test well GM-30A	1975811	290347	NA	191.6	NA	0.1337	0.0016	5.6E-07	84	0.00034

[1] Coordinates State Plane New Mexico West NAD 1983

[2] 18.3 gpm for 8.7 min

ft^2/day - square feet per day

cm/sec - centimeter per second

gpm - gallon per minute

NA - information not available or not determined

0.0E+00

Table 6.G-12 Water Quality at Pictured Cliffs Sandstone Monitoring Well KPC-98-01

Parameter (units)	3/29/1998	11/8/1998	8/23/2007	11/5/2007	2/21/2008	5/27/2008	8/20/2008	11/21/2008
Total Alkalinity as $CaCO_3$ (mg/L)	131	581	750	930	900	870	740	850
Arsenic (mg/L)	<0.005	<0.005	0.0042	0.00193	0.0019	0.002	0.0017	0.0035
Barium (mg/L)	0.02	0.02	0.0138	0.0101	0.0123	0.0236	0.0132	0.0126
Bicarbonate as HCO_3 (mg/L)	132	709	891	1135	1098	1061	903	1037
Boron (mg/L)	0.12	0.61	0.6	1.11	0.7	0.7	0.6	0.7
Ion balance (%)	2.13	3.71	4.6	8.3	2.17	0.49	6.89	1.61
Cadmium (mg/L)	<0.001	<0.001	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Calcium (mg/L)	26.5	33.1	28	25.2	26.8	30.8	28.4	28.6
Carbonateas CO3 (mg/L)	14	<1	12	<10	<10	<10	<10	<10
Chloride (mg/L)	39	177	310	212	234	244	220	236
Chromium (mg/L)	<0.01* (total)	<0.01	0.018	0.124	0.012	0.004	0.001	0.021
Electrical conductivity (EC) (uS/cm)	1380	6550	5510	8250	8250	8250	8730	8700
Copper (mg/L)	<0.01	<0.01	0.0396	0.026	0.0571	0.43	0.0468	0.0807
Fluoride (mg/L)	2.29	1.13	1.3	1.4	1.4	1.3	1.5	1.5
Hydroxide (mg/L)	-	-	<10	<10	<10	<10	<10	<10
Iron (mg/L)	0.46	1.51	0.68	<0.05	<0.05	<0.05	<0.05	<0.05
Total iron (mg/L)	2.51	1.74	0.68	29.5	7.60	2.71	0.16	0.51
Lead (mg/L)	<0.005	0.005	0.0001	<0.0001	0.0003	0.0003	0.0002	0.0001
Magnesium (mg/L)	2.7	5.7	8.2	6.8	7.7	8	7.4	7.7
Manganese (mg/L)	0.013	0.08	0.063	0.0673	0.058	0.051	0.037	0.039
Total manganese (mg/L)	0.038	0.1	0.073	0.111	0.183	0.082	0.044	0.045
Mercury (mg/L)	<0.001	<0.001	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Nitrate (mg/L-N)	1.54	-	<0.02	2.29	1.94	4.46	2.68	1.92
pH (su)	9.1	8	7.78	7.76	7.70	7.79	7.73	7.87
Potassium (mg/L)	8.2	17.3	9.2	7.1	8.6	10	8.5	8.1
Radium-226 (pCi/L)	<1.69	3.92	0.92 ± 0.49	1.0 ± 0.5	1.2 ± 0.5	1.5 ± 0.5	0.76 ± 0.44	0.61 ± 0.36
Radium-228 (pCi/L)	<1.9	5.42	1.2 ± 0.5	1.6 ± 0.6	1.1 ± 0.4	1.2 ± 0.5	1.2 ± 0.5	1.3 ± 0.4
Selenium (mg/L)	<0.005	<0.005	0.005	0.00346	0.006	0.005	0.005	0.011
Silver (mg/L)	<0.01	<0.01	<0.00005	0.00006	<0.00005	0.00007	<0.00005	<0.00005
Sodium (mg/L)	202	1490	2150	1790	1930	2270	1690	1980
Sulfate (mg/L)	350	2680	3900	3350	3300	3800	3300	3400
Total dissolved solids (TDS) (mg/L)	800	4830	6640	6060	6050	5900	5820	6360
Uranium (mg/L)	-	-	0.01901	0.01230	0.01220	0.00952	0.01000	0.01010
Zinc (mg/L)	0.093	0.365	0.002	0.201	0.018	0.022	0.019	0.027

(-) analysis not performed for parameter

mg/L - milligram per liter

µS/cm - microsiemens per centimeter

su - standard units

pCi/L - picocuries per liter

Table 6.G-13 Water Quality at Pictured Cliffs Sandstone Monitoring Well KPC2007-01

Parameter (units)	8/16/2007	11/15/2007	2/19/2008	5/28/2008	8/20/2008	11/20/2008
Total alkalinity as CaCO3 (mg/L)	1480	1870	1900	1280	1600	1440
Arsenic (mg/L)	0.006	0.0058	0.0052	0.0234	0.0025	0.0051
Barium (mg/L)	0.0342	0.0096	0.0214	0.0341	0.0191	0.0173
Bicarbonate as HCO3 (mg/L)	1732	866	415	1488	756	1293
Boron (mg/L)	0.3	0.429	0.5	0.6	0.4	0.5
Ion balance (%)	9	10.4	11.1	6.13	17.9	7.82
Cadmium (mg/L)	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Calcium (mg/L)	13.4	3.6	2.4	18.6	3	11.6
Carbonate as CO3 (mg/L)	36	696	936	36	588	228
Chloride (mg/L)	320	304	292	374	365	580
Chromium (mg/L)	0.005	0.025	0.040	0.008	0.002	0.063
Electrical conductivity (EC) (uS/cm)	8240	8260	8070	7950	8560	9250
Copper (mg/L)	0.0934	0.104	0.0785	0.2470	0.0369	0.0412
Fluoride (mg/L)	1.7	1.5	1.5	1.8	1.6	1.6
Hydroxide as CaCO3 (mg/L)	<10	<10	<10	<10	<10	<10
Iron (mg/L)	<0.05	<0.05	<0.05	0.13	<0.05	<0.05
Total iron (mg/L)	1.11	0.0892	0.93	533	0.17	1.57
Lead (mg/L)	<0.0001	<0.0001	<0.0001	0.0004	0.0002	0.0002
Magnesium(mg/L)	7.3	0.0056	4.2	9.4	4.4	7.1
Manganese (mg/L)	0.034	0.0244	<0.005	0.022	<0.005	0.0785
Total manganese (mg/L)	0.055	0.024	0.022	9.73	0.006	0.137
Mercury (mg/L)	<0.0002	<0.0002	<0.0002	0.001	<0.0002	<0.0002
Nitrate (mg/L-N)	<0.02	<0.02	0.03	0.05	0.65	0.07
pH (su)	8.19	9.82	10.3	8.35	9.85	9.14
Potassium (mg/L)	18.1	76.9	73.3	14.3	35.2	16.2
Radium-226 (pCi/L)	0.18 ± 0.28	0.61 ± 0.39	0.01 ± 0.28	2.0 ± 0.7	0.33 ± 0.32	0.10 ± 0.22
Radium-228 (pCi/L)	0.86 ± 0.57	0.19 ± 0.44	0.37 ± 0.57	0.42 ± 0.45	0.50 ± 0.47	0.37 ± 0.43
Selenium (mg/L)	0.008	0.003	0.004	0.006	0.004	0.008
Silver (mg/L)	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	0.0001
Sodium (mg/L)	1720	2020	1920	1840	1600	2020
Sulfate (mg/L)	2750	2500	2000	2900	2350	2800
Total dissolved solids (TDS) (mg/L)	5820	5820	5650	6790	5640	6280
Uranium (mg/L)	0.00187	0.00149	0.00065	0.00472	0.00080	0.00089
Zinc (mg/L)	0.006	0.004	0.001	0.012	0.003	0.008

mg/L - milligram per liter
µS/cm - microsiemens per centimeter
su - standard units
pCi/L - picocuries per liter

Table 6.G-14 Water Quality at Pictured Cliffs Sandstone Monitoring Well GM-19

Parameter (units)	11/16/1974	8/5/1976	8/8/1977	9/10/1979
Arsenic (mg/L)	<0.5	<0.001	<0.05	0.33
Barium (mg/L)	-	<0.1	<0.5	0.08
Boron (mg/L)	1.03	0.3	1.0	0.88
Cadmium (mg/L)	0.016	<0.001	<0.01	<.01
Chromium (mg/L)	-	0.001	<0.01	<.01
Copper (mg/L)	0.015	0.001	0.02	0.02
Iron (mg/L)	0.4	0.005	<0.05	0.01
Lead (mg/L)	<0.05	0.001	<0.05	0.1
Manganese (mg/L)	0.245	0.088	0.06	0.11
Mercury (mg/L)	<0.0005	<0.0004	<0.001	-
Selenium (mg/L)	<0.05	<0.01	<0.01	0.002
Silver (mg/L)	-	<0.001	<0.05	<.01
Zinc (mg/L)	0.240	0.031	0.07	0.42
Total iron (mg/L)	-	-	-	0.01
Total manganese (mg/L)	-	-	-	0.12
pH (su)	8.1	7.83	7.9	7.5
Electrical conductivity (EC) (uS/cm)	-	-	-	-
Total dissolved solids (TDS) (mg/L)	9172	8437	7810	9270
Fluoride (mg/L)	1.7	0.76	0.9	1.49
Bicarbonate as HCO3 (mg/L)	1000	-	-	-
Carbonate as CO3 (mg/L)	-	-	-	-
Chloride (mg/L)	1020	534.8	668	1077
Sulfate (mg/L)	4050	3685	4000	4535
Calcium (mg/L)	43	13.2	200	-
Magnesium (mg/L)	19	3.83	38	-
Potassium (mg/L)	-	-	-	-
Sodium (mg/L)	3040	1610	2200	-
Hydroxide (mg/L)	-	-	-	-
Total alkalinity (mg/L)	-	-	-	-
Nitrate (mg/L-N)	-	-	1.2	-
Ion balance (%)	2.4	-	-	-

(-) analysis not performed for parameter
mg/L - milligram per liter
µS/cm - microsiemens per centimeter
su - standard units

Table 16.G-15 Water Quality at Pictured Cliffs Sandstone Monitoring Well GM-20

Parameter (units)	11/16/1974	6/27/1975	5/18/1976	10/6/1976	8/22/1977	12/20/1977	9/10/1979
Arsenic (mg/L)	<0.5	-	0.01	0.03	<0.01	<0.01	<0.001
Barium (mg/L)	-	-	0.24	<0.1	<0.5	<0.1	0.1
Boron (mg/L)	0.68	-	0.88	0.2	0.9	1.2	2.24
Cadmium (mg/L)	<0.010	-	0.001	<0.001	<0.01	0.001	<0.1
Chromium (mg/L)	-	-	0.013	0.019	<0.01	0.012	0.01
Copper (mg/L)	0.025	-	0.016	0.006	0.01	0.008	0.03
Iron (mg/L)	0.15	-	0.64	0.066	<0.05	0.35	0.01
Lead (mg/L)	<0.05	-	0.035	0.034	<0.05	<0.001	0.10
Manganese (mg/L)	0.035	-	0.026	0.008	<0.001	0.16	0.29
Mercury (mg/L)	<0.0005	-	<0.0004	<0.0004	<0.001	<0.0004	-
Selenium (mg/L)	<0.05	-	<0.01	<0.01	<0.01	<0.01	0.001
Silver (mg/L)	-	-	<0.001	<0.001	<0.05	<0.01	<.01
Zinc (mg/L)	0.08	-	0.08	<0.001	<0.05	0.04	1.06
Total iron (mg/L)	-	-	-	-	-	-	0.03
Total manganese (mg/L)	-	-	-	-	-	-	0.29
pH (su)	11.8	10.8	9.3	8.6	8.7	7.3	7
Electrical conductivity (EC) (uS/cm)	-	8755	-	-	-	-	-
Total dissolved solids (TDS) (mg/L)	5033	-	5711	5822	5880	5050	5260
Fluoride (mg/L)	-	-	-	-	-	-	-
Bicarbonate as HCO3 (mg/L)	192	290	475	-	462	269	-
Carbonate as CO3 (mg/L)	471	272	105	-	-	-	-
Chloride (mg/L)	1030	-	2118	1280	1430	757	803
Sulfate (mg/L)	1880	-	1725	1830	2050	2380	2250
Calcium (mg/L)	11	-	10.6	8.5	11	9.3	-
Magnesium (mg/L)	0.7	-	4.32	4.56	7	19	-
Potassium (mg/L)	-	-	-	-	-	-	-
Sodium (mg/L)	1640	-	2000	1690	2020	1600	-
Hydroxide (mg/L)	-	-	-	-	-	-	-
Total alkalinity (mg/L)	-	-	-	-	-	-	-
Nitrate (mg/L-N)	-	-	-	0.08	0.6	0.2	-
Ion balance (%)	9.5	-	9.8	-	0.9	2.5	-

(-) analysis not performed for parameter
mg/L - milligram per liter
µS/cm - microsiemens per centimeter
su - standard units

Table 6.G-16 Water Quality at Pictured Cliffs Sandstone Monitoring Well GM-30A

Parameter (units)	5/19/1976	8/22/1977	9/10/1979
Arsenic (mg/L)	<0.01	<0.01	0.0019
Barium (mg/L)	0.4	<0.5	0.03
Boron (mg/L)	0.46	0.6	0.96
Cadmium (mg/L)	<0.001	<0.01	<.01
Chromium (mg/L)	0.010	<0.01	0.01
Copper (mg/L)	0.007	0.01	<.01
Iron (mg/L)	0.49	<0.05	0.01
Lead (mg/L)	0.20	<0.05	0.13
Manganese (mg/L)	0.07	0.04	<.01
Mercury (mg/L)[1]	<0.0004	<0.001	-
Selenium (mg/L)[2]	<0.01	<0.01	0.002
Silver (mg/L)	<0.001	<0.05	<.01
Zinc (mg/L)	0.09	<0.05	0.16
Total iron (mg/L)	-	-	0.02
Total manganese (mg/L)	-	-	0.05
pH (su)	7.6	7.5	7.5
Electrical conductivity (EC) (uS/cm)	-	-	-
Total dissolved solids (TDS) (mg/L)	6573	6930	7070
Fluoride (mg/L)	-	-	-
Bicarbonate (mg/L)	171	210	-
Carbonate (mg/L)	-	-	-
Chloride (mg/L)	1215	1120	1203
Sulfate (mg/L)	422	3100	3105
Calcium (mg/L)	30.8	102	-
Magnesium (mg/L)	17.7	22	-
Potassium (mg/L)	-	-	-
Sodium (mg/L)	2070	2110	-
Hydroxide (mg/L)	-	-	-
Total alkalinity (mg/L)	-	-	-
Nitrate (mg/L-N)	0.51	0.4	-
Ion balance (%)	34	4.5	-

(-) analysis not performed for parameter
mg/L - milligram per liter
µS/cm - microsiemens per centimeter
su - standard units

Table 6.G-17 Water Quality at Pictured Cliffs Sandstone Monitoring Well GM-21

Parameter (units)	11/16/1974	8/4/1976	8/22/1977	9/10/1979
Arsenic (mg/L)	<0.5	<0.01	<0.01	<.0001
Barium (mg/L)	-	<0.1	<0.5	0.05
Boron (mg/L)	0.88	0.7	1.0	1.10
Cadmium (mg/L)	0.081	<0.001	<0.01	<.01
Chromium (mg/L)	-	0.005	<0.01	0.03
Copper (mg/L)	0.025	<0.001	0.01	<0.01
Iron (mg/L)	0.2	0.198	<0.05	0.04
Lead (mg/L)	<0.05	0.001	<0.05	0.26
Manganese (mg/L)	0.05	<0.039	0.07	0.03
Mercury (mg/L)	<0.0005	<0.0004	<0.001	-
Selenium (mg/L)	<0.05	<0.01	<0.01	0.001
Silver (mg/L)	-	<0.001	<0.05	<0.1
Zinc (mg/L)	0.447	0.045	0.06	0.62
Total iron (mg/L)	-	-	-	0.41
Total manganese (mg/L)	-	-	-	0.11
pH (su)	7.9	7.2	7.3	7
Electrical conductivity (EC) (uS/cm)	-	-	-	-
Total dissolved solids (TDS) (mg/L)	6923	6624	6370	6140
Fluoride (mg/L)	0.4	0.2	-	-
Bicarbonate (mg/L)	585	-	-	-
Carbonate (mg/L)	-	-	-	-
Chloride (mg/L)	780	646	150	118
Sulfate (mg/L)	3600	2502	2625	3740
Calcium (mg/L)	423	155	414	-
Magnesium (mg/L)	65	148	62	-
Potassium (mg/L)	-	-	-	-
Sodium (mg/L)	1470	920	1440	-
Hydroxide (mg/L)	-	-	-	-
Total alkalinity (mg/L)	-	-	-	-
Nitrate (mg/L-N)	-	-	0.4	-
Ion balance (%)	8.2	-	-	-
Radium-226 (pCi/L)	-	-	-	0.11
Radium-228 (pCi/L)	-	-	-	-

(-) analysis not performed for parameter

mg/L - milligram per liter

µS/cm - microsiemens per centimeter

su - standard units

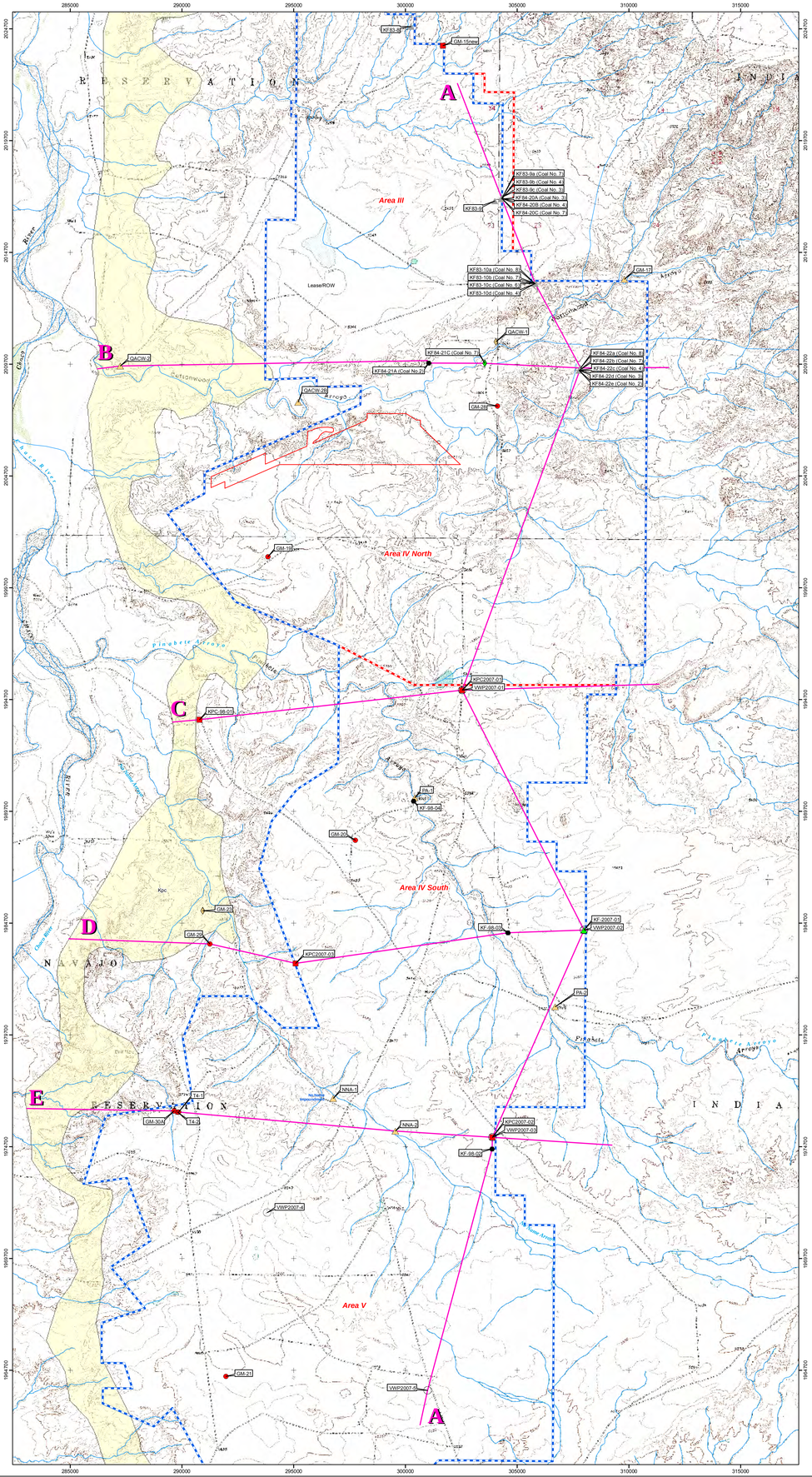
pCi/L - picocuries per liter

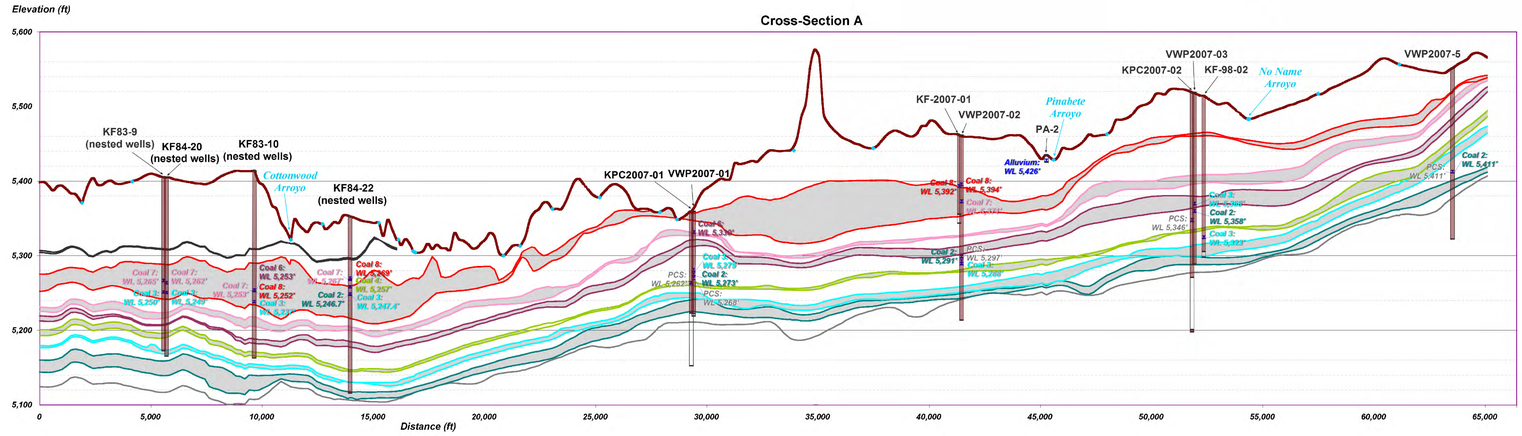
Table 6.G-18 Measured and Modeled Recharge Rates

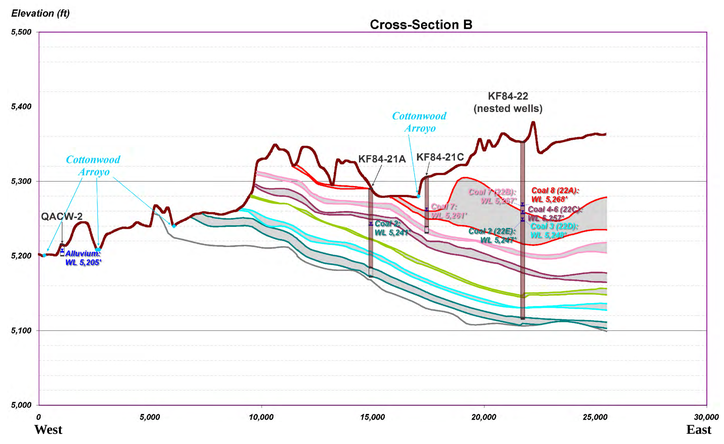
Surface characterization	Recharge range[1] (in/yr)	Mean recharge[1] (in/yr)	Modeled recharge (in/yr)
Badlands	0.002 to 0.01	0.006	
Slopes > 5%			0.002
Slopes: 2 to 5%			0.01
Upland flat	0.02 to 0.05	0.03	
Upland flat (slope <1%)			0.03
Upland (slope 1 to 2%)			0.02
Alluvial valley	0.09	0.09	0.09

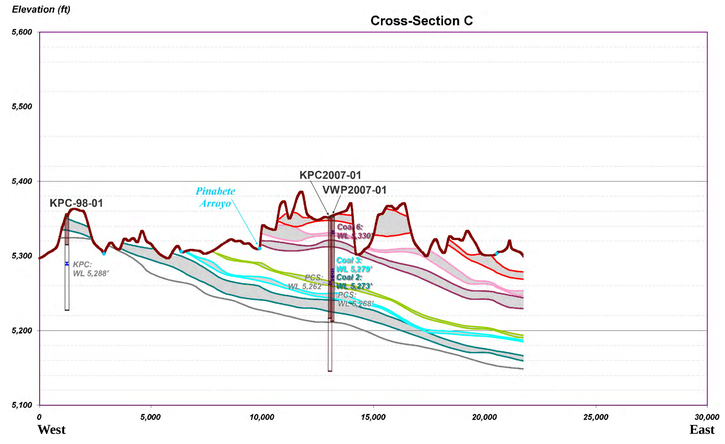
[1]From Stone 1987

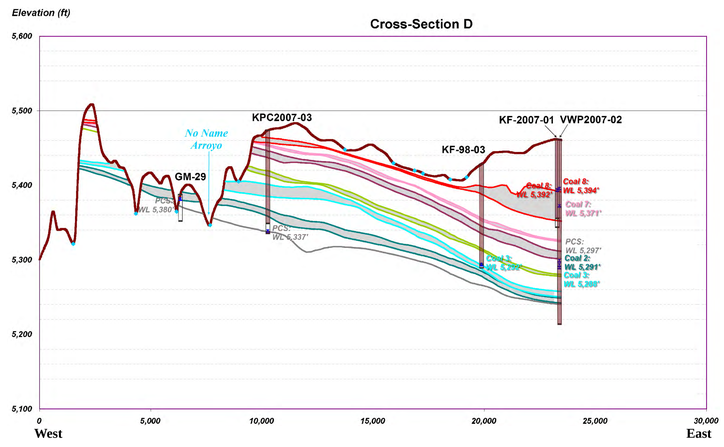
Appendix 6.G Exhibits

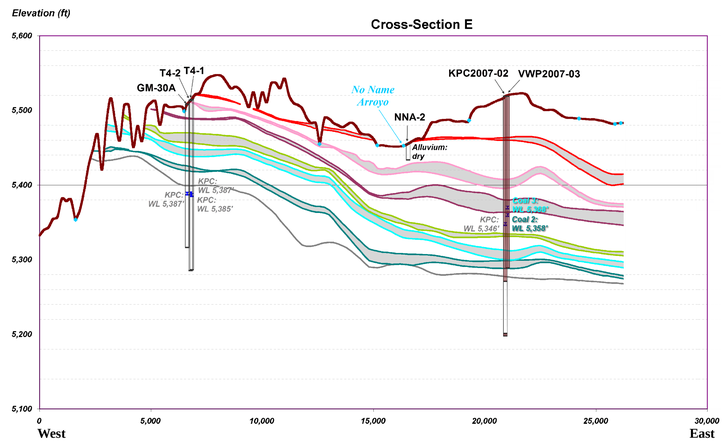












- Abandoned Alluvial Monitoring Well
- Existing Alluvial Monitoring Well
- Well, Coal No. 2, Existing
- No 3. Coal Monitoring Well
- Well, Coal No. 4, Existing
- No 6. Coal Monitoring Well
- No 7. Coal Monitoring Well
- No 8. Coal Monitoring Well
- Fruitland Well or Nested Wells
- Abandoned PCS Monitoring Well
- Existing PCS Monitoring Well
- Nested Vibrating Wire Piezometer
- BNCC Lease Area
- BNCC Permit Area
- Proposed Mining in Area IV North
- Streams
- Pictured Cliffs Formation (Kpc)

Cross-Sections :
- Pictured Cliffs Top
- S2 Coal
- S3 Coal
- S4 Coal
- S6 Coal
- S7 Coal
- S8 Coal
- S9 Coal
- Topo (2000)
- Wells
- Water Levels
- Streams

Projection Information:
State Plane New Mexico West
North American Datum 1927
FIPS 3003
feet

1:24,000

0 1,700 3,400 6,800 Feet

REV. No.	DATE	DRAFT BY	REVISION DESCRIPTION	ENG.	EQO.	PE.
				APPROVALS		

Exhibit 6.G-1

BHP NAVAJO COAL COMPANY

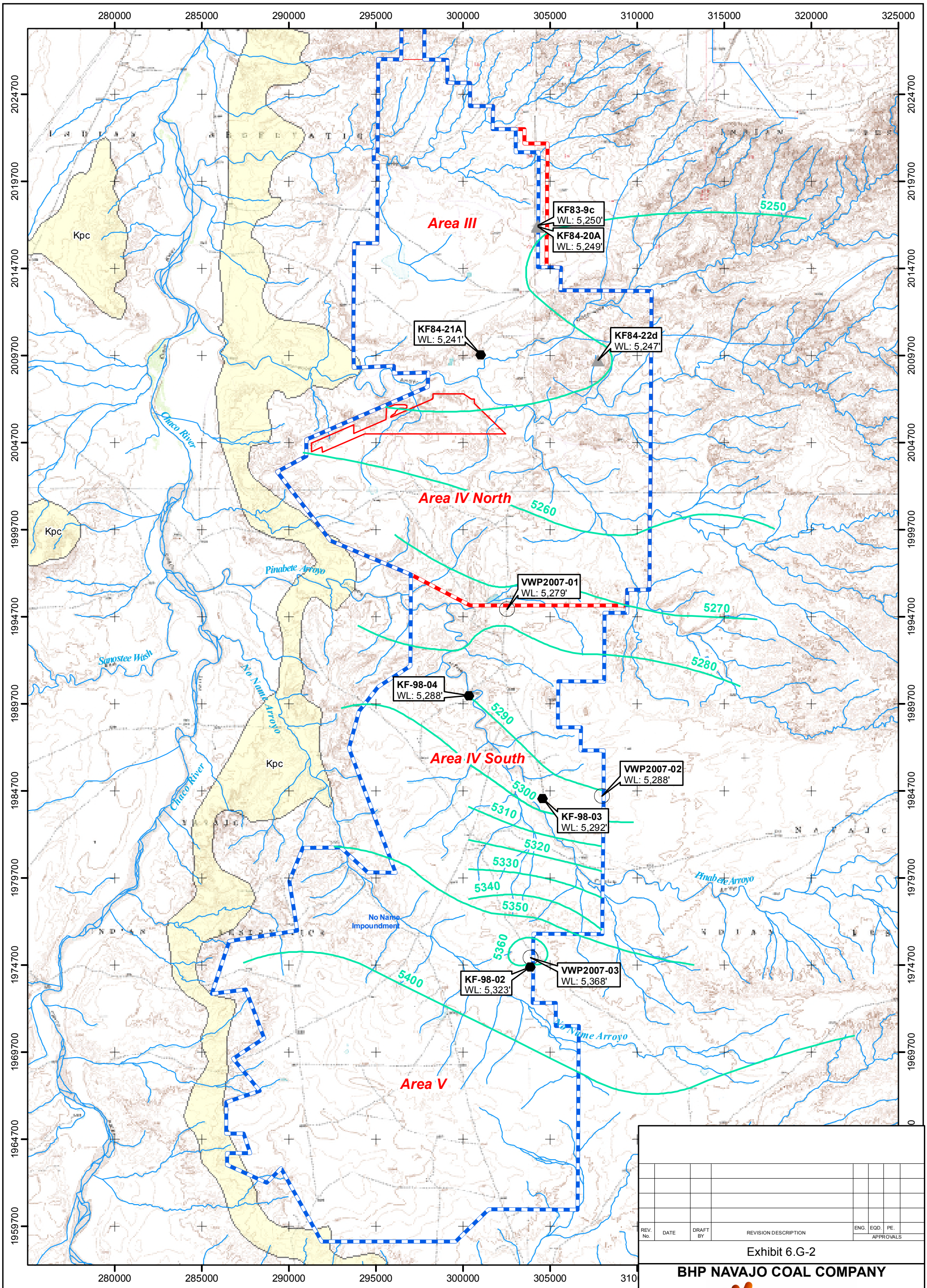
bhpbilliton

P.O.BOX 1717 FRUITLAND,NEW MEXICO 87416/PHONE 505-598-5861/FAX 505-598-3361

Navajo Mine Permit

Hydrogeologic Cross-sections,
Monitoring Wells & Piezometers
for Areas III, IV & V

PREPARED BY: MD	DRAWN BY: MD	PAPER SIZE: 34"x48"
APPROVED BY: APO	DATE: 02/09/2011	



REV. No.	DATE	DRAFT BY	REVISION DESCRIPTION	ENG.	EQD.	PE.
				APPROVALS		

Exhibit 6.G-2

BHP NAVAJO COAL COMPANY

bhpbilliton

P.O.BOX 1717 FRUITLAND,NEW MEXICO 87416/PHONE 505-598-5861/FAX 505-598-3361

Navajo Mine Permit

Coal Seam No.3 Potentiometry

PREPARED BY: MD	DRAWN BY: MD	PAPER SIZE: 11"x17"
APPROVED BY: APO	DATE: 02/09/2011	

N

1:60,000

Projection Information:
State Plane New Mexico West
North American Datum 1927
FIPS 3003
feet

Feet
0 2,750 5,500 11,000

- No 3. Coal Monitoring Well
- Fruitland Nested Wells
- Nested Vibrating Wire Piezometer
- Coal Seam No. 3 Potentiometric Contours
- BNCC Lease Area
- BNCC Permit Area
- Proposed Mining in Area IV North
- Streams
- Pictured Cliffs Formation (Kpc)

285000 290000 295000 300000 305000 310000 315000 320000 325000 330000

2024700 2019700 2014700 2009700 2004700 1999700 1994700 1989700 1984700 1979700 1974700 1969700 1964700 1959700

Area III

Area IV North

Area IV South

Area V

KF83-10a
WL: 5,252'

KF84-22a
WL: 5,269'

KF-2007-01
WL: 5,392'

VWP2007-02
WL: 5,394'

5250 5300 5350 5400 5450

Chaco River

Pinabete Arroyo

No Name Arroyo

Kpc

No Name Impoundment

N A V A J O

I N D I A N R E S E R V A T I O N

285000 290000 295000 300000 305000 310000 315000

N

1:60,000

Projection Information:
State Plane New Mexico West
North American Datum 1927
FIPS 3003
feet

0 2,750 5,500 11,000 Feet

- No 8. Coal Monitoring Well
- Fruitland Nested Well
- Nested Vibrating Wire Piezometer
- Coal No.8 Potentiometric Contours
- BNCC Lease Area
- BNCC Permit Area
- Proposed Mining in Area IV North
- Streams
- Pictured Cliffs Formation (Kpc)

REV. No.	DATE	DRAFT BY	REVISION DESCRIPTION	ENG.	EQD.	PE.
				APPROVALS		

Exhibit 6.G-3

BHP NAVAJO COAL COMPANY

bhpbilliton

P.O.BOX 1717 FRUITLAND,NEW MEXICO 87416/PHONE 505-598-5861/FAX 505-598-3361

Navajo Mine Permit

Coal Seam No.8 Potentiometry

PREPARED BY: MD	DRAWN BY: MD	PAPER SIZE: 11"x17"
APPROVED BY: APO	DATE: 02/09/2011	

GM-15new
WL: 5,265'

GM-28
WL: 5,265'

GM-19
WL: 5,265'

KPC2007-01
WL: 5,262'

VWP2007-01
WL: 5,268'

KPC-98-01
WL: 5,288'

GM-20
WL: 5,333'

VWP2007-02
WL: 5,297'

KPC2007-03
WL: 5,337'

GM-29
WL: 5,306'

T4-1
WL: 5,385'

T4-2
WL: 5,387'

GM-30A
WL: 5,387'

KPC2007-02
WL: 5,346'

VWP2007-4
WL: 5,397'

GM-21
WL: 5,428'

VWP2007-5
WL: 5,411'

Area III

Area IV North

Area IV South

Area V

5260

5280

5300

5320

5340

5360

5380

5400

5420

Kpc

Chaco River

Pinabete Arroyo

Sanostee Wash

No Name Arroyo

No Name impoundment

1:60,000

Projection Information:
State Plane New Mexico West
North American Datum 1927
FIPS 3003
feet

0 2,900 5,800 11,600 Feet

- Abandoned PCS Monitoring Well
- Existing PCS Monitoring Well
- Nested Vibrating Wire Piezometer
- PCS Potentiometric Contour
- BNCC Lease Area
- BNCC Permit Area
- Proposed Mining in Area IV North
- Streams
- Pictured Cliffs Formation (Kpc)

REV. No.	DATE	DRAFT BY	REVISION DESCRIPTION	ENG.	EQD.	PE.
				APPROVALS		

Exhibit 6.G-4

BHP NAVAJO COAL COMPANY

bhpbilliton

P.O.BOX 1717 FRUITLAND,NEW MEXICO 87416/PHONE 505-598-5861/FAX 505-598-3361

Navajo Mine Permit

PCS Potentiometry

PREPARED BY: MD	DRAWN BY: MD	PAPER SIZE: 11"x17"
APPROVED BY: APO	DATE: 02/11/2011	

Attachment 6.G-1

Completion Diagrams and Logs for Monitoring Wells and Vibrating Wire Piezometers

NORWEST
Applied Hydrology

KF2007-01

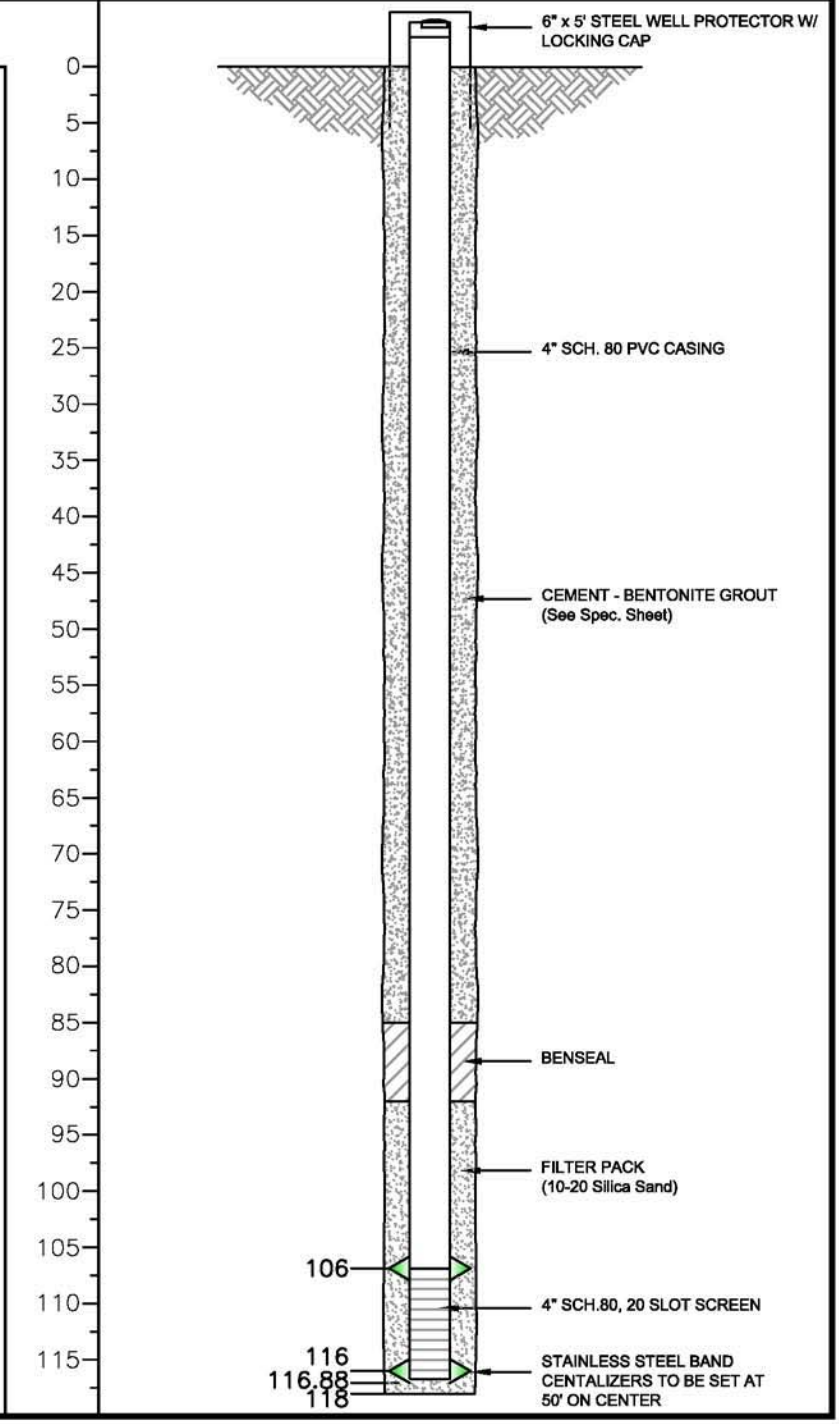
COMPLETION DIAGRAM & LITHOLOGIC LOG

PROJECT: NAVAJO MINE EXTENSION
DRILLING CO: MO-TE
DRILLER: BOB
CLIENT SUPERVISER: COLLETTE BROWN
GEOLOGIST/SUPERVISOR: JOEL SOBOL
AHA JOB#: 4010-00060-10
DRILLING METHOD: AIR ROTARY
BORING STARTED: 7/28/07

WELL TYPE: MONITOR WELL
WELLHEAD TYPE: PROTECTIVE HEAD COVER
WELL COMPLETED: 7/28/07
WELL DEVELOPED: 7/28/07
DATE SURVEYED: 8/29/07
SCREEN SLOT SIZE: 0.02" MILL SLOT
SCREEN TYPE: 4" SCH 80 PVC
FILTER PACK: 10-20 SILICA SAND

CASING DIAMETER: 4"
CASING MATERIAL: SCH 80 PVC
BORING DIAMETER: 8-3/4"
TOP OF CASING ELEV. (FT): 5459.96
GROUND ELEVATION (FT): 5457.22
LOCATION: AREA 4 SOUTH
NORTHING (FT): 1984390.9290
EASTING (FT): 307986.0078

LITHOLOGY LOG



NORWEST
Applied Hydrology

KF98-02

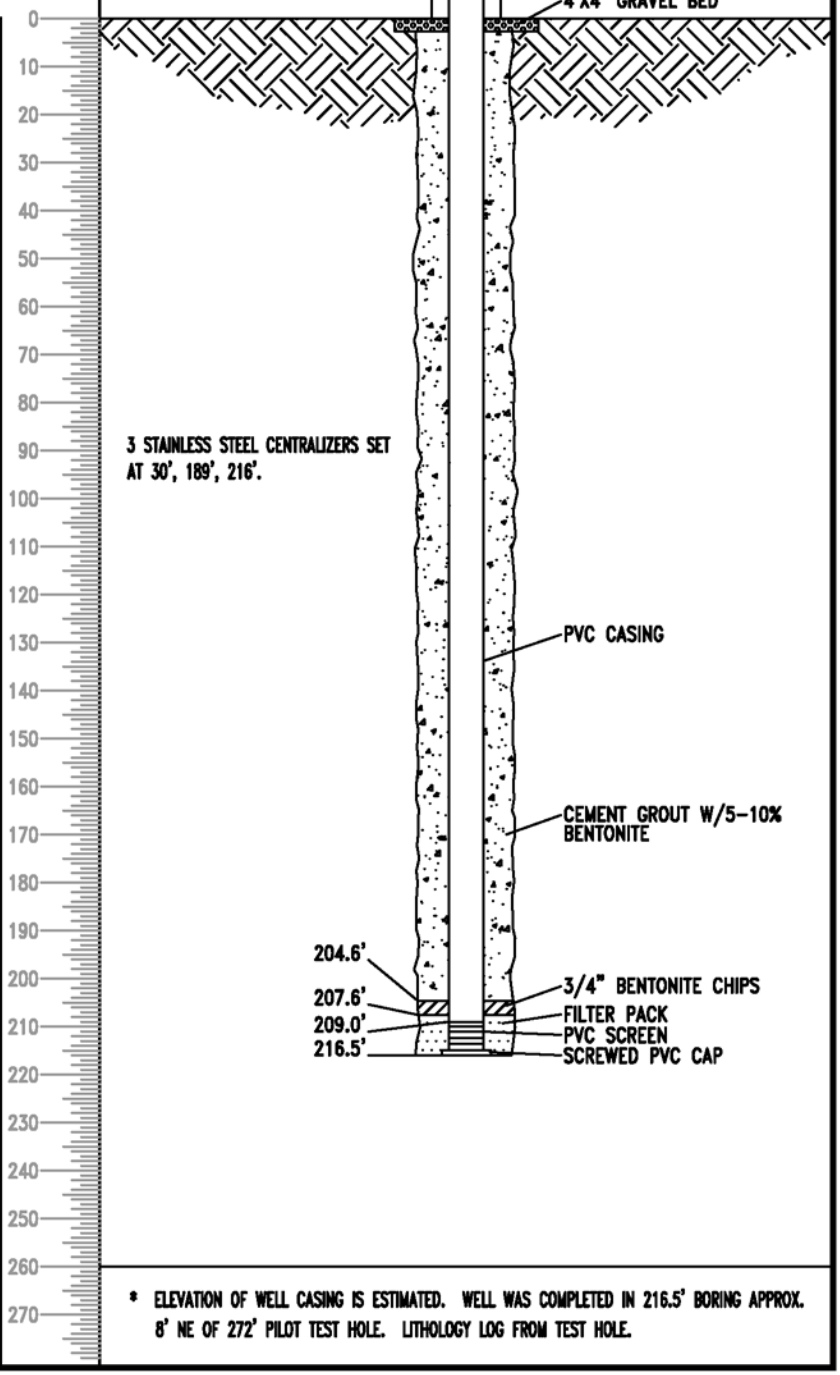
COMPLETION DIAGRAM & LITHOLOGIC LOG

PROJECT: NO NAME
DRILLING CO: SHARPE DRILLING
DRILLER: RUSS SHARPE
CLIENT SUPERVISER: RON VANVALKENBURG
GEOLOGIST/SUPERVISOR: IAN PEARSON
AHA JOB#: 43-4B
DRILLING METHOD: AIR ROTARY
BORING STARTED: 3/22/98

WELL TYPE: MONITORING
WELLHEAD TYPE: STICKUP (1.5')
WELL COMPLETED: 3/23/98
WELL DEVELOPED: 3/28/98
DATE SURVEYED:
SCREEN SLOT SIZE: 0.02" MILL SLOT
SCREEN TYPE: SCH 80 PVC
FILTER PACK: 30-60 SAND

CASING DIAMETER: 4"
CASING MATERIAL: SCH 80 PVC
BORING DIAMETER: 7 7/8"
TOP OF CASING ELEV. (FT): 5507.04
GROUND ELEVATION (FT): 5505.89
LOCATION: AREA 4 SOUTH
NORTHING (FT): 1,974,600.26
EASTING (FT): 303,887.43

LITHOLOGY LOG



* ELEVATION OF WELL CASING IS ESTIMATED. WELL WAS COMPLETED IN 216.5' BORING APPROX. 8' NE OF 272' PILOT TEST HOLE. LITHOLOGY LOG FROM TEST HOLE.

NORWEST
Applied Hydrology

KF98-03

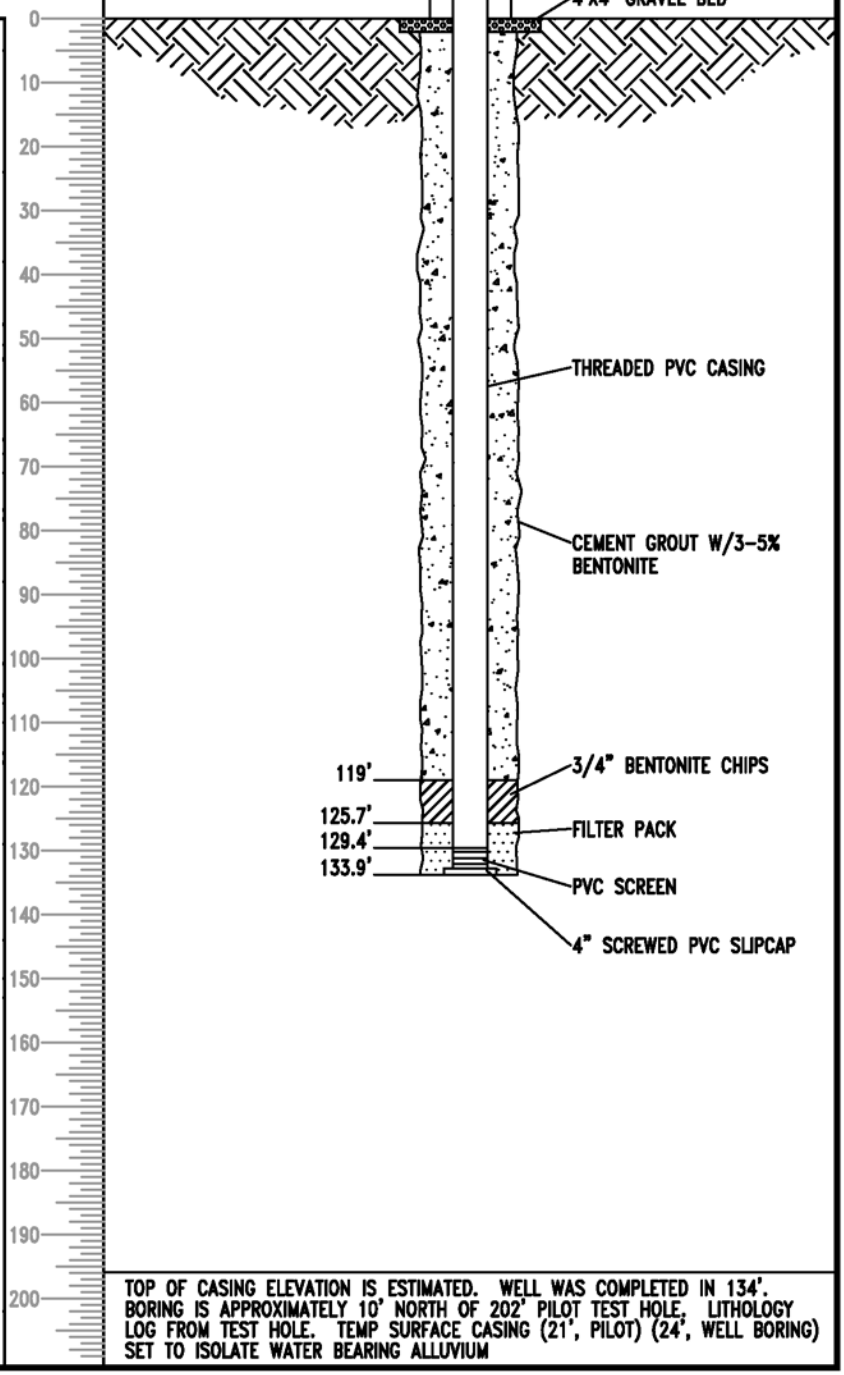
COMPLETION DIAGRAM & LITHOLOGIC LOG

PROJECT: NO NAME
DRILLING CO: SHARPE DRILLING
DRILLER: RUSS SHARPE
CLIENT SUPERVISER: RON VANVALKENBURG
GEOLOGIST/SUPERVISOR: IAN PEARSON
AHA JOB#: 43-4B
DRILLING METHOD: AIR ROTARY
BORING STARTED: 3/25/98

WELL TYPE: MONITORING
WELLHEAD TYPE: STICKUP (2.3')
WELL COMPLETED: 3/27/98
WELL DEVELOPED: 3/28/98
DATE SURVEYED:
SCREEN SLOT SIZE: 0.02" MILL SLOT
SCREEN TYPE: SCH 80 PVC
FILTER PACK: 10-20 SILICA SAND

CASING DIAMETER: 4"
CASING MATERIAL: SCH 80 PVC
BORING DIAMETER: 7 7/8"
TOP OF CASING ELEV. (FT): 5425.53
GROUND ELEVATION (FT): 5423.45
LOCATION: AREA 4 SOUTH
NORTHING (FT): 1,984,271.05
EASTING (FT): 304,599.17

LITHOLOGY LOG



TOP OF CASING ELEVATION IS ESTIMATED. WELL WAS COMPLETED IN 134'. BORING IS APPROXIMATELY 10' NORTH OF 202' PILOT TEST HOLE. LITHOLOGY LOG FROM TEST HOLE. TEMP SURFACE CASING (21', PILOT) (24', WELL BORING) SET TO ISOLATE WATER BEARING ALLUVIUM

NORWEST
Applied Hydrology

KF98-04

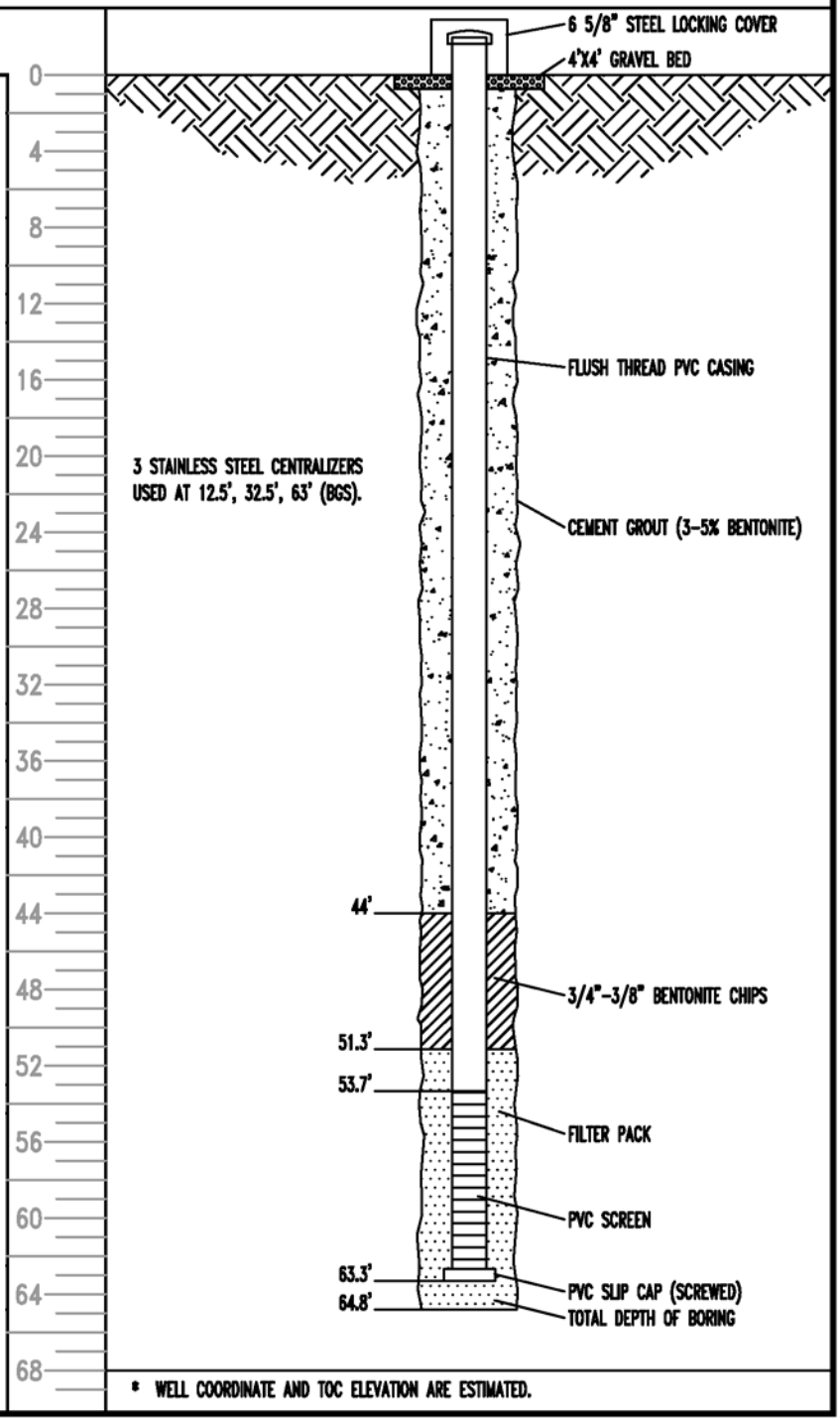
COMPLETION DIAGRAM & LITHOLOGIC LOG

PROJECT: NO NAME
DRILLING CO: SHARPE DRILLING
DRILLER: RUSS SHARPE
CLIENT SUPERVISER: RON VANVALKENBURG
GEOLOGIST/SUPERVISOR: IAN PEARSON
AHA JOB#: 43-4B
DRILLING METHOD: AIR ROTARY
BORING STARTED: 3/27/98

WELL TYPE: MONITORING
WELLHEAD TYPE: STICKUP (1.7')
WELL COMPLETED: 3/28/98
WELL DEVELOPED: 3/28/98
DATE SURVEYED:
SCREEN SLOT SIZE: 0.02" MILL SLOT
SCREEN TYPE: SCH 80 PVC
FILTER PACK: 10-20 SILICA SAND

CASING DIAMETER: 4"
CASING MATERIAL: SCH 80 PVC
BORING DIAMETER: 7 7/8"
TOP OF CASING ELEV. (FT): 5353.38
GROUND ELEVATION (FT): 5351.81
LOCATION: AREA 4 SOUTH
NORTHING (FT): 1,990,163.70
EASTING (FT): 300,368.91

LITHOLOGY LOG



* WELL COORDINATE AND TOC ELEVATION ARE ESTIMATED.

NORWEST
Applied Hydrology

KPC-98-01

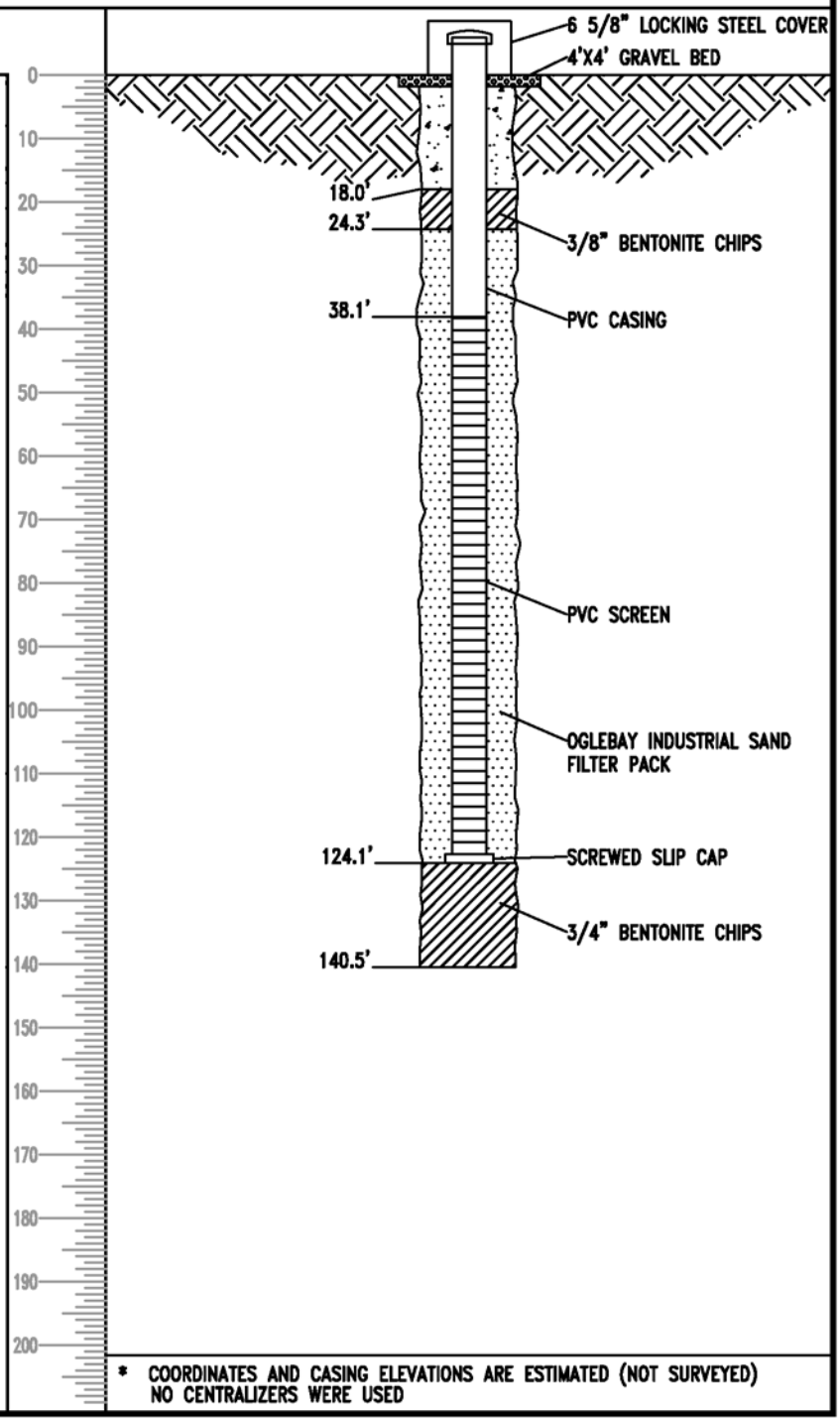
COMPLETION DIAGRAM & LITHOLOGIC LOG

PROJECT: NO NAME
DRILLING CO: SHARPE DRILLING
DRILLER: RUSS SHARPE
CLIENT SUPERVISER: RON VALVALKENBURG
GEOLOGIST/SUPERVISOR: IAN PEARSON
AHA JOB#: 43-4B
DRILLING METHOD: AIR ROTARY
BORING STARTED: 3/20/98

WELL TYPE: MONITORING
WELLHEAD TYPE: STICKUP (1.6')
WELL COMPLETED: 3/21/98
WELL DEVELOPED: 3/28/98
DATE SURVEYED:
SCREEN SLOT SIZE: 0.02" MILL SLOT
SCREEN TYPE: SCH 80 PVC
FILTER PACK: 30-60 SAND

CASING DIAMETER: 4"
CASING MATERIAL: SCH 80 PVC
BORING DIAMETER: 7 7/8"
TOP OF CASING ELEV. (FT): 5366.46
GROUND ELEVATION (FT): 5365.20
LOCATION: AREA 4 SOUTH
NORTHING (FT): 1,993,801.95
EASTING (FT): 290,787.30

LITHOLOGY LOG



* COORDINATES AND CASING ELEVATIONS ARE ESTIMATED (NOT SURVEYED)
NO CENTRALIZERS WERE USED

NORWEST
Applied Hydrology

KPC2007-01

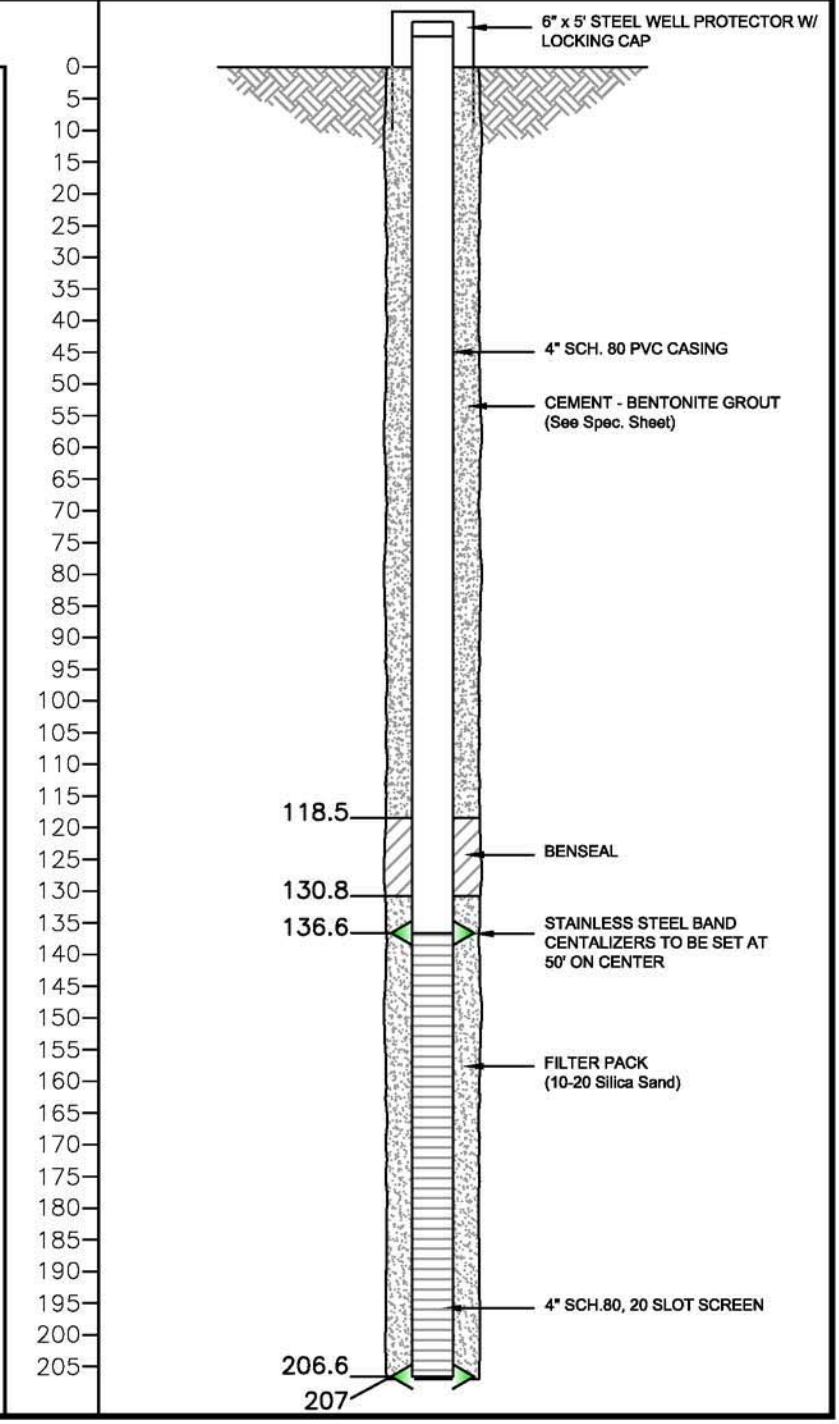
COMPLETION DIAGRAM & LITHOLOGIC LOG

PROJECT: NAVAJO MINE EXTENSION
DRILLING CO: MO-TE
DRILLER: BOB
CLIENT SUPERVISER: COLLETTE BROWN
GEOLOGIST/SUPERVISOR: JOEL SOBOL
AHA JOB#: 4010-00060-10
DRILLING METHOD: AIR ROTARY
BORING STARTED: 7/29/07

WELL TYPE: MONITORING WELL
WELLHEAD TYPE: PROTECTIVE HEAD COVER
WELL COMPLETED: 7/29/07
WELL DEVELOPED: 7/29/07
DATE SURVEYED: 8/29/07
SCREEN SLOT SIZE: 0.02"
SCREEN TYPE: 4" SCH 80 PVC MILL SLOT
FILTER PACK: 10-20 SILICA SAND

CASING DIAMETER: 4"
CASING MATERIAL: 4" SCH 80 PVC
BORING DIAMETER: 8-3/4"
TOP OF CASING ELEV. (FT): 5355.71'
GROUND ELEVATION (FT): 5352.97
LOCATION: AREA 4 SOUTH
NORTHING (FT): 1995102.5555
EASTING (FT): 302595.6035

LITHOLOGY LOG



NORWEST
Applied Hydrology

KPC2007-02

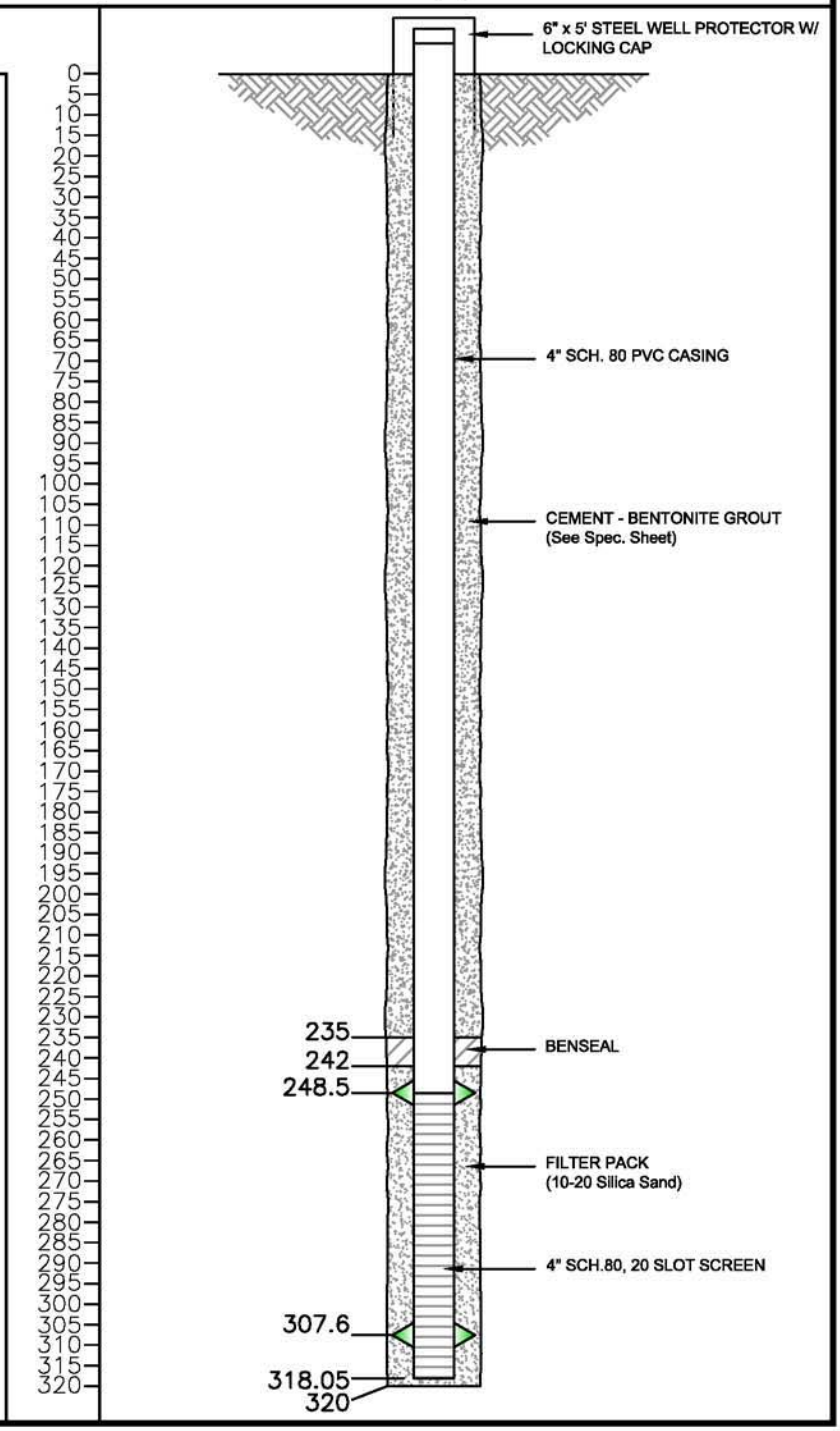
COMPLETION DIAGRAM & LITHOLOGIC LOG

PROJECT: NAVAJO MINE EXTENSION
DRILLING CO: MO-TE
DRILLER: BOB
CLIENT SUPERVISER: COLLETTE BROWN
GEOLOGIST/SUPERVISOR: JOEL SOBOL
AHA JOB#: 4010-00060-10
DRILLING METHOD: AIR ROTARY
BORING STARTED: 7/26/07

WELL TYPE: MONITORING WELL
WELLHEAD TYPE: PROTECTIVE HEAD COVER
WELL COMPLETED: 7/28/07
WELL DEVELOPED: 7/28/07
DATE SURVEYED: 8/29/07
SCREEN SLOT SIZE: 0.02"
SCREEN TYPE: 4" SCH 80 PVC MILL SLOT
FILTER PACK: 10-20 SILICA SAND

CASING DIAMETER: 4"
CASING MATERIAL: 4" SCH 80 PVC
BORING DIAMETER: 8-3/4"
TOP OF CASING ELEV. (FT): 5515.06
GROUND ELEVATION (FT): 5512.18
LOCATION: AREA 4 SOUTH
NORTHING (FT): 1975118.7726
EASTING (FT): 303891.1349

LITHOLOGY LOG



NORWEST
Applied Hydrology

KPC2007-03

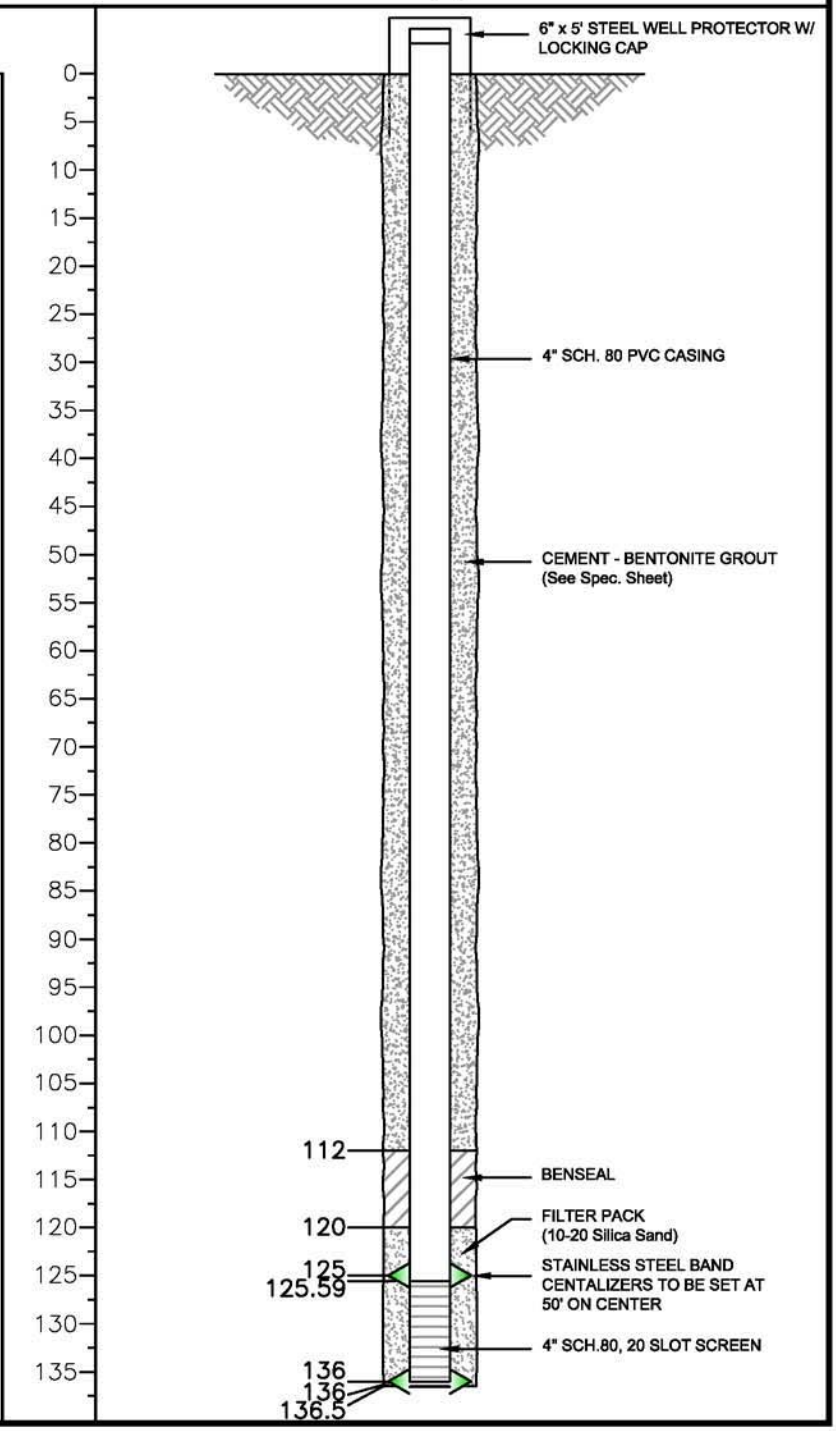
COMPLETION DIAGRAM & LITHOLOGIC LOG

PROJECT: NAVAJO MINE EXTENSION
DRILLING CO: MO-TE
DRILLER: BOB
CLIENT SUPERVISER: COLLETTE BROWN
GEOLOGIST/SUPERVISOR: JOEL SOBOL
AHA JOB#: 4010-00060-10
DRILLING METHOD: AIR ROTARY
BORING STARTED: 7/24/07

WELL TYPE: MONITORING WELL
WELLHEAD TYPE: PROTECTIVE HEAD COVER
WELL COMPLETED: 8/2/07
WELL DEVELOPED: 8/2/07
DATE SURVEYED: 8/29/07
SCREEN SLOT SIZE: 0.02"
SCREEN TYPE: 4" SCH 80 PVC MILL SLOT
FILTER PACK: 10-20 SILICA SAND

CASING DIAMETER: 4"
CASING MATERIAL: 4" SCH 80 PVC
BORING DIAMETER: 8-3/4"
TOP OF CASING ELEV. (FT): 5470.23
GROUND ELEVATION (FT): 5467.83
LOCATION: AREA 4 SOUTH
NORTHING (FT): 1982884.7045
EASTING (FT): 295091.1864

LITHOLOGY LOG



NORWEST
Applied Hydrology

NNA-1

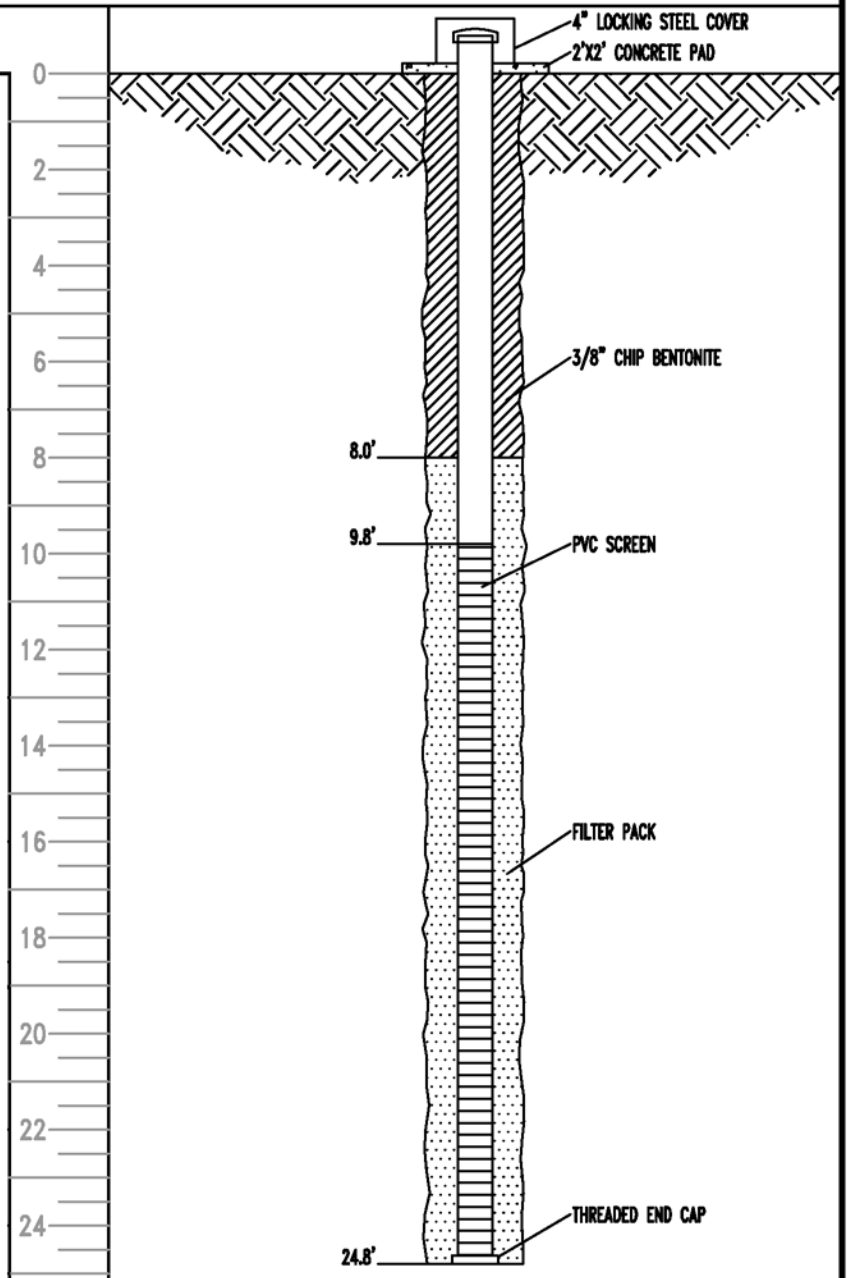
COMPLETION DIAGRAM & LITHOLOGIC LOG

PROJECT: NO NAME
DRILLING CO: PHILIP SERVICES CORP
DRILLER: KELLY PADILLA
CLIENT SUPERVISER: RON VANVALKENBURG
GEOLOGIST/SUPERVISOR: IAN PEARSON
AHA JOB#: 43-4B
DRILLING METHOD: HOLLOW STEM AUGER
BORING STARTED: 3/25/98

WELL TYPE: MONITORING
WELLHEAD TYPE: STICKUP (1.6')
WELL COMPLETED: 3/25/98
WELL DEVELOPED: WELL DRY
DATE SURVEYED:
SCREEN SLOT SIZE: 0.02" MILL SLOT
SCREEN TYPE: SCH 40 PVC
FILTER PACK: 10-20 SILICA SAND

CASING DIAMETER: 2"
CASING MATERIAL: SCH 40 PVC
BORING DIAMETER: 7 1/2"
TOP OF CASING ELEV. (FT): 5431.63
GROUND ELEVATION (FT): 5430.46
LOCATION: AREA 4 SOUTH
NORTHING (FT): 1,976,857.28
EASTING (FT): 296,773.43

LITHOLOGY LOG



* SURVEY COORDINATES AND ELEVATION ARE ESTIMATED. WELL WAS DRY AT COMPLETION AND AS OF 3/30/98

NORWEST
Applied Hydrology

NNA-2

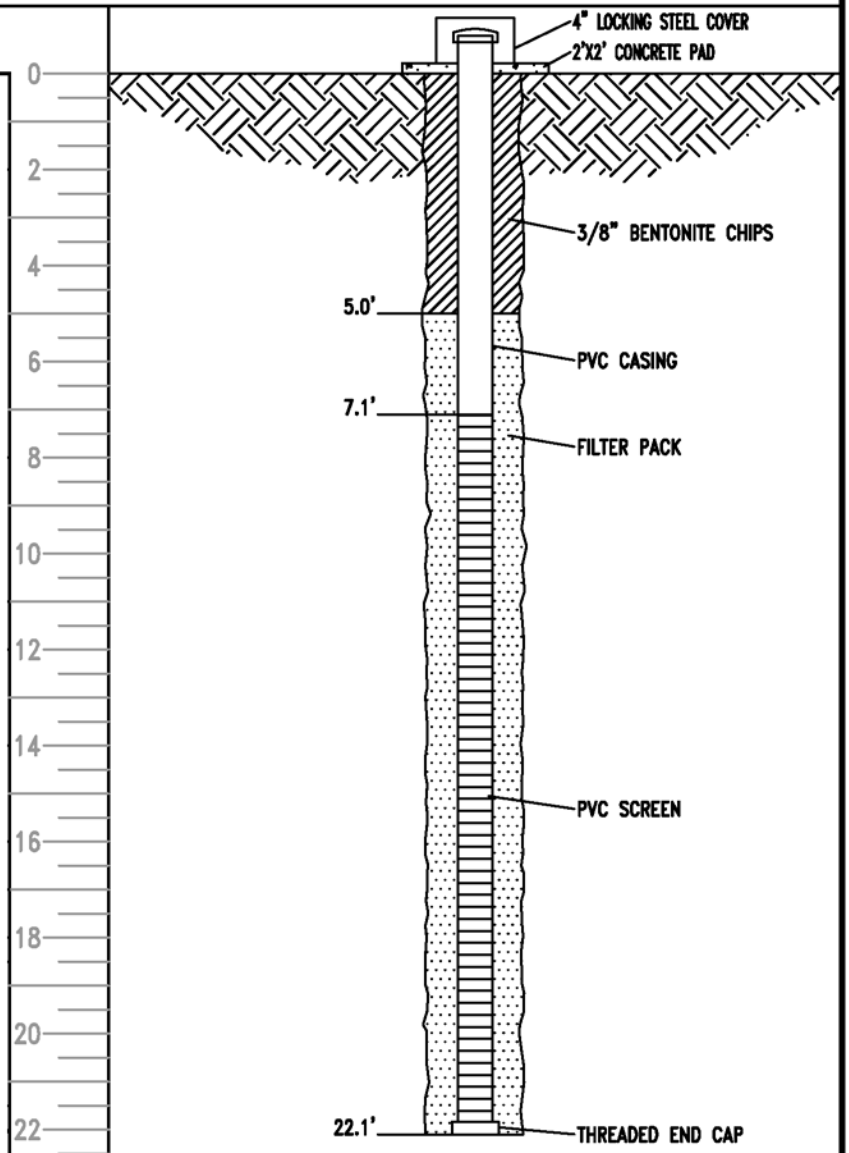
COMPLETION DIAGRAM & LITHOLOGIC LOG

PROJECT: NO NAME
DRILLING CO: PHILIP SERVICES CORP
DRILLER: KELLY PADILLA
CLIENT SUPERVISER: RON VANVALKENBURG
GEOLOGIST/SUPERVISOR: IAN PEARSON
AHA JOB#: 43-4B
DRILLING METHOD: HOLLOW STEM AUGER
BORING STARTED: 3/25/98

WELL TYPE: MONITORING
WELLHEAD TYPE: STICKUP (1.5')
WELL COMPLETED: 3/25/98
WELL DEVELOPED: WELL DRY
DATE SURVEYED:
SCREEN SLOT SIZE: 0.02" MILL SLOT
SCREEN TYPE: SCH 40 PVC
FILTER PACK: 10-20 SILICA SAND

CASING DIAMETER: 2"
CASING MATERIAL: SCH 40 PVC
BORING DIAMETER: 7 1/2"
TOP OF CASING ELEV. (FT): 5455.97
GROUND ELEVATION (FT): 5454.68
LOCATION: AREA 4 SOUTH
NORTHING (FT): 1,975,404.71
EASTING (FT): 299,547.33

LITHOLOGY LOG



* SURVEY COORDINATES AND ELEVATION ARE ESTIMATED. WELL WAS DRY AT COMPLETION AND AS OF 3/30/98

NORWEST
Applied Hydrology

PA-1

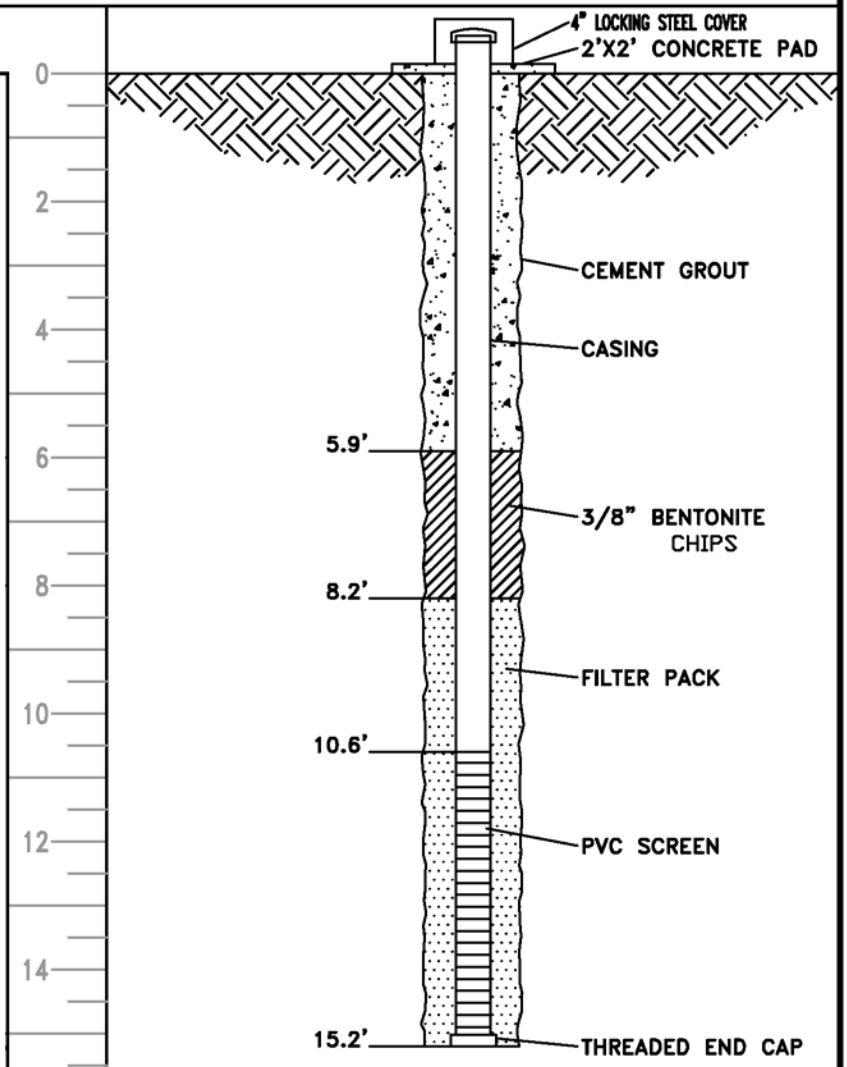
COMPLETION DIAGRAM & LITHOLOGIC LOG

PROJECT: NO NAME
DRILLING CO: PHILIP SERVICES
DRILLER: KELLY PADILLA
CLIENT SUPERVISER: RON VANVALKENBURG
GEOLOGIST/SUPERVISOR: IAN PEARSON
AHA JOB#: 43-4B
DRILLING METHOD: HOLLOW STEM AUGER
BORING STARTED: 3/25/98

WELL TYPE: MONITORING
WELLHEAD TYPE: STICKUP (1.7')
WELL COMPLETED: 3/25/98
WELL DEVELOPED: 3/28/98
DATE SURVEYED:
SCREEN SLOT SIZE: 0.02" MILL SLOT
SCREEN TYPE: SCH 40 PVC
FILTER PACK: 10-20 SILICA SAND

CASING DIAMETER: 2"
CASING MATERIAL: SCH 40 PVC
BORING DIAMETER: 7 1/2"
TOP OF CASING ELEV. (FT): 5352.90
GROUND ELEVATION (FT): 5351.24
LOCATION: AREA 4 SOUTH
NORTHING (FT): 1,990,260.27
EASTING (FT): 300,409.16

LITHOLOGY LOG



* SURVEY COORDINATES AND ELEVATION ARE ESTIMATED
DTW FROM TOC = 11.35' 3/29/98

NORWEST
Applied Hydrology

PA-2

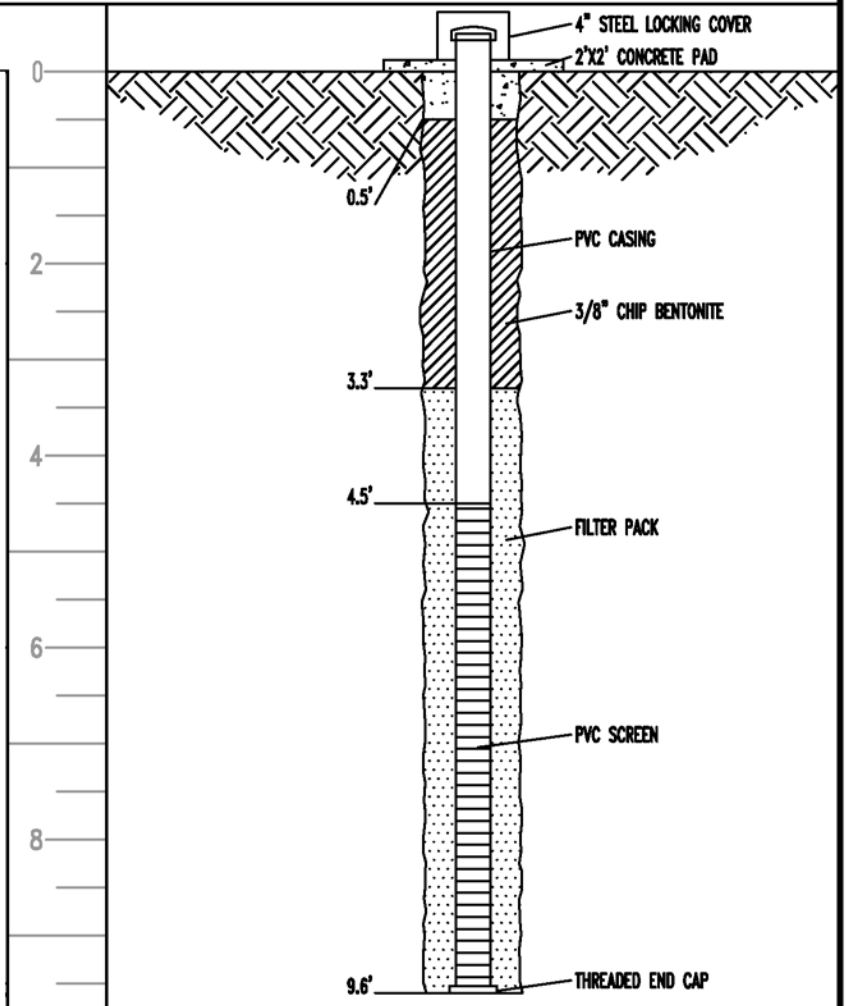
COMPLETION DIAGRAM & LITHOLOGIC LOG

PROJECT: NO NAME
DRILLING CO: PHILIP SERVICES CORP
DRILLER: KELLY PADILLA
CLIENT SUPERVISER: RON VANVALKENBURG
GEOLOGIST/SUPERVISOR: IAN PEARSON
AHA JOB#: 43-4B
DRILLING METHOD: HOLLOW STEM AUGER
BORING STARTED: 3/25/98

WELL TYPE: MONITORING
WELLHEAD TYPE: STICKUP (2.15')
WELL COMPLETED: 3/25/98
WELL DEVELOPED: 3/28/98
DATE SURVEYED:
SCREEN SLOT SIZE: 0.02" MILL SLOT
SCREEN TYPE: SCH 40 PVC
FILTER PACK: 10-20 SILICA SAND

CASING DIAMETER: 2"
CASING MATERIAL: SCH 40 PVC
BORING DIAMETER: 7 1/2"
TOP OF CASING ELEV. (FT): 5431.43
GROUND ELEVATION (FT): 5429.60
LOCATION: AREA 4 SOUTH
NORTHING (FT): 1,980,957.17
EASTING (FT): 306,702.95

LITHOLOGY LOG



* SURVEY COORDINATES AND ELEVATION ARE ESTIMATED
DTW FROM TOC = 7.69' 3/30/98

NORWEST
Applied Hydrology

VWP2007-01

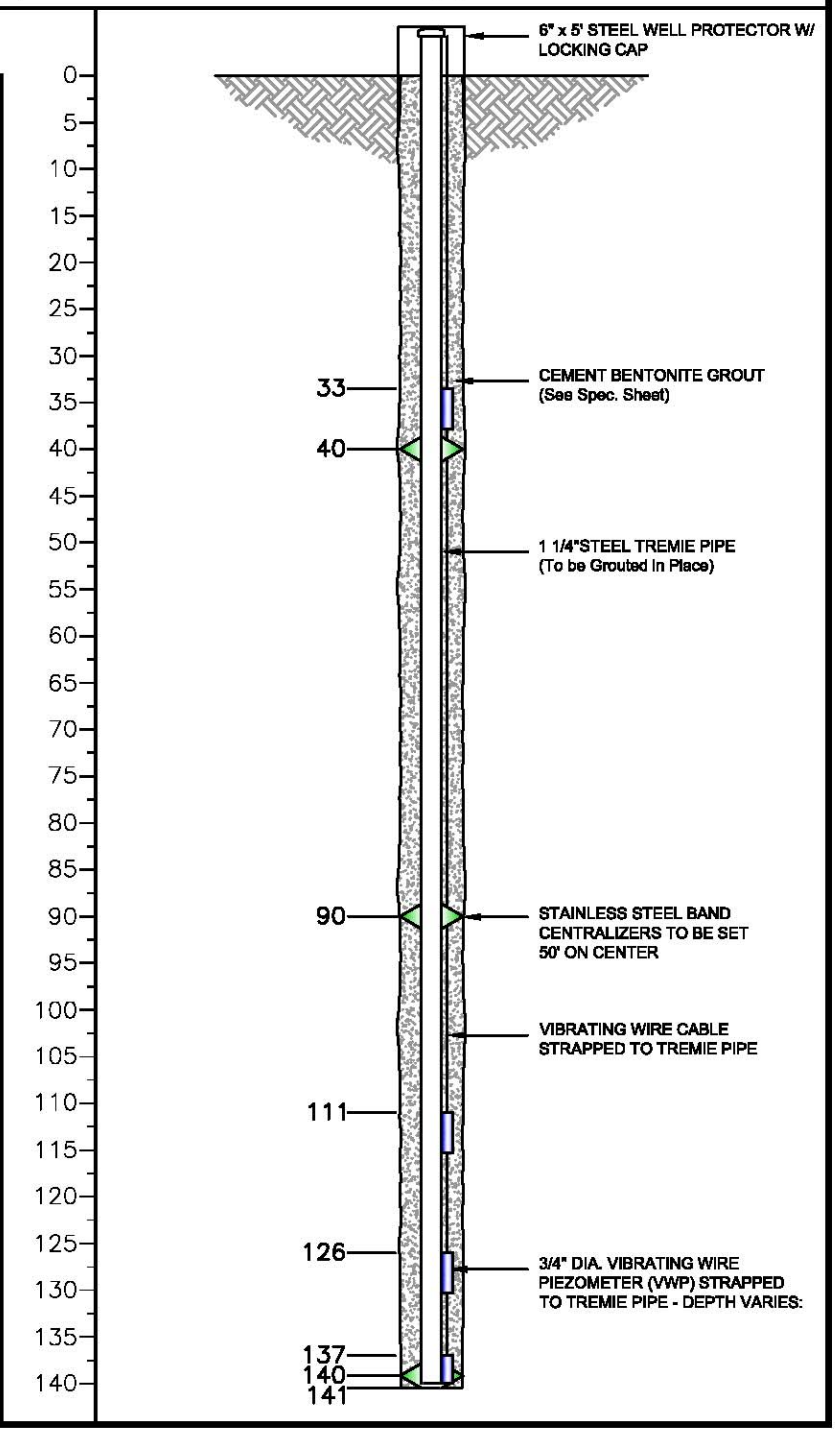
COMPLETION DIAGRAM & LITHOLOGIC LOG

PROJECT: NAVAJO MINE EXTENSION
DRILLING CO: MO-TE
DRILLER: BOB
CLIENT SUPERVISER: COLLETTE BROWN
GEOLOGIST/SUPERVISOR: MIKE LEFRANCOIS
AHA JOB#: 4010-00060-10
DRILLING METHOD: AIR ROTARY
BORING STARTED: 7/23/07

WELL TYPE: TEST HOLE FOR PIEZOMETERS
WELLHEAD TYPE: PROTECTIVE HEAD COVER
WELL COMPLETED: 7/30/07
WELL DEVELOPED: 7/30/07
DATE SURVEYED: 8/29/07
SCREEN SLOT SIZE: N/A
SCREEN TYPE: N/A
FILTER PACK: N/A

CASING DIAMETER: 1-1/4"
CASING MATERIAL: 20' STEEL TREMIE PIPE
BORING DIAMETER: 5-1/8"
TOP OF CASING ELEV. (FT): 5355.44
GROUND ELEVATION (FT): 5352.40
LOCATION: AREA 4 SOUTH
NORTHING (FT): 1995109.4883
EASTING (FT): 302593.5804

LITHOLOGY LOG



NORWEST
Applied Hydrology

VWP2007-02

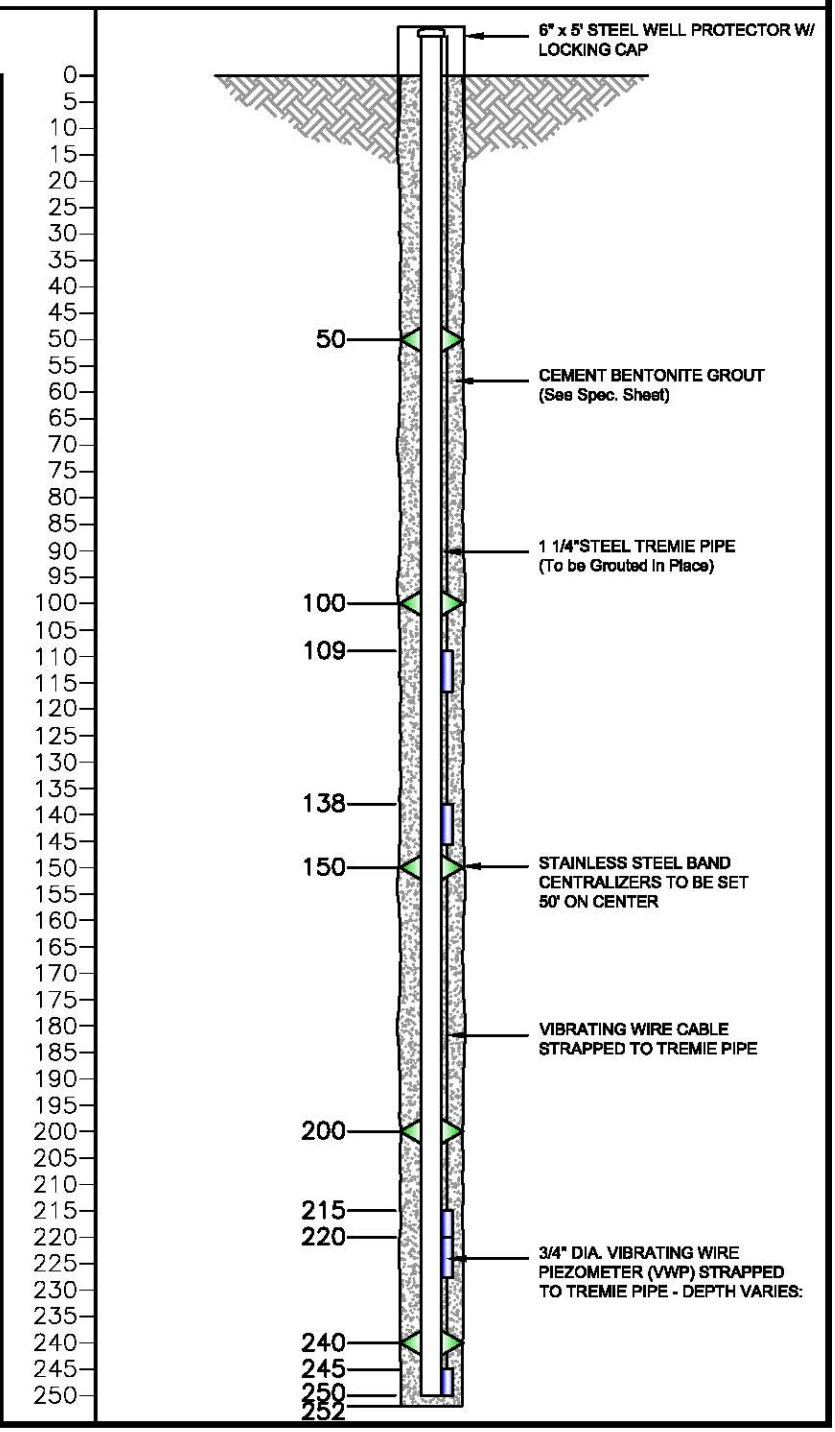
COMPLETION DIAGRAM & LITHOLOGIC LOG

PROJECT: NAVAJO MINE EXTENSION
DRILLING CO: MO-TE
DRILLER: BOB
CLIENT SUPERVISER: COLLETTE BROWN
GEOLOGIST/SUPERVISOR: MIKE LEFRANCOIS
AHA JOB#: 4010-00060-10
DRILLING METHOD: AIR ROTARY
BORING STARTED: 7/23/07

WELL TYPE: TEST HOLE FOR PIEZOMETERS
WELLHEAD TYPE: PROTECTIVE HEAD COVER
WELL COMPLETED: 7/28/07
WELL DEVELOPED: 7/28/07
DATE SURVEYED: 8/29/07
SCREEN SLOT SIZE: N/A
SCREEN TYPE: N/A
FILTER PACK: N/A

CASING DIAMETER: 1-1/4"
CASING MATERIAL: 20' STEEL TREMIE PIPE
BORING DIAMETER: 5-1/8"
TOP OF CASING ELEV. (FT): 5459.61
GROUND ELEVATION (FT): 5456.41
LOCATION: AREA 4 SOUTH
NORTHING (FT): 1984392.0413
EASTING (FT): 307991.9661

LITHOLOGY LOG



NORWEST
Applied Hydrology

VWP2007-03

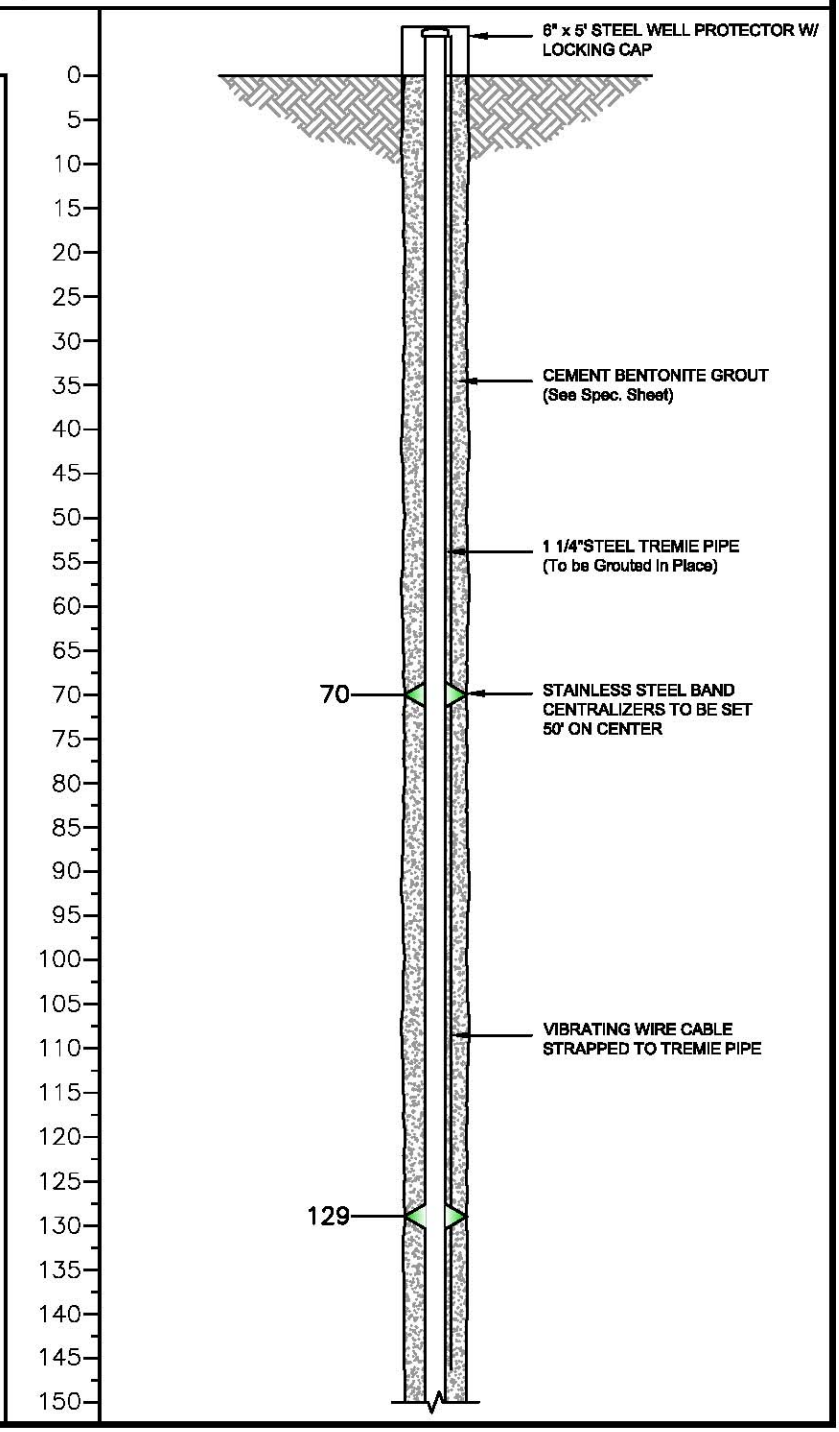
COMPLETION DIAGRAM & LITHOLOGIC LOG

PROJECT: NAVAJO MINE EXTENSION
DRILLING CO: MO-TE
DRILLER: BOB
CLIENT SUPERVISER: COLLETTE BROWN
GEOLOGIST/SUPERVISOR: JOEL SOBOL
AHA JOB#: 4010-00060-10
DRILLING METHOD: AIR ROTARY
BORING STARTED: 7/24/07

WELL TYPE: TEST HOLE FOR PIEZOMETERS
WELLHEAD TYPE: PROTECTIVE HEAD COVER
WELL COMPLETED: 7/24/07
WELL DEVELOPED: 7/24/07
DATE SURVEYED: 8/29/07
SCREEN SLOT SIZE: N/A
SCREEN TYPE: N/A
FILTER PACK: N/A

CASING DIAMETER: 1-1/4"
CASING MATERIAL: 20' STEEL TREMIE PIPE
BORING DIAMETER: 5-1/8"
TOP OF CASING ELEV. (FT): 5514.63
GROUND ELEVATION (FT): 5512.63
LOCATION: AREA 4 SOUTH
NORTHING (FT): 1975124.6347
EASTING (FT): 303891.1617

LITHOLOGY LOG



NORWEST
Applied Hydrology

VWP2007-03

COMPLETION DIAGRAM & LITHOLOGIC LOG

PROJECT: NAVAJO MINE EXTENSION
DRILLING CO: MO-TE
DRILLER: BOB
CLIENT SUPERVISER: COLLETTE BROWN
GEOLOGIST/SUPERVISOR: JOEL SOBOL
AHA JOB#: 4010-00060-10
DRILLING METHOD: AIR ROTARY
BORING STARTED: 7/24/07

WELL TYPE: TEST HOLE FOR PIEZOMETERS
WELLHEAD TYPE: PROTECTIVE HEAD COVER
WELL COMPLETED: 7/24/07
WELL DEVELOPED: 7/24/07
DATE SURVEYED: 8/29/07
SCREEN SLOT SIZE: N/A
SCREEN TYPE: N/A
FILTER PACK: N/A

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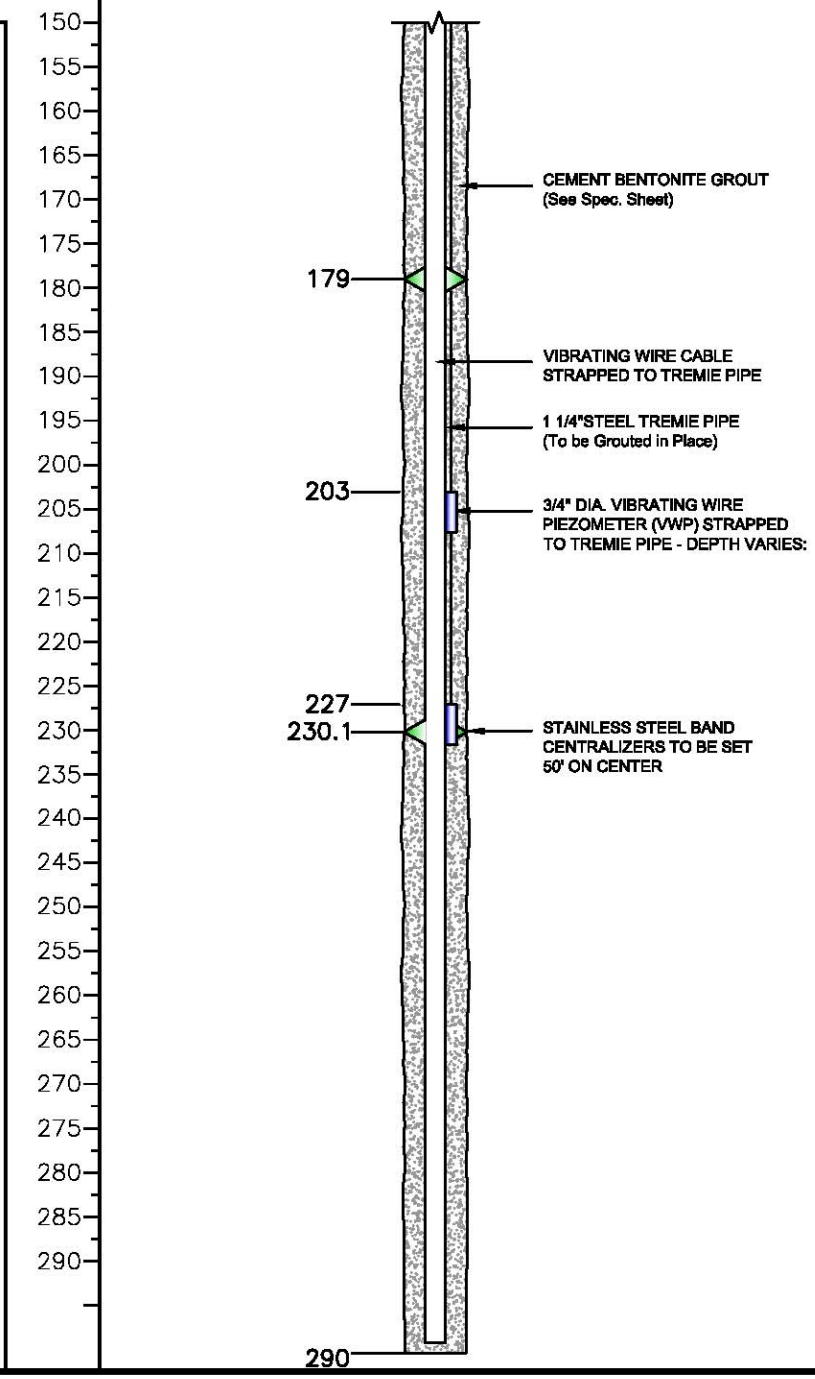
NORTHING (FT): 1975124.6347
EASTING (FT): 303891.1617

LITHOLOGY LOG



NORWEST
Applied Hydrology

VWP2007-04

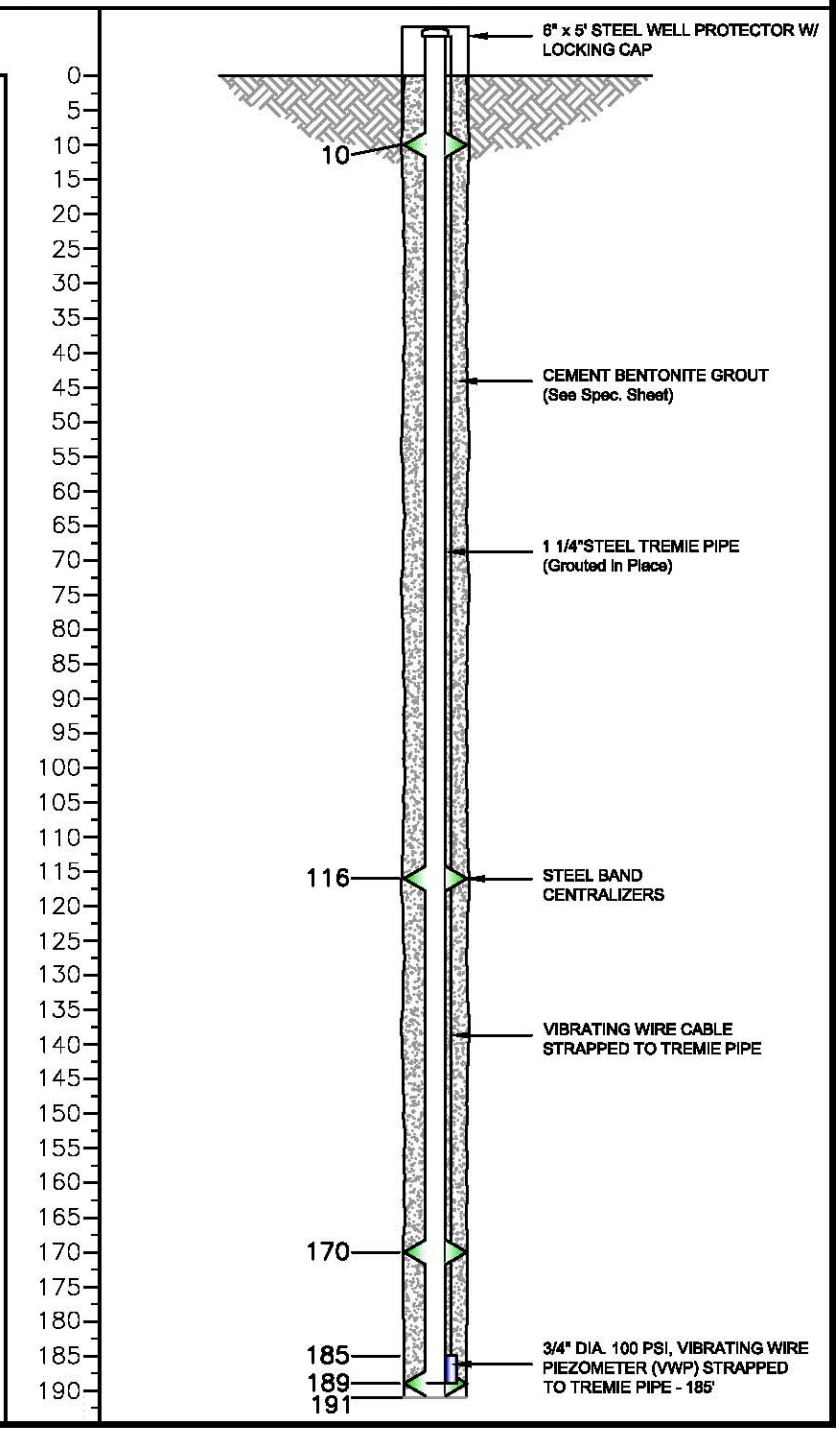
COMPLETION DIAGRAM & LITHOLOGIC LOG

PROJECT: NAVAJO MINE EXTENSION
DRILLING CO: STEWART BROS.
DRILLER: CASEY
CLIENT SUPERVISER:
GEOLOGIST/SUPERVISOR: ED SCHNEIDER
AHA JOB#: 4010-00060-5
DRILLING METHOD: AIR ROTARY
BORING STARTED: 10/4/07

WELL TYPE: HOLE FOR PIEZOMETERS
WELLHEAD TYPE: PROTECTIVE HEAD COVER
WELL COMPLETED: 10/6/07
WELL DEVELOPED: N/A
DATE SURVEYED:
SCREEN SLOT SIZE: N/A
SCREEN TYPE: N/A
FILTER PACK: N/A

CASING DIAMETER: 1-1/4"
CASING MATERIAL: STEEL TREMIE PIPE
BORING DIAMETER: 5-1/8"
TOP OF CASING ELEV. (FT):
GROUND ELEVATION (FT):
LOCATION:
NORTHING (FT):
EASTING (FT):

LITHOLOGY LOG



NORWEST
Applied Hydrology

VWP2007-05

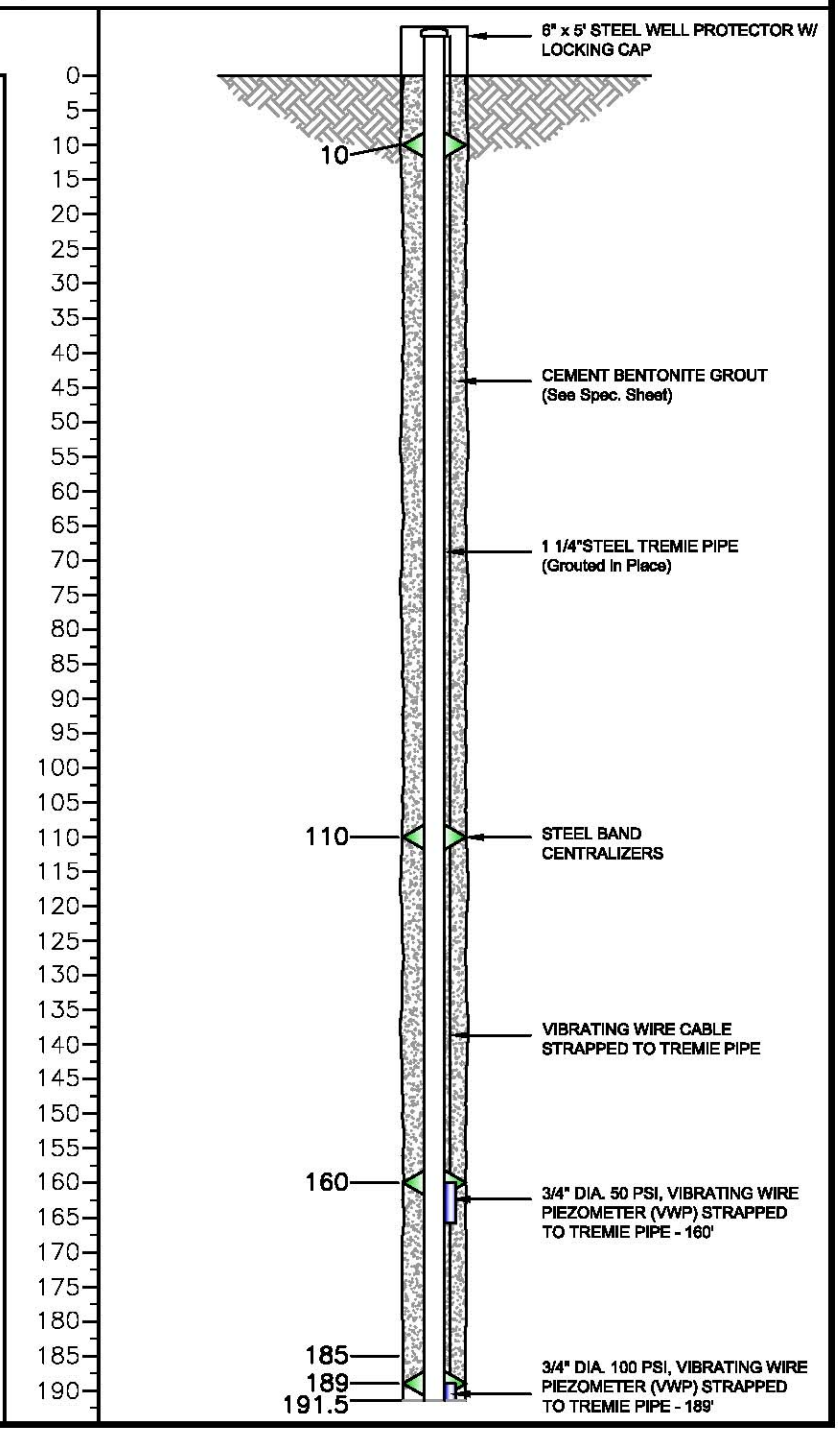
COMPLETION DIAGRAM & LITHOLOGIC LOG

PROJECT: NAVAJO MINE EXTENSION
DRILLING CO: STEWART BROS.
DRILLER: CASEY
CLIENT SUPERVISER:
GEOLOGIST/SUPERVISOR: ED SCHNEIDER
AHA JOB#: 4010-00060-5
DRILLING METHOD: AIR ROTARY
BORING STARTED: 10/6/07

WELL TYPE: HOLE FOR PIEZOMETERS
WELLHEAD TYPE: PROTECTIVE HEAD COVER
WELL COMPLETED: 10/7/07
WELL DEVELOPED: N/A
DATE SURVEYED:
SCREEN SLOT SIZE: N/A
SCREEN TYPE: N/A
FILTER PACK: N/A

CASING DIAMETER: 1-1/4"
CASING MATERIAL: STEEL TREMIE PIPE
BORING DIAMETER: 5-1/8"
TOP OF CASING ELEV. (FT):
GROUND ELEVATION (FT):
LOCATION:
NORTHING (FT):
EASTING (FT):

LITHOLOGY LOG



Appendix 18.O

(Copy of 1989 Appendix 12C)

Solutions to OSMRE Concerns and Deficiencies Related to the

Ground Water Sections of the Navajo Mine Permit Application Package

SOLUTIONS TO OSMRE CONCERNS AND DEFICIENCIES RELATED TO THE GROUND WATER SECTIONS OF THE NAVAJO MINE PERMIT APPLICATION PACKAGE

SUBMITTED TO
BHP UTAH INTERNATIONAL, INC.

SUBMITTED BY
BILLINGS & ASSOCIATES, INC.
ALBUQUERQUE, N.M.

NOVEMBER 1987

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1.0 INTRODUCTION

Billings and Associates, Inc. (BAI) was retained by BHP Utah International, Inc. (UII) to address Permit Application Package (PAP) deficiencies as defined by the Office of Surface Mining, Reclamation and Enforcement (OSMRE). These deficiencies were originally presented in a Request For Proposal letter from Ron Baldwin (UII) on May 18, 1987. Additional deficiencies and a more detailed description of OSMRE concerns were then submitted in a July 8, 1987 letter from UII to BAI. The tone of the detailed deficiencies presented in the July 8, 1987 letter was harsh. It is important for UII and BAI to understand the tone of this letter. The OSMRE must understand that topics such as "realistic determination of PHC" will always be based somewhat on judgement and experience. Where appropriate, we have attempted to bolster OSMRE judgement by technical analysis using numerical models and analytical calculations. However, the basic concept that must be understood by OSMRE is that geohydrologic characteristics, hyrologic setting and mine layout are the controlling factors and not an analytical and/or numerical analysis. If the OSMRE does not grasp this concept, additional studies, testing, analysis and data collection may be encountered.

It is therefore proposed that the approach to be utilized should be short, to the point, while only stressing the important criteria. What is critical, and only that, should be emphasized. For example, forget pumping times for aquifer test information. Rather, stress what are reasonable permeabilities for the units. Forget construction of wells east of the permit area. Rather, what is the general direction of ground-water flow and why is it important. Forget testing to determine storativity. Having test-derived, localized values of storativity is not critical. The use of guidelines in the selection of storativity is commonplace amongst hydrologists and reasonable values can be choosen and incorporated into all calculations. More importantly, permeabilities, saturated thicknesses and the mine layout control effects, not storativity.

2.0 LOCATION

UII's Navajo Mine is located on the western flank of the San Juan Basin approximately fifteen miles west of Farmington, New Mexico. The San Juan Basin is a structural depression lying at the eastern edge of the Colorado Plateau covering approximately 30,000 square miles of northwestern New Mexico and southwestern Colorado. The statigraphic dip throughout the greater part of the area is only 1 to 3 degrees towards the center of the basin with steepening towards the outcrop areas where a monocline can be observed encircling two thirds of the basin.[2]

3.0 FORMATION OF STRATIGRAPHIC UNITS

During the late Cretaceous geologic time period the shoreline of a vast shallow inland sea shifted back and forth across the basin and ultimately receded. Alternating marine and nonmarine sediments were deposited resulting in the following stratigraphic column in the vicinity of the lease area: *Lewis Shale, Pictured Cliffs Sandstone, Fruitland Formation* and the *Kirtland Shale*[2]. Ground-water flow paths in Cretaceous rocks within the lease area are north to northwest towards the San Juan River (see Figure 1).[8]

The *Lewis Shale* results from an offshore deposition of mud with streaks of fine grained sand, silt and limestone. The beach and nearshore deposits of mud and silt are represented as the *Pictured Cliffs Sandstone*. Coastal swamp deposition consisted of organic material, organic-enriched mud and silt, and the occasional accumulation of brackish-water shells. Deltas, estuaries and open lagoons in this environment intercepted local deposition, resulting in horizontally discontinuous coal deposits existing in what is known today as the *Fruitland Formation*. Flood plain deposits consist of fluvial and lacustrine sediments in the low areas adjacent to the coastal swamps and fluvial sediments predominantly composed of

sand in the high areas away from the coastal swamps. These deposits are represented in the *Kirtland Shale*.[1]

4.0 UNIT DESCRIPTION AND CHARACTERISTICS

The *Lewis Shale* is greenish-gray shale with local streaks of yellowish calcareous shale. The thickness is 76 to 475 feet.[2]

The *Pictured Cliffs Sandstone* can be divided into an upper massive sandstone bed and a lower thin layer of interbedded sandstone and shale. The thickness is 25 to 281 feet[2] and is about 110 feet in the permit area.[1] Permeability is on the order of 0.007 feet per day.[2] Using a storativity value of $1.0E^{-06}$ times the aquifer thickness, a confined storage coefficient on the order of $1.0E^{-04}$ is obtained.[10] This value is consistent with previous testing conducted in the Pictured Cliffs Sandstone which yielded values on the order of $3.0E^{-04}$.[11] An unconfined storage coefficient of 0.1 is reasonable for this formation and represents a minimum porosity acceptable. If the unconfined storage coefficient were increased, the net effect would be to reduce the PHC.

The *Fruitland Formation* consists of horizontally discontinuous coal seams and interbedded lithological units. These units are sandstones, siltstones, shales, limestones, and carbonaceous sandstones, siltstones, and shales.[1] Sandstone is generally more abundant in the lower part of the formation with the upper being predominantly siltstone and shale (i.e., *Fruitland* overburden). The thicker coal beds are in the lower third of the formation and are generally noncorrelative and discontinuous. One coal zone (Fruitland Zone) and two coal beds Fruitland 1 (Fr 1) and Fruitland 2 (Fr 2) are identified in the *Fruitland Formation*.[5] The Fr 1 coal bed is generally above the *Pictured Cliffs Sandstone* and dips less than one degree to the east. The thickness is generally greater than ten feet and diminishes in all directions to the point of being absent in the east-central part of the Kirtland quadrangle[5] (the USGS quadrangle adjacent to the east of the quadrangle containing the permit area). The Fr 1 is

overlain by the Fr 2 coal bed. The two beds are separated by a rock interval varying from 6 to 20 feet. The Fruitland 2 also dips less than one degree to the east. The thickness is generally greater than five feet and diminishes in all directions. It is absent in the southeast and northwest parts of the Kirtland quadrangle[5]. Although these coal beds are correlated and mapped as consistent layers for simplicity, they are actually several different coal beds that are lithostratigraphically equivalent but not laterally continuous[5]. Transmissivity of the coal seams and interbedded lithologic units range from 7 to 130 feet squared per day[2], for an average of 70 feet squared per day. Using a combined coal seam and interbedded lithologic unit thickness of 60 feet and $1.0E^{-06}$ times unit thickness, a confined storativity of $6.0E^{-05}$ is obtained, with unconfined storativity assigned 0.1. Remaining coal seams constituting the Fruitland Zone, are less than five feet thick, and are generally noncorrelative and discontinuous.[5] Inasmuch as individual coal seams are not horizontally continuous, it is more sensible to consider the geohydrologic parameters of the coal and interbedded lithologic units as a single geologic unit rather than consider the individual seams. We have followed this approach.

Permeability of the *Fruitland Formation* as a whole, is from 0.004 to 0.04 feet per day using a transmissivity of 1 to 10 feet squared per day[2] and a thickness of 250 feet. Using a storativity value of $1.0E^{-06}$ times the aquifer thickness[10] (i.e., 250 feet), a confined storage coefficient on the order of $3.0E^{-04}$ is obtained. An unconfined storage coefficient of 0.1 is reasonable for this formation.

The lower member of the *Kirtland Shale* ranges from 271 to 1031 feet thick and is a grey shale with some beds of siltstone and sandstone. Permeability of similar rock types is on the order of $1.0E^{-04}$ feet per day.[9] The *Kirtland Shale* and the *Fruitland Formation* are often treated as one unit as they exhibit similar hydrologic properties.[1] Using a storativity value of $1.0E^{-06}$ times the aquifer thickness[10] (i.e., approximately 300 feet), a confined storage coefficient on the order of $3.0E^{-04}$ is obtained. Again, an unconfined storage coefficient of 0.1 is also reasonable for this formation.

5.0 GEOHYDROLOGIC SETTING

An investigation was conducted by the United States Geological Survey (USGS), in cooperation with the Bureau of Land Management (BLM), to obtain baseline geohydrologic information for evaluating the effects of strip coal mining within the *Fruitland Formation* in the San Juan Basin.[1] In their investigation, the USGS concentrated their efforts on four distinct geologic units; "*Pictured Cliffs Sandstone*", "*coal seams and interbedded lithologic units* of the *Fruitland Formation*", "*overburden* of the *Kirtland Shale and Fruitland Formation*", and the "*alluvium*" along the Chaco River. No deficiencies pertaining to the *alluvium* along the Chaco River were outlined by the OSMRE and are therefore not addressed further. Potentiometric values were obtained by the USGS from wells within the remaining three units. Contours were constructed by BAI from these values and are presented on Figures 2, 3 and 4. The regional ground-water flow direction of all three units trends north to northwest. A localized, northeasterly flow component is expected and indicated along outcrop areas, reflecting recharge into the units. This component conceivably exists for a short distance prior to becoming encompassed by the regional flow pattern to the north/northwest. This general flow direction is in agreement with other Cretaceous formations in the San Juan Basin (see Figure 1)[8].

Due to the close proximity of the mine to the recharge area, the saturated/unsaturated border of the *coal seams and interbedded lithologic units* of the *Fruitland Formation* parallels the eastern extent of the mine permit boundary striking approximately 10-15 degrees northeast (Permit Application Package [PAP], Exhibits 12-2 through 12-5). The formation material is essentially dry throughout the middle portions of the mine area. In the northern portion of the mine, the formation becomes artesian on the order of 20 feet. In the southern portion of the mine, artesian conditions on the order of 80 feet are found. Due to the stratigraphy, it is anticipated that the *Pictured Cliffs Sandstone* is artesian beneath the majority of the mine area, while the *overburden* of the *Kirtland Shale and*

Fruitland Formation is anticipated to have a saturated thickness on the order of a few feet throughout the mine area.

UII mining activity will excavate portions of the *Fruitland Formation*. Material to be excavated is bound by a shale layer beneath the bottom most coal seam. Beneath this shale layer lies the low-permeability *Pictured Cliffs Sandstone*, which overlies the low-permeability materials existing in the *Lewis Shale*. Materials to be excavated are bound above by portions of the *Fruitland Formation* and/or the low-permeability, lowest member of the *Kirtland Shale*. Given the discontinuity of the coal seams and the geohydrologic characteristics of the units, it is inappropriate and unrealistic to analyze individual coal seams as if they were separate aquifers. Rather, units to be potentially affected by mining activity should be considered in a manner similar to that described by the USGS: i.e., "*Pictured Cliffs Sandstone*", "*coal seams and interbedded lithologic units* of the *Fruitland Formation*" and the "*overburden of the Kirtland Shale and Fruitland Formation*". It is important to note "*coal seams and interbedded lithologic units* of the *Fruitland Formation*" are treated collectively as one unit by the USGS and by BAI. Similarly, hydrologic parameters such as transmissivity and permeability, should also be treated collectively.

6.0 SPECIFIC DEFICIENCIES AS DEFINED IN MAY 18, 1987 PROPOSAL LETTER

6.1 DEFICIENCY 21.a.-Koch Model

Two broad concerns were raised by the OSMRE concerning conclusions drawn by use of the Koch Model. The first dealt with determination of the Probable Hydrologic Consequences (PHC). The second dealt with Protection of the Hydrologic Balance (PHB). Both concerns center around two hydrologic events; 1) outward propagation of a stress (change in potentiometric surface or commonly termed "drawdown") resulting from flow into the mine area and, 2) transport of potential contaminants from the mine area

into the subsurface environment. Determination of both PHC and PHB are dictated not by the analytical tool used, but by the geohydrologic characteristics, setting and the mine layout within those criteria. The hydrologic events, stress propagation and transport are controlled by the surrounding units. Thus it serves no purpose to argue over the suitability of the Koch model, another model can be used but the results will be similar.

A three dimensional, finite-difference, ground-water model was conceptualized and constructed to evaluate the hydrologic consequences due to stress propagation from pit inflow. From this analysis, it was concluded that stress propagation resulted in minimal impacts to the hydrologic regime as drawdowns of only 2 to 3 feet were computed adjacent to the mine area for the*"coal seams and interbedded lithologic units* of the *Fruitland Formation"*, less than 0.5 feet for the *"Pictured Cliffs Sandstone"* and less than 0.005 feet for the *"overburden Kirtland/Fruitland Formation"*. Detailed model input and output are presented later in this report.

Analytical techniques were used to evaluate the hydrologic event, transport of pollutants into the sub-surface environment. As is the case for propagation of stress, the controlling factor for transport is the geohydrologic characteristics of the surrounding units. A "worst case" conceptualization was incorporated into the analyses. Technical details pertaining to the analyses are presented later in this report. The effects on the nearest discharge point (i.e., the San Juan River) are that the earliest arrival for a pollutant is on the order of 240 years, and that the ratio of the pollutant flux to the 7-day, 10-year recurrence interval discharge of the river is on the order of 0.00021. Ratios of the flux to the average monthly flows of the river are on the order of 2 to 3 times smaller than the 7-day, 10-year recurrence interval discharge (i.e, 0.00021). Batch-leach test results concluded by UII and presented in the PAP indicate pollutants may not even occur. Based on these analyses the impacts due to transport are minimal and are in all probability not measureable.

Other points should be noted prior to presenting details on stress propagation and transport. Applying the term "aquifer" to the units in the lease area is a loose application of the word. The units are not

aquifers, they are low permeability rocks that should actually be considered confining beds, aquitards or perhaps even aquicludes. Wells are not constructed in these units except when absolutely necessary for low yield stock wells and for supplying information for permit applications. It is inappropriate to consider these units as a multiple aquifer system. Mainly because they actually are not aquifers, but rather geologic units. Vertical permeabilities of similar Cretaceous-age units in the San Juan Basin have been modeled as being on the order of $1x10^{-07}$ feet per day[8]. Roughly three orders of magnitude smaller than the horizontal permeability of for example, the *Fruitland Formation* (which is low in and of itself).

Permeabilities of the units to be potentially affected by mining activity are too low for any significant hydrologic consequences to occur. Additionally, mine cuts will not expose sufficient saturated material (predominantly unconfined as mining progresses) for significant changes in the potentiometric surface to occur. The hydrologic balance is secured by the low permeabilities of the surrounding units and not by permeabilities resulting from deposition of waste material.

Stress Propagation

An impact-mode, three dimensional, multi-layer, finite-difference model (MODFLOW) [12] was conceptualized and constructed for evaluation of the stress propagation due to mining activity. Three layers in order of increasing depth were evaluated; 1)*overburden of the Kirtland Shale and Fruitland Formation*, 2)*coal seams and interbedded lithologic units* of the *Fruitland Formation*, and 3) *Pictured Cliffs Sandstone*. A 31 row by 11 column grid network was developed and overlain on the potentially affected area (see Figure 5). Constant head nodes were placed within layers 1 and 2 to simulate hydrologic effects due to mine excavation. Additionally constant head nodes were placed along the San Juan River and Morgan Lake to simulate mining effects at discharge/recharge locations. Individual node status for each layer and aquifer characteristics utilized are presented in Figures 6,7 & 8. Stratigraphic thicknesses and additional geohydrologic information

has been previously discussed. A complete printout of model input and output is presented in Appendix A.

Conceptually, two factors are important to the simulation. First, as mining progresses, a stress is instantly propagated with the result being a rapid drop in the potentiometric surface, however small. Thus if the layer was confined initially (it is only in the extreme northern and southern sections of the permit area), unconfined conditions are caused very rapidly. Consequently, in the excavated area of Layers 1 & 2, the material was simulated as being unconfined from the start. Second, as previously discussed the unsaturated/saturated border roughly parallels the eastern extent of the mine boundary. Mining activity will not intercept saturated material until late in the mine life. We have simulated the PHC as if the mine intercepted saturated material for a total of 12 years. This has resulted in over-calculation of effects as it is doubtful that mining activity will encounter saturated material for even this length of time. One should note where the eastern extent of mining intercepts dry conditions, no impact can occur. This is the case over considerable extent of the mine. Where mining intersects partial saturation, the hydrologic consequences are restricted to the vertical extent of the saturated thickness.

Results of the simulation indicate very minimal effects are observed due to stress propagation. Maximum simulated drawdowns on the order of 0.0004 feet are calculated in the *overburden of the Kirtland Shale and Fruitland Formation* at approximately one and a half miles away from the mining activity. Simulated drawdowns of a maximum of 2 to 3 feet adjacent to the permit area and less than 0.5 feet approximately 15 miles from the permit area are calculated for the *coal seams and interbedded lithologic units* of the *Fruitland Formation*. Calculated maximum drawdowns of 0.5 feet or less are determined for the *Pictured Cliffs Sandstone*. Sources of water for pit inflow are predominantly derived from storage, with an approximate total of 4 acre-feet for the entire simulation (i.e., 12 years) being obtained from capture of surface water (Morgan Lake and the San Juan River). This surface water capture represents the maximum extent of hydraulic impacts on the San Juan River as requested through Deficiency 21.h.. Average inflow to the entire

mine area is approximately 239 acre-feet/year (148 gallons/minute) over a total simulation time of 12 years. It should be noted that a moderate portion of this inflow will not actually be observed in the mine due to evaporation.

Transport of Mining Affected Ground Water

Several assumptions and conditions were incorporated into the "worst case" analysis. They are presented along with the calculations as follows. Assume there is no attentuation or dilution of the chemical constituents of mining-affected ground water as it travels on a migratory path through the *coal seams and interbedded lithologic units* of the *Fruitland Formation* towards the discharge point of the San Juan River. Assume further that the ground water migrated to the extreme northern edge of the lease area through a "dragline aquifer" and appeared at the permit boundary instantaneously, neglecting the time involved to fill and create a gradient in the spoil area. Finally, assume the flow path to the San Juan River is a direct northern line and is not easterly first until it becomes encompassed by the regional flow pattern. Constituents in the mining-affected ground water would therefore migrate at the same rate as the true pore velocity. Based on the above, a "worst case" scenario is presented for evaluation of potential water quality impacts to the San Juan River as requested through Deficiency 21.h..

Pore velocity of ground water is determined by[13]:

$$v=(kI)/n$$

where,
v=pore velocity (feet/day),
k=permeability (feet/day)=1.2 feet/day (69 ft^2/day /60 feet, average of reported values of coal seams and interbedded lithologic units),
I=hydraulic gradient (dimensionless)=0.0051 ft/ft (average gradient of coal seams and interbedded lithologic units as determined from Figure 3),

n=effective porosity= approximately 0.1 for a coal type, sandstone/shale unit[14].

Therefore,
pore velocity=v=0.06 feet day

From the northern edge of the lease area, the shortest distance to the San Juan River, is approximately one mile. The minimum amount of time required for mining-affected ground water to potentially reach the San Juan River is approximately 240 years.

The amount of flux through an aquifer can be estimated using Darcy's Law expressed as[13]:

$$Q=KIA$$

where,
Q=volume rate of flow, (ft^3/day),
K=hydraulic conductivity, (ft/day),
I=hydraulic gradient (dimensionless),
A=cross-sectional area through which flow occurs, (ft^2/day).

In this analysis, the pollutant is simulated as migrating in a due north direction directly towards the San Juan River. The cross-sectional area used represents a unit thickness of 60 feet, with a width of 2 miles normal to the direction of flow (i.e., in an east-west direction). The two mile width is slightly larger than the normal mine width. The cross-sectional area is therefore 633,600 square feet for the *coal seams and interbedded lithologic units* of the *Fruitland Formation* and a flux from the mine area entering into the San Juan River is approximately 3900 ft^3/day (0.05 cfs). It should be noted that a small portion of the mining affected ground water becomes diluted with the total flow from the formation before entering the San Juan River. However, the analysis will proceed as if dilution did not occur.

San Juan River base flow for the 7 day-10 year recurrence interval at the Farmington station is 290 cfs, and is 129 cfs at the Shiprock

station[15]. The contact of the *coal seams and interbedded lithologic units* of the *Fruitland Formation* with the San Juan River is located approximately one third of the distance downstream from Farmington to Shiprock. Therefore, a representative 7 day-10 year recurrence interval discharge for the contact area is approximately 236 cfs. The ratio of mining-affected ground water to the 7 day-10 year recurrence interval discharge is calculated as 0.00021.

A similar analysis was conducted for average monthly flows along the San Juan River. USGS gaging station data for approximately 40 years were compiled for the stations at Shiprock and at Farmington. Interpolated average monthly flow at Fruitland (approximate location of coal seams with the San Juan River) was then computed based on these stations. All three locations are presented on Figure 9. The ratio of discharge from the *coal seams and interbedded lithologic units* to the flow at Fruitland is presented in the table below. This ratio represents the maximum quantity of mining-affected ground water that could be introduced into the San Juan River.

Ratio of Maximum Quantity of Mining Affected Water to Average Flow in San Juan River

Month	Ratio
October	$3.6E^{-05}$
November	$5.8E^{-05}$
December	$7.3E^{-05}$
January	$7.4E^{-05}$
February	$5.1E^{-05}$
March	$2.6E^{-05}$
April	$1.1E^{-05}$
May	$4.6E^{-06}$
June	$6.5E^{-06}$
July	$1.7E^{-05}$
August	$2.7E^{-05}$
September	$3.5E^{-05}$

Given the conditions described above (i.e., no dilution, no attentuation, direct flow path, instantaneous start time and closest possible start location to the discharge location) results above are grossly over-calculated. Additionally, batch-leach testing results concluded by UII and presented in the PAP indicate insignificant increases in pollutant concentrations within the spoil areas and that attentuation affects are present.

It should be noted that the permeability of the *coal seams and interbedded lithologic units* of the *Fruitland Formation* was used in the above transport analysis. Calculation of pollutant velocities as a result of vertical leakage, introduction via inter-tonguing and/or migration through other units would be significantly decreased if permeabilities related to these pathways were used. Permeability of the *coal seams and interbedded lithologic units* of the *Fruitland Formation* is approximately three orders of magnitude greater than the *Pictured Cliffs Sandstone* and two to four orders of magnitude greater than the *overburden Kirtland/Fruitland Formation.*

6.2 DEFICIENCY 21.c.-Storativity

Calculated effects on the hydrologic regime are relatively insensitive to reasonable values of storativity. The size of the storage coefficient depends on wheter the usint is confined or unconfined. If the aquifer is unconfined, the predominant source of water is from gravity drainage of the unit through which the decline in the water table occurs. In such an aquifer, the storage coefficient is virtually equal to the specific yield and ranges from 0.1 to 0.3[9]. If the quifer is confined, the water released from storage when the head declines comes from expansion of the water and from compression of the aquifer. Storativity of confined aquifers are frequently determined from the relationship $1x10^{-06}$ times the unit thickness[10]. Given commonly accepted values of storativity, three factors provide the majority of control on PHC and PHB. First, the permeabilities of the formations to be potentially affected are simply too low for a significant stress to propagate and/or pollutants to rapidly migrate. Second, the boundary of the saturated/unsaturated zone exists on the eastern edge of the permit area throughout most of the mine

which provides for minimal interception of saturated material. Third, progression of mining causes the potentiometric surface to drop at each cut expanding the unconfined boundary of the formation, which provides a severe hampering of propagation of stress. In the PAP, the coal seams in the *Fruitland Formation* were treated as individual aquifers and the OSMRE requested investigation of storativity values. BAI contends that the *coal seams* and their *interbedded lithological units* of the *Fruitland Formation* should be treated as one unit. Using the relationship $1x10^{-06}$ times the thickness of the unit[10], a value of $2.5x10^{-04}$ was obtained for the *coal seams* and *interbedded lithologic units* of the *Fruitland Formation*. A value of 0.1 represents the unconfined portions of the unit[9].

Additional testing to obtain localized storativity values is not technically justified as the results obtained would not alter the conclusion of minimal effects on the hydrologic regime. Using the previously described ground-water model (see Section 6.1) a sensitivity analysis of storativity was conducted. The confined storativity was decreased from its' original value by two orders of magnitude for all layers. Similarly, the unconfined storativity was decreased from a value of 0.1 to 0.05 for all layers. It should be noted that the size of storativity decreases implemented in this analysis are beyond the bounds of what would be considered reasonable values[9 & 10]. In decreasing storativity, the magnitude of stress propagation is increased. Thus, drawdowns are increased. Input and output for the storativity sensitivity analysis are presented in Appendix B.

Results of the sensitivity analysis indicate a maximum drawdown of approximately 1.5 feet outside of mining activity for the *overburden Kirtland/Fruitland Formation*. Drawdown within the majority of the modeled area is calculated as being less than one foot. For the *coal seams and interbedded lithologic units*, a maximum drawdown of approximately 4 feet is observed adjacent to the permit area, with values of approximately one-half to three feet observed throughout the rest of the modelled area. The *Pictured Cliffs Sandstone* yielded a maximum drawdown value of

approximately 2.5 feet with the majority of drawdown values being on the order of 0.5 feet. A total of 10.3 acre-feet of water for the entire 12 year simulation was dervied from the surface sources; San Juan River and Morgan Lake. The above analysis demonstrates that conclusions pertaining to hydrologic consequences are insensitive to reasonable, and in fact even unreasonable, values of storativity. The sensitivity analysis also shows that if one argued that the selected values for storativity were too low, an increase in storativity would decrease the impacts to the hydrologic regime.

6.3 DEFICIENCY 21.d.-Aquifer Test Information

As presented in the PAP, individual coal seams were tested for hydraulic information. Inasmuch, as the individual coal seams in the permit area are generally noncorrelative, discontinuous, and interbedded with varying rock types (PAP, Chapter 11), they should not be considered as separate units for purposes of calculating hydrologic impacts. The USGS has purposely not considered individual coal seams in their evaluation of impacts in the Fruitland Formation and we concur. Tests conducted by other entities and by BAI on similar geologic units in northwestern New Mexico consistently yield the same conclusion; the units can be characterized by extremely low permeabilities. Except to again demonstrate permeabilities are low by considering overall well production and drawdown, the specific tests are of little value as individual tests. Additionally, the coal seams are not in of themselves seperate units, but rather are treated collectively with the *interbedded units* of the *Fruitland Formation*. Therefore, we recommend interpretaions and questions pertaining to individual coal seam tests should be disregarded for purposes of calculating hydrologic impacts and geochemical flux.

Tests reported by the USGS wherein the *coal seams* and *interbedded lithologic units* of the *Fruitland Formation* were treated as one unit, yielded a range of transmissivity values from 7 to 130 feet squared per day[2]. For this type of combined formation, these values are reasonable, expected, and are presented here for future use within the PAP. To the extent the coal seams are

discontinuous, flow and stress propagation is controlled by the permeability of the interbedded lithologic units.

6.4 DEFICIENCY 21.e.-Potentiometric Surfaces

Ground-water flow paths in the Cretaceous rocks of the San Juan Basin are north to northwest trending towards the discharge point of the San Juan River[8](see Figure 1). Contours constructed by BAI using USGS data support a regional flow direction to the northwest for the *Pictured Cliffs Sandstone*, the *coal seams* and *interbedded lithological units* of the *Fruitland Formation*, and the *overburden* of the *Fruitland Formation* and *Kirtland Shale* (see Figures 2, 3 and 4). A localized northeasterly component near the outcrop is expected and indicated on the potentiometric surfaces previously submitted in the PAP (reference: Exhibits 12-2 through 12-5). These potentiometric surfaces represent individual coal seams and are not necessarily reflective of the unit as a whole. Consequently, certain hydrologic impact analyses should not be conducted utilizing these data (see Sections 5.0 and 6.3). The information from the PAP does identify the location of the saturated/unsaturated boundary within the individual coal seams. To that extent, the information is valuable (see Section 6.1). The unsaturated/saturated boundary information presented on Exhibits 12-1 through 12-5 (PAP, Chapter 12) have been collectively interpretated to identify a composite boundary for the *coal seams* and *interbedded lithologic units* of the *Fuitland Formation* as a whole (see attached Plate 1).

Eastern projection of the potentiometric surface should not be conducted for any large distance, based on the PAP potentiometric surfaces. However, projection is not necessary as USGS information allows for determination of the regional flow paths and gradients of the units involved. Similarly, it is not necessary to drill additional wells to the east because: a) the closest receptor is the San Juan River and it has been considered here; b) the analysis of hydrologic effects shows little effect to the east; c) the analysis of hydrologic effects shows essentially no contaminant could reach more than a mile east in reasonable time; d) high-production wells in these geologic units do not and can not exist to the east; e) available data show regional

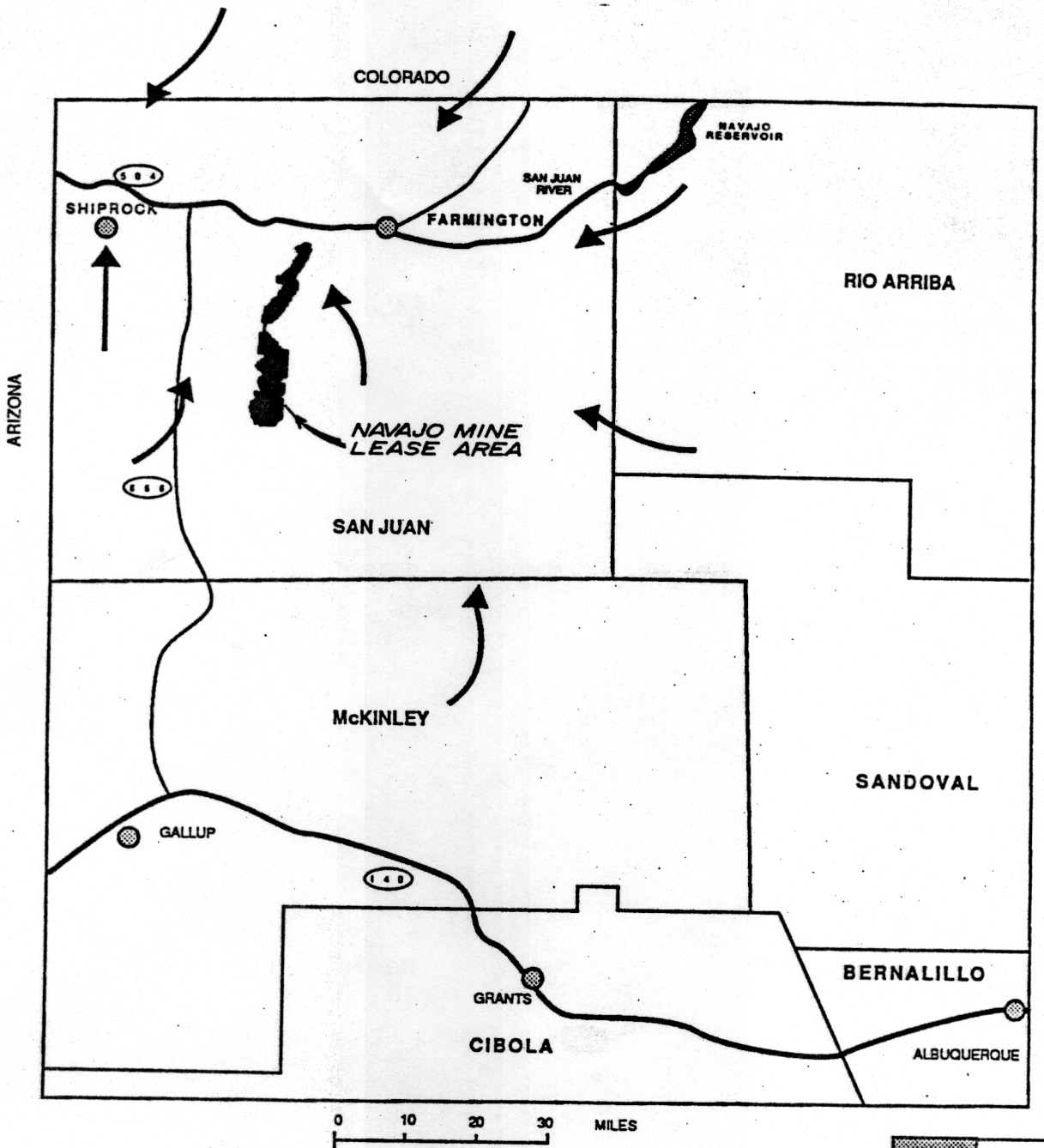
flow is not to the east; and f) these data, as expected match regional flow in geologically adjacent units of the basin.

6.5 DEFICIENCY 21.g.-Shallow Ground Water

Hydraulic impacts to the units beneath Area I and on Morgan Lake were simulated utilizing a ground-water flow model (see Section 6.1-Stress Propagation). These types of impacts were found to be negligible and probably unmeasureable. As such, hydraulic impacts in Area I North are not discussed further. In relation to transport and water quality impacts, the following is provided.

When Morgan Lake was first constructed, the major surface geologic feature in this area was the Pictured Cliffs Sandstone. Some alluvium was also present which, was used in the industrial area for fill material. Consequently, upon completion of Morgan Lake a localized recharge area developed with flow emanating from the lake to the sub-surface. As such, transport or migration of contaminants should not occur from the sub-surface to Morgan Lake. Any contaminants migrating to the San Juan River via the sub-surface from sources such as fuel tanks and coal stockpile runoff, would have to migrate through a minimum of the "worst case" geohydrologic conditions presented in Section 6.1. Given that the contaminant would have to migrate through the Pictured Cliffs Sandstone (i.e., lower permeability than the *coal seams* and *interbedded lithologic units* of the *Fruitland Foramtion*) first, the arrival time of the contaminant to the San Juan River would be greater than 240 years.

Additionally, UII has a current, valid NPDES permit which covers the Industrial Area - Area I North. Zero discharge has occurred since 1977 under this permit, and this will in all probability continue.



reference: Prenzel P.F. & Lyford F.P., 1982, "Estimates of Various Hydraulic Conductivity and Regional Ground-Water Flow Rates in Rocks of Jurassic and Cretaceous Age, San Juan Basin, New Mexico and Colorado", USGS WRI 82-4015

FIGURE 1: GENERALIZED PATTERN OF GROUND-WATER FLOW IN ROCKS OF JURASSIC AND CRETACEOUS AGE IN THE MIDDLE PORTION OF THE SAN JUAN BASIN

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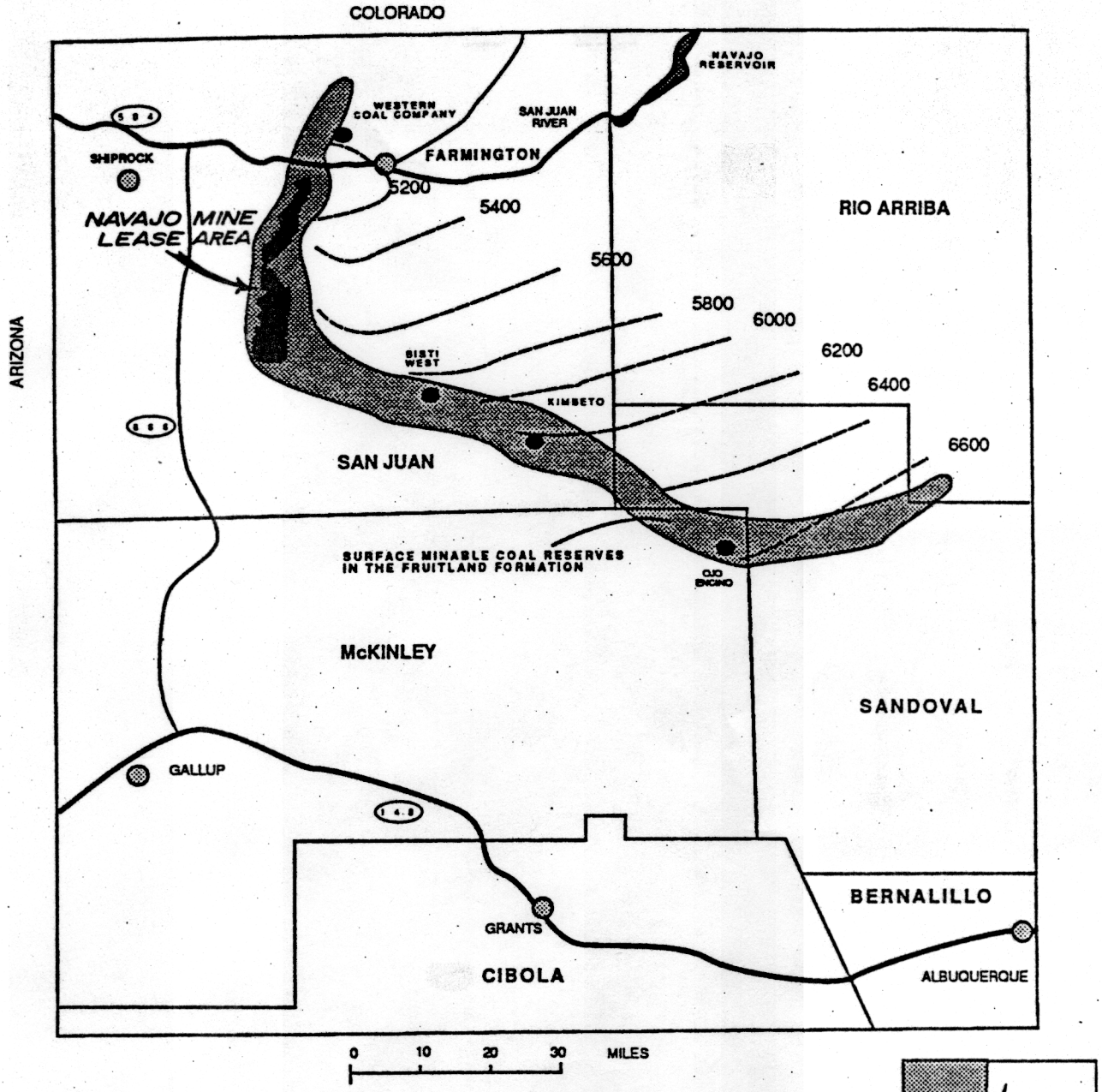
Billings & Associates, Inc. ALBUQUERQUE, NM

September, 1987 BAI



● USGS MONITORING LOCATIONS
*WESTERN COAL COMPANY
*BISTI WEST
*KIMBETO
*OJO ENCINO

reference: Contours were constructed by BAI from data presented in; Myers, R.G. and Wanetaweva, E.D., 1988, "Geomorphology of the Aquifers Affected by the Surface Mining of Coal in the Fruitland Formation in the San Juan Basin, Northwestern New Mexico", USGS WRIR #85-4251.

FIGURE 2: POTENTIOMETRIC SURFACE OF OVERBURDEN KIRTLAND/FRUITLAND FORMATION

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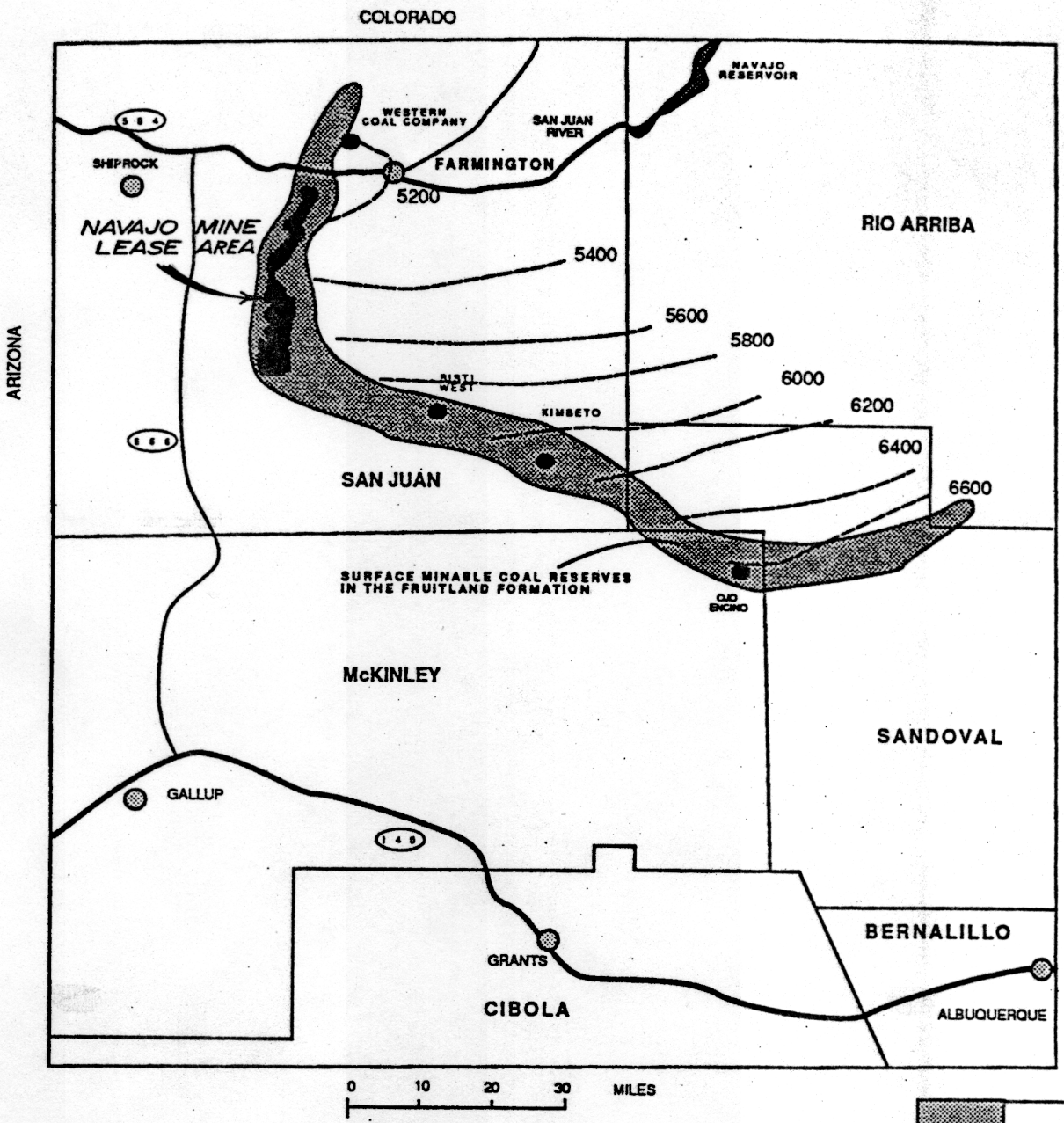
ALBUQUERQUE, NM

September, 1987

BAI



● USGS MONITORING LOCATIONS
*WESTERN COAL COMPANY
*BISTI WEST
*KIMBETO
*OJO ENCINO

References: Contours were constructed by BAI from data provided in; Myers, R.G. and Wasanueva, E.D., 1988, "Geomorphology of the Aquifers Affected by the Surface Mining of Coal in the Fruitland Formation in the San Juan Basin, Northwestern New Mexico", USGS WRIR #86-4251.

FIGURE 3: POTENTIOMETRIC SURFACE OF COAL SEAMS AND INTERBEDDED LITHOLOGIC UNITS

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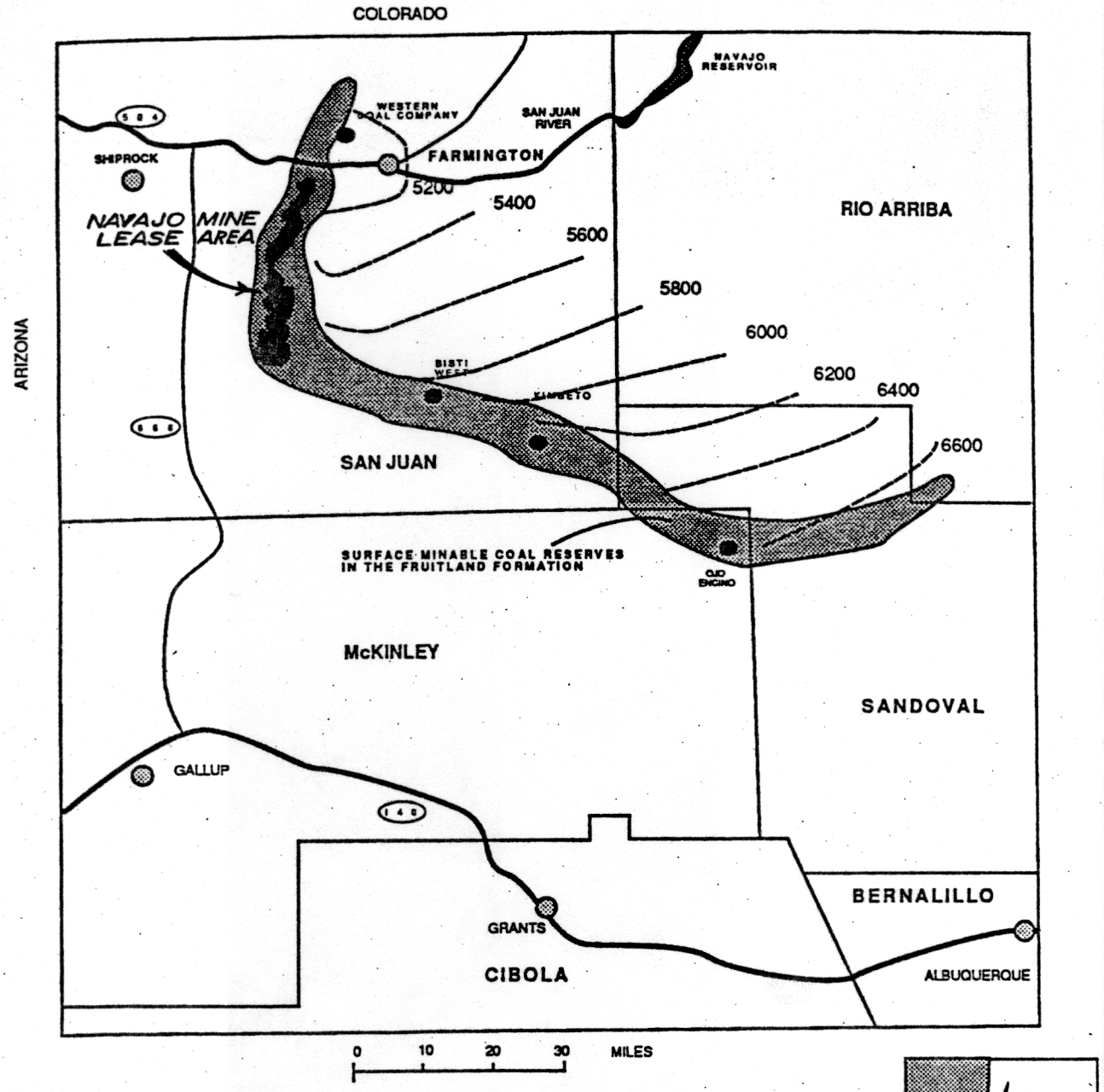

● USGS MONITORING LOCATIONS
*WESTERN COAL COMPANY
*BISTI WEST
*KIMBETO
*OJO ENCINO

reference: Contours were constructed by BAI from data provided in: Myers, R.G. and Williamson, E.D., 1988, "Geomorphology of the Aquifers Affected by the Surface Mining of Coal in the Fruitland Formation in the San Juan Basin, Northwestern New Mexico", USGS WRIR #88-4251.

FIGURE 4: POTENTIOMETRIC SURFACE OF PICTURED CLIFFS SANDSTONE

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Billings & Associates, Inc. ALBUQUERQUE, NM

September, 1987 BAI

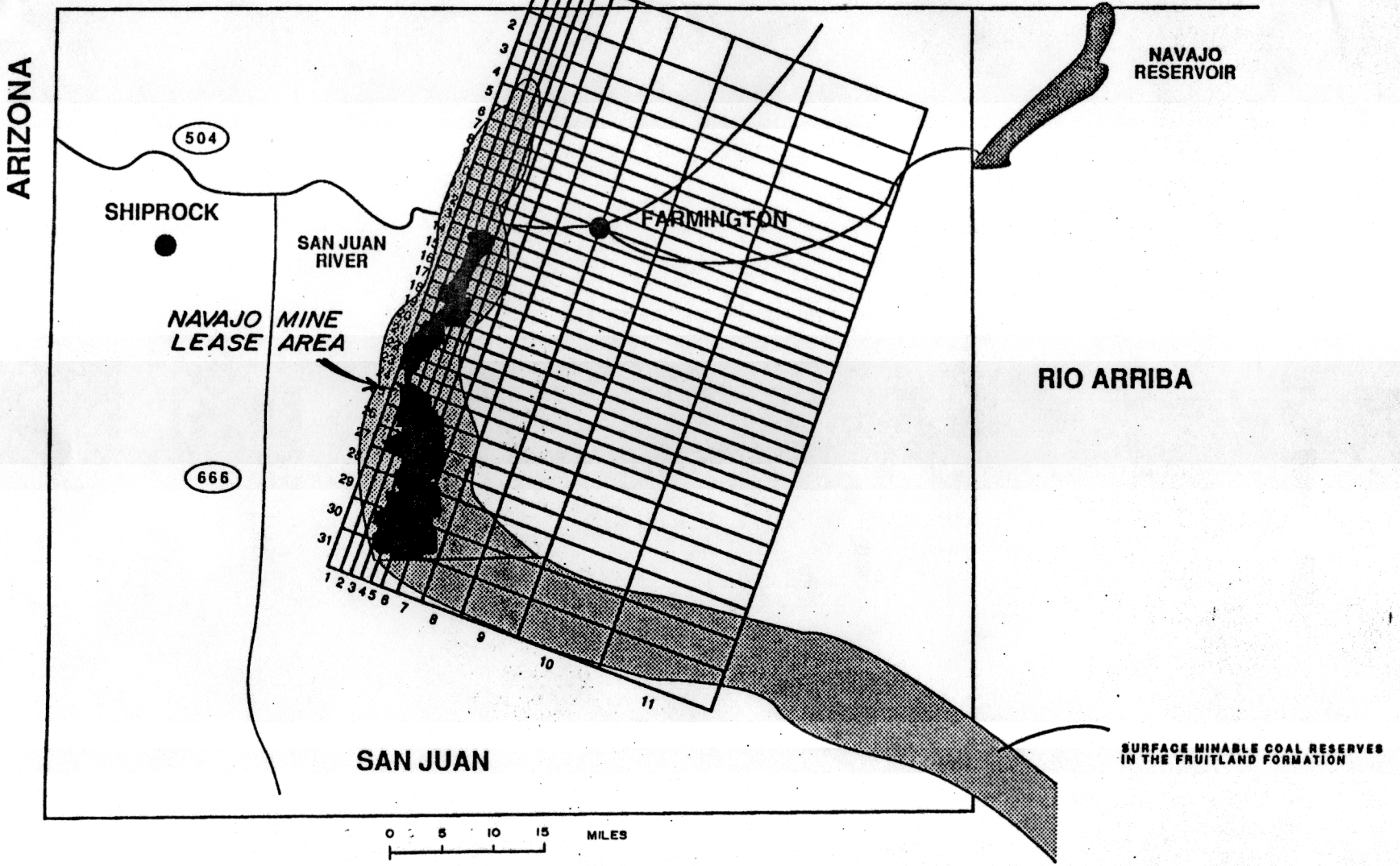

FIGURE 5: MODEL CELL NUMBERS AND GRID NETWORK

BHP-UTAH INTERNATIONAL, INC.

BILLINGS & ASSOCIATES, INC. ALBUQUERQUE, NM

SEPTEMBER, 1987 BAI

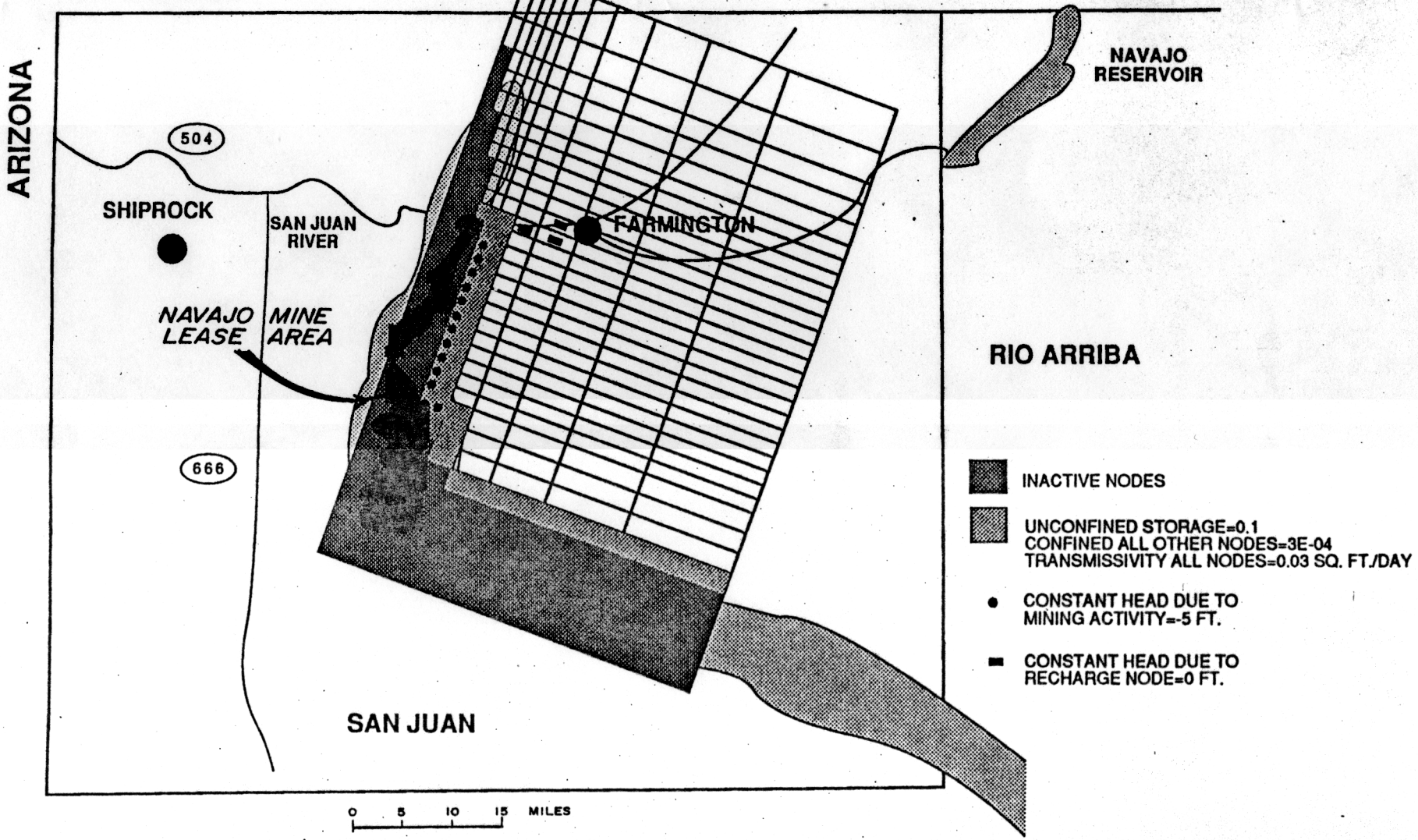

**FIGURE 6: NODE STATUS-
OVERBURDEN KIRTLAND/FRUITLAND**

BHP-UTAH INTERNATIONAL, INC.

BILLINGS & ASSOCIATES, INC. ALBUQUERQUE, NM

SEPTEMBER, 1987 BAI

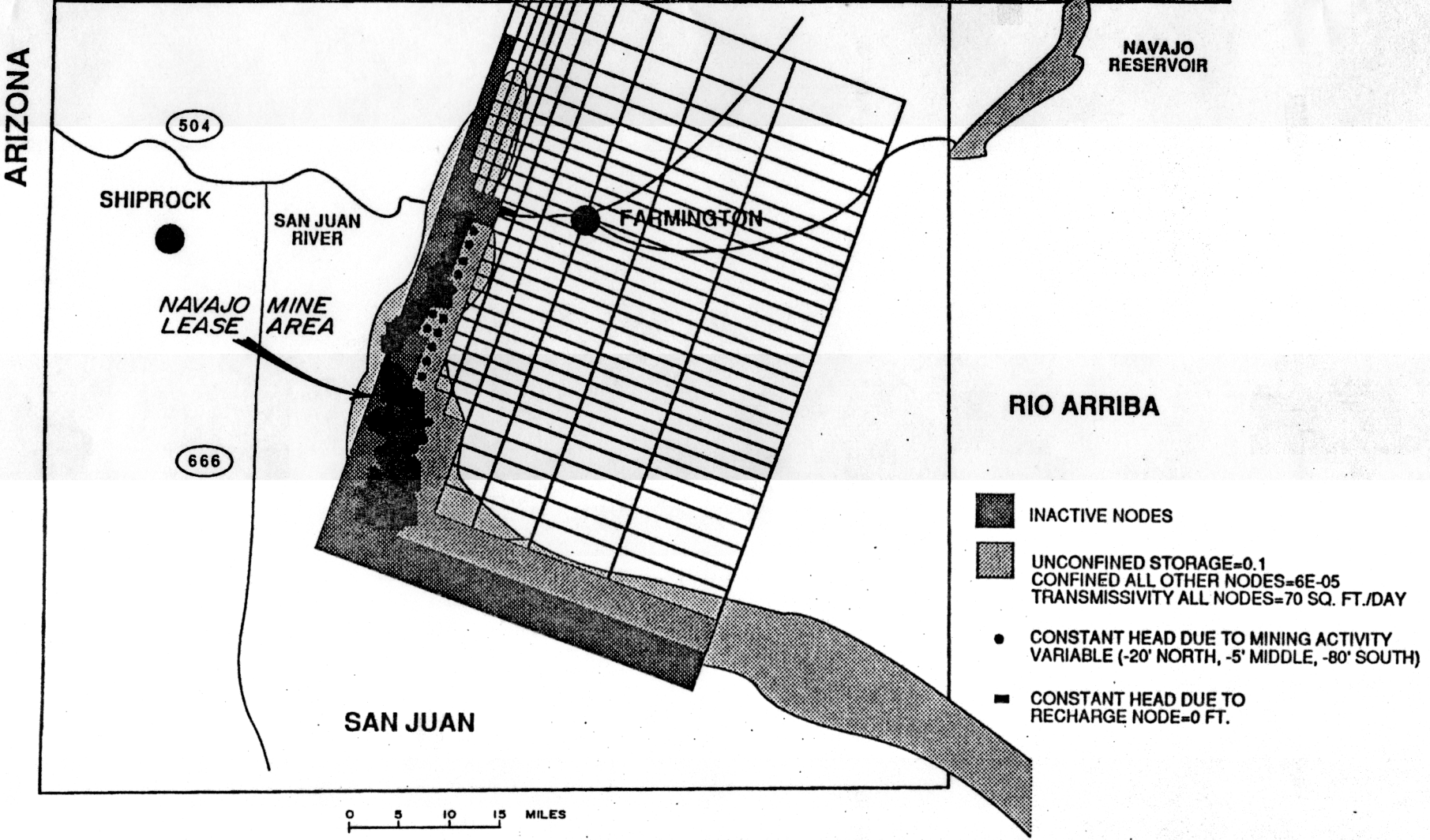

FIGURE 7: NODE STATUS- COAL SEAMS AND INTERBEDDED LITHOLOGIC UNITS

BHP-UTAH INTERNATIONAL, INC.

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SEPTEMBER, 1987 BAI

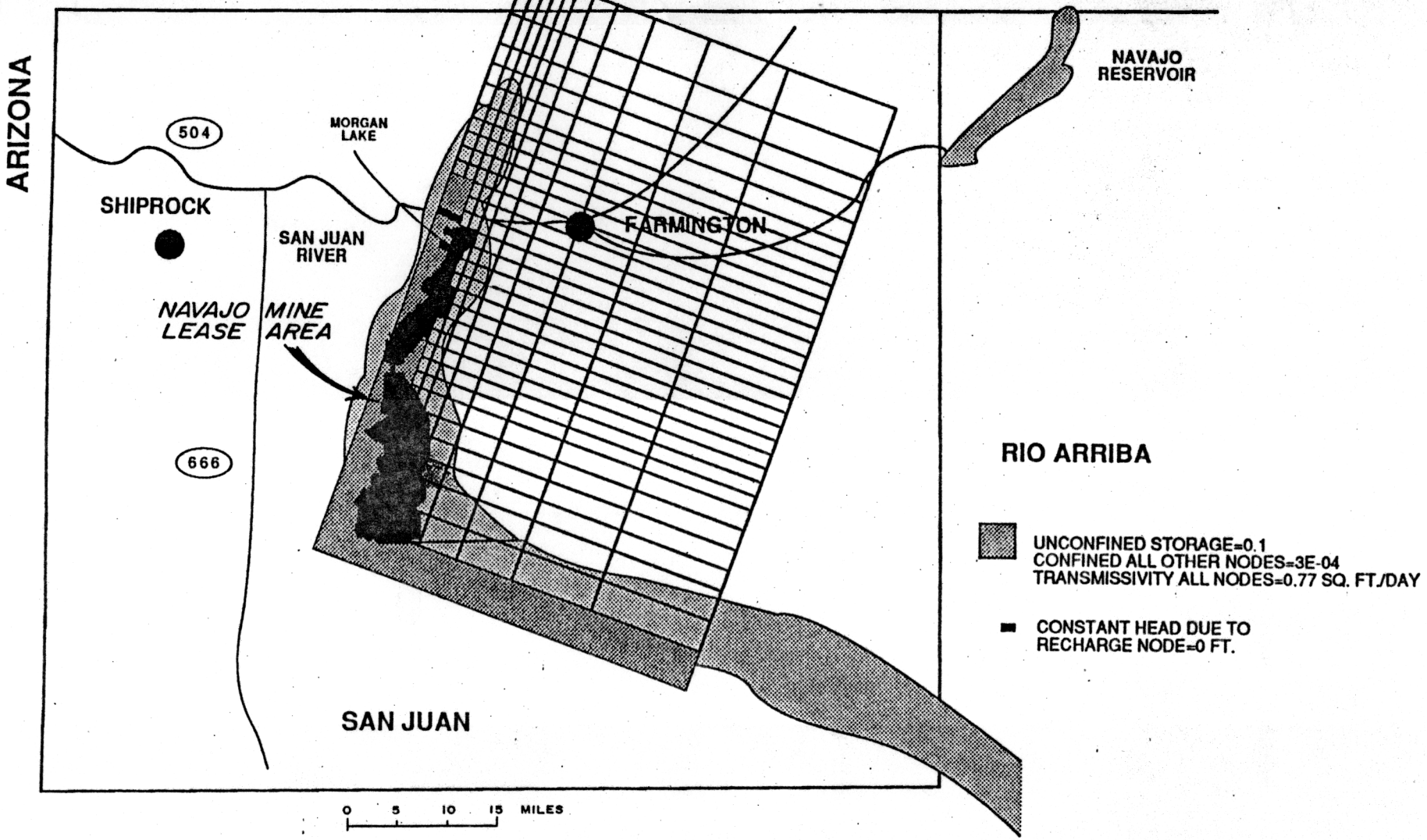


**FIGURE 8: NODE STATUS-
PICTURED CLIFFS SANDSTONE**

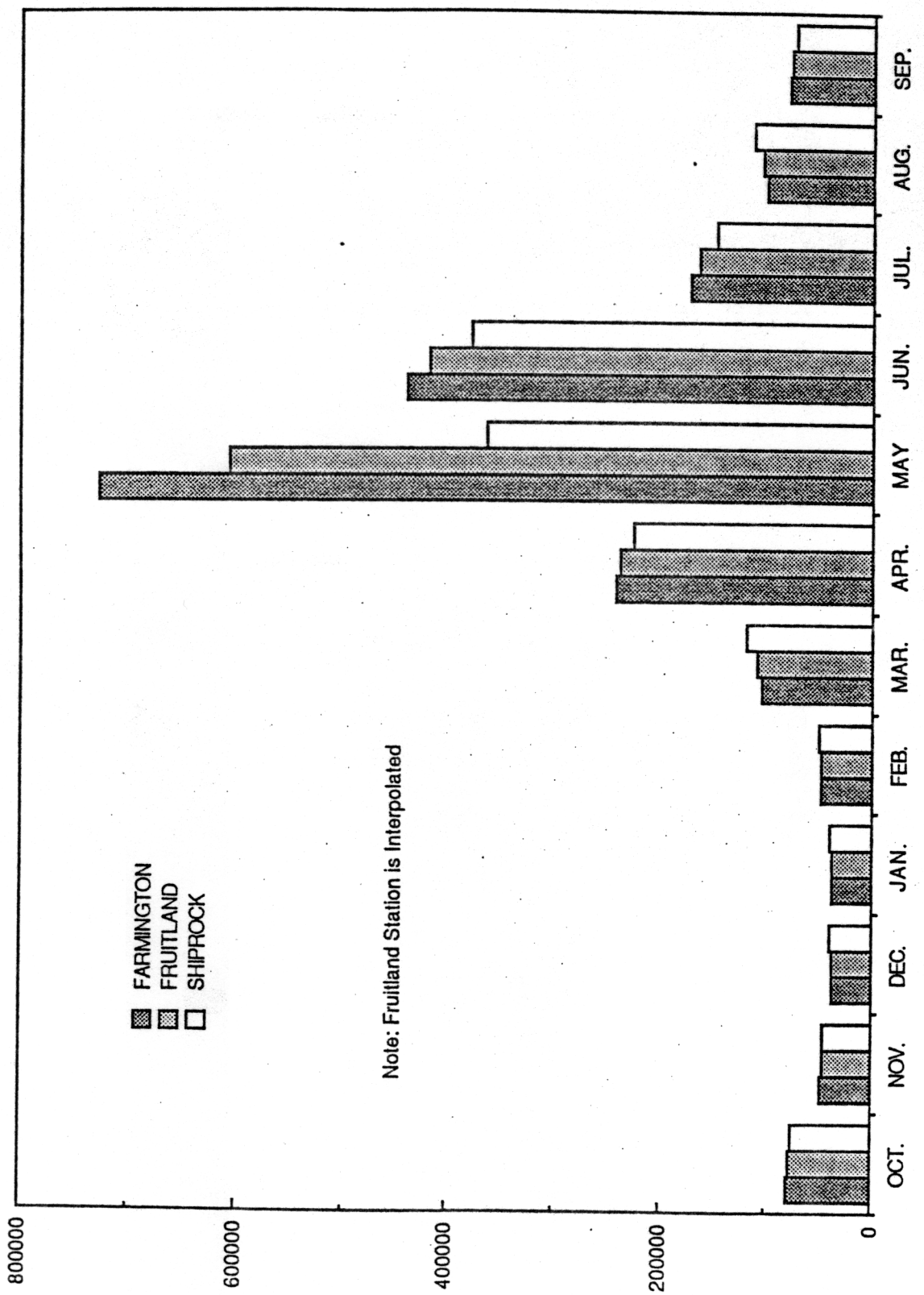
BHP-UTAH INTERNATIONAL, INC.

BILLINGS & ASSOCIATES, INC.
ALBUQUERQUE, NM

SEPTEMBER, 1987

BAI

FIGURE 9. MONTHLY FLOW RATES-SAN JUAN RIVER



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3. Baur, M., 1916, *Contributions to the Geology and Paleontology of San Juan County, New Mexico*: U.S.G.S. Prof. Paper 98 - P.

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8. Frenzel, P.F., Lyford, F.P., 1982, *Estimates of Vertical Hydraulic Conductivity and Regional Ground-water Flow Rates in Rocks of Jurassic and Cretaceous Age, San Juan Basin, New Mexico and Colorado*: U.S.G.S. Water-Resources Investigations 82-4015.

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Prof. Paper 708.

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Appendix 18.P

(Copy of 1989 Appendix 12E)

Special Condition 11/89

The results of water-chemistry analyses are shown in table 2. The water is brackish. The specific conductance of the representative water samples ranges from 3,100 to 11,300 microsiemens per centimeter at 25° Celsius (microsiemens) (a calculated sum of approximately 2,200 to 6,800 milligrams per liter of dissolved solids). The dominant cation (fig. 7) in all samples is sodium. The dominant anion (fig. 7) is chloride except for samples from well 20, which is predominately bicarbonate, and well 29, which is predominately sulfate.

Transmissivities of the Pictured Cliffs Sandstone were determined from the results of slug tests and recovery tests after bailing from selected wells. These values ranged from 0.001 to 3 feet squared per day (Stone and others, 1983).

Coal Seams and Interbedded Lithologic Units of the Fruitland Formation (Late Cretaceous)

The Fruitland Formation overlies and intertongues with the Pictured Cliffs Sandstone and underlies the Kirtland Shale. The contact between the Pictured Cliffs Sandstone and Fruitland Formation is at the top of the massive sandstone underlying the lowermost coal bed. The contact between the Fruitland Formation and Kirtland Shale is at the top of the highest coal or carbonaceous-shale bed (Fassett and Hinds, 1971). The Fruitland Formation is composed of discontinuous, interbedded sandstone, siltstone, shale, coal, limestone, and carbonaceous sandstone, siltstone, and shale. The vertical lithology is somewhat consistent. The thin limestone beds composed of brackish-water pelecypod shells are in the lower part of the formation. The thicker coal beds are in the lower one-fifth to one-third of the formation. Sandstone generally is more abundant in the lower part of the formation. The upper part of the formation predominantly is siltstone and shale. The thickness of the Fruitland Formation generally is less than 300 feet within the study area (Fassett and Hinds, 1971).

Nine observation wells are completed in the coal seams and interbedded lithologic units of the Fruitland Formation (fig. 8; table 3). Water-level measurements for the period of record are shown in figure 9.

The results of water-chemistry analyses are shown in table 4. The water is brackish. The specific conductance of the representative water samples ranges from 1,900 to 13,000 microsiemens (a calculated sum of approximately 1,200 to 8,500 milligrams per liter of dissolved solids). The dominant cation in all samples is sodium (fig. 10). The dominant anion is bicarbonate for samples with specific conductances less than 5,000 microsiemens. The dominant anion for samples with specific conductances greater than 5,000 microsiemens is chloride, except for the sample from well 32, which is sulfate.

Transmissivities of the coal seams and interbedded lithologic units in the Fruitland Formation were determined from the results of slug tests and recovery tests after bailing from selected wells. These values range from 7 to 130 feet squared per day (Stone and others, 1983).

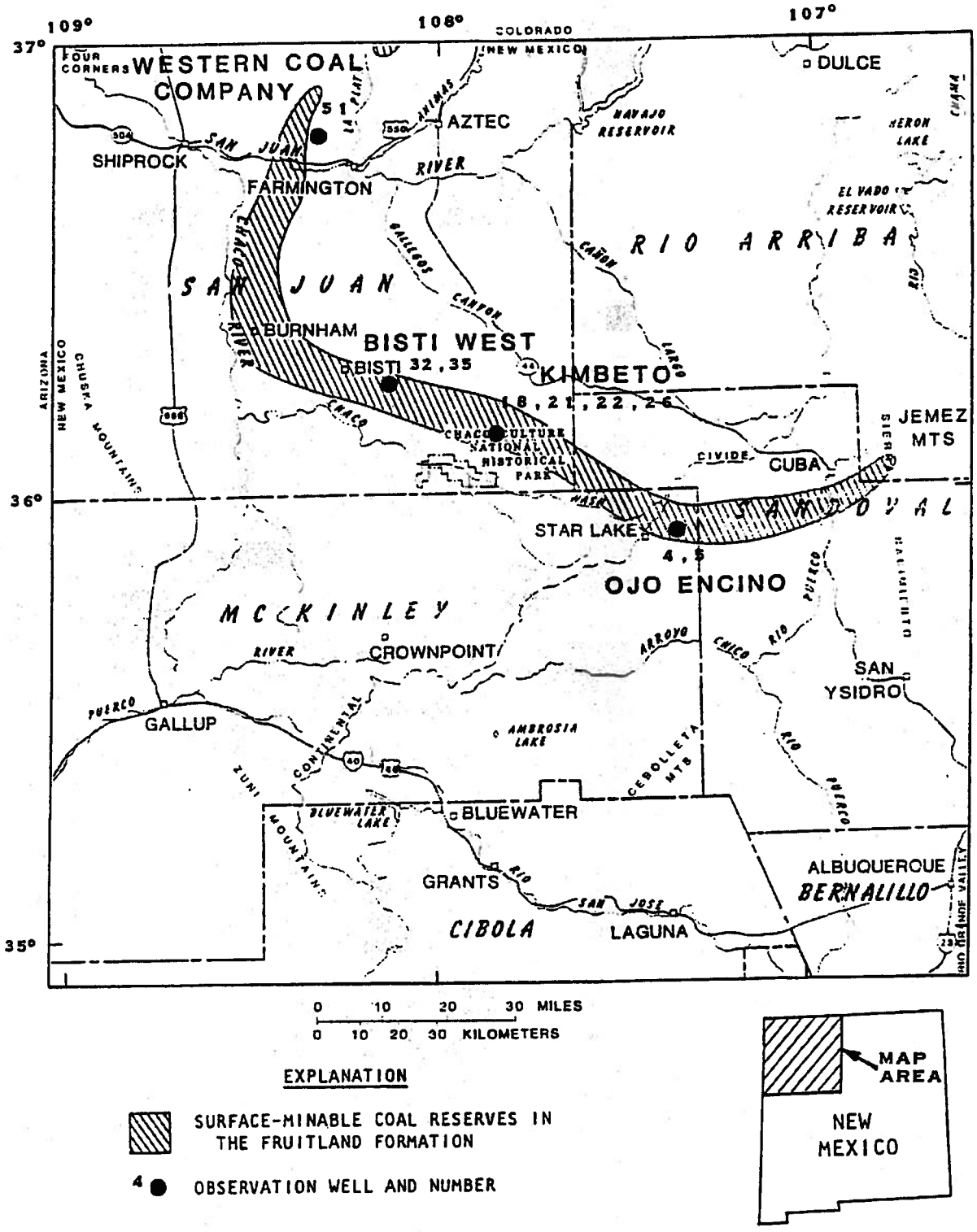


Figure 8.--Location of observation wells completed in coal seams and interbedded lithologic units of the Fruitland Formation.

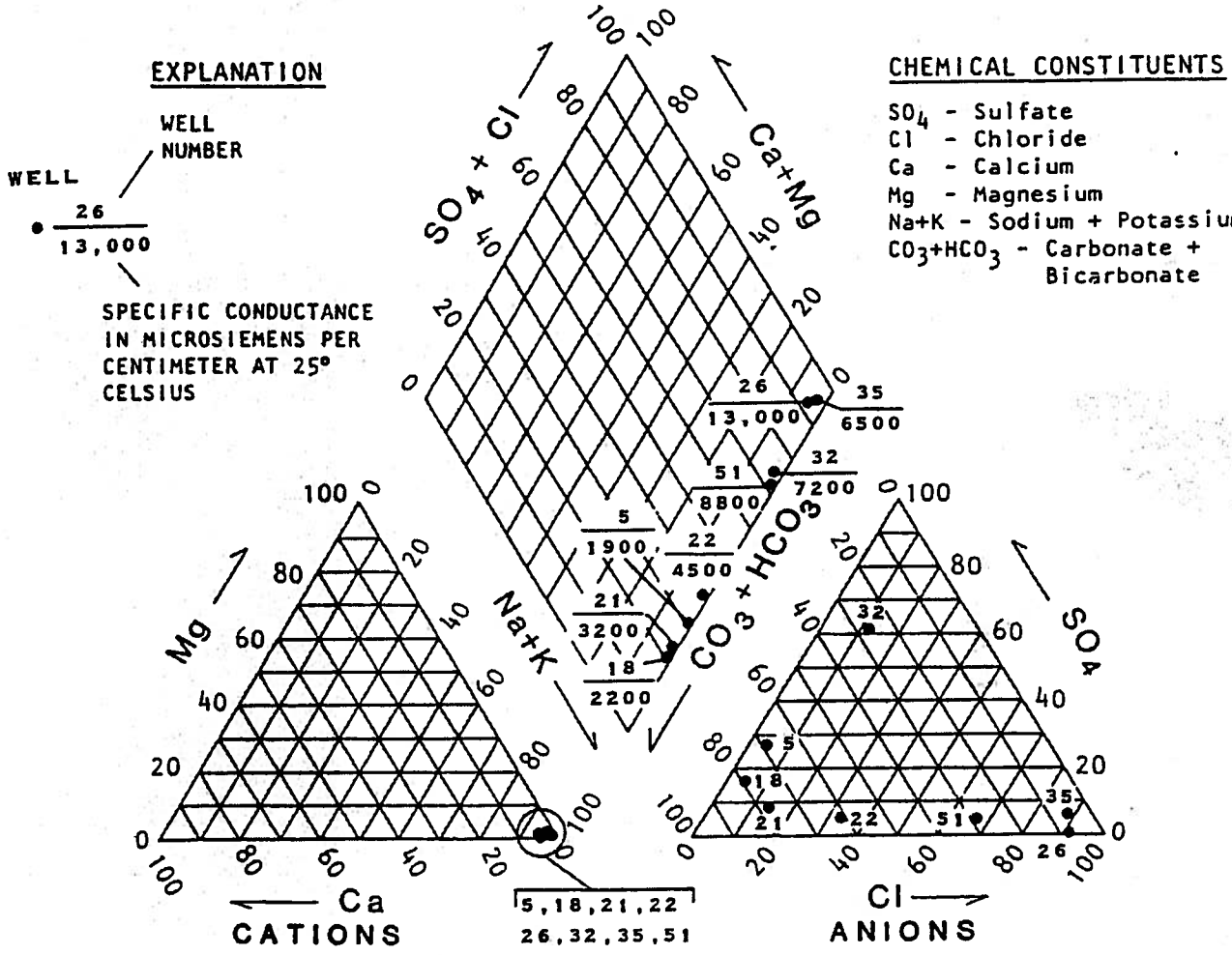


Figure 10.-- Representative chemical analyses of water from selected wells completed in coal seams and interbedded lithologic units of the Fruitland Formation.

Table 3. Records of observation wells completed in the coal seams and interbedded lithologic units of the Fruitland Formation

Number in figure 8	Station number	Date completed	Altitude of land surface (feet)	Well depth (feet)	Casing diameter (inches)	Water level (feet below land surface)	Date measured
4	355446107204801	10-11-78	6,621	250	2	33.90	10-11-78
5	355447107224301	11-11-78	6,675	240	2	68.00	07-25-79
18	360734107523101	09-08-77	6,300	292	1.5	92.78	11-16-77
21	360823107544001	05-10-77	6,330	250	1.5	115.41	08-17-77
22	360849107561801	05-31-77	6,290	225	1.5	86.80	08-17-77
26	361008107543901	07-22-77	6,280	373	1.5	68.30	08-16-77
32	361446108090801	08-23-76	5,920	148	2	62.70	03-02-77
35	361513108090701	08-04-76	5,925	162	2	84.14	03-02-77
51	364845108214201	11-15-77	5,370	715	2	158.85	02-22-78

Appendix 18.Q

(Copy of 1989 Appendix 12A)

Well Completion Records

1985 Reorganization
Amended 10/89
12-A-1

WELL COMPLETION REPORT

Well Name (Kf83-1) Kf-1 Mine Navajo

Location Watson Pit (East)

County San Juan State New Mexico

Driller Jim Gay

Formation Fruitland/Kirtland TD 145

Drill Type Rotary

Drilling Fluid Injection Mist, 135' to 154'

Logs Rotary Cuttings; Geophysical logs; Gamma, Density, & Res.

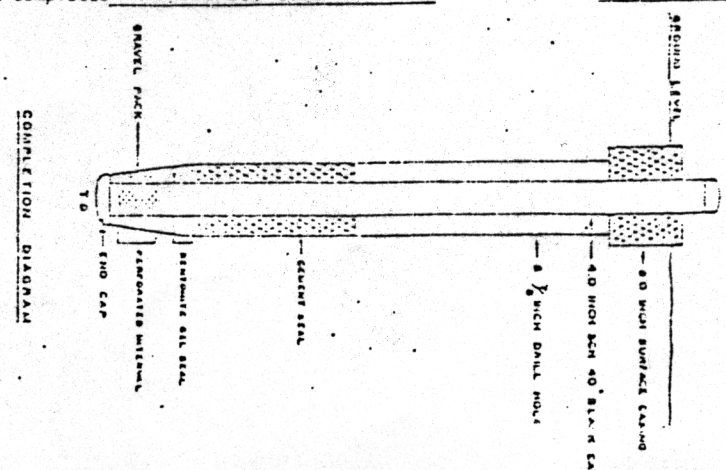
Hours Drilled 5

Note: Hole making 1 gal/min.

Completion Information

Casing Type	4" SCD. 40		
Casing Diameter	4'		
Perforated Casing	20' Slotted		
Blank Casing From	Top 0.0'	to	125'
Surface Casing From		to	
Perforated Casing From	125'	to	145'
Gravel Pack From	123'	to	145'
Gel Seal From	120'	to	123'
Cement Bottom Seal From	145'	to	154'
Cement Top Seal From	50'	to	120'
Packers Used (Y or N)		Centralizers Used (Y or N)	
Initial Water Level			
Elevation		Saturated Thickness	
Pump Installed		Air Lift Installed	
Pump Depth		Air Lift to TD (Y or N)	

Date Completed August 19, 1983 Hours Completed 10



1985 Reorganization
Amended 10/89
12-A-2

WELL DRILLING REPORT

WELL NAME (Kf83-1) Watson Pit (East) Kf - 1

DATE 8/18/83
PAGE 2 of 2

INTERVAL		WATER	LITHOLOGY	DESCRIPTION
0.0	7.0		Alluvial	Lt. Brown, shale, weathered
7.0	9.0		Shale	Gray, soft, oxidized
9.0	11.0		Sltstn	Lt. Gray, Very hard
11.0	12.0		Sandstone	Lt. Gray Hard
12.0	16.0		Shale	Gray, Soft
16.0	17.0		Sltstn	Lt. Gray, Very hard, Fine grained
17.0	36.0		Shale	Gray, Soft
36.0	37.0		Coal	Dull black, Shaley, Soft
37.0	47.0		Shale	Gray, Soft
47.0	48.0		Coal	Hard, Moist
48.0	50.0		Shale	Gray, Soft, Sandy
50.0	55.0		Shale	Gray, Soft
55.0	56.0		Coal	Hard, Moist
56.0	66.0		Shale	Gray, Soft
66.0	76.0		Sltstn	Gray, Moderately hard
76.0	104.0		Sandstone	Lt. Gray, Very hard (Damp @ 97')
104.0	105.0		Shale	Gray, Soft, Silty
105.0	106.0		Sandstone	Gray, Hard
106.0	107.0		Shale	Gray, Hard, Silty
107.0	112.0	5.0'	Coal	Hard, Lustre
112.0	128.0	16.0'	Shale	Gray, Soft
128.0	144.0	16.0'	Coal	Hard, Lustre, H_2S, H_2O bottom half @ less
144.0	154.0		Shale	Gray, Soft
154.0	155.0		Sandstone	PC Formation
				NOTE: Noticeable water invasion @ 132' de
				also at 154' depth. Hole making wa
				less than 2 gallons per minute.

1985 Reorganization
12-A-3

WELL COMPLETION REPORT

Well Name (Kf83-2) Kf - 2 Mine Navajo

Location Custer Pit

County San Juan State New Mexico

Driller Jim Gay

Formation Fruitland TD 172.0'

Drill Type Rotary

Drilling Fluid None

Logs Lithology, Geophysical

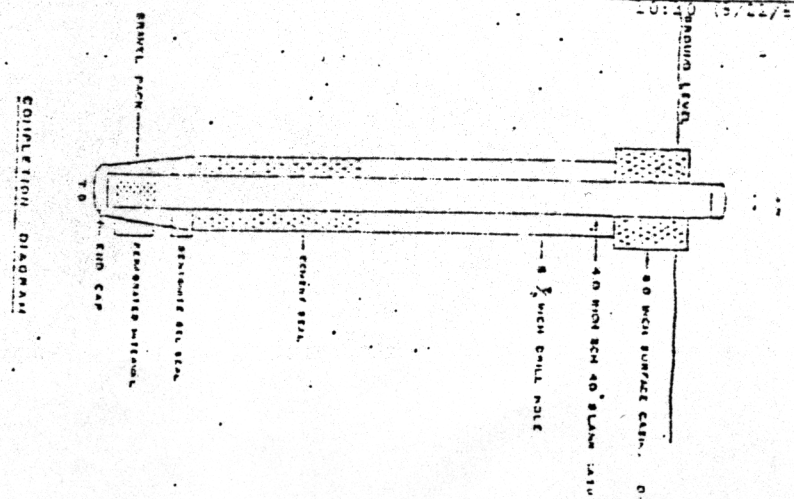
Hours Drilled

Note: No Water

Completion Information

Casing Type 4" SCD. 40
Casing Diameter 4"
Perforated Casing 18'
Blank Casing From 0' to 154'
Surface Casing From 0' to 10'
Perforated Casing From 154' to 172'
Gravel Pack From 152' to 172'
Gel Seal From 150' to 152'
Cement Bottom Seal From to
Cement Top Seal From 10' to 152'
Packers Used (Y or N) Centralizers Used (Y or N)
Initial Water Level None
Elevation Saturated Thickness
Pump Installed Air Lift Installed
Pump Depth Air Lift to TD (Y or N)

Date Completed August 22, 1983 Hours Completed 11:00 (8/19/83)
10:45 (8/22/83)



WELL DRILLER'S REPORT

TE NAME (Kf83-2) Custer Pit Kf - 2 DATE 8-19-83

PAGE 2 2

INTERVAL		WATER	LITHOLOGY	DESCRIPTION
0.0	1.0		Alluvial	Blown sand, tan fine grained.
1.0	4.0		Shale	Gray, soft, clayey, oxidized.
4.0	10.0		Shale	Gray, soft, oxidized.
10.0	30.0		Sandstone	Lt gray, hard, oxidized, fine grained.
30.0	31.0		Shale	Gray, soft, sandstone interbedded.
31.0	37.0		Sandstone	Lt. gray, moderately hard.
37.0	51.0		Shale	Gray, soft.
51.0	56.0		Sandstone	Lt. gray, hard, fine grained.
56.0	71.0		Shale	Gray, slightly hard.
71.0	73.0		Coal	Hard, lustre.
73.0	90.0		Shale	Gray, soft.
90.0	92.0		Shale	Carbonaceous, dark, gray, soft.
92.0	103.0		Shale	Gray, soft.
103.0	107.0	5.0'	Coal	Hard, lustre.
107.0	108.0		Shale	Gray, soft.
108.0	149.0		Sandstone	Lt. gray, hard.
149.0	156.0		Shale	Gray, soft.
156.0	171.0	15.0	Coal	High grade, hard, lustre.
171.0	172.0		Shale	Gray, soft.

NOTE: No water found in well location.

1985 Reorganization
12-A-5

WELL COMPLETION REPORT

Well Name (Kf83-3) Kf - 3 Mine Nevada

Location Doby Pit

County San Juan State New Mexico

Driller Jim Gay

Formation Fruitland TD 149'

Drill Type Rotary

Drilling Fluid None

Logs Lithology and Geophysical

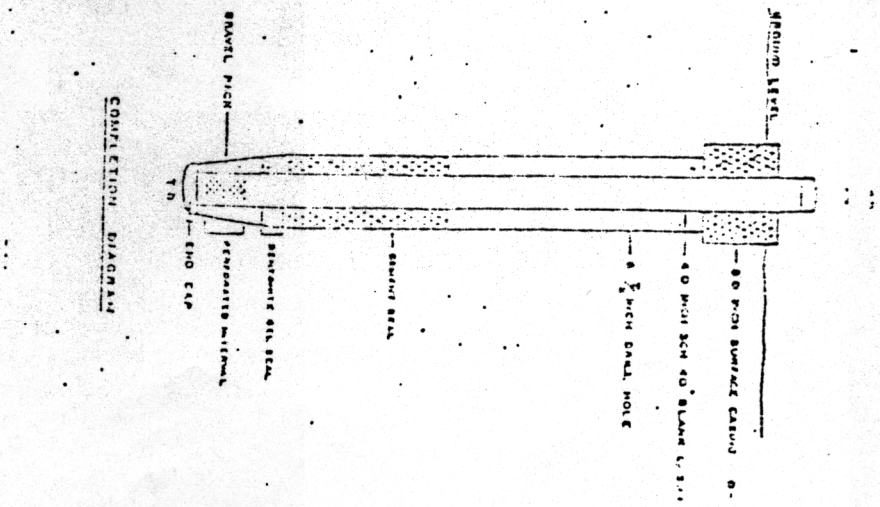
Hours Drilled 3 hours and 45 minutes

Note: No Water

Completion Information

Casing Type	4" SCD. 40		
Casing Diameter	4"		
Perforated Casing	14'		
Blank Casing From	Surface	to	135'
Surface Casing From		to	
Perforated Casing From	135'	to	149'
Gravel Pack From	133'	to	149'
Gel Seal From	131'	to	133'
Cement Bottom Seal From		to	
Cement Top Seal From	0	to	10'
Packers Used (Y or N)		Centralizers Used (Y or N)	
Initial Water Level			
Elevation		Saturated Thickness	
Pump Installed		Air Lift Installed	
Pump Depth		Air Lift to TD (Y or N)	

Date Completed August 22, 1983 Hours Completed 11:00 (8/22/83)



WELL DRILLING REPORT

WELL NAME (Kf83-3) Kf - 3 Doby Pit

DATE 8/22/83
PAGE 1 OF 1

INTERVAL		WATER	LITHOLOGY	DESCRIPTION
0.0	17.0		Alluvial	Blown sand, Tan, Fine grained
17.0	49.0		Sand	Lt. Brown, Soft, Oxidized, Fine grained
49.0	55.0		Shale	Gray, Soft
55.0	65.0		Sandstone	Lt. Gray, Very hard
65.0	70.0		Siltstone	Lt. Gray, Very hard
70.0	75.0		Sandstone	Lt. Gray, Very hard, Fine grained
75.0	96.0		Siltstone	Lt. Gray, Extra hard
96.0	110.0		Sandstone	Lt. Gray, Very hard
110.0	114.0		Shale	Gray, Moderately hard
114.0	130.0		Sandstone	Lt. Gray, Very hard
130.0	137.0		Shale	Gray, Slightly hard
137.0	148.0		Coal	H_2S
148.0	149.0		Shale	Gray, Soft
				NOTE: No water encountered in hole.

WELL COMPLETION REPORT

Well Name (Kf83-4) Kf - 4 Mine Navajo

Location Yazzie Pit

County San Juan State New Mexico

Driller Jim Gay

Formation Fruitland TD 139

Drill Type Mayhew 1250 (Rotary)

Drilling Fluid -

Logs

Hours Drilled

Water in well after 7 days; < 1 Gal./Min.

Completion Information

Casing Type Schedule 40 4" PVC

Casing Diameter 4"

Perforated Casing 4" Slotted

Blank Casing From 0 to 123

Surface Casing From 0 to 10

Perforated Casing From 123 to 138

Gravel Pack From 121 to 138

Gel Seal From 119 to 121

Cement Bottom Seal From to

Cement Top Seal From 69 to 119

Packers Used (Y or N) Centralizers Used (Y or N)

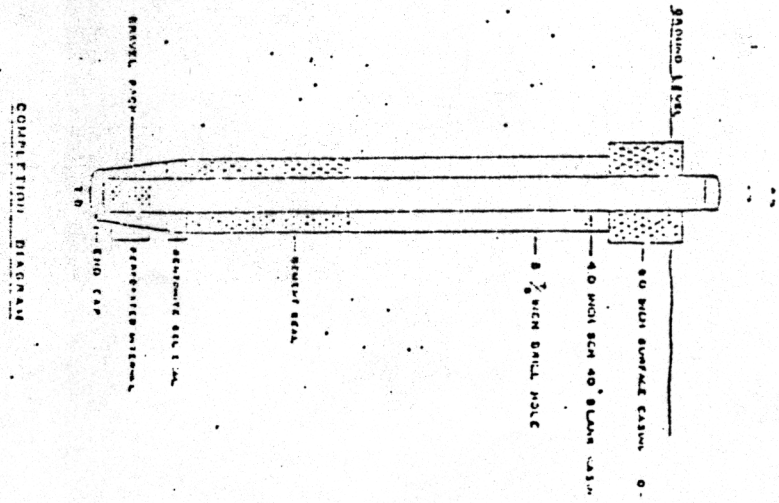
Initial Water Level

Elevation Saturated Thickness

Pump Installed Air Lift Installed

Pump Depth Air Lift to TD (Y or N)

Date Completed 8-03-83 Hours Completed 7:00/8-29-83 12:00/8-31-83



WELL DRILLING REPORT

OIL WELL (Kf83-4) Kf-4

DATE 8-23-83
PAGE

INTERVAL		WATER	LITHOLOGY	DESCRIPTION
0.0	1.0		Alluvial	Sandy, Shaley, weathered.
1.0	2.0		Shale	Lt. brown, soft, oxidized.
2.0	7.0		Sandstone	Lt. gray, hard, silty.
7.0	16.0		Shale	Gray, soft.
16.0	17.0		Sandstone	Lt. gray, hard, parting.
17.0	32.0		Shale	Gray, soft.
32.0	33.0		Coal	Thin, seam, dull black.
33.0	52.0		Shale	Gray, soft.
52.0	54.0		Sandstone	Lt. gray, hard.
54.0	55.0		Shale	Gray, moderately hard.
55.0	64.0		Sandstone	Lt. gray, hard, shale interbedded.
64.0	67.0		Shale	Gray, soft.
67.0	69.0		Sandstone	Lt. gray, very hard, silty.
69.0	78.0		Shale	Gray, soft, with hard S.S. interbedded.
78.0	87.0		Shale	Gray, soft.
87.0	89.0		Shale	Dark gray, carboraceous, soft.
89.0	104.0		Shale	Gray, soft.
104.0	106.0		Sandstone	Lt. gray, very hard, silty.
106.0	109.0		Shale	Gray, soft.
109.0	117.0		Sandstone	Lt. gray, hard, silty.
117.0	127.0		Shale	Gray, soft.
127.0	137.0		Coal	
137.0	138.0		Shale	Gray, soft.
				NOTE: No water in hole.

1985 Reorganization
12-A-9

WELL COMPLETION REPORT

Well Name (Kf83-9(a)) Kf-9A Mine Navajo

Location Area III

County San Juan State New Mexico

Driller Jim Day

Formation Fruitland TD 183' Core 1

Drill Type Rotary

Drilling Fluid Injection (water)

Logs

Hours Drilled

Completion Information

Casing Type 4" schedule 40

Casing Diameter

Perforated Casing 4" slotted

Blank Casing From 0 to 177

Surface Casing From to

Perforated Casing From 177 to 183

Gravel Pack From 175 to 183

Gel Seal From 172 to 175

Cement Bottom Seal From to

Cement Top Seal From to

Packers Used (Y or N) Centralizers Used (Y or N)

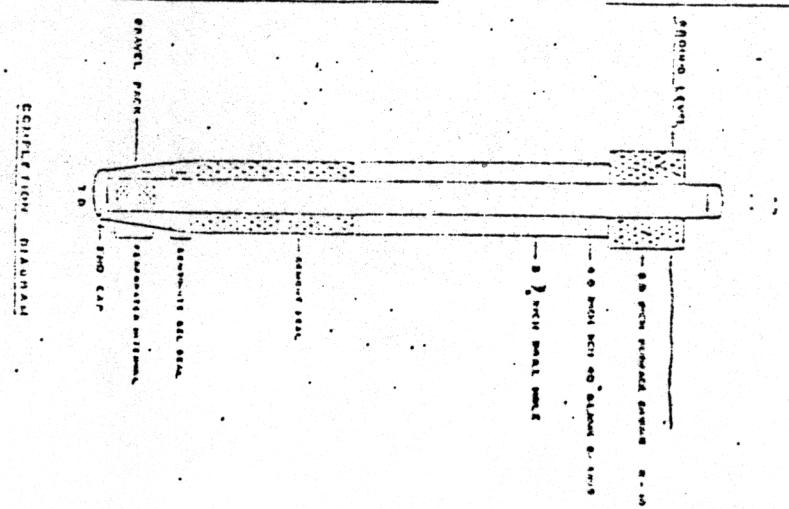
Initial Water Level

Elevation Saturated Thickness

Pump Installed Air Lift Installed

Pump Depth Air Lift to TD (Y or N)

Date Completed Hours Completed



LL NAME (Kf83-9(a)) Kf-9A

DATE 9/26/85
PAGE 1 of 1

INTERVAL	WATER	LITHOLOGY	DESCRIPTION
			Same as 9C

WELL COMPLETION REPORT

Well Name (Kf83-9(b)) Kf-9B Mine Navajo

Location Area III

County San Juan State New Mexico

Driller [illegible]

Formation Fruitland TD 213' Seam 3

Drill Type Rotary

Drilling Fluid Injection (water)

Logs

Hours Drilled

Completion Information

Casing Type 4" schedule 40

Casing Diameter

Perforated Casing 4" slotted

Blank Casing From	0	to	202
Surface Casing From		to	
Perforated Casing From	202	to	213
Gravel Pack From	200	to	213
Gel Seal From	196	to	200
Cement Bottom Seal From		to	
Cement Top Seal From		to	

Packers Used (Y or N) Centralizers Used (Y or N)

Initial Water Level

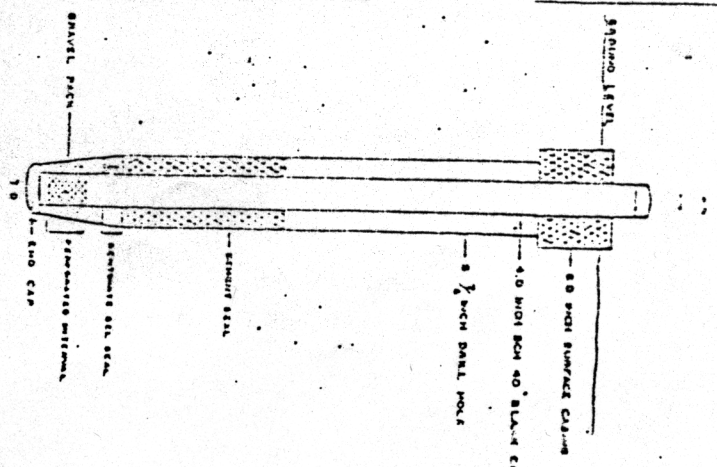
Elevation Saturated Thickness

Pump Installed Air Lift Installed

Pump Depth Air Lift to TD (Y or N)

Date Completed Hours Completed

COMPLETION DIAGRAM



WELL NAME (Kf83-9(b) Kf-9B

DATE 8/26/82
PAGE 1 OF 1

INTERVAL	WATER	LITHOLOGY	DESCRIPTION
			Same as 9c

1985 Reorganization
12-A-13

WELL COMPLETION REPORT

Well Name (Kf83-9(c) Kf-9c Mine Navajo

Location Area III

County San Juan State New Mexico

Driller Jim Gay

Formation Fruitland TD 2221' Zone 2

Drill Type Falling

Drilling Fluid Injection (water)

Logs

Hours Drilled

Completion Information

Casing Type 4" schedule 40

Casing Diameter

Perforated Casing 4" slotted

Blank Casing From 0 to 206

Surface Casing From to

Perforated Casing From 206 to 223

Gravel Pack From 204 to 223

Gel Seal From 202 to 204

Cement Bottom Seal From to

Cement Top Seal From to

Packers Used (Y or N) Centralizers Used (Y or N)

Initial Water Level

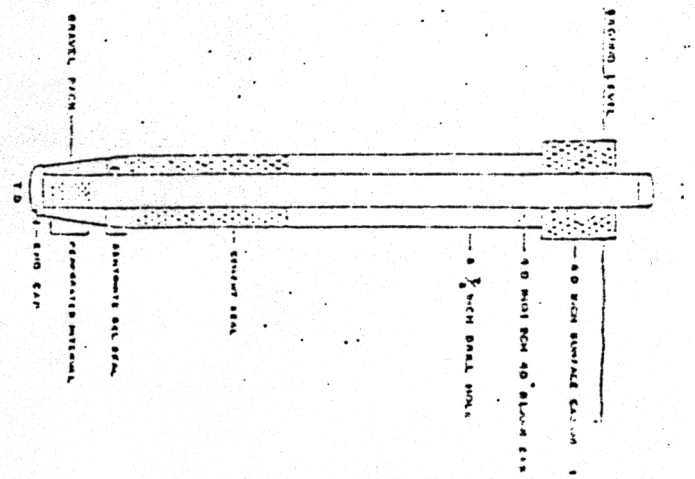
Elevation Saturated Thickness

Pump Installed Air Lift Installed

Pump Depth Air Lift to TD (Y or N)

Date Completed Hours Completed

COMPLETION DIAGRAM



L NAME (Kf83-9(c) Kf-9c

DATE 8 /26/83
PAGE 1 of 1

INTERVAL		WATER	LITHOLOGY	DESCRIPTION
0.0	3.0		Shale	Light Brown, Soft, Sandy
3.0	12.0		Shale	Gray, Clayey
12.0	24.0		Shale	Gray, Soft
24.0	25.0		Siltstone	Light Gray, Very Hard
25.0	87.0		Shale	Gray, Soft
87.0	88.0		Siltstone	Light Gray, Very Hard
88.0	97.0		Shale	Gray, Soft
97.0	108.0		Sandstone	Light Gray, Hard
108.0	110.0		Siltstone	Light Gray, Very Hard
110.0	116.0		Shale	Gray, Soft
116.0	128.9	12.0	Coal	
128.0	149.0		Shale	Gray, Soft
149.0	157.0	8.0	Coal	
157.0	163.0		Shale	Gray, Soft
163.0	166.0		Siltstone	Light Gray, Very Hard
166.0	170.0		Shale	Gray, Soft
170.0	175.0		Sandstone	Light Gray, Very Hard
175.0	178.0		Shale	Gray, Soft
178.0	182.0	4.0	Coal	
182.0	186.0		Shale	Gray, Soft
186.0	187.0	1.0	Coal	
187.0	189.0		Shale	Gray, Soft
189.0	199.0		Sandstone	Light Gray, Hard
199.0	203.0		Shale	Gray, Soft, Silty Band @ 191'
203.0	212.0	9.0	Coal	
212.0	227.0		Shale	Gray, Soft
				Note: Water from 203' to 233' depth in coal beds

WELL COMPLETION REPORT

Well Name (Kf83-10(a) Kf-10A

Location Area III South

County San Juan

Driller Jim Gay

Formation Fruitland

Drill Type Falling 1250 (Rotary)

Drilling Fluid Injection (water)

Logs

Hours Drilled

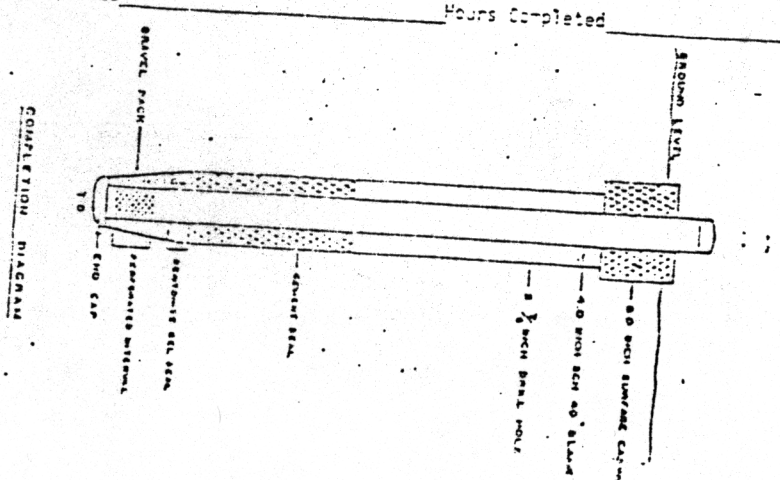
Mine Navajo

State New Mexico

TD 184 Seam 8A

Completion Information

Casing Type	4 " schedule 40 pvc		
Casing Diameter			
Perforated Casing	4 " slotted		
Blank Casing From	0	to	170
Surface Casing From		to	
Perforated Casing From	170	to	184
Gravel Pack From	170	to	184
Gel Seal From	165	to	170
Cement Bottom Seal From		to	
Cement Top Seal From		to	
Packers Used (Y or N)		Centralizers Used (Y or N)	
Initial Water Level			
Elevation		Saturated Thickness	
Pump Installed		Air Lift Installed	
Pump Depth		Air Lift to TD (Y or N)	
Date Completed		Hours Completed	



1985 Reorganization
12-A-16

WELL COMPLETION REPORT

Well Name (Kf83-11) Kf-11 Mine Navajo

Location North end Watson

County San Juan State New Mexico

Driller Jim V. Gay

Formation Kirtland/Fruitland TD 130

Drill Type Falling 1250 (Rotary)

Drilling Fluid H_2O (injected) with Foam.

Logs Lithology - Geophysical

Hours Drilled

Completion Information

Casing Type Schedule 40 PVC 4"

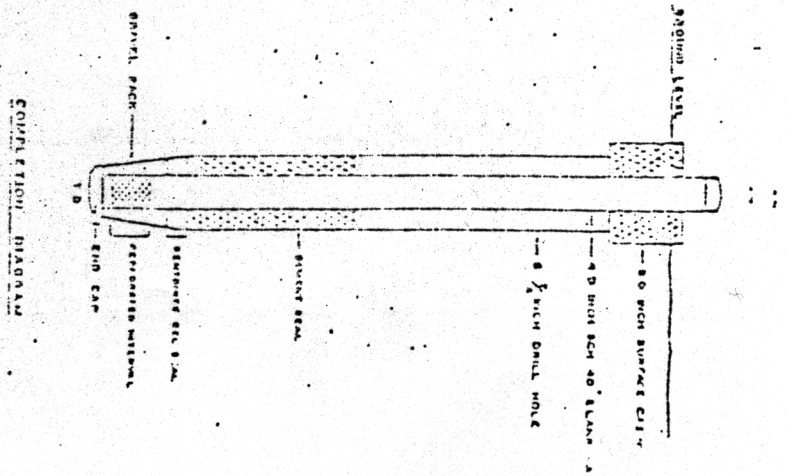
Casing Diameter 7-7/8" Drill Bit

Perforated Casing Schedule 40 4" PVC

Blank Casing From	0	to	86 88
Surface Casing From	0	to	7
Perforated Casing From	86	to	120
Gravel Pack From	77	to	120
Gel Seal From	73	to	77
Cement Bottom Seal From	77	to	7
Cement Top Seal From	30	to	73
Packers Used (Y or N)		Centralizers Used (Y or N)	
Initial Water Level	-0-		
Elevation		Saturated Thickness	
Pump Installed		Air Lift Installed	
Pump Depth		Air Lift to TD (Y or N)	

Date Completed 9-22-83 Hours Completed 84

COMPLETION DIAGRAM



WELL DRILLING REPORT

DATE 9-21-83
PAGE

WELL NAME (Kf83-11) Kf-11

INTERVAL		WATER	LITHOLOGY	DESCRIPTION
0.0	15.0		Alluvial	River sand, tan, medium grained.
15.0	31.0		Gravel	Pebbles with 14" boulders.
31.0	33.0		Shale	Carbonaceous, dark grav, weathered, oxidized.
33.0	37.0		Shale	Grav. soft, with brown streaks.
37.0	42.0		Clay	Tan, soft, (tonstein).
42.0	85.0		Shale	Grav, soft.
85.0	97.0	12.0	Coal	
97.0	100.0		Shale	Grav. soft.

WELL COMPLETION REPORT

Well Name (SJKF84-3) SJKF 84 No. 3

Location ¼SW ¼NW ¼NE Section 11 T29N, R15W

County San Juan

Mine Navajo

Driller Gay

State New Mexico

Formation Fruitland

TD 120

Drill Type Rotary

Drilling Fluid Air/H_2O/Mud

Logs Gamma-Gamma, Gamma-Density, Resistivity, Caliper, Lithology

Hours Drilled 12 4-17-84

Completion Information

Casing Type Sch 40 PVC

Casing Diameter 2.0 Inch ID

Perforated Casing 0.03 mm

Blank Casing From 000.0 to 098 (112-120)

Surface Casing From 000.0 to 126.0

Perforated Casing From 098.0 to 112.0

Gravel Pack From 095.0 to 120.0

Gel Seal From 092.0 to 096.0

Cement Bottom Seal From 000.0 to 092.0

Cement Top Seal From - to -

Packers Used (Y or N) N Centralizers Used (Y or N) N

Initial Water Level 9.34

Elevation 5,110.18 Saturated Thickness 14

Pump Installed N Air Lift Installed Y

Pump Depth Air Lift to TD (Y or N) Y

Date Completed 4-18-84 Hours Completed 3

(SJKF84-3)

WELL COMPLETION REPORT

Interval	Water	Lithology	Description
000 to 020	Mud	Spud	Al, SD, Gravel @ 10 Ft.
020 to 025	Bl.Mud	Gravel	- to 26 Ft., St Surf. Csng - 8.0 Inch
025 to 030	Inj H_2O	SH	BCarb, w/Coal Str
030 to 035		AA	
035 to 036		Coal	
036 to 037		Coal	
037 to 038		Coal	
038 to 039		Coa	SHY
039 to 040		Sh	VCarb, Gry
040 to 045		AA	
045 to 050		AA	
050 to 055		AA	SD L 10%
055 to 060		AA	Slts
060 to 065		AA	Incr. Slts
065 to 070		SLTS	Vshy, Calc, Scarb
070 to 075		AA	Carb
075 to 080		AA	
080 to 085		AA	Carb
085 to 090		AA	
090 to 095		SH	VCarb
095 to 100		AA	Incr. Carb to Coal Str
100 to 101		Coal	
101 to 102		Coal	
102 to 103		Coal	
103 to 104		Coal	
104 to 105		Coal	
105 to 106		Coal	
106 to 107		Coal	
107 to 108		Coal	
108 to 109		Coal	
109 to 110		Coal	
110 to 111		Coal	
111 to 112		Coal	SHY
112 to 115		SH	VCarb, Gry
115 to 120		AA	Carb
		TD	4-17-84

WELL COMPLETION REPORT

Well Name (SJKF84-2) SJKF 84 No. 2

Location ½SW ¼SW ¼SW Section 2 T29N, R15W

County San Juan Mine Navajo

Driller Gay State New Mexico

Formation Fruitland TD 144.0

Drill Type Rotary

Drilling Fluid Air/H_2O/MUD

Logs Gamma-Gamma, Gamma-Density, Resistivity, Caliper, Litho

Hours Drilled 10½ 4-16-84

Completion Information

Casing Type Sch 40 PVC

Casing Diameter 2.0 Inch ID

Perforated Casing 0.03 mm

Blank Casing From 000 to 124.0

Surface Casing From - to -

Perforated Casing From 124.0 to 144.0

Gravel Pack From 122.0 to 144.0

Gel Seal From 118.0 to 122.0

Cement Bottom Seal From 000.0 to 118.0

Cement Top Seal From PAD to -

Packers Used (Y or N) N Centralizers Used (Y or N) N

Initial Water Level 20.27

Elevation 6,129.22 Saturated Thickness 18.5

Pump Installed N Air Lift Installed Y

Pump Depth Air Lift to TD (Y or N) Y

Date Completed 4-17-84 Hours Completed 3

WELL COMPLETION REPORT

(SJKF84-2)

Interval	Water	Lithology	Description
000 to 020		SPUD	Col, All, Gravel @ 14 Feet
020 to 025		GSD	VFG, All
025 to 030		AA	Gravels @ 27 Feet DR LO 1 Ft/n
030 to 035		Gravel	Cobble
035 to 040		SD	VFG, Col, Qal, Incr. Dr, SSHY
040 to 050		SH	SHY, VCarb
050 to 055		AA	
055 to 060		AA	Carb, SD L10%
060 to 065		AA	
065 to 070		AA	SCarb
070 to 075		AA	
075 to 080		AA	
080 to 085		AA	
085 to 090		AA	Incr. Carb
090 to 095		Coal	VSHY, BNY
095 to 100		SH	VCarb to Carb
100 to 105		AA	
105 to 110		AA	SD Incre 05%
110 to 115		AA	Incr. SD
115 to 120		AA	Carb
120 to 125		AA	V Carb, Coal Str
125 to 130		AA	Incr. Coal Str
130 to 135		SH	VCarb
135 to 136		Coal	
136 to 137		Coal	
137 to 138		Coal	
138 to 139		Coal	
139 to 140		Coal	
140 to 141		Coal	
141 to 145		SH	VCarb
		TD	4-16-84

Circulate with clear water to TD

WELL COMPLETION REPORT

Well Name (SJKF84-1) SJKF 84 No. 1

Location ½SW ¼NE ¼SE Section T39N. R15W

County San Juan Mine Navajo

Driller Gav State New Mexico

Formation Fruitland TD 140.0

Drill Type Rotary

Drilling Fluid Air/H_2O/Mud

Logs Litho

Hours Drilled 12½. 4-10 to 4-11. 1984

Completion Information Plugged to Surface

Casing Type

Casing Diameter

Perforated Casing

Blank Casing From to

Surface Casing From to

Perforated Casing From to

Gravel Pack From to

Gel Seal From to

Cement Bottom Seal From to

Cement Top Seal From to

Packers Used (Y or N) Centralizers Used (Y or N)

Initial Water Level

Elevation Saturated Thickness

Pump Installed Air Lift Installed

Pump Depth Air Lift to TD (Y or N)

Date Completed Hours Completed

WELL COMPLETION REPORT

(SJKF84-1)

Interval	Water	Lithology	Description
000 to 020	MUD	SPUD	Col, Qal, Gravel, Cobble, SH
020 to 025		ALL	FG, BRN
025 to 030		GRAVEL	Cobble, poss, H_2O Incr. GPM
030 to 035		AA	
035 to 040		AA	
040 to 045		AA	Incr. Cobble, NO H_2O
045 to 050		AA	
050 to 055		AA	
055 to 060		SD	S-P, VFG, Carb, Incr. DR
060 to 065		AA	
065 to 070		AA	Incr. Carb
070 to 075		AA	
075 to 080		AA	Incr. DR
080 to 085		AA	
085 to 090		AA	
090 to 095		AA	
095 to 100		AA	EOD 4-10-84
100 to 105		AA	
105 to 110		AA	
110 to 115		AA	
115 to 120		AA	
120 to 125		AA	
125 to 130		AA	
130 to 135		AA	
135 to 140		AA	TD

Set 15-Pound cement plug 000 - 140 from bottom coal seam not present.

WELL COMPLETION REPORT

Well Name (KF84-22(a) Kf8422 No. 8

Location Area IV, Cottonwood Arroyo, East of Burnham Road , N2009510.05, E307822.16

County San Juan Mine Navajo

Driller Gay State New Mexico

Formation Fruitland TD 125

Drill Type Rotary

Drilling Fluid Air

Logs Gamma-Gamma, Gamma-Density, Resistivity, Caliper, Litho.

Hours Drilled 1½

Completion Information

Casing Type Sch 40 PVC

Casing Diameter 2.0 inch ID

Perforated Casing 0.03 mm

Blank Casing From 000.0 to 090.0

Surface Casing From - to -

Perforated Casing From 090.0 to 125.0

Gravel Pack From 085.0 to 125.0

Gel Seal From 082.0 to 085.0

Cement Bottom Seal From 000.0 to 082.0

Cement Top Seal From - to -

Packers Used (Y or N) N Centralizers Used (Y or N) N

Initial Water Level 77.57

Elevation 5343.90 Saturated Thickness 24

Pump Installed Air Lift Installed Y

Pump Depth N Air Lift to TD (Y or N) Y

Date Completed 4-27-84 Hours Completed 1½

WELL COMPLETION REPORT

Well Name (KF84-22(b) Kf8422, No. 7

Location Area IV, Cottonwood Arroyo, East of Burnham Road , N2009513.79, E307829.36

County San Juan Mine Navajo

Driller Gav State New Mexico

Formation Fruitland TD 140

Drill Type Rotary

Drilling Fluid Air

Logs Gamma-Gamma, Gamma-Density, Resistivity, Caliper, Litho.

Hours Drilled 2 4-26-84

Completion Information

Casing Type Sch 40 PVC

Casing Diameter 2.0 inch Id

Perforated Casing 0.03 mm

Blank Casing From 000.0 to 134.0

Surface Casing From - to -

Perforated Casing From 134.0 to 140.0

Gravel Pack From 132.0 to 140.0

Gel Seal From 139.0 to 132.0

Cement Bottom Seal From 054.0 to 129.0

Cement Top Seal From 000.0 to 005.0

Packers Used (Y or N) N Centralizers Used (Y or N) N

Initial Water Level 79.06

Elevation 5344.10 Saturated Thickness 6.0

Pump Installed N Air Lift Installed Y

Pump Depth Air Lift to TD (Y or N) Y

Date Completed 4-25-84 Hours Completed 2

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WELL COMPLETION REPORT

Well Name (KF84-22(c) Kf8422, No. 4

Location Area IV, Cottonwood Arroyo, East Burnham Road ,N2009528.55,E307841.20

County San Juan Mine Navajo

Driller Gay State New Mexico

Formation Fruitland TD 2.02

Drill Type Rotary

Drilling Fluid Air

Logs Gamma-Gamma, Gamma-Density, Resistivity, Caliper, Litho. (Same as KFS422,NO.2)

Hours Drilled 2½

Completion Information

Casing Type Sch 40 PVC

Casing Diameter 2.0 inch Id

Perforated Casing 0.03 mm

Blank Casing From 000.0 to 197.0

Surface Casing From - to -

Perforated Casing From 197.0 to 202.0

Gravel Pack From 195.0 to 202.0

Gel Seal From 193.0 to 195.0

Cement Bottom Seal From 118.0 to 193.0

Cement Top Seal From 000.0 to 005.0

Packers Used (Y or N) N Centralizers Used (Y or N) N

Initial Water Level 89.42

Elevation 5344.60 Saturated Thickness 5.0

Pump Installed N Air Lift Installed Y

Pump Depth Air Lift to TD (Y or N) Y

Date Completed 4-26-84 Hours Completed 2½

WELL COMPLETION REPORT

Well Name (KF84-22(d) Kf8422, No. 3

Location Area IV, Cottonwood Arroyo, East of Burnham Road N2009525.42.E307832.96

County San Juan Mine Navajo

Driller Gay State New Mexico

Formation Fruitland TD 220

Drill Type Rotary

Drilling Fluid Air

Logs Gamma-Gamma, Gamma-Density, Resistivity, Caliper, Litho. (Same as KF8422 No.2)

Hours Drilled 2½

Completion Information

Casing Type Sch 40 PVC

Casing Diameter 2.0 inch Id

Perforated Casing 0.03 mm

Blank Casing From 000.0 to 213.0

Surface Casing From - to -

Perforated Casing From 213.0 to 220.0

Gravel Pack From 211.0 to 220.0

Gel Seal From 208.0 to 211.0

Cement Bottom Seal From 133.0 to 208.0

Cement Top Seal From 000.0 to 005.0

Packers Used (Y or N) N Centralizers Used (Y or N) N

Initial Water Level

Elevation Saturated Thickness 7

Pump Installed N Air Lift Installed v

Pump Depth Air Lift to TD (Y or N) Y

Date Completed 4-24-84 Hours Completed 2

WELL COMPLETION REPORT

Well Name (KF84-22(e) Kf8422, No. 2

Location Area IIV, Cottonwood Arroyo, East Burnham Road , N2009531.93, E307820.38

County San Juan Mine Navajo

Driller Gay State New Mexico

Formation Fruitland TD 237

Drill Type Rotary

Drilling Fluid Air

Logs Gamma-Gamma, Gamma-Density, Resistance, Caliper, Litho

Hours Drilled 4

Completion Information

Casing Type Sch 40 PVC

Casing Diameter 2.0 inch Id

Perforated Casing 0.03 mm

Blank Casing From 000.0 to 227.0

Surface Casing From - to -

Perforated Casing From 227.0 to 237.0

Gravel Pack From 225.0 to 237.0

Gel Seal From 222.0 to 225.0

Cement Bottom Seal From 147.0 to 222.0

Cement Top Seal From 000.0 to 005.0

Packers Used (Y or N) N Centralizers Used (Y or N) N

Initial Water Level 98.18

Elevation 53.44.80 Saturated Thickness 10.0

Pump Installed N Air Lift Installed Y

Pump Depth Air Lift to TD (Y or N) Y

Date Completed 4-23-84 Hours Completed 3

WELL COMPLETION REPORT

KF84-22(e)

Interval	Water	Lithology	Description
000 to 020		SPud	Cal, Shale, Brn, Sdy
020 to 025		Sh	Gry, SCarb
025 to 030		Slts	Shy, SCarb
030 to 035		AA	
035 to 040		AA	
040 to 045		AA	
045 to 050		SH	VSdy, Carb
050 to 055		AA	
055 to 060		AA	
060 to 065		AA	
065 to 070		AA	
070 to 075		SH	Carb
075 to 080		SH	VCarb, So Incr. 10%, Gry
080 to 085		AA	
085 to 090		AA	
090 to 095		Coal	
095 to 100		Coal	(No. 8B)
100 to 105		Coal	
105 to 110		SH	SCarb, Prt
110 to 115		Coal	
115 to 120		Coal	(No. 3A)
120 to 125		Coal	
125 to 130		SH	VCarb
135 to 140		Coal	(No. 7)
140 to 145		SH	VCarb, Coal Str
145 to 150		SH	Slts, VCarb
150 to 155		AA	Coal Str (1½ Ft)(No. 6)
155 to 160		Sh	VCarb, Gry
160 to 165		AA	w/ S Coal Str
165 to 170		AA	w/o Coal Str, VCarb
170 to 175		AA	VCarb
175 to 180		SD	VFG, S-P
180 to 185		SD	FMG, S-P, Fe Stn; Fr
185 to 190		SD	MG, Gloc, FR, Fe Stn
190 to 195		AA	Shy
195 to 200		SH	SSdy Incr. 10%, Blk
200 to 203		SS	Incre Carb
203 to 204		Coal	VShy

KF84-22(e)

WELL COMPLETION REPORT

Interval	Water	Lithology	Description
204 to 205		Coal	VShy
205 to 206		Coal SShy	
206 to 207		Coal Slty	
207 to 208		Coal Slty	
208 to 209		Coal	
209 to 210		Coal	
210 to 211		Coal	
211 to 213		Coal	
213 to 214		Coal	
214 to 215		Coal	
215 to 216		Coal	
216 to 217		Coal	
217 to 218		Coal	
218 to 219		Caol	Shy
219 to 220		Coal	Shy
220 to 225		SD	FG, S-P, Fe Stn
225 to 227		Coal	VShy
227 to 230		SH	VCarb, W/S Coal Str
230 to 231		Coal	
231 to 232		Coal	
232 to 233		Coal	(No. 2)
233 to 234		Coal	
234 to 235		Coal	
235 to 236		Coal	
236 to 237		SH	VCarb, Td

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WELL COMPLETION REPORT

Well Name (Kf84-21(a) Kf 8421 No. 7

Location South Area III, Cottonwood Arroyo W. Burnham Road

County San Juan Mine Navajo

Driller Gav State New Mexico

Formation Fruitland TD 75

Drill Type Rotary

Drilling Fluid Air

Logs Gamma-Gamma, Gamma-Density, Resistivity, Cal, Litho (all as 384-05)

Hours Drilled 1

Completion Information

Casing Type Sch 40 PVC

Casing Diameter 2.0 Inch ID

Perforated Casing 0.03 mm

Blank Casing From 000.0 to 069.0

Surface Casing From - to -

Perforated Casing From 069.0 to 075.0

Gravel Pack From 067.0 to 075.0

Gel Seal From 065.0 to 067.0

Cement Bottom Seal From 000.0 to 065.0

Cement Top Seal From - to -

Packers Used (Y or N) N Centralizers Used (Y or N) Y

Initial Water Level 36.02

Elevation 5297.21 Saturated Thickness 6.5

Pump Installed N Air Lift Installed N

Pump Depth ___ Air Lift to TD (Y or N) Y

Date Completed 4-27-84 Hours Completed Y

WELL COMPLETION REPORT

(KF84-21(a)

Interval	Water	Lithology	Description
			4-27-84 and 3-28-84
			Log as Development Drill Site 384-05

WELL COMPLETION REPORT

Well Name (Kf84-21(b) Kf84 21 No. 4

Location South Area III, CTW Arr W. Burnham Road , N.2009864.48, E.300983.33

County San Juan Mine Navajo

Driller Gay State New Mexico

Formation Fruitland TD 95.5 (170.0)

Drill Type Rotary

Drilling Fluid Air

Logs Lithology, Gamma-Gamma, Gamma-Density, Caliper

Hours Drilled 2½/Set Cement Plug 3-8-84

Completion Information

Casing Type Sch 40 PVC

Casing Diameter 2.0 Inch ID

Perforated Casing 0.03mm

Blank Casing From 000.00 to 083.0

Surface Casing From - to -

Perforated Casing From 083.0 to 095.5

Gravel Pack From 080.0 to 095.5

Gel Seal From 077.0 to 080.0

Cement Bottom Seal From 000.00 to 077.0 (095.5 to 170.0)

Cement Top Seal From - to -

Packers Used (Y or N) N Centralizers Used (Y or N) N

Initial Water Level 46.48

Elevation 5292.97 Saturated Thickness 7

Pump Installed N Air Lift Installed Y

Pump Depth Air Lift to TD (Y or N) Y

Date Completed 3-10-84 Hours Completed 2½

WELL COMPLETION REPORT

(Kf84-21(b)

Interval	Water	Lithology	Description
000 to 020	Dry	Spud	Coal, (8B) Col, Carb Shale
	Dry		Hvy H_2S Coal at 16 ft - 18 ft
	Dry		PR (8A) Pr 1 ft 119-20 Coal
020 to 021		Coal	
021 to 025		SH	Gry, Sslty, SCarb
025 to 030		SH	VCarb, Gry.
030 to 031		Coal	
032 to 033		Coal	
033 to 034		Coal	
034 to 035		Coal	
035 to 040		SH	Gry, SCarb, SSlty
040 to 045		AA	
045 to 050		SD	Slty, Carb, SHL 30%
050 to 055		SH	Incr. Carb, Na NOD
055 to 060		AA	
060 to 064		AA	Incr. Carb.
064 to 065	Wet		
065 to 066			
066 to 067			
067 to 068			
068 to 069		SH	VCarb
069 to 070		AA	Incr. Slts, Incr. Carb
070 to 075		AA	Carb, SSlty
075 to 080	Damp	AA	
080 to 082		AA	Incr. Carb
082 to 083		Coal	
083 to 084		Coal	
084 to 085		Coal	
085 to 086		Coal	
086 to 087		Coal	
087 to 088		Coal	
088 to 089	↑ H_2O	SH	VSdy, NA NOD
089 to 090		AA	
090 to 100		SD	VShy, Na NOD
100 to 102	INS	AA	Incr. Carb
102 to 103		Coal	
103 to 104		Coal	

WELL COMPLETION REPORT

(Kf84-21(b)

Interval	Water	Lithology	Description
104 to 105		Coal	
105 to 106		Coal	
106 to 107		Coal	
107 to 108		Coal	
108 to 109		Coal	
109 to 110		Coal	
110 to 111		Coal	
111 to 112		Coal	
112 to 113		Coal	Incr. SH
113 to 114		AA	
114 to 115		SH	VCarb
115 to 120		AA	Carb
120 to 122		AA	
122 to 123		Coal	
123 to 124		Coal	
124 to 125		SH	VSdy, Carb
125 to 130		AA	VCarb
130 to 135	SH	SH	Slty, SCarb
135 to 140		AA	
140 to 145		AA	SDY-S-P
145 to 150		SD	S-P, VFG, SLTY
150 to 155		AA	
155 to 160		AA	
160 to 165		AA	
165 to 170		AA	TD

Set 15 Pound cement plug 75.0 - 170.0
Ream to 95.5

WELL COMPLETION REPORT

Well Name (Kf84-21(c) Kf 84 21 No. 2 - No. 3

Location South Area III, Cottonwood Arroyo, West Burnham Road

County San Juan Mine Navajo

Driller Gay State New Mexico

Formation Fruitland TD 118

Drill Type Rotary

Drilling Fluid Air

Logs Cored - (Same as Kf 84 21 No. 4)

Hours Drilled 3¼ 3-10-84

Completion Information

Casing Type Sch 40 PUC

Casing Diameter 2.0 Inch ID

Perforated Casing 0.03 mm

Blank Casing From 000.00 to 108.0

Surface Casing From - to -

Perforated Casing From 108.0 to 118.0

Gravel Pack From 106.0 to 118.0

Gel Seal From 103. to 106.0

Cement Bottom Seal From 000.0 to 102.0

Cement Top Seal From - to -

Packers Used (Y or N) N Centralizers Used (Y or N) N

Initial Water Level 49.74

Elevation 5228.80 Saturated Thickness 11

Pump Installed N Air Lift Installed Y

Pump Depth Air Lift to TD (Y or N) Y

Date Completed 3-9-84 Hours Completed 3

WELL COMPLETION REPORT

Well Name (Kf84-20(a) Kf 8420 No. 7

Location Lease Line Lowe Pit East. Area III.N2017093.50,E304310.70

County San Juan Mine Navajo

Driller Gay State New Mexico

Formation Fruitland TD 1.90

Drill Type Rotary

Drilling Fluid Air

Logs Gamma-Gamma, Gamma-Density, Caliper (Litho. fr. Kf83, No. 9)

Hours Drilled 1.75 3-7-84

Completion Information

Casing Type Sch 40 PVC

Casing Diameter 2.0 inch ID

Perforated Casing 0.03 mm

Blank Casing From 000.00 to 178.5

Surface Casing From - to -

Perforated Casing From 178.5 to 190.0

Gravel Pack From 176.0 to 190

Gel Seal From 173.0 to 176.0

Cement Bottom Seal From 98.0 to 173

Cement Top Seal From 000.0 to 005.0

Packers Used (Y or N) N Centralizers Used (Y or N) N

Initial Water Level 140.05

Elevation 5402.06 Saturated Thickness 8.0

Pump Installed N Air Lift Installed Y

Pump Depth ___ Air Lift to TD (Y or N) Y

Date Completed 6-7-84 Hours Completed 2

WELL COMPLETION REPORT

(Kf84-20(a)

Interval	Water	Lithology	Description
			Log as Kf83, No. 9

3-7-34

WELL COMPLETION REPORT

Well Name (Kf84-20(b) Kf 8420 No. 4

Location Leaseline Lowe Pit East, Area III ,N2017114.83, E304319.22

County San Juan Mine Navajo

Driller Gay State New Mexico

Formation Fruitland TD 215.5

Drill Type Rotary

Drilling Fluid Air

Logs All from Kf83 No. 9

Hours Drilled 2½ 3-7-84

Completion Information

Casing Type Sch 40 PVC

Casing Diameter 2.0 inch ID

Perforated Casing 0.03 mm

Blank Casing From 000.0 to 206.0

Surface Casing From - to -

Perforated Casing From 206.0 to 215.5

Gravel Pack From 204.0 to 215.5

Gel Seal From 200.0 to 204.0

Cement Bottom Seal From 125.0 to 200.0

Cement Top Seal From 000.0 to 005.0

Packers Used (Y or N) N Centralizers Used (Y or N) N

Initial Water Level 91.77

Elevation 5402.02 Saturated Thickness 9½

Pump Installed N Air Lift Installed Y

Pump Depth Air Lift to TD (Y or N) Y

Date Completed 3-7-84 Hours Completed 3½

WELL COMPLETION REPORT

(Kf84-20(b)

Interval	Water	Lithology	Description
Log as Kf84 No. 9			Damp at 180 Ft, No. 7

WELL COMPLETION REPORT

Well Name (Kf84-20(c) Kf 8420 No. 3

Location Lease line Lowe Pit East, Area III , N2017120.64, E304307.65

County San Juan Mine Navajo

Driller Gay State New Mexico

Formation Fruitland TD 240.0

Drill Type Rotary

Drilling Fluid Air

Logs Gamma-Gamma, Gamma-Density, Resistivity, Caliper

Hours Drilled 2½

Completion Information

Casing Type Sch 40 PVC

Casing Diameter 2.0 Inch ID

Perforated Casing 0.03 mm

Blank Casing From 000.0 to 221.0 (236.0 - 240.0)

Surface Casing From - to -

Perforated Casing From 221.0 to 236.0

Gravel Pack From 219.0 to 240.0

Gel Seal From 215.0 to 219.0

Cement Bottom Seal From 140.0 to 215.0

Cement Top Seal From 000.0 to 005.0

Packers Used (Y or N) N Centralizers Used (Y or N) N

Initial Water Level 154.57

Elevation 5401.78 Saturated Thickness 15

Pump Installed N Air Lift Installed Y

Pump Depth N Air Lift to TD (Y or N) Y

Date Completed 3-6-84 Hours Completed 2

WELL COMPLETION REPORT

(Kf84-20(c)

Interval	Water	Lithology	Description
			Log as Kf83 No. 9 8-19-84

WELL COMPLETION REPORT

Well Name (Kf84-18(a) Kf84 18 No. 8

Location SE Yazzie Highwall, Area II, N2050168.70, E318919.71

County San Juan Mine Navajo

Driller Gay State New Mexico

Formation Fruitland TD 133.0

Drill Type Rotary

Drilling Fluid Air

Logs Lithology, Gamma-Gamma, Gamma-Density, Resistivity, Cal-(all as Kf8418 No.6)

Hours Drilled 1 5-1-84

Completion Information

Casing Type Sch 40 PVC

Casing Diameter 2.0 Inch ID

Perforated Casing 0.03 mm

Blank Casing From 000 to 119

Surface Casing From - to -

Perforated Casing From 119.0 to 133.0

Gravel Pack From 117.0 to 133.0

Gel Seal From 114.0 to 117.0

Cement Bottom Seal From 000.0 to 114.0

Cement Top Seal From - to -

Packers Used (Y or N) N Centralizers Used (Y or N) N

Initial Water Level 112.25

Elevation 5320.99 Saturated Thickness 14.0

Pump Installed N Air Lift Installed Y

Pump Depth ___ Air Lift to TD (Y or N) Y

Date Completed 5-1-84 Hours Completed 2

WELL COMPLETION REPORT

(Kf84-18(a)

Interval	Water	Lithology	Description
000 to 020		Spud	Col, Al, shale, brn
	Log as Kf 84 18 No. 6		
020 to 133		TD	

WELL COMPLETION REPORT

Well Name (Kf84-18(b) Kf8418 No. 6

Location SE Yazzie Highwall, Area II, N2050160.79, E318937.36

County San Juan Mine Navajo

Driller Gay State New Mexico

Formation Fruitland TD 181

Drill Type Rotary

Drilling Fluid Air

Logs Gamma - Gamma, Gamma Density, Resistance, Caliper, Lithology

Hours Drilled 1.75 5-1-84

Completion Information

Casing Type Sch 40 PVC

Casing Diameter 2.0 Inch ID

Perforated Casing 0.30 mm

Blank Casing From 000.0 to 150.0

Surface Casing From - to -

Perforated Casing From 150.0 to 181.0

Gravel Pack From 148.0 to 181.0

Gel Seal From 145.0 to 148.0

Cement Bottom Seal From 071.0 to 145.0

Cement Top Seal From 000.0 to 005.0

Packers Used (Y or N) N Centralizers Used (Y or N) N

Initial Water Level 105 Bgs

Elevation 5321.07 Saturated Thickness Var. Nos. 7,6,5

Pump Installed N Air Lift Installed Y

Pump Depth Air Lift to TD (Y or N) Y

Date Completed 5-1-84 Hours Completed 2½

WELL COMPLETION REPORT

(Kf84-18(b)

Interval		Water	Lithology	Description
000 to	020	Dry	Spud	Al, Col, Shale Brn at 10 ft.
020 to	025	Dry	Sh	Gry, Carb
025 to	030		AA	
030 to	035		AA	DECR Carb, silty
035 to	040		SD	VFG, Silty, Calc NOD, S Carb
040 to	045		SH	SD DECR 10% Carb
045 to	050		SH	Gry, S Carb
050 to	055		AA	
055 to	060		AA	Carb
060 to	065		AA	V Carb
065 to	070		AA	
070 to	075		AA	S Carb
075 to	080		AA	
080 to	085	Dry	AA	DECR Carb
085 to	090		AA	S Silty
090 to	095		AA	
095 to	100		AA	S Carb
100 to	105		SLTS	S Carb
105 to	110		SH	S Carb
110 to	115		SLTS	S Silty, Carb
115 to	118		SH	V Carb, Gry to Brn
118 to	119	Dry	COAL	
119 to	120		COAL	
120 to	121		SH	V Carb
121 to	122		AA	
122 to	123		AA	

WELL COMPLETION REPORT

(Kf84-18(b)

Interval	Water	Lithology	Description
123 to 124		COAL	Brn
124 to 125		COAL	
125 to 126		COAL	
126 to 127	Damp	COAL	
127 to 128	Damp	COAL	
128 to 129	Damp	COAL	
129 to 130	Damp	COAL	
130 to 131		COAL	Bny
131 to 132	Dry	SH	V Carb
132 to 135		AA	
135 to 140		AA	Gry
140 to 145		AA	
145 to 150		AA	
150 to 153	Dry	AA	INCR Carb
153 to 154		COAL	
154 to 155		COAL	
155 to 156	Damp	COAL	Shy
156 to 157		SH	Carb
157 to 160	Ins.	AA	V Carb
160 to 161		COAL	
161 to 162		COAL	
162 to 165		SH	V Carb
165 to 168		AA	
168 to 169		COAL	
169 to 170		COAL	

WELL COMPLETION REPORT

(Kf84-18(b)

Interval		Water	Lithology	Description
170 to	171		COAL	
171 to	175		SH	
175 to	180		AA	Sdy, S Carb
		TD		5-1-84

WELL COMPLETION REPORT

Well Name (Kf84-17) Kf 84 No. 17

Location NAPI , N2068744.9, E327371.48

County San Juan Mine Navajo

Driller Gay State New Mexico

Formation Fruitland TD 310.0

Drill Type Rotary

Drilling Fluid Air

Logs Gamma-Gamma, G-D Res, Ltho Cal

Hours Drilled 4 5-22-84/5-23-84

Completion Information

Casing Type Sch 40 PVC

Casing Diameter 2.0 Inch ID

Perforated Casing .03 mm

Blank Casing From 000 to 276.0

Surface Casing From - to -

Perforated Casing From 276.0 to 310.0

Gravel Pack From 274.0 to 310.0

Gel Seal From 270.0 to 274.0

Cement Bottom Seal From 195.0 to 270.0

Cement Top Seal From 000.0 to 005.0

Packers Used (Y or N) N Centralizers Used (Y or N) N

Initial Water Level 242.00

Elevation 5419.21 Saturated Thickness 23

Pump Installed N Air Lift Installed Y

Pump Depth Air Lift to TD (Y or N) Y

Date Completed 5-23-84 Hours Completed 2

WELL COMPLETION REPORT

(Kf84-17) Interval	Water	Lithology	Description
000 to 020	Ins.	SPUD	QA, Col, Lny Bla, Bln, QA,Col,WN BLN,BRN Sh @ 15 Ft, SHVCarb @ 18 Ft Brn, Fe Str, Gyps
020 to 025	DU	SH	Brn
025 to 030			SH GRR, Carb, Fe Stn
030 to 035		AA	BRN, SCarb
035 to 045		AA	Gry, SSlty
045 to 050		AA	Slty
050 to 055		Slts	Gry
Off to 060		SH	Slty,Gry
060 to 075		AA	
075 to 080		SH	Gry, Carb
080 to 085		AA	
085 to 090		AA	
090 to 095		AA	SCarb
095 to 100		AA	
100 to 105		AA	Incr. Carb
105 to 110		AA	
110 to 115		AA	
115 to 120		AA	
120 to 125		AA	
125 to 130		AA	
130 to 135		AA	
135 to 140		AA	Decr. Carb
140 to 145		AA	
145 to 150		AA	SCarb
150 to 155		AA	
155 to 160		AA	
160 to 165		AA	Carb
170 to 175		AA	
175 to 180		AA	
180 to 185		SH	Gry, VCarb
185 to 190		AA	
190 to 195		AA	Carb
195 to 200		AA	SCarb SSlty
200 to 205		AA	
205 to 210		AA	
210 to 215		AA	

WELL COMPLETION REPORT

(Kf84-17)

Interval	Water	Lithology	Description
215 to 220		AA	
220 to 225		AA	
225 to 230		AA	
230 to 235		AA	Carb
235 to 040		AA	
240 to 245		AA	
245 to 250		AA	
250 to 255		AA	
255 to 260		AA	
260 to 265		AA	
265 to 270		AA	
270 to 275		AA	
275 to 276	Dry	Coal	Bay
276 to 277		Coal	
277 to 278		Coal	Bay
278 to 279		Coal	
279 to 280		Coal	
280 to 281		Coal	
281 to 282		Coal	
282 to 285		SH	VCarb, Gry
285 to 290		SH	VCarb, Gry
290 to 295		Coal	
295 to 300		Coal	
300 to 305		Coal	
305 to 310		Coal	
310 to 315		Coal	
315 to 320		SH	VCarb
320 to 325		SH	Gry, SSlty
325 to 330		AA	
330 to 335		AA	
335 to 340		AA	Decr. Slty, SCarb
340 to 345		AA	
345 to 350		AA	
355 to 360		AA	
360 to 365		AA	
365 to 370		AA	
370 to 375		AA	

WELL COMPLETION REPORT

(Kf84-17) Interval	Water	Lithology	Description
375 to 380		AA	
380 to 400			Set plug to 380, Rean 6¼ to 310.0
			Set Casng 5-23-84

Appendix 18.R

(Copy of 1989 Appendix 12B)

Pictured Cliff and Alluvial

Water Quality Records

APPENDIX 12B

PICTURED CLIFF AND ALLUVIAL

WATER QUALITY RECORDS

WELL NO.: [redacted] GM-18 [redacted] 1985 Reorganization

LOCATION: Mouth of Cottonwood, Downstream

FORMATION: Alluvium

TOTAL DEPTH: Navajo Well

COMMENTS: 12-3-1

SAMPLED:	09/10/79	12/27/79	03/27/80
** Parameter:			
pH	-	-	-
Na	-	-	-
Ca	-	-	-
Mg	-	-	20.2
SO_4	1193.0	1260	1135
Cl	29.7	26.1	28.4
TDS	210.5	2135	2020
Al	0.35	0.15	0.18
As	0.0002	0.4	0.0002
Ba	0.04	0.03	0.02
B	0.11	-	0.01
Cd	<0.01	<0.001	<0.02
Cr total	0.01	0.01	0.02
Co	<0.01	0.02	0.02
Cu	<0.01	<0.005	<0.01
F	2.20	2.2	2.0
Fe	<0.01	0.1	0.04
K	-	-	-
Pb	0.09	<0.001	0.01
Mn	<0.01	0.01	0.02
Mo	0.02	0.03	0.03
Ni	<0.01	<0.005	<0.01
Se	0.001	0.0005	0.0008
Ag	<0.01	0.01	<0.01
Zn	<0.01	0.12	<0.01
NO_3 as N	0.85	<0.01	0.02
PO_4	-	-	-
U_3O_8	0.009	0.011	0.008
Fe^{tot}	0.01	-	0.02
Mn^{tot}	0.01	-	0.02
Hg^{tot}	0.00019	-	<0.000002
Temp. °C			
Conductivity (umhos/cm)			
Water Level (Ft. below LSD			
Cation/Anion Balance			

WELL NO.: GM-9 [redacted] COMMENTS: 1985 Reorganization 12-3-2

LOCATION: Eastside of the Mine, Upstream Chinde

FORMATION: Alluvium

TOTAL DEPTH: 20'

SAMPLED:	09/10/79	03/27/80	09/23/80
** Parameter:			
pH	--	--	--
Na	--	--	--
Ca	--	--	--
Mg	--	--	44
SO_4	5440.	6565	440
Cl	227.	211	218
TDS	9235.	10060	830
Al	0.68	0.57	0.09
As	0.0008	0.0005	0.0008
Ba	0.26	--	0.14
B	0.51	0.3	0.11
Cd	<0.01	<0.01	<0.001
Cr total	0.04	0.03	0.004
Co	<0.01	0.02	<0.01
Cu	0.12	0.02	<0.01
F	1.60	1.8	1.38
Fe	0.04	0.06	46
K	--	--	--
Pb	0.43	0.03	0.014
Mn	0.06	1.02	0.19
Mo	0.07	0.08	0.03
Ni	0.02	0.02	<0.01
Se	0.002	0.0016	0.0006
Ag	<0.01	<0.01	<0.01
Zn	0.13	0.03	3.0
NO_3 as N	0.59	1.9	1.5
PO_4	0.005	--	0.24
U_3O_8	0.08	0.047	0.0019
Fe^{tot}	0.06	0.06	0.01
Mn^{tot}	0.90	0.96	--
Hg^{tot}	0.00019	0.0001	0.00004
Temp. °C			
Conductivity (umhos/cm)			
Water Level (Ft. below LSD			
Cation/Anion Balance			

WELL NO.: GM-17

LOCATION: Cottonwood Arroyo North Fork

FORMATION: Alluvium

TOTAL DEPTH: 20'

COMMENTS:
1985 Reorganization
12-B-3

SAMPLED:	09/10/79	03/10/80	09/24/80
** Parameter:			
pH	--	--	--
Na	--	--	--
Ca	--	--	--
Mg	--	128	160
SO_4	9308	9280	9290
Cl	104	103	1.5
TDS	15210	14490	15020
Al	0.63	0.45	0.43
As	0.0003	0.00002	0.00006
Ba	0.18	0.04	0.06
B	0.29	<0.01	0.28
Cd	0.01	<0.01	<0.001
Cr total	0.03	0.01	0.013
Co	0.02	0.01	< 0.01
Cu	0.02	0.06	0.07
F	0.27	0.4	0.35
Fe	0.03	0.35	18.0
K	--	--	--
Pb	0.33	0.05	0.22
Mn	<0.01	2.26	2.3
Mo	0.05	0.05	0.14
Ni	0.03	< 0.01	0.02
Se	<0.001	0.0025	0.0028
Ag	<0.01	0.01	<0.01
Zn	0.34	0.11	0.57
NO_3 as N	1.06	1.0	0.7
PO_4	<0.005	--	0.01
U_3O_8	0.025	0.020	0.021
Fe^{tot}	0.06	0.05	0.25
Mn^{tot}	0.08	1.78	--
Hg^{tot}	0.00015	0.00007	0.00005
Temp. °C			
Conductivity (umhos/cm)			
Water Level (Ft. below LSD			
Cation/Anion Balance			

WELL NO.: GM-18

LOCATION: Mouth of Cottonwood Downstream

FORMATION: Alluvium

TOTAL DEPTH: Navajo Well

COMMENTS: 1985 Reorganization 12-B-4

SAMPLED:	06/12/80	09/25/80	07/15/81
** Parameter:			
pH	-	-	DRY
Na	-	-	NO
Ca	-	-	SAMPLE
Mg	-	75.0	
SO_4	2335	3750	
Cl	0.7	3	
TDS	3960	6160	
Al	0.36	0.53	
As	0.007	0.0004	
Ba	0.03	0.06	
B	0.11	0.23	
Cd	0.01	<0.001	
Cr total	0.02	0.018	
Co	0.01	<0.01	
Cu	<0.005	0.02	
F	2.10	3.12	
Fe	0.04	0.67	
K	-	-	
Pb	0.008	0.005	
Mn	0.37	0.53	
Mo	0.02	0.13	
Ni	<0.005	0.01	
Se	0.003	0.5	
Ag	0.08	<0.01	
Zn	<0.005	0.021	
NO_3 as N	0.18	0.6	
PO_4	-	-	
U_3O_8	0.010	0.022	
Fe^{tot}	0.25	0.04	
Mn^{tot}	0.40	-	
Hg^{tot}	<0.00005	0.00003	
Temp. °C			
Conductivity (umhos/cm)			
Water Level (Ft. below LSD			
Cation/Anion Balance			

WELL NO.: GM-17

COMMENTS: 1985 Reorganization 12-B-5

LOCATION: Cottonwood Arroyo North Fork

FORMATION: Alluvial

TOTAL DEPTH:

SAMPLED:	03/09/82	06/25/82	09/29/82
** Parameter:			
pH	7.1	7.1	6.1
Na	4710	4690	4720
Ca	310	290	350
Mg	150	140	140
SO_4	9810	9640	9760
Cl	42	120	120
TDS	15900	15600	16000
Al	0.06	0.04	0.04
As	< 0.0001	< 0.0001	0.0002
Ba	0.25	0.32	0.06
B	0.13	0.30	0.66
Cd	< 0.0001	< 0.0001	< 0.001
Cr total	0.10	0.08	0.04
Co	< 0.01	< 0.01	< 0.01
Cu	.0035	0.0044	0.034
F	0.60	0.1	0.10
Fe	0.10	< 0.01	0.48
K	26	26	24
Pb	< 0.01	<0.01	<0.01
Mn	2.7	2.1	1.78
Mo	0.02	0.02	0.02
Ni	<0.01	<0.01	<0.01
Se	<0.0001	<0.0001	<0.0001
Ag	<0.0001	<0.0001	<0.002
Zn	0.09	0.05	0.03
NO_3 as N	1.3	1.1	1.18
PO_4	<0.01	0.01	<.01
U_3O_8	0.001	.001	0.000684
Fe^{tot}	10.0	7.7	1.33
Mn^{tot}	3.8	2.5	2.99
Hg^{tot}	<0.000005	<0.000001	<0.05
Temp. °C	15.7°	15.2°	15.4°
Conductivity (umhos/cm)	15.1	14.4	14.2
Water Level (Ft. below LSD	18.40'	18.15'	17.3'
Cation/Anion Balance	-02	-0.00	-0.32

WELL NO.: GM-17 [redacted]

COMMENTS: 1985 Reorganization 12-B-6

LOCATION: Cottonwood Arroyo North Fork

FORMATION: Alluvium

TOTAL DEPTH: 20'

SAMPLED:	07/15/81	09/17/81	12/15/81
** Parameter:			
pH	6.9	6.7	6.6
Na	4320	4490	4530
Ca	380	400	380
Mg	160	150	150
SO_4	9380	9560	8950
Cl	98	130	430
TDS	15300	15200	15700
Al	0.06	<0.1	0.12
As	<0.0001	0.0008	0.0008
Ba	0.2	0.1	0.28
B	0.31	0.16	0.08
Cd	<0.002	<0.002	<0.002
Cr total	0.03	0.04	0.06
Co	<0.01	<0.01	<0.01
Cu	0.03	0.042	0.03
F	0.3	0.2	0.5
Fe	<0.01	0.08	0.1
K	25	26	24
Pb	<0.02	<0.01	<0.01
Mn	<0.01	0.12	1.02
Mo	0.02	<0.02	0.03
Ni	<0.01	<0.01	<0.01
Se	0.0004	0.0002	<0.00001
Ag	<0.002	<0.002	<0.002
Zn	0.04	0.04	0.04
NO_3 as N	0.57	1.03	4.56
PO_4	0.04	0.02	0.03
U_3O_8	0.00029	0.00041	0012
Fe^{tot}	0.62	0.14	4.75
Mn^{tot}	0.08	0.76	1.75
Hg^{tot}	.000139	<.00010	.00001
Temp. °C	16.7°	16.7°	14.1°
Conductivity (umhos/cm)	0.85	13.9	13.5
Water Level (Ft. below LSD	6.15'	15.65'	16.1'
Cation/Anion Balance	0.64	-0.88	-0.84

WELL NO.: GM-10 [redacted] COMMENTS: 1985 Reorganization 12-3-7

LOCATION:

FORMATION:

TOTAL DEPTH:

SAMPLED:	03/04/82	06/24/82	09/29/82
** Parameter:			
pH	7.1	6.9	6.45
Na	1890	1850	3490
Ca	600	560	760
Mg	220	230	250
SO_4	3110	3740	4090
Cl	2200	1600	4190
TDS	8710	8330	13,200
Al	0.09	<0.01	0.05
As	0.0002	<0.0001	0.0001
Ba	0.46	0.30	0.10
B	0.38	0.85	1.30
Cd	<0.0001	<0.0001	<0.001
Cr total	<0.01	<0.01	0.05
Co	<0.01	<0.01	<0.01
Cu	0.02	0.0033	0.030
F	1.1	0.60	0.7
Fe	0.31	0.40	0.07
K	12	11	15
Pb	<0.01	<0.01	<0.01
Mn	0.79	0.54	0.92
Mo	0.04	<0.01	<.01
Ni	<0.01	<0.01	<0.01
Se	0.00010	<0.0001	<0.0001
Ag	0.00010	<0.0001	<0.002
Zn	0.61	0.41	4.06
NO_3 as N	0.32	0.15	0.10
PO_4	<0.01	<0.01	<.01
U_3O_8	0.0013	0.0016	0.000005
Fe^{tot}	6.5	11	9.24
Mn^{tot}	0.80	0.81	0.94
Hg^{tot}	<0.000005	<.000001	0.000014
Temp. °C	9.7°	18.3°	17.4°
Conductivity (umhos/cm)	7.4	8.0	18.6
Water Level (Ft. below LSD	--	--	--
Cation/Anion Balance	±1.0	0.62	-0.13

WELL NO.: GM-10 [redacted] COMMENTS: 1985 Reorganization 12-B-8

LOCATION:

FORMATION:

TOTAL DEPTH:

SAMPLED:	07/13/81	08/16/81	12/14/81
** Parameter:			
pH	6.8	6.9	6.8
Na	1130	1120	1120
Ca	490	490	500
Mg	210	220	220
SO_4	3180	3200	2770
Cl	660	720	960
TDS	6260	6130	6080
Al	0.06	0.1	0.07
As	≤0.0001	.0001	0.0005
Ba	0.67	0.25	0.38
B	1.33	0.79	0.53
Cd	≤0.002	≤0.002	≤0.002
Cr total	0.03	0.06	0.13
Co	≤0.01	≤0.01	≤0.01
Cu	0.008	0.187	0.024
F	0.9	0.8	5.8
Fe	0.95	0.03	0.05
K	9.4	10	10
Pb	≤0.02	≤0.01	≤0.01
Mn	0.32	0.27	0.57
Mo	≤0.01	≤0.02	0.06
Ni	≤0.01	≤0.01	≤0.01
Se	≤0.0001	≤0.0001	≤.00001
Ag	≤0.002	≤0.002	≤ 0.002
Zn	0.77	1.24	2.42
NO_3 as N	0.62	1.16	0.62
PO_4	0.03	0.02	0.02
U_3O_8	0.00018	0.000240	0.0008
Fe^{tot}	17.1	37	70
Mn^{tot}	0.41	0.73	2.50
Hg^{tot}	0.000166	≤0.00010	≤0.00001
Temp. °C	19.9°	19.2°	14.9°
Conductivity (umhos/cm)	5.2	4.8	4.5
Water Level (Ft. below LSD	--	--	--
Cation/Anion Balance	--	--	--

WELL NO.: GM-10

LOCATION: West of Mine Area in Chinde Wash

FORMATION: Alluvium

TOTAL DEPTH: Navajo Well

COMMENTS:
1985 Reorganization
12-3-9

SAMPLED:	06/12/80	09/23/80
** Parameter:		
pH	-	-
Na	-	-
Ca	-	-
Mg	-	215
SO_4	2920	3580
Cl	380	2130
TDS	5270	9130
Al	0.44	0.80
As	0.001	0.0005
Ba	0.03	0.06
B	0.76	0.96
Cd	<0.005	<0.001
Cr total	0.03	0.03
Co	0.02	0.02
Cu	< 0.005	0.01
F	0.71	0.72
Fe	0.32	3.52
K	-	-
Pb	0.009	0.009
Mn	0.82	0.87
Mo	0.03	0.15
Ni	0.005	0.02
Se	0.002	0.2
Ag	0.14	0.01
Zn	0.31	5.3
NO_3 as N	1.33	2.0
PO_4	-	-
U_3O_8	0.011	0.015
Fe^{tot}	1.69	0.06
Mn^{tot}	0.90	-
Hg^{tot}	0.00006	0.00016
Temp. °C		
Conductivity (umhos/cm)		
Water Level (Ft. below LSD		
Cation/Anion Balance		

WELL NO.: GM-10

COMMENTS: 1985 Reorganization 12-B-10

LOCATION: West of Mine Area in Chinde Wash

FORMATION: Alluvium

TOTAL DEPTH: Navajo Well

SAMPLED:	09/10/79	12/27/79	03/27/80
** Parameter:			
pH	-	-	-
Na	-	-	-
Ca	-	-	-
Mg	-	-	-
SO_4	2657	2880	2915
Cl	417	858	613
TDS	5010	6075	5660
Al	0.56	0.31	0.51
As	0.0002	0.0002	< 0.0002
Ba	0.15	0.05	0.03
B	0.79	-	0.7
Cd	<0.01	0.005	0.01
Cr total	0.03	0.03	0.02
Co	<0.01	0.04	0.02
Cu	0.01	0.02	<0.01
F	0.79	0.6	0.9
Fe	0.02	3.0	3.47
K	-	-	-
Pb	0.27	<0.001	0.01
Mn	0.32	0.47	0.61
Mo	0.04	0.06	0.06
Ni	0.02	0.02	0.01
Se	<0.001	0.0005	0.0008
Ag	<0.01	0.05	0.01
Zn	0.56	0.48	0.39
NO_3 as N	0.45	0.20	0.3
PO_4	-	-	-
U_3O_8	0.009	0.011	0.01
Fe^{tot}	0.05	-	1.34
Mn^{tot}	0.45	-	0.58
Hg^{tot}	0.00022	0.00003	0.00011
Temp. °C			
Conductivity (umhos/cm)			
Water Level (Ft. below LSD			
Cation/Anion Balance			

WELL NO.: GM-18

LOCATION: Downstream Cottonwood

FORMATION: Alluvium

TOTAL DEPTH:

COMMENTS: Dry No Sample

1985 Reorganization
12-B-11

SAMPLED:	09/17/81	12/15/81	03/09/82
** Parameter:			
pH	DRY	DRY	DRY
Na	NO	NO	NO
Ca	SAMPLE	SAMPLE	SAMPLE
Mg			
SO_4			
Cl			
TDS			
Al			
As			
Ba			
B			
Cd			
Cr total			
Co			
Cu			
F			
Fe			
K			
Pb			
Mn			
Mo			
Ni			
Se			
Ag			
Zn			
NO_3 as N			
PO_4			
U_3O_8			
Fe^{tot}			
Mn^{tot}			
Hg^{tot}			
Temp. °C			
Conductivity (umhos/cm)			
Water Level (Ft. below LSD			
Cation/Anion Balance			

WELL NO.: GM-18

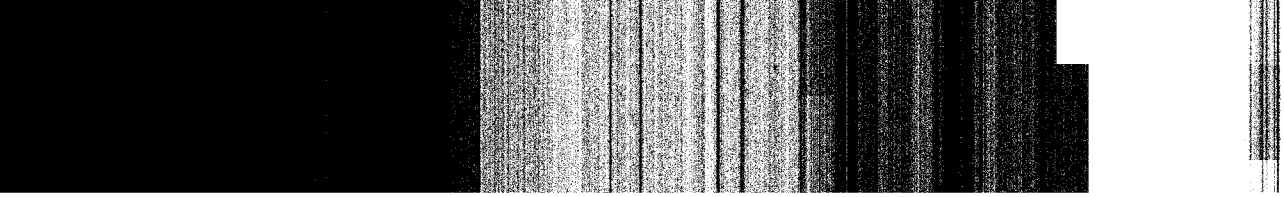
LOCATION:Cottonwood Arroyo Downstream

FORMATION: Alluvium

TOTAL DEPTH:Navajo Well

COMMENTS: 1985 Reorganization 12-B-12

SAMPLED:	06/25/82	09/29/82
** Parameter:		
pH	DRY	DRY
Na	NO	NO
Ca	SAMPLE	SAMPLE
Mg		
SO_4		
Cl		
TDS		
Al		
As		
Ba		
B		
Cd		
Cr total		
Co		
Cu		
F		
Fe		
K		
Pb		
Mn		
Mo		
Ni		
Se		
Ag		
Zn		
NO_3 as N		
PO_4		
U_3O_8		
Fe^{tot}		
Mn^{tot}		
Hg^{tot}		
Temp. °C		
Conductivity (umhos/cm)		
Water Level (Ft. below LSD		
Cation/Anion Balance		



WELL NO.: GM-9

COMMENTS: 1985 Reorganization 12-B-13

LOCATION: Chinde

FORMATION: Alluvium

TOTAL DEPTH: 20'

SAMPLED:	03/09/82	06/25/82	09/29/82
** Parameter:			
pH	DRY	DRY	DRY
Na	NO	NO	NO
Ca	SAMPLE	SAMPLE	SAMPLE
Mg			
SO_4			
Cl			
TDS			
Al			
As			
Ba			
B			
Cd			
Cr total			
Co			
Cu			
F			
Fe			
K			
Pb			
Mn			
Mo			
Ni			
Se			
Ag			
Zn			
NO_3 as N			
PO_4			
U_3O_8			
Fe^{tot}			
Mn^{tot}			
Hg^{tot}			
Temp. °C			
Conductivity (umhos/cm)			
Water Level (Ft. below LSD			
Cation/Anion Balance			

WELL NO.: GM-9

COMMENTS: Well Went Dry

LOCATION:

1985 Reorganization
12-B-14

FORMATION: Alluvium

TOTAL DEPTH: 20'

SAMPLED:	07/15/81	09/17/81	12/14/81
** Parameter:			
pH	DRY	DRY	DRY
Na	NO	NO	NO
Ca	SAMPLE	SAMPLE	SAMPLE
Mg			
SO_4			
Cl			
TDS			
Al			
As			
Ba			
B			
Cd			
Cr total			
Co			
Cu			
F			
Fe			
K			
Pb			
Mn			
Mo			
Ni			
Se			
Ag			
Zn			
NO_3 as N			
PO_4			
U_3O_8			
Fe^{tot}			
Mn^{tot}			
Hg^{tot}			
Temp. °C			
Conductivity (umhos/cm)			
Water Level (Ft. below LSD			
Cation/Anion Balance			

Appenidx 18.S

CHINDE ARROYO POST-MINING HYDROLOGY & SEDIMENTOLOGY

(2 YR-6 HR, 10 YR-6 HR, 25 YR-6 HR, & 100 YR-6 HR STORM EVENTS)

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Chinde Arroyo Post-Mine Hydrology and Sedimentology

The hydrology model and drainage subdivisions are presented on Exhibit 11-75. The design data for the Chinde Permanent Diversion are presented in the Interim Permit.

Revised August 2012

GEOMAT Inc.
915 Malta Avenue
Farmington, NM 87401

Phone: (505) 327-7928

General Information

Storm Information:

Storm Type:	NRCS TYPE II-70
Design Storm:	2 yr - 6 hr
Rainfall Depth:	0.800 inches

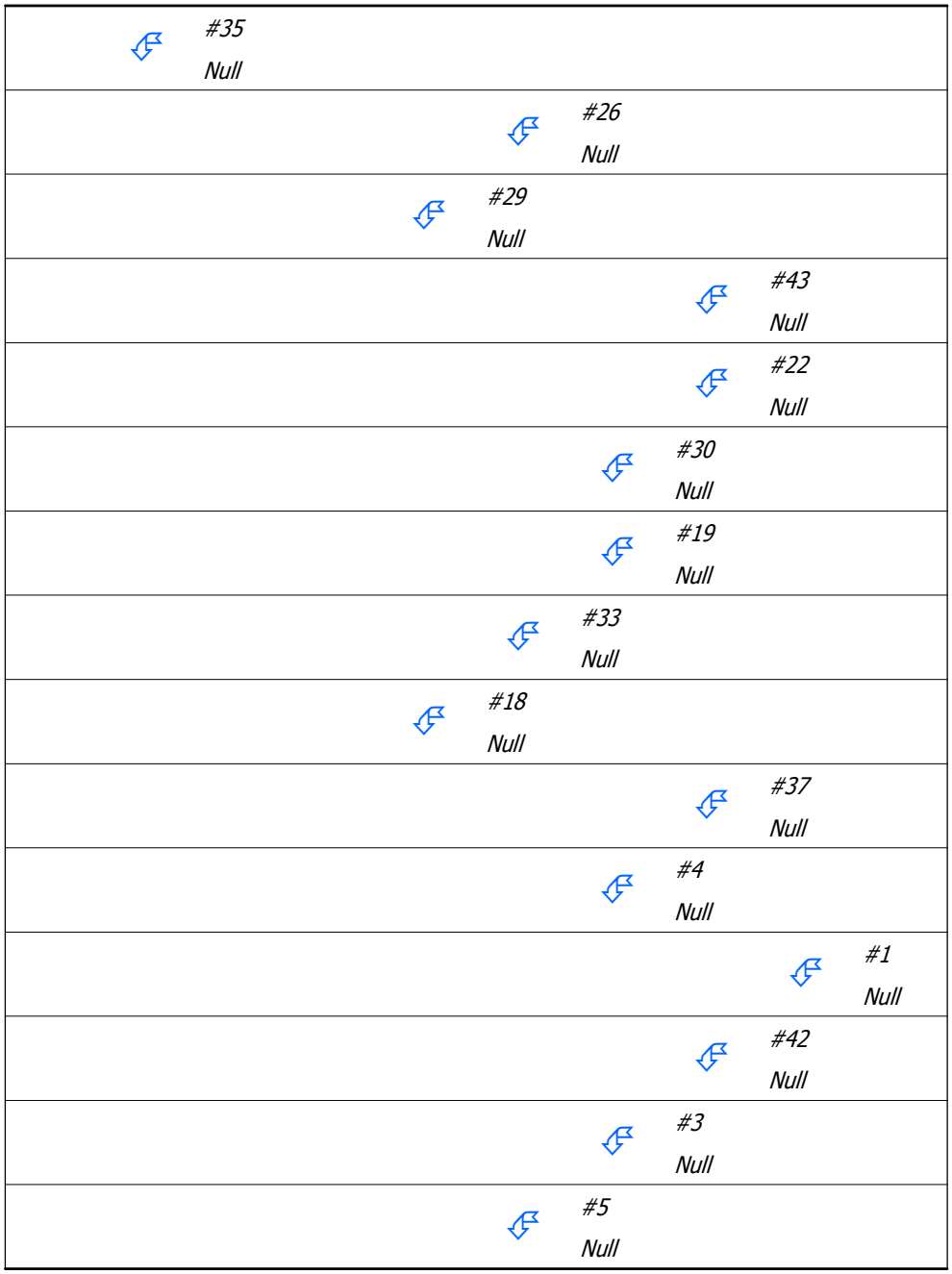
Particle Size Distribution:

Size (mm)	PostMine-LoamySand	PreMine-LoamySand	PreMine-Badlands	LoamySand Postmining
2.0000	100.000%	100.000%	100.000%	0.000%
0.1000	26.500%	30.000%	83.500%	0.000%
0.0500	14.000%	17.000%	77.000%	0.000%
0.0020	11.000%	11.000%	56.000%	0.000%
0.0010	0.000%	0.000%	0.000%	0.000%

Structure Networking:

Type	Stru #	(flows into)	Stru #	Musk. K (hrs)	Musk. X	Description
Null	#1	==>	#42	1.386	0.156	S1
Null	#3	==>	#5	0.000	0.000	S3
Null	#4	==>	#5	0.000	0.000	S4
Null	#5	==>	#6	0.778	0.334	S5
Null	#6	==>	#40	1.263	0.275	S6
Null	#7	==>	#44	0.622	0.321	S7
Null	#8	==>	#44	0.379	0.327	S8 at PP-11
Null	#9	==>	#44	0.205	0.345	S9 at PP-9
Null	#10	==>	#44	0.108	0.367	S10 at PP-8
Null	#11	==>	#44	0.035	0.389	S11 at PP-7
Null	#12	==>	#27	0.346	0.347	S12 at PP-5
Null	#13	==>	#27	0.429	0.325	S13 at PP-4
Null	#14	==>	#38	0.749	0.206	S14
Null	#15	==>	#41	0.000	0.000	S15
Null	#16	==>	#38	0.043	0.404	S16
Null	#17	==>	#32	0.000	0.000	S17
Null	#18	==>	#40	0.434	0.164	S18
Null	#19	==>	#33	0.000	0.000	S19
Null	#21	==>	#27	0.256	0.341	S21 at PP-3B
Null	#22	==>	#30	0.493	0.224	S22
Null	#23	==>	#24	0.494	0.312	S23 at PP-1A
Null	#24	==>	End	0.000	0.000	S24
Null	#25	==>	#28	0.678	0.320	S25 at PP-1
Null	#26	==>	#29	0.164	0.191	S26
Null	#27	==>	#45	0.340	0.311	S27
Null	#28	==>	#23	0.101	0.361	S28
Null	#29	==>	#40	0.660	0.307	S29
Null	#30	==>	#33	0.000	0.000	S30
Null	#31	==>	#32	0.274	0.297	S31
Null	#32	==>	#23	0.403	0.327	S32
Null	#33	==>	#18	0.510	0.309	S33
Null	#34	==>	#38	0.601	0.202	S34
Null	#35	==>	#23	0.080	0.367	S35
Null	#36	==>	#27	0.202	0.356	S36 at PP-3C
Null	#37	==>	#4	1.717	0.316	S37
Null	#38	==>	#39	0.165	0.329	S38 at Doby Channel
Null	#39	==>	#15	0.342	0.321	S39 at Doby Permanent Imp.
Null	#40	==>	#41	0.000	0.000	S40

Type	Stru #	(flows into)	Stru #	Musk. K (hrs)	Musk. X	Description
Null	#41	==>	#32	0.216	0.318	S41
Null	#42	==>	#3	1.479	0.221	S42
Null	#43	==>	#30	0.289	0.246	S43
Null	#44	==>	#27	0.609	0.308	S44
Null	#45	==>	#28	0.174	0.349	S45
Null	#46	==>	#28	0.532	0.347	S46 at PP-3A
Null	#47	==>	#28	0.515	0.342	S47 at PP-3
Null	#48	==>	#28	0.587	0.321	S48 at PP-2
Null	#49	==>	#28	0.669	0.328	S49 at PP-0



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#6 *Null*
#40 *Null*
#34 *Null*
#16 *Null*
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#15 *Null*
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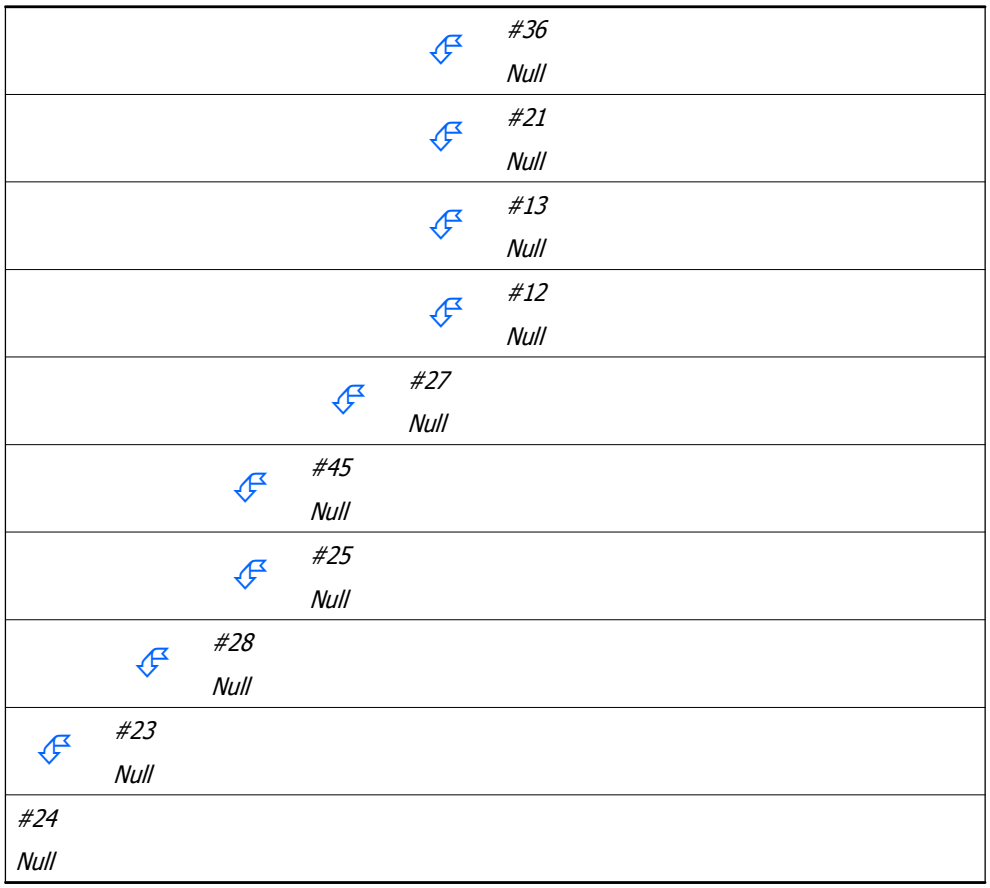
#32 *Null*
#49 *Null*
#48 *Null*
#47 *Null*
#46 *Null*
#11 *Null*
#10 *Null*
#9 *Null*
#8 *Null*
#7 *Null*
#44 *Null*



Structure Routing Details:

Stru #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#1	5. Nearly bare and untilled, and alluvial valley fans	0.60	23.00	3,844.22	0.77	1.386
#1	**Muskingum K:**					**1.386**
#5	8. Large gullies, diversions, and low flowing streams	1.30	124.00	9,554.00	3.41	0.778
#5	**Muskingum K:**					**0.778**
#6	8. Large gullies, diversions, and low flowing streams	0.48	45.00	9,415.70	2.07	1.263
#6	**Muskingum K:**					**1.263**
#7	8. Large gullies, diversions, and low flowing streams	1.03	70.00	6,812.80	3.04	0.622
#7	**Muskingum K:**					**0.622**
#8	8. Large gullies, diversions, and low flowing streams	1.14	50.00	4,371.40	3.20	0.379
#8	**Muskingum K:**					**0.379**
#9	8. Large gullies, diversions, and low flowing streams	1.60	45.00	2,810.50	3.79	0.205
#9	**Muskingum K:**					**0.205**

Stru #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#10	8. Large gullies, diversions, and low flowing streams	2.45	45.00	1,836.50	4.69	0.108
#10	**Muskingum K:**					**0.108**
#11	8. Large gullies, diversions, and low flowing streams	3.93	30.00	762.50	5.95	0.035
#11	**Muskingum K:**					**0.035**
#12	8. Large gullies, diversions, and low flowing streams	1.66	80.00	4,821.90	3.86	0.346
#12	**Muskingum K:**					**0.346**
#13	8. Large gullies, diversions, and low flowing streams	1.12	55.00	4,901.50	3.17	0.429
#13	**Muskingum K:**					**0.429**
#14	5. Nearly bare and untilled, and alluvial valley fans	1.43	46.00	3,212.06	1.19	0.749
#14	**Muskingum K:**					**0.749**
#16	8. Large gullies, diversions, and low flowing streams	5.68	64.00	1,127.00	7.14	0.043
#16	**Muskingum K:**					**0.043**
#18	8. Large gullies, diversions, and low flowing streams	0.08	1.00	1,298.19	0.83	0.434
#18	**Muskingum K:**					**0.434**
#21	8. Large gullies, diversions, and low flowing streams	1.49	50.00	3,365.00	3.65	0.256
#21	**Muskingum K:**					**0.256**
#22	5. Nearly bare and untilled, and alluvial valley fans	1.92	47.00	2,453.50	1.38	0.493
#22	**Muskingum K:**					**0.493**
#23	8. Large gullies, diversions, and low flowing streams	0.88	44.00	5,006.00	2.81	0.494
#23	**Muskingum K:**					**0.494**
#25	8. Large gullies, diversions, and low flowing streams	1.03	76.00	7,403.00	3.03	0.678
#25	**Muskingum K:**					**0.678**
#26	5. Nearly bare and untilled, and alluvial valley fans	1.12	7.00	623.30	1.05	0.164
#26	**Muskingum K:**					**0.164**
#27	8. Large gullies, diversions, and low flowing streams	0.87	30.00	3,432.70	2.80	0.340
#27	**Muskingum K:**					**0.340**
#28	8. Large gullies, diversions, and low flowing streams	2.16	35.00	1,618.04	4.41	0.101
#28	**Muskingum K:**					**0.101**
#29	8. Large gullies, diversions, and low flowing streams	0.81	52.00	6,415.80	2.70	0.660
#29	**Muskingum K:**					**0.660**
#31	8. Large gullies, diversions, and low flowing streams	0.69	17.00	2,459.00	2.49	0.274

Stru #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#31	**Muskingum K:**					**0.274**
#32	8. Large gullies, diversions, and low flowing streams	1.14	53.00	4,654.00	3.20	0.403
#32	**Muskingum K:**					**0.403**
#33	8. Large gullies, diversions, and low flowing streams	0.83	42.00	5,032.70	2.74	0.510
#33	**Muskingum K:**					**0.510**
#34	5. Nearly bare and untilled, and alluvial valley fans	1.32	33.00	2,492.07	1.15	0.601
#34	**Muskingum K:**					**0.601**
#35	8. Large gullies, diversions, and low flowing streams	2.44	33.00	1,354.01	4.68	0.080
#35	**Muskingum K:**					**0.080**
#36	8. Large gullies, diversions, and low flowing streams	1.96	60.00	3,062.00	4.19	0.202
#36	**Muskingum K:**					**0.202**
#37	5. Nearly bare and untilled, and alluvial valley fans	1.35	55.00	4,071.00	1.16	0.974
	8. Large gullies, diversions, and low flowing streams	1.49	146.00	9,792.00	3.66	0.743
#37	**Muskingum K:**					**1.717**
#38	8. Large gullies, diversions, and low flowing streams	1.19	23.00	1,938.00	3.26	0.165
#38	**Muskingum K:**					**0.165**
#39	8. Large gullies, diversions, and low flowing streams	1.04	39.00	3,758.00	3.05	0.342
#39	**Muskingum K:**					**0.342**
#41	8. Large gullies, diversions, and low flowing streams	0.99	23.00	2,325.20	2.98	0.216
#41	**Muskingum K:**					**0.216**
#42	5. Nearly bare and untilled, and alluvial valley fans	1.84	132.00	7,189.15	1.35	1.479
#42	**Muskingum K:**					**1.479**
#43	5. Nearly bare and untilled, and alluvial valley fans	2.73	47.00	1,722.00	1.65	0.289
#43	**Muskingum K:**					**0.289**
#44	8. Large gullies, diversions, and low flowing streams	0.83	50.00	5,994.90	2.73	0.609
#44	**Muskingum K:**					**0.609**
#45	8. Large gullies, diversions, and low flowing streams	1.71	42.00	2,456.80	3.92	0.174
#45	**Muskingum K:**					**0.174**
#46	8. Large gullies, diversions, and low flowing streams	1.65	122.00	7,378.00	3.85	0.532
#46	**Muskingum K:**					**0.532**
#47	8. Large gullies, diversions, and low flowing streams	1.50	102.00	6,814.00	3.67	0.515

Stru #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#47	**Muskingum K:**					**0.515**
#48	8. Large gullies, diversions, and low flowing streams	1.04	67.00	6,452.00	3.05	0.587
#48	**Muskingum K:**					**0.587**
#49	8. Large gullies, diversions, and low flowing streams	1.17	92.00	7,838.00	3.25	0.669
#49	**Muskingum K:**					**0.669**

Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc. (ml/l)	24VW (ml/l)
#35	105.000	105.000	6.74	0.39	17.1	1	0.00	0.00
#26	217.200	217.200	59.04	3.30	279.9	90,188	3.65	2.45
#29	26.000	243.200	56.21	3.79	276.6	79,527	2.17	1.43
#43	809.500	809.500	9.30	2.51	19.6	7,597	2.11	1.60
#22	163.500	163.500	33.91	2.25	163.9	76,981	0.26	0.18
#30	142.400	1,115.400	40.06	6.73	193.1	54,797	1.64	0.62
#19	451.400	451.400	27.65	3.48	117.2	34,113	16.54	11.87
#33	0.000	1,566.800	67.24	10.21	310.3	46,250	9.33	4.45
#18	126.600	1,693.400	64.42	10.27	304.3	45,953	8.71	4.08
#37	3,024.600	3,024.600	7.60	3.77	12.9	3,352	0.43	0.32
#4	2,965.700	5,990.300	32.68	9.96	54.4	6,496	2.06	1.28
#1	755.100	755.100	4.45	1.13	5.7	4,814	1.50	1.14
#42	2,360.600	3,115.700	13.60	5.97	18.8	3,341	0.65	0.45
#3	1,550.000	4,665.700	29.60	13.05	53.9	5,555	1.24	0.68
#5	0.000	10,656.000	56.78	23.01	108.3	5,986	1.62	0.94
#6	2,008.700	12,664.700	82.62	33.81	520.0	53,643	1.34	0.28
#40	231.000	14,832.300	112.42	48.73	1,145.2	60,279	4.71	1.33
#34	235.300	235.300	0.18	0.05	0.1	2,459	1.35	1.05
#16	1,570.700	1,570.700	1.69	0.57	1.5	2,465	1.29	1.00
#14	6,695.200	6,695.200	28.29	12.06	102.8	16,924	6.19	2.30
#38	0.000	8,501.199	28.09	12.68	104.4	16,512	6.08	2.24
#39	0.000	8,501.199	28.00	12.68	104.4	16,524	6.09	2.24
#15	539.400	9,040.600	28.65	12.95	106.1	16,263	6.05	2.26
#41	0.000	23,872.900	137.79	61.68	1,251.2	59,575	6.13	1.52
#31	148.400	148.400	0.55	0.07	0.8	10,549	6.91	5.11
#17	939.500	939.500	9.17	1.10	17.2	23,748	12.93	6.21
#32	153.600	25,114.400	140.17	62.93	1,258.4	57,030	5.89	1.51
#49	10.780	10.780	6.65	0.20	18.3	96,950	25.17	16.60
#48	8.290	8.290	5.11	0.16	13.7	94,055	24.42	16.10
#47	12.350	12.350	7.62	0.23	21.4	98,482	25.57	16.87
#46	6.480	6.480	4.00	0.12	10.4	91,416	23.73	15.65
#11	151.040	151.040	47.50	2.30	200.4	93,501	6.14	4.08
#10	34.470	34.470	21.26	0.65	59.7	98,648	25.61	16.89
#9	69.790	69.790	24.50	1.08	85.6	86,384	7.27	4.78
#8	28.530	28.530	17.59	0.54	44.9	90,027	23.37	15.41
#7	201.870	201.870	41.14	2.81	208.2	77,913	0.00	0.00
#44	201.750	687.450	109.25	10.43	734.6	1,688,672	297.99	8.94

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc. (ml/l)	24VW (ml/l)
#36	12.330	12.330	7.60	0.23	17.2	79,990	20.77	13.68
#21	63.380	63.380	22.25	0.98	97.3	107,240	9.03	5.95
#13	25.880	25.880	9.09	0.40	18.9	52,250	4.40	2.88
#12	78.130	78.130	27.43	1.21	71.0	64,654	5.44	3.57
#27	210.960	1,078.130	116.58	13.36	939.1	2,424,866	385.72	8.05
#45	15.500	1,093.630	112.69	13.65	916.3	89,723	12.75	6.88
#25	343.070	343.070	30.20	3.01	141.9	48,521	0.00	0.00
#28	570.420	2,045.020	140.41	17.65	1,124.7	2,206,739	290.90	6.06
#23	192.200	27,456.620	210.14	81.06	2,399.2	614,756	73.58	2.61
#24	201.360	27,657.980	208.20	83.87	2,483.0	137,115	10.21	1.65

Particle Size Distribution(s) at Each Structure

Structure #35 (S35):

Size (mm)	In/Out
2.0000	100.000%
0.1000	57.049%
0.0500	32.328%
0.0020	20.918%
0.0010	0.000%

Structure #26 (S26):

Size (mm)	In/Out
2.0000	100.000%
0.1000	100.000%
0.0500	100.000%
0.0020	88.600%
0.0010	0.000%

Structure #29 (S29):

Size (mm)	In/Out
2.0000	100.000%
0.1000	98.380%
0.0500	97.742%
0.0020	95.151%
0.0010	0.000%

Structure #43 (S43):

Size (mm)	In/Out
2.0000	100.000%
0.1000	100.000%
0.0500	77.795%
0.0020	50.338%

Size (mm)	In/Out
0.0010	0.000%

Structure #22 (S22):

Size (mm)	In/Out
2.0000	100.000%
0.1000	100.000%
0.0500	100.000%
0.0020	99.053%
0.0010	0.000%

Structure #30 (S30):

Size (mm)	In/Out
2.0000	100.000%
0.1000	100.000%
0.0500	98.496%
0.0020	93.440%
0.0010	0.000%

Structure #19 (S19):

Size (mm)	In/Out
2.0000	100.000%
0.1000	82.508%
0.0500	46.754%
0.0020	30.253%
0.0010	0.000%

Structure #33 (S33):

Size (mm)	In/Out
2.0000	100.000%
0.1000	93.393%
0.0500	78.952%
0.0020	69.573%
0.0010	0.000%

Structure #18 (S18):

Size (mm)	In/Out
2.0000	100.000%
0.1000	95.312%
0.0500	80.549%
0.0020	70.977%
0.0010	0.000%

Structure #37 (S37):

Size (mm)	In/Out
2.0000	100.000%
0.1000	100.000%
0.0500	100.000%
0.0020	66.067%
0.0010	0.000%

Structure #4 (S4):

Size (mm)	In/Out
2.0000	100.000%
0.1000	100.000%
0.0500	71.451%
0.0020	46.895%
0.0010	0.000%

Structure #1 (S1):

Size (mm)	In/Out
2.0000	100.000%
0.1000	100.000%
0.0500	72.911%
0.0020	47.178%
0.0010	0.000%

Structure #42 (S42):

Size (mm)	In/Out
2.0000	100.000%
0.1000	100.000%
0.0500	88.399%
0.0020	60.563%

Size (mm)	In/Out
0.0010	0.000%

Structure #3 (S3):

Size (mm)	In/Out
2.0000	100.000%
0.1000	100.000%
0.0500	82.104%
0.0020	60.059%
0.0010	0.000%

Structure #5 (S5):

Size (mm)	In/Out
2.0000	100.000%
0.1000	100.000%
0.0500	76.753%
0.0020	53.447%
0.0010	0.000%

Structure #6 (S6):

Size (mm)	In/Out
2.0000	100.000%
0.1000	100.000%
0.0500	99.165%
0.0020	94.029%
0.0010	0.000%

Structure #40 (S40):

Size (mm)	In/Out
2.0000	100.000%
0.1000	97.742%
0.0500	93.040%
0.0020	86.721%
0.0010	0.000%

Structure #34 (S34):

Size (mm)	In/Out
2.0000	100.000%
0.1000	65.968%
0.0500	37.382%
0.0020	24.188%
0.0010	0.000%

Structure #16 (S16):

Size (mm)	In/Out
2.0000	100.000%
0.1000	72.345%
0.0500	40.995%
0.0020	26.526%
0.0010	0.000%

Structure #14 (S14):

Size (mm)	In/Out
2.0000	100.000%
0.1000	98.699%
0.0500	63.121%
0.0020	43.355%
0.0010	0.000%

Structure #38 (S38 at Doby Channel):

Size (mm)	In/Out
2.0000	100.000%
0.1000	98.285%
0.0500	62.776%
0.0020	43.093%
0.0010	0.000%

Structure #39 (S39 at Doby Permanent Imp.):

Size (mm)	In/Out
2.0000	100.000%
0.1000	98.285%
0.0500	62.776%
0.0020	43.093%

Size (mm)	In/Out
0.0010	0.000%

Structure #15 (S15):

Size (mm)	In/Out
2.0000	100.000%
0.1000	97.541%
0.0500	62.215%
0.0020	42.749%
0.0010	0.000%

Structure #41 (S41):

Size (mm)	In/Out
2.0000	100.000%
0.1000	97.725%
0.0500	90.427%
0.0020	82.993%
0.0010	0.000%

Structure #31 (S31):

Size (mm)	In/Out
2.0000	100.000%
0.1000	37.795%
0.0500	19.967%
0.0020	15.688%
0.0010	0.000%

Structure #17 (S17):

Size (mm)	In/Out
2.0000	100.000%
0.1000	66.522%
0.0500	37.560%
0.0020	24.855%
0.0010	0.000%

Structure #32 (S32):

Size (mm)	In/Out
2.0000	100.000%
0.1000	98.112%
0.0500	90.443%
0.0020	82.874%
0.0010	0.000%

Structure #49 (S49 at PP-0):

Size (mm)	In/Out
2.0000	100.000%
0.1000	83.500%
0.0500	77.000%
0.0020	56.000%
0.0010	0.000%

Structure #48 (S48 at PP-2):

Size (mm)	In/Out
2.0000	100.000%
0.1000	83.500%
0.0500	77.000%
0.0020	56.000%
0.0010	0.000%

Structure #47 (S47 at PP-3):

Size (mm)	In/Out
2.0000	100.000%
0.1000	83.500%
0.0500	77.000%
0.0020	56.000%
0.0010	0.000%

Structure #46 (S46 at PP-3A):

Size (mm)	In/Out
2.0000	100.000%
0.1000	83.500%
0.0500	77.000%
0.0020	56.000%

Size (mm)	In/Out
0.0010	0.000%

Structure #11 (S11 at PP-7):

Size (mm)	In/Out
2.0000	100.000%
0.1000	100.000%
0.0500	100.000%
0.0020	81.647%
0.0010	0.000%

Structure #10 (S10 at PP-8):

Size (mm)	In/Out
2.0000	100.000%
0.1000	83.500%
0.0500	77.000%
0.0020	56.000%
0.0010	0.000%

Structure #9 (S9 at PP-9):

Size (mm)	In/Out
2.0000	100.000%
0.1000	100.000%
0.0500	100.000%
0.0020	76.767%
0.0010	0.000%

Structure #8 (S8 at PP-11):

Size (mm)	In/Out
2.0000	100.000%
0.1000	83.500%
0.0500	77.000%
0.0020	56.000%
0.0010	0.000%

Structure #7 (S7):

Size (mm)	In/Out
2.0000	100.000%
0.1000	100.000%
0.0500	100.000%
0.0020	100.000%
0.0010	0.000%

Structure #44 (S44):

Size (mm)	In/Out
2.0000	100.000%
0.1000	88.489%
0.0500	83.160%
0.0020	71.400%
0.0010	0.000%

Structure #36 (S36 at PP-3C):

Size (mm)	In/Out
2.0000	100.000%
0.1000	83.500%
0.0500	77.000%
0.0020	56.000%
0.0010	0.000%

Structure #21 (S21 at PP-3B):

Size (mm)	In/Out
2.0000	100.000%
0.1000	100.000%
0.0500	100.000%
0.0020	76.767%
0.0010	0.000%

Structure #13 (S13 at PP-4):

Size (mm)	In/Out
2.0000	100.000%
0.1000	100.000%
0.0500	100.000%
0.0020	76.767%

Size (mm)	In/Out
0.0010	0.000%

Structure #12 (S12 at PP-5):

Size (mm)	In/Out
2.0000	100.000%
0.1000	100.000%
0.0500	100.000%
0.0020	76.767%
0.0010	0.000%

Structure #27 (S27):

Size (mm)	In/Out
2.0000	100.000%
0.1000	90.756%
0.0500	86.439%
0.0020	72.216%
0.0010	0.000%

Structure #45 (S45):

Size (mm)	In/Out
2.0000	100.000%
0.1000	93.289%
0.0500	88.732%
0.0020	74.124%
0.0010	0.000%

Structure #25 (S25 at PP-1):

Size (mm)	In/Out
2.0000	100.000%
0.1000	100.000%
0.0500	100.000%
0.0020	100.000%
0.0010	0.000%

Structure #28 (S28):

Size (mm)	In/Out
2.0000	100.000%
0.1000	93.491%
0.0500	89.343%
0.0020	76.236%
0.0010	0.000%

Structure #23 (S23 at PP-1A):

Size (mm)	In/Out
2.0000	100.000%
0.1000	95.717%
0.0500	89.563%
0.0020	79.365%
0.0010	0.000%

Structure #24:

Size (mm)	In/Out
2.0000	100.000%
0.1000	100.000%
0.0500	95.158%
0.0020	85.098%
0.0010	0.000%

Structure Detail:

Structure #35 (Null)

S35

Structure #26 (Null)

S26

Structure #29 (Null)

S29

Structure #43 (Null)

S43

Structure #22 (Null)

S22

Structure #30 (Null)

S30

Structure #19 (Null)

S19

Structure #33 (Null)

S33

Structure #18 (Null)

S18

Structure #37 (Null)

S37

Structure #4 (Null)

S4

Structure #1 (Null)

S1

Structure #42 (Null)

S42

Structure #3 (Null)

S3

Structure #5 (Null)

S5

Structure #6 (Null)

S6

Structure #40 (Null)

S40

Structure #34 (Null)

S34

Structure #16 (Null)

S16

Structure #14 (Null)

S14

Structure #38 (Null)

S38 at Doby Channel

Structure #39 (Null)

S39 at Doby Permanent Imp.

Structure #15 (Null)

S15

Structure #41 (Null)

S41

Structure #31 (Null)

S31

Structure #17 (Null)

S17

Structure #32 (Null)

S32

Structure #49 (Null)

S49 at PP-0

Structure #48 (Null)

S48 at PP-2

Structure #47 (Null)

S47 at PP-3

Structure #46 (Null)

S46 at PP-3A

Structure #11 (Null)

S11 at PP-7

Structure #10 (Null)

S10 at PP-8

Structure #9 (Null)

S9 at PP-9

Structure #8 (Null)

S8 at PP-11

Structure #7 (Null)

S7

Structure #44 (Null)

S44

Structure #36 (Null)

S36 at PP-3C

Structure #21 (Null)

S21 at PP-3B

Structure #13 (Null)

S13 at PP-4

Structure #12 (Null)

S12 at PP-5

Structure #27 (Null)

S27

Structure #45 (Null)

S45

Structure #25 (Null)

S25 at PP-1

Structure #28 (Null)

S28

Structure #23 (Null)

S23 at PP-1A

Structure #24 (Null)

S24

Subwatershed Hydrology Detail:

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
#35	1	105.000	0.255	0.000	0.000	82.400	M	6.74	0.389
	Σ	**105.000**						**6.74**	**0.389**
#26	1	217.200	0.311	0.000	0.000	91.000	M	59.04	3.298
	Σ	**217.200**						**59.04**	**3.298**
#29	1	26.000	0.083	0.000	0.000	91.000	M	16.03	0.493
	Σ	**243.200**						**56.21**	**3.791**
#43	1	809.500	2.463	0.000	0.000	81.600	M	9.30	2.511
	Σ	**809.500**						**9.30**	**2.511**
#22	1	163.500	0.425	0.000	0.000	90.300	M	33.91	2.246
	Σ	**163.500**						**33.91**	**2.246**
#30	1	142.400	0.245	0.000	0.000	90.300	M	39.22	1.969
	Σ	**1,115.400**						**40.06**	**6.726**
#19	1	451.400	1.009	0.000	0.000	86.500	M	27.65	3.481
	Σ	**451.400**						**27.65**	**3.481**
#33	Σ	**1,566.800**						**67.24**	**10.207**
#18	1	126.600	0.592	0.000	0.000	75.700	M	0.37	0.062
	Σ	**1,693.400**						**64.42**	**10.269**
#37	1	3,024.600	5.355	0.000	0.000	78.100	M	7.60	3.770
	Σ	**3,024.600**						**7.60**	**3.770**
#4	1	654.900	1.236	0.423	0.345	79.900	M	7.59	1.361
	2	699.700	1.092	0.423	0.345	78.500	M	5.56	0.988
	3	547.300	0.989	0.423	0.345	78.100	M	3.96	0.683
	4	1,063.800	1.498	0.000	0.000	81.400	M	16.41	3.159
	Σ	**5,990.300**						**32.68**	**9.961**
#1	1	755.100	2.032	0.000	0.000	78.700	M	4.45	1.130
	Σ	**755.100**						**4.45**	**1.130**
#42	1	1,327.100	2.923	3.078	0.144	77.200	M	3.68	1.219
	2	894.200	3.620	0.000	0.000	82.100	M	8.67	3.087
	3	139.300	1.214	0.000	0.000	82.600	M	3.31	0.533
	Σ	**3,115.700**						**13.60**	**5.970**
#3	1	1,550.000	2.670	0.000	0.000	83.500	M	25.46	7.075

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
	Σ	**4,665.700**						**29.60**	**13.045**
#5	**Σ**	**10,656.000**						**56.78**	**23.006**
#6	1	505.100	2.338	0.620	0.328	76.200	M	1.05	0.312
	2	638.400	4.585	0.478	0.304	78.800	M	2.24	0.984
	3	557.000	2.219	0.000	0.000	88.100	M	24.53	5.515
	4	308.200	0.485	0.478	0.304	89.900	M	55.38	3.994
	Σ	**12,664.700**						**82.62**	**33.810**
#40	1	190.700	1.159	0.000	0.000	75.700	M	0.43	0.094
	2	40.300	0.082	0.757	0.302	91.000	M	24.85	0.764
	Σ	**14,832.300**						**112.42**	**48.728**
#34	1	235.300	2.496	0.000	0.000	74.400	M	0.18	0.055
	Σ	**235.300**						**0.18**	**0.055**
#16	1	1,570.700	2.944	0.000	0.000	75.100	M	1.69	0.565
	Σ	**1,570.700**						**1.69**	**0.565**
#14	1	2,999.900	5.968	5.461	0.261	77.600	M	5.86	3.173
	2	1,855.400	3.914	1.286	0.322	78.800	M	7.29	2.859
	3	730.800	1.418	0.000	0.000	85.400	M	28.29	4.693
	4	1,109.100	2.763	1.418	0.312	78.000	M	4.25	1.339
	Σ	**6,695.200**						**28.29**	**12.064**
#38	**Σ**	**8,501.199**						**28.09**	**12.684**
#39	**Σ**	**8,501.199**						**28.00**	**12.684**
#15	1	539.400	1.116	0.000	0.000	75.700	M	1.24	0.265
	Σ	**9,040.600**						**28.65**	**12.949**
#41	**Σ**	**23,872.900**						**137.79**	**61.678**
#31	1	148.400	0.298	0.000	0.000	75.700	M	0.55	0.073
	Σ	**148.400**						**0.55**	**0.073**
#17	1	823.800	1.069	0.713	0.220	75.700	M	1.93	0.405
	2	115.700	0.456	0.000	0.000	85.000	M	9.17	0.694
	Σ	**939.500**						**9.17**	**1.099**
#32	1	118.100	0.555	0.108	0.329	75.700	M	0.36	0.058
	2	35.500	0.245	0.000	0.000	75.700	M	0.14	0.018
	Σ	**25,114.400**						**140.17**	**62.926**
#49	1	10.780	0.065	0.000	0.000	91.000	M	6.65	0.204

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
	Σ	**10.780**						**6.65**	**0.204**
#48	1	8.290	0.045	0.000	0.000	91.000	M	5.11	0.157
	Σ	**8.290**						**5.11**	**0.157**
#47	1	12.350	0.059	0.000	0.000	91.000	M	7.62	0.234
	Σ	**12.350**						**7.62**	**0.234**
#46	1	6.480	0.048	0.000	0.000	91.000	M	4.00	0.123
	Σ	**6.480**						**4.00**	**0.123**
#11	1	151.040	0.223	0.000	0.000	91.000	M	47.50	2.304
	Σ	**151.040**						**47.50**	**2.304**
#10	1	34.470	0.114	0.000	0.000	91.000	M	21.26	0.653
	Σ	**34.470**						**21.26**	**0.653**
#9	1	69.790	0.147	0.000	0.000	91.000	M	24.50	1.077
	Σ	**69.790**						**24.50**	**1.077**
#8	1	28.530	0.100	0.000	0.000	91.000	M	17.59	0.541
	Σ	**28.530**						**17.59**	**0.541**
#7	1	201.870	0.448	0.000	0.000	90.400	M	41.14	2.806
	Σ	**201.870**						**41.14**	**2.806**
#44	1	201.750	0.552	0.000	0.000	91.000	M	39.39	3.053
	Σ	**687.450**						**109.25**	**10.434**
#36	1	12.330	0.045	0.000	0.000	91.000	M	7.60	0.234
	Σ	**12.330**						**7.60**	**0.234**
#21	1	63.380	0.148	0.000	0.000	91.000	M	22.25	0.978
	Σ	**63.380**						**22.25**	**0.978**
#13	1	25.880	0.150	0.000	0.000	91.000	M	9.09	0.399
	Σ	**25.880**						**9.09**	**0.399**
#12	1	78.130	0.143	0.000	0.000	91.000	M	27.43	1.206
	Σ	**78.130**						**27.43**	**1.206**
#27	1	210.960	0.549	0.000	0.000	75.700	M	0.64	0.104
	Σ	**1,078.130**						**116.58**	**13.355**
#45	1	15.500	0.077	0.000	0.000	91.000	M	9.56	0.294
	Σ	**1,093.630**						**112.69**	**13.649**
#25	1	343.070	0.737	0.000	0.000	87.300	M	30.20	3.005

Stru #	SWS #	SWS Area (ac)	Time of Conc (hrs)	Musk K (hrs)	Musk X	Curve Number	UHS	Peak Discharge (cfs)	Runoff Volume (ac-ft)
	Σ	**343.070**						**30.20**	**3.005**
#28	1	349.420	0.740	0.000	0.000	75.700	M	0.95	0.172
	2	221.000	0.613	0.253	0.339	75.700	M	0.64	0.109
	Σ	**2,045.020**						**140.41**	**17.653**
#23	1	192.200	0.380	0.000	0.000	75.700	M	0.66	0.095
	Σ	**27,456.620**						**210.14**	**81.062**
#24	1	201.360	0.410	0.000	0.000	90.400	M	43.31	2.807
	Σ	**27,657.980**						**208.20**	**83.869**

Subwatershed Sedimentology Detail:

Stru #	SWS #	Soil K	L (ft)	S (%)	C	P	PS #	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc (ml/l)	24VW (ml/l)
#35	1	0.220	125.00	9.30	0.3080	1.0000	2	17.1	50,992	29.67	18.54
	Σ							**17.1**	**1**	**0.00**	**0.00**
#26	1	0.209	75.00	12.70	0.3940	1.0000	3	279.9	90,188	3.65	2.45
	Σ							**279.9**	**90,188**	**3.65**	**2.45**
#29	1	0.210	150.00	7.20	0.3990	1.0000	3	27.2	60,426	15.69	10.32
	Σ							**276.6**	**79,527**	**2.17**	**1.43**
#43	1	0.183	200.00	3.30	0.3520	1.0000	2	19.6	7,597	2.11	1.60
	Σ							**19.6**	**7,597**	**2.11**	**1.60**
#22	1	0.205	100.00	11.40	0.3870	1.0000	3	163.9	76,981	0.26	0.18
	Σ							**163.9**	**76,981**	**0.26**	**0.18**
#30	1	0.207	200.00	3.70	0.2070	1.0000	3	28.2	15,955	0.88	0.58
	Σ							**193.1**	**54,797**	**1.64**	**0.62**
#19	1	0.187	150.00	7.70	0.3940	1.0000	2	117.2	34,113	16.54	11.87
	Σ							**117.2**	**34,113**	**16.54**	**11.87**
#33	**Σ**							**310.3**	**46,250**	**9.33**	**4.45**
#18	1	0.190	175.00	4.30	0.3150	1.0000	1	0.6	8,389	5.33	4.16
	Σ							**304.3**	**45,953**	**8.71**	**4.08**
#37	1	0.150	400.00	2.00	0.3220	1.0000	2	12.9	3,352	0.43	0.32
	Σ							**12.9**	**3,352**	**0.43**	**0.32**

Stru #	SWS #	Soil K	L (ft)	S (%)	C	P	PS #	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc (ml/l)	24VW (ml/l)
#4	1	0.160	400.00	2.00	0.3320	1.0000	2	8.0	5,768	2.21	1.66
	2	0.130	200.00	3.50	0.3070	1.0000	2	5.7	5,609	2.26	1.71
	3	0.147	200.00	3.70	0.2900	1.0000	2	4.3	6,128	2.57	1.95
	4	0.121	175.00	4.20	0.2900	1.0000	2	24.0	7,435	2.73	2.04
	Σ							**54.4**	**6,496**	**2.06**	**1.28**
#1	1	0.147	300.00	2.80	0.3070	1.0000	2	5.7	4,814	1.50	1.14
	Σ							**5.7**	**4,814**	**1.50**	**1.14**
#42	1	0.142	300.00	2.10	0.3360	1.0000	2	4.3	3,396	1.08	0.83
	2	0.167	400.00	1.20	0.3480	1.0000	2	9.7	3,064	0.60	0.45
	3	0.180	400.00	1.60	0.3370	1.0000	2	2.8	5,241	2.16	1.60
	Σ							**18.8**	**3,341**	**0.65**	**0.45**
#3	1	0.179	300.00	2.00	0.3420	1.0000	2	42.1	5,816	1.65	1.24
	Σ							**53.9**	**5,555**	**1.24**	**0.68**
#5	Σ							**108.3**	**5,986**	**1.62**	**0.94**
#6	1	0.170	200.00	3.30	0.3350	1.0000	2	1.6	4,808	2.44	1.90
	2	0.176	200.00	3.70	0.3370	1.0000	2	5.4	5,305	0.72	0.54
	3	0.196	100.00	10.70	0.3770	1.0000	3	193.2	34,494	0.00	0.00
	4	0.203	100.00	10.60	0.3800	1.0000	3	261.7	67,342	0.00	0.00
	Σ							**520.0**	**53,643**	**1.34**	**0.28**
#40	1	0.190	175.00	4.40	0.3150	1.0000	1	0.8	7,618	4.64	3.70
	2	0.210	150.00	7.20	0.3990	1.0000	3	44.4	61,057	15.85	10.87
	Σ							**1,145.2**	**60,279**	**4.71**	**1.33**
#34	1	0.109	300.00	2.60	0.3650	1.0000	2	0.1	2,459	1.35	1.05
	Σ							**0.1**	**2,459**	**1.35**	**1.05**
#16	1	0.120	400.00	1.70	0.3520	1.0000	2	1.5	2,465	1.29	1.00
	Σ							**1.5**	**2,465**	**1.29**	**1.00**
#14	1	0.175	400.00	1.30	0.3310	1.0000	2	8.4	2,601	0.33	0.26
	2	0.175	300.00	2.00	0.3170	1.0000	2	11.4	3,861	0.68	0.51
	3	0.189	175.00	4.70	0.3530	1.0000	2	85.8	18,241	7.74	5.67
	4	0.256	300.00	2.10	0.3050	1.0000	2	8.1	5,779	1.58	1.21
	Σ							**102.8**	**16,924**	**6.19**	**2.30**
#38	Σ							**104.4**	**16,512**	**6.08**	**2.24**
#39	Σ							**104.4**	**16,524**	**6.09**	**2.24**
#15	1	0.190	200.00	3.30	0.3150	1.0000	1	1.7	5,816	3.55	2.83

Stru #	SWS #	Soil K	L (ft)	S (%)	C	P	PS #	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc (ml/l)	24VW (ml/l)
	Σ							**106.1**	**16,263**	**6.05**	**2.26**
#41	Σ							**1,251.2**	**59,575**	**6.13**	**1.52**
#31	1	0.190	175.00	4.43	0.3150	1.0000	1	0.8	10,549	6.91	5.11
	Σ							**0.8**	**10,549**	**6.91**	**5.11**
#17	1	0.190	200.00	3.20	0.3150	1.0000	1	2.6	6,000	3.68	2.93
	2	0.197	150.00	6.30	0.2820	1.0000	2	15.9	24,920	13.85	9.30
	Σ							**17.2**	**23,748**	**12.93**	**6.21**
#32	1	0.190	300.00	3.00	0.3150	1.0000	1	0.4	5,964	3.80	2.96
	2	0.190	300.00	2.40	0.3150	1.0000	1	0.1	5,230	3.45	2.51
	Σ							**1,258.4**	**57,030**	**5.89**	**1.51**
#49	1	0.210	75.00	14.40	0.3990	1.0000	3	18.3	96,950	25.17	16.60
	Σ							**18.3**	**96,950**	**25.17**	**16.60**
#48	1	0.210	75.00	14.40	0.3990	1.0000	3	13.7	94,055	24.42	16.10
	Σ							**13.7**	**94,055**	**24.42**	**16.10**
#47	1	0.210	75.00	14.40	0.3990	1.0000	3	21.4	98,482	25.57	16.87
	Σ							**21.4**	**98,482**	**25.57**	**16.87**
#46	1	0.210	75.00	14.40	0.3990	1.0000	3	10.4	91,416	23.73	15.65
	Σ							**10.4**	**91,416**	**23.73**	**15.65**
#11	1	0.204	75.00	12.80	0.3960	1.0000	3	200.4	93,501	6.14	4.08
	Σ							**200.4**	**93,501**	**6.14**	**4.08**
#10	1	0.210	75.00	13.10	0.3990	1.0000	3	59.7	98,648	25.61	16.89
	Σ							**59.7**	**98,648**	**25.61**	**16.89**
#9	1	0.210	100.00	10.60	0.3990	1.0000	3	85.6	86,384	7.27	4.78
	Σ							**85.6**	**86,384**	**7.27**	**4.78**
#8	1	0.210	75.00	12.40	0.3990	1.0000	3	44.9	90,027	23.37	15.41
	Σ							**44.9**	**90,027**	**23.37**	**15.41**
#7	1	0.211	100.00	11.10	0.3920	1.0000	3	208.2	77,913	0.00	0.00
	Σ							**208.2**	**77,913**	**0.00**	**0.00**
#44	1	0.210	150.00	6.90	0.3990	1.0000	1	135.9	46,542	28.25	19.57
	Σ							**734.6**	**1,688,672**	**297.99**	**8.94**
#36	1	0.210	75.00	12.20	0.3990	1.0000	3	17.2	79,990	20.77	13.68
	Σ							**17.2**	**79,990**	**20.77**	**13.68**

Stru #	SWS #	Soil K	L (ft)	S (%)	C	P	PS #	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc (ml/l)	24VW (ml/l)
#21	1	0.210	75.00	14.40	0.3990	1.0000	3	97.3	107,240	9.03	5.95
	Σ							**97.3**	**107,240**	**9.03**	**5.95**
#13	1	0.210	150.00	6.90	0.3990	1.0000	3	18.9	52,250	4.40	2.88
	Σ							**18.9**	**52,250**	**4.40**	**2.88**
#12	1	0.201	150.00	8.00	0.3940	1.0000	3	71.0	64,654	5.44	3.57
	Σ							**71.0**	**64,654**	**5.44**	**3.57**
#27	1	0.190	150.00	6.70	0.3150	1.0000	1	1.4	12,820	8.18	6.35
	Σ							**939.1**	**2,424,866**	**385.72**	**8.05**
#45	1	0.190	175.00	5.90	0.3150	1.0000	1	9.7	36,574	25.55	16.77
	Σ							**916.3**	**89,723**	**12.75**	**6.88**
#25	1	0.186	100.00	10.46	0.3770	1.0000	3	141.9	48,521	0.00	0.00
	Σ							**141.9**	**48,521**	**0.00**	**0.00**
#28	1	0.190	175.00	5.90	0.3150	1.0000	1	2.2	12,079	7.58	5.98
	2	0.190	175.00	5.90	0.3150	1.0000	1	1.4	11,914	7.55	5.94
	Σ							**1,124.7**	**2,206,739**	**290.90**	**6.06**
#23	1	0.190	150.00	6.70	0.3150	1.0000	1	1.4	13,988	9.08	6.85
	Σ							**2,399.2**	**614,756**	**73.58**	**2.61**
#24	1	0.211	100.00	11.10	0.3920	1.0000	3	213.9	80,440	0.68	0.46
	Σ							**2,483.0**	**137,115**	**10.21**	**1.65**

Subwatershed Time of Concentration Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#1	1	5. Nearly bare and untilled, and alluvial valley fans	4.45	103.00	2,312.00	2.110	0.304
		8. Large gullies, diversions, and low flowing streams	2.03	110.00	5,414.45	4.270	0.352
		5. Nearly bare and untilled, and alluvial valley fans	1.57	97.00	6,194.12	1.250	1.376
#1	**1**	**Time of Concentration:**					**2.032**
#3	1	5. Nearly bare and untilled, and alluvial valley fans	1.32	140.00	10,633.45	1.140	2.590
		8. Large gullies, diversions, and low flowing streams	5.53	113.00	2,042.00	7.050	0.080
#3	**1**	**Time of Concentration:**					**2.670**
#4	1	5. Nearly bare and untilled, and alluvial valley fans	1.72	60.00	3,483.10	1.310	0.738

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
		8. Large gullies, diversions, and low flowing streams	1.45	94.00	6,477.39	3.610	0.498
#4	**1**	**Time of Concentration:**					**1.236**
#4	2	5. Nearly bare and untilled, and alluvial valley fans	5.90	110.00	1,863.01	2.420	0.213
		8. Large gullies, diversions, and low flowing streams	1.43	163.00	11,361.26	3.590	0.879
#4	**2**	**Time of Concentration:**					**1.092**
#4	3	5. Nearly bare and untilled, and alluvial valley fans	5.81	100.00	1,722.00	2.400	0.199
		8. Large gullies, diversions, and low flowing streams	2.04	248.00	12,174.16	4.280	0.790
#4	**3**	**Time of Concentration:**					**0.989**
#4	4	5. Nearly bare and untilled, and alluvial valley fans	4.95	105.00	2,123.01	2.220	0.265
		8. Large gullies, diversions, and low flowing streams	1.96	366.00	18,657.28	4.200	1.233
#4	**4**	**Time of Concentration:**					**1.498**
#6	1	5. Nearly bare and untilled, and alluvial valley fans	1.36	125.00	9,201.32	1.160	2.203
		8. Large gullies, diversions, and low flowing streams	3.46	94.00	2,715.03	5.580	0.135
#6	**1**	**Time of Concentration:**					**2.338**
#6	2	5. Nearly bare and untilled, and alluvial valley fans	0.88	130.00	14,813.12	0.930	4.424
		8. Large gullies, diversions, and low flowing streams	4.76	181.00	3,801.00	6.540	0.161
#6	**2**	**Time of Concentration:**					**4.585**
#6	3	5. Nearly bare and untilled, and alluvial valley fans	0.70	35.00	5,028.01	0.830	1.682
		8. Large gullies, diversions, and low flowing streams	2.49	228.00	9,161.04	4.730	0.537
#6	**3**	**Time of Concentration:**					**2.219**
#6	4	5. Nearly bare and untilled, and alluvial valley fans	4.17	73.00	1,752.02	2.040	0.238
		8. Large gullies, diversions, and low flowing streams	3.61	183.00	5,073.04	5.690	0.247
#6	**4**	**Time of Concentration:**					**0.485**
#7	1	5. Nearly bare and untilled, and alluvial valley fans	4.93	42.00	852.50	2.210	0.107
		8. Large gullies, diversions, and low flowing streams	2.93	185.00	6,312.20	5.130	0.341
#7	**1**	**Time of Concentration:**					**0.448**
#8	1	5. Nearly bare and untilled, and alluvial valley fans	5.03	12.00	238.70	2.240	0.029
		8. Large gullies, diversions, and low flowing streams	5.35	95.00	1,777.10	6.930	0.071
#8	**1**	**Time of Concentration:**					**0.100**

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#9	1	5. Nearly bare and untilled, and alluvial valley fans	20.30	20.00	98.50	4.500	0.006
		8. Large gullies, diversions, and low flowing streams	5.55	200.00	3,604.00	7.060	0.141
#9	**1**	**Time of Concentration:**					**0.147**
#10	1	5. Nearly bare and untilled, and alluvial valley fans	21.56	105.00	487.10	4.640	0.029
		8. Large gullies, diversions, and low flowing streams	4.91	100.00	2,035.10	6.650	0.085
#10	**1**	**Time of Concentration:**					**0.114**
#11	1	5. Nearly bare and untilled, and alluvial valley fans	14.06	45.00	320.00	3.750	0.023
		8. Large gullies, diversions, and low flowing streams	4.63	215.00	4,646.90	6.450	0.200
#11	**1**	**Time of Concentration:**					**0.223**
#12	1	5. Nearly bare and untilled, and alluvial valley fans	16.38	25.00	152.60	4.040	0.010
		8. Large gullies, diversions, and low flowing streams	5.07	165.00	3,254.40	6.750	0.133
#12	**1**	**Time of Concentration:**					**0.143**
#13	1	5. Nearly bare and untilled, and alluvial valley fans	3.47	27.00	777.50	1.860	0.116
		8. Large gullies, diversions, and low flowing streams	8.69	95.00	1,093.40	8.840	0.034
#13	**1**	**Time of Concentration:**					**0.150**
#14	1	5. Nearly bare and untilled, and alluvial valley fans	1.01	216.00	21,486.12	1.000	5.968
#14	**1**	**Time of Concentration:**					**5.968**
#14	2	5. Nearly bare and untilled, and alluvial valley fans	1.41	235.00	16,630.10	1.180	3.914
#14	**2**	**Time of Concentration:**					**3.914**
#14	3	5. Nearly bare and untilled, and alluvial valley fans	2.19	43.00	1,966.00	1.470	0.371
		8. Large gullies, diversions, and low flowing streams	1.60	105.00	6,562.00	3.790	0.480
		5. Nearly bare and untilled, and alluvial valley fans	1.08	23.00	2,124.12	1.040	0.567
#14	**3**	**Time of Concentration:**					**1.418**
#14	4	5. Nearly bare and untilled, and alluvial valley fans	1.08	112.00	10,345.00	1.040	2.763
#14	**4**	**Time of Concentration:**					**2.763**
#15	1	5. Nearly bare and untilled, and alluvial valley fans	1.51	43.00	2,851.08	1.220	0.649
		8. Large gullies, diversions, and low flowing streams	2.54	42.00	1,652.04	4.780	0.096
		8. Large gullies, diversions, and low flowing streams	1.03	42.00	4,065.04	3.040	0.371
#15	**1**	**Time of Concentration:**					**1.116**

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#16	1	5. Nearly bare and untilled, and alluvial valley fans	1.30	105.00	8,103.10	1.130	1.991
		8. Large gullies, diversions, and low flowing streams	0.15	6.00	3,981.42	1.160	0.953
#16	**1**	**Time of Concentration:**					**2.944**
#17	1	5. Nearly bare and untilled, and alluvial valley fans	2.55	70.00	2,746.30	1.590	0.479
		8. Large gullies, diversions, and low flowing streams	1.66	137.00	8,228.09	3.870	0.590
#17	**1**	**Time of Concentration:**					**1.069**
#17	2	5. Nearly bare and untilled, and alluvial valley fans	4.36	149.00	3,419.07	2.080	0.456
#17	**2**	**Time of Concentration:**					**0.456**
#18	1	5. Nearly bare and untilled, and alluvial valley fans	2.56	25.00	977.70	1.590	0.170
		8. Large gullies, diversions, and low flowing streams	1.06	50.00	4,705.29	3.090	0.422
#18	**1**	**Time of Concentration:**					**0.592**
#19	1	5. Nearly bare and untilled, and alluvial valley fans	4.92	45.00	914.00	2.210	0.114
		8. Large gullies, diversions, and low flowing streams	2.64	185.00	7,019.00	4.870	0.400
		5. Nearly bare and untilled, and alluvial valley fans	1.12	21.00	1,872.15	1.050	0.495
#19	**1**	**Time of Concentration:**					**1.009**
#21	1	5. Nearly bare and untilled, and alluvial valley fans	9.77	30.00	307.10	3.120	0.027
		8. Large gullies, diversions, and low flowing streams	4.96	145.00	2,924.38	6.680	0.121
#21	**1**	**Time of Concentration:**					**0.148**
#22	1	5. Nearly bare and untilled, and alluvial valley fans	4.15	54.00	1,300.01	2.030	0.177
		8. Large gullies, diversions, and low flowing streams	3.22	155.00	4,807.09	5.380	0.248
#22	**1**	**Time of Concentration:**					**0.425**
#23	1	5. Nearly bare and untilled, and alluvial valley fans	6.91	43.00	622.00	2.620	0.065
		8. Large gullies, diversions, and low flowing streams	2.65	147.00	5,545.07	4.880	0.315
#23	**1**	**Time of Concentration:**					**0.380**
#24	1	5. Nearly bare and untilled, and alluvial valley fans	5.30	55.00	1,038.01	2.300	0.125
		8. Large gullies, diversions, and low flowing streams	3.06	191.00	6,252.04	5.240	0.331
#24	**1**	**Time of Concentration:**					**0.410**
#25	1	5. Nearly bare and untilled, and alluvial valley fans	3.47	55.00	1,583.00	1.860	0.236
		8. Large gullies, diversions, and low flowing streams	3.07	291.00	9,483.00	5.250	0.501

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#25	**1**	**Time of Concentration:**					**0.737**
#26	1	5. Nearly bare and untilled, and alluvial valley fans	9.72	75.00	772.00	3.110	0.068
		8. Large gullies, diversions, and low flowing streams	3.54	175.00	4,938.06	5.640	0.243
#26	**1**	**Time of Concentration:**					**0.311**
#27	1	5. Nearly bare and untilled, and alluvial valley fans	4.62	22.00	475.80	2.150	0.061
		8. Large gullies, diversions, and low flowing streams	1.58	105.00	6,636.00	3.770	0.488
#27	**1**	**Time of Concentration:**					**0.549**
#28	1	5. Nearly bare and untilled, and alluvial valley fans	2.41	30.00	1,246.00	1.550	0.223
		8. Large gullies, diversions, and low flowing streams	1.19	72.00	6,071.40	3.260	0.517
#28	**1**	**Time of Concentration:**					**0.740**
#28	2	5. Nearly bare and untilled, and alluvial valley fans	8.54	125.00	1,463.00	2.920	0.139
		8. Large gullies, diversions, and low flowing streams	0.78	35.00	4,506.00	2.640	0.474
#28	**2**	**Time of Concentration:**					**0.613**
#29	1	8. Large gullies, diversions, and low flowing streams	3.10	49.00	1,581.61	5.280	0.083
#29	**1**	**Time of Concentration:**					**0.083**
#30	1	5. Nearly bare and untilled, and alluvial valley fans	5.85	40.00	684.20	2.410	0.078
		8. Large gullies, diversions, and low flowing streams	2.10	55.00	2,622.00	4.340	0.167
#30	**1**	**Time of Concentration:**					**0.245**
#31	1	5. Nearly bare and untilled, and alluvial valley fans	2.79	25.00	895.90	1.670	0.149
		9. Small streams flowing bankfull	1.16	60.00	5,192.70	9.670	0.149
#31	**1**	**Time of Concentration:**					**0.298**
#32	1	5. Nearly bare and untilled, and alluvial valley fans	5.14	35.00	681.00	2.260	0.083
		8. Large gullies, diversions, and low flowing streams	2.98	88.00	2,957.08	5.170	0.158
		5. Nearly bare and untilled, and alluvial valley fans	1.83	28.00	1,528.05	1.350	0.314
#32	**1**	**Time of Concentration:**					**0.555**
#32	2	8. Large gullies, diversions, and low flowing streams	0.96	25.00	2,601.10	2.940	0.245
#32	**2**	**Time of Concentration:**					**0.245**
#34	1	5. Nearly bare and untilled, and alluvial valley fans	1.50	164.00	10,964.76	1.220	2.496
#34	**1**	**Time of Concentration:**					**2.496**
#35	1	8. Large gullies, diversions, and low flowing streams	3.24	144.00	4,442.11	5.400	0.228

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
		5. Nearly bare and untilled, and alluvial valley fans	8.78	26.00	296.00	2.960	0.027
#35	**1**	**Time of Concentration:**					**0.255**
#36	1	5. Nearly bare and untilled, and alluvial valley fans	8.73	20.00	229.10	2.950	0.021
		8. Large gullies, diversions, and low flowing streams	9.39	75.00	798.50	9.190	0.024
#36	**1**	**Time of Concentration:**					**0.045**
#37	1	5. Nearly bare and untilled, and alluvial valley fans	1.16	240.00	20,629.19	1.070	5.355
#37	**1**	**Time of Concentration:**					**5.355**
#40	1	5. Nearly bare and untilled, and alluvial valley fans	3.09	22.00	711.21	1.750	0.112
		8. Large gullies, diversions, and low flowing streams	0.66	61.00	9,198.59	2.440	1.047
#40	**1**	**Time of Concentration:**					**1.159**
#40	2	8. Large gullies, diversions, and low flowing streams	5.10	103.00	2,019.72	6.770	0.082
#40	**2**	**Time of Concentration:**					**0.082**
#42	1	5. Nearly bare and untilled, and alluvial valley fans	3.45	93.00	2,694.01	1.850	0.404
		8. Large gullies, diversions, and low flowing streams	2.37	100.00	4,211.05	4.620	0.253
		5. Nearly bare and untilled, and alluvial valley fans	1.17	103.00	8,811.70	1.080	2.266
#42	**1**	**Time of Concentration:**					**2.923**
#42	2	5. Nearly bare and untilled, and alluvial valley fans	0.62	63.00	10,166.21	0.780	3.620
#42	**2**	**Time of Concentration:**					**3.620**
#42	3	5. Nearly bare and untilled, and alluvial valley fans	1.24	60.00	4,853.19	1.110	1.214
#42	**3**	**Time of Concentration:**					**1.214**
#43	1	5. Nearly bare and untilled, and alluvial valley fans	1.12	93.00	8,290.98	1.050	2.193
		8. Large gullies, diversions, and low flowing streams	3.42	185.00	5,404.14	5.550	0.270
#43	**1**	**Time of Concentration:**					**2.463**
#44	1	5. Nearly bare and untilled, and alluvial valley fans	9.26	17.00	183.60	3.040	0.016
		8. Large gullies, diversions, and low flowing streams	1.63	120.00	7,383.30	3.820	0.536
#44	**1**	**Time of Concentration:**					**0.552**
#45	1	5. Nearly bare and untilled, and alluvial valley fans	4.08	17.00	416.50	2.020	0.057
		8. Large gullies, diversions, and low flowing streams	2.47	135.00	5,464.70	4.710	0.322
#45	**1**	**Time of Concentration:**					**0.077**

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#46	1	5. Nearly bare and untilled, and alluvial valley fans	6.02	15.00	249.00	2.450	0.028
		8. Large gullies, diversions, and low flowing streams	9.50	65.00	684.00	9.240	0.020
#46	**1**	**Time of Concentration:**					**0.048**
#47	1	5. Nearly bare and untilled, and alluvial valley fans	9.17	30.00	327.00	3.020	0.030
		8. Large gullies, diversions, and low flowing streams	8.13	75.00	923.00	8.550	0.029
#47	**1**	**Time of Concentration:**					**0.059**
#48	1	5. Nearly bare and untilled, and alluvial valley fans	9.77	26.00	266.00	3.120	0.023
		8. Large gullies, diversions, and low flowing streams	9.93	75.00	755.00	9.450	0.022
#48	**1**	**Time of Concentration:**					**0.045**
#49	1	5. Nearly bare and untilled, and alluvial valley fans	11.84	45.00	380.00	3.440	0.030
		8. Large gullies, diversions, and low flowing streams	8.50	95.00	1,117.00	8.740	0.035
#49	**1**	**Time of Concentration:**					**0.065**

Subwatershed Muskingum Routing Details:

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
#4	1	8. Large gullies, diversions, and low flowing streams	1.61	93.00	5,787.18	3.800	0.423
#4	**1**	**Muskingum K:**					**0.423**
#4	2	8. Large gullies, diversions, and low flowing streams	1.61	93.00	5,787.18	3.800	0.423
#4	**2**	**Muskingum K:**					**0.423**
#4	3	8. Large gullies, diversions, and low flowing streams	1.61	93.00	5,787.00	3.800	0.423
#4	**3**	**Muskingum K:**					**0.423**
#6	1	8. Large gullies, diversions, and low flowing streams	1.16	84.00	7,218.35	3.230	0.620
#6	**1**	**Muskingum K:**					**0.620**
#6	2	8. Large gullies, diversions, and low flowing streams	0.77	35.00	4,531.33	2.630	0.478
#6	**2**	**Muskingum K:**					**0.478**
#6	4	8. Large gullies, diversions, and low flowing streams	0.77	35.00	4,531.33	2.630	0.478
#6	**4**	**Muskingum K:**					**0.478**
#14	1	5. Nearly bare and untilled, and alluvial valley fans	0.99	153.00	15,503.09	0.990	4.349
		8. Large gullies, diversions, and low flowing streams	1.65	125.00	7,564.29	3.850	0.545

Stru #	SWS #	Land Flow Condition	Slope (%)	Vert. Dist. (ft)	Horiz. Dist. (ft)	Velocity (fps)	Time (hrs)
		5. Nearly bare and untilled, and alluvial valley fans	1.08	23.00	2,124.12	1.040	0.567
#14	**1**	**Muskingum K:**					**5.461**
#14	2	8. Large gullies, diversions, and low flowing streams	1.65	125.00	7,564.29	3.850	0.545
		5. Nearly bare and untilled, and alluvial valley fans	1.46	11.00	755.02	1.200	0.174
		5. Nearly bare and untilled, and alluvial valley fans	1.08	23.00	2,124.12	1.040	0.567
#14	**2**	**Muskingum K:**					**1.286**
#14	4	5. Nearly bare and untilled, and alluvial valley fans	2.19	43.00	1,966.00	1.470	0.371
		8. Large gullies, diversions, and low flowing streams	1.60	105.00	6,562.00	3.790	0.480
		5. Nearly bare and untilled, and alluvial valley fans	1.08	23.00	2,124.00	1.040	0.567
#14	**4**	**Muskingum K:**					**1.418**
#17	1	5. Nearly bare and untilled, and alluvial valley fans	1.80	62.00	3,443.10	1.340	0.713
#17	**1**	**Muskingum K:**					**0.713**
#28	2	8. Large gullies, diversions, and low flowing streams	1.43	47.00	3,281.00	3.590	0.253
#28	**2**	**Muskingum K:**					**0.253**
#32	1	8. Large gullies, diversions, and low flowing streams	1.18	15.00	1,268.00	3.260	0.108
#32	**1**	**Muskingum K:**					**0.108**
#40	2	8. Large gullies, diversions, and low flowing streams	0.75	53.00	7,067.40	2.590	0.757
#40	**2**	**Muskingum K:**					**0.757**
#42	1	5. Nearly bare and untilled, and alluvial valley fans	0.48	37.00	7,646.20	0.690	3.078
#42	**1**	**Muskingum K:**					**3.078**

General Information

Storm Information:

Storm Type:	NRCS TYPE II-70
Design Storm:	10 yr - 6 hr
Rainfall Depth:	1.300 inches

Particle Size Distribution:

Size (mm)	PostMine-LoamySand	PreMine-LoamySand	PreMine-Badlands	LoamySand Postmining
2.0000	100.000%	100.000%	100.000%	0.000%
0.1000	26.500%	30.000%	83.500%	0.000%
0.0500	14.000%	17.000%	77.000%	0.000%
0.0020	11.000%	11.000%	56.000%	0.000%
0.0010	0.000%	0.000%	0.000%	0.000%

Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc. (ml/l)	24VW (ml/l)
#35	105.000	105.000	34.94	1.78	100.6	62,899	38.87	25.23
#26	217.200	217.200	149.15	8.41	794.3	97,572	6.23	4.30
#29	26.000	243.200	142.24	9.66	788.8	86,948	4.57	3.07
#43	809.500	809.500	50.81	12.47	124.7	9,912	3.52	2.60
#22	163.500	163.500	90.71	5.94	490.1	85,154	2.88	2.00
#30	142.400	1,115.400	114.77	23.61	696.9	63,391	6.07	2.05
#19	451.400	451.400	97.46	11.47	462.7	40,773	21.43	15.38
#33	0.000	1,566.800	210.54	35.08	1,159.7	52,716	14.09	6.41
#18	126.600	1,693.400	204.67	36.02	1,150.1	52,159	13.53	6.01
#37	3,024.600	3,024.600	65.38	30.93	140.2	4,485	0.59	0.44
#4	2,965.700	5,990.300	242.29	68.42	479.8	9,006	3.20	1.83
#1	755.100	755.100	38.31	8.32	57.7	6,877	2.52	1.87
#42	2,360.600	3,115.700	81.86	37.34	146.5	4,130	0.86	0.60
#3	1,550.000	4,665.700	131.14	66.55	305.8	6,911	1.74	0.85
#5	0.000	10,656.000	329.74	134.97	785.6	8,285	2.61	1.35
#6	2,008.700	12,664.700	432.28	173.35	2,264.0	59,995	6.02	0.95
#40	231.000	14,832.300	504.75	222.39	4,336.9	795,191	110.81	1.98
#34	235.300	235.300	5.37	1.44	5.9	4,019	1.15	0.86
#16	1,570.700	1,570.700	35.51	10.69	41.7	3,811	0.98	0.73
#14	6,695.200	6,695.200	109.82	77.36	535.7	18,635	6.54	1.80
#38	0.000	8,501.199	140.79	89.49	583.4	14,969	5.14	1.66
#39	0.000	8,501.199	140.24	89.49	583.4	217,474	74.72	1.66
#15	539.400	9,040.600	147.33	93.50	615.0	14,460	4.98	1.68
#41	0.000	23,872.900	614.96	315.89	4,951.8	48,313	7.96	1.89
#31	148.400	148.400	18.25	1.11	25.3	26,137	15.80	10.09
#17	939.500	939.500	46.09	8.66	109.7	25,571	11.91	4.31
#32	153.600	25,114.400	626.48	326.80	5,053.6	42,558	7.18	1.91
#49	10.780	10.780	14.67	0.52	48.3	93,379	24.24	17.13
#48	8.290	8.290	11.28	0.40	36.0	90,587	23.52	16.61
#47	12.350	12.350	16.81	0.60	56.2	94,857	24.63	17.40
#46	6.480	6.480	8.82	0.31	27.3	88,042	22.86	16.14
#11	151.040	151.040	116.50	5.87	559.4	98,332	8.20	5.66
#10	34.470	34.470	46.91	1.67	157.1	95,018	24.67	17.43
#9	69.790	69.790	59.15	2.75	236.7	89,525	8.85	6.09
#8	28.530	28.530	38.83	1.38	118.2	86,703	22.51	15.89
#7	201.870	201.870	109.73	7.38	619.6	86,357	2.51	1.74
#44	201.750	687.450	284.09	26.82	2,082.5	1,873,682	361.94	10.76

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc. (ml/l)	24VW (ml/l)
#36	12.330	12.330	16.78	0.60	45.2	77,024	20.00	14.11
#21	63.380	63.380	53.71	2.49	269.2	111,105	10.99	7.57
#13	25.880	25.880	21.93	1.02	52.3	54,178	5.36	3.67
#12	78.130	78.130	66.21	3.07	196.5	67,028	6.63	4.55
#27	210.960	1,078.130	311.57	35.57	2,682.3	243,209	43.85	9.78
#45	15.500	1,093.630	302.97	36.32	2,630.0	92,889	15.52	8.70
#25	343.070	343.070	100.61	9.41	527.5	57,160	0.00	0.00
#28	570.420	2,045.020	407.64	51.80	3,424.2	2,287,178	356.79	7.43
#23	192.200	27,456.620	674.75	381.81	8,614.4	177,504	30.26	2.81
#24	201.360	27,657.980	669.44	389.19	8,920.2	88,242	12.16	2.30

General Information

Storm Information:

Storm Type:	NRCS TYPE II-70
Design Storm:	25 yr - 6 hr
Rainfall Depth:	1.600 inches

Particle Size Distribution:

Size (mm)	PostMine-LoamySand	PreMine-LoamySand	PreMine-Badlands	LoamySand Postmining
2.0000	100.000%	100.000%	100.000%	0.000%
0.1000	26.500%	30.000%	83.500%	0.000%
0.0500	14.000%	17.000%	77.000%	0.000%
0.0020	11.000%	11.000%	56.000%	0.000%
0.0010	0.000%	0.000%	0.000%	0.000%

Structure Summary:

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc. (ml/l)	24VW (ml/l)
#35	105.000	105.000	57.19	2.92	175.0	65,337	40.85	27.02
#26	217.200	217.200	209.64	11.90	1,167.5	100,297	7.19	5.01
#29	26.000	243.200	200.98	13.68	1,164.2	90,017	5.54	3.75
#43	809.500	809.500	86.70	20.82	224.1	10,709	4.06	2.99
#22	163.500	163.500	130.15	8.49	733.0	88,436	3.90	2.72
#30	142.400	1,115.400	168.73	36.76	1,079.3	63,984	7.53	2.50
#19	451.400	451.400	150.53	17.44	746.5	43,169	23.21	16.68
#33	0.000	1,566.800	316.59	54.20	1,825.7	54,023	15.63	7.07
#18	126.600	1,693.400	309.21	56.05	1,820.5	52,623	14.91	6.68
#37	3,024.600	3,024.600	120.74	56.36	276.6	4,874	0.80	0.60
#4	2,965.700	5,990.300	437.19	121.49	918.7	9,824	3.70	2.09
#1	755.100	755.100	71.15	14.91	113.2	7,576	2.99	2.20
#42	2,360.600	3,115.700	142.66	65.47	273.7	4,410	0.98	0.69
#3	1,550.000	4,665.700	213.99	112.38	537.6	7,374	1.94	0.93
#5	0.000	10,656.000	577.74	233.86	1,456.3	9,072	3.04	1.53
#6	2,008.700	12,664.700	739.33	294.25	3,804.5	61,725	8.28	1.26
#40	231.000	14,832.300	851.67	369.52	6,996.2	53,925	8.94	2.28
#34	235.300	235.300	11.61	2.98	13.7	4,536	1.46	1.08
#16	1,570.700	1,570.700	73.96	21.50	93.0	4,259	1.24	0.93
#14	6,695.200	6,695.200	196.17	136.53	956.9	19,869	6.86	1.79
#38	0.000	8,501.199	242.86	161.01	1,063.6	14,996	5.10	1.67
#39	0.000	8,501.199	242.05	161.01	1,063.6	15,098	5.14	1.67
#15	539.400	9,040.600	254.95	168.89	1,121.1	14,345	4.86	1.67
#41	0.000	23,872.900	1,050.10	538.41	8,117.4	46,562	8.83	2.09
#31	148.400	148.400	38.39	2.18	56.0	29,012	18.01	11.65
#17	939.500	939.500	93.50	16.00	216.1	27,812	13.52	4.80
#32	153.600	25,114.400	1,070.33	558.84	8,340.4	40,006	7.83	2.14
#49	10.780	10.780	19.69	0.74	69.1	92,209	23.94	17.33
#48	8.290	8.290	15.14	0.57	51.5	89,451	23.22	16.81
#47	12.350	12.350	22.56	0.84	80.5	93,669	24.32	17.60
#46	6.480	6.480	11.84	0.44	39.1	86,936	22.57	16.33
#11	151.040	151.040	163.03	8.31	820.2	100,690	9.10	6.34
#10	34.470	34.470	62.96	2.36	225.0	93,828	24.36	17.63
#9	69.790	69.790	81.69	3.89	344.5	90,501	9.81	6.86
#8	28.530	28.530	52.11	1.95	169.4	85,613	22.23	16.08
#7	201.870	201.870	157.34	10.54	925.7	89,759	3.55	2.48
#44	201.750	687.450	408.59	38.06	3,064.5	1,801,850	360.50	11.55

	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc. (ml/l)	24VW (ml/l)
#36	12.330	12.330	22.52	0.84	64.8	76,052	19.75	14.28
#21	63.380	63.380	74.19	3.53	391.8	112,304	12.17	8.52
#13	25.880	25.880	30.29	1.44	76.2	54,777	5.94	4.14
#12	78.130	78.130	91.45	4.35	286.1	67,765	7.35	5.13
#27	210.960	1,078.130	448.66	51.31	3,968.0	2,438,567	465.81	10.61
#45	15.500	1,093.630	436.41	52.37	3,894.9	87,692	15.67	9.55
#25	343.070	343.070	152.70	14.12	836.3	60,115	0.00	0.00
#28	570.420	2,045.020	602.66	77.42	5,194.0	2,257,277	382.39	8.19
#23	192.200	27,456.620	1,109.14	641.99	13,792.6	631,058	122.18	3.04
#24	201.360	27,657.980	1,104.33	652.53	14,331.9	91,220	15.21	2.67

General Information

Storm Information:

Storm Type:	NRCS TYPE II-70
Design Storm:	100 yr - 6 hr
Rainfall Depth:	2.000 inches

Particle Size Distribution:

Size (mm)	PostMine-LoamySand	PreMine-LoamySand	PreMine-Badlands	LoamySand Postmining
2.0000	100.000%	100.000%	100.000%	0.000%
0.1000	26.500%	30.000%	83.500%	0.000%
0.0500	14.000%	17.000%	77.000%	0.000%
0.0020	11.000%	11.000%	56.000%	0.000%
0.0010	0.000%	0.000%	0.000%	0.000%

Structure Summary:

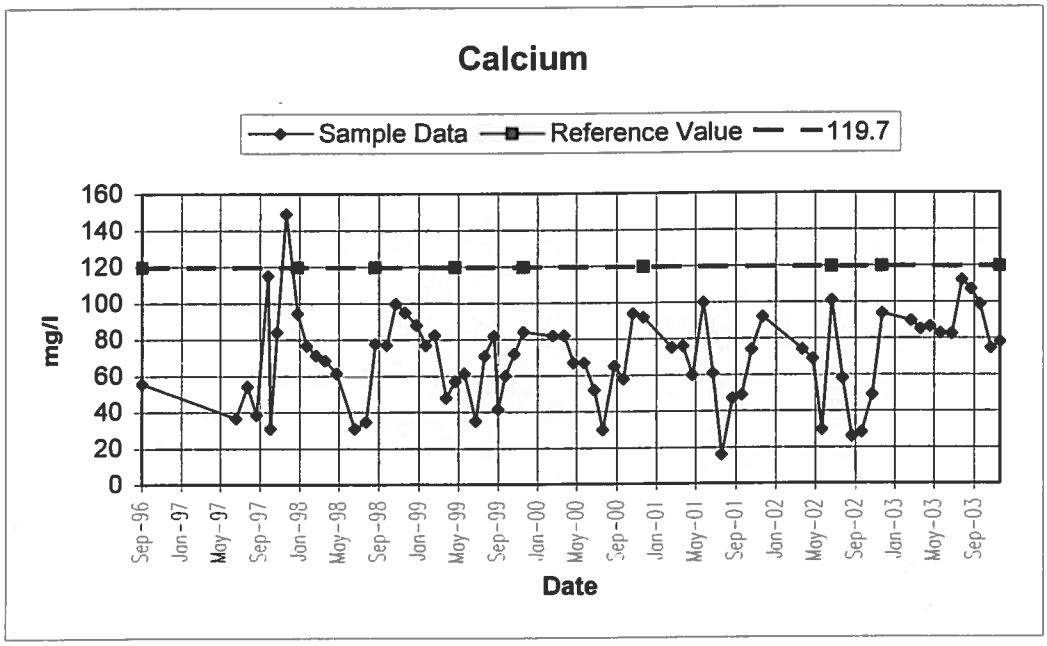
	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc. (ml/l)	24VW (ml/l)
#35	105.000	105.000	90.41	4.68	294.7	67,189	42.39	28.59
#26	217.200	217.200	293.53	16.84	1,712.3	102,780	8.09	5.69
#29	26.000	243.200	282.87	19.36	1,714.3	93,056	6.48	4.40
#43	809.500	809.500	143.18	33.86	389.7	11,471	4.58	3.37
#22	163.500	163.500	185.62	12.13	1,092.0	91,488	4.87	3.42
#30	142.400	1,115.400	247.35	56.63	1,662.4	64,764	8.95	2.94
#19	451.400	451.400	229.24	26.27	1,188.2	45,487	24.94	17.96
#33	0.000	1,566.800	472.33	82.90	2,850.7	55,253	17.07	7.70
#18	126.600	1,693.400	464.22	86.30	2,848.6	53,606	16.26	7.26
#37	3,024.600	3,024.600	212.29	97.91	516.9	5,262	1.04	0.78
#4	2,965.700	5,990.300	754.26	207.15	1,678.1	10,606	4.22	2.36
#1	755.100	755.100	125.01	25.58	210.0	8,215	3.43	2.52
#42	2,360.600	3,115.700	240.07	110.64	497.6	4,766	1.16	0.80
#3	1,550.000	4,665.700	341.85	184.57	924.0	7,844	2.16	1.01
#5	0.000	10,656.000	976.83	391.72	2,602.1	9,817	3.48	1.73
#6	2,008.700	12,664.700	1,228.78	485.77	6,276.6	63,341	10.31	1.53
#40	231.000	14,832.300	1,400.49	600.43	11,161.1	67,647	12.78	2.55
#34	235.300	235.300	22.80	5.65	28.7	5,038	1.78	1.32
#16	1,570.700	1,570.700	141.75	40.02	189.6	4,698	1.52	1.13
#14	6,695.200	6,695.200	336.25	231.98	1,659.7	21,089	7.20	1.81
#38	0.000	8,501.199	407.42	277.65	1,877.9	15,109	5.14	1.71
#39	0.000	8,501.199	406.29	277.65	1,877.9	322,705	109.71	1.71
#15	539.400	9,040.600	428.54	292.09	1,989.1	14,393	4.88	1.71
#41	0.000	23,872.900	1,743.15	892.52	13,150.2	44,696	9.45	2.28
#31	148.400	148.400	72.81	3.99	112.6	31,382	19.86	13.00
#17	939.500	939.500	175.15	28.18	402.9	29,770	14.97	5.25
#32	153.600	25,114.400	1,776.95	928.81	13,594.1	37,591	8.26	2.36
#49	10.780	10.780	26.44	1.04	99.0	91,072	23.64	17.54
#48	8.290	8.290	20.33	0.80	73.8	88,347	22.94	17.01
#47	12.350	12.350	30.29	1.20	115.3	92,515	24.02	17.82
#46	6.480	6.480	15.89	0.63	56.0	85,862	22.29	16.53
#11	151.040	151.040	227.39	11.76	1,200.4	102,828	9.93	7.00
#10	34.470	34.470	84.55	3.34	322.4	92,672	24.06	17.85
#9	69.790	69.790	112.64	5.50	500.9	91,390	10.83	7.70
#8	28.530	28.530	69.98	2.76	242.7	84,555	21.95	16.28
#7	201.870	201.870	224.36	15.03	1,377.8	92,955	4.55	3.20
#44	201.750	687.450	584.88	53.99	4,500.7	1,682,639	347.57	12.34

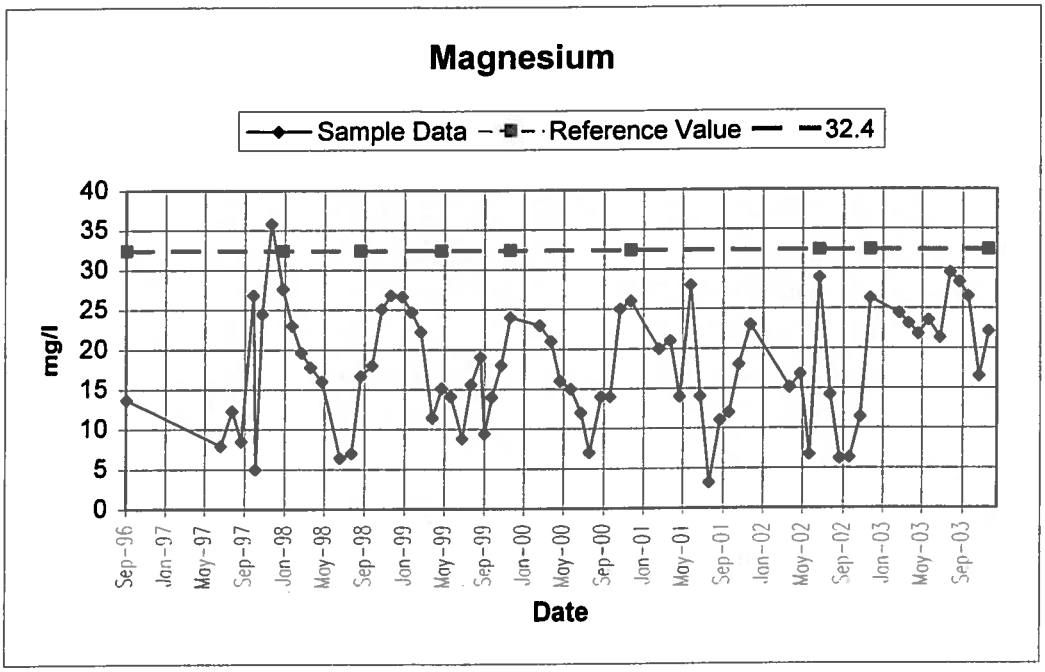
	Immediate Contributing Area (ac)	Total Contributing Area (ac)	Peak Discharge (cfs)	Total Runoff Volume (ac-ft)	Sediment (tons)	Peak Sediment Conc. (mg/l)	Peak Settleable Conc. (ml/l)	24VW (ml/l)
#36	12.330	12.330	30.24	1.19	92.8	75,109	19.50	14.45
#21	63.380	63.380	102.30	4.99	569.7	113,398	13.43	9.57
#13	25.880	25.880	41.77	2.04	110.8	55,323	6.55	4.65
#12	78.130	78.130	126.11	6.16	416.0	68,437	8.11	5.75
#27	210.960	1,078.130	643.72	74.02	5,864.9	2,424,149	489.40	11.49
#45	15.500	1,093.630	627.59	75.52	5,769.6	86,816	16.59	10.50
#25	343.070	343.070	228.94	21.03	1,311.3	62,941	0.00	0.00
#28	570.420	2,045.020	888.17	115.51	7,876.5	2,312,423	424.95	9.03
#23	192.200	27,456.620	1,830.13	1,054.15	21,937.1	1,446,411	311.34	3.27
#24	201.360	27,657.980	1,821.22	1,069.19	22,819.8	93,869	18.02	2.99

Appendix 18.T

Surface Water Quality Monitoring Data Analysis for Stations CD-1 & CD-2 (1996-2003)

SURFACE WATER MONITORING DATA





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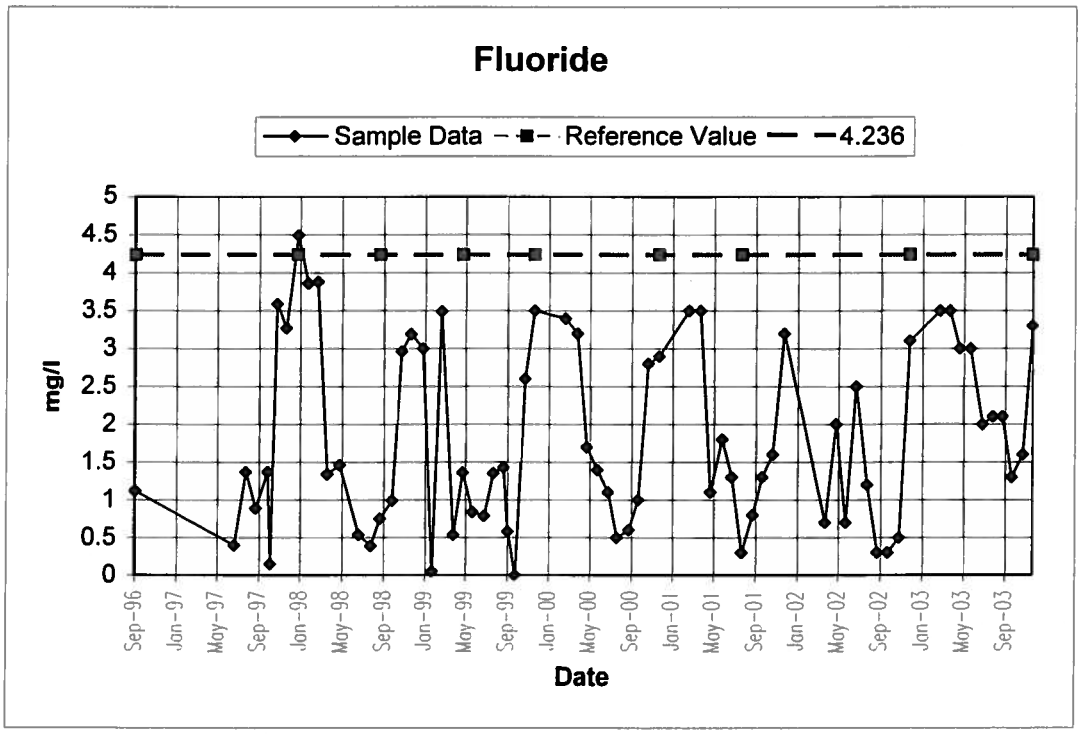
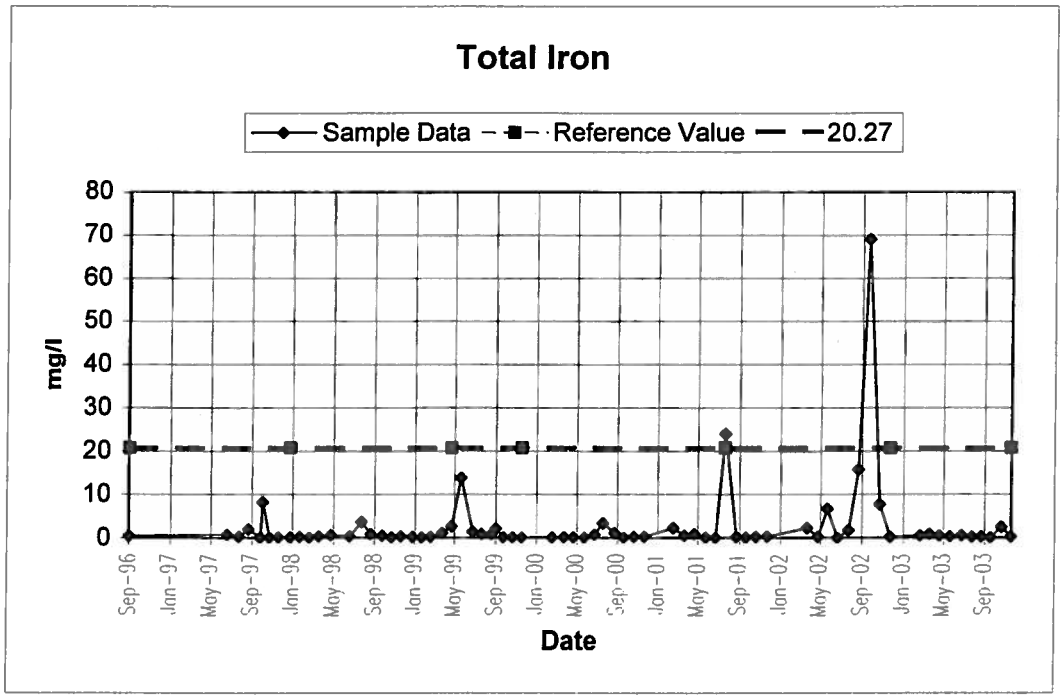
SURFACE WATER MONITORING DATA





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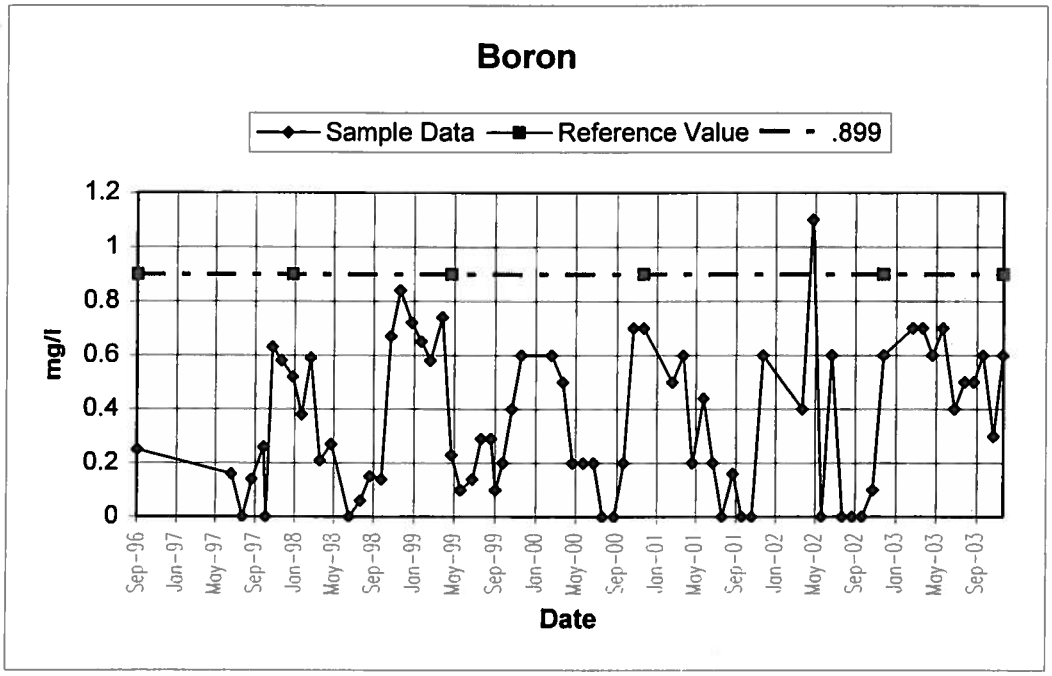
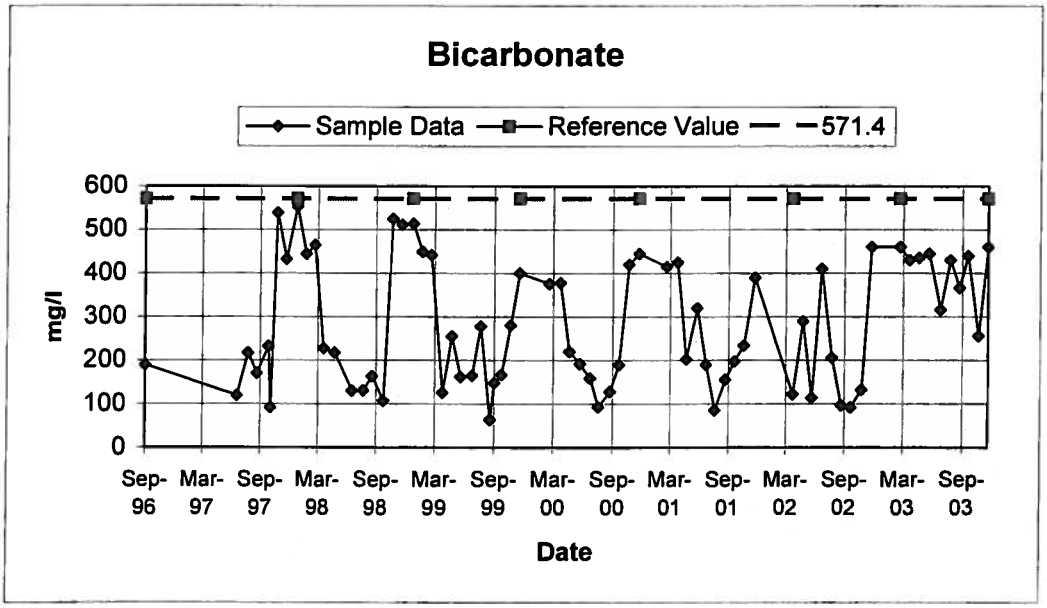
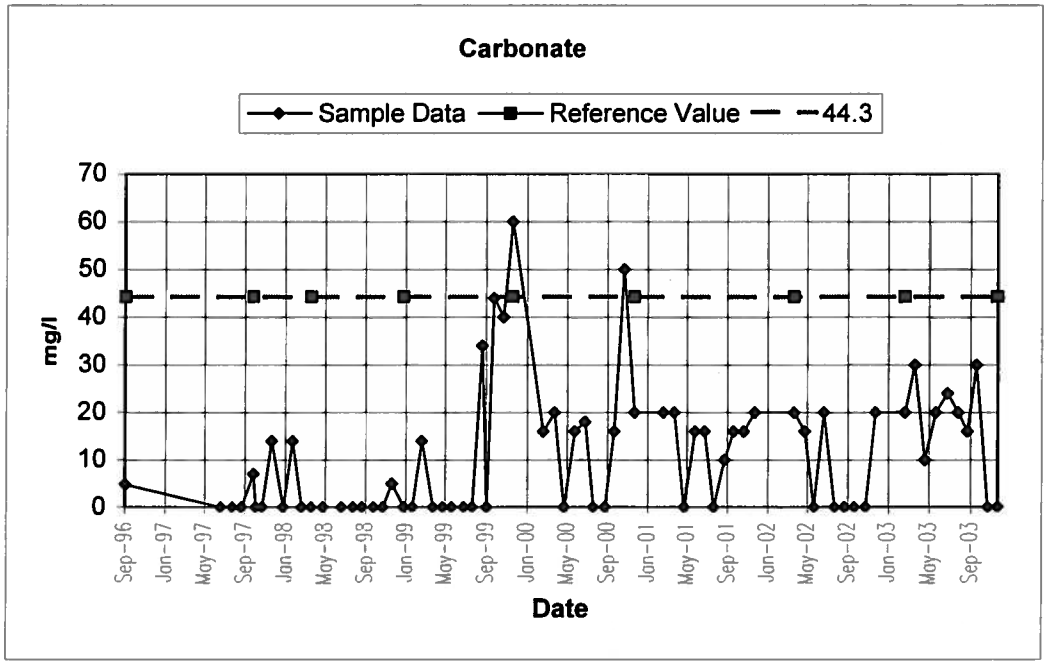
SURFACE WATER MONITORING DATA

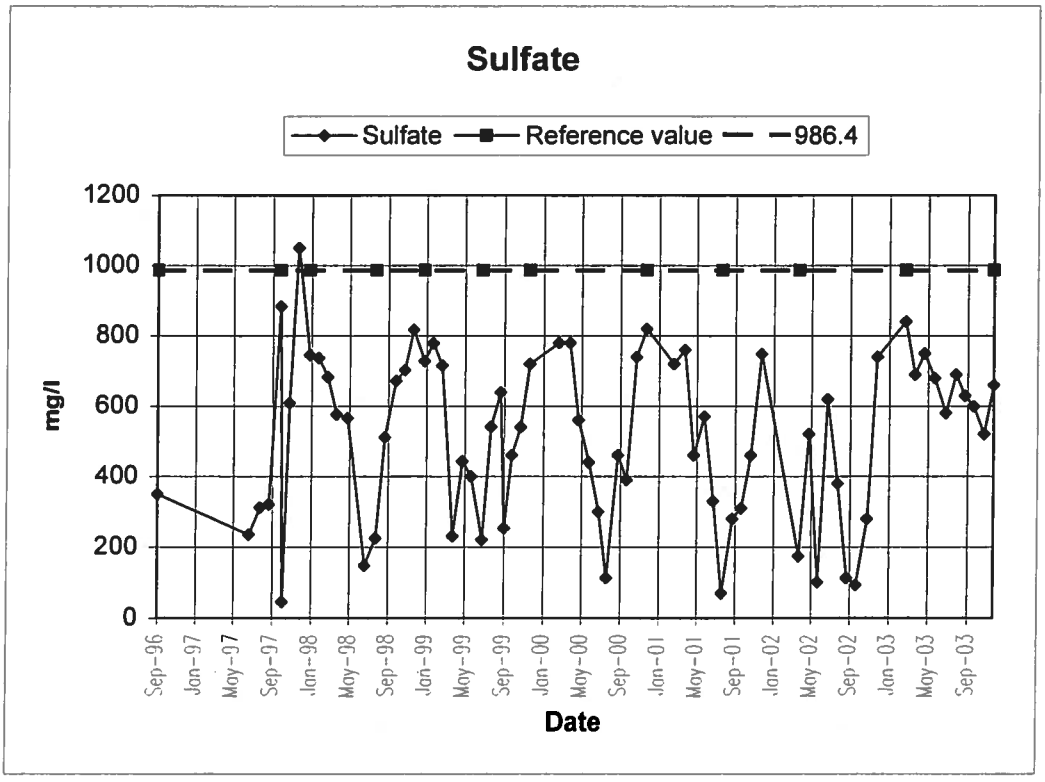




(5/04)

SURFACE WATER MONITORING DATA





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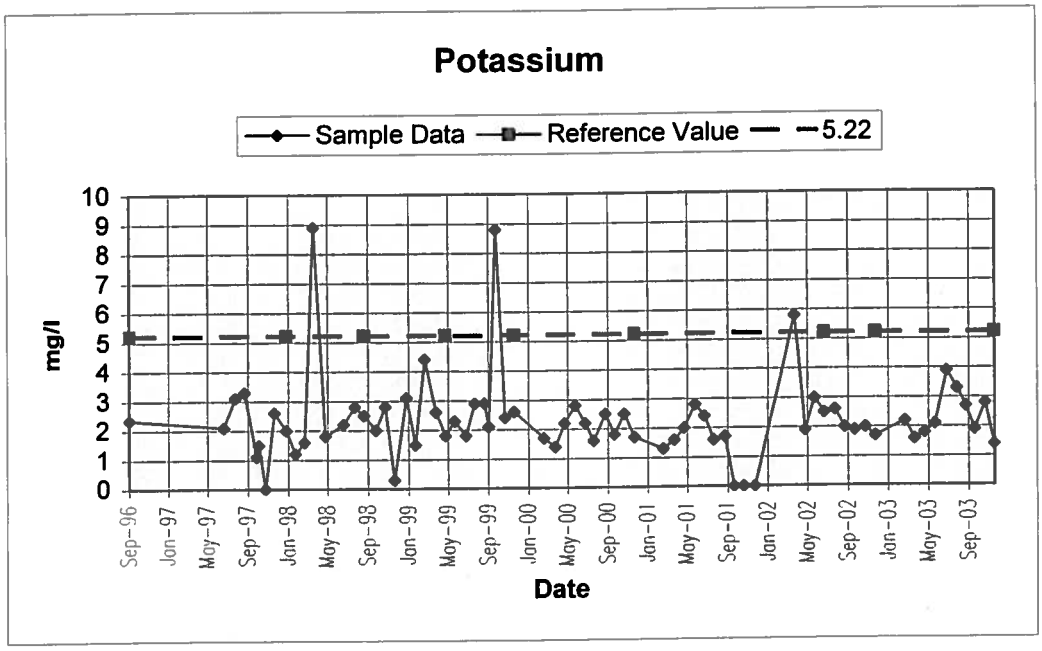

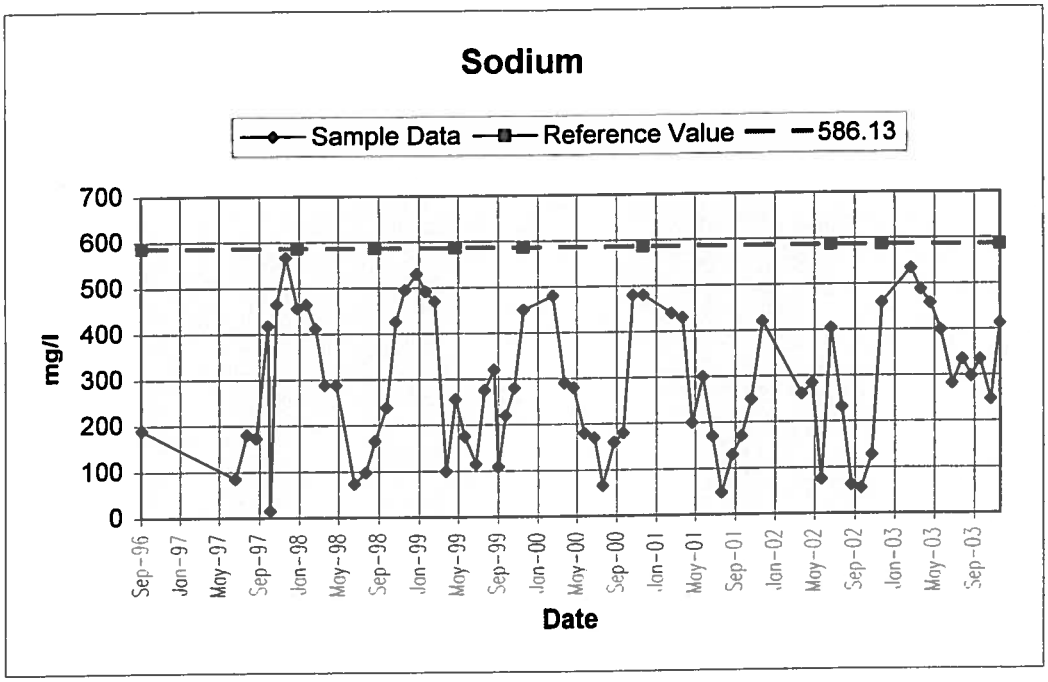

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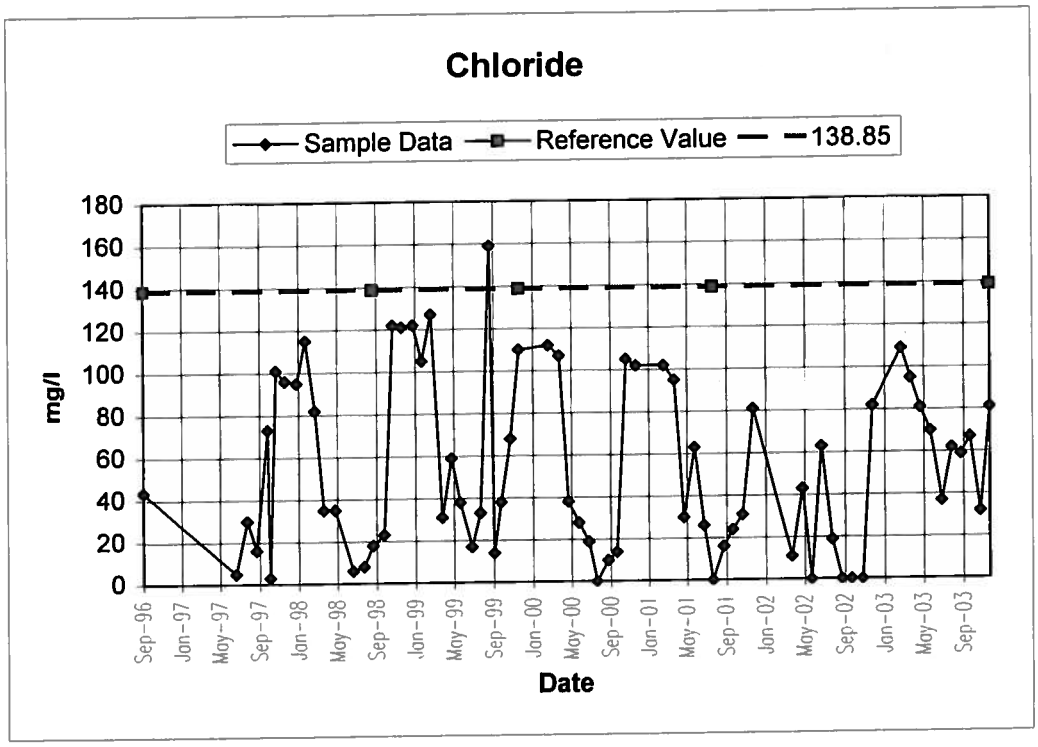

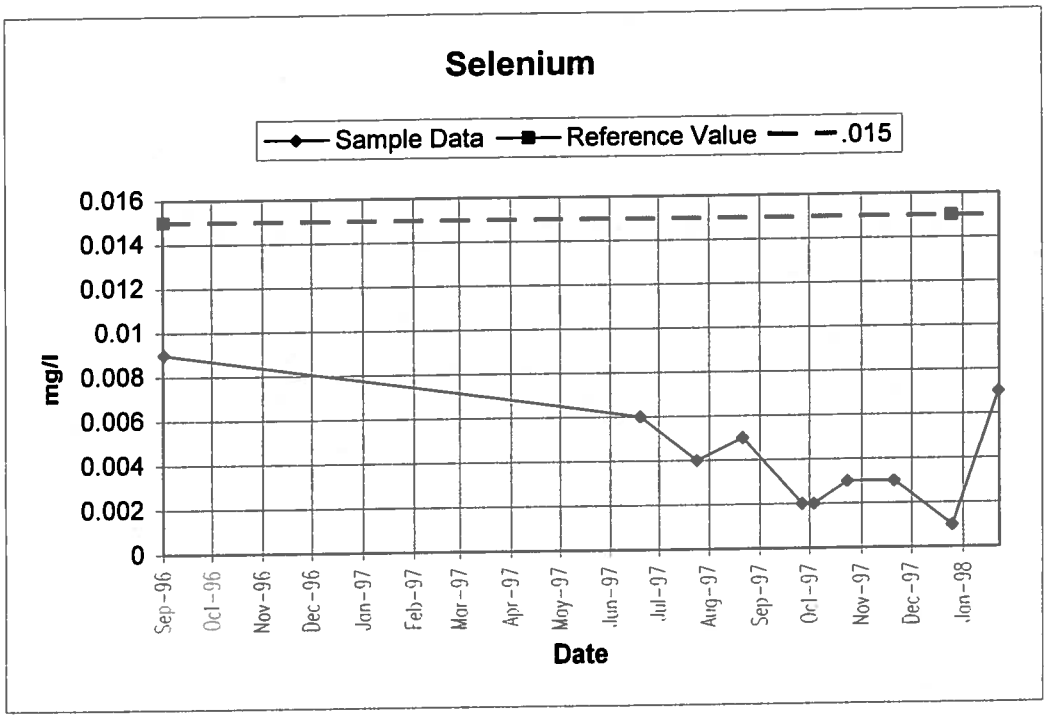

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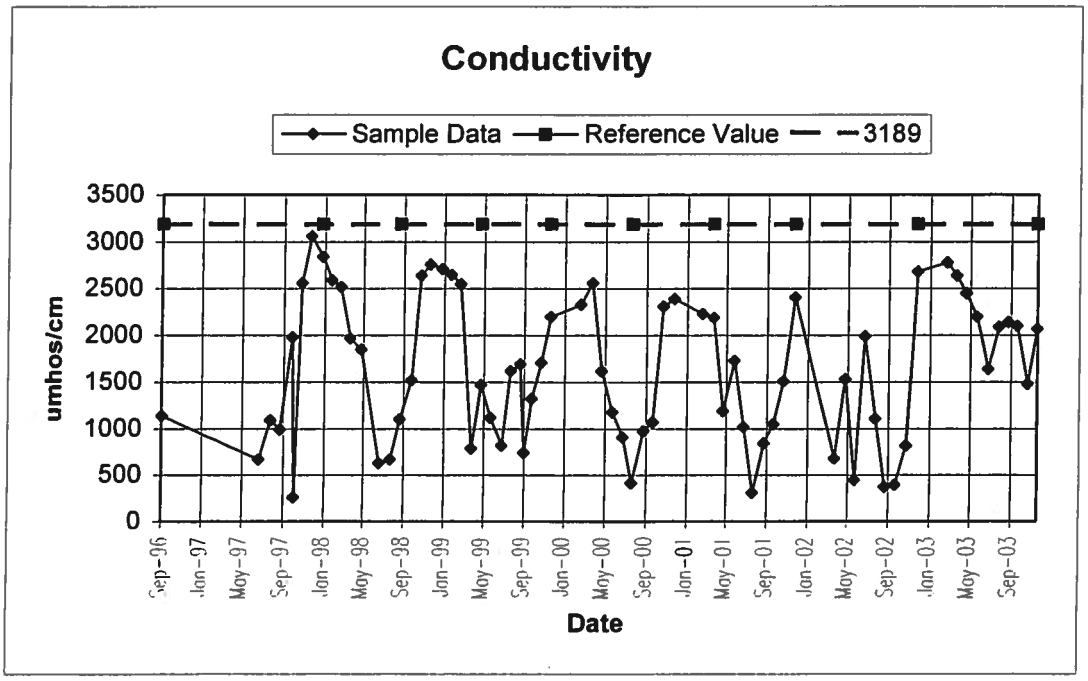
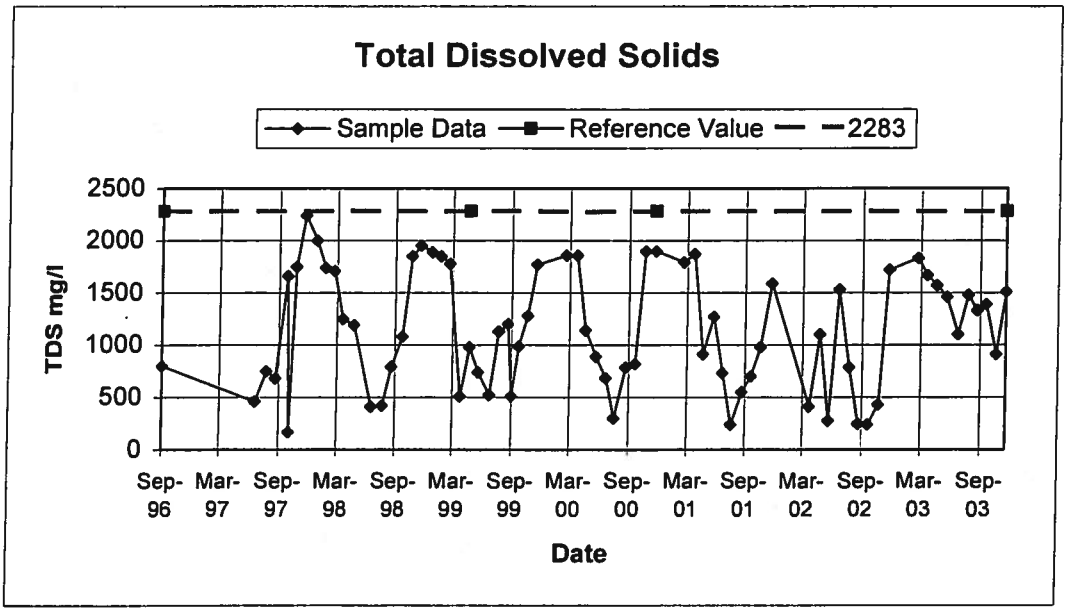
SURFACE WATER MONITORING DATA





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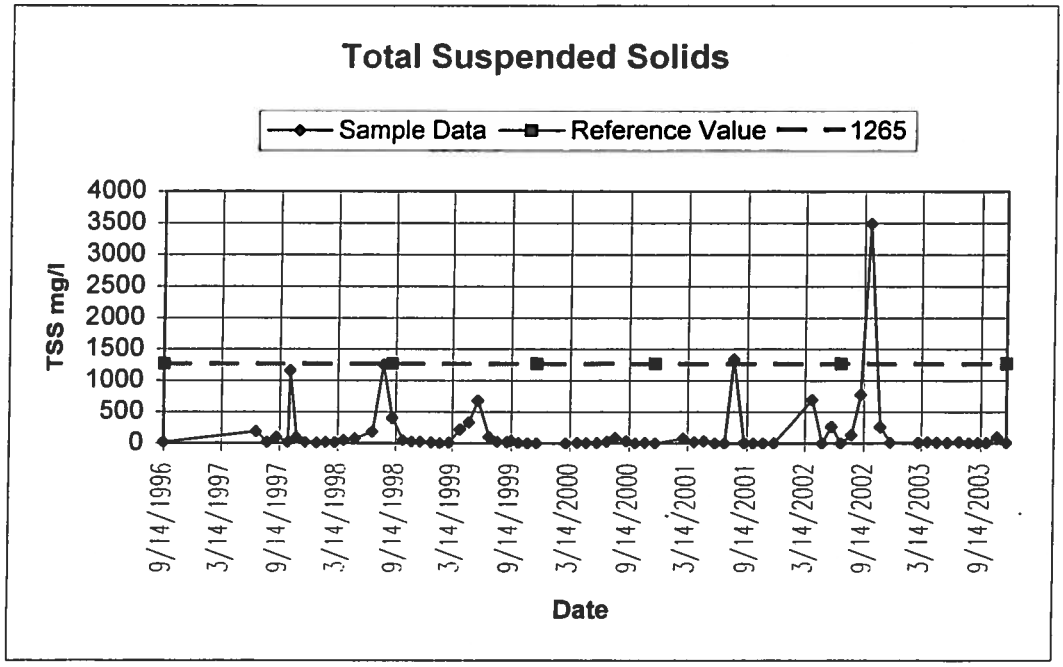

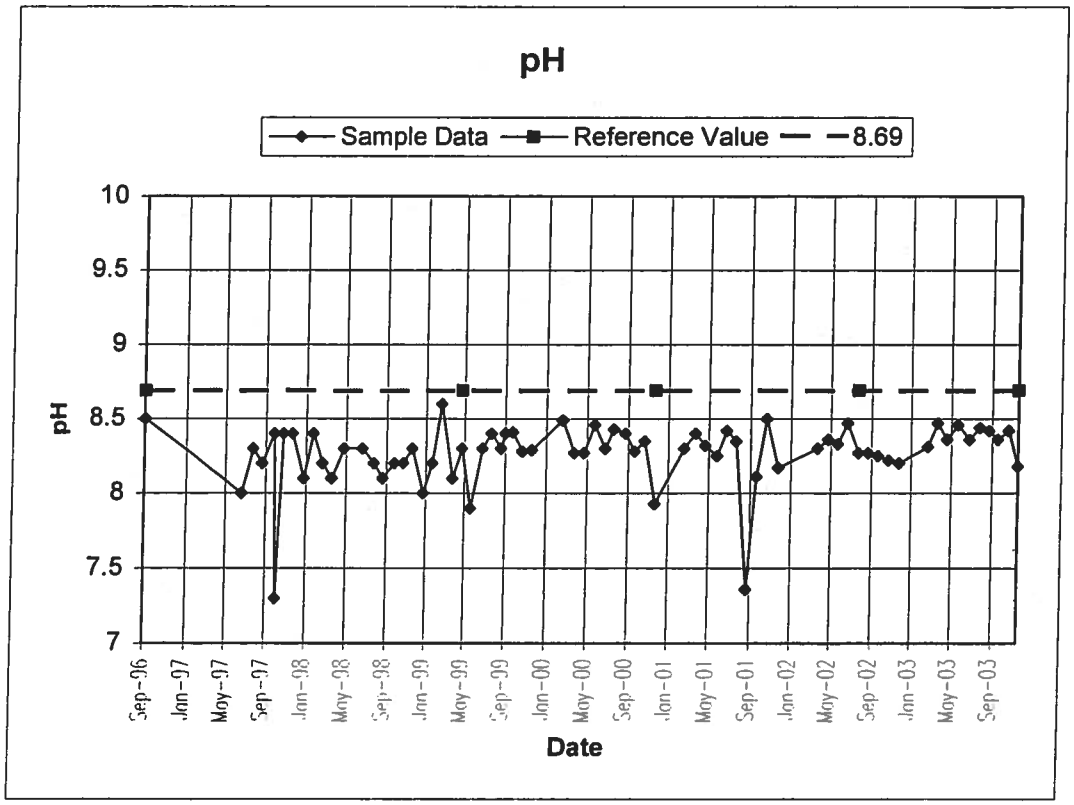

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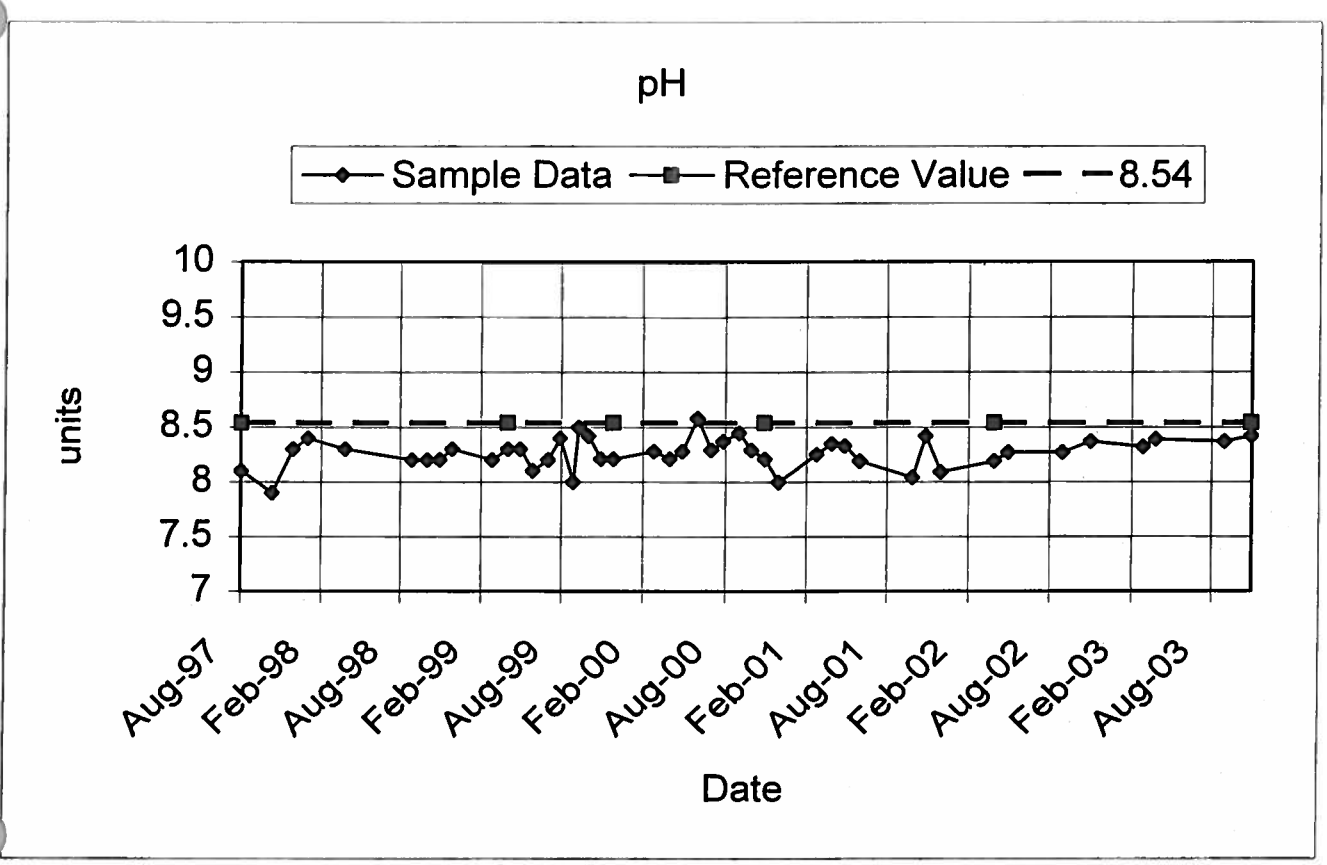

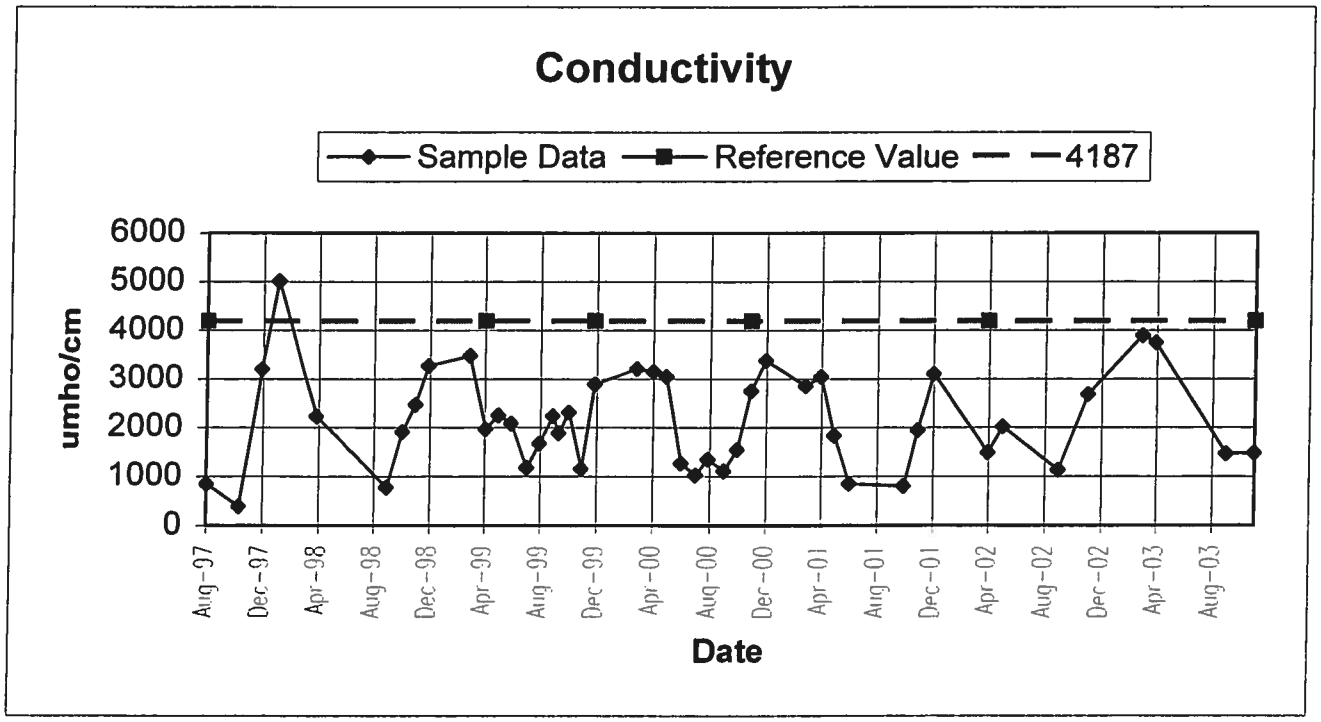

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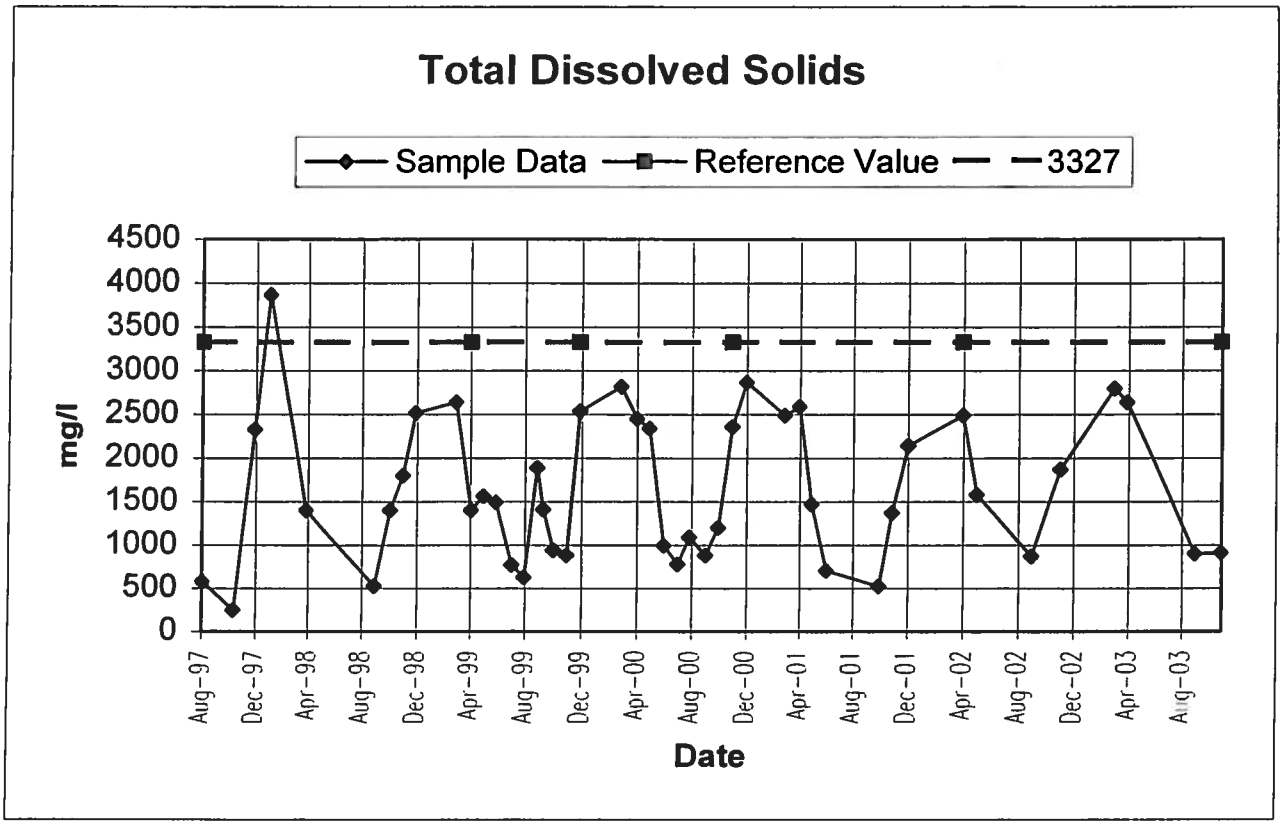

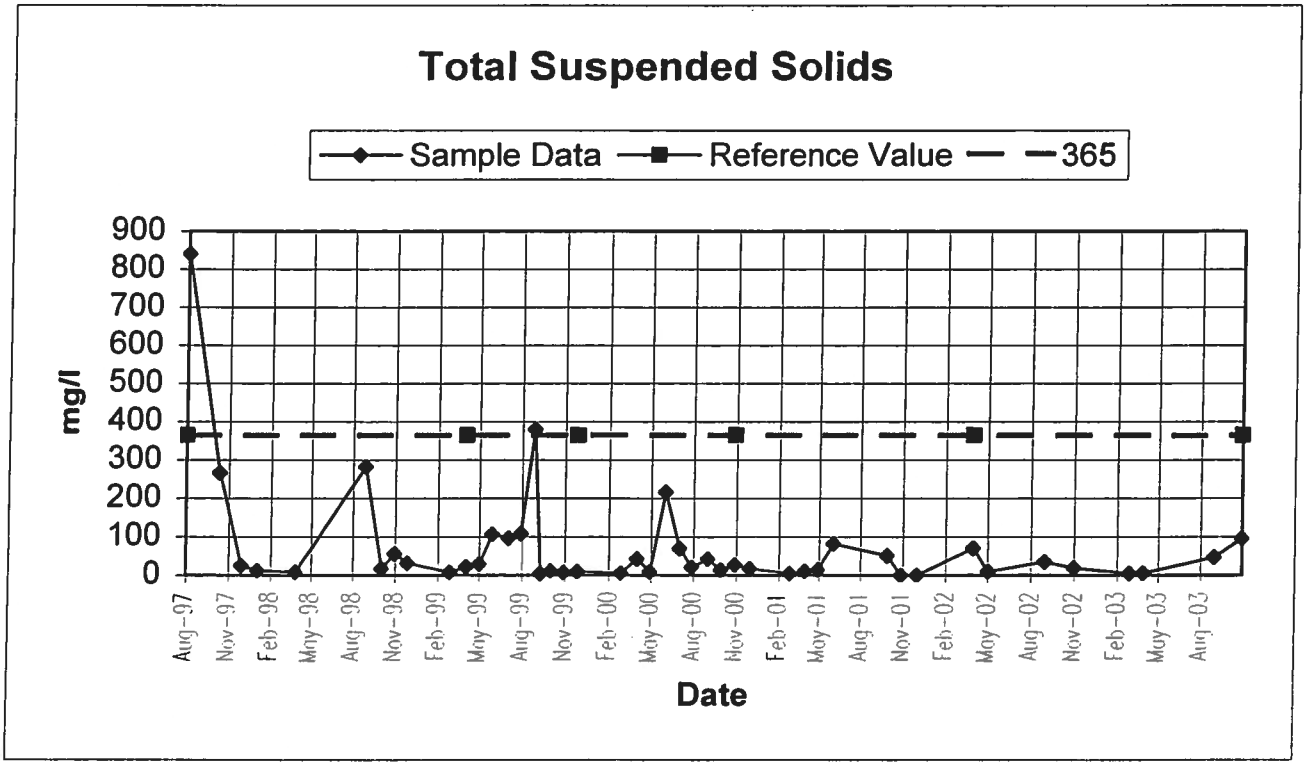

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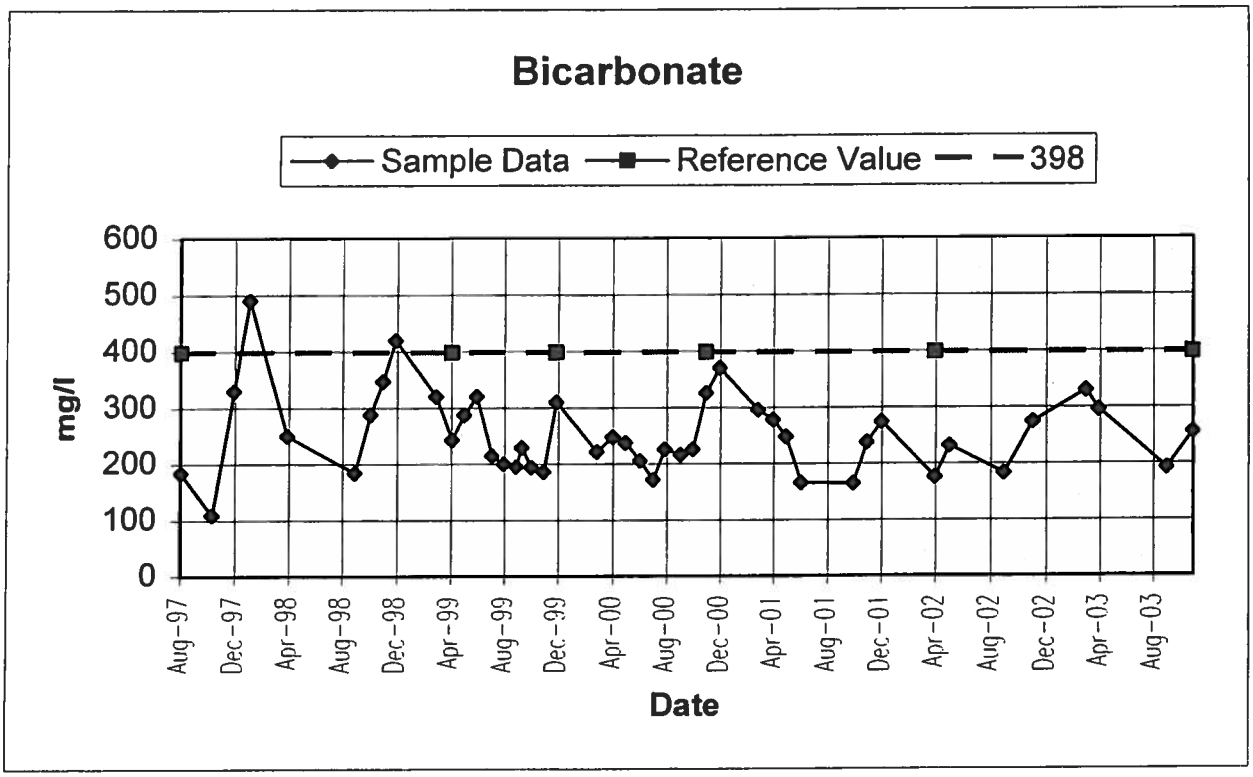

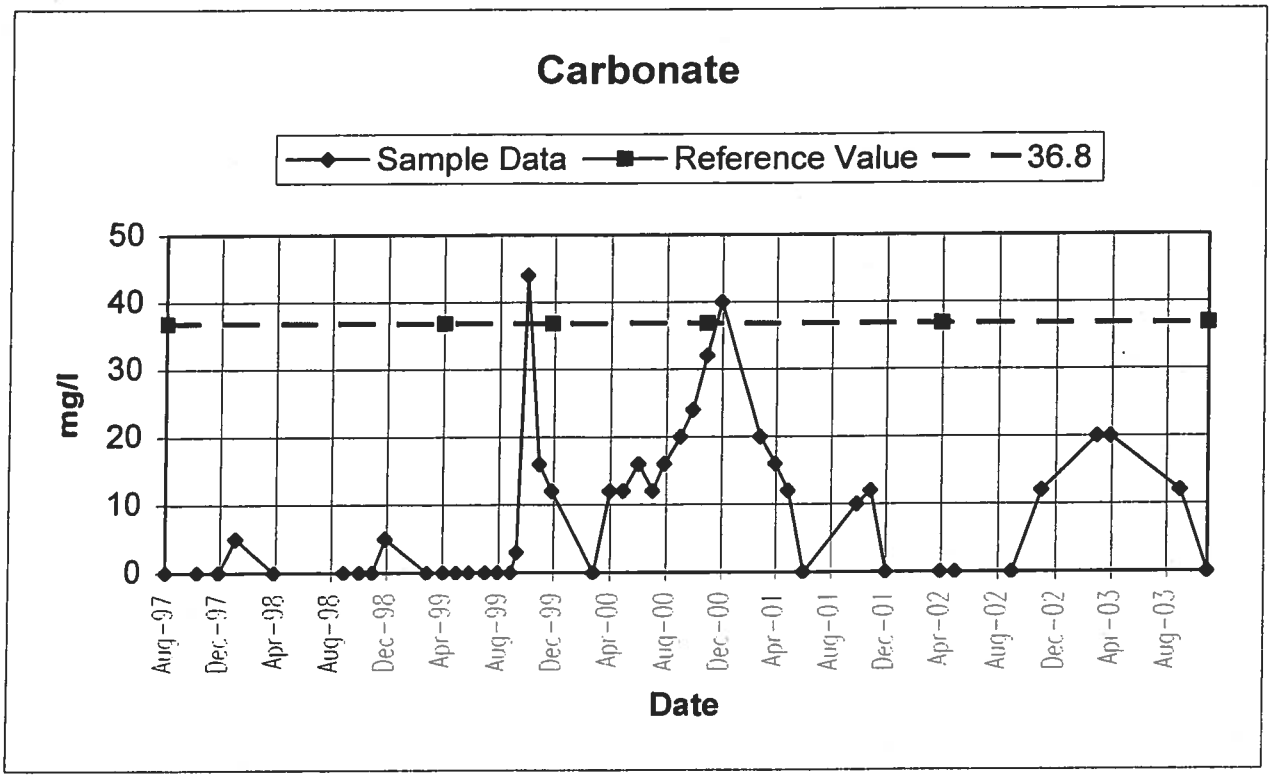

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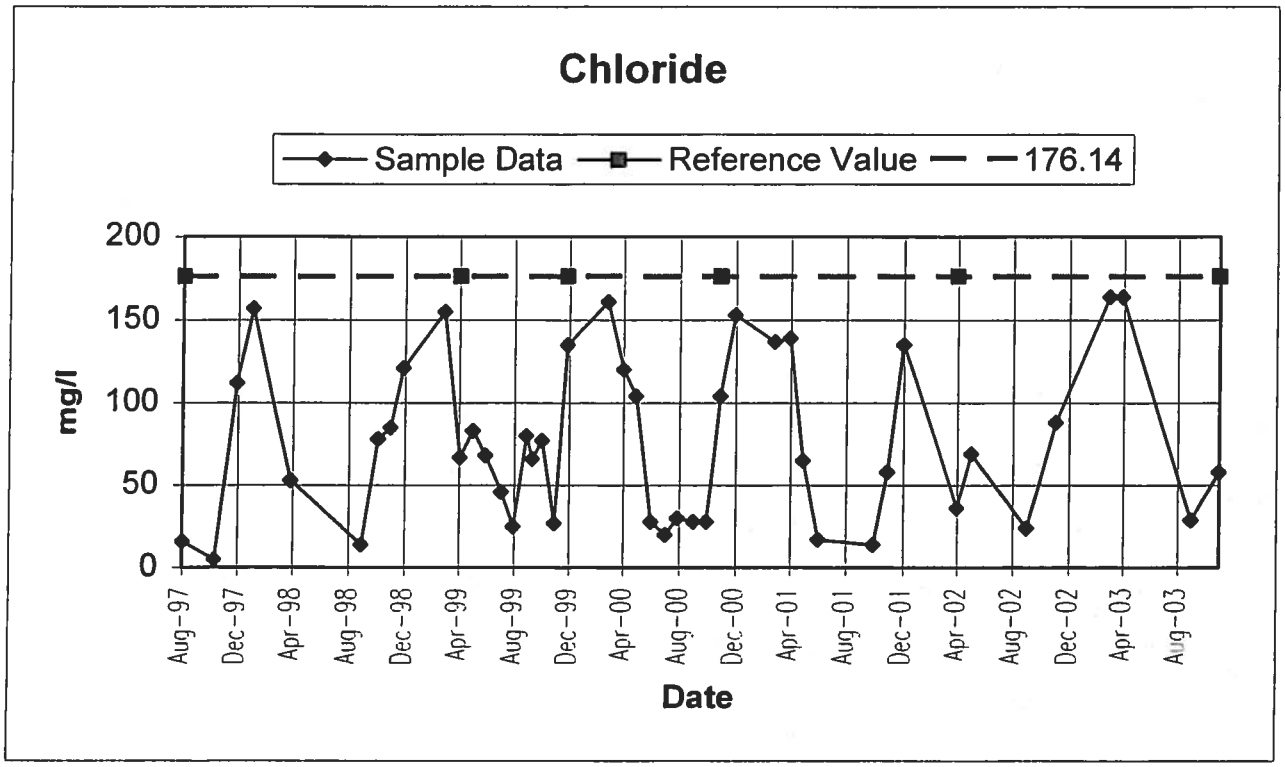

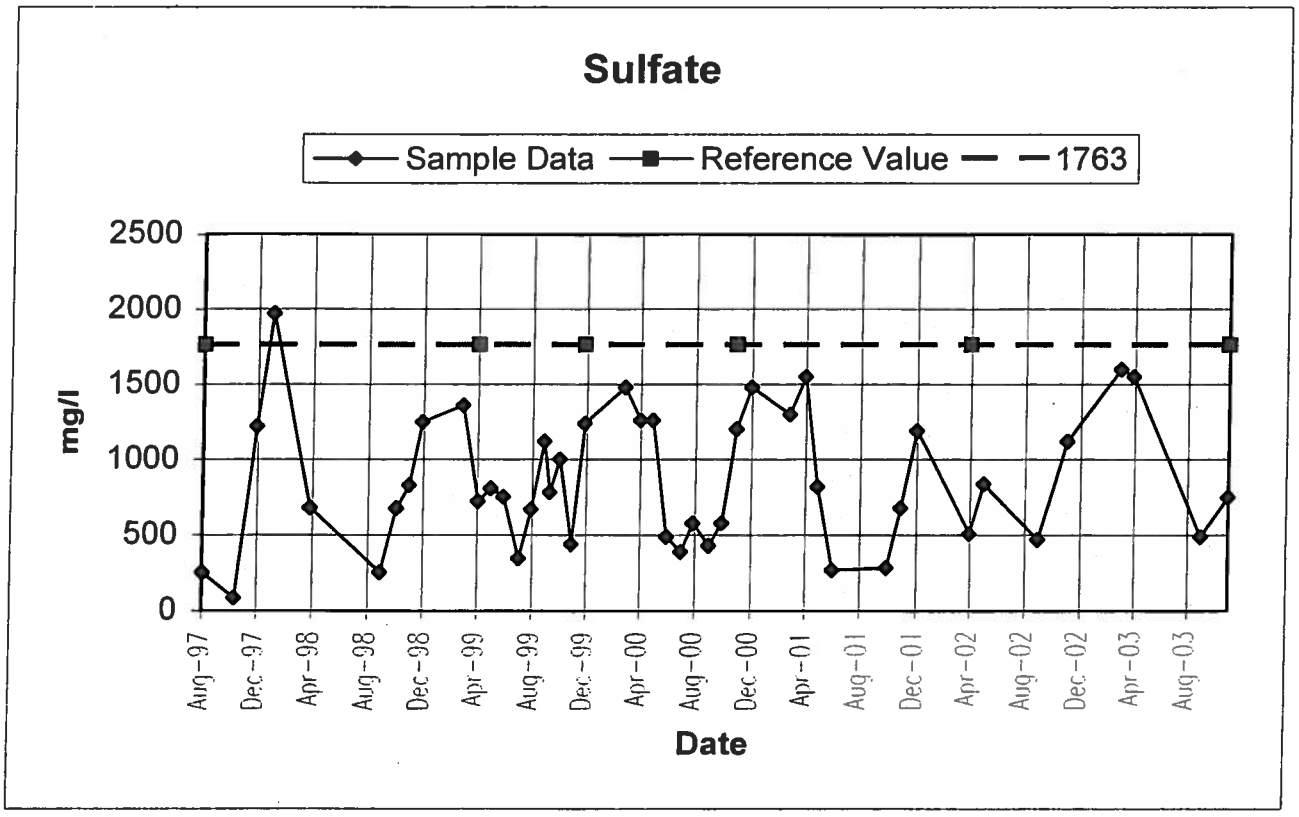

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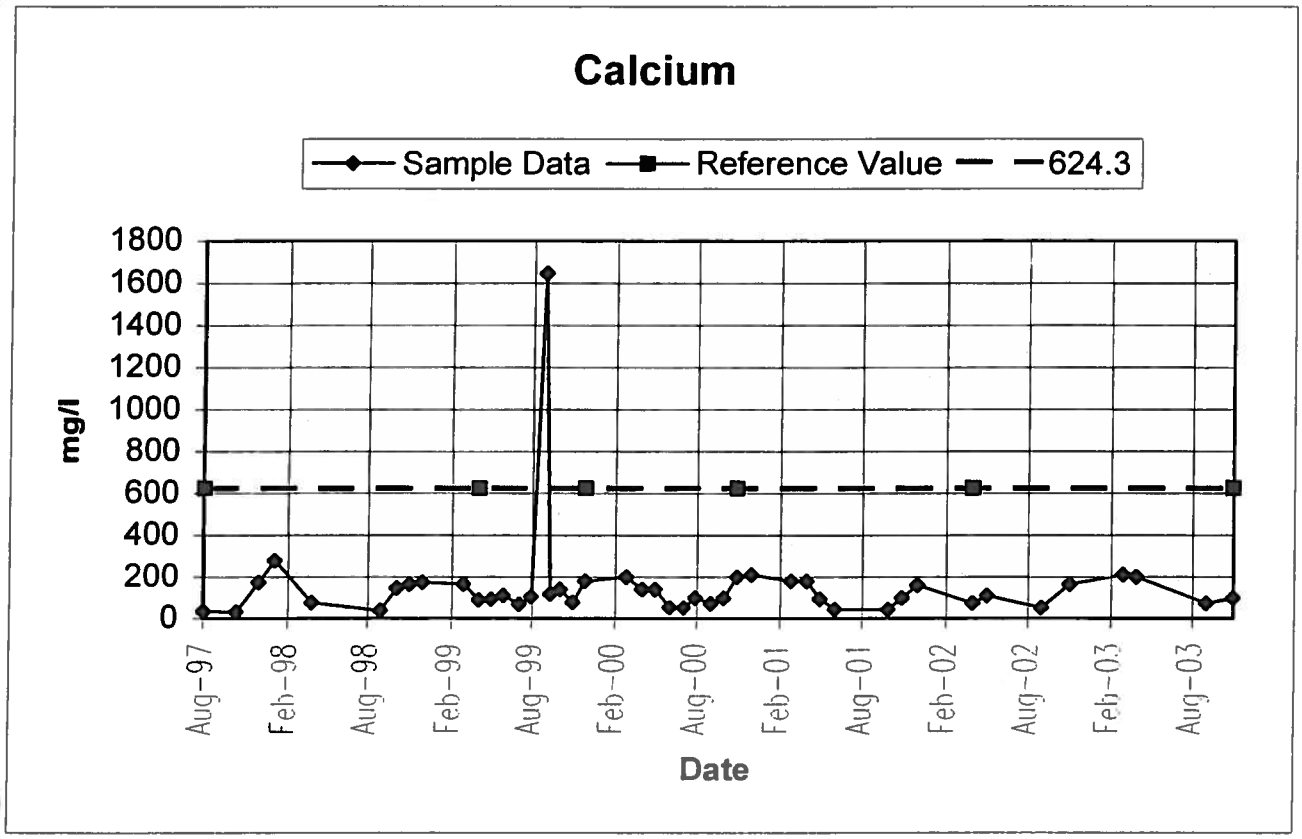

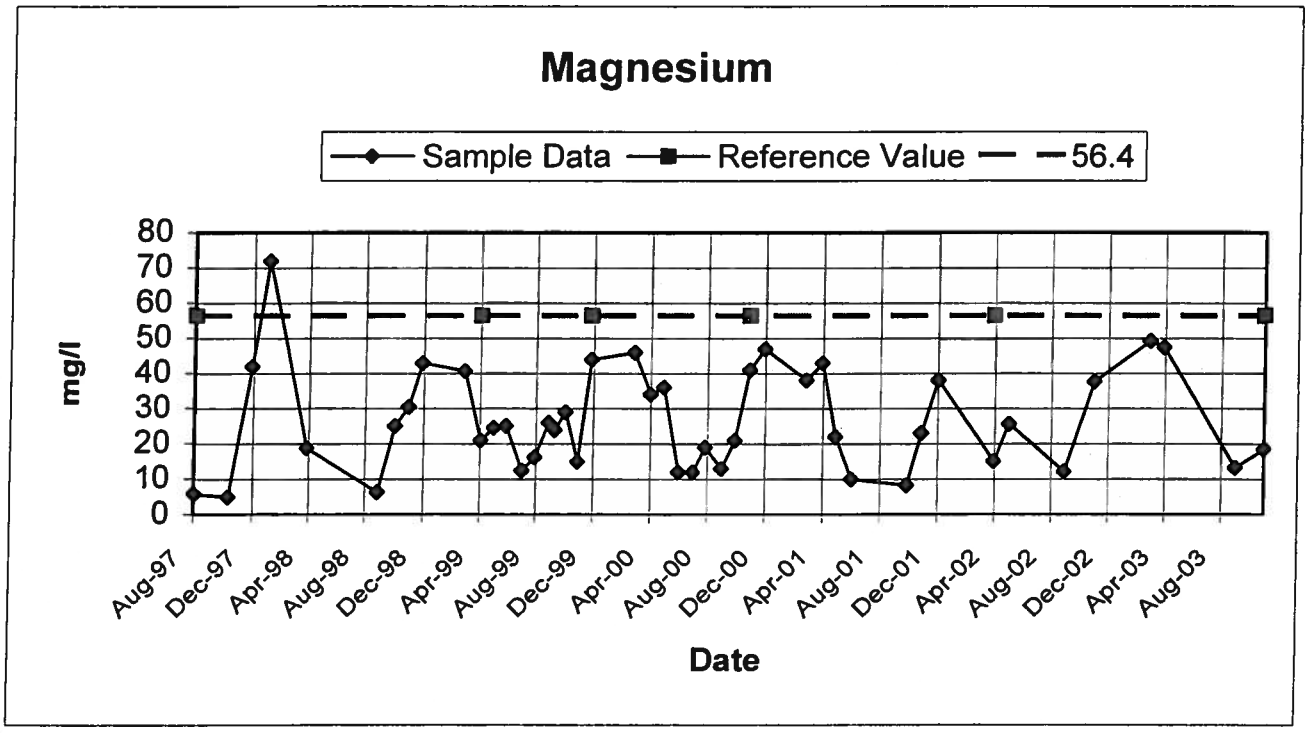

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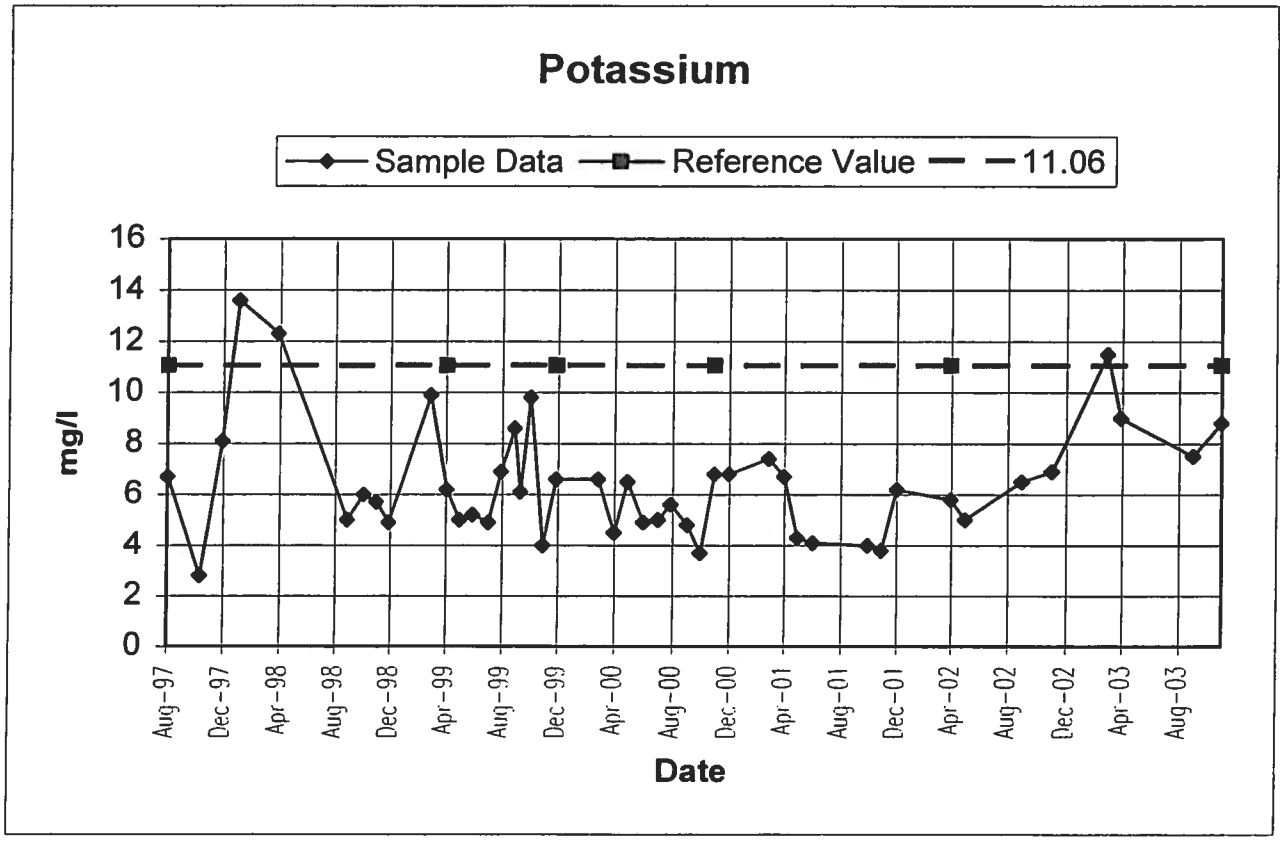

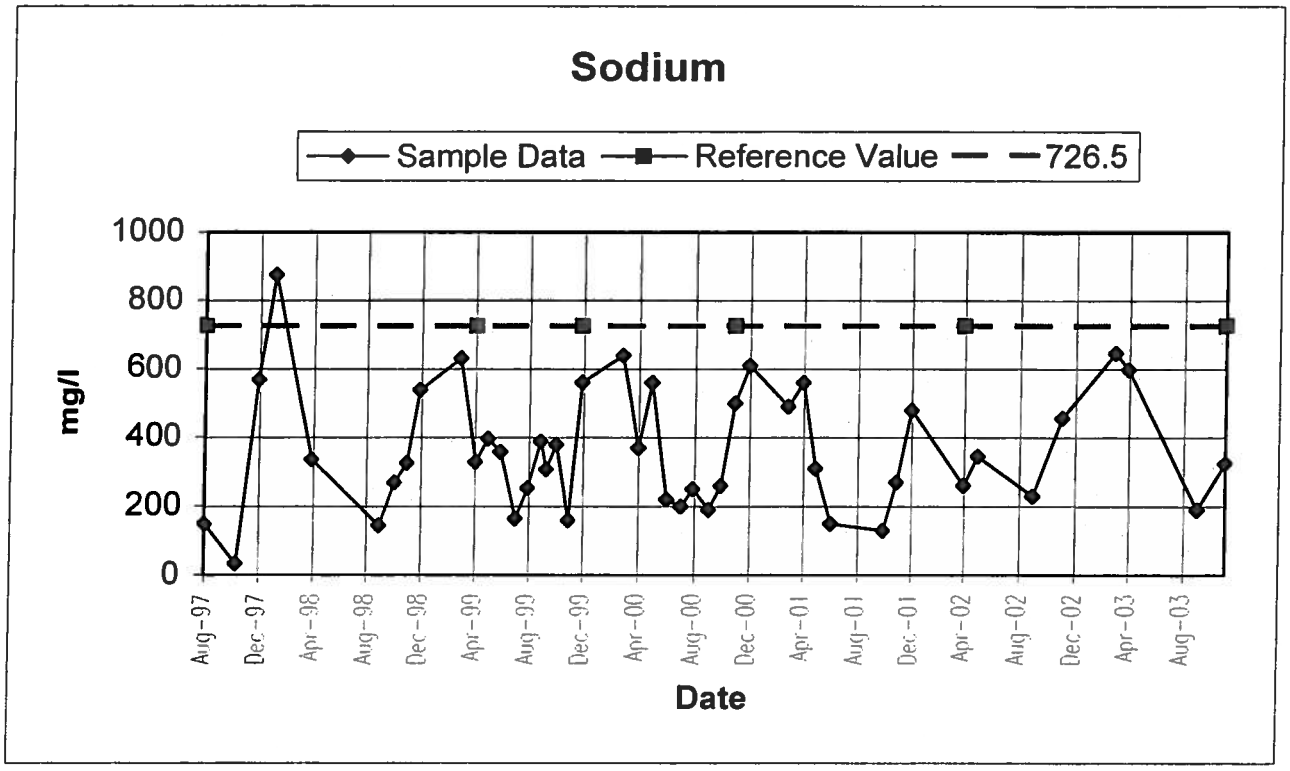

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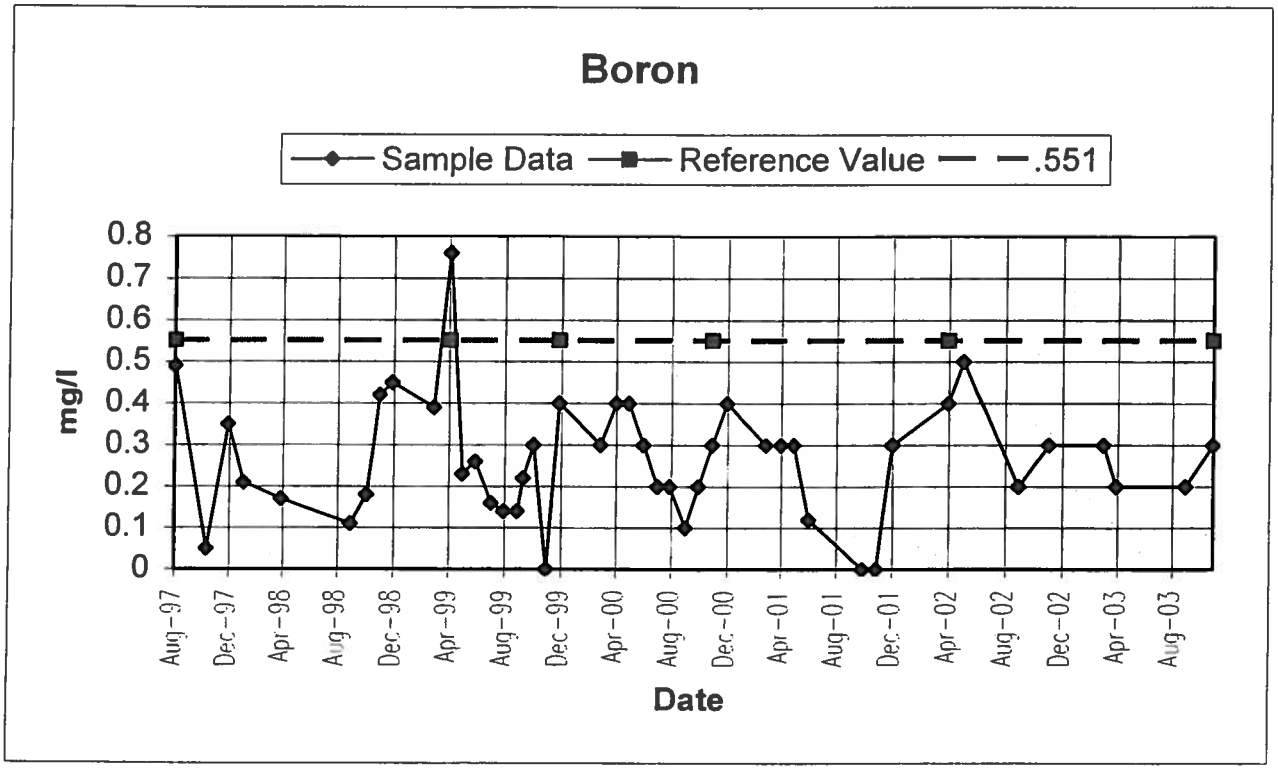

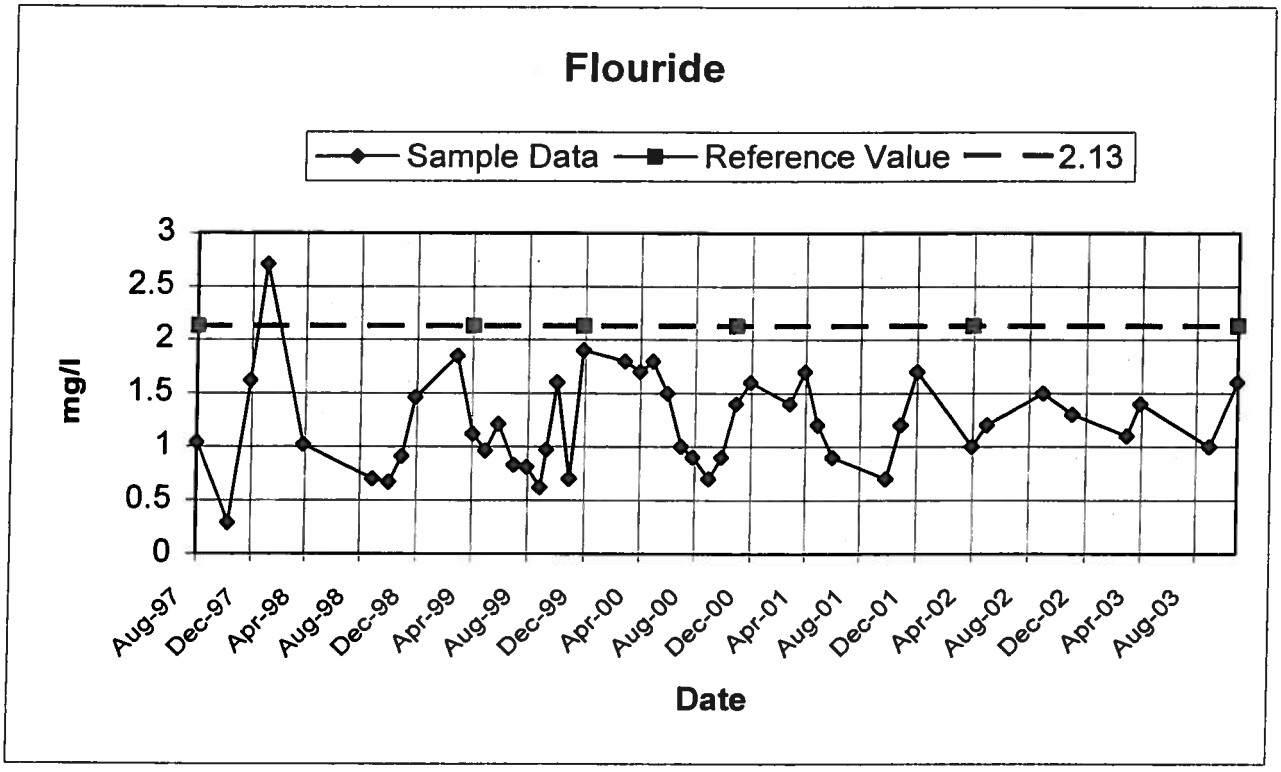

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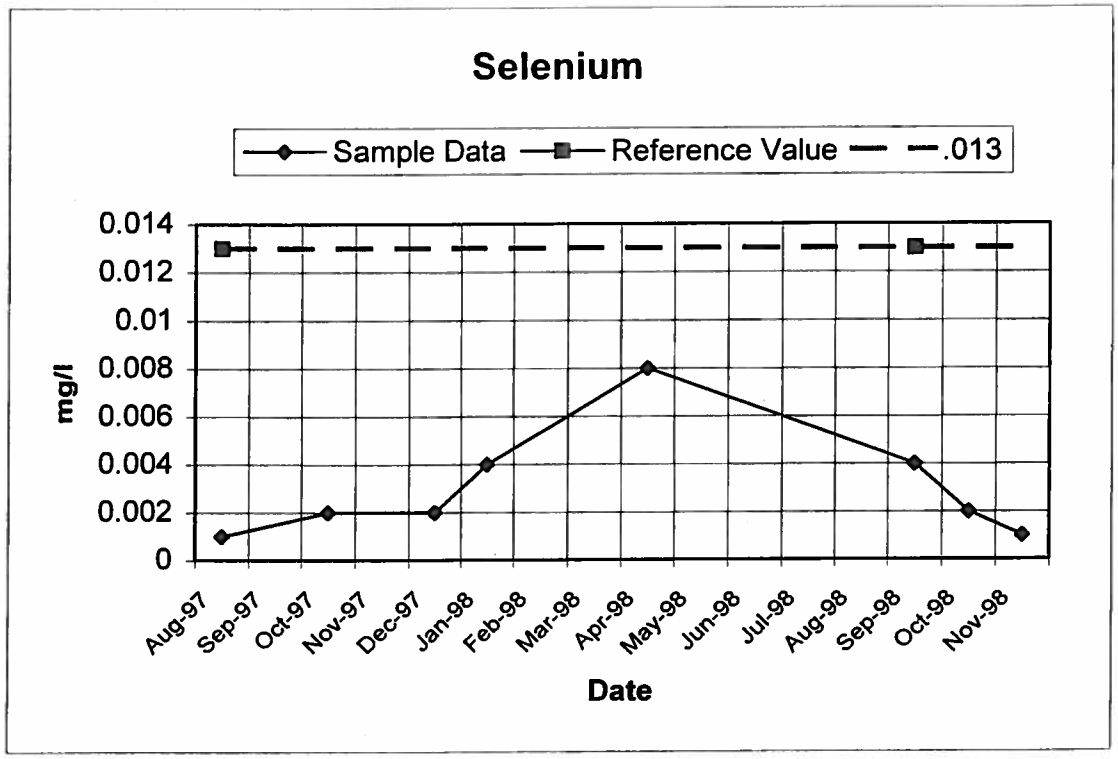

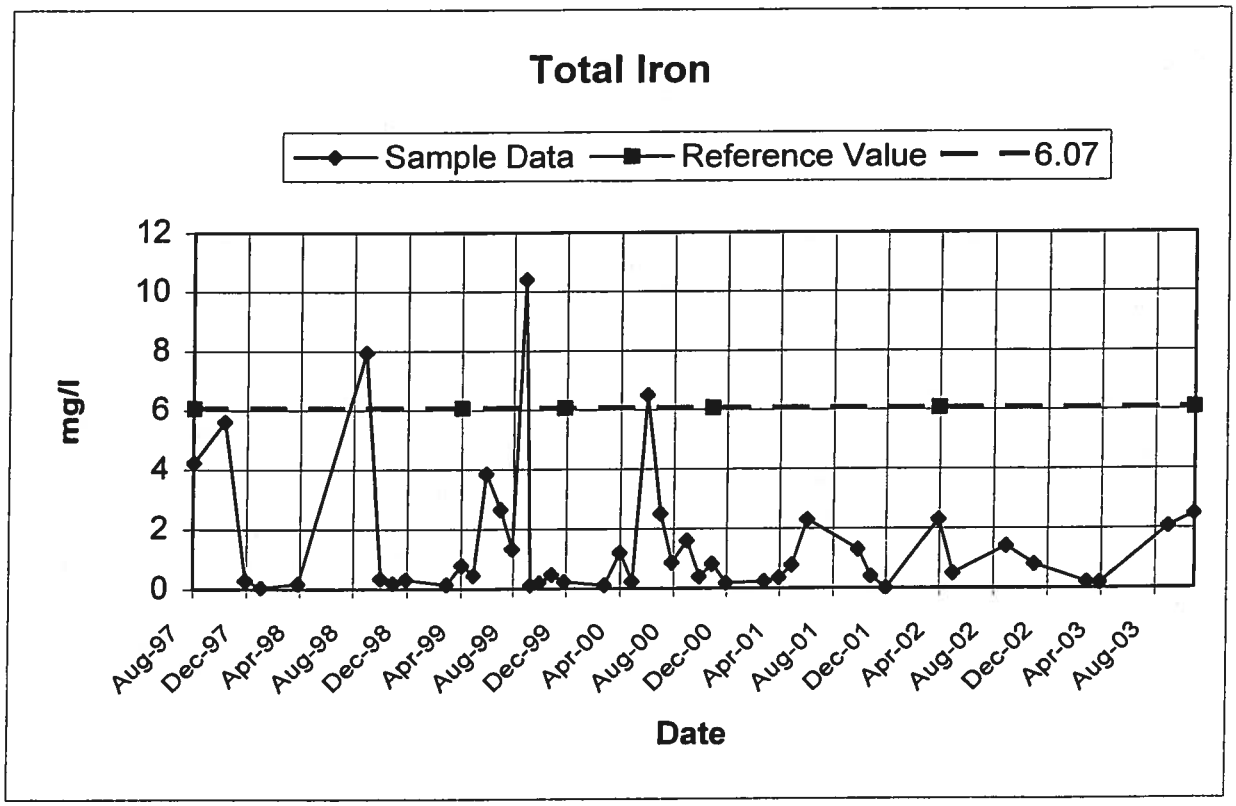

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