

CHAPTER 16

HYDROLOGIC MONITORING PROGRAM



HYDROLOGIC MONITORING PROGRAM

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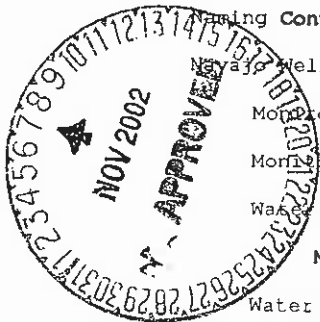


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HYDROLOGIC MONITORING PROGRAM

Introduction

A hydrological monitoring program has been implemented at the Black Mesa and Kayenta Mines since 1979. The program was initially developed and has evolved to address the hydrologic monitoring requirements for surface coal mining and reclamation activities on Indian lands at 30 CFR Parts 715.17, 30 CFR Parts 780.21 (i and j), and 30 CFR Part 816.41.

The hydrologic monitoring program for the Black Mesa and Kayenta Mines is unique for several reasons. Monitoring sites are distributed over a large geographical area (approximately 100 square miles) within which several discrete coal resource areas have been, are currently, or will be mined over an approximate 40-year period. Lands within the permitted area fall under several different non-regulated (pre-law) and regulated (post-law) jurisdictional areas, resulting in variable monitoring requirements and objectives (see Drawing No. 85360 entitled "Jurisdictional Permit Map" for spatial delineation of pre-law, pre-interim program permit, interim program permit AZ-0001, and permanent program permits AZ-0002A and AZ-0001D lands). Challenging surface and ground water monitoring conditions such as variable and unstable drainage and stream channel conditions, violent streamflows, heavy sediment loads, low-yielding aquifers with poor water quality, deep aquifers, etc., confront hydrologists responsible for design and implementation of the program. This program addresses all factors in a single plan applicable to all areas on the Black Mesa Leasehold. Peabody Western Coal Company (PWCC) agrees to follow one hydrologic monitoring and reporting plan (this plan) for the surface water and ground water monitoring for both the Kayenta and Black Mesa Mines.

Purpose

The main thrusts of the hydrological program are to define baseline conditions for ground and surface water quantity and quality; to define the degree of interaction or communication between the ground and surface water systems; to provide a check on the PHC (Probable Hydrologic Consequences) results determined for mining and postmining periods; to determine the presence or absence of any seasonal variability and define the ranges of such variability; to assess the trends, magnitude, and extent of any measurable mining impacts to the hydrologic system; to determine when monitoring needs to be escalated at certain sites (when the magnitude and extent of impacts measurably exceed PHC

projections), or when monitoring can be relaxed at sites (sufficient background database, collecting parameters of little value, rate, and magnitude of change is unmeasurable or has been defined and is declining towards premining levels); and to provide site-specific hydrologic data which will be utilized in bond release applications.

Surface Water

Stream Monitoring.

Naming Conventions, Locations, Parameters Monitored, Coordinates, and Elevations. The stream monitoring program for the Black Mesa/Kayenta Mines consists of 4 principal and one idled monitoring stations at which a variety of automated and manual instrumentation, samplers, and equipment are, or can be, utilized to collect streamflow, stream water quality, and channel geometry. Locations of the historic principal stream monitoring stations are presented on Exhibit ~~86500~~ ⁸⁵⁶⁰⁰. Locations of the current stream monitoring sites are shown on Exhibit 93500. Stream monitoring data are collected using a variety of instrumentation and several techniques. Thus, at any one of the stream monitoring stations, there may be several instruments and/or devices and techniques utilized to collect the data. Tables 1 and 2 present a listing of the principal stream monitoring stations and/or their associated instruments/devices, all identified with discrete site ID's to distinguish instrument and device types and/or types of data collected at each. Table 1 presents surface elevations, UTM coordinates, and Peabody coordinates for each principal stream monitoring station. Table 2 presents the parameters monitored at each principal station, instrument, and device. Table 2 also details the various instrument/device site ID's for each principal stream monitoring station.

Location and Monitoring Rationale. Several criteria were considered in picking the number and locations of stream monitors. Initially, above- and below-mining monitoring site locations were selected on the four principal washes (Yellow Water Canyon, Coal Mine, Moenkopi, and Dinnebito) transecting the leasehold where sufficient above-mining watershed areas existed. In addition, four below-mining sites were selected on the principal tributaries to Yellow Water Canyon, Coal Mine, and Moenkopi Washes. In July of 2001 and July of 2002, OSM approved PWCC's cessation of monitoring at all of the above-mining and principal tributary monitoring sites, as they had provided data necessary to fulfill the monitoring objectives. The remaining four active stream monitoring sites, CG34, SW25, SW26, and SW155 continue to provide data in accordance with program objectives. The straightness of channel reaches, channel widths, channel and bank stability, and streambed characteristics were considered in selecting the specific sampling locations and methodologies.



TABLE 1

Elevations and Coordinates for Each
Principal Stream Monitoring Station

| | | Surface Elevation | <u>UTM</u> | | <u>Peabody</u> | |
|-------------------|-----------------|----------------------|---------------|---------------|----------------|---------------|
| Stream Site ID | Site Name | | N-S Coord. | E-W Coord. | N-S Coord. | E-W Coord. |
| FLUM15* | Stream Site 15 | 6525.26 | 4043445.00 | 550891.00 | - 3150.40 | 18224.30 |
| SW25 | Stream Site 25 | 6100.29 | 4031023.61 | 549994.25 | -43760.00 | 14964.30 |
| SW26 | Stream Site 26 | 6159.21 | 4031664.45 | 551384.04 | -41662.00 | 19528.30 |
| CG34 | Stream Site 34 | 6700.80 | 4026145.88 | 563002.80 | -59751.40 | 57457.40 |
| SW155 | Stream Site 155 | 6135.63 | 4031364.80 | 551236.81 | -42643.50 | 19040.00 |

Note: Surface elevations are in feet above mean sea level, and coordinates are in feet.

- Negative coordinates denote southings.

* FLUM15 has been idled.



TABLE 2

Instrument/Device Site ID's for Parameters Monitored
at Each Principle Stream Monitoring Station

| Stream Site ID | Parameters Monitored |
|----------------|----------------------|
| CWQ15* | Water quality |
| FLUM15* | Flows, water quality |
| X-SEC(1-5)-15* | Flows |
| SW25 | Flows, water quality |
| X-SEC(1-4)-25 | Flows |
| SW26 | Flows, water quality |
| X-SEC(1-4)-26 | Flows |
| CG34 | Flows, water quality |
| SSWQ-34 | Water quality |
| X-SEC(1-4)-34 | Flows |
| SW155 | Flows, water quality |
| X-SEC(1-4)-155 | Flows |

NOTES: CG = Crest Gage SW = Ultrasonic gage with stilling well,
X-SEC = Cross Section manual water quality
CWQ = Composite Water Quality SSWQ = Single Stage Water Quality

* FLUM15, including CWQ15 and X-SEC(1-5)-15, have been idled.



NPDES pond discharges as a result of storm runoff have been so few (72 through June 2002) and are of such a small flow rate (few cfs) compared to undisturbed watershed runoff that any chemical and suspended sediment changes from pond discharges to the normal channel flow are negligible. Measured runoff volume and flow rates at the above-mining stream monitoring sites and all stream sites when the runoff originates entirely from undisturbed watersheds, are baseline flow data. Baseflow occurs intermittently along some reaches of the principal washes and tributaries. The only intermittent reach to date that could potentially be impacted by resaturated spoil is along Coal Mine Wash adjacent to and downgradient from the N1/N2 mining area. As was discussed above, the baseflow, of which spoil water could only comprise a portion, is so small in relation to average storm flows in Coal Mine Wash that the effects on streamflow chemistry in Coal Mine Wash are negligible (i.e. unmeasurable). All streamflow chemistry data, excepting any baseflow chemistry measured adjacent to the N1/N2 mining area, are considered to be a continuation of baseline data (see Pages 116 to 119 in the 1991 Hydrological Data Report for the Black Mesa and Kayenta Mines).

Water Quality Parameters and Rationale. A full suite water quality parameter list (Table 3) has been developed for surface monitoring sites. Provided sampleable flows occur, at least two full suite water quality samples for water chemistry will be collected per stream site per year: one monitoring normal baseflow, and one monitoring rainfall runoff.

The minimum sampleable flow event is a function of the fixed and manual sampling instrumentation used at each stream monitoring site, channel geometry, and the amount of channel bed scour or aggradation occurring at the site. Single stage water quality sampler sites require the lower sampler intakes be submerged to a certain depth before the samplers will collect a sample. Pump sampler sites do not have this limitation, but are positioned high enough above the channel bed to avoid sampling bedload and thereby biasing total recoverable trace metal analyses. Manual samplers such as USDH-48 samplers require a minimum flow height to keep the intake horizontal with the channel bed and the sample bottle sloped downward towards the rear. Dip sampling requires sufficient flow to keep the sample bottle mouth horizontal, and proper technique to minimize surging and sediment bias of water chemistry.

Channel geometries will affect what the minimum sampleable flow may be. A narrow incised channel will permit the sampling of smaller flow volumes than wider, flat-bottomed channels. Finally, the degree and frequency of channel bed change at a stream station will affect the minimum sampleable event.

Of the samplers described above, the dip sampling technique permits sampling the smallest flows, whereas the single stage water quality samplers would represent the higher end of the minimum sampleable events. At the low flow end, the channel thalwegs are extremely unstable and constantly changing, thus affecting the flow volume necessary to achieve the various flow depths needed for sampling. A detailed discussion of the methodology and limitations of flow and stream water quality monitoring is presented in later sections of this Chapter and should be reviewed along with this section to provide the reader with a good understanding of the limitations of monitoring fluvial systems in this type of environment.

Table 3 presents the full suite of stream water quality parameters and the laboratory detection limits. The full suite includes all trace elements for which there are State of Arizona, Federal, or Navajo Nation livestock standards, and encompasses all significant parameters necessary to perform QA/QC checks on the laboratory data, including those parameters that are integral for making mining impact assessments (see Pages 42 to 51 in the 1991 Hydrological Data Report for the Black Mesa and Kayenta Mines; and Table 4, Tab 6, 2001 Reclamation Status and Monitoring Report, Black Mesa and Kayenta Mines).

Monitoring Frequencies and Reporting. Frequencies for the monitoring of streamflows and water quality are presented in Table 4. Surface water monitoring will continue at some level until the associated incremental bond releases are accomplished. PWCC shall request for modifications to be made to the surface water monitoring requirements, parameters analyzed, and sampling and reporting frequencies when monitoring is no longer necessary to achieve the purposes set forth in the introduction to the Chapter; or the operation has minimized disturbance to the hydrologic balance in the permit and adjacent areas and prevented material damage to the hydrologic balance outside the permit area, water quantity and quality are suitable to support approved postmining land uses, and the water rights of others have been protected or replaced. At the present, PWCC shall report surface water data within 60 days of the end of each of the first three quarters of a calendar year. The fourth quarter and annual surface water report shall be combined as one and shall be reported within 120 days of the end of the calendar year as part of the Reclamation Status and Monitoring Report for Black Mesa and Kayenta Mines. Included with the annual hydrology report (AHR), all surface water quality, flow (stream and spring), and pond water level data will be submitted to OSM on magnetic media in a format agreed to by PWCC and OSM.



TABLE 3

Full Suite of Chemical Parameters for Stream, Pond,
Spring, and Navajo Well* Monitoring

| Chemical Parameter | Detection Limit (mg/l) |
|-------------------------------|---------------------------|
| Alkalinity as CaCO_3 | 1 |
| Bicarbonate as HCO_3 | 1 |
| Carbonate as CO_3 | 1 |
| Hardness as CaCO_3 | 1 |
| pH | .1 ^A |
| Conductivity at 25°C | 1 ^B |
| Calcium, dissolved | 1 |
| Magnesium, dissolved | 1 |
| Sodium, dissolved | 1 |
| Potassium, dissolved | 1 |
| Chloride | 1 |
| Sulfate | 4 |
| SAR | xx.x ^C |
| Fluoride | .02 |
| Iron, dissolved | .1 |
| Iron, dissolved | .02 |
| Iron, total | .02 |
| Manganese, dissolved | .01 |
| Manganese, total | .01 |
| Nitrogen, nitrate | .02 |
| Nitrogen, nitrite | .01 |
| Nitrogen, nitrate + nitrite | .02 |
| Aluminum, total recoverable | .05 |
| Arsenic, total recoverable | .001 |
| Boron, dissolved | .02 |
| Cadmium, total recoverable | .005 |
| Chromium, total recoverable | .01 |
| Copper, total recoverable | .01 |

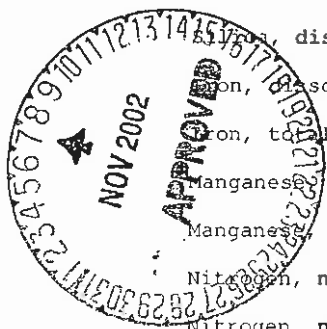


TABLE 3 (Con't)

Full Suite of Chemical Parameters for Stream, Pond,
Spring, and Navajo Well* Monitoring
(Continued)

| Chemical Parameter | Detection Limit (mg/l) |
|--------------------------------------|---------------------------|
| Lead, total recoverable | .02 |
| Mercury, total recoverable | .0001 |
| Selenium, total recoverable | .001 |
| Vanadium, total recoverable | .01 |
| Zinc, total recoverable | .01 |
| Solids, total suspended | 2 |
| Solids, total dissolved (180°C) | 2 |
| Solids, total dissolved (calculated) | 2 |
| TDS (gravimetric)/TDS (calculated) | x.xx ^C |
| Cations sum | xx.xx ^D |
| Anions sum | xx.xx ^D |
| Cation/Anion balance | xx.xx ^E |

A = pH units

B = umhos/cm

C = unitless

D = meq/l

E = %

* Suite analyzed for Navajo wells does not include total Fe and total Mn



TABLE 4

Surface Water Monitoring and Reporting Frequencies

| Surface Location Type | Water Quality ³ | Field Parameters ⁴ | Reporting |
|--|----------------------------|-------------------------------|--|
| Surface Water Monitoring Sites ¹ | (2) | (2) | Quarterly, except annually for hydrographs from recording stations SW25, SW26, and SW155 |
| | Water Level | Water Quality ³ | Sediment Accumulation |
| | Semiannually | Semiannually ⁶ | Annually |
| Permanent ⁵ Impoundments | (7) | (7) | (8) |
| Sedimentation Ponds and Temporary Impoundments | (7) | (7) | (7) & (9) |

¹Monitoring sites: 15**, 25, 26, 34, 155.

²Samples to be obtained during baseflow and rainfall runoff periods. When sampleable flow occurs, a minimum of one rainfall runoff sample and one baseflow sample, per year, will be collected at each site.

³Water quality samples shall be analyzed for the full suite of chemical parameters (Table 3).

⁴Field parameters include: Specific conductance (EC), pH, temperature, and salinity.

⁵Refer to Drawing number B5405 for impoundment monitoring locations.

⁶Samples to be obtained during low and high water level periods.

⁷Monitoring and reporting of sedimentation ponds, temporary impoundments, and any other point source shall be in accordance with National Pollutant Discharge Elimination System Permit No. AZ-0022179.

⁸Monitoring of sedimentation accumulation in sedimentation ponds and temporary impoundments shall be in accordance with the operation plan for each impoundment as described in the Sedimentation Ponds and Impoundments, Maintenance, and Reclamation section of Chapter 6 of the approved permit.

⁹Annual pond report committed to in Chapter 6 of the approved permit.

^{*}Permanent impoundments will be monitored for the parameters and at the frequencies specified for a minimum of four years during the six-year time intervals specified in Table 10. Prior to the six-year time intervals specified in Table 10, permanent impoundment (externally draining) monitoring shall be in accordance with the requirements of NPDES Permit AZ-0022179, and sediment accumulation shall be monitored in accordance with the operation plan for impoundments described in the Sedimentation Ponds and Impoundments, Maintenance, and Reclamation section of Chapter 6 of the approved permit.

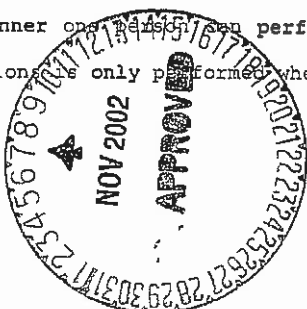
**Interim land hydrology site. Idled as of July, 2001

Revised 09/20/02

Flow Monitoring and Analysis Methodology. Streamflow measurements at the Black Mesa and Kayenta Mines are obtained using: current meters (Smoot and Novak, 1968; Rantz et al., 1982; Marsh-McBirney, Inc.), the slope-area method (Dalrymple and Benson, 1967; Benson and Dalrymple, 1967; Jarrett, 1986; Hartley and Smith, 1989; Hartley, 1991; and Aldridge and Garrett, 1978), pulse generators coupled with stilling wells and data loggers (Rantz et al., 1982; Leopold and Stevens, Inc., 1985; and CSI, 1990), ultrasonic gages coupled with data loggers (CSC Corp., 1990; CSI, 1990), crest-stage gages (Buchanan and Somers, 1974), and floats (Rantz et al., 1982). Baseflow measurements are obtained using current meters, portable cutthroat flumes (Skogerboe et al., 1973), or visual estimates where low flow precludes use of these other devices.

Each of the above-referenced methodologies has its limitations and a few modifications to some of the flow measurement techniques have been necessary. A brief discussion of these follows. Current metering is time consuming and is especially difficult to do on the rising limbs of flows and when flow stages are rapidly changing. Typical flow hydrographs show rising limbs of from five to ten minutes in duration. One is limited to wading where there are no catwalks at sites. Because of the very high flow velocities and unstable channel beds, many of the flows are unwardable. The very sediment- and debris- laden flows interfere with both rotating cup and electromagnetic current meter operation. Lightning creates unsafe conditions in which to current-meter meter. The method requires that someone be present during the flow, which is often difficult to accomplish. A modification to the current meter technique that Peabody utilizes is the 0.6 depth method, which is recommended where flow stages are rapidly changing.

The slope-area method is also very time consuming. The technique assumes that the channel configuration during the flow is the same as it was before and after the flow. Roughness coefficients must either be assumed or empirically determined. The flow equations do not fully describe the hydraulic processes, especially in expanding reaches. High water marks are sometimes difficult to determine, and the technique is less accurate for small flows. A modification to the slope-area technique that Peabody employs is the establishment of permanent cross sections with fixed rebars. A string line is stretched across each set of level rebars and vertical measurements of the distance between the high water mark and the string are made at each channel bank in order to determine the water surface elevation. In this manner one can perform the surveying. Detailed surveying of the channel cross sections is only performed when measurable channel bed change occurs.



Attachment 1 presents location maps of the slope-area cross sections at the principal stream monitoring sites listed in Table 1. Because channel bank erosion can significantly influence slope-area measurements, slope-area cross section station locations may be moved up- or downstream on a periodic basis. Thus, the slope-area station locations are not permanently fixed locations nor is this implied on the figures presented in Attachment 1.

The principal limitation with the pulse generator measurement of flows is the stilling well. If small entrance slots are used, they easily clog, preventing the water level inside the stilling well from changing as rapidly as the streamflow level. If the stilling well inlet slots are large, significant amounts of sediment and debris fill the stilling well, preventing recording of the flow recession. Cleaning the stilling wells after each flow is labor intensive and the stilling wells are prone to freezing in the winter months.

Ultrasonic water level gaging is not as accurate as water level recording in an unplugged stilling well. Turbulence on the water surface and heavy snowfall affect the stage readings to some degree. In a 96-day test conducted by Peabody, the ultrasonic water levels were within ± 0.03 feet of the true water level 98 percent of the time.

Crest stage gages are typically located on the channel sides off the channel bottom. Thus, this type of gage is of no use for monitoring low flows. The gages are susceptible to being washed out and clogged by debris and sediment. This type of flow gage requires considerable maintenance and can only be used for obtaining peak flows.

There are several limitations associated with taking discharge measurements with floats.

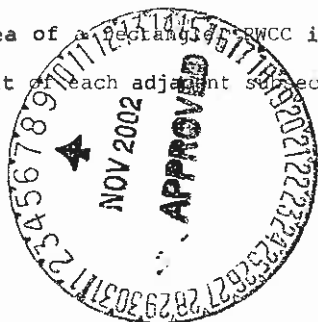
The technique requires that someone be present during the flow. Many of the flows occur when it is not possible. The technique requires that one apply certain assumptions about the vertical velocity profile in order to convert surface velocities to mean velocities. It is difficult to ensure that the float stays in the same position relative to the channel banks over the length of the measurement reach. It requires more time to measure float velocities in several portions of the cross section. In flows with rapidly changing stage, this can lead to measurable discharge errors. The technique assumes that the channel cross-section remains relatively unchanged during the flow event.

Measurements of baseflow with a cutthroat flume also have limitations. The technique requires a visual estimate of the flow rate to set the throat width. The technique is limited to flows not exceeding 2.2 cfs (maximum install and converge flow towards the flume, and the channel must be steeper downstream to avoid discharge for PWCC's flume).

The technique requires channel modification work to prevent pooling of water at the flume exit. Visual estimates of discharge are typically used for flows of less than 0.5 GPM (gallons per minute), and where other techniques are unsuitable or unusable.

As can readily be seen from the aforementioned discussion, all flow measurement techniques have limitations, particularly with the type of streamflows that occur on Black Mesa. The most frequently used flow measurement technique is the slope-area method (flagging of high water marks for follow-up surveying of water surface elevations). The technique does not require that someone be present at the time of the flow, it requires minimal time to flag or measure the high water marks, and is applicable to all but small flows. The next most frequently used techniques are the pulse generator and ultrasonic stage recorder methods. These also do not require field personnel to be present during the flow event, and are the only two techniques that provide continuous flow hydrograph stage values. Current metering is the next most frequently used technique. The technique requires personnel to be present during the flow event, requires larger amounts of time to perform, and is limited to low wadable flows or moderate to low flows at the two sites with catwalks (FLUM15 and SW25). Current metering is used to provide calibration checks for the other flow measurement techniques and the flow rating curves. Cutthroat flumes are used only for baseflow measurements and float, crest gage, or visual measurements are used only when the other flow measurement techniques cannot be used.

Analysis methodologies used for slope-area data are described in Benson and Dalrymple, 1967 and Dalrymple and Benson, 1967. Input data formats for the digital computation of discharge from slope-area data is described in Lara and Davidian (no date). Analysis methodologies for calculating continuous flow from stage data (pulse generator and ultrasonic data) and developing flow rating curves are presented in Kennedy, 1983 and Kennedy, 1984, respectively. Crest gage stage data are converted to discharge values using the Manning formula (Chow, 1959). Current meter and float data analyses for discharge computations are presented in Rantz and others, 1982. PWCC uses one modification to the USGS computational approach for current meter data. Rather than calculating the area of each subsection of the flow cross section by taking the depth of the measuring point, extending that depth to the midpoint of each adjacent subsection and calculating the area of a rectangle, PWCC interpolates a slope from each point of measurement to the midpoint of each adjacent subsection and calculates the area of a



trapezoid. The slope of the trapezoid is calculated from the change in depth between three adjacent points of measurement and the horizontal distances between the three adjacent points. This modification would apply to any float discharge computations as well.

Surface and dip samples must be obtained from wadable flows if one wants other than a sample from the flow edge. The samples collected are most probably not isokinetically collected samples, and the technique requires that personnel be present during the flow.

Automatic pump samplers are only available at one stream monitoring site (FLUM15), which has been idled. The technique does not require that personnel be present during the flow, but is still affected by plugging. The technique does permit monitoring of the rising limb as well as the peak and recession. Flow discharges can be determined from rating tables and slope-area measurements. It is questionable whether pump samplers allow isokinetic sample collection, and pump samplers do require extensive maintenance.

Stream Water Quality Monitoring and Analysis Methodology. Stream water quality measurements at the Black Mesa and Kayenta Mines are obtained using depth-integrated samplers (Edwards and Glysson, 1988; USGS, 1982), pump samplers (Edwards and Glysson, 1988), single stage samplers (Edwards and Glysson, 1988; Guy and Norman, 1970) and surface or dip sampling (Edwards and Glysson, 1988; Guy and Norman, 1970).

The limitations for the water quality sampling methodologies center on suspended constituents (sediment and solids) and vertical and horizontal representation in the flow.

Many of the trace metals are absorbed onto the suspended sediment. Because the laboratory analysis type for the surface water trace metals is the total recoverable analysis, it is important that the sample reflect as true a representation of the metal load transported via the suspended sediment and in solution as is practicable. The single stage water quality samplers are an experimental modification to the water quality monitoring program.

The samplers operate on the same principles as single stage sediment samplers, only they are sized to accommodate one gallon bottles. Depth-integrated water quality samples composited from two to six verticals in the flow cross section are given first priority. If manpower or flow conditions are such that wading or catwalk depth integrating is not possible, water quality samples obtained with composite pump samplers (FLUM15) or manually using the surface dip method are the next most frequently used methods. Single stage water quality samplers are used at the most distant, non-automated site (CG34) when



personnel are not present during the flows. Should FLUM15 become reactivated, a composite pump sampler primarily will be used to collect water quality samples, and periodically the surface or dip sampling method will be used. Any or all water quality sampling methods described above will be utilized to obtain samples at required frequencies listed in Table 4. Surface or dip samples are most commonly used to collect samples in all flows when personnel are available, however, single-stage samplers and, in the future, composite pump samplers, may be relied upon as a backup to the manual method.

Sample handling, preservation, and transport methods are presented in Tables 5 and 6. Field water quality measurements are performed in the field or, if conditions and manpower do not permit the field analyses, the parameters are run at the environmental laboratory within the maximum holding times specified on Table 5. An exception to this are samples obtained from composite and single stage water quality samplers. Samples are accepted if they are collected within 24 hours of when they were taken. All pH measurements for these samples are performed in the environmental lab within the referenced 24 hour period.

Water quality data analysis techniques include both graphical and statistical methods. Graphical analysis techniques include trilinear diagram plots (Hem, 1985), Schoeller plots (Freeze and Cherry, 1979), and nonparametric trend plots (Sen, 1968). Statistical analyses include ordinary moment statistics and nonparametric trend statistics and slope estimates (Hirsch et al., 1991; Helsel and Hirsch, 1992; Kendall, 1975; Sen, 1968; and Gilbert, 1987). Laboratory water quality analyses for the suite of chemical parameters listed in Table 3 are run according to the methodology in the most recent edition of "Standard Methods for the Examination of Water and Wastewater" (APHA, 1989). The specific methods (method numbers) by chemical parameter are presented in Attachment 2.

Integrated Stream Monitoring Approach. Each of the previous sections have focused on parameter-specific monitoring priorities. During a particular runoff event, all the priorities come into play and the general monitoring approach is dictated by an integration of all of the priorities. Top priority must be given to any stream monitoring site where no water quality samples have been collected for the year. Stream flow data is given the next priority. If time, conditions, and manpower permit, current metering is conducted. At a minimum, high water marks are staked before conducting another sampling function or going to another site.

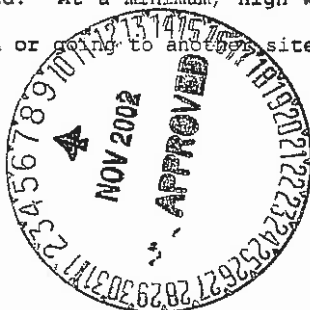


Table 5

Water Sample Handling, Preservation, and Transport Times

| Parameter | Container | Preservation | Maximum Storage Regulatory |
|--|-------------------|---|-------------------------------|
| Acidity | Plastic/Glass | Refrigeration | 14 days |
| Alkalinity | Plastic/Glass | Refrigeration | 14 days |
| BOD | Plastic/Glass | Refrigeration | 48 hours |
| Boron | Plastic | None Required | 28 days |
| Bromide | Plastic/Glass | None Required | 28 days |
| COD | Plastic/Glass | Add H ₂ SO ₄ to pH 2 | 28 days |
| Coliforms | Plastic (sterile) | Refrigeration | 24 hours |
| Chlorophyll | Plastic/Glass | 30 days in dark: freeze | 30 days |
| Chromium VI | Plastic/Glass | Refrigeration | 48 hours |
| Color | Plastic/Glass | Refrigeration | 48 hours |
| Conductivity | Plastic/Glass | Refrigeration | 28 days |
| Cyanide, Total | Plastic/Glass | Add NaOH to pH 12, Refrigeration | 14 days |
| Fluoride | Plastic/Glass | None Required | 28 days |
| Hardness | Plastic/Glass | Add HNO ₃ to pH 2 | 6 months |
| Metals, general | Plastic/Glass | Add HNO ₃ to pH 2 | 6 months |
| Mercury | Plastic/Glass | Add HNO ₃ to pH 2, Refrigeration | 28 days |
| Nitrogen, Ammonia | Plastic/Glass | Add H ₂ SO ₄ to pH 2, Refrigeration | 28 days |
| Nitrogen, NO ₃ /NO ₂ | Plastic/Glass | Refrigeration | 28 days |
| Nitrogen, Nitrite | Plastic/Glass | Refrigeration | 28 days |
| Nitrogen, Nitrate (non-chlorinated) | Plastic/Glass | Refrigeration | 28 days |
| Nitrogen, Total | Plastic/Glass | Refrigeration | 28 days |
| Oil and Grease | Glass | Refrigeration | 48 hours |
| Organic Carbon | Glass | Add H ₂ SO ₄ to pH 2, Refrigeration | 14 days |
| Phenols | Glass | Add H ₂ SO ₄ to pH 2, Refrigeration | 28 days |
| pH | Glass | Add H ₂ SO ₄ to pH 2, Refrigeration | 28 days |
| Phosphate | Plastic/Glass | Add H ₂ SO ₄ to pH 2, Refrigeration | 28 days |
| Phosphate, Total | Plastic/Glass | Add H ₂ SO ₄ to pH 2, Refrigeration | 28 days |
| Residue | Plastic/Glass | Analyze Immediately | 2 hours |
| Silica | Plastic | Filter, Refrigeration | 48 hours |
| Sulfate | Plastic/Glass | H ₂ SO ₄ to pH 2, Refrigeration | 28 days |
| Sulfide | Plastic/Glass | Refrigeration | 14 days |
| Toluene | Glass Vial | Refrigeration | 28 days |
| | | HCL | 28 days |
| | | | 7 days |



TABLE 6
Sample Filtration Requirements

| Color | Code | Sample Type/Preservative | Bottle Type | Analysis |
|----------|----------|--|------------------|---|
| No Color | U | Raw/No Chemical Preservatives | Plastic | Acidity, Alkalinity (total), BOD, Chlorine, EC, Odor, pH, Solids (dissolved, settleable, suspended total & volatile), Sulfite, Surfactants, Turbidity |
| White | W | Filtered/No Chemical Preservatives | Plastic | Alkalinity (Bicarbonate, Carbonate, Hydroxide), Boron, Bromide, Chloride, Chromium +6, Color, Fluoride, Iodide, Nitrate/Nitrite, Phosphate (ortho), Silica, Sulfate |
| Red | R | Raw/Acidified (HNO ₃) | Plastic | Total or Total Recoverable metals |
| Green | G | Filtered/Acidified (HNO ₃) | Plastic | Dissolved metals |
| Yellow | Y or Y/G | Raw/Acidified (H ₂ SO ₄) | Plastic or glass | Total COD, Nitrogen (Ammonia, Organic & Total), Phenols, Phosphorus (Organic, Total), TOC |
| Blue | B or B/G | Filtered/Acidified (H ₂ SO ₄) | Plastic or Glass | Dissolved COD, DOC, Dissolved Nutrients |
| Tan | T | Raw/Preserved (Zinc Acetate) | Plastic | Sulfide |
| Orange | O | Raw/Acidified (H ₂ SO ₄) | Glass (1000ml) | Oil and Grease |
| Pink | P | Raw/Preserved (NaOH) | Plastic | Cyanides |
| Sterile | ST | Raw/Preserved (Sodium Thiosulfate) | Plastic/Sterile | Coliforms |

ADDITIONAL INFORMATION

- Cool all samples to 4° C
- Filtered samples are to be filtered through 0.45 micron membrane filters except samples for DOC. Use 0.45 micron silver mesh filters for DOC samples.
- Phenols require a glass bottle.



Permanent Impoundment Monitoring.

Two types of permanent impoundments are monitored on Peabody's leasehold - permanent internal impoundments (PII's) and externally draining permanent impoundments (PI's). PII's have been monitored in the pre-law and postlaw (interim program) areas for bond release purposes (30 CFR 816.49b criteria and water quality and quantity representative of pre-July 6, 1990 reclamation) for those areas disturbed prior to July 6, 1990. Fifteen pre-law and interim land PII's representative of those proposed to be left as permanent impoundments in areas disturbed prior to July 6, 1990 have been monitored continuously and/or periodically for water persistence and water quality since 1981 (see Exhibits 85600 and 93500 for the locations of the 15 PII's that have been monitored). Since more than one monitoring site name has been used for these 15 PII's in the past, Table 7 is presented to cross reference past site ID's with the current database site ID's.

Twenty-eight PI's are proposed to be left in the final reclamation. To date, 13 of these 28 proposed PI's have been monitored periodically to obtain a preliminary indication of water level fluctuations and water quality. The locations of the 28 PI's are shown on Exhibit 85324 (see Table 8 for the monitoring site ID's for the 28 proposed PI's).

Naming Conventions/Site ID's, Coordinates, and Elevations. Table 8 presents a detailed list of the site ID's for impoundments proposed to be left in the final reclaimed landscape. Site ID's used by Engineering (Exhibit 85405) and Reclamation (Exhibit 85324) differ from the hydrologic monitoring Site ID's. Table 8 presents a cross referencing of the Site ID's so that Exhibits 85600, 85324, 85405, and 93500 can be correctly interpreted. Some of the impoundments do not exist at the present; however, they are proposed during the course of the entire mining operation. Numbers in parentheses are the Engineering and Reclamation site ID's used. Table 9 presents coordinates and elevations for all impoundments using the hydrology site ID designations.

Monitoring Approach and Frequencies. Sufficient monitoring data exists for the appropriate decision regarding the inclusion of the PII's (pre-July 6, 1990) in the reclaimed landscape to be made (see Volume 9, Chapter 15; Volume 11, Chapters 16 and 17 of the Permit and the 1986 through 1991 Annual Hydrological Data Reports). The monitoring of the PII's (pre-July 6, 1990) is no longer necessary to achieve the purposes set forth in this monitoring chapter and the areas draining to these ponds are those defined in forthcoming bond release application packages or they exist in prelaw disturbance areas.

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TABLE 7

Cross Reference for Current and Historic PII Site ID's

| Current Site ID* | Historic Site ID's Used |
|------------------|---|
| PII112-P | 112, Permanent Internal Impoundment 112, PII112 |
| PII113-P | 113, Permanent Internal Impoundment 113, PII113 |
| J27-RC-P | 116, Permanent Internal Impoundment 116, PII116 |
| PII117-P | 117, Permanent Internal Impoundment 117, PII117 |
| PII118-P | 118, Permanent Internal Impoundment 118, PII118 |
| PII119-P | 119, Permanent Internal Impoundment 119, PII119 |
| PII120-P | 120, Permanent Internal Impoundment 120, PII120 |
| PII121-P | 121, Permanent Internal Impoundment 121, PII121 |
| PII122-P | 122, Permanent Internal Impoundment 122, PII122 |
| PII123-P | 123, Permanent Internal Impoundment 123, PII123 |
| J27-RB-P | 124, Permanent Internal Impoundment 124, PII124 |
| N1-RA-P | 125, Permanent Internal Impoundment 125, PII125 |
| N2-RA-P | 212, Permanent Internal Impoundment 212, PII212, PIIN2-RA |
| N2-RB-P | 206, Permanent Internal Impoundment 206, PII206, PIIN2-RB |
| N2-RC-P | ---, Permanent Internal Impoundment N2-RC, PIIN2-RC |

* Site ID's used on Exhibits 85600 and 93500

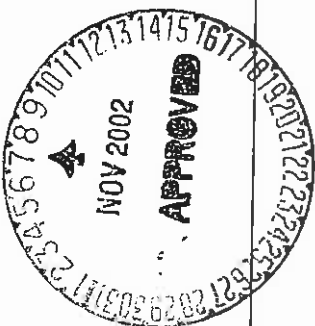


TABLE 8

Hydrology Site ID's Cross Referenced With
Engineering and Reclamation Site ID's for Permanent
Impoundments to be left in the Final Reclaimed Landscape

| Hydrology ID's* | Engr./Recl. ID's** | Hydrology ID's | Engr./Recl. ID's |
|-----------------|--------------------|----------------|------------------|
| J1-RA-P | (J1-RA, J1-PI#1) | N1-PII#1-P | (N1-PII#1) |
| J1-RB-P | (J1-RB, J1-PI#2) | N1-PII#2-P | (N1-PII#2) |
| J2-A-P | (J2-A) | N1-RA-P | (N1-RA, N1-PI#3) |
| J3-D-P | (J3-D) | N1-PII#4-P | (N1-PII#4) |
| J3-E-P | (J3-E) | N1-RB-P | (N1-PII#5) |
| J3-G-P | (J3-G, J3-G(PI)) | N1-PII#6-P | (N1-PII#6) |
| J3-PII#1-P | (J3-PII#1) | N1-PII#7-P | (N1-PII#7) |
| J3-PII#2-P | (J3-PII#2) | N2-RA-P | (N2-RA) |
| J3-PII#3-P | (J3-PII#3) | N2-RB-P | (N2-RB) |
| J3-PII#4-P | (J3-PII#4) | N2-RC-P | (N2-RC) |
| J3-PII#5-P | (J3-PII#5) | N5-A-P | (N5-A) |
| J7-DAM-P | (J7-DAM) | N6-L-P | (N6-L) |
| J7-JR-P | (J7-JR) | N7-D-P | (N7-D) |
| J7-R-P | (J7-R) | N7-E-P | (N7-E) |
| J16-A-P | (J16-A) | N8-RA-P | (N8-RA, N8-PI#1) |
| J16-G-P | (J16-G) | N10-A1-P | (N10-A1) |
| J16-L-P | (J16-L) | N10-D-P | (N10-D) |
| J19-RB-P | (J19-RB) | N10-G-P | (N10-G) |
| J21-A-P | (J21-A) | N11-A-P | (N11-A) |
| J21-C-P | (J21-C) | N11-G-P | (N11-G) |
| J21-I-P | (J21-I) | N12-C-P | (N12-C) |
| J27-RA-P | (J27-RA) | N14-D-P | (N14-D) |
| J27-RB-P | (J27-RB) | N14-F-P | (N14-F) |
| J27-RC-P | (J27-RC) | N14-G-P | (N14-G) |
| TPF-D-P | (TPF-D, TPF-PI#1) | N14-H-P | (N14-H) |
| TPF-E-P | (TPF-E) | | |

*All -P site ID's (not in parentheses) are used in the Hydrology sections and on Exhibits 85600 and 93500

**Corresponding Engineering and Reclamation site ID's in parentheses and are those shown on Exhibits 85324 and 85405

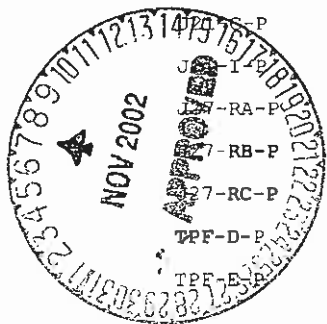


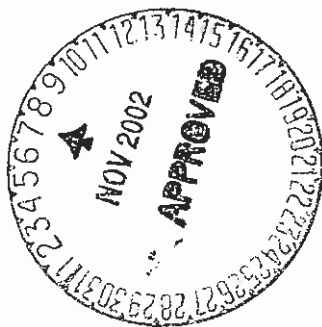
TABLE 9
Elevations and Coordinates for Existing
Permanent Impoundments

| Site I.D. | UTM | | | Peabody | |
|------------|-----------|------------|------------|------------|------------|
| | Surface | Northing | Easting | Northing | Easting |
| | Elevation | Coordinate | Coordinate | Coordinate | Coordinate |
| J1-RA-P | 6698.00 | 4039606.13 | 555728.81 | -15650 | 33920 |
| J1-RB-P | 6644.50 | 4038568.00 | 554886.39 | -19050 | 31140 |
| J2-A-P | 6348.30 | 4037593.09 | 550995.64 | -22240 | 18380 |
| J3-D-P | 6469.10 | 4036079.80 | 553752.68 | -27200 | 27376 |
| J3-E-P | 6533.00 | 4037179.89 | 554553.17 | -23597 | 30020 |
| J3-G-P | 6510.00 | 4035453.49 | 551934.62 | -29250 | 21410 |
| J3-PII#1-P | 6552.00 | 4037147.92 | 552751.49 | -23700 | 24120 |
| J3-PII#2-P | 6479.50 | 4036167.94 | 552418.72 | -26910 | 23010 |
| J3-PII#3-P | 6490.50 | 4035252.10 | 552201.60 | -29910 | 22280 |
| J3-PII#4-P | 6483.00 | 4035246.07 | 552458.18 | -29930 | 23120 |
| J3-PII#5-P | 6515.00 | 4034998.73 | 552200.16 | -30740 | 22270 |
| J7-Dam-P | 6368.40 | 4031256.95 | 554584.72 | -43000 | 30000 |
| J7-JR-P | 6710.00 | 4032532.00 | 560083.00 | -39875 | 48140 |
| J7-R-P | 6317.00 | 4028561.00 | 553756.00 | -52800 | 27300 |
| J16-A-P | 6635.00 | 4039575.68 | 562262.50 | -15756 | 55313 |
| J16-G-P | 6576.00 | 4038977.39 | 561291.15 | -17715 | 52120 |
| J16-L-P | 6573.40 | 4037031.24 | 560866.80 | -24090 | 50690 |
| J19-RB-P | 6880.00 | 4034963.00 | 563859.00 | -31960 | 60580 |
| J21-A-P | 6933.00 | 4032549.91 | 567788.25 | -38777 | 73260 |
| J21-C-P | 6894.50 | 4031787.04 | 566644.78 | -41275 | 69500 |
| J21-I-P | 6804.90 | 4028460.00 | 563497.00 | -53300 | 59280 |
| J27-RA-P | 6541.00 | 4054545.29 | 534980.42 | -33890 | 33500 |
| J27-RB-P | 6562.00 | 4054643.89 | 534623.53 | -35060 | 33830 |
| J27-RC-P | 6467.00 | 4054225.26 | 534939.49 | -34030 | 32450 |
| N1-PII#1-P | 6980.00 | 4044862.08 | 553609.49 | 1570 | 27090 |
| N1-PII#2-P | 6645.50 | 4043921.10 | 552835.70 | -1750 | 24500 |
| N1-RA-P | 6600.00 | 4043610.36 | 553095.21 | -2530 | 25380 |
| N1-PII#4-P | 6630.00 | 4043494.09 | 552143.09 | -2910 | 22260 |
| N1-RB-P | 6620.00 | 4043341.66 | 552843.43 | -3410 | 24550 |
| N1-PII#6-P | 6618.00 | 4043185.74 | 552025.94 | -3920 | 21870 |
| N1-PII#7-P | 6580.00 | 4042975.20 | 552326.58 | -4610 | 22850 |
| N2-RA-P | 6556.50 | 4043661.03 | 554136.31 | -2365 | 28790 |
| N2-RB-P | 6664.50 | 4045173.65 | 554312.99 | 2590 | 29400 |
| N2-RC-P | 6820.00 | 4046374.18 | 555191.33 | 6522 | 32301 |
| N5-A-P | 6461.20 | 4041772.19 | 552404.47 | -8551 | 23080 |
| N6-L-P | 6512.00 | 4043213.00 | 553761.00 | -4699 | 27572 |
| N7-D-P | 6611.20 | 4043997.45 | 551048.07 | -1260 | 18685 |
| N7-E-P | 6562.40 | 4043979.21 | 551339.85 | -1320 | 19640 |
| N8-RA-P | 6624.00 | 4046301.00 | 550281.00 | 5500 | 16200 |



TABLE 9 (Con't)
Elevations and Coordinates for Existing
Permanent Impoundments

| Site I.D. | Surface Elevation | UTM | | Peabody | |
|-----------|----------------------|------------|------------|------------|------------|
| | | Northing | Easting | Northing | Easting |
| | | Coordinate | Coordinate | Coordinate | Coordinate |
| N10-A1-P | 6628.00 | 4044338.91 | 555857.53 | -146 | 34440 |
| N10-D-P | 6581.50 | 4043746.76 | 555011.97 | -2085 | 31659 |
| N10-G-P | 6735.00 | 4045885.00 | 556938.00 | -4020 | 38050 |
| N11-A-P | 6588.00 | 4043969.00 | 555145.00 | -2240 | 32130 |
| N11-G-P | 6746.00 | 4044120.00 | 557146.00 | -1780 | 38700 |
| N12-C-P | 6584.60 | 4043384.70 | 554912.57 | -3271 | 31326 |
| N14-D-P | 6653.30 | 4039958.50 | 560255.71 | -14500 | 48750 |
| N14-F-P | 6659.70 | 4040340.58 | 562009.35 | -13250 | 54500 |
| N14-G-P | 6661.00 | 4040508.63 | 562542.73 | -12700 | 56250 |
| N14-H-P | 6719.00 | 4041226.31 | 563622.35 | -10350 | 59800 |
| TPF-D-P | 6719.31 | 4043389.53 | 549498.96 | -3250 | 13600 |
| TPF-E-P | 6548.50 | 4043127.74 | 549931.24 | -4108 | 15010 |

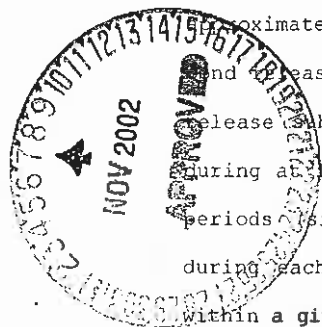


The emphasis on permanent impoundment monitoring will shift to focusing on the externally draining permanent impoundments adjacent to all current and proposed future mining. Exceptions to this will be the continued monitoring of PIIs J1-RA-P and J1-RB-P until the bond release application for the parcel draining to these ponds is submitted. Also, PII J19-RB-P when completed and its watershed stabilized, and PII J3-G-P will eventually be monitored.

Since bond release will be accomplished through a series of applications over a range of years, there is no need to monitor all externally draining permanent impoundments and the one proposed permanent internal impoundment (J19-RB-P) simultaneously.

The approach will be to focus on monitoring groups of ponds in time frames that correspond to proposed bond release and/or permanent impoundment design submittal and construction schedules. Bond release submittals are proposed to be made approximately 10 to 12 years following the conclusion of mining in a particular mining area or portion of a mining area that drains to a discrete group of ponds. Typically, final permanent impoundment design submittals are proposed to occur approximately one year prior to final design construction work which in turn is scheduled to occur approximately one to two years prior to the respective bond release submittal (refer to Drawing 85406 (Volume 22), and Table 4 in Chapter 6 (Volume 1) for proposed permanent construction dates). These dates must be qualified as proposed only. Mine plan and reclamation changes may significantly affect these dates. Until revisions occur, these are the dates when PWCC anticipates design and construction activities to occur.

Hydrologic monitoring for the permanent impoundment criteria specified in 30 CFR 816.49b will be conducted once the disturbed areas have been stabilized. Stabilization of the disturbed areas involves regrading and the successful re-establishment of vegetation. These two activities normally require five to six years. This leaves a period of approximately six years within which hydrologic monitoring for permanent impoundment and bond release criteria can be conducted on stabilized watersheds prior to anticipated bond release submittals. The permanent impoundment hydrologic monitoring will be conducted during at least four of the six years. Table 10 summarizes the proposed pond monitoring periods (six-year intervals) and the proposed permanent impoundments to be monitored during each six-year monitoring interval. Permanent impoundment monitoring frequencies within a given year and parameters monitored are specified in Table 4. The permanent



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The approach will be to focus on monitoring groups of ponds in time frames that correspond to proposed bond release and/or permanent impoundment design submittal and construction schedules. Bond release submittals are proposed to be made approximately 10 to 12 years following the conclusion of mining in a particular mining area or portion of a mining area that drains to a discrete group of ponds. Typically, final permanent impoundment design submittals are proposed to occur approximately one year prior to final design construction work which in turn is scheduled to occur approximately one to two years prior to the respective bond release submittal (refer to Drawing 85406 (Volume 22), and Table 4 in Chapter 6 (Volume 1) for proposed permanent construction dates). These dates must be qualified as proposed only. Mine plan and reclamation changes may significantly affect these dates. Until revisions occur, these are the dates when FWCC anticipates design and construction activities to occur.

Hydrologic monitoring for the permanent impoundment criteria specified in 30 CFR 816.49b will be conducted once the disturbed areas have been stabilized. Stabilization of the disturbed areas involves regrading and the successful re-establishment of vegetation. These two activities normally require five to six years. This leaves a period of approximately six years within which hydrologic monitoring for permanent impoundment and bond release criteria can be conducted on stabilized watersheds prior to anticipated bond release submittals. The permanent impoundment hydrologic monitoring will be conducted at least four of the six years. Table 10 summarizes the proposed pond monitoring periods (six-year intervals) and the proposed permanent impoundments to be monitored during each six-year monitoring interval. Permanent impoundment monitoring frequencies within a given year and parameters monitored are specified in Table 4. The permanent



impoundment monitoring intervals and the impoundments monitored must be qualified as proposed. Mine plan and reclamation changes may significantly affect these anticipated monitoring dates. The information presented in Table 10 is based on the mining and reclamation schedules currently available. Should mine plan revisions occur, Table 10 will be revised to reflect these changes.

Permanent Impoundment Sediment Accumulation Methodology. Fixed stakes or rebars are installed on the pond shorelines (sufficiently above the zone of fluctuating water levels). The stakes define transect lines across and longitudinal to the pond configuration along which measurements of depth to sediment will be taken at fixed distances from each shore. A measurement of the elevation of the water surface is made and all depth measurements are related to this pond surface elevation. Depending on surveying manpower availability, the fixed distances from each shore at which depth to top of sediment measurements are made will be determined using surveying equipment or measuring tapes. When these ponds contain water, depths to top of the sediment are made using any of three techniques: lowering flat weighted objects 1) suspended by calibrated line or 2) attached to metal rods, or by using a 3) hand-held sonic ranging device (similar to a "fish finder" on a boat). Depending on surveying manpower availability, sediment surveys involve surveying several or numerous random points over the pond surfaces at which depth to sediment measurements are taken. When these ponds are dry surveying becomes a simple matter of measuring a sufficient number of pond-bottom elevations with which to calculate a difference in sediment volume between successive surveys. At present, volume of sediment accumulation is calculated using the software program "STOCK", which computes a volumetric difference between two contour surfaces.

Permanent Impoundment Water Quality Sampling and Analysis Methodology. Permanent impoundment water quality samples are obtained by dip sampling either from the shore or a boat if the sample is obtained when the sediment survey is being conducted. Dip sampling is utilized because the pond water depths are typically shallow enough that wind will cause mixing of pond water, thereby preventing development of vertically stratified zones in the pond water. Sample handling, preservation, transport, and data analysis and laboratory analysis methodologies are the same as those described for stream water quality in this Chapter.

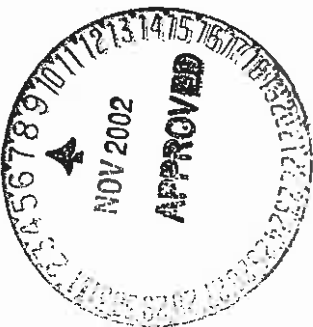


TABLE 10

Monitoring Intervals for Hydrologic Permanent Impoundment
Criteria and Sediment

Ponds/Year Ranges

| Completed Monitoring Criteria | | Current and Future Monitored Impoundments | | | | |
|-------------------------------|-------|---|-----------|-----------|-----------|-----------|
| 1986-1994 | | 2000-2006 | 2003-2009 | 2004-2010 | 2010-2016 | 2015-2021 |
| N1-RA | N1-RA | J1-RA | J21-A | J7-R | J3-D | J2-A |
| N2-RA | N7-D | J1-RB | | J19-RB | J3-G | J3-E |
| N2-RB | N7-E | J16-A | | N5-A | | J7-DAM |
| N2-RC | N8-RA | J16-G | | N6-L | | J7-JR |
| N7-D | | J16-L | | | | J21-C |
| N7-E | | N10-A1 | | | | J21-I |
| | | N10-D | | | | N10-G |
| | | N11-A | | | | N12-C |
| | | N11-G | | | | TPF-D |
| | | N14-D | | | | TPF-E |
| | | N14-F | | | | |
| | | N14-G | | | | |
| | | N14-H | | | | |



NPDES Monitoring.

A copy of NPDES Permit No. AZ0022179 is presented in Attachment 3. The above-referenced permit contains chemical parameters to be monitored, sampling frequencies, effluent and reporting requirements applicable to discharges resulting from pond (lagoon) dewatering, as well as discharges that result from rainfall. The permit does not use the term snowmelt discharge. It is implicit that it is runoff volumes for a particular storm duration, return period, and intensity the effluent limitations apply to. If the snowmelt runoff volume for a 24-hour period is greater than the 10-year, 24-hour storage volume of a sediment pond, resultant discharges will not be analyzed for settleable solids. Pond discharges resulting from snowmelt runoff under any circumstances other than those described above will be analyzed for settleable solids.

The NPDES ponds have been grouped into three categories of ponds depending on the type of disturbance and effluent the pond may receive. When precipitation discharges occur, only one pond from each category of ponds that may be discharging need be sampled. PWCC will include copies of the monthly NPDES monitoring reports, including any discharge monitoring reports (DMR's) submitted to EPA in a given quarter, as part of the quarterly monitoring reports submitted to OSM. For discharges that result from dewatering, PWCC will obtain a sample from each discharge point described in the operating plan for dewatering sediment ponds and impoundments on the Black Mesa leasehold (see Chapter 6, Facilities). Upon dewatering of any sediment pond or impoundment, PWCC will sample each discharge point at the frequencies and for the parameters outlined in the NPDES Permit. In the event that a parameter or parameters exceed the permit effluent limits at the pond outfall, downstream monitoring of the same discharge and failing parameter or parameters must be conducted and reported.

Because the development of new mining areas on the PWCC leasehold is ongoing, new sediment ponds (NPDES discharge points) will be constructed during the five-year permit term. Following the completion of additional new ponds, PWCC has and will continue to request modifications to the existing NPDES permit to incorporate new ponds.

Small Watershed Monitoring.

A special study, referred to as the Interim Land Small Watershed Study, was initiated by Peabody Coal Company in 1985, and completed in 1992. This study is not considered part of the formal hydrologic monitoring program because it is largely experimental in nature, as exact guidelines for hydrologic bond release were not available from OSM when the study

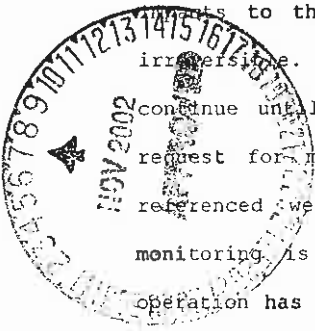
was initiated. For this reason the main body of the Small Watershed Study shall reside in an Attachment (Attachment 4) to this chapter rather than in the body of the monitoring program.

The Small Watershed Study was implemented to define the hydrologic processes governing the quantity and quality of runoff on all interim and post law lands reclaimed prior to July 6, 1990. The data will be used to define the overland flow portion of runoff as well as channelized runoff from reclaimed areas. The data will be available for use in the evaluation and calibration of computer models should this approach be used to predict hydrologic responses in ungaged reclaimed watersheds on Black Mesa. The information presented in Attachment 4 describes instrumental and computational methodologies utilized during the study.

Ground Water

Ground Water Monitoring Purpose, Contingencies, and Reporting.

Unless further defined in this Chapter, the purpose of the Navajo, Wepo, and alluvial well monitoring is: 1) to define baseline conditions and seasonal variability so the ground water portion of the hydrologic description can be adequately described; 2) to provide site specific ground water data for development of PHC analyses and conclusions; 3) to determine or define the existing and/or future use potential of those portions of all the aquifers being studied; 4) to assess over time (before and during mining and through the bond monitoring periods) the magnitude and extent of mining impacts to the quantity and quality of the ground water aquifers and to verify if these characteristics of the impacts are within the ranges and limits predicted and described by the PHC analysis and the CHIA analysis; 5) to determine if the established and defined water rights and use of others have been reasonably protected and not precluded; and, 6) to help define if any mining impacts to the ground water aquifers are short term or long term and reversible or irreversible. Navajo, Wepo, alluvial, and spoil well monitoring at some level shall continue until the associated incremental bond releases are accomplished. PWCC shall request for modifications to be made to the monitoring requirements for the above-referenced wells, parameters analyzed and sampling and reporting frequencies when monitoring is no longer necessary to achieve the purposes set forth above or; the operation has minimized disturbance to the hydrologic balance in the permit and adjacent areas and prevented material damage to the hydrologic balance outside the permit area,



water quantity and quality are suitable to support approved postmining land uses, and the water rights of others have been protected or replaced.

At the present, PWCC shall report ground water data within 60 days of the end of each of the first three quarters of a calendar year. The fourth quarter and annual ground water report shall be combined as one and shall be reported within 120 days of the end of the calendar year. Included with the Annual Hydrology Report (herein termed the AHR, but which is included as part of the Annual Reclamation Status and Monitoring Report) all ground water quality and ground water level data will be submitted to OSM on magnetic or other media in a format agreed to by PWCC and OSM.

Naming Conventions, Locations, Coordinates, and Elevations.

The ground water monitoring program for the Black Mesa/Kayenta Mines presently consists of 10 Navajo wells, 26 Wepo wells, 36 alluvial wells, one J16 spoil well, seven springs, and one special study cistern (Sagebrush Well). Locations of the historic ground water monitoring sites are presented on Exhibit 85600. The locations of the current ground water monitors are shown on Exhibit 93500. Site ID's, surface elevations, UTM coordinates, and Peabody coordinates are presented in Table 11. As new wells or replacement wells or other ground water monitoring sites are added to the network, Table 11 will be revised following the surveying of these sites. Also, Attachments 8, 9, 11, and 14 in Chapter 15 of the Permit will be revised as additional or replacement wells are added to the monitoring network and when any additional aquifer testing is performed.

Navajo Well Monitoring.

Monitoring Approach and Rationale. PWCC will monitor pumpage and water levels at each Navajo well according to the approach and frequencies presented in Table 12. Monitoring for formation losses in a pumping well bore and in wells that are part of an active well field is not recommended. Well efficiencies affect measurements, as do interferences from adjacent pumping wells.

Water level recoveries during the limited periods when pumps are cycled off are used as estimates of formation water levels and losses. The system is one that cannot be well maintained because transducer, cable, and bubbler line replacement can only be accomplished at seven of the monitoring sites when a pump is pulled. In several instances, the time between pump pulls can range from 3 to 8 years. The system is quite susceptible to voltage surges from lightning strikes and dragline usage.



TABLE 11

Site ID's, Elevations, and Coordinates for the
Ground Water Monitoring Sites and Springs

| Ground Water Monitor Site ID | Surface Elevation | UTM | | Peabody | |
|------------------------------------|----------------------|-------------------------|-----------------------|-------------------------|-----------------------|
| | | Northring Coordinate | Easting Coordinate | Northring Coordinate | Easting Coordinate |
| NAV2 | 6540.01 | 4039678.44 | 551952.54 | -16255.52 | 21811.84 |
| NAV3 | 6449.37 | 4032974.86 | 555787.04 | -38350.34 | 34330.56 |
| NAV3OBS | 6445.90 | 4032769.00 | 555848.00 | -38370.00 | 34200.00 |
| NAV4 | 6226.94 | 4033623.18 | 552775.76 | -36218.16 | 24399.22 |
| NAV5 | 6596.07 | 4037733.49 | 554143.72 | -22677.87 | 28972.90 |
| NAV6 | 6677.92 | 4039912.51 | 556346.70 | -15624.52 | 36113.74 |
| NAV6OBS | 6674.00 | 4039628.00 | 556397.00 | -15789.00 | 36140.00 |
| NAV7 | 6384.40 | 4030234.06 | 553108.65 | -47321.39 | 25424.73 |
| NAV8 | 6661.88 | 4042961.89 | 551109.05 | - 5461.46 | 19097.99 |
| NAV9 | 6391.56 | 4027659.21 | 552196.99 | -55759.50 | 22388.38 |
| WEPO40 | 6593.73 | 4043294.81 | 553141.38 | - 4448.31 | 25769.09 |
| WEPO41 | 6783.03 | 4046648.42 | 554025.21 | 6681.96 | 28740.16 |
| WEPO42 | 6625.30 | 4044508.69 | 555663.75 | - 505.59 | 34070.69 |
| WEPO43R | 6601.69 | 4040155.37 | 552642.86 | -14053.73 | 23846.46 |
| WEPO44 | 6666.42 | 4038715.82 | 554479.50 | -19536.59 | 30068.53 |
| WEPO45 | 6522.02 | 4036843.04 | 552651.72 | -25654.25 | 24036.20 |
| WEPO46 | 6446.70 | 4034382.24 | 555033.21 | -33717.12 | 31879.38 |
| WEPO47R | 6277.78 | 4028643.29 | 552984.87 | -51855.04 | 24768.56 |
| WEPO49 | 6629.24 | 4040663.75 | 562500.16 | -13238.32 | 56433.31 |
| WEPO51 | 6702.45 | 4046431.69 | 550608.56 | 6028.08 | 17519.40 |
| WEPO52 | 6654.21 | 4045897.63 | 552478.01 | 4243.17 | 23647.93 |
| WEPO53 | 6683.76 | 4042637.42 | 555114.58 | - 6672.40 | 32219.67 |
| WEPO54 | 6620.92 | 4039951.23 | 560202.18 | -15538.80 | 48876.92 |
| WEPO55 | 6484.70 | 4038398.14 | 549690.02 | -20438.46 | 14388.91 |
| WEPO56 | 6420.25 | 4038100.71 | 551611.82 | -21447.35 | 20693.32 |
| WEPO57 | 6463.04 | 4036185.05 | 553976.46 | -27836.80 | 28374.35 |
| WEPO58 | 6336.72 | 4033315.18 | 551797.81 | -37212.88 | 21183.37 |
| WEPO59 | 6295.74 | 4031782.90 | 551554.49 | -42239.37 | 20358.73 |
| WEPO60 | 6463.91 | 4028614.84 | 555417.17 | -52676.24 | 32976.54 |
| WEPO61 | 6510.06 | 4027429.03 | 551612.47 | -56505.37 | 20465.48 |
| WEPO62R | 6831.42 | 4037682.76 | 562744.50 | -22347.95 | 56967.70 |
| WEPO65 | 6814.00 | 4031964.00 | 561107.00 | -40999.90 | 51351.50 |
| WEPO66 | 6905.68 | 4030868.11 | 565625.57 | -45450.41 | 66529.13 |
| WEPO67 | 6902.30 | 4027859.05 | 561635.32 | -55253.22 | 53373.83 |
| WEPO68 | 7063.11 | 4033053.60 | 567464.94 | -37627.94 | 72384.28 |
| NSPG22 | 6534.89 | 4043430.21 | 554271.66 | - 3330.59 | 29251.23 |
| NSPG91 | 6612.32 | 4044493.80 | 555676.67 | - 573.77 | 34078.21 |
| NSPG92 | 6415.61 | 4034411.91 | 555053.60 | -33620.08 | 31946.83 |
| NSPG111 | 6851.79 | 4043135.06 | 561742.71 | - 5136.96 | 53970.40 |
| NSPG147 | 6338.05 | 4032871.24 | 553363.91 | -37980.87 | 26086.61 |
| NSPG149 | 6410 | 4029066.79 | 551960.31 | -50446.80 | 21412.20 |

TABLE 11 (Con't)

Site ID's, Elevations, and Coordinates for the
Ground Water Monitoring Sites and Springs

| Ground Water | | UTM | | Peabody | |
|------------------|-----------|------------|------------|------------|------------|
| Monitor Site | Surface | Northing | Easting | Northing | Easting |
| ID | Elevation | Coordinate | Coordinate | Coordinate | Coordinate |
| ALUV13R | 6713.36 | 4047140.91 | 554106.70 | 8297.46 | 29016.02 |
| ALUV17 | 6619.11 | 4044668.04 | 556062.63 | 10.83 | 35382.94 |
| ALUV19 | 6333.53 | 4038783.56 | 550737.85 | -19190.74 | 17835.53 |
| ALUV23R | 6652.41 | 4040719.44 | 563339.88 | -13069.64 | 59191.08 |
| ALUV27R | 6588.64 | 4036995.19 | 561606.09 | -25247.16 | 53459.76 |
| ALUV29 | 6265.47 | 4031540.76 | 553889.28 | -43073.64 | 28019.94 |
| ALUV31R | 6179.32 | 4031311.05 | 552116.32 | -43797.96 | 22195.33 |
| ALUV69 | 6740.56 | 4047829.13 | 554944.34 | 10452.48 | 31935.86 |
| ALUV71 | 6652.99 | 4046088.97 | 552902.67 | 4864.18 | 25045.35 |
| ALUV72 | 6591.12 | 4044781.95 | 551693.13 | 593.53 | 21052.28 |
| ALUV77 | 6775.53 | 4047370.47 | 559398.10 | 8826.76 | 46379.11 |
| ALUV80R | 6546.97 | 4043599.22 | 554204.64 | - 3421.27 | 29271.81 |
| ALUV83 | 6419.82 | 4041296.00 | 551842.95 | -11006.40 | 21350.96 |
| ALUV87 | 6729.58 | 4042280.76 | 564778.89 | - 7968.05 | 63941.77 |
| ALUV89R | 6550.37 | 4039406.86 | 561137.46 | -17341.76 | 51938.32 |
| ALUV93 | 6190.83 | 4032897.34 | 551894.69 | -38586.32 | 21494.38 |
| ALUV95 | 6150.64 | 4031992.08 | 551425.27 | -41550.44 | 19938.01 |
| ALUV98R | 6748.32 | 4038629.34 | 564128.47 | -19944.81 | 61744.84 |
| ALUV99R | 6923.45 | 4035789.04 | 566753.38 | -29313.83 | 70314.62 |
| ALUV101R | 6679.17 | 4035517.38 | 561786.63 | -30101.92 | 54027.61 |
| ALUV104R | 6273.18 | 4028735.17 | 552798.63 | -52237.17 | 24381.69 |
| ALUV105R | 6383.98 | 4028612.63 | 555222.37 | -52680.23 | 32336.95 |
| ALUV106R | 6423.13 | 4029238.06 | 555642.96 | -50663.07 | 33738.64 |
| ALUV108R | 6917.68 | 4032956.03 | 568090.93 | -38637.21 | 74658.13 |
| ALUV165 | 6591.79 | 4036865.16 | 561534.89 | -25672.86 | 53223.84 |
| ALUV168 | 6865.98 | 4032310.81 | 567338.16 | -40742.81 | 72175.90 |
| ALUV169 | 6837.89 | 4031328.48 | 566174.43 | -43948.24 | 68338.80 |
| ALUV170 | 6820.27 | 4030662.12 | 565793.33 | -46129.49 | 67076.44 |
| ALUV172 | 6159.90 | 4031514.08 | 551470.03 | -43120.50 | 20076.92 |
| ALUV180 | 6534.08 | 4043709.46 | 550944.02 | - 2914.90 | 18574.79 |
| ALUV181 | 6529.58 | 4043448.33 | 550747.46 | - 3768.87 | 17925.05 |
| ALUV182 | 6499.74 | 4042740.90 | 550471.88 | - 6201.99 | 17006.63 |
| ALUV183 | 6487.54 | 4042672.11 | 552888.52 | - 6520.97 | 24911.93 |
| ALUV187 | 6339.93 | 4039106.39 | 550683.51 | -18129.97 | 17662.55 |
| ALUV199 | 6729.35 | 4036694.73 | 564210.07 | -26297.59 | 61980.11 |
| ALUV200 | 6612.05 | 4044665.03 | 555830.32 | 4.87 | 34620.18 |
| SAGEBRUSH (WELL) | 6365 | 4028420.19 | 555087.92 | -52624.10 | 31669.20 |
| SPL161 | 6336.29 | 4038861.56 | 56721.06 | -18477.46 | 56911.31 |
| SSPG150 | 6704.57 | 4037934.64 | 561480.73 | -21498.93 | 52823.07 |
| SSPG151 | 6606.89 | 4039196.39 | 561847.79 | -17362.95 | 54050.20 |

TABLE 12

Types of Navajo Well Monitoring and Monitoring Frequencies¹

| Monitor Site ID | Volume Pumped | Water ² Levels | Field ³ Water Quality Parameters | Full Suite ⁴ Water Quality |
|-----------------------|------------------|------------------------------|---|---|
| NAV2 | Weekly | ** | Quarterly | Annual |
| NAV3 | Weekly | ----- | Quarterly | Annual |
| NAV3OBS | ----- | Continuous or Quarterly | ----- | ----- |
| NAV4 | Weekly | ** | Quarterly | Annual |
| NAV5 | Weekly | ** | Quarterly | Annual |
| NAV6 | Weekly | ----- | Quarterly | Annual |
| NAV6OBS | ----- | Continuous or Quarterly | ----- | ----- |
| NAV7 | Weekly | ** | Quarterly | Annual |
| NAV8 | Weekly | ** | Quarterly | Annual |
| NAV9 | Weekly | Continuous or Quarterly | Quarterly | Annual |

¹The Navajo well field qualifies as a public drinking water system and as such is subject to monitoring for compliance with the Safe Drinking Water Act. Bacteria, primary and secondary inorganic chemicals, radiochemicals, semi-volatile organics, volatile organics, and Pb/Cu are monitored and reported to NNEPA. Navajo Wells 2, 4, 7, and 8 comprise the potable water system.

²Water level monitoring frequencies will be attempted but may not be achievable for reasons stated in the text.

³When only field water quality parameters are monitored, TDS, pH, EC, salinity, and temperature are measured or analyzed.

⁴The full suite of chemical parameters is that suite presented in Table 3 of this chapter.

** Supplemental water level data shall be collected at these sites, but not at any set frequency.



PWCC'S approach will be to obtain continuous or at least quarterly water level data at the three wells where separate observation bores or an access tube are being used for the monitoring. This would be at wells NAV3OBS, NAV6OBS, and NAV9. At these sites transducers or airlines can be more easily pulled and replaced if they malfunction or drift and two of the borings are approximately 100 feet away from the effects of pumping wells. At the other five sites, Peabody will obtain at least quarterly water level measurements providing the airline tubes and attached airflow regulators are operating correctly. Interpretations of the water level monitoring data will be qualitative at best. Looking for 2 to 5 feet of formation loss from well records of water levels that can change as much as 300 - 700 feet because of well losses when pumps are cycled on and off is extrapolating the data beyond its true resolution. Water quality monitoring is not affected by whether pumps can be pulled or not. The only requirement is that a pump must have been turned on at least 24 hours prior to the sampling to obtain a representative sample.

Monitoring Parameters and Frequencies. The types of monitoring and the monitoring frequencies at the Navajo wells are presented in Table 12. The Navajo well field qualifies as a public drinking water system and as such is subject to monitoring for compliance with the Safe Drinking Water Act (SDWA). Currently, five bacteria samples are collected once a month from representative points in the Navajo well potable water distribution system. The bacteria sampling locations are determined from an EPA approved sample-siting plan. Bacteria samples are analyzed by a certified laboratory for total coliform and the results are forwarded to NNEPA. In addition to bacteria analyses, primary and secondary inorganic chemicals in the Navajo well water are analyzed every three years; radiochemicals are analyzed for on four-year intervals; volatile organic compounds, semi-volatile compounds and Pb/Cu are analyzed on a rotating three-year schedule. Future monitoring for compliance with the Phase 2 SDWA requirements will be coordinated with NNEPA. A vulnerability assessment has been presented to NNEPA for their consideration. Monitoring frequencies for the current SDWA requirements are presented in Table 13. The above-referenced monitoring and reporting will be performed in compliance with the requirements of 40 CFR Parts 141, 142 and 143. Records of all SDWA data are maintained at the mine.



TABLE 13

Specific Monitoring Requirements for Compliance
With the Safe Drinking Water Act

| Parameters | Monitoring Frequencies | Sampling Sites |
|----------------------------------|---|-----------------------------|
| Coliform Bacteria | Monthly | 5 water distribution points |
| Inorganic Chemicals ¹ | Once during 2004, 2007, and 2010 | Navajo Wells* |
| Radiochemicals ² | Initial four consecutive quarterly samples, starting 3 rd quarter, 2004. Results will determine if additional samples are required in 2009 | Navajo Wells* |
| Nitrate/Nitrite | Annually | Navajo Wells* |
| Pb/Cu (total) | Once during 2002, 2005 and 2008 | Water distribution points |
| Volatile Organic Chemicals | Once during 2003, 2006, and 2009 | Navajo Wells* |
| Asbestos | Once during 2003. Results will determine if additional samples are required in 2012 | Water distribution points |
| Pesticides/SOC's/PCB's | Once during 2004, 2007, and 2010 | Navajo Wells* |

¹Includes Beryllium, Thallium and CN.

²Includes gross alpha, Radium 226/228, and Uranium.

*Navajo wells means only those wells serving the potable water system (2, 4, 7, & 8)



Water Level and Pumpage Monitoring and Analysis Methodologies. Navajo well water level measurements were obtained historically using REDA down hole PSI units in combination with surface readouts and printers; separate Druck and Keller transducers in combination with Campbell Scientific, Inc. (CSI) dataloggers; and electric tapes. The present monitoring approach emphasizes nitrogen gas bubbler systems in combination with surface transducers and CSI dataloggers. Garber and Koopman (1968) present generalized water level measurement techniques that would partly address the use of transducers, bubbler systems, electric tapes, and dataloggers, but many of the actual procedures are instrumentation-specific and information regarding their use is minimal and largely limited to that printed in owners manuals and in the standard operating procedures (SOP's) established by PWCC.

Each of the above instrumentation types have their limitations and a brief discussion of these is warranted. The REDA PSI units had a PSI range of 0-5000, thus limiting the resolution of water level data measured using these units. Significant amounts of water level data were lost due to lightning strikes and dragline-induced voltage surges. The PSI units could only be replaced when a pump was pulled and they were principally designed to interface only with REDA surface readouts and printers. Turn-around times on readouts and printers being repaired or replaced were lengthy.

Druck and Keller transducers were available in a variety of PSI ranges so their water level resolution was good. They were principally used in the observation wells and the Well 9 external access tube because PWCC was not sure how well they would hold up in the pumping wells during pump placement or removal. One Keller transducer was attached to the pump column pipe in Well 4 during pump replacement. It failed in less than four months. Druck had a long turn-around time on repairs or replacements; whereas, Keller's turn-around time was better. The units were difficult to install in observation wells because safety cables had to be run in addition to the transducer's cable. Also, moisture on the inside of the well casing caused problems when trying to lower the transducer. All Druck and Keller transducers failed within six months of their installation in the Navajo well bores.



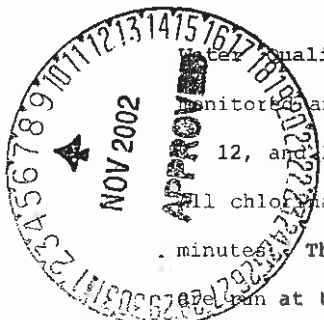
Bubbler systems can only be installed on the pumping wells when the pumps are removed. There is no assurance that air lines are not damaged during pump installation. The water level response for recovering water levels is lagged because additional time is needed for sufficient back pressure to build up in the air line to offset increased water heights above the bottom air tube inlet, thus continuous monitoring with air bubbler systems is not possible when pumps are being cycled on and off. In lieu of continuous monitoring, instantaneous water level measurements are taken. Since the system employs surface transducers, checks and repairs on these transducers can be made in a more timely manner.

Pumps must be removed from the pumping wells in order to use electric tapes and pump-pulls can be several years apart. Transducers would have to be removed from the observation wells to permit the use of electric tapes in them. At great depths, there can be considerable line stretch which affects the accuracy of water level readings. Moisture on the inside of the well casing causes the tape to stick and never reach true water level. Finally, the electric tape measurement technique is labor intensive.

Navajo well water level data are collected using dataloggers, instantaneous bubbler line gage readings, and electric tapes. The data is downloaded from the dataloggers using storage modules and then uploaded to PC's for conversion and storage which is accomplished using CSI programs. Instantaneous and visual observations are manually reduced to average daily values and entered into a PC database. Navajo well water levels are presented in quarterly data reports in both table and hydrograph form.

Well pumpage is measured using totalizing flow meters. The flow meters are read and recorded weekly. Pumpage values are manually entered onto PC's and compiled using PC programs. The pumpage data is reported quarterly to the USGS and both Tribes and annually in the hydrologic data report.

Water Quality Monitoring and Analysis Methodologies. The water quality parameters monitored and the frequencies of collection for the Navajo wells are referenced in Tables 12, and 13. Side taps have been drilled into the well head piping at each Navajo well. All chlorinators are shut off and the side taps are opened and allowed to flow for 5 - 10 minutes. The water quality samples are collected and the field water quality parameters are run at the well house unless unforeseen conditions would necessitate running the field parameters in the environmental lab. Water quality samples are collected only after it has been confirmed that the pump has been on for at least 24 hours. Sample handling,



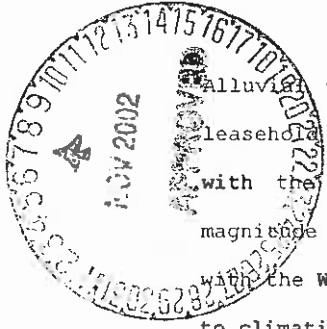
preservation, and transport methods are presented in Tables 5 and 6. Field and laboratory parameters are run within the maximum holding times specified on Table 5.

Water quality analysis techniques are the same as those described for stream water quality. Laboratory water quality analyses for the suite of chemical parameters referenced in Table 13 are run according to the methodology in the most current edition of "Standard Methods for the Examination of Water and Wastewater" (APHA, 1989). The specific analysis method numbers by chemical parameter are presented in Attachment 2.

Navajo Well Completions. Navajo well completion information is presented in Volume 10, Chapter 15, Attachment 19 of the permit.

Wepo and Alluvial Well Monitoring.

Monitoring Approach and Rationale. Wepo monitoring wells are located such that they are in the immediate downgradient flow path from areas to be disturbed by mining. They are positioned so they won't be removed by the mining activity and thus will provide data from before, during, and after mining from a constant point. Through aquifer testing and water level and quality monitoring the use potential in terms of yield and quality is defined. Monitoring during and after mining defines the magnitude and extent of any mining impacts on the water quantity or quality and whether a water use potential is lost in the short or long term. Additionally, some Wepo wells are located upgradient from mining, below dry pits, and in areas no longer proposed for mining. Data from these wells are used to assess changes due to climatic and other natural factors as well as to further describe the water use potential of other areas of the aquifer.



Alluvial wells are positioned above and below mining along the stream courses to the leasehold boundaries. Data collected from the wells define recharge/discharge relations with the Wepo aquifer, the water use potential of the alluvial aquifer, and the magnitude and extent of mining impacts, if any, to the use potential of the aquifer. As with the Wepo wells, alluvial wells positioned above mining are used to assess changes due to climatic and natural phenomena.

Wepo or alluvial wells with high baseline TDS and SO_4 levels may show increases in these constituent concentrations that preclude a preexisting water use, may be short term or long term, and of great areal extent or very limited extent. The principal objectives of

the monitoring program will have been met once these factors are defined because the more easily determined parameters (water level fluctuations, flow gradients and directions, recharge and aquifer characteristics) will already have been determined earlier in the monitoring program.

Monitoring Parameters and Frequencies. The types of monitoring and the monitoring frequencies at the Wepo and alluvial wells are presented in Table 14. As noted at the bottom of Table 14, Peabody performs additional water quality monitoring at 3 of the Wepo wells to assess the impacts, if any, of the solid waste landfill on the local Wepo water quality. The background (unaffected) Wepo and alluvial wells are principally used as a check on possible climatic induced effects on the monitoring data and do not warrant the same sampling frequencies as the wells potentially affected by mining. Should future mining cause any current background wells to become affected, Table 14 will be revised to reflect this and monitoring frequencies will be adjusted to whatever the frequencies for affected wells are at that time.

Water Level Monitoring and Analysis Methodology. All water levels taken in Wepo and alluvial wells are obtained using electric tapes with two exceptions. Water levels in WEPO42 and ALUV168 are measured with a steel measuring tape. The use of electric tapes is described in Driscoll (1986) and all depth to water measurements are taken from defined datum points. All water level measurements are converted to depth below ground surface (calculated by subtracting out casing stick-up heights) and/or elevations using calculators or PC programs. Ground water level data is presented in tables and/or water level hydrographs.

Wepo and Alluvial Well Water Quality Monitoring.

Water Quality Parameters and Rationale. The suite of ground water quality parameters for which the Wepo, alluvial, and spoil wells are analyzed is presented in Table 15. The suite includes all parameters that have Arizona, Federal, or Navajo Nation livestock drinking water limits, all significant parameters necessary to perform QA/QC checks on laboratory data, and those parameters necessary for evaluating mining impacts. Irrigation standards were not used because the low well yields and water quality preclude irrigation practices using the Wepo and alluvial aquifers in the area. The aquifer test and water quality sections of Chapter 15 (Hydrologic Description) and the alluvial valley floor section of Chapter 17 (Protection of

TABLE 14
Types of Wepo Well, Alluvial Well, and
Spring Monitoring and Monitoring Frequencies¹

| Monitor Site I.D. | Water Levels | ² Field Water Quality Parameters | Full Suite Water Quality | Potentially Affected or Unaffected | Interim or Permanent |
|-------------------------|-----------------|---|--------------------------------|---|----------------------------|
| WEPO40 | annual | annual | annual | A | P |
| WEPO41 | idled | idled | idled | U | I |
| WEPO42 | annual | annual | annual | A | P |
| WEPO43R | annual | annual | annual | A | P |
| WEPO44 | annual | annual | annual | A | P |
| WEPO45* | annual | annual | annual | A | P |
| WEPO46 | annual | annual | annual | A | P |
| WEPO47R | annual | annual | annual | U | P |
| WEPO49 | annual | annual | annual | A | P |
| WEPO51 | idled | idled | idled | U | I |
| WEPO52 | idled | idled | idled | U | I |
| WEPO53 | annual | annual | annual | U | P |
| WEPO54 | annual | annual | annual | A | P |
| WEPO55 | annual | annual | annual | A | P |
| WEPO56* | annual | annual | annual | A | P |
| WEPO57* | annual | annual | annual | A | P |
| WEPO58 | annual | annual | annual | U | P |
| WEPO59 | annual | annual | annual | U | P |
| WEPO60 | annual | annual | annual | U | P |
| WEPO61 | annual | annual | annual | U | P |
| WEPO62R | annual | annual | annual | U | P |
| WEPO65 | annual | annual | annual | U | P |
| WEPO66 | annual | annual | annual | U | P |
| WEPO67 | annual | annual | annual | U | P |
| WEPO68 | annual | annual | annual | U | P |
| WEPO178 | idled | idled | idled | A | I |
| ALUV178R | idled | idled | idled | U | I |
| ALUV17 | annual | annual | annual | A | P |
| ALUV19* | semiannual | semiannual | semiannual | A | P |
| ALUV23R | annual | annual | annual | A | P |
| ALUV27R | idled | idled | idled | A | P |
| ALUV29 | annual | annual | annual | U | P |
| ALUV31R | idled | idled | idled | U | P |
| ALUV69 | idled | idled | idled | U | I |
| ALUV71 | idled | idled | idled | U | I |
| ALUV72 | idled | idled | idled | U | I |
| ALUV77 | idled | idled | idled | U | P |
| ALUV80R** | semiannual | semiannual | semiannual | A | P |
| ALUV83** | semiannual | semiannual | semiannual | A | P |
| ALUV87 | annual | annual | annual | U | P |
| ALUV89R | annual | annual | annual | A | P |
| ALUV93 | annual | annual | annual | U | P |



TABLE 14 (Con't)
Types of Wepo Well, Alluvial Well, and
Spring Monitoring and Monitoring Frequencies¹

| Monitor Site I.D. | Water Levels | ² Field Water Quality Parameters | Full Suite Water Quality | Potentially Affected or Unaffected | Interim or Permanent |
|-------------------------|-----------------|---|--------------------------------|---|----------------------------|
| ALUV95 | annual | annual | annual | U | P |
| ALUV98R | annual | annual | annual | U | P |
| ALUV99R | annual | annual | annual | U | P |
| ALUV101R | annual | annual | annual | A | P |
| ALUV104R | annual | annual | annual | U | P |
| ALUV105R | annual | annual | annual | U | P |
| ALUV106R | annual | annual | annual | U | P |
| ALUV108R | annual | annual | annual | U | P |
| ALUV165 | annual | annual | annual | A | P |
| ALUV168 | annual | annual | annual | U | P |
| ALUV169 | annual | annual | annual | A | P |
| ALUV170** | semiannual | semiannual | semiannual | A | P |
| ALUV172 | annual | annual | annual | U | P |
| ALUV180 | idled | idled | idled | A | I |
| ALUV181 | idled | idled | idled | A | I |
| ALUV182 | annual | annual | annual | A | P |
| ALUV193** | semiannual | semiannual | semiannual | A | P |
| ALUV197** | semiannual | semiannual | semiannual | A | P |
| ALUV199 | annual | annual | annual | A | P |
| ALUV200 | annual | annual | annual | A | P |
| NSPG91 | annual | annual | annual | A | P |
| NSPG92 | annual | annual | annual | A | P |
| NSPG111 | annual | annual | annual | A | P |
| NSPG147 # | annual | annual | annual | A | P |
| NSPG149 ## | quarterly | ----- | ----- | U | I |
| NSPG150 ## | quarterly | annual | annual | A | I |
| SSPG150 | annual | annual | annual | A | P |
| SSPG151 | annual | annual | annual | A | P |
| PL151 | annual | annual | annual | A | P |

Monitoring frequencies for all well and spring sites are dependent on nature and constancy of chemical trending. Should potentially detrimental mining-related trends develop, at OSM's direction, monitoring frequency and type of monitoring may be modified.

²Field water quality parameters include pH, EC, temperature, and salinity.

*Wepo wells 45, 56, and 57 are also monitored annually for toluene and either dissolved or total organic carbon to address potential impacts from the former solid waste landfill at J3.

**These wells currently show chemical trending due to potential mining or natural impacts, and are monitored semiannually for chemistry and water levels.

Flow, field parameters, and full suite water quality measurements are collected annually, at a minimum, at this site. A special study is currently underway at this spring.

These sites are being monitored at OSM's request until concerns over potential mining-related impacts have been addressed. At Sagebrush Well, water chemistry parameters include: dissolved Ca, Mg, Na, K, SiO₂, Se, TDS, SO₄, HCO₃, Cl, and field water quality parameters.

TABLE 15

Full Suite of Chemical Parameters For Wepo,
Alluvial, and Spoil Aquifer Monitoring

| Chemical Parameter | Detection Limit (mg/l) |
|-------------------------------|---------------------------|
| Alkalinity as CaCO_3 | 1 |
| Bicarbonate as HCO_3 | 1 |
| Carbonate as CO_3 | 1 |
| Hardness as CO_3 | 1 |
| pH | .1 ^A |
| Conductivity at 25°C | 1 ^B |
| Calcium, dissolved | 1 |
| Magnesium, dissolved | 1 |
| Sodium, dissolved | 1 |
| Potassium, dissolved | 1 |
| Chloride | 1 |
| Sulfate | 4 |
| SAR | XX.X ^C |
| Fluoride | .02 |
| Silica, dissolved | .1 |
| Iron, dissolved | .02 |
| Iron, total | .02 |
| Manganese, dissolved | .01 |
| Manganese, total | .01 |
| Nitrogen, nitrate | .02 |
| Nitrogen, nitrite | .01 |
| Nitrogen, nitrate + nitrite | .02 |
| Aluminum, dissolved | .05 |
| Arsenic, dissolved | .001 |
| Boron, dissolved | .02 |
| Cadmium, dissolved | .005 |
| Chromium, dissolved | .01 |
| Copper, dissolved | .01 |
| Lead, dissolved | .02 |
| Mercury, dissolved | .0001 |



TABLE 15 (Con't)
Full Suite of Chemical Parameters For Wepo,
Alluvial, and Spoil Aquifer Monitoring

| Chemical Parameter | Detection Limit (mg/l) |
|--------------------------------------|---------------------------|
| Selenium, dissolved | .001 |
| Vanadium, dissolved | .01 |
| Zinc, dissolved | .01 |
| Solids, total suspended | 2 |
| Solids, total dissolved (180°C) | 2 |
| Solids, total dissolved (calculated) | 2 |
| TDS (gravimetric)/TDS (calculated) | X.XX ^C |
| Cations sum | XX.XX ^D |
| Anions sum | XX.XX ^D |
| Cation/Anion balance | XX.XX ^E |

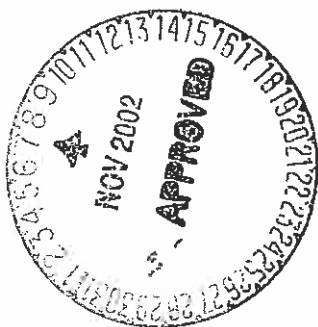
A = pH units

B = umhos/cm

C = unitless

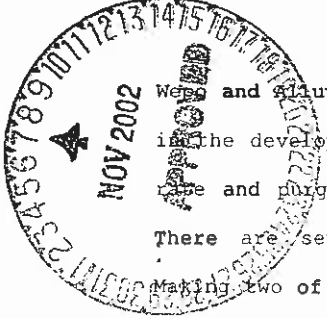
D = meq/l

E = %



the Hydrologic Balance) to the permit substantiate the low well yields and poorer water quality, and the lack of any evidence of Wepo or alluvial well water use for irrigation practices, respectively. The detection limits used are at least a factor of 5 to 10 below the recommended livestock drinking water concentration limits.

The rationale behind the Wepo and alluvial aquifer water quality monitoring is to determine if there are any applicable or potential uses for the water based on the chemistry and to determine if any changes in parameter concentrations due to mining inhibit or prevent that continued water use. This is the same rationale used for negotiating surface coal mine monitoring programs with the States of Colorado and Montana. Both State programs have approved running all ground water analyses for dissolved concentrations only. Consistent with this approach, all trace elements analyzed in Wepo and alluvial ground water quality analyses will be analyzed for dissolved concentrations. The following is offered as justification for this approach. Ground water flow is predominantly laminar and non-turbid, thus the transport of sediment with ground water flow should be negligible. No sampling technique for a monitoring well is totally passive. When sampling low permeability formations, such as the Wepo and alluvial aquifers on the leasehold, the very steep hydraulic gradients at the well bore from dewatering causes turbulent flow in the aquifer and sand pack resulting in a very turbid sample. Giddings (1983) states, "When this turbid sample is acidified (following standard preservation techniques for heavy metals), metallic ions that were absorbed on or contained within the clays and silts are released, causing elevated concentrations of metals in the sample. This masking may be so great as to render the sample useless for detection of certain metals depending on the nature of the sediments and the degree of turbidity." Finally, EPA has orally communicated to Peabody that there is no regulatory mandate that trace metals in ground water samples must be analyzed for total recoverable concentrations.



Wepo and Alluvial Water Quality Monitoring and Analysis Methodology. The principal objective in the development of a well sampling methodology is to find a seasonally reproducible purge rate and purge volume that will yield a representative sample of that zone in the aquifer. There are several variables involved in collecting samples from heterogeneous aquifers. Making two of these variables constants (purge rates and volumes) should help ensure that the sample was taken from approximately the same horizontal distance out into the aquifer each time. Criteria evaluated in determining the unique purge rates and volumes for each well are:

- 1) sample purge rates should be less than discharge rates used during well development;

2) purge rates and volumes should maximize the percent aquifer contribution, but should not be so great that the well bore goes dry during any season of the year (seasonality can only be determined if the same purge rate and volume is removed each time, otherwise samples will be obtained from different points in the aquifers which would introduce another variable); 3) purge rates and volumes should cause minimal turbidity in the well bore; and 4) field pH, conductivity, temperature, D.O., and turbidity variability should be minimized as much as is practical considering the aquifer characteristics and the above criteria.

Unique purge rates and volumes have been developed following the above criteria for each alluvial and Wepo monitoring well being sampled for water quality. These rates and volumes are used with each sampling round. There are a few wells that yield so little water the above criteria cannot be employed. In these cases, the wells are pumped and/or bailed at as low a rate as possible and sampled prior to going dry or following one or more recoveries after being pumped dry.

Field water quality parameters are run in the field unless unforeseen conditions necessitate running them in the environmental lab. Sample handling, preservation, and transport methods are presented on Tables 5 and 6. Field and laboratory parameters are run within the maximum holding times specified on Table 5. Water quality data analysis techniques are the same as those described for stream water quality. Laboratory water quality analyses for the suite of chemical parameters shown in Table 15 are run according to the methodology in the most current edition of "Standard Methods for the Examination of Water and Wastewater" (APHA, 1989). The specific analysis method numbers by chemical parameters are presented in Attachment 2.

Wepo and Alluvial Well Installations, Completion, and Development. The drilling of Wepo wells has been and is being accomplished using mud rotary or air rotary techniques. Alluvial wells are and will be installed using hollow stem auger or mud rotary techniques. The well bores are completed with PVC casing and screen. Completion techniques employed in the screened zones include Marifi wrap and natural pack or silica sand without Marifi wrap in the alluvial wells and washed pea gravel or silica sand in the Wepo wells. The sand pack is placed around the screen to a height above the screen. From this point to approximately four or five feet below ground surface, cuttings, bentonite pellets or more sand is backfilled in the annular space. The top four or five feet of annular space is sealed with cement grout or concrete.



Locking well covers are embedded in the grout and secured around the portion of the blank casing extending above ground surface. A typical Wepo or alluvial well completion is shown in Figure 1. Lithologic logs and specific completion information for all alluvial and Wepo wells are presented in Volume 10, Chapter 15, Attachment 11 and Volume 9, Chapter 15, Attachment 8, respectively. Following the completion of all new and replacement Wepo and alluvial wells, lithologic log and well completion information will be added to Attachments 8 and 11 to Chapter 15. All Wepo and alluvial wells are developed employing techniques that include bailing, airlifting, surging, back flushing, and pumping.

Wepo and Alluvial Well Abandonment. All monitoring wells will be abandoned using acceptable procedures. Well abandonment procedures to be used include: 1) cutting the casing off a foot below ground surface or even with the ground surface; 2) filling the well bore from the bottom to 20 feet below ground surface with high solids bentonite grout or cement using a tremie line to ensure that the bore water is displaced; 3) grouting the top 20 feet of the well bore with cement; 4) removing all locking well covers and protective fences; and 5) scarifying and seeding the ground surface in the immediate vicinity of the well.

Spoil Well Monitoring.

Spoil Well Monitoring Purpose and Approach. Spoil well monitoring is conducted to: 1) define the extent and magnitude of resaturation; 2) determine the re-establishment of ground water flow directions; 3) quantify aquifer characteristics such as hydraulic conductivity in order to assess the re-establishment of horizontal recharge capacities and; 4) define the water use potential, if any, of the spoil aquifer. To date, only portions of the N7, N2, J16, and J1/N6 mining areas have intercepted measurable amounts of water in the Wepo formation. Peabody has historically conducted spoil monitoring at N2, and a special study (with no set monitoring parameters or frequencies) has been performed at two spoil wells in the N7 mining area. One spoil well has been constructed and is being monitored in the J16 mining area. Potential spoil wells in the J1/N6, J19, and J21 mining areas will be negotiated with OSM on a case-by-case basis.

Future spoil wells will be installed in representative (considering saturated thicknesses and spatial distribution) reclamation of the above-referenced and proposed wet pits. The wells shall be installed once sufficient reclamation has been completed and the spoil has had time to at least partially resaturate. Monitoring of future spoil wells shall be conducted as described in Table 16 until the above purposes for spoil well monitoring have been satisfied and/or the regulatory authority approves their removal.

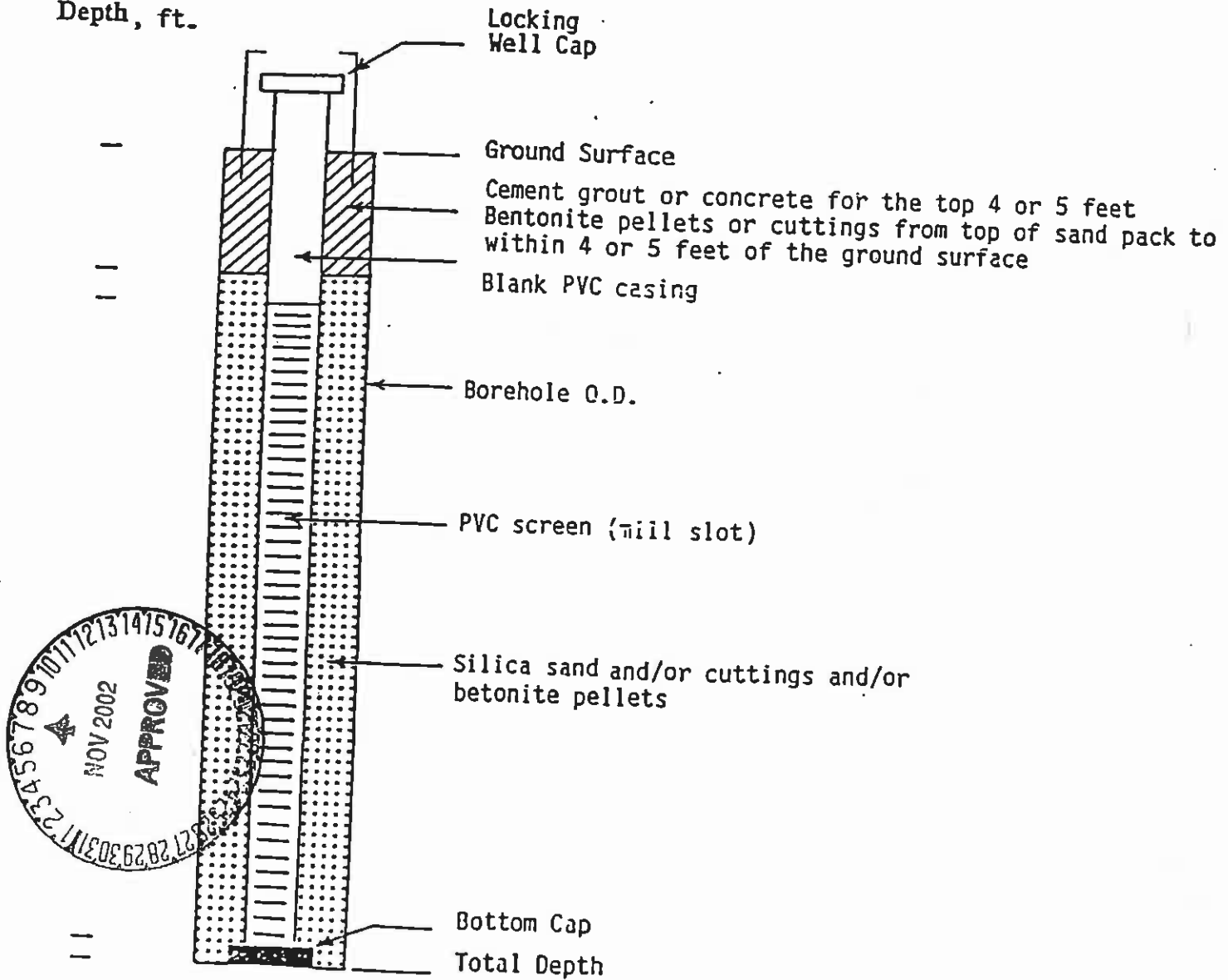
FIGURE 1
 Typical Wepo, Alluvial or Spoil Well Completion
 PEABODY COAL COMPANY - WESTERN DIVISION
 MONITOR WELL CONSTRUCTION DIAGRAM

Mine: Black Mesa

Monitor Well Name: _____

Construction Diagram

Depth, ft.



Spoil Well Monitoring Parameters and Frequencies. Table 16 presents a list of the spoil wells currently being monitored, the parameters monitored, and the monitoring frequencies. The six N14 piezometers/spoil wells adjacent to N14-D-P (SPL141-146) were abandoned because they had served their useful purpose of providing outslope spoil information in that area. The ten spoil wells around N2-RA-P (SPL207-211) and N2-RB-P (SPL188 & SPL201-204) have been abandoned as the necessary water quantity and quality data have been obtained and the areas are in the final stages of release of liability. Two special-study spoil wells in the N7 mining area (SPL176 & SPL177) were abandoned during 2001, in anticipation of release of liability of that area. The N7 special study is described in Attachment 5 to this chapter.

Two spoil wells to be installed in the J16 mining area were committed to by Peabody in mining Permit No. AZ-0001C. Three spoil wells drilled to date in the J16 reclamation have not intercepted any saturated spoil. One of the wells (SPL161) drilled in the J16 spoil was completed and is being monitored, although it has remained dry to date. All future spoil wells will be monitored according to the plan outlined in Table 16. The locations of all historic and currently monitored spoil wells are shown on Exhibits 85600 and 93500, respectively.

Spoil Well Water Level and Quality Monitoring and Analysis Methodologies. Spoil monitoring and analysis methodologies are the same as those described for the Wepo and alluvial wells.

Spoil Well Completions and Abandonment. Spoil wells are constructed using hollow stem auger, mud rotary, and air rotary techniques. Spoil well completions, development techniques, and abandonment procedures are the same as those described for the Wepo and alluvial wells.

Spring Monitoring.

Spring Monitoring Purpose and Approach. Spring monitoring is conducted to define baseline water quantity and quality, the seasonal variability of the parameters, the water use potential, and if the flow or chemistry is significantly impacted by adjacent mining. The approach was to monitor semiannually and then annually for flow and chemistry at those springs it was felt mining had the potential to impact. If a use can be defined for the spring, monitoring will assess whether mining has precluded that use. If mining does significantly disrupt or destroy a usable spring, PWCC will provide comparable interim or alternative water supplies.

TABLE 16

Spoil Well Monitoring Parameters and Frequencies

| Monitor | | Field | Full Suite ² |
|-------------------------------------|--------------|--------------------------|-------------------------|
| Site I.D. | Water Levels | Water Quality Parameters | Water Quality |
| SPL161 ¹ | annual | annual | annual |
| All Future Monitors ³ | annual | annual | annual |

¹Spoil well SPL161 will be monitored for water levels until the bond release application for the reclamation containing it is approved.

²Table 15 water quality parameters

³Any future special study spoil well monitoring shall be conducted at no set frequency, however, parameters and frequencies set forth in this table will be used as a guideline.



Springs typically occur at outcrops or where they have been exposed by channel down cutting and are very localized. As such, they are strongly influenced by variations in precipitation. During drought periods, springs may disappear and during wetter periods springs may reoccur or new ones may form. Given this, it is quite possible new or former springs previously not monitored will come to the attention of PWCC or the regulatory agency (i.e., Hogan Gulch Spring and Goat Spring #2). As these situations arise, PWCC will perform an analysis of the potential for mining to detrimentally impact the water quantity or quality of the spring. The analysis may incorporate geologic information, potentiometric surface and ground water flow direction data, local natural water level fluctuations, and pit inflow drawdown projections that incorporate actual proximate water level responses in monitoring wells. Based on the above-referenced analysis, if a potential for detrimental impact to the water quantity or water quality of the spring from mining can be shown, the spring will be incorporated into the monitoring program and monitored for water quantity or quality or both depending on the potential impact. If detrimental mining impacts to the spring are not demonstrated, the spring will be sampled twice for flow and water quality (Table 3 parameters) with the sampling events spaced at six months apart. This will be done to establish background data that can be compared against any purported future impacts. No additional monitoring beyond the two sampling rounds will be conducted and the spring(s) will not be incorporated into the monitoring program. All such spring monitoring data will be reported to OSM in the quarterly or annual monitoring data reports.

Spring Monitoring Parameters and Frequencies. The parameters monitored and monitoring frequencies at springs are described in Table 14. The specific chemical parameters monitored are presented in Table 3. The locations of all historic and currently monitored springs are presented on Exhibits 85600 and 93500, respectively.

Spring Flow and Quality Monitoring and Analysis Methodologies. Typically, spring seeps require some kind of artificial control in order to measure or sample them. If depressions can be shoveled such that either samples can be dipped or obtained as the flow overtops the depression, this type of approach is followed. If flows are too diffuse and depressions cannot feasibly be excavated, they are either estimated or not estimated. This is a judgment call by the field technician on a case-by-case basis. If the field technician does not feel comfortable qualifying diffuse seepage, no flow value is assigned. If the seep is too diffuse, it most likely can't be sampled. Where artificial

controls or pipes are viable or already in place, springs flows from these controls or pipes are monitored by timing the filling rate of a calibrated device. If depressions must be excavated, samples are usually obtained several days later after the turbidity has cleared from the water.

Flow rates are calculated using hand held calculators by dividing the flow volume by the time necessary for that volume to occur. Chemistry data analyses for springs are the same as those described for ground water quality analyses. Field water quality parameters are run in the field unless unforeseen conditions necessitate running them in the environmental lab. Sample handling, preservation, and transport methods are presented on Tables 5 and 6. Field and laboratory parameters are run within the maximum holding times specified in Table 5. Laboratory water quality analyses for the suite of chemical parameters shown in Table 3 are run according to the methodology in the most current edition of "Standard Methods for the Examination of Water and Wastewater" (APHA, 1989). The specific analysis method numbers by chemical parameter are presented in Attachment 2.

Aquifer Testing Methodology. The Wepo, alluvial, and spoil aquifers tested to date on the leasehold were low yielding and heterogeneous, which made it difficult to apply the classic aquifer test techniques found in most ground water texts. In many cases, techniques influencing smaller portions of the aquifers (slug tests) or new techniques designed for low yielding aquifers were tested and employed. Aquifer tests are grouped under two main categories, confined and unconfined. Within each category there are test techniques that require algebraic solutions or type curve solutions and may be used with single or multiple wells. Table 17 presents a summary of this information. Theis drawdown and recovery (Theis, 1935), Cooper straight-line (Cooper, et al, 1946), and Walton type-curve solutions (Walton, 1962) could only be applied to those confined Wepo wells with resultant transmissivities of approximately 70 gal/day-ft or more. This is because a certain pumping duration is necessary to remove casing storage effects (Schafer, 1977) from the time drawdown data in order for the true slope to the drawdown data and valid transmissivity values to be determined.

A new technique developed by McWhorter (1982) and tested by Nazareth (1981) and Smith and Cochran (1982) was utilized on those Wepo wells with transmissivities typically less than 70 gal/day-ft. The McWhorter technique was preferred over slug tests because slug tests are susceptible to well bore skin effects. McWhorter's technique permits pumpage of the

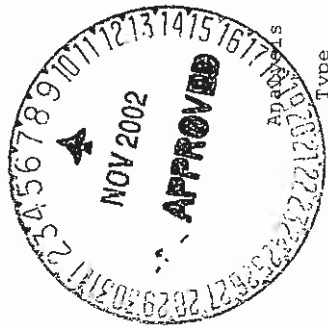


TABLE 17

Summary of Aquifer Tests Used to Date at
Wepo, Alluvial, and Spoil Wells

Confined

Unconfined

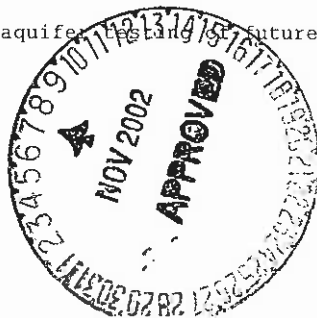
| Technique * | Single or Multiple Well | | Analysis Type | | Single or Multiple Well | |
|----------------------------|-------------------------|-------------|----------------------------|------------|-------------------------|----------|
| | Technique * | Technique * | Type | Type | Technique * | Type |
| Theis Drawdown | Type curve or algebraic | Both | Boulton or Neuman | Type curve | Multiple | Multiple |
| Theis Recovery | Algebraic | Both | unconfined | Algebraic | Single | Single |
| Cooper-Jacob Straight Line | Algebraic | Single | Bouwer & Rice slug | Algebraic | Single | Single |
| Walton Leaky Artesian | Type curve | Multiple | Skibitzke slug | Type curve | Single | Single |
| Cooper et al slug | Type curve | Single | Rising-head pneumatic slug | Type curve | Single | Single |
| McWhorter modified slug | Type curve or algebraic | Single | | | | |

*Literature reference describing the use and calculations of each of the above techniques are given in references at the end of this Chapter. Bennett (1989), Bennett and Patten (1992), Bouwer (1978), Dawson and Istok (1991), Driscoll (1986) and Stallman (1983) were also consulted for design and analysis of aquifer tests.

well for dimensionless time periods thus allowing for responses in the aquifer beyond the well bore.

None of the alluvial wells tested by Peabody in the early 1980's lent themselves to pumping analyses using submersible pumps available at that time. The well bores would go dry before meaningful time-drawdown data responses could be obtained. Where the saturated portion of the alluvial aquifer was shallow enough and the local hydraulic conductivities adequate, pits were excavated into the alluvial aquifer and used as substitutes for the pumping well. The adjacent alluvial wells were used as observation wells during the pumping tests. These tests were analyzed using Boulton's unconfined type curve solution (which is very similar to Neuman's unconfined type curve solution) as described by Lohman (1972). With the advent of small diameter (less than 2") submersible pumps in the early 1990's, recent aquifer testing on alluvial wells has been somewhat simplified. Pumping rates as low as 0.05 gallons per minute (GPM) can now be achieved, and varying the speed of the pump can control discharge rate (see also Sternberg, 1967). More recently, two additional testing procedures have been used with encouraging results. Skibitzke (1958) describes a modified slug test wherein successive volumes of water are removed from the well (akin to a step-drawdown pump test, only utilizing a bailer), and Levy (1993) and Renner (1993) developed a rising-head pneumatic-slug method using air pressure to artificially depress the water surface within a well casing. Both of these procedures can be used on wells with low transmissivities, however the latter method can only be used on wells where water levels within the well casing never drop below the top-most screened section throughout duration of the test. All other alluvial aquifer tests have been performed using slug injection or withdrawal tests as described by Cooper et al (1967). This slug test can be applied to both confined and unconfined (type curves representing α values of 10^{-1} and 10^{-2}) conditions. The alluvium on the leasehold exhibits both types of ground water flow depending on lithologic and depth factors.

Wepo and alluvial aquifer tests results are presented in Volume 9, Chapter 15, Attachment 9 and Volume 10, Chapter 15, Attachment 14 to the permit, respectively. As new or replacement Wepo or alluvial monitoring wells are incorporated into the monitoring program, they will be tested and the results added to the respective attachments. An additional attachment to Chapter 15 (Attachment 25 in Volume 10A) will be created following the aquifer testing of future spoil monitoring wells.



Aquifer test analyses follow the equations and type curve solutions presented in the literature for each test type. Past analyses have been hand calculated. Future aquifer test analyses will utilize hand calculations and/or AQTESOLV or similar PC software computational programs (Duffield and Rumbaugh, 1991).

N7 Mining Area Special Interim Land Study.

PWCC initiated a special study in the N7/N8 mining area in 1992 to evaluate the spoil and Wepo aquifer immediately adjacent to and upgradient of a reach of the Yellow Water Canyon Wash alluvial aquifer that appeared to be showing persistent and increasing trends in chemical parameter concentrations resulting from mining impacts. This study and the monitoring approach used are described in Attachment 5 of this chapter.

The N7 Special Study formally comprised two spoil wells and two shallow Wepo aquifer wells, and informally included monitoring results from three permanent and one temporary impoundments in both the N7 and N8 interim land areas. This study was concluded in 2001, when all four of the wells and the temporary sediment pond were removed as part of PWCC's Reclamation Liability Release Application (RLRA) for the N7 and N8 Mining Areas. Included in this RLRA are the summary analysis of monitoring data and outcome of this special study, and the reader is directed to that document for specific findings and interpretation of results.

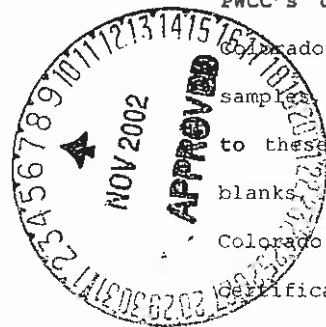
Quality Assurance

ACZ Laboratories Quality Assurance Program.

PWCC's current contract laboratory is ACZ Laboratories located in Steamboat Springs, Colorado. Quality assurance checks performed by the laboratory include standard reference samples, in-process calibration to standards, blanks, duplicates, and spikes. In addition to these internal controls, PWCC provides external controls by periodically submitting blanks, prepared reference standards, and duplicate samples. The States of Arizona and Colorado also require ACZ to successfully pass performance valuation checks and laboratory certifications. A detailed discussion of ACZ's quality assurance program, analytical methodologies, and precision and accuracy controls is presented in Attachment 2.

Water Quality Data QA.

PWCC requires all outside laboratory analysis reports include information that permits independent evaluation of the quality of the water analysis. This additional analysis



quality assurance information includes gravimetrically determined TDS as well as calculated TDS and the TDS ratio (gravimetric)/TDS (calc.) and the sum of cations and anions as well as the cation/anion ratio. Lab conductivities are required so that these values may be compared against TDS values for the same analysis. The gravimetric/calculated TDS ratio should be 1.0 or within ± 10 percent of 1.0. The ratio of cations to anions should also be 1.0. Deviations of cations to anions greater than ± 5 percent from 1.0 are considered suspect. Conductivities are also compared to TDS (gravimetric) values. The literature suggests that a TDS/conductivity ratio of from 0.55-0.75 should occur. However, waters high in sulfate and saturated with respect to gypsum can equal or even exceed 1.0. This can occur with water samples collected on the leasehold. Because of the wider possible range, PWCC personnel evaluate this latter parameter by looking at historic ranges for the ratio on a site-by-site basis. QA/QC procedures specific to the Navajo well water quality samples are outlined in Attachment 6. Navajo well water quality criteria have been defined upon which resampling requirements will be based.

A chemistry consultant (Dr. Foust) was retained to address water quality QA/QC issues. He evaluated six different ratios of ion pairs and recommended a seventh. Information pertaining to this analysis was submitted to OSM in the 1991 Hydrologic Data Report.

A limiting factor with all the water quality analysis accuracy checks is the fact that the checks can only evaluate the quality of the macroconstituent data. There are no comparable checks for the microconstituents (trace metals). Dr. Foust evaluated analysis modifications that could improve the accuracy of trace metal data. Analytical changes

recommended included measuring ICP emissions for trace metals at two analytical lines and using ICP cleaning prior to running any trace elements analyzed using ICP. OSM approval of the latter modification, if necessary, was requested by Peabody on July 23, 1992.

PWCC's water quality QA checks are performed manually at this time at the mine. The thrust of the future non-Navajo well water quality QA program is to develop a computer program to automatically perform several of the aforementioned QA checks on all water analyses by site. What will be developed in conjunction with the QA ratio checks is a means of detecting outliers, impacts, and trends. The possible use of Shewart-Cusum control charts, maximum likelihood estimators for censored data, and Mann-Kendall/Sen tests will be investigated (Gibbons, 1991; Starks, 1989). In the interim, PWCC will

continue to spot check laboratory analyses for cation/anion, TDS (grav.)/TDS (calc.), and TDS/conductivity ratios as checks on the accuracy of the analyses. A more generalized check that is and will continue to be employed is the comparison of a new value to the historic range of values for that parameter at a given site.

Streamflow Data QA.

Current meter data quality assurance includes: 1) checking that there is a complete wetted perimeter for the cross section; 2) proof reading all values entered on the PC to be calculated by PC programs; 3) comparing subsection velocities to cross section shape; 4) checking the percent of the total cross section that was assigned zero velocity; and 5) comparing discharge values to slope-area discharges for the same flow and time, if available.

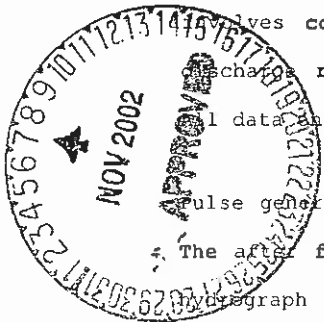
The following describes the principal QA procedures followed for slope-area data. The variation in discharge between cross sections is evaluated. Total variation in discharge for all sections should not exceed 50%. If the variation in discharge is high, the parameters measured at the sections yielding the anomalous discharges are reevaluated for errors or deletion. In comparing water surface evaluations at both sides of a cross section, the higher elevations should occur on the outside of bends in the channel.

Single elevations from one side or the other of a cross section are used when the resultant discharge for the section compares favorably with those discharges calculated for the other sections. Anomalous discharges due to expanding reaches are discarded, as the technique is not valid in expanding reaches. All attempts are made to calculate the final discharge using at least three reaches following any editing. A final check

involves comparing the Froude number against current meter measurements for the same discharge range (if available) and adjusting the Manning's roughness (n) if necessary. All data entered into PC computational programs is proof read for transcription errors.

A pulse generator in combination with stilling well data is QA checked two principal ways.

1. The after flow channel bed level is compared to the bottom of the stilling well and the hydrograph recession is reviewed to see if it plateaus prematurely. This is usually an indication of plugging within the stilling well and data for the remainder of the flow hydrograph must be discarded or qualified.



Ultrasonic gage data QA is largely dependent on air and water temperature data collected at the same sites and recorded on dataloggers. Air and water temperatures are examined for times corresponding to water rises, particularly in the winter months. Ice build up can cause false indications of flow whereas quantification of flows resulting from melting snow and ice are desired. Stock passing beneath the gage can cause erratic and anomalous stage values. The short-term duration of these anomalies as well as hoof prints around the monitoring sites are evidence of such. Snowfall can cause erratic gage readings and snow accumulations are recorded by the gages, as streamflows would be. Field notes regarding storms and site conditions at site visitations, as well as proximate precipitation gage data, are important information in making decisions regarding the accuracy of the data. Historic seasonal gage height trends at the sites are very helpful in assessing what data is likely erratic and should be discarded.

QA for crest gage data includes comparison of peak discharge values with slope-area data for the same flow, checking crest gage high water elevations with water marks on the channel banks and floodplains and inspecting the gage inlets for evidence of plugging or debris buildup that could have affected the flow stage mark.

Float discharge data QA involves comparing subsection velocities with cross section shape (the thalweg portion would not be expected to have one of the lower velocities), comparing the resultant discharge with slope-area discharge data for the same flow when it is available, making any necessary adjustments to the velocity values to correct for the fact that they are surface velocities and noting any field remarks regarding whether the float stayed in the right portion of the flow cross section during the velocity measurement. QA during the operation of a cutthroat flume includes proper leveling of the flume while taking gage measurements, allowing 20 minutes after installation of the flume for flow stabilization before taking any flow measurements, and preventing submergence effects by checking upstream and downstream flow prior to collecting measurements. The QA of cutthroat flume data is principally a comparison with periodic current meter data for the baseflow.



Well Water Level and Pumpage Data QA.

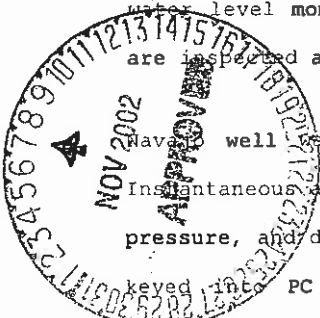
The following describes the QA methods incorporated in Wepo, alluvial, spoil, and Navajo water level monitoring and water level data analysis. PWCC personnel conducting the water level monitoring of Wepo, alluvial, and spoil wells may take the previous levels into the field as a reference. If significant differences occur between the current and previous

levels a second measurement is performed to confirm that no error has been made. During water level data reduction, the water levels are compared against historic ranges for the levels to identify any outliers. Any wells showing measurable changes in water level are evaluated in terms of their proximity to pits being pumped or in terms of possible climatic factors (i.e., alluvial aquifer responses to channel flows and channel transmission loss recharge).

The remainder of this discussion will describe historic and current QA procedures regarding Navajo well water level monitoring instrumentation and data reduction. Several different monitoring instrumentation approaches have been employed with varying degrees of success (discussed previously in the Navajo well monitoring section). The current water level monitoring approach consists of air bubbler lines and pressure gages in conjunction with surface transducers or in conjunction with surface transducers and dataloggers.

Navajo well water level monitoring instrumentation QA associated with air bubbler monitoring of Navajo well water levels utilizes pump amperage recordings as well as acceptable water level range information. The pump is first checked to determine if it is on or off and how long it has been on or off. This allows the field staff to determine whether to use historic pumping water level ranges, historic static water level ranges, or historic transition water level ranges for a comparison. Next, the battery power, cabinet temperature, pressure gage, and datalogger readings are noted. The pressure gage and datalogger readings should not differ by more than a few feet. At the Navajo wells being instantaneously measured, the power supply must be turned on and the system is pressurized multiple times until two successive stable readings are obtained on the pressure gage and datalogger. If stable readings are not obtained at either the continuous or instantaneous water level monitors, the airlines are checked for leaks and/or the surface transducers are inspected and/or the dataloggers and pressure gages are checked.

Navajo well water level data QA is handled at the mine by environmental scientists. Instantaneous and continuous recordings are reduced by hand, with time, well number, date, pressure, and discharge readings noted. Once reduced, the Navajo well water level data is keyed into PC data files at the mine and reviewed against the hard copy data for transcription errors. All datalogger data is loaded directly into PC files at the mine where it is edited on the screen. Navajo well water level data is checked at the mine against historic levels and pumpage records prior to submission of any data reports.



The above discussion describes what has been done historically as well as at the present regarding Navajo well water level QA. QA programs and monitoring instrumentation are a continually evolving process. No discrete segment of the above water level QA discussion should be interpreted as the only approaches and/or monitoring instrumentation to be used in the Navajo well water level monitoring portion of the hydrologic monitoring program.

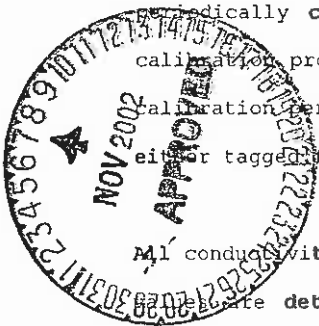
Navajo well pumpage at each well is recorded by totalizing flow meters. Each meter is read weekly for total pumpage volume, hours that the pumpage occurred over and pumpage rate. The data are compiled and checked at the mine. The total hours times the average pumpage rate is used to check the total pumpage volumes values. When the totalizers have malfunctioned, the total pumpage volume has been estimated from the product of the average pumpage rate and the hours pumped.

The USGS has performed calibration checks at each meter by tapping into the piping and measuring the flow volume over time with manometers and Cox flow meters. This calibration was performed at each Navajo well in 1986 and 1988. The USGS used a ± 10 percent difference criteria for flow meter replacement purposes. None of the Peabody flowmeters deviated from USGS readings by 10 percent. However, Peabody replaced any meter that deviated by more than 5 percent. The meter at Well 5 deviated by 6 percent in the 1988 check and was immediately replaced.

Field Water Quality Instrumentation QA.

All pH meters used are calibrated using a two-point calibration at the beginning of each day of sampling and at each monitoring site being sampled. Additionally, pH meters are periodically compared against laboratory pH meters for their accuracy. If two-point calibration problems are encountered, the pH electrode is discarded and another two-point calibration performed with a new electrode. If the meter still will not calibrate, it is either tagged for repair or discarded.

All conductivity meters are calibrated at least quarterly using prepared KCl solutions. K values are determined to check the correctness of measured EC values for EC standard solutions. K values (measured EC/temperature corrected EC) are measured for two different prepared buffers. The measured EC for a water sample times the average of the two K values determined previously, is compared against the temperature corrected EC value for the water sample. If there is greater than 10 percent difference, the conductivity probe is tagged for repair or inspection and the above procedure is performed with a new probe.



If the difference is still greater than 10 percent with the new probe, the instrument is either sent into the providing vendor for repair, or is discarded. Salinity readings are obtained from the conductivity meters and the meter QA is addressed in the above discussion. Temperature probes built into the pH meters are used to measure water temperature levels. Temperature comparisons with laboratory thermometers are conducted to check the accuracy level of pH meter temperature probes.

Performance Audits.

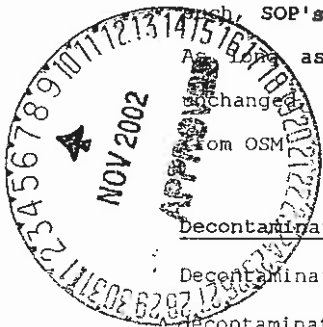
PWCC retains consultants on a periodic basis to evaluate different facets of the hydrologic monitoring program. PWCC's surface water flow monitoring and slope-area analyses were evaluated by consultants, including stream station rating curves, using the hydrologic analysis program HEC2. Both ground and surface water quality sampling and field parameter analysis techniques were evaluated by outside consultants. The ground water quality database and the historic as well as present laboratory analytical procedures for water quality analyses were evaluated in detail by an outside consultant. Consultants were also utilized to evaluate all the hydrology SOP's and to rewrite the SOP manual in more detail. Recommendations from the above-referenced studies have been evaluated by PWCC and, in several cases, implemented. Where the recommendations have involved changes in laboratory analysis techniques, PWCC has requested EPA's input and issued formal requests to OSM for approval to implement the changes.

PWCC devotes a portion of the technical staff's time to reviewing pertinent hydrologic literature regarding instrumentation changes or modifications to analytical procedures.

The technology of the science of hydrology is, and will continue to be, evolving. As such, SOP's will periodically require revisions and new instrumentation will be utilized. As the parameters monitored, frequencies, and monitoring fundamentals remain unchanged, incorporation of new or different instrumentation does not require approval from OSM. SOP and QA/QC manuals will be maintained at the mine.

Decontamination.

Decontamination procedures are a part of any quality assurance program. PWCC employs decontamination procedures with their Wepo, alluvial, and spoil well water level monitoring; their manual and automated stream water quality sampling; their well water quality sampling; and their field water quality monitoring. Electric tape water level probes and line are rinsed in tap (Navajo) water following each water level measurement. All composite water quality containers are washed with soap and water, acid-rinsed, and



rinsed in deionized (DI) water following extraction and measurement of samples. Laboratory sample bottles are not recycled and are washed, acid rinsed, and rinsed in DI water prior to being shipped. Automated and single stage water quality tubing is cleared and rinsed with DI water at site visits following flow events. Dedicated discharge tubing is used at the Navajo well sites. The tubing is rinsed with DI water and thoroughly purged with the Navajo well water before a Navajo well water quality sample is taken. The Wepo, alluvial, and spoil well sampling apparatuses (peristaltic, bladder, and submersible pumps and bailers) include large volumes of discharge line and large surface areas of equipment to be rinsed. This would require huge volumes of DI water and it is questionable whether this is warranted considering the chemical parameters being monitored and the typical TDS levels encountered in Wepo, alluvial, and spoil wells. In lieu of rinsing the pumping apparatus with DI water, PWCC is using Navajo well water that has a TDS concentration ranging between 100 - 150 mg/l. Only 8 or 9 of the 24 Wepo wells and 1 of the 26 non-dry alluvial wells presently being sampled have TDS values less than 1,000 mg/l and these typically range from 500 - 900 mg/l. Most Navajo well water quality analyses show only 3-4 trace metals at concentrations above the detection limits for the analysis instrumentation and the reported values are either at or very close to the detection limits. The use of Navajo well water for rinse and purge water will in no way jeopardize the inorganic chemical results of water samples pumped from the Wepo, alluvial, and spoil monitoring wells. For this purpose, Navajo well rinse water will be transported to the Wepo, alluvial, and spoil well sampling sites in large plastic carboys. The outside of the pumps and lines are thoroughly rinsed prior to, or as the device is being lowered into the well bore. Rinsing is conducted such that rinse water will not run into the well bores.

For flow-through sampling at each well, the pump and line are purged of well water by pumping Navajo water through the pumping apparatus. All electrodes and probes utilized with pH, temperature, and conductivity meters in the field are thoroughly rinsed with DI water before and after use. Flow-through boxes are utilized to permit the continuous monitoring of field parameters during well sampling. The flow through box is rinsed with Navajo water before being used at each well.

Monitoring Program Personnel and Responsibilities

Organization.

The organization for the hydrological monitoring program consists of an Environmental Affairs Supervisor (EAS), who oversees all responsibilities assigned to the Environmental

Scientist (ES) and Field Program Personnel (FPP) regarding the monitoring program as required by the mine permit.

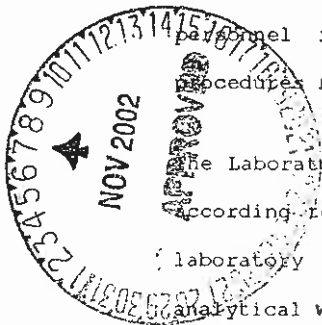
The EAS and ES oversee and review hydrologic monitoring data, sampling protocol, technical changes required by the mine permit, laboratory performance, and other duties as necessary to ensure a high level of QA/QC is maintained in the hydrologic monitoring program. The EAS and ES formulate the water quality sampling protocol and ensure that approved methods are followed consistently with appropriate QA/QC measures in the collection of hydrogeologic data and water samples, and the processing of samples to the contract laboratory. The EAS and ES review incoming data for agreement with historical data, and evaluate the laboratory and geochemical integrity of information as it is processed into the database. The EAS and ES take the lead role in the operation and maintenance of the database for the hydrologic monitoring data.

The EAS and ES coordinate all activities related to hydrologic monitoring requirements at the field level. The EAS and ES oversee the execution of the sampling protocol by the field staff as dictated by the written procedures described in the SOP and QA/QC manuals.

The FPP and Field Staff (FS), which includes contractors, perform all activities required for the hydrologic monitoring program at the field level. The FS collect hydrologic monitoring data and water samples as dictated by the written procedures described in the SOP and QA/QC manuals. The FS communicate directly with the ES regarding sampling and data collection problems, changes, and improvements. The FS review incoming laboratory analytical data for accuracy and completeness before forwarding to the ES and EAS and load field data into the database as necessary.

The Senior Laboratory Supervisor (SLS) oversees all laboratory business and supervises personnel in the execution of laboratory analyses and adherence to written QA/QC procedures required by State and Federal agencies and programs.

The Laboratory Quality Control Manager (LQCM) develops the laboratory analytical protocol according to the requirements of State and Federal agencies and programs that certify a laboratory to perform analytical services. The LQCM ensures proper execution of analytical work according to the written QA/QC protocol and trains and supervises the work of laboratory analysts. The LQCM communicates directly with clientele about analytical services.



The Laboratory Analyst (LA) performs the analysis of samples according to specific methodologies and appropriate QA/QC protocol. The LA communicates directly with the LQCM, EAS and ES about analytical problems and instrument operation. The Laboratory Staff (LS) perform functions to support the business of operating an analytical laboratory.

Training.

Training in hydrologic techniques and computations is provided by senior hydrologists or experienced field staff that have already had the training to other field staff or new staff. In-house training is provided in most aspects of the hydrological monitoring program. Technical training through outside consultants or short courses is also provided to senior hydrologists and/or field staff as needs arise.

Education and Background.

The EAS possesses a B.S. degree in hydrology and over 22 years of experience in hydrologic design and monitoring. ES, FPP, and FS possess M.S. or B.S. degrees in hydrology or hydrogeology and 16 years of combined experience in hydrologic design and monitoring.

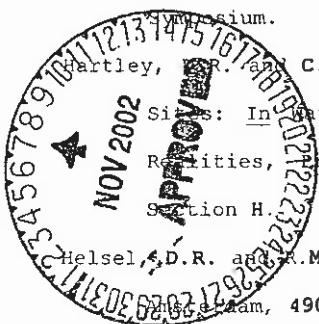


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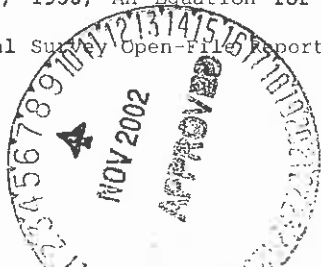
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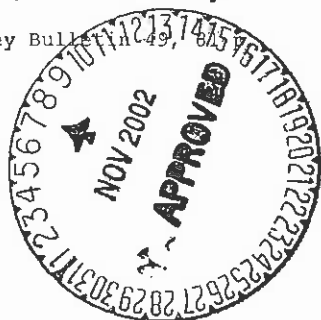
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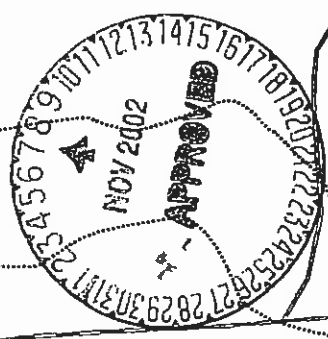
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ATTACHMENT 1
SLOPE-AREA CROSS SECTION LOCATION MAPS
FOR STREAM MONITORING SITES



1-1

Revised 09/20/02

SLOPE AREA CROSS SECTION MAP-SITE 15

Map By: PWCC-JM/ERD Plot Date: Thursday July 23, 2002
Scale: 1 inch = 200 Feet Flight Date: N/A
Contour Interval: 10' Plot For: Jim Ohlman

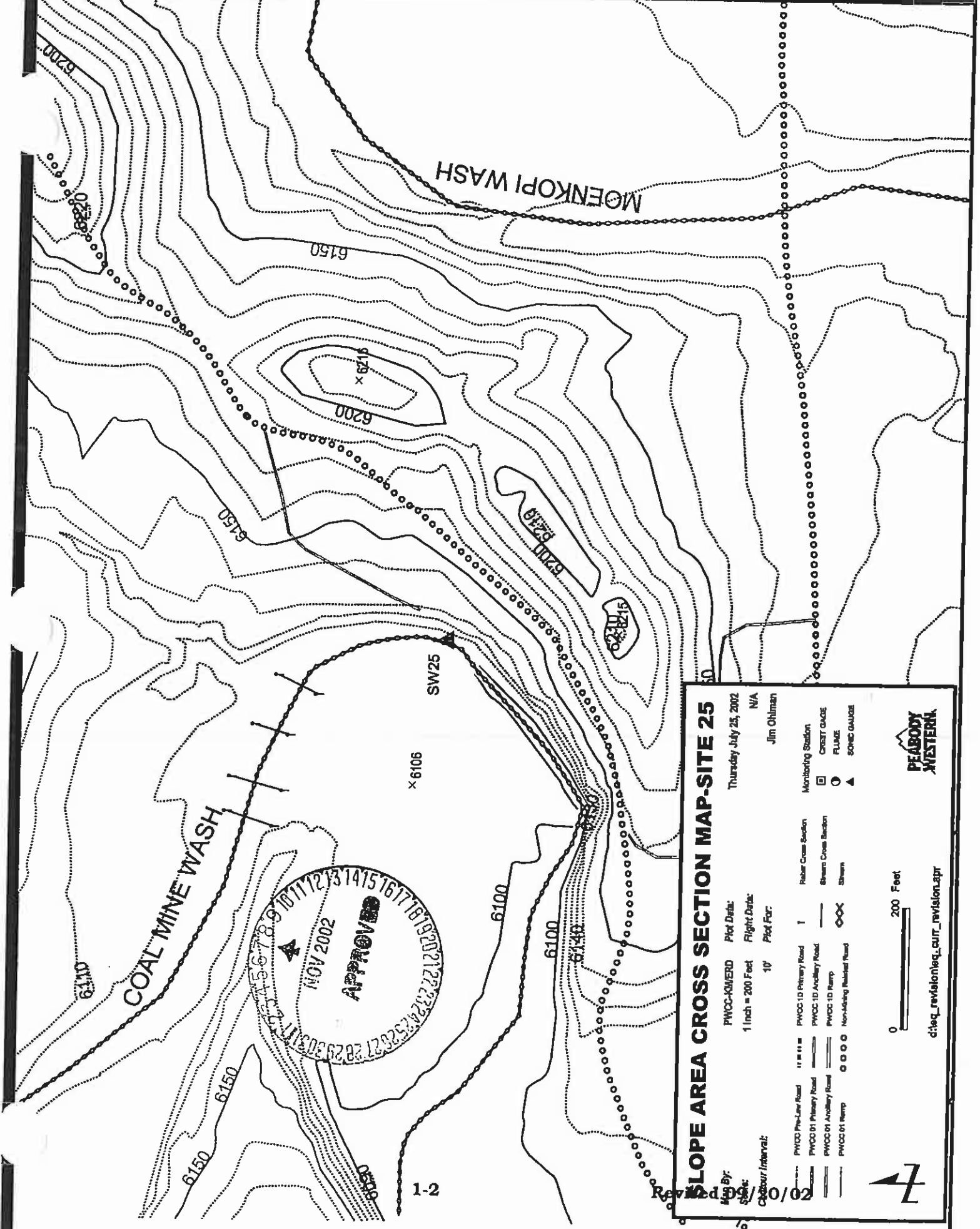
Monitoring Station
PWCC Pre-Low Road
PWCC 01 Primary Road
PWCC 01 Auxiliary Road
PWCC 01 Ramp
PWCC 10 Primary Road
PWCC 10 Auxiliary Road
PWCC 10 Ramp
Non-Mining Related Road
Pier Cross Section
Stream Cross Section
Stream
Crest Gauge
Flume
Bong Gauge



0 100 Feet

PEABODY
WESTERN

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SLOPE AREA CROSS SECTION MAP-SITE 25

Thursday July 25, 2002
 N/A
 Jim Ohlman

Monitoring Station
☒ CREST GAGE
☐ FLUME
☐ SONIC GUAGE

1
 Rubber Cross Section
 Stream Cross Section
 Stream

1
 PWCC Pre-Low Road
 PWCC 01 Primary Road
 PWCC 1D Auxiliary Road
 PWCC 01 Ramp
 Non-Mining Related Road

1
 PWCC 1D Primary Road
 PWCC 1D Auxiliary Road
 PWCC 1D Ramp
 Non-Mining Related Road

1
 PWCC 1D Primary Road
 PWCC 1D Auxiliary Road
 PWCC 1D Ramp
 Non-Mining Related Road

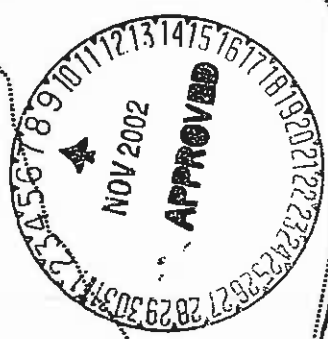


PEABODY WESTERN

dlcwg_revlon1eq_curt_revlon1apr

APPROVED
 NOV 2002
 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25

1-2



x 6155

MOENKOPI WASH

SW26

I-3

Revised 09/20/02

SLOPE AREA CROSS SECTION MAP-SITE 26

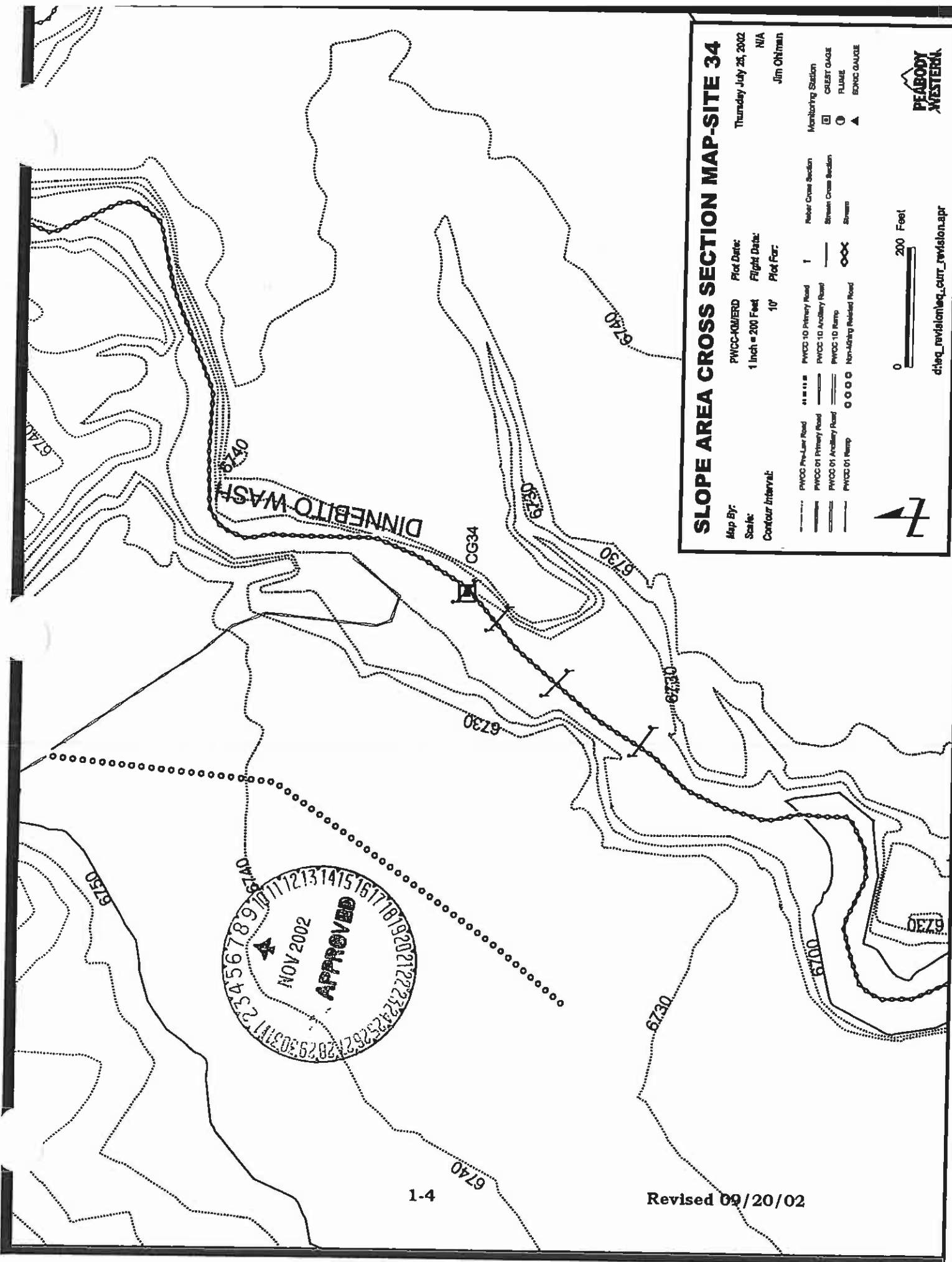
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Scale: 1 inch = 200 Feet Flight Date: N/A
Contour Interval: 10' Plot For: Jim Ohlman

- | | | |
|----------------------------|----------------------------|--------------------------|
| --- PWCC Pre-Land Road | --- PWCC 10 Primary Road | --- Neuter Cross Section |
| --- PWCC 01 Primary Road | --- PWCC 10 Auxiliary Road | --- Stream Cross Section |
| --- PWCC 01 Auxiliary Road | --- PWCC 10 Ramp | --- Stream |
| --- PWCC 01 Ramp | --- Non-Landmark Road | |



PEABODY
WESTERN

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SLOPE AREA CROSS SECTION MAP-SITE 34

Map By: PWCC-KM/ERD Plot Date: Thursday July 25, 2002
 Scale: 1 Inch = 200 Feet Flight Date: N/A
 Contour Interval: 10' Plot For: Jim Ohlman

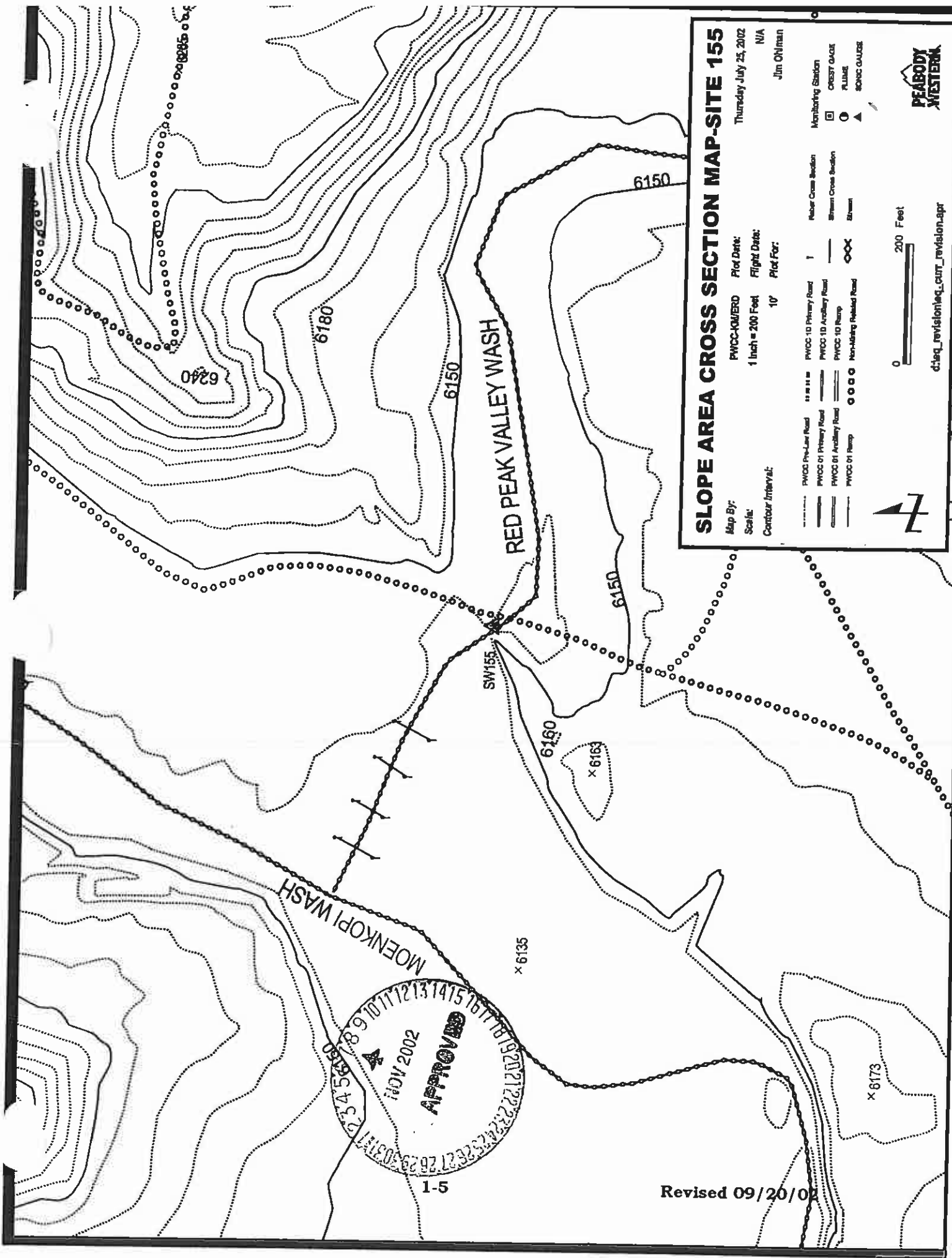
Monitoring Station
 CREST GAUGE
 FLUME
 SONIC GAUGE

PWCC Pre-Low Road
 PWCC 01 Primary Road
 PWCC 01 Auxiliary Road
 PWCC 01 Ramp
 PWCC 10 Primary Road
 PWCC 10 Auxiliary Road
 PWCC 10 Ramp
 Non-Adjoining Related Road

Rebar Cross Section
 Stream Cross Section
 Stream



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SLOPE AREA CROSS SECTION MAP-SITE 155

Map By: PWCC-KU/ERD Plot Date: Thursday July 25, 2002
 Scale: 1 inch = 200 Feet Flight Date: N/A
 Contour Interval: 10' Plot For: Jim Ohlman

- | | | | |
|---|---|---|---|
| <ul style="list-style-type: none"> PWCC Pre-Low Road PWCC D1 Primary Road PWCC D1 Auxiliary Road PWCC D1 Pump | <ul style="list-style-type: none"> PWCC D1 Primary Road PWCC D1 Auxiliary Road PWCC D1 Pump Non-Mining Related Road | <ul style="list-style-type: none"> Natural Cross Section Stream Cross Section Stream | <ul style="list-style-type: none"> Monitoring Station CREST GAUGE PLUME SONIC GAUGE |
|---|---|---|---|

0 200 Feet

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Revised 09/20/02

ATTACHMENT 2
ACZ LABS ANALYSIS PROCEDURES
AND QA/QC MANUAL

ACZ Laboratories, Inc.
30400 Downhill Drive
Steamboat Springs, CO 80487

QUALITY ASSURANCE PROGRAM

Document Description: The following pages summarize the quality assurance protocols and plans for all analyses performed by ACZ Laboratories, Inc.

APPROVALS: Russell V. Vande Velde
President

Russell V. Vande Velde Dated: 3/28/91

Ralph V. Poulsen

Vice President

Ralph V. Poulsen Dated: 3/28/91

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INTRODUCTION

ACZ Laboratories, Inc. provides a wide range of analytical testing services to clients throughout the United States. We began in 1980 with the goal of providing the scientifically accurate information needed to resolve complex environmental issues and questions. Over the years, our experienced laboratory staff gained an excellent reputation for producing quality analytical data which assisted our clients with project planning, risk assessment, and decision analyses. We continually work to refine our techniques, invest in state-of-the art instrumentation, and develop cost-effective measures of sample management to sustain our reputation for excellence.

We, at ACZ Laboratories, Inc., operate within the framework of an extensive Quality Assurance Program to ensure our clients receive consistently good, high-caliber data. Our in-house Quality Assurance Program meets or exceeds the requirements outlined in the "Handbook for Analytical Quality Control in Water and Wastewater Laboratories" (EPA/EMSL), "Test Methods for Evaluating Solid Waste" (EPA SW-846), and the Manual for the Certification of Laboratories Analyzing Drinking Water - Criteria and Quality Assurance" (EPA/EMSL). The following pages were written to provide our clients and prospective clients with an outline our in-house Quality Assurance Program and sample management procedures.

OBJECTIVE

Our Quality Assurance Program encompasses all laboratory operations and dictates specific procedures and guidelines to control all activities influencing data quality. Our Quality Assurance/Quality Control (QA/QC) plans and protocols provide a framework which helps our chemists/technicians achieve our Data Quality Objectives (DQO's). ACZ Laboratories, Inc.'s QA/QC framework ensures the precision, accuracy, and consistency of the analytical data we generate.

We strive for consistent standards of quality that conform to each client's overall project quality assurance requirements. If a client has specific project goals that require modification of our quality assurance guidelines, we may deviate from our Quality Assurance Program, but, only if more stringent controls are requested.

The specific data accuracy and measurement precision goals of our Quality Assurance Program are listed in Appendix A, "Drinking Water Analytical Methods"; Appendix B, "Water and Wastewater Analytical Methods"; and Appendix E, "Organic Methods for Water, Wastewater, and Solid Waste Analyses".

Our Quality Assurance Plan is subdivided into five (5) major areas.

- Organization and Responsibility
- Laboratory Operations
- Internal Quality Control
- External Quality Control
- Quality Assessment

ORGANIZATION AND RESPONSIBILITY

Ultimately, it is Ralph V. Poulsen's, (Vice President), responsibility to apply and administer ACZ Laboratories, Inc.'s Quality Assurance Program. Mr. Poulsen works directly with all laboratory personnel implementing various aspects of the program and reviews laboratory data to ensure that it meets our established requirements. Scott Habermehl, (QA/QC Officer) assists Mr. Poulsen in directing our Quality Assurance Program. Mr. Habermehl oversees our participation in numerous performance evaluation studies and operates our computerized Laboratory Information Management System (LIMS)

Our chemists and laboratory technicians devote twenty to thirty percent of their time fulfilling specific quality control related tasks outlined in our Quality Assurance Program. Each chemist/technician performs quality control check sample analyses, reports his/her findings to the section manager and informs the section manager of any irregularities or deficiencies in the quality control data. When necessary, Mr. Poulsen and Mr. Habermehl are consulted, and immediate corrective action initiated.

We thoroughly train new laboratory personnel in the analytical techniques and operating principles of the methods employed in various sample analyses. A designated chemist and the section manager closely supervise every new employee until he/she exhibits proficiency in accepted laboratory techniques. Once a chemist/ technician demonstrates a technological aptitude within the framework of our Quality Assurance Program, he/she will be assigned to oversee a particular laboratory procedure. We document this training process and retain a copies of all documentation in the employee's personnel file.

At ACZ Laboratories, Inc., we recognize the necessity and ultimate benefit of continuing education. We strongly encourage and support employee participation in advanced training courses, seminars, and professional organizations and meetings. Additionally, we hold weekly laboratory meetings to discuss procedures, work schedules, and problems requiring immediate attention. We encourage all employees to become actively involved in the laboratory's operations and believe this is a tremendous benefit to employees, managers and administrators.

INTERNAL QUALITY CONTROL

The majority of our quality control data is generated internally. We use this information to continually determine the accuracy and precision of our laboratory data. Internal quality control consists of the following:

- Proper instrument calibration, operation and maintenance.
- Use of high-quality chemicals and standards.
- Standard reference quality control sample analyses combined with analyses of blank(s), spike(s), duplicate(s), surrogate standard(s).

Methodology

At ACZ Laboratories, Inc., we use methods promulgated by the U.S. Environmental Protection Agency, the U.S. Geological Survey, and other Federal and State agencies which regulate and certify environmental laboratories. The tests we perform for specific parameters can be found appended to this document in Appendix A, ("Drinking Water Analytical Methods"); Appendix B, ("Water and Wastewater Analytical Methods"); and Appendix E, ("Organic Methods for Water, Wastewater, and Solid Waste Analyses").

Instrument Calibration Schedules

Chemists/technicians calibrate all laboratory instruments in accordance with manufacturer's guidelines or as required by approved methods. Instrument operators are responsible for documenting instrument operation, maintenance, and repairs. We maintain service contracts on all major systems to guarantee quick response to instrument failure(s) and expert repair(s) when/if necessary. This section provides an overview of the calibration schedules utilized for our major laboratory instruments.

Atomic Absorption and ICP Spectrophotometers

AA and ICP operators use one (1) sample blank and three (3) calibration standard reference samples prior to each analytical run. During each analytical "run", we analyze one (1) calibration standard, one (1) sample blank, one (1) spiked sample, and one (1) duplicate sample for every ten (10) field samples to verify instrument calibration.

Colorimetric Spectrophotometers

For each analytical "run", the chemist/technician uses one (1) blank and four (4) standard to calibrate colorimetric instrumentation. The absorbance values (standard calibration values) generated determine instrument response prior to initiating the field sample "run". Following calibration procedures, and during the field sample "run", the chemist/technician analyzes one (1) blank and one (1) mid-point standard for every ten (10) field samples to verify initial calibration and instrument stability.

Gas Chromatographs (GC)

Gas Chromatograph operators perform a three (3)-point calibration, covering a full-range of concentrations, as least once a month, or more frequently if necessary. The chemists verify and document instrument calibration daily for all compounds analyzed during a sample "run". Response factor and retention time stability must conform to our internal quality control guidelines prior to sample analyses. The GC chemists/technicians employ continuing calibration standards (CCS) during sample analyses and following ten (10) sample "runs" the chemist/technician will re-verify GC calibration.

Gas Chromatograph/Mass Spectrometer (GC/MS)

GC/MS operators verify and document instrument tuning every twelve (12) hours during operation using Bromofluorobenzene (BFB) or Decafluorotriphenylphosphine (DFTPP). A quantitized standard mixture is also introduced at twelve (12) hour increments to check instrument response factors and retention times. At a minimum, the US-EPA's GC/MS operating criteria must be satisfied prior to sample analyses. Additionally, prior to sample analyses, the operator evaluates instrument sensitivity, stability, and chromatographic performance to meet internal quality control criteria.

Glassware and Laboratory Supplies

ACZ Laboratories, Inc. uses only laboratory grade glassware and supplies purchased from nationally known supply houses. Prior to use, our technicians wash all laboratory glassware in alconox and rinse in deionized water. Trace metal glassware is rinsed in a 1:1 Nitric Acid solution before being rinsed in deionized water. Nutrient analysis glassware is rinsed in 1:1 Hydrochloric Acid followed by a deionized water rinse. We oven-bake all organic analyses glassware following deionized water rinsing and prior to use. Glassware not immediately used is stored in an enclosed, dust-free environment.

Reagents, Solvents, and Water

Our chemists/technicians use only high-quality reagent grade chemicals. Chemical containers are dated when received and when opened. Chemicals or reagents are never used after the expiration date. We store all chemicals according to the manufacturer's guidelines including the use of isolated cabinets to avoid contamination.

Reagent water is prepared in a two-stage purification system. Initially, the water is distilled in an all-glass still then passed through mixed-bed ion exchange cartridges. Distilled/deionized water from this system has a conductivity of less than 2 umhos/cm. A record containing weekly conductivity and Ph readings keeps tabs on this system's efficiency. Water necessary for organic analyses is charcoal filtered prior to use. Quality assurance protocol requires reagent blanks to be analyzed every ten (10) samples to detect possible failure(s) in the reagent water system.

Quality Control Samples

Our instrument operators use blank, spike, duplicate, and standard reference samples as a direct measure of method accuracy, precision, and bias. Our QA/QC Officer programmed our computerized LIM System to automatically include quality control samples, at regular intervals (ten [10] field samples), in all analytical "runs". We use this data to establish accuracy and precision 'control limits', for each analytical method applied at ACZ Laboratories, Inc. Control Limits employed must be equal to, or better than, the control limits reported in the approved methods (regulatory guidelines). Appendix F, "Development of Precision and Accuracy Control Limits", outlines the calculation of these 'control limits'.

Analytical Standards

Our QA/QC Officer or the 'responsible' chemist (chemist charged with method[s] oversight) prepares a working standard from stock solution to use during all sample "runs". These working standards must agree to within ten (10) percent of US-EPA supplied reference standards or be discarded. Labels on analytical standard bottles contain the reagent name, preparer's name, preparation date, expiration date, and any special handling requirements. Chemists/technicians replace all stock solutions and standards on a regular schedule. Stock solutions are replaced as frequently as necessary and remain in-house no longer than one (1) year.

Standard Reference Samples

Personnel, at ACZ Laboratories, Inc., use standard reference samples to measure and determine the accuracy and precision of the analytical methods we employ. Instrument operators analyze two (2) standard reference samples in each sample "run". Measured recoveries must be within 10% of the standard (true) value, otherwise the "run" is terminated and corrective action initiated.

In-Process Calibration Standards

In addition to analyzing (2) standard reference samples per "run", we analyze one (1) standard for every ten (10) samples (AA, ICP, Colorimetric instruments) to verify instrument stability and initial calibration. Values obtained must be within ten (10) percent of the standard (true) value, otherwise, the sample run is terminated.

Blank Samples

Instrument operators perform one (1) blank sample analysis for every ten (10) field sample analyses (AA, ICP, Colorimetric instruments) to monitor contaminant influences during the sample "run". Contamination levels must be less than half the Method Detection Limit (MDL). If an instrument detects a compound/element above this 'contamination threshold level' the chemist/technician aborts the sample run and takes immediate corrective action.

Spiked Samples

The chemist/technician spikes ten (10) percent of the samples, or sample extracts, in each sample "run" to determine instrument measurement accuracy. The instrument operator calculates the percent spike recovery and plots this data on a quality control chart. If the recovery values are not within acceptable limits (+ 25%), the sample "run" is discontinued and corrective action initiated.

Duplicate Samples

At a minimum, ten (10) percent of samples in a sample "run" are duplicates. The chemist/technician uses comparative data generated by duplicate samples to determine instrument precision. The relative percent difference between samples and duplicate samples is determined and plotted on Quality Control Charts. If the calculated percent difference value exceeds analytical quality control limits, the "run" is investigated and corrective action is started.

Surrogate Standards

The efficiency of a sample extraction influences the accuracy and precision of many organic analyses. Prior to sample extraction, organic preparation personnel add surrogate compounds to each field sample, blank, spike, and duplicate sample. Following sample analysis, the chemist/technician calculates, records, and compares the surrogate recovery value(s) to established quality control guidelines. Samples with surrogate recovery deviating from quality control criteria are investigated for possible laboratory preparation/analysis deficiencies, re-extracted, and/or re-analyzed.

EXTERNAL QUALITY CONTROL

ACZ Laboratories, Inc., participates in a number of external quality control activities that support our internal quality control measures. These external activities provide a yardstick by which to gauge the effectiveness and reliability of our internal Quality Control Program

Certifications

ACZ Laboratories, Inc. is certified to perform analyses by the following regulatory bodies:

- State of Alabama
Surface Mining Reclamation Commission
Water and Overburden Analyses
- State of Arizona
Department of Health Services
Drinking Water Analyses
- State of California
Department of Health Services
Water, Wastewater, Soil, Hazardous Waste Analyses
- State of Colorado
Department of Health
Drinking Water Analyses
- State of North Dakota
Department of Health
Drinking Water Analyses
- State of Utah
Department of Health
Water, Wastewater, Soil, Hazardous Waste Analyses
- State of Washington
Department of Ecology
Water and Wastewater analyses
- U. S. Department of the Interior
Office of Surface Mining Small Operators Assistance Program
Water and Overburden Analyses

ACZ Laboratories, Inc. has been, and will be, subjected to meticulous laboratory inspection, by the certifying agencies listed above, in order to maintain our credentials. Additionally, these agencies require our participation in special "audit sample" examinations which regularly test our analytical methods, analytical results, and overall laboratory proficiency.

Performance Evaluation Samples

To retain our various certifications, we also participate in the Water Pollution and Drinking Water performance evaluation studies. Every three (3) months, ACZ Laboratories, Inc. receives samples to be analyzed for specified parameters. Following analyses, we submit our results to the regulating agencies for evaluation and comment.

We also participate in round-robin testing studies sponsored by the U.S. Geological Survey (USGS), U.S. Department of the Interior-Office of Surface Mining (USDOT-OSM), and the Applied Products Group (APG). Laboratory evaluation is based on laboratory comparison to the mean values generated by participants. Upon request, we will gladly furnish our clients and prospective clients with copies of these laboratory proficiency examinations for review and/or reference. (Copies of previous Water Pollution and APG studies are shown in Appendix G).

Blind Samples

Many of our clients submit spiked, blank, or reference samples to us for analysis. Other clients split sample and compare our data with that of another laboratory. We openly invite and encourage clients and potential clients to enact any external quality control procedures they feel necessary.

QUALITY ASSESSMENT

The data assessment protocol used at ACZ Laboratories, Inc. provides a carefully documented measure of our analytical performance. We believe proper quality assessment of all generated data is the key to an effective Quality Assurance Program.

Quality Control Data Tracking Program

Apart from our computerized Laboratory Information Management (LIM) System, the QA/QC Officer maintains an extensive database of all quality control data generated by our laboratory. Routine data reviews (by Mr. Poulsen and Mr. Habermehl) aid in the immediate identification of deficient laboratory techniques, practices, and/or methods. Once problems are detected, corrective action plans are implemented to alleviate known deficiencies and/or poor laboratory technique.

We chart all quality control data (Quality Control Charts) and retain this information on our computer system. The Quality Control Charts address the precision and accuracy, and provides a standardized comparison for all parameters measured. We implement corrective action whenever quality control data does not conform with established guidelines. Following section supervisor review of quality control information, the chemists/technicians submit all analytical data (quality control + field sample results) to our Data Entry Clerk.

The Data Entry Clerk inputs quality control data into the LIM System on a daily basis. Information includes:

- Analyses Performed (coded)
- Date of Analysis(es)
- Analyst(s)
- Standard Reference Sample Information
(incl. sample ID, true value, & observed value)
- Spike sample information
(incl. sample ID, spike value, & observed value)
- Duplicate Sample Information
(incl. sample ID, first & second observed values)

From the information entered, our computer system calculates the necessary quality control data for QA/QC Analyses, (e.g., the percent recovery for standard reference samples and spike samples, and the percent difference for duplicate samples). Also the computer calculates and updates the mean, standard deviation value, warning levels (@ two std. dev.), and control limits (@ three std. dev.) for each analytical method.

The quality control data produced allows our QA/QC Officer to generate numerous Quality Control Charts monthly. Mr. Poulsen reviews, signs, and stores this information as part of a permanent record. Our QA/QC Officer provides copies to the chemists/technicians for review and study. Additional copies are retained in Standard Operating Manual for each analytical method.

Quality Control Charts inform laboratory personnel of the precision and acceptability of the generated data. Analytical results are unacceptable under the following conditions:

- When any quality control data point outside established control limits.
- When seven (7) consecutive data points lie on the same side of the mean value.

Corrective Action

We implement corrective action procedures in a number of scenarios as outlined in this document. When problems are identified, the sample(s) involved are re-extracted and re-analyzed to provide our client's with accurate data. We thoroughly document, for future reference, any problematic areas and the corrective steps utilized to correct the discrepancy. When we detect a problem, we increase the frequency of quality control checks until we are certain the problem no longer exists.

Data Validation

Each chemist/technician reviews quality control data prior to submitting any information to the Data Entry Clerk. Our LIM System performs several data checks, (e.g. cation-anion balances), to validate entered information. The computer alarms (prints an on-screen message) when entered data, or data calculated are outside established guidelines. Samples involved must then be re-analyzed for suspect parameters.

Upon completion analyses and data reduction, the section supervisor reviews, verifies, and validates the resultant sample information. All laboratory reports are then signed by the section supervisor and/or the Vice President prior to release to the requesting agent.

Document Control

We organize and store copies of all documents generated at our laboratory. Copies of client correspondence, chain-of-custody forms, analytical reports, analysis(es) requests forms, sample worksheets, master worklists, instrument journals, and analytical work lists are stored in a centralized filing area. Our filing system serves as a "back-up" to our computerized LIM System and can be used to trace all analytical information from sample receipt to final report.

Our QA/QC Officer operates and maintains our computerized LIM System. Additionally, we receive software and hardware support via agreements with the computer system's manufacturer. The QA/QC Officer "backs-up" magnetically retained data weekly and archives data (on magnetic tape) on a quarterly basis.

Inventory Control

Our laboratory Purchasing Agent orders all laboratory supplies and performs inventory control. Books detailing the chemical, grade, quantity, price and purchase date are maintained for easy reference. Reagent bottles are dated when received and opened, and discarded when past manufacturer's expiration date. We store all supplies in areas as contaminant-free as possible, yet provide our chemists/technicians with easy access.

CONCLUSION

At ACZ Laboratories, Inc., we take great pride in the quality of the analytical work we perform. Our Quality Assurance Program acts as the framework from which we operate. We constantly strive to improve our analytical techniques, update our quality assurance plans, and educate ourselves to sustain our reputation for excellence and provide our clients with the most accurate and precise environmental laboratory data possible.

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- USGS, Methods for Determination of Inorganic Substances in Water and Fluvial Sediments, 1979.
- USGS, Methods for Determination of Organic Substances in Water and Fluvial Sediments, Open File Rep. 82-1004, 1983.

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APPENDIX A

DRINKING WATER ANALYTICAL METHODS

Inorganic and Organic Parameters in Drinking Water

DRINKING WATER ANALYTICAL METHODS

Inorganic Parameters in Drinking Water

| Parameter | *Method | Detection Limit (mg/l) |
|-----------|---|------------------------|
| Arsenic | EPA 206.2, Atomic Absorption - Furnace | 0.001 |
| Barium | EPA 200.7, ICP Spectrophotometer | 0.01 |
| Cadmium | EPA 213.2, Atomic Absorption - Furnace | 0.005 |
| Chromium | EPA 218.3, Atomic Absorption - Furnace | 0.01 |
| Fluoride | EPA 340.2, Ion Specific Electrode | 0.1 |
| Lead | EPA 239.2, Atomic Absorption - Furnace | 0.001 |
| Mercury | EPA 245.2, Atomic Absorption - Cold Vapor | 0.0002 |
| Nitrate | EPA 353.2, Automated Colorimetric - Cadmium Reduction | 0.02 |
| Selenium | USGS I-2667-81, Atomic Absorption - Hydride | 0.001 |
| Silver | EPA 272.2, Atomic Absorption - Furnace | 0.01 |

* Methods of Chemical Analysis of Water and Waste, EPA 600/4-79-020
 Methods for Determination of Inorganic Substances in Water and Fluvial Sediments, USGS, 1979

Organic Parameters in Water

| Parameter | Method |
|-----------------------------------|------------------------|
| Trihalomethanes | EPA Method 524, GC/MS |
| Organochlorine Pesticides | EPA Method 608, GC/ECD |
| Polynuclear Aromatic Hydrocarbons | EPA Method 610, GC/FID |
| Chlorinated Hydrocarbons | EPA Method 612, GC/EC |
| Chlorinated Herbicides | EPA Method 615, GC/ECD |
| Purgeables (VOC) | EPA Method 624, GC/MS |
| Base/Neutral Acids | EPA Method 625, GC/MS |

APPENDIX B

WATER AND WASTEWATER

Inorganic Analytical Methods

WATER AND WASTEWATER

Inorganic Analytical Methods

| Parameter | Method | Detection Limit (mg/l) |
|-----------------------|--|------------------------|
| Acidity | EPA 305.1, Titrimetric | 1.0 |
| Alkalinity | EPA 310.1, Titrimetric | 1.0 |
| Aluminum | EPA 200.7, ICP Spectrophotometer | 0.05 |
| Aluminum (low level) | EPA 202.2, Atomic Absorption - Furnace | 0.002 |
| Antimony | EPA 204.2, Atomic Absorption - Furnace | 0.001 |
| Arsenic | EPA 206.2, Atomic Absorption - Furnace | 0.001 |
| Barium | EPA 200.7, ICP Spectrophotometer | 0.01 |
| Barium (low level) | EPA 208.2, Atomic Absorption - Furnace | 0.005 |
| Beryllium | EPA 200.7, ICP Spectrophotometer | 0.005 |
| Beryllium (low level) | EPA 210.2, Atomic Absorption - Furnace | 0.0005 |
| Bismuth | EPA 200.7, ICP Spectrophotometer | 0. |
| Bicarbonate | EPA 310.1, Titrimetric | 1.0 |
| BOD | EPA 405.1, 5-day (20 C) | 1.0 |
| Boron | EPA 200.7, ICP Spectrophotometer | 0.02 |
| Bromide | EPA 320.1, Titrimetric | 2.0 |
| Bromide (low level) | USGS I-127-78, Colorimetric | 0.01 |
| Cadmium | EPA 200.7, ICP Spectrophotometer | 0.005 |
| Cadmium (low level) | EPA 213.2, Atomic Absorption - Furnace | 0.0001 |
| Calcium | EPA 200.7, ICP Spectrophotometer | 1.0 |
| Calcium | EPA 215.1, Atomic Absorption - Flame | 0.1 |

| Parameter | Method | Detection Limit (mg/l) |
|-----------------------------------|--|------------------------|
| Carbonate | EPA 310.1, Titrimetric | 1.0 |
| Chloride | EPA 325.2, Automated - Ferrocyanide | 1.0 |
| Chromium | EPA 200.7, ICP Spectrophotometer | 0.01 |
| Chromium (low level) | EPA 218.2, Atomic Absorption - Furnace | 0.001 |
| Chromium, (+6) | Standard Methods 312B, Colorimetric | 0.005 |
| Cobalt | EPA 200.7, ICP Spectrophotometer | 0.02 |
| COD | EPA 410.4, Ampule Method Colorimetric | 5.0 |
| Color | EPA 110.1 or 110.2 (units) | 5.0 |
| Conductivity | EPA 120.1, Meter | 1.0 |
| Copper | EPA 200.7, ICP Spectrophotometer | 0.01 |
| Copper (low level) | EPA 220.2, Atomic Absorption - Furnace | 0.001 |
| Cyanide, Total | EPA 335.3, Automated UV or Manual Distillation | 0.002 |
| Cyanide, Amenable to Chlorination | EPA 335.1, Titrimetric, Spectrophotometric | 0.002 |
| Cyanide, Weak Acid Dissociable | EPA 335.3, Manual Distillation | 0.002 |
| Fluoride | EPA 340.2, Ion Selective Electrode | 0.1 |
| Fluoride | EPA 340.3, Automated - Complexone | 0.02 |
| Hardness, Total | EPA 130.2, Calculation | 1.0 |
| Iodide | EPA 345.1, Titrimetric | 2.0 |
| Gallium | EPA 200.7, ICP Spectrophotometer | 0. |
| Gold | EPA 231.2, Atomic Absorption - Furnace | 0.002 |
| Iron | EPA 200.7, ICP Spectrophotometer | 0.02 |
| Iron (low level) | EPA 236.2, Atomic Absorption - Furnace | 0.001 |
| Lanthanum | EPA 200.7, ICP Spectrophotometer | 0. |

| Parameter | Method | Detection Limit (mg/l) |
|----------------------------|---|------------------------|
| Lead | EPA 239.1, Atomic Absorption - Flame | 0.02 |
| Lead (low level) | EPA 239.2, Atomic Absorption - Furnace | 0.001 |
| Lithium | EPA 200.7, ICP Spectrophotometer | 0.1 |
| Lithium | Standard Method 3111 B, Atomic Absorption - Flame | 0.02 |
| Magnesium | EPA 200.7, ICP Spectrophotometer | 1.0 |
| Magnesium | EPA 242.1, Atomic Absorption - Flame | 0.01 |
| Manganese | EPA 200.7, ICP Spectrophotometer | 0.01 |
| Manganese (low level) | EPA 243.2, Atomic Absorption - Furnace | 0.0002 |
| Mercury | EPA 245.2, Atomic Absorption - Cold Vapor | 0.0002 |
| Molybdenum | EPA 200.7, ICP Spectrophotometer | 0.05 |
| Molybdenum (low level) | EPA 246.2, Atomic Absorption - Furnace | 0.001 |
| Nickel | EPA 200.7, ICP Spectrophotometer | 0.02 |
| Nickel (low level) | EPA 249.2, Atomic Absorption - Furnace | 0.001 |
| Nitrogen, Ammonia | EPA 350.1, Automated - Phenate | 0.05 |
| Nitrogen, Nitrate | EPA 353.2, Automated - Cadmium Reduction | 0.02 |
| Nitrogen, Nitrate/Nitrite | EPA 353.2, Automated - Cadmium Reduction | 0.01 |
| Nitrogen, Organic | By Total Ammonia | 0.1 |
| Nitrogen, Total (Kjeldahl) | USGS I-2552-78, BD 40 Digestion, Colorimetric | 0.1 |
| Oil & Grease | EPA 413.1, Gravimetric | 1.0 |
| Organic Carbon | ASTM D 4129-82, Coulometric Detection | 1.0 |
| pH | EPA 150.1, Meter | 0.1 |
| Phenols | EPA 420.2, Automated 4-AAP or Manual Distillation | 0.01 |

| Parameter | Method | Detection Limit (mg/l) |
|----------------------------------|--|------------------------|
| Phosphorus, Total | EPA 365.1, Automated with Digestion | 0.01 |
| Phosphorus, Ortho | EPA 365.1, Automated - Ascorbic Acid | 0.01 |
| Phosphorus, Organic/Hydrolyzable | By Difference | 0.01 |
| Potassium | EPA 200.7, ICP Spectrophotometer | 1.0 |
| Potassium | EPA 258.1, Atomic Absorption - Flame | 0.1 |
| Scandium | EPA 200.7, ICP Spectrophotometer | 0. |
| Selenium | USGS I-2667-81, Atomic Absorption - Furnace | 0.001 |
| Silica | EPA 200.7, ICP Spectrophotometer | 0.1 |
| Silver | EPA 200.7, ICP Spectrophotometer | 0.01 |
| Silver (low level) | EPA 272.2, Atomic Absorption - Furnace | 0.0005 |
| Sodium | EPA 200.7, ICP Spectrophotometer | 1.0 |
| Sodium | EPA 273.1, Atomic Absorption - Flame | 0.1 |
| Solids, Dissolved | EPA 160.1, Gravimetric, (180 C) | 2.0 |
| Solids, Settleable | EPA 160.5, Volumetric, Imhoff Cone (ml/l/hr) | 2.0 |
| Solids, Suspended | EPA 160.2, Gravimetric, (105 C) | 2.0 |
| Solids, Total | EPA 160.3, Gravimetric, (105 C) | 2.0 |
| Solids, Volatile | EPA 160.4, Gravimetric, (550 C) | 2.0 |
| Strontium | EPA 200.7, ICP Spectrophotometer | 0.02 |
| Sulfate | EPA 375.3, Gravimetric | 4.0 |
| Sulfide | EPA 376.1, Titrimetric | 0.2 |
| Sulfite | EPA 377.1, Titrimetric | 2.0 |
| Surfactant | EPA 425.1, Colorimetric | 0.02 |
| Tellurium | EPA 200.7, ICP Spectrophotometer | 0. |

| Parameter | Method | Detection Limit (mg/l) |
|----------------------|--|------------------------|
| Thallium | EPA 279.2, Atomic Absorption - Furnace | 0.002 |
| Thiocyanate | ASTM D 4193-82, Colorimetric | 0.1 |
| Tin | EPA 200.7, ICP Spectrophotometer | 0.2 |
| Titanium | EPA 200.7, ICP Spectrophotometer | 0.005 |
| Tungsten | EPA 200.7, ICP Spectrophotometer | 0.1 |
| Turbidity | EPA 180.1, Nephelometric (N.T.U.) | 0.1 |
| Vanadium | EPA 200.7, ICP Spectrophotometer | 0.01 |
| Vanadium (low level) | EPA 286.2, Atomic Absorption - Furnace | 0.002 |
| Zinc | EPA 200.7, ICP Spectrophotometer | 0.01 |

* NOTE: Alternative methods can be used upon client request to obtain lower detection limits for many of the parameters listed.

APPENDIX C

WATER AND WASTEWATER

Inorganic Parameter Holding Times

WATER AND WASTEWATER

Inorganic Parameter Holding Times

| Parameter | Sample Container | Preservation Technique | Sample Transport | Holding Time (days) |
|-----------------------------------|------------------|------------------------------|------------------|---------------------|
| Acidity | Plastic | Refrigeration | Cool to 4 C | 14 |
| Alkalinity | Plastic | Refrigeration | Cool to 4 C | 14 |
| BOD | Plastic | Refrigeration | Cool to 4 C | 48 hrs. |
| Boron | Plastic | | | 28 |
| Bromide | Plastic | | | 28 |
| COD | Plastic | Sulfuric Acid to pH ≤ 2 | Cool to 4 C | 28 |
| Chloride | Plastic | | | Immed. |
| Chlorine | Plastic | None Required | | 28 |
| Chromium (+6) | Plastic | Refrigeration | Cool to 4 C | 24 hrs. |
| Color | Plastic | Refrigeration | Cool to 4 C | 48 hrs. |
| Conductivity | Plastic | Refrigeration | Cool to 4 C | 28 |
| Cyanide: | | | | |
| Total | Plastic | NaOH to pH ≥ 12 (Dark) | Cool to 4 C | 14 |
| Free | Plastic | NaOH to pH ≥ 12 (Dark) | Cool to 4 C | 14 |
| WAD | Plastic | NaOH to pH ≥ 12 (Dark) | Cool to 4 C | 14 |
| Fluoride | Plastic | | | 28 |
| Iodide | Plastic | Refrigeration | Cool to 4 C | 24 hrs. |
| Hardness: Calcium Magnesium | Plastic | Nitric Acid to pH ≤ 2 | | 180 |

Inorganic Parameter Holding Times

| Parameter | Sample Container | Preservation Technique | Sample Transport | Holding Time (days) |
|---|------------------|------------------------------|------------------|---------------------|
| Metals: [except for Chromium (+6) & Mercury] | Plastic | | | 180 |
| Total Metals | | Nitric Acid to pH ≤ 2 | | 180 |
| Dissolved Metals | | Nitric Acid to pH < 2 | | 180 |
| Mercury: Dissolved | Plastic | Nitric Acid to pH ≤ 2 | Cool to 4 C | 28 |
| Total | Plastic | Nitric Acid to pH ≤ 2 | Cool to 4 C | 28 |
| Nitrogen: Ammonia | Plastic/Glass | Sulfuric Acid to pH ≤ 2 | Cool to 4 C | 28 |
| NO ₃ /NO ₂ | Plastic/Glass | Sulfuric Acid to pH ≤ 2 | Cool to 4 C | 28 |
| Nitrate | Plastic/Glass | Refrigeration | Cool to 4 C | 48 hrs. |
| Nitrite | Plastic/Glass | Refrigeration | Cool to 4 C | 48 hrs. |
| Total | Plastic/Glass | Sulfuric Acid to pH ≤ 2 | Cool to 4 C | 28 |
| Oil & Grease | Glass (1-ltr) | Sulfuric Acid to pH ≤ 2 | Cool to 4 C | 28 |
| Organic Carbon: TOC | Glass | Sulfuric Acid to pH ≤ 2 | Cool to 4 C | 28 |
| DOC | Glass | Sulfuric Acid to pH ≤ 2 | Cool to 4 C | 28 |
| pH | Plastic | | | Immed. |
| Phenols: Dissolved | Glass | Sulfuric Acid to pH ≤ 2 | Cool to 4 C | 28 |
| Total | Glass | Sulfuric Acid to pH ≤ 2 | Cool to 4 C | 28 |

Inorganic Parameter Holding Times

| Parameter | Sample Container | Preservation Technique | Sample Transport | Holding Time (days) |
|-----------------------------------|------------------|------------------------------------|------------------|---------------------|
| Phosphorus: Hydrolyzable | Plastic | Sulfuric Acid to pH ≤ 2 | Cool to 4 C | 28 |
| Ortho- Phosphate, Dissolved | Plastic | Refrigeration | Cool to 4 C | 48 hrs. |
| Total | Glass | Sulfuric Acid to pH ≤ 2 | Cool to 4 C | 28 |
| Total, Dissolved | Plastic/Glass | Refrigeration | Cool to 4 C | 48 hrs. |
| Silica | Plastic | | Cool to 4 C | 28 |
| Sodium | Plastic | Refrigeration | Cool to 4 C | 180 |
| Solids: Dissolved | Plastic | Refrigeration | Cool to 4 C | 7 |
| Settleable | Plastic | Refrigeration | Cool to 4 C | 48 hrs. |
| Suspended | Plastic | Refrigeration | Cool to 4 C | 7 |
| Total | Plastic | Refrigeration | Cool to 4 C | 7 |
| Volatile | Plastic | Refrigeration | Cool to 4 C | 7 |
| Sulfate | Plastic | Refrigeration | Cool to 4 C | 28 |
| Sulfide | Plastic | Zinc Acetate + NaOH to pH ≥ 9 | Cool to 4 C | 7 |
| Sulfite | Plastic | 1-ml of 2.5% EDTA solution | Cool ≤ 50 C | Immed. |
| Surfactant | Plastic | Refrigeration | Cool to 4 C | 48hrs |
| Susp. Seds. | Plastic | None Required | Cool to 4 C | |
| Turbidity | Plastic | Refrigeration (Dark) | Cool to 4 C | 48 hrs. |

APPENDIX D

WATER AND WASTEWATER

Inorganic Water Sample Bottle & Preservative Information

Inorganic Water Samples Bottle & Preservative Information

| | | | | |
|-----------------------|---|--|---|--|
| Color Code: | None | White | Red | Green |
| Letter Code: | U | W | R | G |
| Sample Type: | Raw | Filtered | Raw | Filtered |
| Preservative: | None | None | Nitric Acid | Nitric Acid |
| Bottle Type: | Plastic | Plastic | Plastic | Plastic |
| Bottle Volume: | 250-500 ml | 250-500 ml | 250 ml | 250 ml |
| Analyses: | Acidity BOD Chlorine Conductivity Odor Orthophosphate pH Solids: Settleable Suspended Volatile Sulfite Surfactants Turbidity | Alkalinity: (Bicarbonate & Carbonate & Hydroxide) Boron Bromide Chloride Chromium VI Color Fluoride Iodide Nitrogen: Nitrate/Nitrite Orthophosphate (Dissolved Only) Silica Sodium Solids: (Dissolved; if TDS Only) Sulfate | Metals: (Total Only) Metals: (Total Recoverable) | Metals: (Dissolved Only) Calcium Magnesium Sodium |

Inorganic Water Sample Bottle & Preservative Information

| | | | | |
|-----------------------|---------------|-----------------------|---------------|-----------------------|
| Color Code: | Yellow | Yellow (Glass) | Blue | Blue (Glass) |
| Letter Code: | Y | YG | B | BG |
| Sample Type: | Raw | Raw | Filtered | Filtered |
| Preservative: | Sulfuric Acid | Sulfuric Acid | Sulfuric Acid | Sulfuric Acid |
| Bottle Type: | Plastic | Glass with Teflon Cap | Plastic | Glass with Teflon Cap |
| Bottle Volume: | 250 ml | 250 ml | 250 ml | 250 ml |

| | | | | |
|------------------|---|--|--|---|
| Analyses: | <p>*Nitrogen: (Total Only) Ammonia Organic Total</p> <p>*Phosphorus: (Total Only)</p> | <p>COD: (Total Only)</p> <p>*Nitrogen: (Total Only) Ammonia Organic Total</p> <p>Phenols: (Total Only)</p> <p>*Phosphorus: (Total Only)</p> <p>TOC</p> | <p>Nitrogen: (Dissolved Only) Ammonia Organic Total</p> <p>*Phosphorus: (Dissolved Only)</p> | <p>COD: (Dissolved Only)</p> <p>DOC</p> <p>Nitrogen: (Dissolved Only)</p> <p>Phenols: (Dissolved Only)</p> <p>*Phosphorus: (Dissolved Only)</p> |
|------------------|---|--|--|---|

* Parameters may be analyzed from either glass or plastic containers.

Inorganic Water Sample Bottle & Preservative Information

| | | | | |
|-----------------------|-----------------------------------|---------------|----------------------------------|------------------------------|
| Color Code: | Tan | Orange | Pink | Sterile |
| Letter Code: | T | O | P | ST |
| Sample Type: | Raw | Raw | Raw | |
| Preservative: | Sodium Hydroxide and Zinc Acetate | Sulfuric Acid | Sodium Hydroxide | Sodium Thiosulfate |
| Bottle Type: | Plastic | Glass | Plastic | Plastic |
| Bottle Volume: | 250 ml | 1000 ml | 500 ml | 125 ml |
| <hr/> | | | | |
| Analyses: | Sulfide | Oil & Grease | Cyanide: Free Total WAD | Coliforms: Fecal Total |

APPENDIX E

ORGANIC METHODS FOR WATER, WASTEWATER, AND SOLID WASTE ANALYSES

Surface and Drinking Water Analyses

Groundwater and Solid Waste Analyses

ORGANIC SURFACE & DRINKING WATER ANALYSES

| EPA Method | Compound Class | Analytical Technique | Sample Preparation | Detection Range (ug/l) |
|------------|-----------------------------------|----------------------|--------------------|------------------------|
| 601 | Purgeable Halocarbons | GC/Hall | purge & trap | 1.0 |
| 8015 | Non-Halogenated Volatile Organics | GC/FID | purge & trap | 50.0 |
| ASTM D3328 | Total Petroleum Hydrocarbons | GC/FID | 3510, dir. inj. | 0.2 mg/l |
| 602 | Purgeable Aromatic Compounds | GC/PID | purge & trap | 1.0 |
| 602 | BTEX | GC/PID | purge & trap | 1.0 |
| 603 | Acrolein and Acrylonitrile | GC/MS | purge & trap | 100.0 |
| 604 | Phenols | GC/MS | 3510 | 10.0 - 50.0 |
| 608 | Organochlorine Pesticides | GC/ECD | 3510 | 0.05 - 0.1 |
| 608 | Polychlorinated Biphenyls (PCB's) | GC/ECD | 3510 | 0.5 - 1.0 |
| 612 | Chlorinated Hydrocarbons | GC/ECD | 3510 | 0.2 - 1.5 |
| 614 | Organophosphorus Pesticides | GC/NPD | 3510 | 0.2 - 1.4 |
| 615 | Chlorophenoxy Acid Herbicides | GC/ECD | 3510 | 0.5 - 2.0 |
| 624 | Purgeable Volatile Organic Acids | GC/MS | purge & trap | 5.0 - 10.0 |
| 625 | Base/Neutral Acids | GC/MS | 3510 | 10.0 - 50.0 |
| 501.1 | Trihalomethanes | GC/Hall | purge & trap | 1.0 - 2.0 |
| 524.2 | VOC's | GC/MS | purge & trap | 1.0 - 2.0 |

Instrument Nomenclature:

GC - Gas Chromatograph
GC/MS - Gas Chromatograph/
Mass Spectrometer

Sample Preparation Method:

purge & trap - Direct Injection of Liquid
Samples into Instrumentation.

Detectors:

ECD - Electron Capture
FID - Flame Ionization
PID - Photo-Ionization
NPD - Nitrogen Phosphorus

3510 - Separatory Funnel Extraction
of Liquid Samples.

ORGANIC SURFACE & DRINKING WATER ANALYSES

| EPA Method | Compound Class | Sample Collection | Sample Preservation | Holding Time (days) |
|------------|-----------------------------------|-------------------|---------------------|---------------------|
| 601 | Purgeable Halocarbons | (2) 40-ml vial | HCl | fourteen (14) |
| 8015 | Non-Halogenated Volatile Organics | (2) 40-ml vial | HCl | fourteen (14) |
| ASTM D3328 | Total Petroleum Hydrocarbons | 1-ltr amber | — | fourteen (14) |
| 602 | Purgeable Aromatic Compounds | (2) 40-ml vial | HCl | fourteen (14) |
| 602 | BTEX | (2) 40-ml vial | HCl | fourteen (14) |
| 603 | Acrolein and Acrylonitrile | (2) 40-ml vial | HCl | fourteen (14) |
| 604 | Phenols | 1-ltr amber | -- | seven (7) |
| 608 | Organochlorine Pesticides | 1-ltr amber | -- | seven (7) |
| 608 | Polychlorinated Biphenyls (PCB's) | 1-ltr amber | — | seven (7) |
| 612 | Chlorinated Hydrocarbons | 1-ltr amber | — | seven (7) |
| 614 | Organophosphorus Pesticides | 1-ltr amber | -- | seven (7) |
| 615 | Chlorophenoxy Acid Herbicides | 1-ltr amber | — | seven (7) |
| 624 | Purgeable Volatile Organics | (2) 40-ml vial | HCl | fourteen (14) |
| 625 | Base/Neutral Acids | (2) 1-ltr amber | — | seven (7) |
| 501.1 | Trihalomethanes | (2) 40-ml vial | HCl | fourteen (14) |
| 524.2 | VOC's | (2) 40-ml vial | HCl | fourteen (14) |

Nomenclature:

1-ltr amber - One (1)-liter amber glass bottle with a teflon lined cap.

40-ml vial - 40-ml glass vial with a teflon-lined septa cap. Volatile Organic Analysis (VOA) vial.

(2) - A separate, duplicate, sample should be collected and submitted as a back-up.

NOTE: - We include a VOA vial Trip Blank with sample container shipments to detect contaminant problems which may be encountered in transit. Analysis performed for internal QA/QC.

ORGANIC - GROUNDWATER & SOLID WASTE ANALYSES

| EPA Method | Compound Class | Analytical Technique | Sample Preparation | Detection Range (ug/kg) |
|------------|-----------------------------------|----------------------|--------------------|-------------------------|
| 8010 | Purgeable Halocarbons | GC/Hall | 5030 | 1.0 - 10.0 |
| 8015 | Non-Halogenated Volatile Organics | GC/FID | 5030 | 2500 |
| ASTM D3328 | Total Petroleum Hydrocarbons | GC/FID | 5030 | 10 mg/kg |
| 8020 | Purgeable Aromatic Compounds | GC/PID | 5030 | 50.0 |
| 8020 | BTEX | GC/PID | 5030 | 50.0 |
| 8030 | Acrolein and Acrylonitrile | GC/MS | 5030 | 100.0 |
| 8040 | Phenols | GC/MS | 3550 | 330.0 - 1600 |
| 8080 | Organochlorine Pesticides | GC/ECD | 3550 | 1.5 - 16.5 |
| 8080 | PCB's | GC/ECD | 3550 | 0.5 - 1.0 |
| 8120 | Chlorinated Hydrocarbons | GC/ECD | 3550 | 7.0 - 50.0 |
| 8140 | Organophosphorus Pesticides | GC/NPD | 3550 | 7.0 - 50.0 |
| 8150 | Chlorophenoxy Acid Herbicides | GC/ECD | 3550 | 20.0 - 65.0 |
| 8240 | Purgeable Volatile Organics | GC/MS | 5030 | 5.0 - 10.0 |
| 8270 | Base/Neutral Acids | GC/MS | 3550 | 330.0 - 1600 |

Instrument

Nomenclature:

GC - Gas Chromatograph
 GC/MS - Gas Chromatograph/
 Mass Spectrometer

Detectors:

ECD - Electron Capture
 FID - Flame Ionization
 PID - Photo-Ionization
 NPD - Nitrogen Phosphorus

Sample

Preparation

Method:

3550 - Sonication Extraction
 of Solid Samples.

5030 - Direct Injection of
 Liquid Samples, Solid
 Samples are mixed
 prior to injection.

ORGANIC - GROUNDWATER & SOLID WASTE ANALYSES

| EPA Method | Compound Class | Sample Collection | Sample Preservative | *Holding Time (Days) |
|------------|-------------------------------------|-------------------------------|---------------------|--------------------------------|
| 8010 | Purgeable Halocarbons | 500-ml jar 2-(40-ml vial) | — (HCl) | fourteen (14) fourteen (14) |
| 8015 | Non-Halogenated Volatile Organics | 500-ml jar 2-(40-ml vial) | — (HCl) | fourteen (14) fourteen (14) |
| 8020 | Aromatic Volatile Organic Compounds | 500-ml jar 2-(40-ml vial) | -- (HCl) | fourteen (14) fourteen (14) |
| 8030 | Acrolein and Acrylonitrile | 500-ml jar 2-(40-ml vial) | — (HCl) | fourteen (14) fourteen (14) |
| 8040 | Phenols | 500-ml jar (1-ltr amber) | — (HCl) | fourteen (14) seven (7) |
| 8080 | Organochlorine Pesticides | 500-ml jar (1-ltr amber) | -- -- | fourteen (14) seven (7) |
| 8120 | Chlorinated Hydrocarbons | 500-ml jar (1-ltr amber) | -- -- | fourteen (14) seven (7) |
| 8140 | Organophosphorus Pesticides | 500-ml jar (1-ltr amber) | -- -- | fourteen (14) seven (7) |
| 8150 | Chlorophenoxy Acid Herbicides | 500-ml jar (1-ltr amber) | -- — | fourteen (14) seven (7) |
| 8240 | Purgeable Volatile Organic Acids | 500-ml jar 2-(40-ml vial) | — (HCl) | fourteen (14) fourteen (14) |
| 8270 | Base/Neutral Acids | 500-ml jar 2-(1-ltr amber) | — -- | fourteen (14) seven (7) |

Nomenclature:

- 1-ltr amber - One (1)-liter amber glass bottle with teflon-lined cap.
- 500-ml jar - 500 gram capacity wide mouth jar with a teflon-lined cap for solid samples.
- 40-ml vial - 40-ml glass vial with a teflon-lined septa cap. Volatile Organic Analyses (VOA) vial.

NOTE: - Multiple tests may be performed from a single jar of solid sample. Solid/soil analyses usually require, at a minimum, thirty (30) grams of sample per analytical method.

- * - Holding Times refer to sample extraction period and depend on sample matrix.
- Analysis must occur within 40 days of extraction.

APPENDIX F

DEVELOPMENT OF PRECISION AND ACCURACY CONTROL LIMITS

Development of Precision and Accuracy Control Limits

Initially, we will define the terms which are used to develop our control limits:

| | | |
|------|---|---|
| %D | - | Relative Difference |
| %R | - | Percent Recovery |
| X | - | Mean Value |
| X(D) | - | Mean of the Percent Differences |
| X(R) | - | Mean of the Percent Recoveries |
| n | - | Number of Test Results |
| S | - | Sample Standard Deviation |
| S(D) | - | Standard Deviation of Percent Differences |
| S(R) | - | Standard Deviation of Percent Recoveries |
| UCL | - | Upper Control Limit |
| LCL | - | Lower Control Limit |

Precision is generally defined as the difference between data generated from repetitive measurements and is one of the criteria used to assess the quality of the analytical results we produce. We recalculate precision control limits following analyses of twenty (20) duplicate sample sets. The Relative Percent Difference (%D) is determined by equation (1):

(1)

$$\%D = \frac{\text{Sample value (1)} - \text{Sample Value (2)}}{[\text{Sample Value (1)} + \text{Sample Value (2)}] / 2} \times 100$$

The Relative Percent Difference (%D) must be within twenty (20) percent, otherwise, affected samples must be reanalyzed and, if necessary, redigested.

The correctness of the generated data, or accuracy, is also used to measure the quality of the analytical results. Accuracy control limits are recalculated following a combination of twenty (20) spike and reference samples. Spike and reference samples Percent Recoveries (%R) are determined using equation (2):

(2)

$$\%R = \frac{\text{Observed Value} - \text{Background Value}}{\text{Spike Value}} \times 100$$

NOTE: Any sample dilution due to the spiking process must be accounted for in calculating (%R).

Percent Recovery (%R) must be in the range of seventy-five (75) to one hundred twenty-five (125%) percent of the total recovery. If we determine that (%R) falls outside this range, then all affected samples must be redigested and reanalyzed.

The Mean [X(R)] and the Sample Standard Deviation [S(R)] may be calculated using equations (3) and (4):

(3)

$$X(R) = \frac{\sum_{i=1}^n P(i)}{n}$$

(4)

$$S(R) = \sqrt{\frac{\sum_{i=1}^n P(i)^2 - \left(\sum_{i=1}^n P(i) \right)^2 / n}{n - 1}}$$

From this information we can easily solve for the Upper Control Limit (UCL) and the Lower Control Limit (LCL) using equation (5) and (6):

(5)

$$UCL = X(R) + 3[S(R)]$$

(6)

$$LCL = X(R) - 3[S(R)]$$

We consider both precision and accuracy control limits to be validated if none of the initializing data exceeds the control limit values and if fifty (50) percent, or more, of the generated data lies within an interval of \pm one (1) standard deviation.

APPENDIX G
EXTERNAL QUALITY CONTROL STUDIES
PERFORMANCE EVALUATION STUDIES

PERFORMANCE EVALUATION REPORT

DATE: 12/26/

WATER POLLUTION STUDY NUMBER WP025

LABORATORY: C0026 ACZ

| ANALYTES | SAMPLE NUMBER | REPORT VALUE | TRUE VALUE* | ACCEPTANCE LIMITS | WARNING LIMITS | PERFORMANCE EVALUATION |
|---------------------------------------|------------------|-----------------|----------------|----------------------|-------------------|---------------------------|
| TRACE METALS IN MICROGRAMS PER LITER: | | | | | | |
| ALUMINUM | 1 | 1360 | 1428 | 1150- 1680 | 1220- 1620 | ACCEPTABL |
| | 2 | 75.8 | 45.7 | 20.6- 85.7 | 28.8- 77.4 | ACCEPTABL |
| ARSENIC | 1 | 295 | 312 | 252- 373 | 267- 358 | ACCEPTABL |
| | 2 | 48 | 51.9 | 39.4- 61.9 | 42.3- 59.1 | ACCEPTABL |
| BERYLLIUM | 1 | 764 | 806 | 660- 917 | 693- 884 | ACCEPTABL |
| | 2 | 21.6 | 20.9 | 16.2- 25.5 | 17.4- 24.4 | ACCEPTABL |
| CADMIUM | 1 | 6.9 | 6.35 | 4.20- 8.85 | 4.78- 8.27 | ACCEPTABL |
| | 2 | 77.3 | 72.0 | 60.4- 82.5 | 63.2- 79.7 | ACCEPTABL |
| COBALT | 1 | 435 | 452 | 382- 509 | 398- 493 | ACCEPTABL |
| | 2 | 28.0 | 27.2 | 22.6- 32.2 | 23.8- 30.9 | ACCEPTABL |
| CHROMIUM | 1 | 12 | 11.0 | 5.67- 16.3 | 7.00- 14.9 | ACCEPTABL |
| | 2 | 104 | 105 | 82.0- 124 | 87.3- 119 | ACCEPTABL |
| COPPER | 1 | 676 | 720 | 638- 789 | 657- 770 | ACCEPTABL |
| | 2 | 24.3 | 25.2 | 19.9- 31.0 | 21.3- 29.6 | ACCEPTABL |
| IRON | 1 | 35.7 | 32.5 | 22.5- 48.9 | 25.8- 45.6 | ACCEPTABL |
| | 2 | 1250 | 1230 | 1070- 1390 | 1110- 1350 | ACCEPTABL |
| MERCURY | 1 | 5.6 | 6.01 | 4.27- 6.54 | 4.55- 6.25 | ACCEPTABL |
| | 2 | 46.0 | 44.0 | 33.2- 53.4 | 35.7- 50.9 | ACCEPTABL |
| MANGANESE | 1 | 583 | 551 | 468- 628 | 488- 608 | ACCEPTABL |
| | 2 | 19.8 | 19.3 | 15.4- 23.6 | 16.4- 22.6 | ACCEPTABL |
| NICKEL | 1 | 1020 | 940 | 820- 1050 | 849- 1020 | ACCEPTABL |
| | 2 | 45.1 | 41.8 | 33.8- 49.5 | 35.8- 47.5 | ACCEPTABL |
| LEAD | 1 | 33.5 | 32.2 | 24.7- 40.7 | 26.7- 38.7 | ACCEPTABL |
| | 2 | 1310 | 1344 | 1140- 1550 | 1190- 1500 | ACCEPTABL |

BASED UPON THEORETICAL CALCULATIONS, OR A REFERENCE VALUE WHEN NECESSARY.

PERFORMANCE EVALUATION REPORT

DATE: 12/26/90

WATER POLLUTION STUDY NUMBER WP025

LABORATORY: C0028

| ANALYTES | SAMPLE NUMBER | REPORT VALUE | TRUE VALUE* | ACCEPTANCE LIMITS | WARNING LIMITS | PERFORMANCE EVALUATION |
|----------|------------------|-----------------|----------------|----------------------|-------------------|---------------------------|
|----------|------------------|-----------------|----------------|----------------------|-------------------|---------------------------|

TRACE METALS IN MICROGRAMS PER LITER:

| | | | | | | |
|------------|---|------|------|-------------|-------------|-----------------|
| SELENIUM | 1 | 27.3 | 30.0 | 20.1- 36.8 | 22.2- 34.7 | ACCEPTABLE |
| | 2 | 121 | 130 | 90.7- 155 | 98.9- 147 | ACCEPTABLE |
| VANADIUM | 1 | 60.7 | 58.1 | 46.6- 69.8 | 49.7- 66.7 | ACCEPTABLE |
| | 2 | 265 | 255 | 218- 291 | 228- 281 | ACCEPTABLE |
| ZINC | 1 | 34.5 | 25.4 | 17.6- 36.9 | 20.1- 34.5 | ACCEPTABLE |
| | 2 | 790 | 768 | 671- 853 | 694- 831 | ACCEPTABLE |
| ANTIMONY | 3 | 28.5 | 24.0 | 14.4- 31.6 | 16.6- 29.4 | ACCEPTABLE |
| | 4 | 175 | 157 | 110- 201 | 122- 189 | ACCEPTABLE |
| SILVER | 3 | 1.3 | 1.20 | 0.748- 1.61 | 0.856- 1.50 | ACCEPTABLE |
| | 4 | 22.0 | 12.4 | 9.58- 15.2 | 10.3- 14.5 | NOT ACCEPTABLE |
| LITHIUM | 3 | 10.4 | 11.0 | 6.79- 15.9 | 7.96- 14.7 | ACCEPTABLE |
| | 4 | 69.5 | 67.9 | 51.1- 85.1 | 55.7- 80.5 | ACCEPTABLE |
| MOLYBDENUM | 3 | 9.2 | 9.58 | 4.74- 14.3 | 6.09- 12.9 | ACCEPTABLE |
| | 4 | 55.9 | 56.0 | 33.8- 74.7 | 39.6- 68.9 | ACCEPTABLE |
| THORIUM | 3 | 17.1 | 16.8 | 13.5- 21.2 | 14.5- 20.2 | ACCEPTABLE |
| | 4 | 46.7 | 46.7 | 36.1- 57.6 | 39.0- 54.7 | ACCEPTABLE |
| TITANIUM | 3 | 281 | 260 | 216- 297 | 227- 286 | ACCEPTABLE |
| | 4 | 59 | 50.9 | 38.5- 62.1 | 41.7- 58.9 | CHECK FOR ERROR |

MINERALS IN MILLIGRAMS PER LITER: (EXCEPT AS NOTED)

| | | | | | | |
|-----------------------------------|---|-----|------|------------|------------|------------|
| HARDNESS | 3 | 4.6 | 4.60 | 4.52- 4.68 | 4.54- 4.66 | ACCEPTABLE |
| | 4 | 8.3 | 8.33 | 7.96- 8.50 | 8.03- 8.44 | ACCEPTABLE |
| SPEC. COND. (UMHOS/CM AT 25 C) | 1 | 68 | 67.8 | 57.5- 76.4 | 59.8- 74.0 | ACCEPTABLE |
| | 2 | 751 | 770 | 676- 838 | 696- 819 | ACCEPTABLE |

BASED UPON THEORETICAL CALCULATIONS, OR A REFERENCE VALUE WHEN NECESSARY.

PERFORMANCE EVALUATION REPORT

DATE: 12/26/9

WATER POLLUTION STUDY NUMBER WP025

LABORATORY: CO028

| ANALYTES | SAMPLE NUMBER | REPORT VALUE | TRUE VALUE* | ACCEPTANCE LIMITS | WARNING LIMITS | PERFORMANCE EVALUATION |
|----------|------------------|-----------------|----------------|----------------------|-------------------|---------------------------|
|----------|------------------|-----------------|----------------|----------------------|-------------------|---------------------------|

MINERALS IN MILLIGRAMS PER LITER: (EXCEPT AS NOTED)

| | | | | | | |
|--------------------------------|---|------|-------|-------------|-------------|---------------|
| TDS AT 180 C | 1 | 30.9 | 32.8 | 11.0- 58.8 | 16.9- 52.9 | ACCEPTABL |
| | 2 | 472 | 412 | 294- 542 | 325- 511 | ACCEPTABL |
| TOTAL HARDNESS (AS CaCO3) | 1 | 12.9 | 12.0 | 8.28- 15.6 | 9.19- 14.6 | ACCEPTABL |
| | 2 | 201 | 200 | 183- 216 | 187- 212 | ACCEPTABL |
| CALCIUM | 1 | 2.7 | 3.00 | 2.49- 3.58 | 2.63- 3.44 | ACCEPTABL |
| | 2 | 53.0 | 55.4 | 48.1- 62.1 | 49.8- 60.3 | ACCEPTABL |
| MAGNESIUM | 1 | 1.5 | 1.10 | 0.929- 1.31 | 0.978- 1.26 | NOT ACCEPTABL |
| | 2 | 16.7 | 15.0 | 12.9- 17.1 | 13.4- 16.6 | CHECK FOR ERR |
| SODIUM | 1 | 6.8 | 5.45 | 4.47- 6.60 | 4.74- 6.33 | NOT ACCEPTABL |
| | 2 | 65.0 | 50.7 | 44.7- 56.0 | 46.1- 54.5 | NOT ACCEPTABL |
| POTASSIUM | 1 | 2.4 | 3.00 | 2.41- 3.44 | 2.54- 3.31 | NOT ACCEPTABL |
| | 2 | 23.9 | 26.0 | 21.6- 30.9 | 22.8- 29.8 | ACCEPTABL |
| TOTAL ALKALINITY (AS CaCO3) | 1 | 7.0 | 6.69 | 2.62- 9.74 | 3.51- 8.85 | ACCEPTABL |
| | 2 | 43 | 47.3 | 39.5- 50.4 | 40.8- 49.1 | ACCEPTABL |
| CHLORIDE | 1 | 9.5 | 8.66 | 7.19- 11.7 | 7.75- 11.1 | ACCEPTABL |
| | 2 | 148 | 142 | 131- 154 | 134- 151 | ACCEPTABL |
| FLUORIDE | 1 | .24 | 0.180 | 0.110-0.256 | 0.128-0.238 | CHECK FOR ERR |
| | 2 | .95 | 0.910 | 0.772- 1.03 | 0.804-0.997 | ACCEPTABL |
| SULFATE | 1 | 7.8 | 8.00 | 5.00- 10.5 | 5.70- 9.84 | ACCEPTABL |
| | 2 | 94 | 90.0 | 74.7- 102 | 78.1- 98.6 | ACCEPTABL |

NUTRIENTS IN MILLIGRAMS PER LITER:

| | | | | | | |
|------------------|---|------|------|------------|------------|-----------|
| AMMONIA-NITROGEN | 1 | 9.2 | 8.76 | 6.97- 10.4 | 7.38- 10.0 | ACCEPTABL |
| | 2 | 1.57 | 1.60 | 1.20- 1.99 | 1.29- 1.90 | ACCEPTABL |

* BASED UPON THEORETICAL CALCULATIONS, OR A REFERENCE VALUE WHEN NECESSARY.

PERFORMANCE EVALUATION REPORT

DATE: 12/26/9

WATER POLLUTION STUDY NUMBER WP025

LABORATORY: C0028

| ANALYTES | SAMPLE NUMBER | REPORT VALUE | TRUE VALUE* | ACCEPTANCE LIMITS | WARNING LIMITS | PERFORMANCE EVALUATION |
|----------|------------------|-----------------|----------------|----------------------|-------------------|---------------------------|
|----------|------------------|-----------------|----------------|----------------------|-------------------|---------------------------|

NUTRIENTS IN MILLIGRAMS PER LITER:

| | | | | | | |
|------------------|---|------|-------|-------------|-------------|------------|
| NITRATE-NITROGEN | 1 | 3.22 | 3.20 | 2.52- 3.85 | 2.68- 3.69 | ACCEPTABLE |
| | 2 | .66 | 0.650 | 0.473-0.828 | 0.515-0.786 | ACCEPTABLE |
| ORTHOPHOSPHATE | 1 | .196 | 0.190 | 0.145-0.235 | 0.155-0.224 | ACCEPTABLE |
| | 2 | 5.25 | 5.30 | 4.48- 6.10 | 4.67- 5.90 | ACCEPTABLE |
| JELDHL-NITROGEN | 3 | 7.4 | 7.00 | 5.01- 8.72 | 5.45- 8.28 | ACCEPTABLE |
| | 4 | 21.3 | 26.9 | 19.5- 32.1 | 21.0- 30.6 | ACCEPTABLE |
| OTAL PHOSPHORUS | 3 | 8.85 | 8.20 | 6.32- 9.62 | 6.72- 9.23 | ACCEPTABLE |
| | 4 | .521 | 0.625 | 0.449-0.772 | 0.488-0.733 | ACCEPTABLE |

DEMANDS IN MILLIGRAMS PER LITER:

| | | | | | | |
|----------|---|------|------|------------|------------|------------|
| OD | 1 | 128 | 121 | 96.0- 138 | 101- 133 | ACCEPTABLE |
| | 2 | 21.3 | 18.2 | 8.16- 28.3 | 10.7- 25.8 | ACCEPTABLE |
| | 1 | 45.4 | 48.0 | 40.8- 55.4 | 42.7- 53.5 | ACCEPTABLE |
| | 2 | 6.6 | 7.20 | 5.72- 8.96 | 6.14- 8.54 | ACCEPTABLE |
| -DAY BOD | 1 | 86.7 | 76.6 | 45.1- 108 | 52.9- 100 | ACCEPTABLE |
| | 2 | 13.4 | 12.6 | 6.15- 18.9 | 7.74- 17.4 | ACCEPTABLE |

PCB'S IN MICROGRAMS PER LITER:

| | | | | | | |
|---------------------|---|------|------|------------|------------|------------|
| CB-AROCOR 1016/1242 | 2 | 5.68 | 6.50 | 2.29- 8.85 | 3.13- 8.01 | ACCEPTABLE |
| CB-AROCOR 1260 | 1 | 4.52 | 4.27 | 1.22- 6.16 | 1.85- 5.52 | ACCEPTABLE |

BASED UPON THEORETICAL CALCULATIONS, OR A REFERENCE VALUE WHEN NECESSARY.

PERFORMANCE EVALUATION REPORT

DATE: 12/26/9

WATER POLLUTION STUDY NUMBER WP025

LABORATORY: CO028

| ANALYTES | SAMPLE NUMBER | REPORT VALUE | TRUE VALUE* | ACCEPTANCE LIMITS | WARNING LIMITS | PERFORMANCE EVALUATION |
|----------|------------------|-----------------|----------------|----------------------|-------------------|---------------------------|
|----------|------------------|-----------------|----------------|----------------------|-------------------|---------------------------|

PCB'S IN OIL IN MILLIGRAMS PER KILOGRAM:

| | | | | | | |
|------------------|---|------|------|------------|------------|-----------|
| PCB IN OIL- 1254 | 1 | 39.3 | 26.3 | 4.04- 46.7 | 9.50- 41.2 | ACCEPTABL |
|------------------|---|------|------|------------|------------|-----------|

| | | | | | | |
|------------------|---|------|------|------------|------------|-----------|
| PCB IN OIL- 1260 | 2 | 62.6 | 50.0 | 1.58- 82.7 | 12.0- 72.3 | ACCEPTABL |
|------------------|---|------|------|------------|------------|-----------|

PESTICIDES IN MICROGRAMS PER LITER:

| | | | | | | |
|-----------|---|------|------|-------------|-------------|-----------|
| CHLORDANE | 3 | 1.57 | 1.50 | 0.744- 1.98 | 0.902- 1.82 | ACCEPTABL |
| | 4 | 6.71 | 6.73 | 3.36- 8.78 | 4.06- 8.09 | ACCEPTABL |

| | | | | | | |
|--------|---|-----|-------|-------------|-------------|-----------|
| ALDRIN | 1 | .17 | 0.158 | .0409-0.224 | .0643-0.201 | ACCEPTABL |
| | 2 | .47 | 0.483 | .0955-0.654 | 0.166-0.583 | ACCEPTABL |

| | | | | | | |
|---------|---|-----|-------|-------------|-------------|-----------|
| DT DRIN | 1 | .1 | 0.142 | .0478-0.218 | .0694-0.196 | ACCEPTABL |
| | 2 | .36 | 0.508 | 0.211-0.716 | 0.275-0.652 | ACCEPTABL |

| | | | | | | |
|-----|---|-----|-------|-------------|-------------|-----------|
| DDD | 1 | .13 | 0.181 | .0585-0.311 | .0907-0.279 | ACCEPTABL |
| | 2 | .82 | 0.773 | 0.406- 1.08 | 0.491-0.991 | ACCEPTABL |

| | | | | | | |
|-----|---|-----|-------|-------------|-------------|-----------|
| DDE | 1 | .12 | 0.217 | .0902-0.308 | 0.118-0.280 | ACCEPTABL |
| | 2 | .3 | 0.425 | 0.173-0.602 | 0.228-0.547 | ACCEPTABL |

| | | | | | | |
|-----|---|-----|-------|-------------|-------------|-----------|
| DDT | 1 | .11 | 0.173 | .0421-0.306 | .0756-0.273 | ACCEPTABL |
| | 2 | .45 | 0.553 | 0.252-0.812 | 0.323-0.740 | ACCEPTABL |

| | | | | | | |
|------------|---|-----|-------|-------------|-------------|-----------|
| HEPTACHLOR | 1 | .23 | 0.193 | .0680-0.255 | .0917-0.231 | ACCEPTABL |
| | 2 | .64 | 0.623 | 0.125-0.920 | 0.226-0.819 | ACCEPTABL |

VOLATILE HALOCARBONS IN MICROGRAMS PER LITER:

| | | | | | | |
|--------------------|---|------|------|------------|------------|---------------|
| 1,2 DICHLOROETHANE | 1 | 14.5 | 13.3 | 8.79- 18.3 | 10.0- 17.1 | ACCEPTABL |
| | 2 | 34.6 | 26.7 | 18.3- 36.0 | 20.5- 33.7 | CHECK FOR ERF |

BASED UPON THEORETICAL CALCULATIONS, OR A REFERENCE VALUE WHEN NECESSARY.

**DOUBLE BLIND STUDY – APG JANUARY 1991
TRACE METALS**

| | | Reported | True Value | % Recovery | Mean | No. Labs | Deviations from Mean |
|-----------|----------|----------|------------|------------|---------|----------|----------------------|
| Aluminum | ICP (50) | 60 | 57.32 | 105 | 61.69 | 39 | 0.14 |
| | | 160 | 162.4 | 99 | 169.23 | 44 | 0.34 |
| Arsenic | GFAA (1) | 18 | 19.85 | 91 | 19.56 | 48 | 0.51 |
| | | 160 | 157.6 | 102 | 156.94 | 44 | 0.14 |
| Barium | ICP (20) | 200 | 217.36 | 92 | 217.34 | 45 | 1.22 |
| | | 1820 | 1944.1 | 94 | 1916.24 | 45 | 0.67 |
| Beryllium | ICP (5) | 55 | 62.82 | 88 | 62.66 | 39 | 1.53 |
| | | 92 | 108.04 | 85 | 107.20 | 37 | 1.84 |
| Boron | ICP (20) | 50 | 28.34 | 176 | 40.8 | 20 | 1.53 |
| | | 640 | 625.00 | 102 | 582 | 28 | 1.84 |
| Cadmium | ICP (5) | 93 | 95.42 | 97 | 93.72 | 69 | 0.08 |
| | | 133 | 138.36 | 96 | 136.45 | 68 | 0.37 |
| Chromium | ICP (10) | 60 | 52.45 | 114 | 52.45 | 82 | 1.42 |
| | | 110 | 184.63 | 60 | 181.63 | 83 | 3.56 Unaccept |
| Cobalt | ICP (10) | 60 | 64.9 | 92 | 64.70 | 30 | 0.93 |
| | | 200 | 205.1 | 98 | 206.50 | 31 | 0.60 |
| Copper | ICP (10) | 20 | 28.45 | 70 | 28.97 | 87 | 2.43 Warning |
| | | 240 | 275.23 | 87 | 273.76 | 85 | 2.28 Warning |
| Iron | ICP (20) | 30 | 44.24 | 68 | 45.19 | 78 | 2.45 Warning |
| | | 260 | 282.13 | 92 | 281.84 | 84 | 1.18 |
| Lead | GFAA (1) | 40 | 52.85 | 76 | 51.96 | 70 | 1.89 |
| | | 290 | 271.4 | 107 | 272.91 | 74 | 0.72 |
| Manganese | ICP (10) | 50 | 60.49 | 83 | 56.05 | 58 | 1.28 |
| | | 200 | 202 | 99 | 199.31 | 58 | 0.05 |

Data set contained extreme values not removed by the t-test. Statistics generated from points < 2X the true value.

**DOUBLE BLIND STUDY – APG JANUARY 1991
TRACE METALS**

| | | Reported | True Value | % Recovery | Mean | No. Labs | Deviations from Mean |
|------------|----------|----------|------------|------------|---------|----------|----------------------|
| Mercury | CV (.1) | 0.4 | 0.7 | 57 | 0.74 | 54 | 1.84 |
| | | 1.8 | 2.99 | 60 | 3.08 | 54 | 2.81 Unaccept |
| Nickel | ICP (20) | 60 | 54.73 | 110 | 55.51 | 62 | 0.44 |
| | | 190 | 169.5 | 112 | 167.43 | 65 | 1.12 |
| Molybdenum | ICP (50) | < 50 | 29.76 | | 30.97 | 22 | |
| | | 200 | 223 | 90 | 211.74 | 25 | 0.51 |
| Selenium | HGA (1) | 13 | 17.11 | 76 | 16.42 | 44 | 0.99 |
| | | 90 | 100.23 | 90 | 97.52 | 44 | 0.33 |
| Silver | ICP (10) | < 10 | 14.7 | 0 | 15.17 | 55 | |
| | | 170 | 130.52 | 130 | 134.41 | 59 | 1.88 |
| Thallium | GFAA (1) | 23 | 24.97 | 92 | 24.70 | 20 | 0.45 |
| | | 530 | 647.95 | 82 | 607.36 | 24 | 0.75 |
| Vanadium | ICP (10) | 30 | 28.75 | 104 | 28.89 | 30 | 0.30 |
| | | 1000 | 1018.72 | 98 | 1035.86 | 30 | 0.70 |
| Zinc | ICP (10) | 70 | 67.37 | 104 | 68.42 | 79 | 0.27 |
| | | 110 | 114.98 | 96 | 116.19 | 79 | 0.69 |

DEMAND

| | | | | | | |
|-----|-----|--------|-----|--------|----|------|
| BOD | 149 | 149.68 | 100 | 150.92 | 80 | 0.06 |
| | 26 | 20.82 | 125 | 20.85 | 81 | 1.03 |
| COD | 242 | 240.98 | 100 | 230.43 | 76 | 0.68 |
| | 32 | 33.52 | 95 | 31.13 | 75 | 0.11 |
| TOC | 94 | 90.72 | 104 | 91.00 | 47 | 0.35 |
| | 11 | 12.62 | 87 | 12.77 | 48 | 1.57 |

DOUBLE BLIND STUDY - APG DECEMBER 1991

| | | Reported | True Value | % Recover | Mean | No. Labs | Deviations from Mean |
|--|--|----------|------------|-----------|------|----------|----------------------|
|--|--|----------|------------|-----------|------|----------|----------------------|

SOLIDS

| | | | | | | | |
|------------------|---------------|-----|-----|-----|----|----|------|
| Suspended Solids | EPA 160.2 (2) | 52 | 69 | 75 | NR | 86 | 1.49 |
| | | 134 | 139 | 96 | NR | 81 | 0.31 |
| Dissolved Solids | EPA 160.1 (2) | 214 | 205 | 104 | NR | 50 | 0.07 |
| | | 426 | 416 | 102 | NR | 46 | 0.04 |

DEMAND

| | | | | | | | |
|-----|----------------|------|-------|-----|------|----|------|
| BOD | EPA 405.1 | 176 | 172 | 102 | 155 | 63 | 0.06 |
| | | 37.5 | 28.6 | 131 | 26.6 | 65 | 1.03 |
| COD | EPA 410.4 | 240 | 278 | 86 | 266 | 53 | 0.78 |
| | | 55 | 46.1 | 119 | 42.9 | 55 | 1.14 |
| TOC | ASTM D 4129-82 | 110 | 104.6 | 105 | 103 | 29 | 0.35 |
| | | 20 | 17.4 | 115 | 17.9 | 33 | 1.57 |

VOLATILES - 8240 (GC/MS)

| | | | | | | |
|------------------------|------|-------|------|-------|----|------|
| Benzene | 33.8 | 26.9 | 126 | 26.0 | 25 | 0.89 |
| | 79.2 | 79.3 | 100. | 74.8' | 20 | 0.76 |
| Chlorobenzene | 29.9 | 27.2 | 110 | 25.8 | 25 | 0.65 |
| | 60.4 | 68.7 | 88 | 65.7 | 24 | 0.58 |
| 1,2 Dichlorobenzene | 10.3 | 10.7 | 96 | 10.0 | 17 | 0.23 |
| | 102 | 115 | 89 | 106 | 16 | 0.29 |
| Ethylbenzene | 8.5 | 8.2 | 104 | 7.7 | 22 | 0.66 |
| | 66.2 | 75.2 | 88 | 71.5 | 24 | 0.41 |
| Toluene | 7.42 | 6.43 | 115 | 6.0 | 22 | 1.80 |
| | 53.1 | 56.8 | 93 | 53.3 | 25 | 0.03 |
| Tetrachloroethene | 21.6 | 20.6 | 105 | 18.9 | 26 | 0.40 |
| | 165 | 194.8 | 85 | 173.8 | 25 | 0.27 |
| 1,1,1 -Trichloroethane | 17.3 | 13.9 | 124 | 12.4 | 24 | 1.43 |
| | 58 | 56.1 | 103 | 53.5 | 25 | 0.51 |
| 1,1,2 Trichloroethane | 46 | 44.7 | 103 | 43.3 | 26 | 0.26 |
| | 109 | 133 | 82 | 131.9 | 26 | 0.91 |

**DOUBLE BLIND STUDY – APG JANUARY 1991
TRACE METALS**

| | | Reported | True Value | % Recovery | Mean | No. Labs | Deviations from Mean |
|-----------|----------|----------|------------|------------|---------|----------|----------------------|
| Aluminum | ICP (50) | 60 | 57.32 | 105 | 61.69 | 39 | 0.14 |
| | | 160 | 162.4 | 99 | 169.23 | 44 | 0.34 |
| Arsenic | GFAA (1) | 18 | 19.85 | 91 | 19.56 | 48 | 0.51 |
| | | 160 | 157.6 | 102 | 156.94 | 44 | 0.14 |
| Barium | ICP (20) | 200 | 217.36 | 92 | 217.34 | 45 | 1.22 |
| | | 1820 | 1944.1 | 94 | 1916.24 | 45 | 0.67 |
| Beryllium | ICP (5) | 55 | 62.82 | 88 | 62.66 | 39 | 1.53 |
| | | 92 | 108.04 | 85 | 107.20 | 37 | 1.84 |
| Iron | ICP (20) | 50 | 28.34 | 176 | 40.8 | 20 | 1.53 |
| | | 640 | 625.00 | 102 | 582 | 28 | 1.84 |
| Cadmium | ICP (5) | 93 | 95.42 | 97 | 93.72 | 69 | 0.08 |
| | | 133 | 138.36 | 96 | 136.45 | 68 | 0.37 |
| Chromium | ICP (10) | 60 | 52.45 | 114 | 52.45 | 82 | 1.42 |
| | | 110 | 184.63 | 60 | 181.63 | 83 | 3.56 Unaccept |
| Cobalt | ICP (10) | 60 | 64.9 | 92 | 64.70 | 30 | 0.93 |
| | | 200 | 205.1 | 98 | 206.50 | 31 | 0.60 |
| Copper | ICP (10) | 20 | 28.45 | 70 | 28.97 | 87 | 2.43 Warning |
| | | 240 | 275.23 | 87 | 273.76 | 85 | 2.28 Warning |
| Iron | ICP (20) | 30 | 44.24 | 68 | 45.19 | 78 | 2.45 Warning |
| | | 260 | 282.13 | 92 | 281.84 | 84 | 1.18 |
| Lead | GFAA (1) | 40 | 52.85 | 76 | 51.96 | 70 | 1.89 |
| | | 290 | 271.4 | 107 | 272.91 | 74 | 0.72 |
| Manganese | ICP (10) | 50 | 60.49 | 83 | 56.05 | 58 | 1.28 |
| | | 200 | 202 | 99 | 199.31 | 58 | 0.05 |

• Data set contained extreme values not removed by the t-test. Statistics generated from points < 2X the true value.

**DOUBLE BLIND STUDY - APG JANUARY 1991
TRACE METALS**

| | | Reported | True Value | % Recovery | Mean | No. Labs | Deviations from Mean |
|------------|----------|----------|---------------|---------------|---------|-------------|-------------------------|
| Mercury | CV (-1) | 0.4 | 0.7 | 57 | 0.74 | 54 | 1.84 |
| | | 1.8 | 2.99 | 60 | 3.08 | 54 | 2.81 Unaccept |
| Nickel | ICP (20) | 60 | 54.73 | 110 | 55.51 | 62 | 0.44 |
| | | 190 | 169.5 | 112 | 167.43 | 65 | 1.12 |
| Molybdenum | ICP (50) | < 50 | 29.76 | | 30.97 | 22 | |
| | | 200 | 223 | 90 | 211.74 | 25 | 0.51 |
| Selenium | HGA (1) | 13 | 17.11 | 76 | 16.42 | 44 | 0.99 |
| | | 90 | 100.23 | 90 | 97.52 | 44 | 0.33 |
| Silver | ICP (10) | < 10 | 14.7 | 0 | 15.17 | 55 | |
| | | 170 | 130.52 | 130 | 134.41 | 59 | 1.88 |
| Thallium | GFAA (1) | 23 | 24.97 | 92 | 24.70 | 20 | 0.45 |
| | | 530 | 647.95 | 82 | 607.36 | 24 | 0.75 |
| Vanadium | ICP (10) | 30 | 28.75 | 104 | 28.89 | 30 | 0.30 |
| | | 1000 | 1018.72 | 98 | 1035.86 | 30 | 0.70 |
| Zinc | ICP (10) | 70 | 67.37 | 104 | 68.42 | 79 | 0.27 |
| | | 110 | 114.98 | 96 | 116.19 | 79 | 0.69 |

DEMAND

| | | | | | | |
|-----|-----|--------|-----|--------|----|------|
| BOD | 149 | 149.68 | 100 | 150.92 | 80 | 0.06 |
| | 26 | 20.82 | 125 | 20.85 | 81 | 1.03 |
| COD | 242 | 240.98 | 100 | 230.43 | 76 | 0.68 |
| | 32 | 33.52 | 95 | 31.13 | 75 | 0.11 |
| TOC | 94 | 90.72 | 104 | 91.00 | 47 | 0.35 |
| | 11 | 12.62 | 87 | 12.77 | 48 | 1.57 |

PERFORMANCE EVALUATION REPORT

DATE: 12/26/9

WATER POLLUTION STUDY NUMBER 7P025

LABORATORY: C0028

| ANALYTES | SAMPLE NUMBER | REPORT VALUE | TRUE VALUE± | ACCEPTANCE LIMITS | WARNING LIMITS | PERFORMANCE EVALUATION |
|---|------------------|-----------------|----------------|----------------------|-------------------|---------------------------|
| VOLATILE HALOCARBONS IN MICROGRAMS PER LITER: | | | | | | |
| CHLOROFORM | 1 | 10.5 | 9.74 | 6.16- 13.4 | 7.08- 12.5 | ACCEPTABLE |
| | 2 | 43.8 | 37.4 | 24.4- 49.7 | 27.6- 46.4 | ACCEPTABLE |
| 1,1,1 TRICHLOROETHANE | 1 | 7.61 | 7.86 | 4.44- 11.7 | 5.37- 10.7 | ACCEPTABLE |
| | 2 | 68.2 | 58.3 | 35.9- 77.2 | 41.1- 72.0 | ACCEPTABLE |
| TRICHLOROETHENE | 1 | 11.5 | 10.5 | 6.43- 13.7 | 7.36- 12.8 | ACCEPTABLE |
| | 2 | 54.2 | 47.4 | 30.1- 60.8 | 34.0- 56.9 | ACCEPTABLE |
| CARBONTETRACHLORIDE | 1 | 7.23 | 6.81 | 3.72- 9.98 | 4.52- 9.18 | ACCEPTABLE |
| | 2 | 65.3 | 54.7 | 34.1- 77.0 | 39.6- 71.6 | ACCEPTABLE |
| TETRACHLOROETHENE | 1 | 12.4 | 11.7 | 6.64- 16.4 | 7.88- 15.2 | ACCEPTABLE |
| | 2 | 48.8 | 54.0 | 32.1- 74.1 | 37.4- 68.8 | ACCEPTABLE |
| DICHLOROMETHANE | 1 | 9.79 | 10.1 | 6.59- 13.8 | 7.51- 12.9 | ACCEPTABLE |
| | 2 | 69.1 | 62.5 | 43.3- 83.7 | 48.5- 78.5 | ACCEPTABLE |
| BROMOCHLOROMETHANE | 1 | 12.9 | 12.6 | 7.63- 17.8 | 8.93- 16.5 | ACCEPTABLE |
| | 2 | 47.8 | 44.7 | 29.1- 61.1 | 33.2- 57.0 | ACCEPTABLE |
| BROMOFORM | 1 | 12.0 | 14.4 | 7.78- 19.5 | 9.26- 18.0 | ACCEPTABLE |
| | 2 | 73.4 | 66.1 | 40.4- 95.6 | 47.5- 88.5 | ACCEPTABLE |
| ETHYLENE CHLORIDE | 1 | 13.2 | 12.3 | 6.29- 17.4 | 7.70- 16.0 | ACCEPTABLE |
| | 2 | 50.5 | 42.6 | 23.1- 58.1 | 27.5- 53.7 | ACCEPTABLE |
| CHLOROBENZENE | 1 | 13.9 | 13.9 | 8.97- 18.7 | 10.2- 17.4 | ACCEPTABLE |
| | 2 | 66.6 | 63.0 | 43.1- 79.7 | 47.8- 75.0 | ACCEPTABLE |

VOLATILE AROMATICS IN MICROGRAMS PER LITER:

| | | | | | | |
|---------|---|------|------|------------|------------|------------|
| BENZENE | 1 | 19.8 | 17.9 | 11.9- 23.7 | 13.4- 22.2 | ACCEPTABLE |
| | 2 | 93.8 | 82.0 | 55.7- 107 | 62.2- 100 | ACCEPTABLE |

BASED UPON THEORETICAL CALCULATIONS, OR A REFERENCE VALUE WHEN NECESSARY.

PERFORMANCE EVALUATION REPORT

DATE: 12/26/9

WATER POLLUTION STUDY NUMBER WP025

LABORATORY: CO028

| ANALYTES | SAMPLE NUMBER | REPORT VALUE | TRUE VALUE* | ACCEPTANCE LIMITS | WARNING LIMITS | PERFORMANCE EVALUATION |
|---|------------------|-----------------|----------------|----------------------|-------------------|---------------------------|
| VOLATILE AROMATICS IN MICROGRAMS PER LITER: | | | | | | |
| ETHYLBENZENE | 1 | 10.6 | 9.60 | 5.43- 12.9 | 6.38- 12.0 | ACCEPTABL |
| | 2 | 65.1 | 58.4 | 39.1- 76.6 | 43.9- 71.8 | ACCEPTABL |
| TOLUENE | 1 | 13.2 | 12.9 | 8.80- 16.8 | 9.83- 15.8 | ACCEPTABL |
| | 2 | 101 | 93.8 | 62.5- 119 | 69.8- 112 | ACCEPTABL |
| 1,2-DICHLOROBENZENE | 1 | 13.8 | 13.5 | 8.69- 17.9 | 9.90- 16.7 | ACCEPTABL |
| | 2 | 64.9 | 59.2 | 39.1- 77.2 | 44.1- 72.2 | ACCEPTABL |
| 1,3-DICHLOROBENZENE | 1 | 20.4 | 19.7 | 12.1- 26.0 | 13.9- 24.2 | ACCEPTABL |
| | 2 | 58.0 | 52.5 | 34.0- 67.5 | 38.4- 63.1 | ACCEPTABL |
| 1,4-DICHLOROBENZENE | 1 | 15.1 | 15.3 | 9.55- 21.1 | 11.1- 19.6 | ACCEPTABL |
| | 2 | 50.8 | 48.4 | 31.8- 65.7 | 36.2- 61.2 | ACCEPTABL |
| MISCELLANEOUS PARAMETERS: | | | | | | |
| CYANIDE (IN MG/L) | 1 | .556 | 0.540 | 0.392-0.681 | 0.428-0.645 | ACCEPTABL |
| | 2 | .111 | 0.110 | .0613-0.146 | .0720-0.135 | ACCEPTABL |
| NON-FILTERABLE RESIDUE (IN MG/L) | 1 | 15.3 | 16.6 | 11.9- 21.2 | 13.1- 20.0 | ACCEPTABL |
| | 2 | 40.9 | 42.4 | 34.9- 50.0 | 36.7- 48.1 | ACCEPTABL |
| OIL AND GREASE (IN MG/L) | 1 | 27.6 | 38.0 | 23.9- 45.1 | 26.6- 42.5 | ACCEPTABL |
| | 2 | 16.3 | 20.0 | 10.6- 25.4 | 12.4- 23.6 | ACCEPTABL |
| TOTAL PHENOLICS (IN MG/L) | 1 | 4.97 | 3.14 | 1.63- 4.66 | 2.01- 4.27 | NOT ACCEPTABL |
| | 2 | .344 | 0.372 | 0.149-0.596 | 0.205-0.539 | ACCEPTABL |

* BASED UPON THEORETICAL CALCULATIONS, OR A REFERENCE VALUE WHEN NECESSARY.



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
75 Hawthorne Street
San Francisco, CA 94105

DEC 29 2000

In Reply Refer
To Mail Code: WTR-5

Brian Dunfee
Peabody Western Coal Company
P.O. Box 650
Kayenta, AZ 86033

RE: Peabody Western Coal Company
Black Mesa/Kayenta Mine Area
NPDES Permit No. AZ0022179

Enclosed is a copy of the above captioned National Pollutant Discharge Elimination System (NPDES) permit. The NPDES permit is hereby issued upon the date of signature and shall become effective thirty-three (33) days from the date of this cover letter, unless a petition is filed with the Environmental Appeals Board (EAB) to review any conditions of the final permit under 40 CFR 124.19(a), as revised at 65 Fed. Reg. 30886,30911 (May 15, 2000). A copy of such petition should be sent to the EPA address listed above.

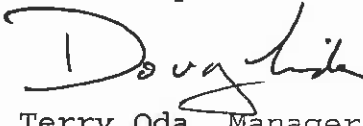
The staff at the U.S. Environmental Protection Agency (EPA) has reviewed the NPDES permit application for the above captioned facility and have prepared a draft permit in accordance with the Clean Water Act (CWA). EPA has also published a public notice of its tentative decision to issue this permit. After considering the expressed views of all interested persons and agencies, and pertinent Federal statutes and regulations, EPA, pursuant to 40 CFR 124, prepared the above captioned final permit.

As stated in newly-revised 40 CFR 124.19(a), within 33 days after EPA issues the final permit, any person who filed comments on the draft permit or participated in the public hearing may petition the EAB to review any condition of the permit decision. Any person who failed to file comments or failed to participate in a public hearing on the draft permit may petition for administrative review only with regard to changes made from the draft to the final permit. The petition shall include a statement of the reasons supporting the review, including a demonstration that any issue being raised was raised during the public comment period (including any public hearing) to the extent required by these regulations and, when appropriate, a showing that the

condition in question is based on: (1) a finding of fact or conclusion of law that is clearly erroneous; or (2) an exercise of discretion or an important policy consideration that the EAB should, in its discretion, review. Under 40 CFR 124.16 and 124.60, a petition for review under 40 CFR 124.19 stays the force and effect of the contested conditions of the final permit until final agency action under 40 CFR 124.19(f).

EPA will routinely deny any request for an evidentiary hearing that is postmarked later than the 33rd day from the date of this cover letter. If you have any questions regarding the procedures outline above, please call Doug Liden at 415/744-1920.

Sincerely,


for

Terry Oda, Manager
CWA Standards and Permits Office
Water Division

cc: (w/ enclosures)
Patrick Antonio, Navajo EPA
Ferrel H. Secakuku, The Hopi Tribe
Debra Bills, USFWS
John Nystedt, NNDFW
Linda Taunt, ADEQ

J. Cochran

AUTHORIZATION TO DISCHARGE UNDER THE
NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM

In compliance with the provisions of the Clean Water Act, as amended, (33 U.S.C. 1251 et seq., the "Act"),

Peabody Western Coal Company
Black Mesa/Kayenta Mine Complex
PO Box 650
Kayenta, AZ 86033

is authorized to discharge runoff from the retention ponds located throughout the mine lease area, at the outfalls listed in Appendix A hereof, in accordance with effluent limitations, monitoring requirements and other conditions set forth herein, and in the attached pages of EPA Region 9 "Standard Federal NPDES Permit Conditions," dated May 10, 1990.

This permit shall become effective on JANUARY 31st, 2001.

This permit and the authorization to discharge shall expire at midnight, five years after the effective date, on

FEBRUARY 1st, 2006.

Signed this 29th day of DECEMBER, 2000.

For the Regional Administrator

Alexis Strauss
Alexis Strauss, Director
Water Division
U.S. EPA, Region 9

A. EFFLUENT LIMITATIONS AND MONITORING REQUIREMENTS

1. During the period beginning from the effective date of this permit, and lasting until its expiration, the permittee shall not discharge to receiving waters except from those discharge points identified in Appendix A and in accordance with both the effluent limits contained in paragraphs A.2, A.3, and A.4, and the narrative water quality standards cited in paragraph A.6.
2. Discharges resulting from lagoon dewatering (or discharges not resulting from precipitation events) shall be monitored and limited to not cause water quality standard violations in the receiving waters or as follows, whatever is more stringent:
 - a. Discharge from active mining areas, reclaimed areas and roads, explosive storage areas, and well rehabilitation activities; Discharge Serial No. 005, 008, 010, 012, 013, 014, 018, 021, 022, 024, 025, 026, 027, 030, 031, 032, 033, 035, 036, 037, 039, 041, 045, 048 through 052, 066, 069, 070, 071, 079, 080, 081, 082, 086 through 090, 128, 141 through 148, 150, 151, 153, 156, 157, 159 through 165, and 168 through 179:

| Effluent Parameter | Units | Limit | | Monitoring | |
|--------------------|-------|--------------------|--------------------------|-------------------------|----------|
| | | Daily Max | Monthly Avg ¹ | Frequency | Sample |
| Flow | MGD | ** | ** | continuous ² | estimate |
| Iron, total | mg/l | 7.0 | 3.5 | once/week | discrete |
| TSS | mg/l | 70.0 | 35.0 | once/week | discrete |
| pH | S.U. | between 6.5 to 9.0 | | once/week | discrete |

** Monitoring Only

¹ For a discharge lasting less than twenty-four hours and at a frequency of no more than once/month, the monthly average shall not apply. Discharger must certify that these two stipulations are met on Discharge Monitoring Reports.

² To determine total flow in gallons for each dewatering activity and duration of dewatering activity.

- b. Discharge from preparation areas, shops, material storage facilities, and coal transportation facilities; Discharge Serial No. 001, 002, 003, 009, 016, 017, 043, 047, 054, 083, 094, 095, 098, 099, 103 through 107, 118, 126, 127, 130, 133, 136, 137, 140, 149, 152, & 167:

| Effluent Parameter | Units | Limit | | Monitoring | |
|--------------------|-------|--------------------|--------------------------|-------------------------|----------|
| | | Daily Max | Monthly Avg ¹ | Frequency | Sample |
| Flow | MGD | ** | ** | continuous ² | estimate |
| Iron, total | mg/l | 7.0 | 3.5 | once/week | discrete |
| TSS | mg/l | 70.0 | 35.0 | once/week | discrete |
| Oil & Grease | mg/l | 15.0 | -- | once/week | discrete |
| pH | S.U. | between 6.5 to 9.0 | | once/week | discrete |

** Monitoring Only

¹ For a discharge lasting less than twenty-four hours and at a frequency of no more than once/month, the monthly average shall not apply. Discharger must certify that these two stipulations are met on Discharge Monitoring Reports.

² To determine total flow in gallons for each dewatering activity and duration of dewatering activity.

c. Discharge of sanitary wastewaters; Discharge Serial No. 139:

| Effluent Parameter | Units | Limit | | Monitoring | |
|--------------------|--------|--------------------|--------------------------|-------------------------|----------|
| | | Daily Max | Monthly Avg ¹ | Frequency | Sample |
| Flow | MGD | ** | ** | continuous ² | estimate |
| Iron, total | mg/l | 7.0 | 3.5 | once/week | discrete |
| TSS | mg/l | 70.0 | 35.0 | once/week | discrete |
| Oil & Grease | mg/l | 15.0 | -- | once/week | discrete |
| BOD ₅ | mg/l | 30.0 | -- | once/week | discrete |
| Fecal Coliform | 100 ml | 1,000 | -- | once/week | discrete |
| pH | S.U. | between 6.5 to 9.0 | | once/week | discrete |

** Monitoring Only

¹ For a discharge lasting less than twenty-four hours and at a frequency of no more than once/month, the monthly average shall not apply. Discharger must certify that these two stipulations are met on Discharge Monitoring Reports.

² To determine total flow in gallons for each dewatering activity and duration of dewatering activity.

3. Discharges resulting from a rainfall event less than or

equal to a 10-year, 24-hour precipitation event (1.80 inches within a 24 hour period):

- a. Discharges from active mining areas, reclaimed areas and roads, explosive storage areas, and well rehabilitation activities; Discharge Serial No. 005, 008, 010, 012, 013, 014, 018, 021, 022, 024, 025, 026, 027, 030, 031, 032, 033, 035, 036, 037, 039, 041, 045, 048 through 052, 066, 069, 070, 071, 079, 080, 081, 082, 086 through 090, 128, 141 through 148, 150, 151, 153, 156, 157, 159 through 165, and 168 through 179:

| Effluent Parameter | Units | Limit | | Monitoring | |
|--------------------|-------|--------------------|-------------|------------|----------|
| | | Daily Max | Monthly Avg | Frequency | Sample |
| Flow | MGD | ** | ** | once/day | estimate |
| Settleable Solids | ml/l | 0.5 ¹ | -- | once/day | discrete |
| pH | S.U. | between 6.5 to 9.0 | | once/day | discrete |

** Monitoring Only

¹ Maximum not to be exceeded at any time.

- b. Discharges from preparation areas, shops, material storage facilities, and coal transportation facilities; Discharge Serial No. 001, 002, 003, 009, 016, 017, 043, 047, 054, 083, 094, 095, 098, 099, 103 through 107, 118, 126, 127, 130, 133, 136, 137, 140, 149, 152, and 167:

| Effluent Parameter | Units | Limit | | Monitoring | |
|--------------------|-------|--------------------|-------------|------------|----------|
| | | Daily Max | Monthly Avg | Frequency | Sample |
| Flow | MGD | ** | ** | once/day | estimate |
| Settleable Solids | ml/l | 0.5 ¹ | -- | once/day | discrete |
| Oil & Grease | mg/l | 15.0 | -- | once/day | discrete |
| pH | S.U. | between 6.5 to 9.0 | | once/day | discrete |

** Monitoring Only

¹ Maximum not to be exceeded at any time.

- c. Discharge of sanitary wastewaters; Discharge Serial No. 139:

| Effluent Parameter | Units | Limit | | Monitoring | |
|--------------------|--------|--------------------|-------------|------------|----------|
| | | Daily Max | Monthly Avg | Frequency | Sample |
| Flow | MGD | ** | ** | once/day | estimate |
| Settleable Solids | ml/l | 0.5 ¹ | -- | once/day | discrete |
| Oil & Grease | mg/l | 15.0 | -- | once/day | discrete |
| BOD ₅ | mg/l | 30.0 | -- | once/day | discrete |
| Fecal Coliform | 100 ml | 1,000 | -- | once/day | discrete |
| pH | S.U. | between 6.5 to 9.0 | | once/day | discrete |

** Monitoring Only

¹ Maximum not to be exceeded at any time.

4. Discharge resulting from a rainfall event greater than a 10-year, 24-hour precipitation event (1.80 inches within a 24-hour period):

- a. Discharges from active mining areas, reclaimed areas and roads, explosive storage areas, and well rehabilitation activities; Discharge Serial No. 005, 008, 010, 012, 013, 014, 018, 021, 022, 024, 025, 026, 027, 030, 031, 032, 033, 035, 036, 037, 039, 041, 045, 048 through 052, 066, 069, 070, 071, 079, 080, 081, 082, 086 through 090, 128, 141 through 148, 150, 151, 153, 156, 157, 159 through 165, and 168 through 179:

| Effluent Parameter | Units | Limit | | Monitoring | |
|--------------------|-------|--------------------|-------------|------------|----------|
| | | Daily Max | Monthly Avg | Frequency | Sample |
| Flow | MGD | ** | ** | once/day | estimate |
| pH | S.U. | between 6.5 to 9.0 | | once/day | discrete |

** Monitoring only

- b. Discharges from preparation areas, shops, material storage facilities, and coal transportation facilities; Discharge Serial No. 001, 002, 003, 009, 016, 017, 043, 047, 054, 083, 094, 095, 098, 099, 103 through 107, 118, 126, 127, 130, 133, 136, 137, 140, 149, 152, and 167:

| Effluent Parameter | Units | Limit | | Monitoring | |
|--------------------|-------|--------------------|-------------|------------|----------|
| | | Daily Max | Monthly Avg | Frequency | Sample |
| Flow | MGD | ** | ** | once/day | estimate |
| Oil & Grease | mg/l | 15.0 | -- | once/day | discrete |
| pH | S.U. | between 6.5 to 9.0 | | once/day | discrete |

** Monitoring /only

c. Discharge of sanitary wastewaters; Discharge Serial No. 139:

| Effluent Parameter | Units | Limit | | Monitoring | |
|--------------------|--------|--------------------|-------------|------------|----------|
| | | Daily Max | Monthly Avg | Frequency | Sample |
| Flow | MGD | ** | ** | once/day | estimate |
| Oil & Grease | mg/l | 15.0 | -- | once/day | discrete |
| BOD ₅ | mg/l | 30.0 | -- | once/day | discrete |
| Fecal Coliform | 100 ml | 1,000 | -- | once/day | discrete |
| pH | S.U. | between 6.5 to 9.0 | | once/day | discrete |

** Monitoring only

5. Seepage Study

Peabody Western Coal Company will continue to implement the seepage management plan proposed on October 10, 1997 and revised in Appendix G of the first annual monitoring report. Reports on monitoring shall continue to be submitted annually. The first report was submitted prior to the May 23, 2000 expiration date of the permit. The next report shall be submitted prior to April 15, 2001, and any subsequent reports by April 15th of that particular year. These reports should include seep location maps, inspection summaries, and monitoring results. Furthermore, the reports should include revisions to the seepage management plan that may be implemented to minimize impacts to the prevailing hydrologic balance and to meet water quality standards.

6. Until U.S. EPA approves the Navajo Nation and Hopi Tribal water quality standards, all discharges shall meet the State of Arizona's narrative water quality standards:

a. Navigable waters shall be free from pollutants in amounts or combinations that:

- (I). Settle to form bottom deposits that inhibit or prohibit the habitation of aquatic life or that impair recreational uses;
- (II) Cause objectionable odor in the area in which the navigable water is located;
- (III) Cause off-taste or odor in drinking water;
- (IV) Cause off-flavor in aquatic organisms or waterfowl;
- (V) Are toxic to humans, animals, plants or other organisms;
- (VI) Cause the growth of algae or aquatic plants that inhibit or prohibit the habitation, growth or propagation of other aquatic life or that impair recreational uses;
- (VII) Cause or contribute to a violation or an aquifer water quality standard prescribed in A.A.C. R18-11-405 or A.A.C. R18-11-406; or,
- (VIII) Change the color of the navigable water from natural background levels of color.

b. Navigable waters shall be free from oil, grease and other pollutants that float as debris, foam, or scum; or that cause a film or iridescent appearance on the surface of the water; or that cause a deposit on a shoreline, bank or aquatic vegetation. The discharge of lubricating oil or gasoline associated with the normal operation of a recreational watercraft shall not be considered a violation of this narrative standard.

7. Additional Guidance:

- a. Samples required in A.2 must be collected from the point of discharge.
- b. Samples required in A.3 and A.4 may be collected from a sampling point representative of the type of discharge, rather than from each point of discharge.

8. For the purposes of this permit, the gage stations used to monitor rainfall for specific discharge points shall be:

| <u>Peabody Gage No.</u> | <u>Discharge Points</u> |
|-------------------------|---|
| 1. (ARG1) * | 048, 049, 050, 051, 052, 069, 070, 071, 087, 088, 089, 090, 147, 163, 169, 170, 171, 172, 173 |
| 5. (ARG2R) * | 017, 018, 026, 027, 047, 086, 098, 105, 141, 142, 149, 178 |
| 7. (ARG7R) * | 008, 009, 013, 014, 016, 081, 094, 159, 160, 161, 162, 164, 165 |
| 8. (ARG6R) * | 024, 025, 030, 031, 032, 033, 035, 036, 039, 041, 043, 103, 104, 127, 128, 130, 133, 168 |
| 9. (ARG9) * | 001, 002, 003, 005, 010, 012, 021, 022, 037, 045, 082, 083, 099, 139, 140, 150, 151, 153, 157 |
| 10. (ARG3R) * | 054, 066, 095, 106, 107, 118, 126, 136, 137, 143, 144, 145, 146, 152, 167 |
| 11. (ARG200) * | 079, 080, 148, 156, 174, 175, 176, 177, 179 |

* Values in parenthesis denote PWCC site identifier designations.

9. Best Management Practices:

Within 90 days of permit issuance, Peabody Western Coal Company shall submit to USEPA and the Navajo EPA a description of all Best Management Practices (BMPs) currently required by Office of Surface Mining (OSM) to protect water quality.

10. Reopener:

This permit may be reopened for the imposition of new water quality-based effluent limitations if and when Navajo Nation and Hopi Tribe site-specific water quality standards are approved by EPA.

This permit may also be reopened for the imposition of Best Management Practices (BMPs) if EPA determines that current BMPs required by the Office of Surface Mining (OSM) are

insufficient to protect water quality standards.

The permit may also be reopened for the imposition of selenium and/or nitrate monitoring and limits as specified under Section 5.

B. Monitoring and Reporting

1. Reporting

Discharge data obtained during the previous month shall be summarized and reported monthly. If there was no discharge for the month, indicate "Zero Discharge". The report shall include the data required in A.2, A.3, A.4, and A.8. Monthly data should be submitted no later than the 15th day of the following month. Signed copies of these and all other reports required herein shall be submitted to the Regional Administrator, the Navajo Nation, and the Hopi Tribe at the following addresses:

Water Division
U.S. Environmental Protection Agency
Region 9, Attn: WTR-7
75 Hawthorne Street
San Francisco, CA 94105
Telephone: (415) 744-1905

Navajo Nation Environmental Protection Agency
Attn: NPDES Program
P.O. Box 339
Window Rock, AZ 86515
Telephone: (520) 871-7185

Hopi Tribe Department of Natural Resources
Water Resources Office
P.O. Box 123
Kykotsmovi, AZ 86039
Telephone: (520) 734-2441

2. Intermittent Discharge Monitoring

If the discharge is intermittent, rather than continuous, then on the first day of each such intermittent discharge, the permittee shall monitor and record data for all the characteristics listed in the monitoring requirements, after which the frequencies of analysis listed in the monitoring requirements shall apply for the duration of each such intermittent discharge. In no event shall the permittee be

required to monitor and record data more often than twice the frequencies listed on the monitoring requirements.

3. Monitoring Modifications

Monitoring, analytical, and reporting requirements may be modified by the Regional Administrator upon due notice.

4. Inspection and Entry

The permittee shall allow representatives of the Hopi Tribe and Navajo Nation to accompany the Regional Administrator, or an authorized representative, on inspections performed under authority of Section 10 Inspection and Entry of the EPA, Region 9, "Standard Federal NPDES Permit Conditions".

D. Definitions

1. The "monthly or weekly average" concentration, other than for fecal coliform bacteria, means the arithmetic mean of measurements made during the monthly or weekly period, respectively. The "monthly or weekly average" concentration for fecal or total coliform bacteria means the geometric mean of measurements made during a monthly or weekly period, respectively. The geometric mean is nth root of the product of n numbers.
2. A "discrete" or "grab" sample means any individual sample collected in less than 15 minutes.
3. The "daily maximum" discharges means the total discharge by weight during any calendar day. The daily maximum effluent limitation requires that the stated daily maximum discharge for any one day cannot be exceeded.
4. The "daily maximum" concentration means the measurement made on any single sample which shall not be exceeded. The daily maximum concentration effluent limitation requires that the stated daily maximum concentration for any one day cannot be exceeded.

APPENDIX A

| <u>Discharge Serial No.</u> | <u>Outfall Number</u> | <u>Latitude Deg.Min.Sec.</u> | <u>Longitude Deg.Min.Sec.</u> | <u>Receiving Water</u> |
|---------------------------------|---------------------------|----------------------------------|-----------------------------------|----------------------------|
| 001 | N1-F | 36-31-45 | 110-24-45 | Coal Mine Wash |
| 002 | N1-L | 36-31-45 | 110-24-15 | Coal Mine Wash |
| 003 | N1-M | 36-32-30 | 110-24-15 | Coal Mine Wash |
| 005 | N5-A | 36-31-15 | 110-24-45 | Coal Mine Wash |
| 008 | N10-A1 | 36-32-45 | 110-22-30 | Coal Mine Wash |
| 009 | N10-C | 36-32-00 | 110-24-00 | Coal Mine Wash |
| 010 | J3-A | 36-28-45 | 110-25-00 | Coal Mine Wash Trib. |
| 012 | N6-E | 36-30-30 | 110-25-15 | Coal Mine Wash Trib. |
| 013 | N10-B | 36-33-00 | 110-22-15 | Coal Mine Wash Trib. |
| 014 | N10-D | 36-32-30 | 110-23-00 | Coal Mine Wash Trib. |
| 016 | N12-C | 36-32-15 | 110-23-15 | Coal Mine Wash Trib. |
| 017 | BM-A1 | 36-26-30 | 110-24-00 | Moenkopi Tributary |
| 018 | J3-D | 36-28-15 | 110-24-00 | Moenkopi Tributary |
| 021 | N6-C | 36-29-30 | 110-22-45 | Moenkopi Tributary |
| 022 | N6-D | 36-29-15 | 110-23-00 | Moenkopi Tributary |
| 024 | N14-F | 36-30-30 | 110-18-30 | Moenkopi Tributary |
| 025 | N14-G | 36-30-30 | 110-18-15 | Moenkopi Tributary |
| 026 | MW-A | 36-27-30 | 110-23-45 | Moenkopi Wash |
| 027 | MW-B | 36-27-30 | 110-23-45 | Moenkopi Wash |
| 030 | J16-D | 36-30-00 | 110-18-30 | Moenkopi Tributary |
| 031 | J16-E | 36-30-00 | 110-18-30 | Moenkopi Tributary |
| 032 | J16-F | 36-30-00 | 110-18-45 | Moenkopi Tributary |
| 033 | J16-G | 36-29-45 | 110-19-00 | Moenkopi Tributary |
| 035 | J16-I | 36-29-15 | 110-19-30 | Moenkopi Tributary |
| 036 | J16-K | 36-29-00 | 110-19-15 | Moenkopi Tributary |
| 037 | N6-F | 36-30-45 | 110-22-30 | Moenkopi Tributary |
| 039 | N14-H | 36-30-45 | 110-17-30 | Moenkopi Tributary |
| 041 | N14-M | 36-30-00 | 110-19-00 | Moenkopi Tributary |
| 043 | N14-Q | 36-30-00 | 110-19-15 | Moenkopi Tributary |
| 045 | WW-6 | 36-30-00 | 110-22-15 | Moenkopi Tributary |
| 047 | J7-DAM | 36-25-30 | 110-23-30 | Red Peak Valley |
| 048 | J7-G | 36-25-00 | 110-24-15 | Red Peak Valley |
| 049 | J7-CD | 36-24-45 | 110-22-15 | Sagebrush Wash |
| 050 | J7-E | 36-24-45 | 110-22-30 | Sagebrush Wash |
| 051 | J7-F | 36-24-30 | 110-22-30 | Sagebrush Wash |
| 052 | J7-K | 36-24-30 | 110-23-00 | Sagebrush Wash |
| 054 | N1-AC | 36-32-00 | 110-25-45 | Yellow Water Canyon |
| 066 | N7-A1 | 36-32-15 | 110-26-00 | Yellow Water Canyon |
| 069 | J7-I | 36-24-45 | 110-24-30 | Yucca Flat Wash Trib. |
| 070 | J7-J | 36-24-30 | 110-24-30 | Yucca Flat Wash Trib. |
| 071 | J7-M | 36-24-15 | 110-24-15 | Yucca Flat Wash Trib. |
| 079 | J21-A | 36-26-15 | 110-14-45 | Dinnebito Wash |
| 080 | J21-B | 36-26-15 | 110-14-45 | Dinnebito Wash |
| 081 | N1-O | 36-32-00 | 110-24-00 | Coal Mine Wash |

| | | | | |
|-----|---------|----------|-----------|-------------------------|
| 082 | N5-E | 36-31-15 | 110-25-00 | Coal Mine Wash |
| 083 | N5-F | 36-31-15 | 110-25-00 | Coal Mine Wash |
| 086 | WW-4 | 36-26-45 | 110-24-45 | Moenkopi Wash |
| 087 | WW-9 | 36-23-45 | 110-24-45 | Yucca Flat Wash Trib. |
| 088 | WW-9A | 36-23-45 | 110-24-45 | Yucca Flat Wash Trib. |
| 089 | WW-9B | 36-23-45 | 110-24-45 | Yucca Flat Wash Trib. |
| 090 | WW-9C | 36-24-15 | 110-24-30 | Yucca Flat Wash Trib. |
| 094 | N10-B1 | 36-33-00 | 110-22-15 | Coal Mine Wash Trib. |
| 095 | KM-D | 36-31-30 | 110-25-15 | Coal Mine Wash Trib. |
| 098 | BM-SS | 36-27-00 | 110-23-45 | Moenkopi Tributary |
| 099 | J3-E | 36-28-45 | 110-23-30 | Moenkopi Tributary |
| 103 | N14-B | 36-31-00 | 110-20-30 | Moenkopi Tributary |
| 104 | N14-C | 36-30-00 | 110-19-15 | Moenkopi Tributary |
| 105 | BM-B | 36-26-45 | 110-24-00 | Moenkopi Wash Trib. |
| 106 | KM-A3 | 36-31-45 | 110-26-00 | Yellow Water Canyon |
| 107 | KM-B | 36-31-30 | 110-26-00 | Yellow Water Canyon |
| 118 | TPC-A | 36-33-00 | 110-29-15 | Long House Valley Trib. |
| 126 | TS-A | 36-33-45 | 110-31-00 | Klethla Valley |
| 127 | J16-A | 36-30-00 | 110-18-15 | Moenkopi Wash Trib. |
| 128 | J16-J | 36-29-15 | 110-19-15 | Moenkopi Wash Trib. |
| 130 | N14-P | 36-31-00 | 110-20-30 | Moenkopi Wash Trib. |
| 133 | J16-L | 36-30-45 | 110-19-30 | Reed Valley |
| 136 | KM-TPB | 36-31-15 | 110-28-00 | Yellow Water Canyon Tr. |
| 137 | KM-TPB1 | 36-33-00 | 110-28-00 | Yellow Water Canyon Tr. |
| 139 | KM-E | 36-31-15 | 110-25-30 | Coal Mine Wash Trib. |
| 140 | J2-A | 36-29-00 | 110-25-45 | Wild Ram Valley |
| 141 | J3-F | 36-28-00 | 110-25-15 | Coal Mine Wash Trib. |
| 142 | J3-G | 36-28-00 | 110-25-15 | Coal Mine Wash Trib. |
| 143 | N7-D | 36-32-30 | 110-25-45 | Yellow Water Canyon Tr. |
| 144 | N7-E | 36-32-30 | 110-25-30 | Yellow Water Canyon |
| 145 | N8-A | 36-33-15 | 110-26-00 | Yellow Water Canyon Tr. |
| 146 | N8-B | 36-33-30 | 110-26-00 | Yellow Water Canyon Tr. |
| 147 | J7-A | 36-25-30 | 110-23-30 | Red Peak Valley |
| 148 | J21-C | 36-26-00 | 110-15-30 | Dinnebito Wash |
| 149 | J27-A | 36-27-15 | 110-23-15 | Moenkopi Wash Trib. |
| 150 | N6-G | 36-29-30 | 110-23-00 | Coal Mine Wash |
| 151 | N6-H | 36-29-30 | 110-23-00 | Coal Mine Wash |
| 152 | TS-B | 36-33-30 | 110-31-15 | Klethla Valley |
| 153 | N6-I | 36-31-45 | 110-24-15 | Coal Mine Wash |
| 156 | J21-J | 36-26-00 | 110-16-30 | Red Peak Valley |
| 157 | N6-J | 36-31-45 | 110-24-00 | Coal Mine Wash |
| 159 | N11-A | 36-32-20 | 110-22-40 | Coal Mine Wash |
| 160 | N11-C | 36-32-25 | 110-22-35 | Coal Mine Wash |
| 161 | N11-E | 36-32-35 | 110-22-25 | Coal Mine Wash |
| 162 | N11-G | 36-32-30 | 110-21-40 | Coal Mine Wash |
| 163 | J7-B1 | 36-25-10 | 110-23-58 | Red Peak Valley |
| 164 | N6-L | 36-31-58 | 110-23-58 | Coal Mine Wash |
| 165 | N6-M | 36-32-12 | 110-23-27 | Coal Mine Wash |

Permit No. AZ0022179

| | | | | |
|-----|--------|----------|-----------|---------------------|
| 167 | TPF-E | 36-32-00 | 110-26-02 | Yellow Water Canyon |
| 168 | N14-T | 36-30-20 | 110-18-20 | Moenkopi Tributary |
| 169 | J7-R | 36-24-05 | 110-24-00 | Yucca Flat Wash |
| 170 | J7-S | 36-24-05 | 110-23-50 | Yucca Flat Wash |
| 171 | J7-T | 36-24-00 | 110-23-40 | Yucca Flat Wash |
| 172 | J7-U | 36-24-10 | 110-23-30 | Yucca Flat Wash |
| 173 | J7-V | 36-24-10 | 110-23-20 | Yucca Flat Wash |
| 174 | J21-D | 36-25-39 | 110-15-37 | Dinnebito Wash |
| 175 | J21-E | 36-25-32 | 110-15-49 | Dinnebito Wash |
| 176 | J21-F | 36-25-23 | 110-16-00 | Dinnebito Wash |
| 177 | J21-G | 36-24-44 | 110-16-40 | Dinnebito Wash |
| 178 | J27-RC | 36-27-08 | 110-23-02 | Moenkopi Tributary |
| 179 | J7-JR | 36-26-13 | 110-19-52 | Red Peak Valley |

Revised December 29, 2000

Fact Sheet

Peabody Western Coal Company
Black Mesa Mining Complex
NPDES Permit No. AZ0022179

Contact Information

John Cochran, Supervisor, Environmental Affairs
PO Box 650
Kayenta, AZ 86033
(520) 677-5018 (phone)
(520) 677-5048 (fax)

Facility Description

Peabody Western Coal Company (PWCC) operates the Black Mesa and Kayenta Coal Mines in northeastern Arizona. The northern portion of the two coal mines is on the Navajo Nation. The southern portion of the two coal mines is on both Navajo and Hopi Indian lands. These mining facilities are multi-seam, multi-pit coal mines producing bituminous coal. The coal is sized and stored at preparation facilities located at each mine. No additional coal treatment, such as washing or drying, occurs at these facilities. The lease area currently contains five working open pits, and six reclaimed previously mined pits, and produces approximately 12 million tons of coal annually.

The Office of Surface Mining Reclamation and Enforcement (OSMRE) required PWCC to control all surface runoff water with the potential of being contaminated from contact with mining activities. In order to comply with this requirement, PWCC have constructed approximately 160 sedimentation ponds. EPA Region 9 includes 110 of these as discharge points under an NPDES permit. Since the original NPDES permit was issued in 1983, subsequent modifications have been made to the permit to add and delete certain sediment ponds as authorized points of discharge. The NPDES permit only allowed discharges due to storm events, and required that the 107 impoundments be maintained with adequate capacity to contain the surface runoff from a 10-year 24-hour storm event.

Water Quality Standards

Pursuant to the Water Quality Act of 1987 (WQA) and the "EPA Policy for the Administration of Environmental Programs on Indian Reservations" (November 8, 1984), EPA will work directly with Indian Tribal governments on a one-to-one basis, rather than as subdivision of other governmental units. This conforms with the Federal Indian Policy of January 24, 1983. Both the Navajo Nation and Hopi Tribe have received Treatment as a State (TAS) for Section 106 of the Clean Water Act (CWA); however, both tribes have not yet applied or otherwise received TAS for the purposes of Section 303 of the CWA. Both tribes utilized Section 106 grant money to develop water quality standards which have yet to be approved under

Section 303 by EPA Region 9. In the interim, state water quality standards will be protected until such time as when EPA approves the tribal standards.

In the last permit, by the tributary rule, state water quality standards applicable to discharge from this facility are those for the Little Colorado River below Lyman Reservoir. The protected uses for this segment were: Aquatic and Wildlife including warm water fishery, Domestic Water Source, Full Body Contact, Agricultural Irrigation, and Agricultural Livestock Watering. In 1992, the State of Arizona adopted new water quality standards which included an additional use for this segment: Fish Consumption (acute and chronic chemical specific). In 1996, the State of Arizona adopted new water quality standards, which includes standards for tributaries of listed surface waters. The receiving waters (unlisted tributaries) at PWCC are considered ephemeral in nature. Using the 1996 water quality standards on these unlisted ephemeral tributaries, the aquatic and wildlife [ephemeral] and partial body contact standards would apply.

EPA has published water quality criteria in 1986 EPA's Quality Criteria for Water ("Gold Book") for both chronic impacts to fresh water organisms and human health as it relates to drinking water and consumption of fresh water organisms.

Rationale for Permit Limits

Potential discharges from the three types of impoundments at this facility have been placed into three categories relating to the cause of discharge. These categories are: discharges resulting from lagoon de-watering (or discharges not resulting from a precipitation event); discharges resulting from a precipitation event less than or equal to a 10-year 24-hour storm; and, discharges resulting from a precipitation event greater than a 10-year 24-hour storm. Surface Mining Control and Reclamation Act (SMCRA) regulations require PWCC to maintain adequate capacity in sediment ponds. One option for doing this is to de-water the ponds.

Effluent limits for Total Iron, Total Suspended Solids, and Settleable Solids are based on the effluent limitations guidelines for the Coal Mining Point Source Category at 40 CFR 434. The pH limits are water quality based. Additional limits on Oil & Grease, 5-day Biochemical Oxygen Demand, and Fecal Coliform are based on Best Professional Judgement (BPJ) to protect the beneficial uses of the receiving water. These limits are continued from the previous permit.

Rationale for Permit Reopener

This permit may be reopened for the imposition of new water quality-based effluent limitations when Navajo and Hopi site-specific water quality standards are approved by EPA. Both tribes have passed their water quality standards but, under a new review procedure, EPA has yet to approve either of the tribe's standards.

This permit may also be reopened for the imposition of selenium and/or nitrate monitoring. The concern to monitor for selenium is based on past monitoring data of seeps submitted by PWCC, which indicated a few concentrations approached the 33 ug/l acute standard

for protection of aquatic and wildlife (ephemeral) criterion, and occasionally exceeded the chronic (ephemeral) criterion of 2 ug/l. A numeric permit limitation for selenium is not included because there is insufficient data to demonstrate a reasonable potential for violations of the selenium water quality standard. In addition to the selenium levels in the seeps, the frequency and the potential of the seep-water to reach a waters of the U.S. need to be better understood before determining what standard should apply (i.e. "acute" or "chronic") and whether any dilution factor can be allowed in calculation of a limit. As mentioned in the section below, this a study of the seepage issue is required in this permit.

The concern to monitor for nitrate is based on documented impacts to livestock that utilize the PWCC effluent for watering. PWCC reported that the 1989 deaths of 60 Navajo sheep was caused by high nitrate concentrations in the effluent. The concentration of nitrate was attributed to a mine operator washing ammonium nitrate from his truck into a stream. Although PWCC has indicated that this practice has been discontinued, the severity of the impact to livestock justifies the inclusion of nitrate monitoring under 40 CFR 122.44(i). Similar to the selenium monitoring requirement, no numeric permit limitation for nitrate is included. The regulations at 40 CFR 122.44(i) allow requirements for monitoring as determined to be necessary on a case-by-case basis pursuant to section 405(d)(4) of the CWA.

This permit may also be reopened for the imposition of Best Management Practices (BMPs) if EPA determines that current BMPs required by OSMRE are insufficient to protect water quality standards.

Seepage Issue

Evidence of water seepage from the earthen impoundments constructed at this facility was noted during an EPA inspection on April 30, 1987. The seepage fluctuates substantially depending on weather conditions and the level of water impounded, and would be exceedingly difficult to monitor. Any attempt to stop such seepage would require major construction, with significant impact on the environment in the vicinity of the impoundments. Water quality analysis, and comparison with comparable existing water quality data from undisturbed areas on the lease area, indicate that the seepage water quality is indistinguishable from alluvial water quality upstream of any mine related disturbances. On the basis of this information, while it is clearly within EPA authority to place limits on seepage from the impoundments, EPA has not placed such limits on impoundment seepage from this facility. However, the last NPDES permit had a requirement for PWCC to undertake a seepage study. PWCC proposed a seepage management plan on October 10, 1997. EPA and the Navajo Nation EPA reviewed and approved this plan. This renewed permit will carry on the seepage study requirement by requiring continued submission of annual monitoring reports.

Tributary Rule Issue

PWCC believes that the application of Little Colorado River water quality standards, via the tributary rule to those sections of Moenkopi Wash and Dinnebito Wash that cross their mine leasehold, is inappropriate. PWCC asserts that sufficient site-specific

monitoring data exist to justify the establishment of stream standards for the predominantly ephemeral channels that cross their leasehold. Both Indian tribes have passed water quality standards but these have yet to be approved by EPA. Neither tribes have site-specific water quality standards for PWCC.

Endangered Species Act (ESA) Determination:

According to an April 20, 2000 memo from David Harlow of the US Fish and Wildlife Service (USFWS) to Jerry Gavette of Office of Surface Mining (OSM), the following list of listed threatened or endangered (T&E) species, or proposed species, may occur in the project area:

Threatened:

Navajo sedge (*Carex specuicola*)
Apache Trout (*Oncorhynchus Apache*)
Little Colorado Spinedace (*Lepidomeda vittata*)
Loach Minnow (*Tiaroga Cobitis*)
Spikedace (*Meda fulgida*)
Bald Eagle (*Haliaeetus leucocephalus*)
Mexican Spotted Owl (*Strix occidentalis lucida*)

Endangered:

Pebbles Navajo cactus (*Pediocactus Peeblesianus var peeblesianus*)
Black-footed Ferret (*Mustela nigripes*)
Southwestern Willow Flycatcher (*Empidonax trailli extimus*)

Candidate

Chiracahua Leopard Frog (*Rana chiricahuensis*)

Experimental

California Condor (*Gymnops californianus*)

EPA has determined that this action will have **no effect** on T&E species. This is because permitted discharge from the impoundments occurs extremely infrequently (not since the fall of '98), and because there are no T&E aquatic species listed in the area of the discharges. Furthermore, all NPDES discharges appear to be in compliance with water quality standards necessary to protect wildlife. The June 1990 Environmental Impact Statement (EIS) for the Black Mesa and Kayenta mines examined the entire project as proposed and its potential effects on T&E species. The EIS concluded that the mining operations would have only minor impacts on T&E species. None of those minor impacts is attributed to NPDES-related discharges. While other actions at the mine such as coal exploration or the building of sediment ponds may effect habitat for these species, these actions are already regulated by OSM, and ESA review must be made during the permitting of all such actions by OSM. In fact, such a review was just conducted for an exploration project that includes the construction of 21 miles of temporary roads and 230 drilling pads (November, 1999). According to this review, USFWS and the Navajo Nation Department of Fish and Wildlife (NNDFW) both concurred that the action would not affect any of the above-listed species. PWCC also recently concluded a 1999/2000 baseline vegetation report for J9 Coal Resource Area and J9 Haul Road Corridor (September 2000), and its 1999

Wildlife Monitoring Report (March 30, 2000). Such studies are required by the Office of Surface Mining. Neither indicates that discharges from the impoundments are having any effect on T&E species.

Pertinent excerpts from these reports are available from EPA upon request. If upon further review of these or future studies, EPA, OSM, USFWS, NNEPA or NNDFW concludes that this permitted action is having any effect on T&E species, this permit may be reopened for the purpose of conducting formal consultation.

Response to PWCC Comments submitted December 2000
Draft NPDES Permit (No. AZ0022179)

December 28, 2000

EPA has made all minor changes in the permit as requested in the comments. EPA is only responding to comments where changes were not made as requested, or where clarification was requested. EPA is also attaching a copy of the comments.

Comment: PWCC is not aware the State of Arizona included "cold-water" fishery as one of the protected uses for the Little Colorado River below Lyman Reservoir, but understands Aquatic and Wildlife – Warm Water was one of the original designated protected uses.

Response: This was an error. Cold-water fishery is not one of the protected uses.

Comment: PWCC believes the USEPA should provide clarification regarding which monitoring data submitted in the past indicated a selenium concentration in excess of the 0.02 mg/l water quality standard. PWCC believes the data was collected from seeps, not from pond effluent. Recent review of historical water quality collected from ponds at the Black Mesa Complex show out of hundreds of analyses, selenium greater than 0.02 mg/l was measured only once in just three impoundments. Of the three, only one (Pond J16-E, Discharge Serial Number 031) has any potential to discharge to waters of the U.S., and as of the date of these comments, no NPDES discharge has yet occurred. What is the source of the 0.02 standard for selenium mentioned, State of Arizona?

Response: As you note, the data that indicates the higher selenium levels is from the seeps. Seeps from the impoundments that reach a water of the U.S. is considered a "discharge" under the Clean Water Act, and therefore must meet water quality standards. It is for this reason that we are requiring continued monitoring of the seeps and including a re-opener clause in the permit. Because, as you note, no discharge has yet to occur from the impoundment that has high selenium levels, we have not included a limit, but have required continuation of monitoring.

The source of the 20 ug/l (.02 mg/l) standard for selenium is the 1996 Arizona Water Quality Standards, acute standard for protection of Aquatic and Wildlife, Warm Water Fishery, as well as the standard for "agricultural irrigation," which is another protected use of the Little Colorado River, downstream of Lyman Reservoir. As noted in the Fact Sheet, the protected uses for "tributaries" that are ephemeral include only Partial Body Contact and Aquatic and Wildlife (ephemeral). The acute standard for the latter is 33 ug/l and the chronic standard is 2.0 ug/l. Because of the uncertainty as to which Arizona standard should apply in absence of tribal standards, and in the absence of better information to indicate the potential for the seeps to reach waters of the U.S., and the level of dilution achieved in the receiving water, no selenium limit is currently established on these seeps. However, a reopener clause is included, which allows the imposition of a limit if further information should indicate one is warranted.

Comment: PWCC would like the USEPA to clarify language in the third sentence, as it indicates the Navajo Nation and Hopi Tribe have jurisdiction of the mine leasehold. PWCC would like the USEPA to clarify of what do both tribes have jurisdiction?

Response: This statement was intended to reflect that Navajo and Hopi water quality standards, (rather than Arizona standards), are the standards will ultimately apply to discharges from the mines, once the standards are approved by EPA. USEPA remains the NPDES permitting authority.

PWCC Comments on the November 2000
Draft NPDES Permit (No. AZ0022179)

December 13, 2000

General

The contact individual at Peabody Western Coal Company's (PWCC) Black Mesa/Kayenta Mine Complex is John Cochran, Supervisor Environmental Affairs. His telephone number is (520) 677-5018, and his fax number is (520) 677-5048. The address for sending correspondence is P.O. Box 650, Kayenta, Arizona, 86033.

The renewal application (NPDES Permit No. AZ0022179) was submitted to the USEPA on November 19, 1999. Since that date, two ponds currently listed in the permit as approved outfalls have been reclaimed. The two ponds are N2-G (Discharge Serial No. 065) and WW-9D (Discharge Serial No. 091). Both ponds were reclaimed in 2000 after receiving approval from the Office of Surface Mining Reclamation and Enforcement (OSMRE).

Changes in surface water control plans for a proposed mining area (J23) have resulted in PWCC no longer needing to construct Pond J21-K (Discharge Serial No. 166), and in lieu of constructing the pond, planning to build Pond J7-JR downstream of Pond J21-K during 2001. Because of these developments, PWCC requests USEPA delete Ponds N2-G (065), WW-9D (091), and J21-K (166) from the permit, and add Pond J7-JR (179).

The following comments are presented according to the page number and section in the November 2000 draft NPDES permit.

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The list of discharge serial numbers listed in Section A.2.a. should be modified to delete outfalls 015 (N10-E), 065 (N2-G), 091(WW-9D), and 166 (J21-K), and add outfall number 179 (J7-JR). Outfall 015 (Pond N10-E) was deleted from the permit in the March 1999 modification.

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The list of discharge serial numbers listed in Section A.3.a. should be modified to delete outfalls 015 (N10-E), 065 (N2-G), 091(WW-9D), and 166 (J21-K), and add outfall number 179 (J7-JR). The word "materials" in the first sentence of Section A.3.b. should be changed to "material".

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The list of discharge serial numbers listed in Section A.4.a. should be modified to delete outfalls 015 (N10-E), 065 (N2-G), 091(WW-9D), and 166 (J21-K), and add outfall number 179 (J7-JR).

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PWCC believes the language in Section A.5. is too restrictive. Peabody believes it is appropriate to include seep location maps, inspection summaries, and monitoring reports in each annual report. However, in light of information contained in the first Annual Seepage Monitoring and Management Report submitted on April 5, 2000, PWCC does not feel rigorous assessments of seepage data in comparison with water quality standards and the prevailing hydrologic balance will be warranted on an annual basis. The report included an analysis of the impacts to the hydrologic balance utilizing mixing analyses and down-gradient water quality data. The mixing analyses demonstrated that the seeps had little potential to impact the prevailing hydrologic balance, mainly due to the low seepage flow volumes. Further review of the data submitted in the 1999 annual seepage report, compared with data previously submitted in the 1995 seepage study report, show no significant changes in chemical concentrations or flow volumes at the more persistent seeps monitored (e.g. Seeps below J7-DAM). PWCC does not believe subsequent annual seepage reports should include detailed assessments of data in comparison with the prevailing hydrologic balance, especially if additional monitoring data collected at the seeps show no increases in flow volumes or concentrations of chemical constituents.

PWCC recommends removing the requirement to assess the seepage data in comparison with water quality standards and the prevailing hydrologic balance in each annual seepage report, unless new seeps are found and monitored, or significant increases in chemical concentrations or flow volumes are measured.

Finally, the third sentence should be revised to reflect that the first report was submitted prior to the May 23, 2000 expiration date of the permit, and the last sentence should be modified to correct a typographical error (may, instead of nay).

Page 8 of 10

The lists of discharge points for each respective Peabody Gage No. in Section A.8. should be modified as follows:

1. (ARG1) – Delete discharge points 046, 073, 076, 077, 091, and 138.
5. (AIRQ2R) – Rename PWCC site identifier AIRQ2R to ARG2R, delete discharge point 019.

7. (AIRQ7R) – Rename PWCC site identifier AIRQ7R to ARG7R, delete discharge points 001, 002, 003, 015, 037, 153, 157, and 158.
8. (AIRQ6R) - Rename PWCC site identifier AIRQ6R to ARG6R, delete discharge point 038, add discharge points 036, 127, and 133.
9. (MET9) - Rename PWCC site identifier MET9 to ARG9, add discharge points 001, 002, 003, 037, 153, and 157.
10. (AIRQ3R) – Rename PWCC site identifier AIRQ3R to ARG3R, delete discharge points 065 and 121.
11. (AIRQ200) – Rename PWCC site identifier AIRQ200 to ARG200, delete discharge points 036, 127, 133, and 166, add discharge point 179.

Page 9 of 10

In Section B.1., the fourth sentence should be modified to read “Monthly data should be submitted no later than the 15th day...”.

APPENDIX A

Discharge serial numbers 065 (N2-G), 091 (WW-9D), and 166 (J21-K) should be deleted from Appendix A, since both Ponds N2-G and WW-9D have been reclaimed as explained above, and plans to build Pond J21-K have been cancelled.

Discharge serial number 179 (J7-JR) should be added to Appendix A, as plans have been made to construct this new pond before the end of 2001. Pond J7-JR will receive runoff from active mining areas, and may receive runoff from reclaimed areas, roads, and explosive storage areas (Categories A.2.a., A.3.a., and A.4.a.). The location proposed for constructing Pond J7-JR is latitude 36 degrees, 26 minutes, and 13 seconds, and the longitude is 110 degrees, 19 minutes, and 52 seconds. The receiving water for Pond J7-JR is Red Peak Valley.

Following the deletion of Ponds N2-G (065), WW-9D (091), and J21-K), and the addition of Pond J7-JR (179), the final version of the NPDES permit should contain 105 approved outfalls. Finally, Appendix A should be modified to show only one set of table headings at the top of each page.

Fact Sheet dated November 1, 2000

The comments provided below are listed according to the subject headers shown on the November 1, 2000 fact sheet.

Facility Description

PWCC's lease area currently contains six reclaimed previously mined pits. Also, PWCC currently has approximately 160 sedimentation ponds, and the current NPDES permit includes 110 of the ponds as discharge points.

Water Quality Standards

A space should be added to separate paragraphs. PWCC is not aware the State of Arizona included cold water fishery as one of the protected uses for the Little Colorado River below Lyman Reservoir, but understands Aquatic and Wildlife – Warm Water was one of the original designated protected uses.

Again, PWCC disagrees with the language that begins with "The Red Book sets an iron standard ..." The Red Book does not set standards. The Red Book Quality Criteria for Water (USEPA July 1976) contains a section entitled "The Philosophy of Quality Criteria" in which the following quote is contained:

"Water quality criteria do not have direct regulatory impact, but they form the basis for judgement in several Environmental Protection Agency programs..."

Rationale for Permit Limits

SMCRA regulations do require PWCC to maintain adequate capacity in sediment ponds. However, lagoon dewatering is one of several options available to PWCC in order to meet the SMCRA requirement. SMCRA does not specify which method must be used to maintain adequate capacity.

Rationale for Permit Reopener

PWCC believes the USEPA should provide clarification regarding which monitoring data submitted in the past indicated a selenium concentration in excess of the 0.02 mg/l water quality standard. PWCC believes the data was collected from seeps, not from pond effluent. Recent review of historical water quality collected from ponds at the Black Mesa Complex show out of hundreds of analyses, selenium greater than 0.02 mg/l was measured only once in just three impoundments. Of the three, only one (Pond J16-E, Discharge Serial Number 031) has any potential to discharge to waters of the U.S., and as of the date of these comments, no NPDES discharge has yet occurred. What is the source of the 0.02 standard for selenium mentioned, State of Arizona?

The 1989 deaths of 60 Navajo sheep were caused by high concentrations of nitrate in runoff upstream of Pond BM-A1, not effluent from the pond.

Tributary Rule Issue

PWCC would like the USEPA to clarify language in the third sentence, as it indicates the Navajo Nation and Hopi Tribe have jurisdiction of the mine leasehold. PWCC would like the USEPA to clarify of what do both tribes have jurisdiction?

ATTACHMENT 4
INTERIM LAND SMALL WATERSHED STUDY

Small Watershed Studies

Introduction. A hydrological monitoring program has been implemented in post-1977 SMCRA reclaimed coal resource areas and a small undisturbed area on Black Mesa. The objective of this program is to evaluate and define the hydrology of small reclaimed watersheds and the hydrologic processes governing the water quality of runoff from these areas. The program is designed to monitor: (1) precipitation; (2) runoff; (3) water chemistry; (4) sediment loads; and (5) soil moisture. Monitoring instrumentation will provide data for evaluating hydrologic processes that govern reclamation hydrology. Data will be used to select, evaluate and calibrate computer models that will predict hydrologic responses in ungauged reclaimed watersheds on Black Mesa. Data and model predictions will ultimately be used to document reclamation hydrology for the purpose of meeting bond release criteria.

Monitoring Areas. Reclamation hydrology monitoring instrumentation installed on Black Mesa as of June, 1985 is concentrated in four small watersheds, all less than 50 acres. Three watersheds are located in coal resource areas mined after the adoption of SMCRA (see Figure 1). They are: (1) J-27 study area; (2) J-1/N-6 study area; and (3) N-2 study area. Drainage development in these areas is minimal, as overland flow is dominant. They are typified by contour-furrowed slopes of 30% or less. All have reestablished vegetation at least two years old.

A fourth watershed has been selected for instrumentation in an unmined area west of and adjacent to the reclaimed J-3 mining area (see Figure 1). This area is predominantly pinyon-juniper with some sagebrush grassland. Slopes range from 5% to 50%, and drainage is well defined. This watershed has been selected for the purpose of comparing hydrologic response from reclaimed areas to a similar-sized unmined, "undisturbed" area. Table 1 presents elevations and Peabody coordinates for each monitoring site established as part of the small watershed studies.

Rain Gauges. Six automated tipping bucket rain gauges are located in the four watershed study areas. One gauge is situated at the watershed centroid in the three reclaimed study areas: J-1/N-6; N-2; and J-27. Centroids have been used in many hydrologic investigations to define watershed lag and runoff characteristics. Three precipitation gauges are located at accessible, equidistant locations in the undisturbed watershed west of J-3. The gauges are placed on metal stands set in concrete and the lower portion of

SMALL WATERSHED STUDY AREAS

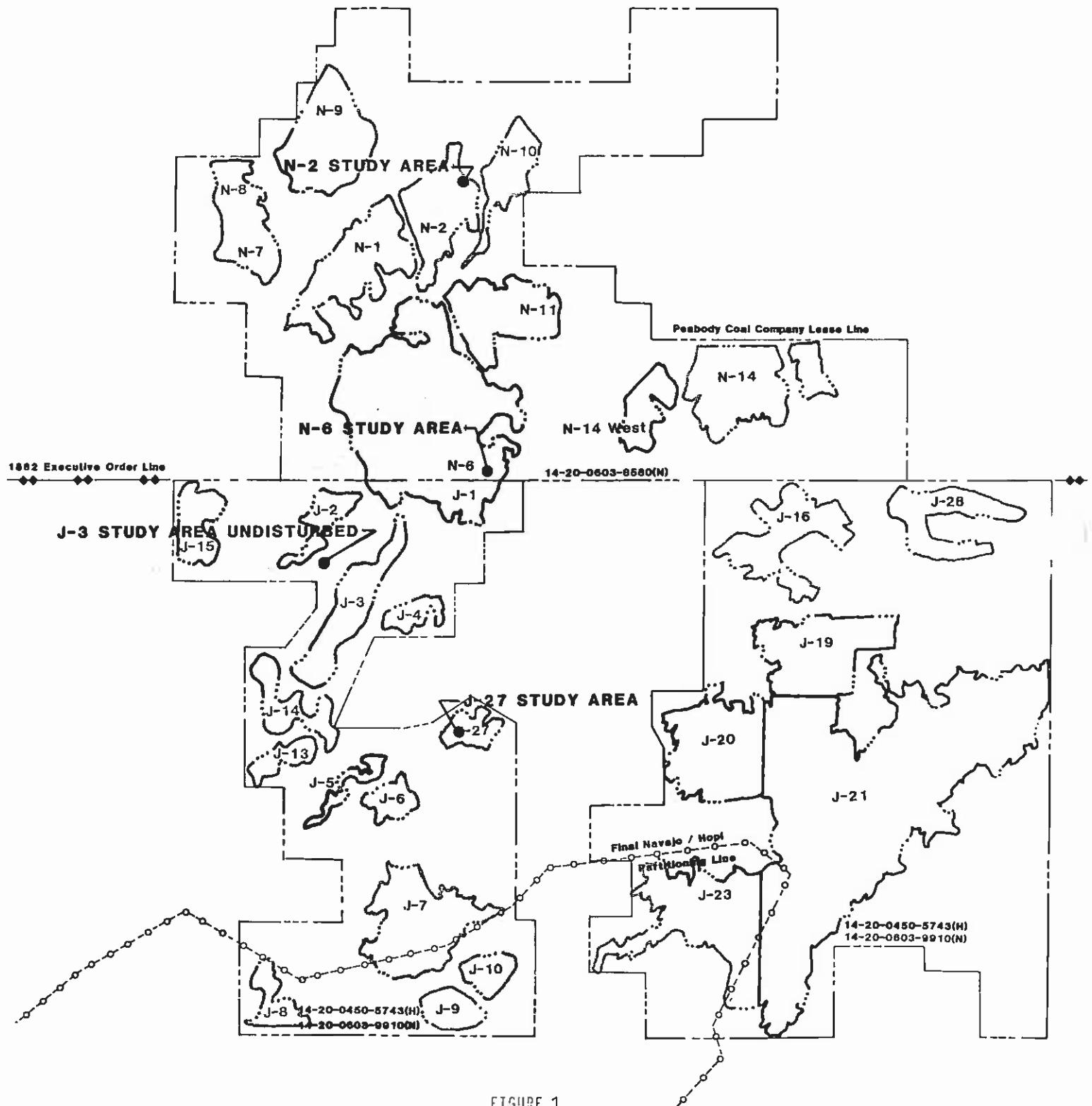


FIGURE 1
Small Watershed Study Locations

TABLE 1

Small Watershed Studies
Monitoring Site Elevations and Coordinates

| Site | Elevation | Peabody Coordinates | |
|------------------------|-----------|---------------------|-----------|
| | | East | North |
| (N2 Reclaimed Area) | | | |
| 220 (Rain gage) | 6812.26 | 32,212.1 | 5,688.9 |
| 221 (Plot) | 6845.70 | 32,704.7 | 5,799.8 |
| 222 (Plot) | 6845.64 | 32,702.9 | 5,774.1 |
| 223 (Plot) | 6839.89 | 32,579.9 | 5,523.0 |
| 224 (Plot) | 6839.85 | 32,566.4 | 5,509.3 |
| 225 (Plot) | 6897.27 | 31,673.1 | 4,984.5 |
| 226 (Plot) | 6895.31 | 31,620.8 | 5,017.3 |
| 227 (Flume) | 6800.59 | 32,234.5 | 5,688.9 |
| 228 (Flume) | 6805.15 | 32,413.0 | 5,717.6 |
| (J1/N6 Reclaimed Area) | | | |
| 260 (Rain gage) | 6677.09 | 34,910.1 | -14,838.8 |
| 261 (Plot) | 6714.90 | 34,742.3 | -14,955.7 |
| 262 (Plot) | 6713.98 | 34,737.9 | -14,983.1 |
| 263 (Plot) | 6720.36 | 34,852.0 | -14,759.8 |
| 264 (Plot) | 6720.90 | 34,851.3 | -14,737.7 |
| 265 (Plot) | 6736.89 | 34,733.0 | -14,523.9 |
| 266 (Plot) | 6737.25 | 34,732.9 | -14,498.9 |
| 267 (Flume) | 6728.58 | 34,880.6 | -14,532.3 |
| 268 (Flume) | 6714.52 | 34,850.4 | -14,903.9 |
| (J-27 Reclaimed Area) | | | |
| 270 (Rain gage) | 6544.17 | 33,660.4 | -35,021.5 |
| 271 (Plot) | 6529.77 | 33,180.9 | -34,764.5 |
| 272 (Plot) | 6524.59 | 33,269.1 | -34,443.9 |
| 273 (Plot) | 6537.36 | 33,299.8 | -34,949.9 |
| 274 (Plot) | 6537.49 | 33,317.7 | -34,955.9 |
| 275 (Plot) | 6528.05 | 33,387.2 | -34,525.6 |

TABLE 1
(Continued)

| Site | Elevation | Peabody Coordinates | |
|-----------------------------------|-----------|---------------------|-----------|
| | | East | North |
| (J-27 Reclaimed Area) (Continued) | | | |
| 276 (Plot) | 6527.33 | 33,376.2 | -34,498.4 |
| 277 (Flume) | 6520.37 | 33,349.1 | -34,762.1 |
| (J-3 Undisturbed Area) | | | |
| 300 (Rain gage) | 6578.14 | 22,775.5 | -22,497.2 |
| 301 (Rain gage) | 6555.11 | 23,635.5 | -22,080.8 |
| 302 (Rain gage) | 6537.07 | 22,993.9 | -21,654.7 |
| 303 (Plot) | 6543.54 | 23,373.1 | -21,730.1 |
| 304 (Plot) | 6545.29 | 23,503.2 | -22,035.3 |
| 305 (Plot) | 6537.65 | 23,404.7 | -22,089.1 |
| 306 (Plot) | 6548.21 | 22,755.4 | -22,173.0 |
| 307 (Plot) | 6515.83 | 22,535.4 | -21,674.0 |
| 308 (Plot) | 6462.14 | 22,427.6 | -21,240.9 |
| 309 (Flume) | 6445.23 | 22,458.2 | -21,131.4 |
| 310 (Flume) | 6537.59 | 22,524.5 | -21,986.3 |



FIGURE 2
Typical Direct Reading Rain Gauge Used
In Monitoring Program

each gauge is protected with the body of a 55-gallon metal drum.

In all four study areas, direct reading rain gauges (Figure 2) are located at the runoff plots to help define rainfall amounts and the areal distribution of rainfall events. These gauges are Tru-chek plastic collectors from which data is collected on a storm basis.

Intensity, duration and total amounts of rainfall are calculated from these data and used to quantify storm distributions and "rainfall kinetic energy". Analysis of rainfall amounts from the gauge network in each area using the Thiessen or Isohyetal methods yields areal distributions of rainfall for each storm.

Flumes. Six "Santa Rita" Supercritical Flow Flumes of three capacities are located in the four watershed study areas. The three sizes of flumes have rated capacities of 12, 20 and 100 cfs, and are constructed of metal according to design specifications outlined in U.S.D.A. Technical Bulletin Number 1655 (Smith et al. 1982).

Each flume consists of a curved entrance approach with a cylindroid surface and a 3% sloped throat section in which flow passes at supercritical velocities. Flume locations have been chosen so that at least one foot of overfall at the downstream end is insured to maintain supercritical flow and eliminate backwater effects. Overall flume design allows for accurate measurements of sediment-laden flow and a consistent "self-cleaning" feature. Structural dimensions vary among the three different capacity-rated flumes and are presented in Figures 3 through 5.

In the N-2 watershed study area, two 12 cfs flumes (Figure 6) are located at endpoints of gentle swales upslope from a small basin into which the watershed drains. Twenty-foot long earthen berms attached to and extending laterally from the upstream flume ends direct runoff into the flumes.

In the J-1/N-6 watershed study area, two 12 cfs flumes (Figure 7) are situated in a small channel that dissects the watershed. One flume is located downchannel near a small basin into which the watershed drains. The other is situated in the same channel near the upper end of the area.

SANTA RITA FLUME - TRIANGULAR SECTION DESIGN CAPACITY 12 ft^3/s

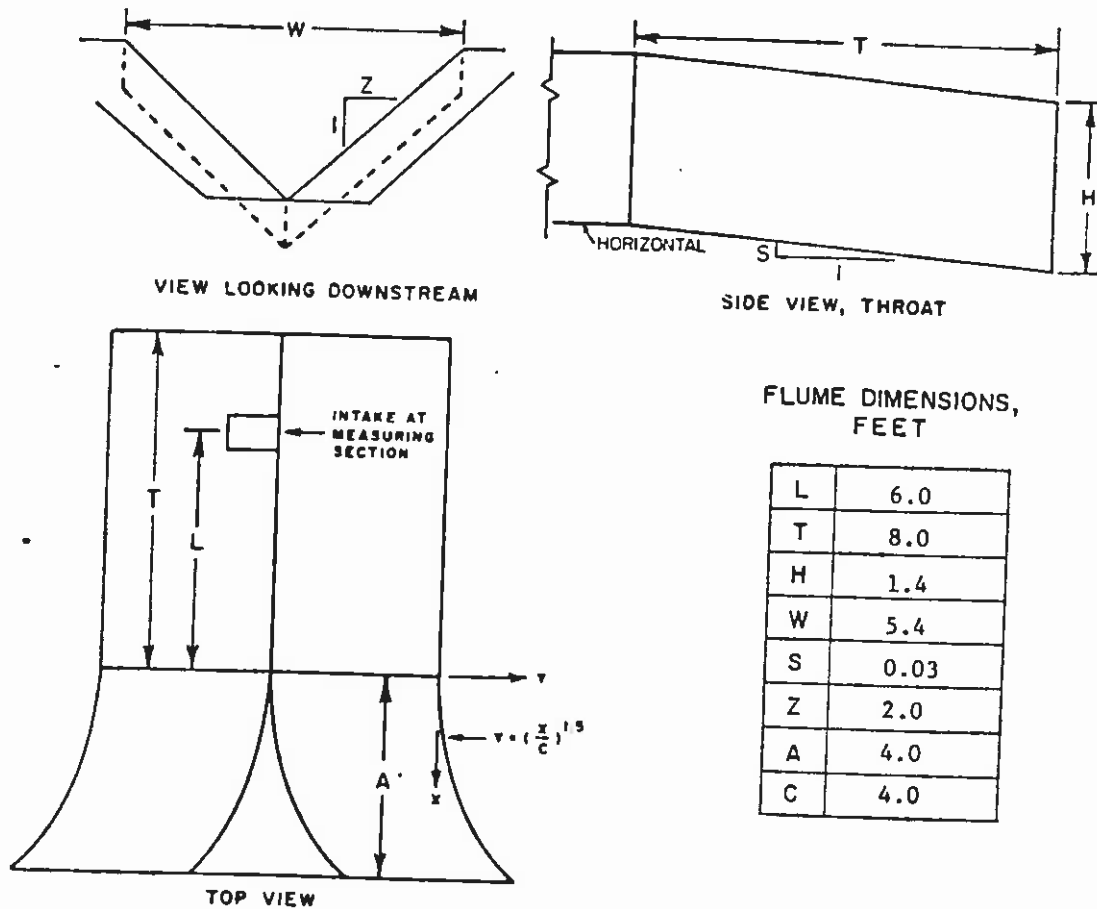


FIGURE 3

Structural Dimensions of the 12 cfs
 Santa Rita Supercritical Flow Flume

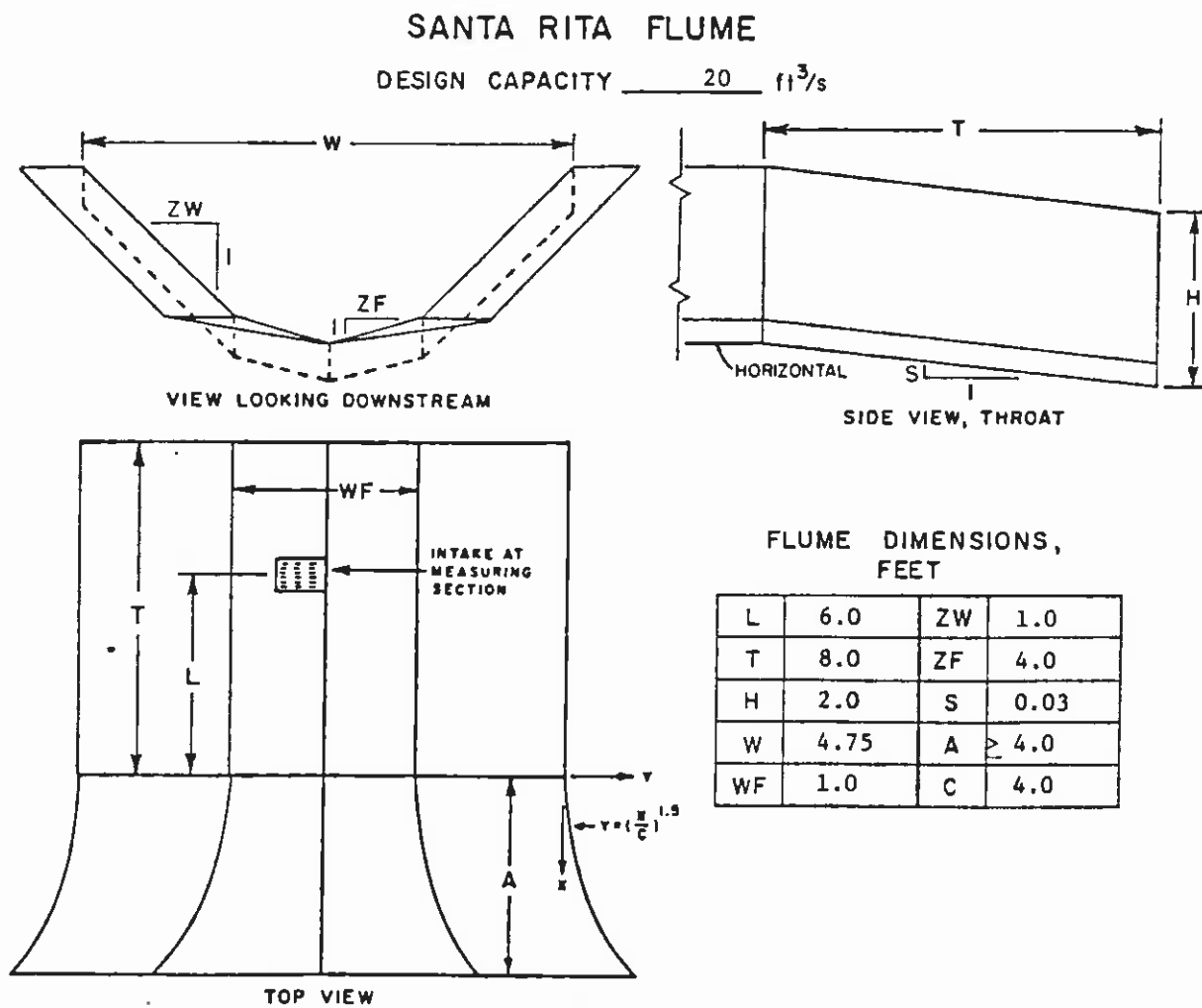


FIGURE 4
Structural Dimensions of the 20 cfs
Santa Rita Supercritical Flow Flume

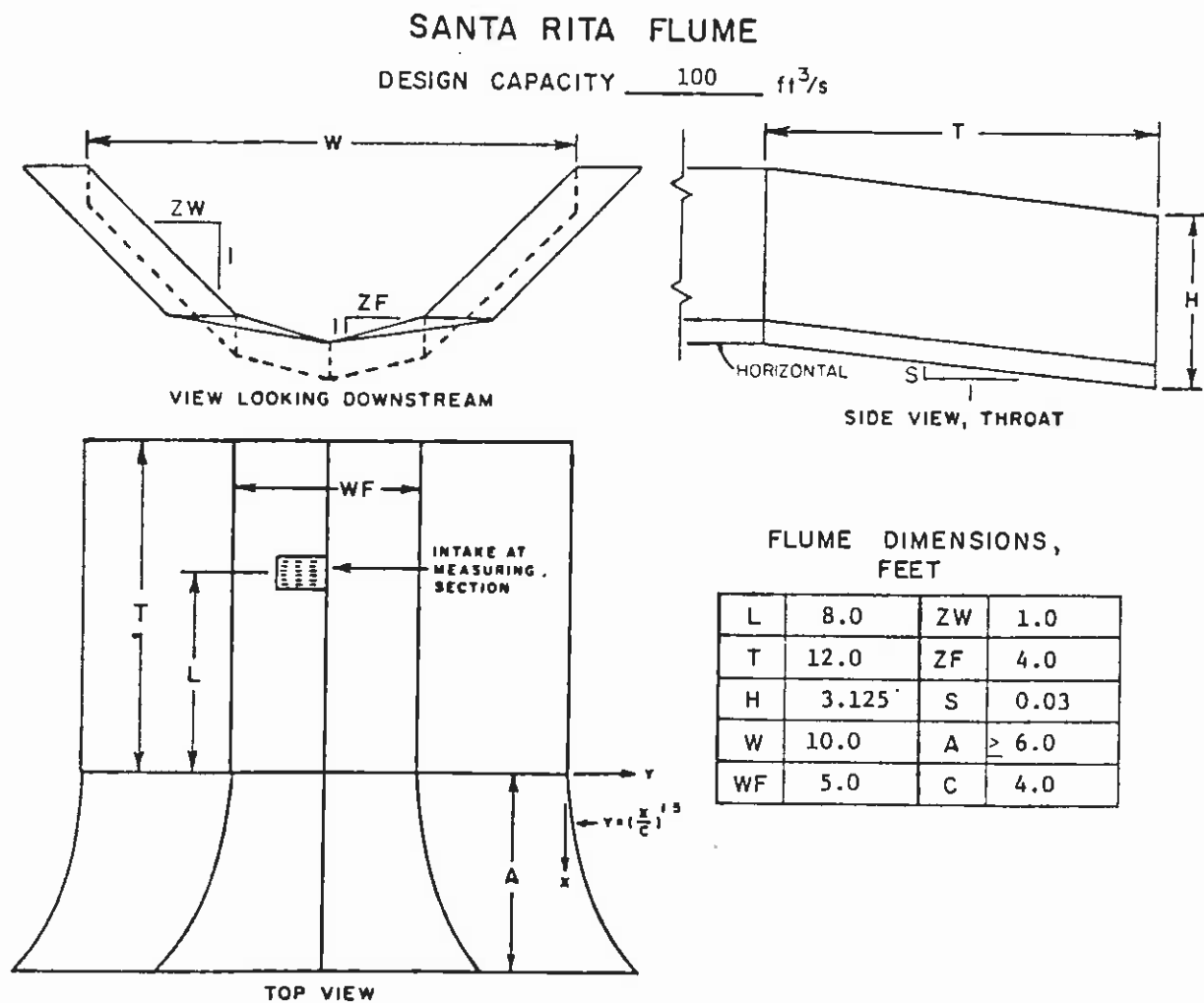


FIGURE 5
Structural Dimensions of the 100 cfs
Santa Rita Supercritical Flow Flume

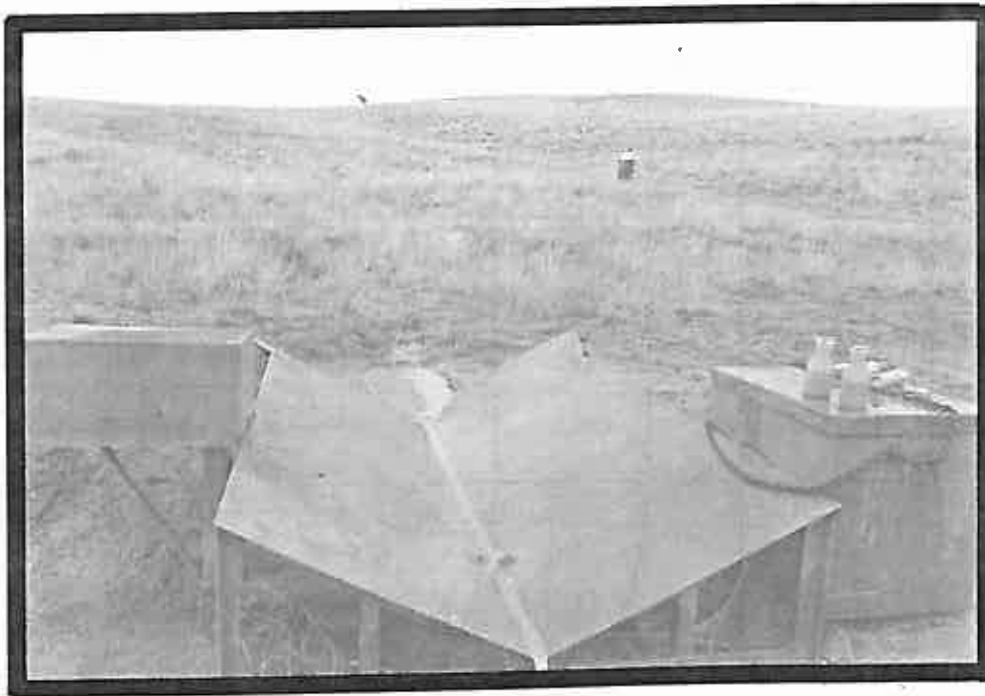


FIGURE 6

12 cfs Santa Rita Supercritical
Flow Flume in N-2

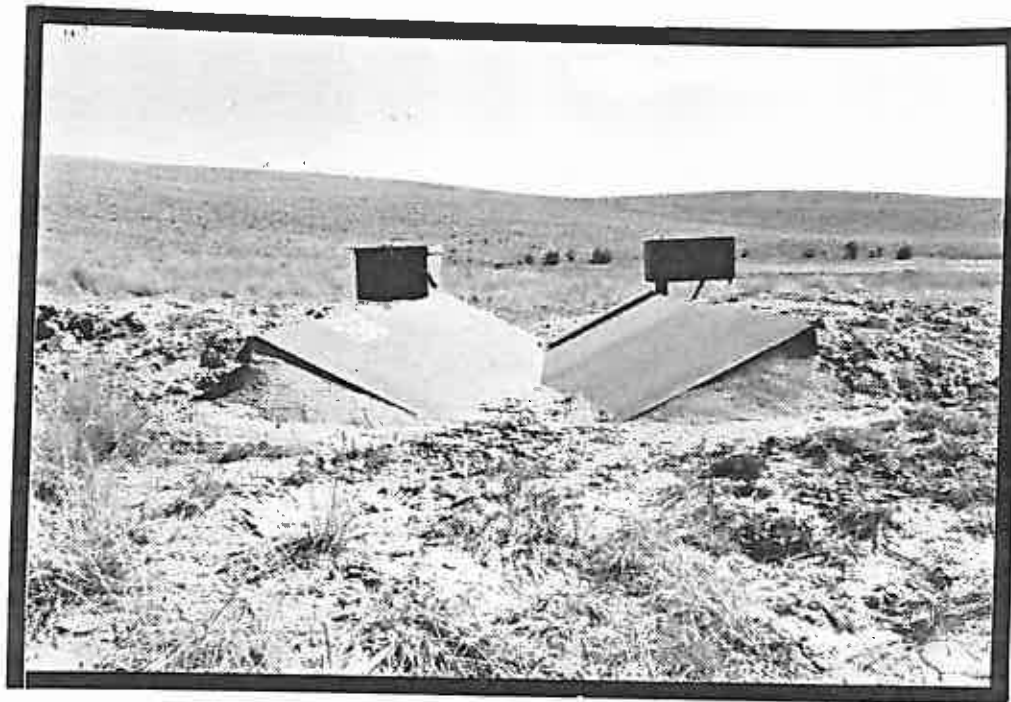


FIGURE 7

12 cfs Santa Rita Supercritical Flow Flume in J-1/N-6

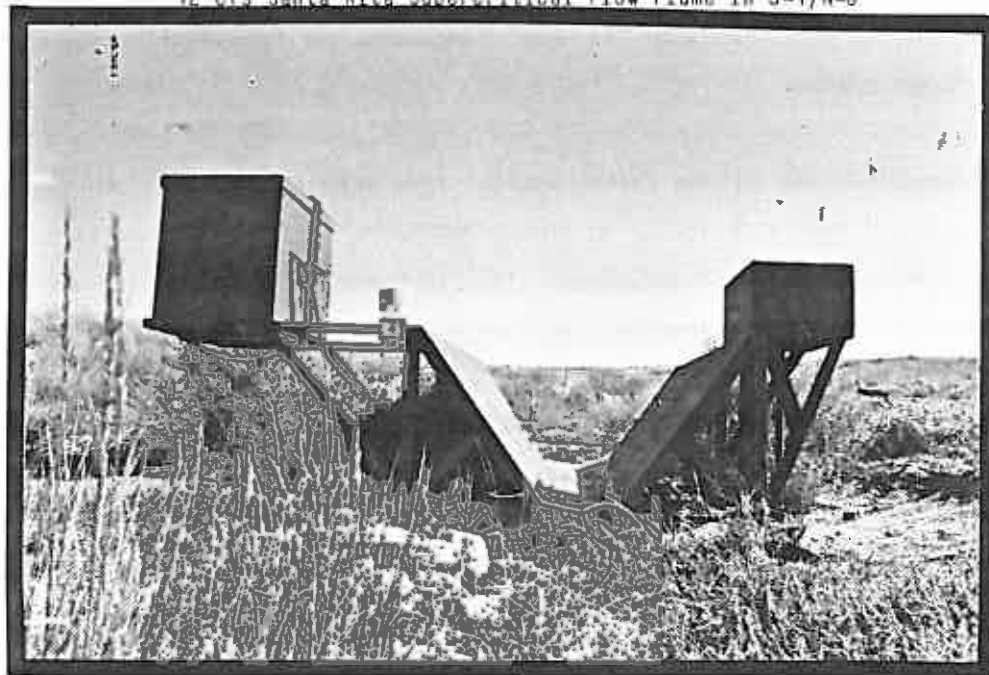


FIGURE 8

20 cfs Santa Rita Supercritical Flow Flume in J-27

A 20 cfs flume (Figure 8) is situated in the lower end of a straight reach of channel that was established in a large swale in the J-27 watershed study area. The flume dimensions cause no flow constriction in the channel, and it has not been necessary to construct berm extensions from the wing walls.

In the unmined watershed study area west of J-3, a 100 cfs flume (Figure 9) is located in the well-defined channel at the watershed outlet. This flume "fits" the channel configuration causing no appreciable flow restriction.

These flumes establish monitoring points at which storm runoff data, water quality samples and sediment samples are gathered. All are considered endpoints of small watersheds in which hydrologic processes are quantified and investigated as part of this monitoring program.

Water Flow and Quality Instrumentation. Each of the six flumes is equipped with instruments to allow gathering of runoff, water chemistry and sediment data. On one side of each flume, a stilling well made of 3" square tubing is used for accessing flow stage via a Steven's Pulse generator coupled with a Campbell Scientific data logger. The stage data recorded by this instrument are used to calculate the time distribution of discharge during runoff events.

On the opposite side of the throat section from the stilling well at each flume is positioned a 2 1/2' x 2 1/2' x 4' steel instrument shelter which contains the water chemistry and sediment instrumentation. This instrumentation consists of one Isco Model 1680 high speed sequential sampler. The sampler is connected to the throat of the flume by a 7' length of 3/8" tygon tubing. The Isco sampler is activated by the data logger, which also records each time that the sampler automatically collects a sample. The sampler is also equipped to completely purge the sample lines between each sampling interval. The intake port for the sampler is positioned in each flume near the bottom of the throat section. Intake ports are positioned shallow enough to sample low flows but above the bottom to sufficiently avoid sampling bedload during higher flows.

Water chemistry and sediment analyses are performed on samples retrieved from the automated samplers. Water chemistry samples are composited according to the portion of the flow hydrograph from which they were obtained (rising limb, hydrograph peak, or recession limb). At least one sample collected annually either by the automated samplers



FIGURE 9

100 cfs Santa Rita Supercritical Flow Flume
In the Unmined Watershed Near J-3

or manually is analyzed for the modified full suite of chemical parameters listed in Table 3 of Chapter 16. Subsequent samples collected manually (grab samples) or automatically (automated samples) will be analyzed for either the modified full suite (Table 3, Chapter 16) or short list (Table 4, Chapter 16) of chemical parameters. Grab samples, taken in the channel near each flume depending on manpower, flow frequency and site accessibility, provide checks on the performance of the ISCO sampler and the validity of compositing samples. Sampling, sample preservation, handling and analysis techniques are done in accordance with Guy (1969), Brown, et al. (1970), USEPA (1983), and methods as outlined in Peabody's current contract laboratory's QA/QC manual, presented in Attachment 5 to Chapter 16.

The accuracy of the discharge and sediment data described above will be checked with periodic manual measurements. Current meters will be periodically used to measure runoff velocity distributions in the channel cross-section immediately above each flume. These discharge measurements will be compared to the stage-discharge curves (Figures 10 through 12) calculated using each flume's specified hydraulic relationships. These comparisons will provide a "check" on the performance of the water level recorder and the validity of the stage-discharge curves.

A manually operated sediment sampler (USDH-48) will be periodically used to take depth-integrated samples at selected verticals in the flow cross-section during runoff events. Calculations of sediment loads using this data will provide a means to verify or adjust sediment load calculations obtained from automated sampler data.

Sample frequency is dependent on the number of runoff events that occur at each flume; therefore, data collection will be attempted on a storm basis depending on manpower availability. Water chemistry information analyzed from water samples collected at the flumes will provide a data base with which the water quality of runoff from reclaimed areas will be characterized and evaluated. Sediment load information calculated from automated samplers and manual collection methods will be used to define and evaluate erosion rates occurring on reclaimed areas. The effects of sediment-laden runoff from reclaimed areas on receiving streams will be studied by comparing sediment loads measured in the large channels dissecting the leasehold with sediment yields measured in reclaimed areas.

1 2 3 4 5 6 7 8 9 1

1 2 3 4 5 6 7 8 9 1

1 2 3 4 5 6 7 8 9 1

1 2 3 4 5 6 7 8 9 1

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1 2 3 4 5 6 7 8 9 1

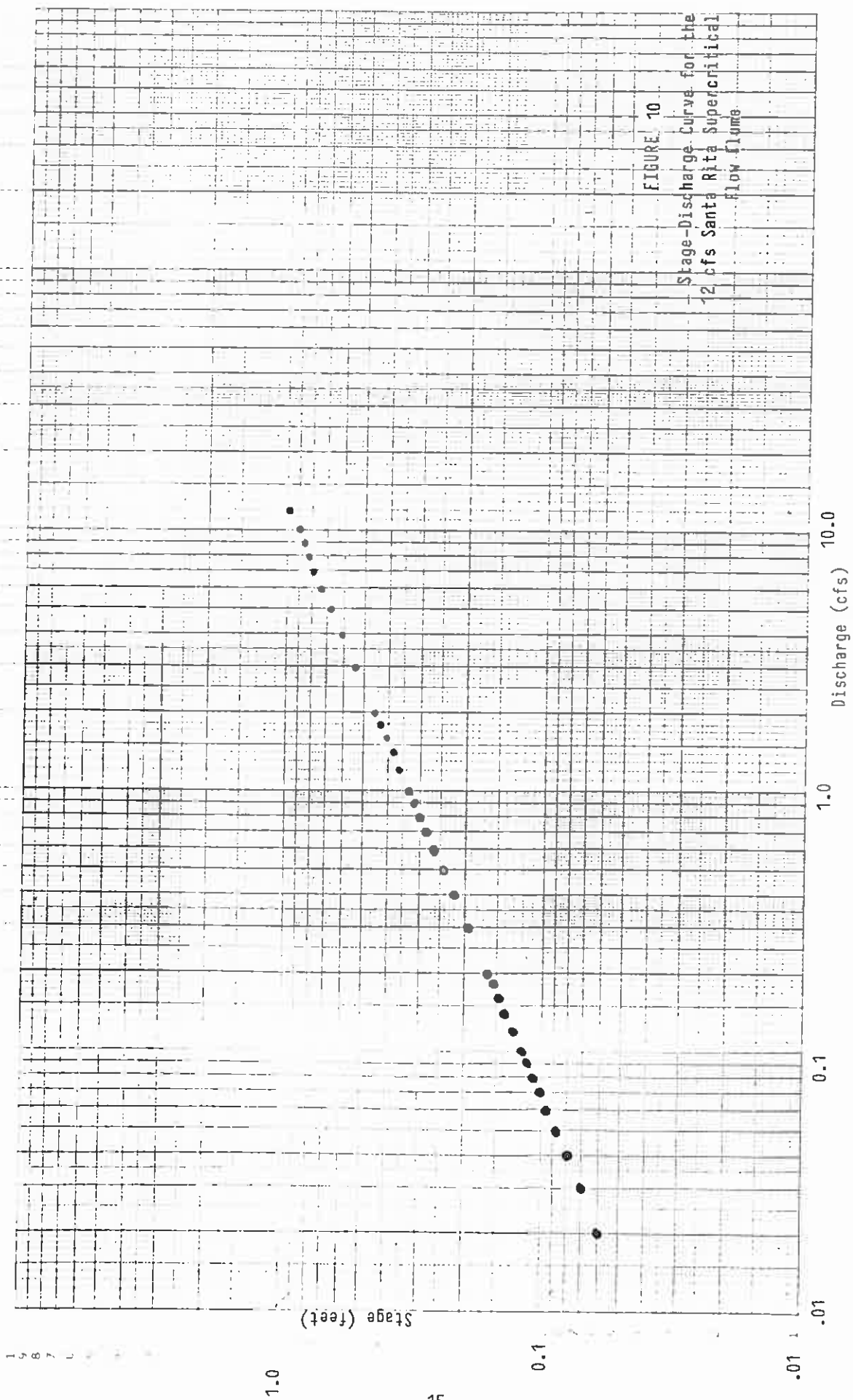
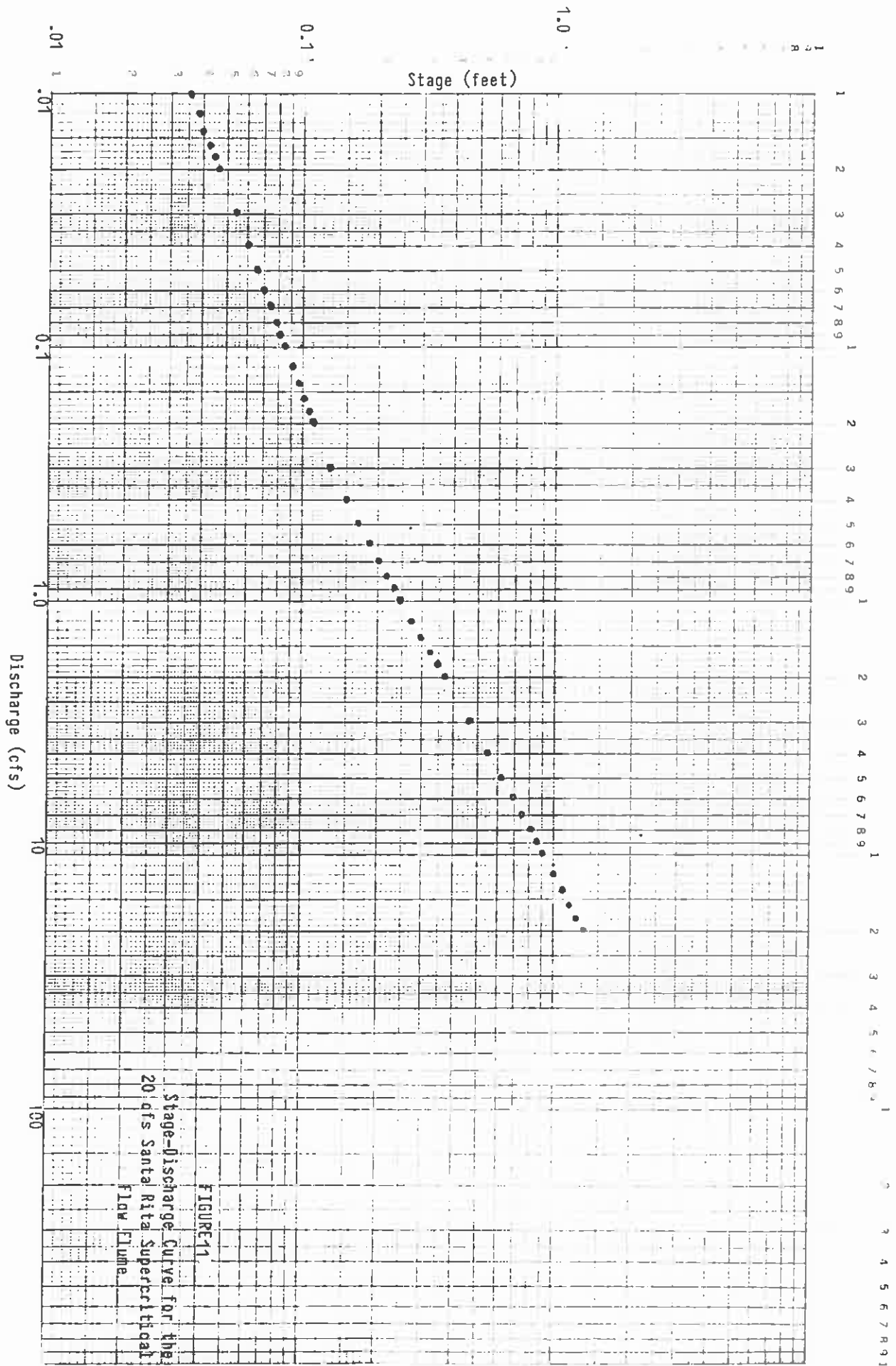
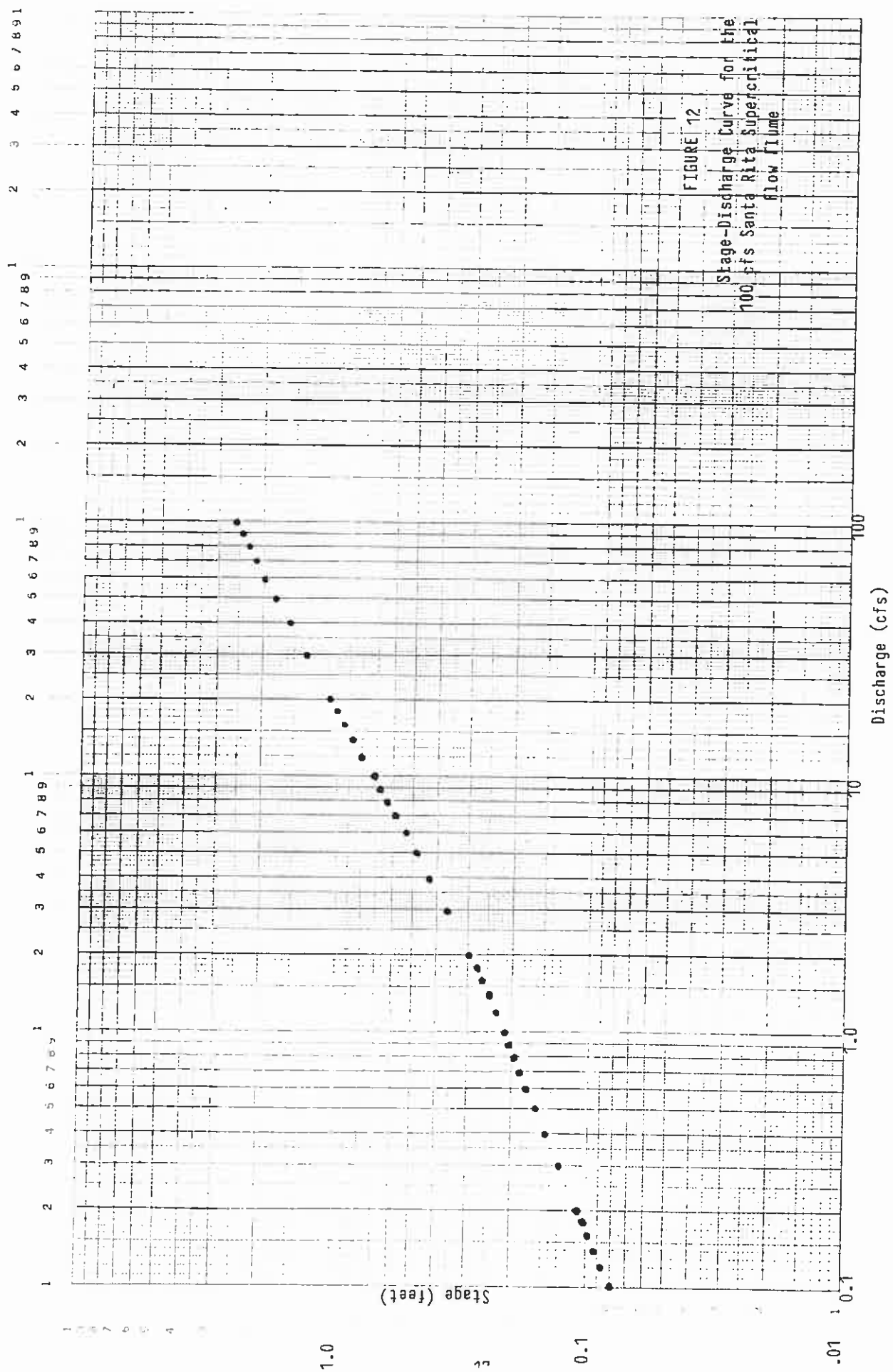


FIGURE 10

Stage-Discharge Curve for the
12 cfs Santa Rita Supercritical
Flow Flume





Runoff Plots. A total of 24 runoff plots are located in the four study areas. Plots are 10 feet wide by 35 feet long, constructed with 16 gauge sheet metal (Figures 13a and b). Plot sizes selected have been used in the development of the Universal Soil Loss Equation. A 35-foot length is sufficient for the establishment of overland flow conditions, but not long enough to prevent installation in remote conditions. A triangular sill forms the lower edge of the plot and funnels water to a barrel collection system (Figure 14a). The collection barrels consist of three 30-gallon plastic barrels, all set in 55-gallon drums recessed and located below the plot (Figure 14b). Two-inch I.D. PVC piping conveys runoff from the sill to the 30-gallon collection barrels.

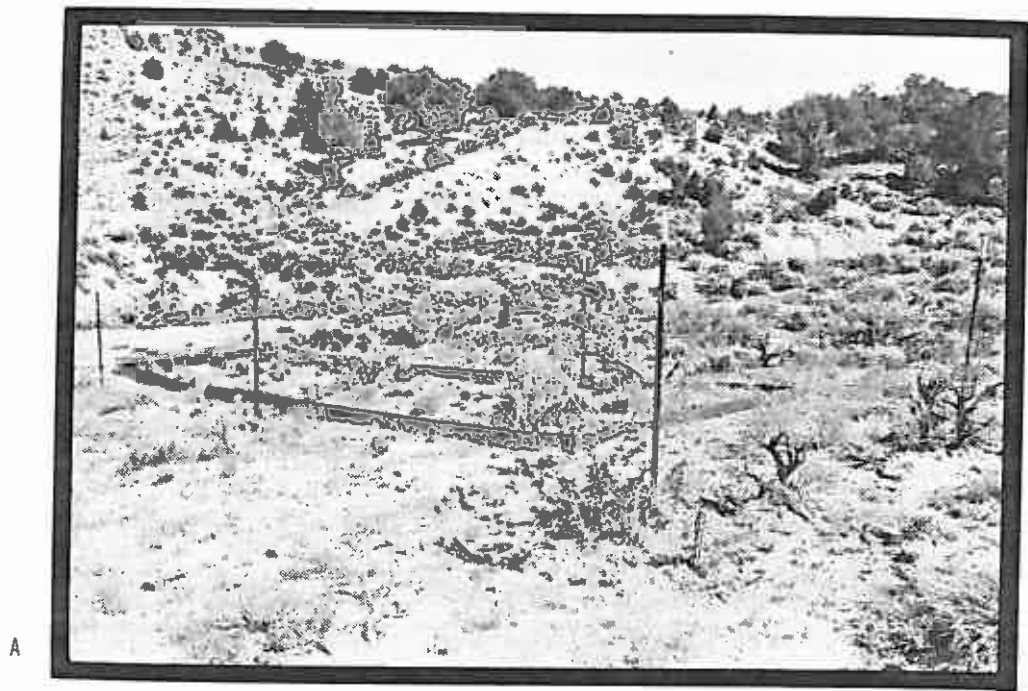
In each of the three reclaimed study areas, 6 plots are located in pairs on three ranges of slope: (1) extreme; (2) minimum; and (3) average watershed slope, calculated by the contour-length method (Williams and Berndt, 1976).

In the J-3 undisturbed watershed, 6 plots are located on similar slopes (10% to 13%, approximate average watershed slope) in varying cover types and densities. Two plots are located in minimal and maximal sagebrush shrubland cover. The remaining four plots are located in the pinyon-juniper woodland at sites with conditions representative of the range of canopy and understory vegetation development.

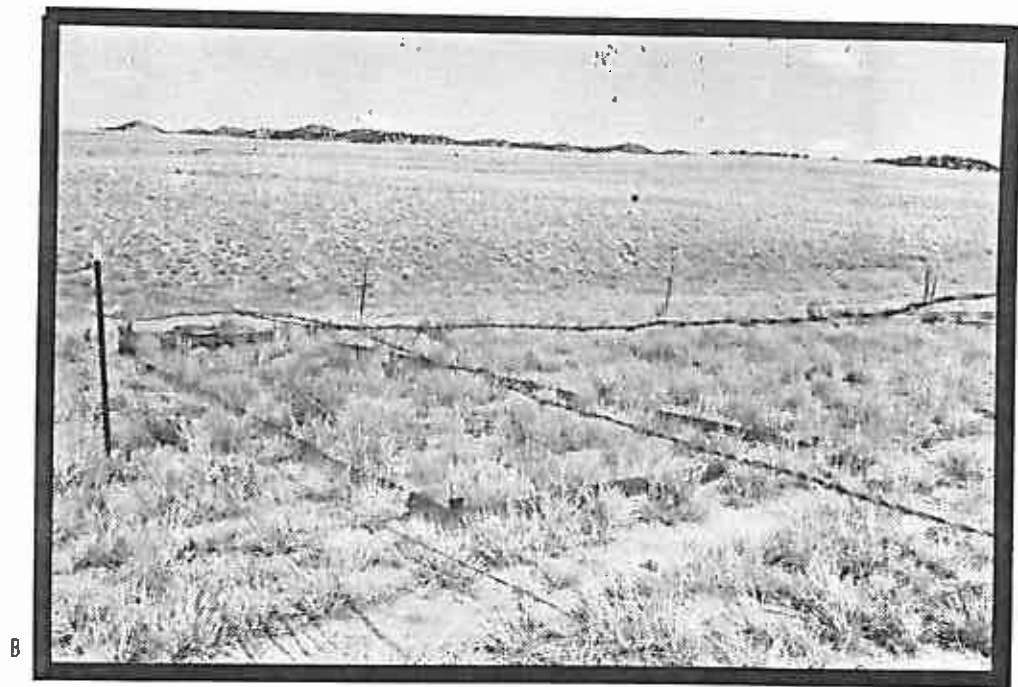
Runoff collected in the barrels is sampled on a storm-basis, except during times of back-to-back storms or manpower and time limitations. Sampling consists of measuring the volume of runoff in each barrel by using depth-volume relationships of each 30 gallon barrel. Aluminum sulfate is then added to the collected runoff in each barrel to flocculate the fine suspended particles. Once flocculation has occurred, excess water is withdrawn using a peristaltic pump. The remaining sediment mass is dried, weighed, and recorded. Data from samples obtained in barrels at each plot will allow for the calculation of total eroded sediment mass per plot on a storm basis.

Sediment mass and concentration measurements taken from the plots will be used to evaluate and quantify the effects of cover, soil erodability, slope, rainfall, and management techniques on sediment production from post-1977 SMCRA reclamation efforts.

Soil Moisture Blocks. Seventy-two byouocous gypsum-blocks each having 5-foot lead wires are located at runoff plots in each of the four watershed study areas (Figure 15). Three plots in each area have been selected for soil block instrumentation. In each of these



J-3 Study Area



J-27 Study Area

FIGURE 13
Typical Runoff Plots



Triangular Sill



Collection Barrel System

FIGURE 14
Runoff Plot Collection System



FIGURE 15

Typical Byouocous Gypsum-Block
Soil Moisture Monitor

plots, three soil blocks are buried at two sites at depths of 30, 10 and 2 centimeters. Soil block locations in each plot are 7 feet from the top and 7 feet from the bottom of the 35-foot long plot. The varying depths at which blocks are placed were chosen to yield data documenting the depth-distribution of soil moisture.

The measurement of electrical resistance in these blocks in-situ will be calibrated against the water content in the soil. Soil, water content information, combined with infiltration rates periodically measured using ring infiltrometers will allow for quantification of the moisture holding and infiltration characteristics of soils in the 12 monitored runoff plots. This information will aid in investigations of watershed response to precipitation. Also, on a periodic basis, soil samples will be taken from similar depths outside of, but adjacent to the instrumented runoff plots, and will be gravimetrically analyzed for moisture content. These measurements will provide for additional evaluation and calibration of electrical resistance readings for the soil blocks.

Literature Cited

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- USEPA. "Manual of Methods for Chemical Analysis of Water and Wastes." EPA-600/4-79-020. Environmental Monitoring and Support Laboratory, Office of Research and Development, Cincinnati, Ohio (1983).
- Williams, J.R., and Berndt, H.D. "Determining the Universal Soil Loss Equation's Length-Slope Factor for Watersheds". Proceedings of the National Soil Erosion Conference (May 25-26, 1976).

ATTACHMENT 5

Persistent trends in some of the major ion and trace element concentrations (i.e., Mg, SO₄, TDS, alkalinity, F, B, and NO₃) along a reach of Yellow Water Canyon Wash below the N-7 mining area have been observed. A study, which consisted of four wells (see Drawing 85600 and the RLRA for the N7 and N8 mining areas) was conducted to help PWCC better understand the possible geochemical mechanisms causing the ion concentrations, to further define the magnitudes and extent of the concentration increases, and to segregate out other potential chemical sources.

Two of the wells, SPL176 and SPL177, were completed in the N-7/8 spoil, and two, SWEPO175 and SWEPO179 were completed in the shallow bedrock beneath or adjacent to the spoil. These wells, plus the rest of the monitoring wells are included on Exhibit 85600.

The spoil wells were installed using a hollow stem auger rig. Two-inch ID PVC casing and screen was used. A screen slot size of 0.020-inch was selected and the annular pack material around the screen is 8-16 silica sand. Above the screen, auger cuttings were used as annular fill and the top four to five feet was sealed with concrete grout.

The shallow bedrock and Wepo wells were installed using an air rotary rig. A foam additive was used to control circulation and remove the cuttings. Four-inch ID PVC casing and screen was used. Screen slot sizes were 0.020-inch and 8-16 silica sand was placed in the annular space around the screen. From above the screened zones to within four to five feet of the ground surface, bentonite pellets were placed in the annular space. The tops were sealed with concrete grout. Locking steel well covers were placed around all wells.

Rotary rig drill cuttings and drilling fluid or foam were contained in mud pits excavated adjacent to the well bores. Following completion of the wells, the cuttings and fluid were hauled as each mud pit was graded over. At auger-drilled sites, the cuttings were dispersed throughout the immediate area as best as was reasonably practicable.

Well development techniques were the same as those described in the Wepo and alluvial monitoring installation section of this chapter. The wells were completed during April of 1992. The duration of the study was estimated to be at least two years. The wells were abandoned in 2001 using the procedures specified in this chapter.

The parameters monitored and the monitoring frequencies at the special study wells were determined by PWCC. Drill cuttings were analyzed using paste samples, and dilution extract samples for mineral types and further characterization of overburden and spoil chemistry. Isotope analyses were run on water samples collected from select wells to assist in characterizing ground water sources and flow, and sources of nitrogen and sulfur. Inorganic chemical sampling was conducted in select wells for reduced suites of chemical species that appear to be exhibiting gradual or pulsing trends. At least one full suite of chemical parameters was analyzed for at each special study well, providing there is sufficient water available for sampling. Information obtained from the water quality analyses was incorporated in statistical computations, trend plots, and geochemical models to help determine the chemical mechanisms and reactions that caused the chemistry observed along Yellow Water Canyon Wash immediately below the N7/8 mining area.

Sampling concerns were the same as those discussed under the Wepo and alluvial water quality sampling sections in this chapter. Because of the concerns regarding sample analysis bias owing to increased turbidity caused during sampling, sampling apparatuses and purge rates were utilized with an emphasis on minimizing the amount of entrained sediment. Attempts were made to optimize purge rates, percent aquifer contributions, and overall sampling times. Sample preservation, handling, and analysis techniques were conducted in accordance with the methodology in the 17th edition of "Standard Methods for the Examination of Water and Wastewater" (APHA, 1989). Specific information regarding laboratory analysis techniques, and laboratory quality assurance is presented in Attachment 2.

PWCC reported on the study, including data collected as part of the study, on an annual basis from 1992 to 2001. The information was included as a separate section in the Annual Hydrology Reports. The summary analysis of monitoring data and outcome of this special study is presented in the RLRA for the N7 and N8 mining areas. PWCC submitted this document to the OSMRE in September of 2001.



ATTACHMENT 6

I. Introduction

An effective Navajo aquifer water quality QA program involves a combination of sampling and handling QA, laboratory QA, and QA procedures for checking the correctness of analyses. Because there are eight Navajo wells and all drawdown cones intersect one another, loss of chemical data at one or two of the wells will not jeopardize the capability of the N-aquifer monitoring program to detect material damage to the hydrologic balance of the N-aquifer. If measurable water quality change were to occur in the N-aquifer beneath the Peabody leasehold, it would be detected at more than one or two of the wells. Interestingly, since 1993, the USGS has only found it necessary to sample one to three of the eight Peabody production wells (USGS, 1986 and following years). One of their monitoring objectives is to look for changes in N-aquifer water chemistry due to D-aquifer leakage.

Since analyses like TDS are performed gravimetrically and most of the other chemical parameters are run using analytical instrumentation, errors in TDS analyses have no bearing on the quality of the other parameter analyses. Thus, decisions regarding resampling and reanalysis will be on a parameter basis rather than a parameter suite basis.

II. Field Sampling QA Procedures

Each pumping well has a circular chart recorder built into the main switchbox/controller for the downhole pump. These recorders measure line amperage and are set to record continuously. Because the water distribution system has multiple pumps tied into the system and the wells are cycled on and off, it is necessary to determine that a particular pump is accounting for the flow through a meter and that the pump has been on at least 24 hours prior to sampling. This is accomplished by a visual inspection of the amperage chart for each pump.

A discharge line (Tygon or medical grade silicone tubing), which is attached to the gate valve faucet at each wellhead, is used to collect the water quality samples. At Wells 2 and 8, the chlorination systems are unplugged prior to sampling. The valve is opened and flushed for 3 to 4 minutes (approximately 20 gallons) to remove any rust and residual chlorine. The flow rate is reduced to 0.75 to 1.5 gpm and is directed into a flow-through

box containing the pH buffers, pH electrode, and conductivity probe suspended from a plastic holder. This permits equilibration of the pH buffers with the well water. The field parameters (temperature, pH, and conductivity) are checked every four to five minutes. Three consecutive stable readings of these field parameters are required before a N-aquifer water quality sample is taken. Sample handling, preservation, and transport methods are presented in Tables 5 and 6 of Chapter 16. Field and laboratory parameters, with the exception of NO₂ and PO₄, are run within the maximum holding times specified on Table 5.

III. Laboratory QA Procedures

PWCC's current contract laboratory is ACZ Laboratories located in Steamboat Springs, Colorado. Quality assurance checks performed by the laboratory include standard reference samples, in-process calibration to standards, blanks, duplicates, and spikes. In addition to these internal controls, PWCC provides external controls by periodically submitting blanks, prepared reference standards, and duplicate samples. The States of Arizona and Colorado also require ACZ to successfully pass performance evaluation checks and laboratory certifications. A detailed discussion of ACZ's quality assurance program, analytical methodologies, and precision and accuracy controls is presented in Attachment 2 to this chapter.

IV. QA Procedures For Checking the Correctness of Analyses

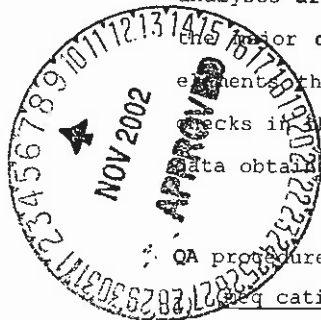
Procedures employed by PWCC for checking the correctness of N-aquifer water quality analyses are divided into two sets. The first set of procedures are designed to evaluate the major chemical constituents and the second set of procedures to evaluate the trace elements that do not occur at concentrations which would influence any of the accuracy checks in the first set of procedures. The QA checks are performed on all the Navajo well data obtained each year.

QA procedures for the macroconstituents include two ratios:

$$\frac{(\text{meq cations} - \text{meq anions})}{\text{meq. cations} + \text{meq anions}} \times 100 = \text{Cation/Anion Balance (CAB)}$$

$$2) \text{ TDS (gravimetric) / TDS (calculated)} = \text{TDS Ratio}$$

For samples with anion sums <3.0 meq/L, the cation/anion balance acceptance range is ±5 percent (Wells 2 to 7 and 9). Because Well 8 has a higher anion sum, its cation/anion balance acceptance range is ±3 percent.



The acceptance range for the TDS ratio is from 0.85 to 1.15 ($\pm 15\%$). This range has been selected because it is not uncommon for one or more of the macroconstituents to be below the limit of detection. Not knowing what the true value for a censored parameter is (<1 for most of the macroconstituents, <4 for SO_4), it is not included in the calculation and will introduce an additional amount of error. Also, if the $\text{pH} > 8.3$, ionic silica may be present which would cause additional error in the calculated TDS. The slightly larger acceptance range for the TDS ratio should account for these additional sources of error.

The two ratios involve 11 chemical parameters and 12 chemical analyses [TDS (gravimetric), Ca, Mg, Na, K, CO_3 , HCO_3 , SO_4 , Cl, F, NO_3 , and SiO_2]. Table 6-1 summarizes the number of chemical parameters and which parameters are evaluated by each of the macroconstituent QA checks. If the CAB has too large an error, and K, Cl, F, NO_3 , and SiO_2 are within the limits specified in Table 6-2, Ca, Mg, Na, CO_3 , HCO_3 , and SO_4 will be rerun during the same year. If the TDS ratio has too large an error but the CAB error is acceptable, only the TDS (gravimetric) and/or SiO_2 will be rerun during the same year. If both the ratios have too large an error, all 12 chemical analyses will be rerun during the same year.

Trace elements do not lend themselves to any of the analyses described above. Their concentrations are orders of magnitude lower and the values are predominantly censored. PWCC is unaware of any valid, proven statistical techniques for analyzing highly censored data sets with multiple detection levels. PWCC chose what they believe is a reasonable trace metal QA approach based on the following:

1. The three laboratories PWCC has utilized historically did not use common analytical instrumentation or procedures in their trace metal analyses, which resulted in data sets with ranges of censoring levels and parameter concentrations greatly influenced by sample matrix interferences. This problem of non-constant variance in the trace metal concentrations over time is referred to as heteroscedasticity. To avoid this problem, only trace metal concentration ranges measured by ACZ Labs (11/85 on) were used to help determine parameter retest concentrations (see Table 6-2 in this attachment).
2. OSM did not establish any trace metal material damage criteria in their CHIA analysis, thus Federal and Navajo Nation domestic drinking water standards were taken into account when establishing reasonable retest concentration levels.



TABLE 6-1

The Number of Chemical Analyses and Macro-Constituent
Parameters Represented by the QA/QC Ratios

| QA/QC Ratio | Number of Chemical Analyses | Chemical Parameters Represented |
|--|--------------------------------|--|
| $\frac{\text{meqC} - \text{meqA}}{\text{meqC} + \text{meqA}} \times 100$ | 10 | Ca, Mg, Na, K, CO ₃ SO ₄ , Cl, F, NO ₃ |
| $\frac{\text{TDS (gravimetric)}}{\text{TDS (calculated)}}$ | 12 | Ca, Mg, Na, K, CO ₃ , HCO ₃ , SO ₄ , Cl, F, NO ₃ , SiO ₂ |

C = cations

A = anions

TDS gravimetric = solids residue dried at 180° C



TABLE 6-2

Range of Trace Constituent Concentrations in Navajo Water Samples Collected
From 11/85 to 6/02 and Specified Concentrations at Which Retests Will Be Run

| Chemical Parameter | NAV2 | NAV3 | NAV4 | NAV5 | NAV6 | NAV7 | NAV8 | NAV9 | Retest Concentration | Domestic Drinking Water Standard** |
|-----------------------|-----------|-----------|-----------|----------|-----------|------------|------------|-----------|-------------------------|---------------------------------------|
| Ag* | <20 | <20 | <20 | <10-20 | <10-10 | <20 | <20 | <20 | >50 ug/l | 100 ug/l |
| Al* | .009-0.2 | .03-0.05 | <0.05 | <0.05 | <0.2 | <0.03-.16 | <0.03-.06 | <0.03-.06 | >0.05 mg/l | 0.05-0.2 mg/l |
| As* | 2-8 | 1-5 | 2-5 | 2-5 | 2-5 | 1-4 | <1-3 | 2-4 | >10 ug/l | 10-50 ug/l |
| B | 10-20 | <20-30 | <20-40 | <20-60 | 10-30 | <20-30 | <20-60 | 10-60 | >60 ug/l | NS |
| Ba* | 10-20 | <10-10 | <3-20 | <10-10 | <10-20 | <10 | <10-40 | <10 | >100 ug/l | 2000 ug/l |
| Be | <0.002 | <0.002 | <0.002 | <0.002 | <0.002 | <0.002 | <0.1 | <0.002-.4 | >4 ug/l | 4.0 ug/l |
| Cd* | <5 | <3-10 | <3-10 | <3-5 | <5 | <5 | <5 | <5 | >5 ug/l | 5 ug/l |
| Cl | 2-4 | 2-5 | 3-8 | 2-10 | 1-4 | 2-8 | 3-12 | 1-3 | >25 mg/l | 250 mg/l |
| Cr* | <50 | <20 | <10-30 | 10-10 | <20 | <10-20 | 10-20 | <20 | >50 ug/l | 100 ug/l |
| Cu* | <50 | 10-20 | <10-50 | <20 | 10-20 | <10-20 | <20 | <20 | >50 ug/l | 1300 ug/l |
| CN | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | >0.1 mg/l | 0.2 mg/l |
| F | .1-2 | .1-3 | <0.1-3 | <0.1-3 | <0.1-2 | <0.1-6 | .1-3 | <0.1-3 | >0.35 mg/l | 2-4 mg/l |
| Fe | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.01-.03 | <0.01-.05 | <0.01-.02 | >15 ug/l | 0.3 mg/l |
| Pb* | <20 | <20 | <20 | <20 | <20 | <20 | <20 | <20 | >0.05 mg/l | 15-50 ug/l |
| Mn | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | <0.005-.03 | <0.005-.01 | <0.02 | >1 ug/l | 0.05 mg/l |
| Hg* | <0.2 | <0.2 | <0.2 | <0.1-8 | <0.1-2 | <0.1-2 | <0.1-2 | <0.1-8 | N/A | 2.0-2.1 ug/l |
| Mo* | <50 | <50 | <50 | <50 | <50 | <50 | <50 | <50 | N/A | NS |
| Ni* | <20 | <20 | <10-20 | <20 | <20 | <20 | <20 | <20 | >3 mg/l | 10 mg/l |
| NO3 | .6-1.0 | .6-.83 | .6-1.1 | .64-1.09 | .57-.84 | .64-1.08 | .55-2.07 | .6-.95 | >0.2 mg/l | 1 mg/l |
| NO2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | N/A | 6.5-9.0 su |
| PH | 7.6-9.2 | 8.4-9.6 | 8.0-9.4 | 8.4-9.5 | 8.5-9.2 | 8.3-9.5 | 7.4-8.3 | 7.9-9.2 | >3 ug/l | 6 ug/l |
| Sb* | <1 | <1-2 | <2 | <1-3 | <1-1 | <1-2 | <1-3 | <1-1 | >10 ug/l | 50 ug/l |
| Se* | <1-1 | <1-1 | <1-2 | <1-3 | <1-1 | <1-3 | 1-7 | <1-2 | >32 mg/l | NS |
| SiO2 | 21.1-26.2 | 19.1-23 | 20-25.2 | 20-25 | 19.4-24.5 | 17.9-24.4 | 16.4-22 | 17.9-22.9 | >1 ug/l | 2.0 ug/l |
| Tl* | <0.002 | <0.002 | <0.002 | <0.004 | <0.004 | <0.002 | <0.002 | <0.002 | N/A | NS |
| V* | 7-30 | 9-30 | 7-30 | 7-30 | 8-20 | <10-20 | 8-14 | 6-20 | >0.12 mg/l | 5 mg/l |
| Zn* | .01-.08 | <0.01-.04 | <0.01-.05 | <0.05 | <0.01-.05 | <0.01-.07 | .01-0.05 | <0.01-.03 | | |

* Total recoverable concentration. All other concentrations are dissolved except Be, CN, and Tl, which are totals.
** Standards are taken from USEPA (2000, 2001) and NNEPA (2001). Secondary standards include Ag, Al, Cl, Fe, Mn, pH, SO4, Zn and the lower limits for F and Cu.

NS No standards have been established for these constituents.
N/A No retest criteria have been established for these constituents.

3. A trace metal value falling outside a historic range could result from one of three factors. First, an impact trend could be starting or further developing. Second, the value could be a real value and the historic range was too limited (total recoverable analyses have only been run since 1989) to encompass all the likely natural variability for that parameter. Third, the value is a true outlier due to laboratory error.

Thus, in setting retest concentration levels for Navajo water trace metals: 1) only ACZ Laboratory data was used to establish historic ranges; 2) because this data in the case of total recoverable concentrations is only available since 1989, possible future natural concentration fluctuations were assumed to be twice those measured over the last 13 years; 3) water quality impact change in an aquifer like the Navajo aquifer and with trace metals should not be abrupt and of high magnitude, but rather gradual with small amounts of change; 4) thus, initial impact-related increases would likely fall below retest levels and not require retesting, whereas true outliers are usually gross errors and would likely exceed the retest concentrations; 5) retest concentrations in most cases are sufficiently below the domestic drinking water standards that persistent increasing concentrations (true impacts) would be retested and confirmed well before a health standard would be jeopardized and remedial measures could be evaluated; and 6) in those cases where the analysis detection limit is at the drinking water standard (Al, Fe, and Mn) there is no latitude on a retest level and the standard is used (since the Fe standard is only for staining concerns, its retest level is slightly above the standard).

Retest values that do not appreciably change shall be considered valid (may be due to longer term natural variability or the start of an impact trend). In such cases, more data will be necessary to determine if the change is not only persistent but if it is increasing in magnitude with time. The subsequent samples shall be collected at the frequencies and for the parameters specified in the main text of Chapter 16. PWCC commits to performing one complete full suite water quality analysis for each Navajo well on an annual basis, performing the retests for all parameters where retest criteria were exceeded, and submitting the data to OSM in the annual report each year.

TDS gravimetric levels will be analyzed for quarterly (requirement of Special Condition 10) along with field parameters. Since only TDS (not the suite of parameters in Table 3

of Chapter 16) is analyzed for, the CAB and TDS Ratio cannot be used as criteria to evaluate the accuracy of the TDS values. In the absence of these, TDS ranges are used. The TDS ranges are presented in Table 6-3 and are based on historic TDS data variability (especially ACZ lab data to minimize inter-lab variability) and with known outliers excluded. Retesting of TDS concentrations will be conducted for all values falling below or above the low and high acceptable range values. PWCC will report the TDS or retest TDS and field parameter values in the quarterly report for the quarter the data was collected in.

The retest criteria for Al, Fe, and Mn are right at or slightly above the domestic drinking water standards for these parameters. Historical data indicate the drinking water standards have been exceeded more than once at some of the Navajo wells. If these retesting levels prove to be too restrictive (naturally occurring levels of the constituents are often above the retest levels), PWCC reserves the right to renegotiate with OSM revised retest concentrations.

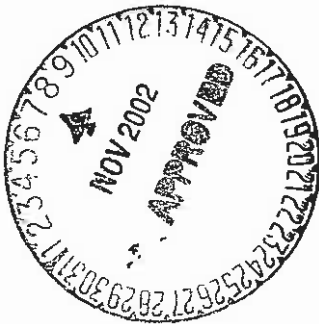


TABLE 6-3

Acceptable Ranges of TDS Concentrations For
Each Navajo Well

| <u>Well</u> | <u>Acceptable TDS</u> <u>Range (mg/l)</u> |
|-------------|--|
| NAV2 | 85-150 |
| NAV3 | 80-145 |
| NAV4 | 95-170 |
| NAV5 | 120-200 |
| NAV6 | 80-160 |
| NAV7 | 110-180 |
| NAV8 | 250-350 |
| NAV9 | 75-145 |

