ALTERNATE METHODS OF SURFACE MINING SEDIMENT CONTROL AND MEASURING WATER QUALITY IN STREAMS[1]

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Abstract.--Over the last 10 years, a method for controlling erosion and sediment production has evolved at the McKinley Mine in western New Mexico. The result is a system of sediment control that uses few sedimentation ponds in conjunction with contour furrows, detention berms, and other methods. The system is still being improved and modified to improve performance and satisfy regulatory requirements.

Conventional surface water monitoring technology is not capable of adequately measuring and sampling runoff events at the mine due to physical effects of streamflow on equipment. An automated, self-contained, flexible monitoring system has been developed to meet the special mine conditions.

INTRODUCTION

This paper is really two papers that ›scribe the practices at the McKinley Mine that :ovide sedimentation control which avoids the lverse environmental consequences of sediment ›nds that the preceeding paper describes while ıtisfying the legal requirements described in .e following paper. The practices include both diment control and measurement of the effects the mine's practices on the streams as they leave the mining area. The first part will describe the alternate sediment control practices that have evolved over time at the mine and the problems that have been encountered and the second part will describe the automated water monitoring system that has been developed to deal with the unusual conditions of the mine.

The alternate sediment control practices used at the McKinley Mine have evolved over the last ten years in response to what has been learned about sediment control structures and changes in regulations governing coal mining. Although the practices are called sediment control, their function is one of erosion control and their benefits are in meeting the regulations covering discharge from coal mining areas, in satisfying the rules concerning minimizing the impacts of such discharge on the area's hydrologic balance, in improving the quality of revegetation on reclaimed areas, and in protecting the utility of the reclaimed areas.

EVOLUTION OF THE ALTERNATE SEDIMENT CONTROL PRACTICES

The first practice used at the mine was the creation of contour furrows by a modified Rome disc. The disc has oversize platens at four foot intervals that form six-inch deep furrows as it is pulled in front of the seeder when reclaimed mined

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is revegetated. The disc was originally a low cost method intended to reduce the formation of rills and gullies that destroyed seeded areas before the vegetation established itself sufficiently to inhibit erosion. Subsequently, rules adopted by the New Mexico Mining and Mineral Division (MMD) to satisfy the Federal Department of Interior Office of Surface Mining Reclamation and Enforcement (OSM) permanent program allowed the use of alternate sediment control in place of sedimentation ponds if the alternate contained the runoff from the 10-year/24-hour storm. Using standard Soil Conservation Service models the furrows were predicted to be sufficient to contain the desired volume of runoff on slopes as steep as 5:1. On steeper slopes their tilted cross-section lost enough storage that the model predicted runoff, and since the disc spacing was fixed, there was no way to provide any additional storage.

To provide sufficient storage to meet the regulatory requirements a series of detention berms was added to the furrows. The berms are similiar to the terraces described in Chapter 8 of the SCS Engineering Field Manual (SCS, 1984), but are usually smaller. Of course, at the time we were unaware of the SCS manual so we reinvented a nomograph that would allow the staff to properly size berms for a particular area. Generally, berms are between 6 inches and 24 inches deep and less than 200 feet apart. The intent was to have smaller structures that are closer together than the SCS terraces to be less obtrusive and have greater redundancy. Also since the area is being reclaimed as rangeland rather than cropland, there is no need to provide spacing for agricultural machinery and row crops between the berms.

The design nomograph is different from the SCS nomograph in several ways. First, it is specific to the McKinley Mine since it is based on the soil runoff curve numbers for the mine's conditions and considers only the mine area's design storm. Second, it includes a sediment storage volume sufficient for ten years and storm storage equal to twice the runoff of the 10-year/24-hour storm. (The additional storage was included as a safety factor to compensate for variations in berm construction since storms less than the design storm appeared to be exceeding the capacity of the furrows.) The development of the nomograph is straightforward and once accomplished provides an easy way to select berm height and spacing for a particular surface condition and slope.

There is one additional evolutionary stage in berm development. While the original design was intended to satisfy the MMD rules, the OSM ultimately became the lead agency reviewing the mine's environmental controls because of the mixed jurisdiction of lance within the McKinley Mine permit boundary. The OSM does not have an alternate sediment control provision in their regulations and so reviewed the mine's system under the siltation structure regulations. Of course, the berms and furrows did not meet the design criteria concerning spillways. The solution was to create two types of berms; interior berms which are the same as the berms described above and perimeter berms which include spillways capable of passing the design storm for permanent structures. The perimeter berms are to be used along the boundary between reclaimed land and other areas such as undisturbed land, facilities, and roads. In this way the regulations are satisfied and berms and furrows are satisfactory sedimentation control for reclaimed areas.

Of course, not all of the mine is reclaimed land. There must also be a sediment control system for the shops, mining pits, roads, and rail facilities. For drainage from the shops and offices non-discharging sedimentation ponds have been built. Despite the adverse impacts of ponds, they were the most appropriate control methods for these areas because the affected drainage area is small, the facilities are permanent (at least for the life of the mine), and ponds provide an additional method to contain any spills or contamination that results from the fuel storage, oil and grease, and solvents that are concentrated in the area.

For the active mining pits and ungraded spoils any drainage is contained in the pit and disposed of through evaporation. The pit drainage collects in the lower end of the pit and is either left there to evaporate or is pumped to another area to be contained and evaporated if coal removal is being done where the water naturally collects. Drainage from the ungraded spoils collects in between the spoil ridges and either stay there or flows into the pit along one of the access ramps. The only area that might drain away from the pit is the outslope of the last ungraded spoil ridge behind mining. Drainage from this relatively small area is to be contained by a berm built along the base of the spoil outslope during the grading process.

For roads and railroads, the OSM rules are different in that they do not specify that all drainage must pass through siltation structures but that drainage must be treated by the best available technology. After presenting the arguments to OSM on the adverse impacts of sediment ponds, an agreement was reached that the goal for drainage from roads and the railro[ad] would be to maintain sheet flow wherever possib[le] and where concentrated flow did occur it would be conveyed by noneroding structures to undisturbed areas.

The last area to be covered to provide a complete sedimentation control system is the treatment of rills and gullies when they do occur. For small rills they will be filled by hand. Larger rills and persistent rills will be stabilized using a series of fabric fences or straw bale filters. Gullies are to be stabilized using porous check dams designed an[d] installed according to the method developed by the USDA Forest Service (Heede 1966, 1976 and 1977).

There will be some areas in the reclamation rills and gullies persist despite all ts to avoid them. In these areas the el that forms will be stabilized where the ntrated flow threatens to continually erode reclaimed areas. It is necessary to allow ne formation of channels in the reclamation they were there before mining. Although erms and furrows are intended to hold as precipitation as possible, runoff will occur eeds to be allowed for in the overall nation and sedimentation control system. ization is likely to be channel rip-rap ossibly gabions to hold meanders until the ation has had a chance to establish itself.

ERIENCE WITH ALTERNATE SEDIMENT CONTROL

From the description of the alternate nt control, it should be apparent that the s not developing new technology but is ng available methods. Even in using methods some new problems are found. In the furrows alone, they worked well as long y were put in late enough that the vegeta- ad a chance to emerge before the area was an intense thunderstorm. Where they were ace soon enough the area would develop so ills and so much of the topsoil would be ced that the only way to repair the damage regrade the topsoil and reseed the entire This was unsatisfactory in the long run e the frequence of the washouts was such s much as 20% to 30% of the area would o be graded and seeded twice.

he one problem with the furrows was that erator did not always follow the contour. they were off countour they channeled water low spot on the furrow which then over- that furrow and all the furrows below it g a rill that went all the way down the le. The solution was to survey in stakes) guide the operator, especially in draws e the natural instinct is cut across them than follow the contour around them.

ding the berms to the furrows was also d to help since they would add to the but failures continued to be frequent. bination of berms and furrows together containment system that has a capacity than three times the runoff from the /24-hour storm, plus the berms add sedi- orage. Using the SEDIMOT II runoff model nate the capacity of the combination of nd furrows, this much storage should be ent to completely contain the runoff from than the weight of the grader to compact t as it is built or to use multiple pass tion techniques. Another alternative is a specialized plow or similar device l dig the trench and compact the bank at time. Modified construction methods investigated in the next several years, present emphasis is on building the erimeter berms to meet regulatory s.

Some other problems in berms and furrows have been solved by familiarizing the people building the berms with their purpose and design. Some of the early berms failed because they were not installed soon enough after topsoil replacement 100-year storm for slopes less than 5:1. However, in the field the berms and furrows breached so often that they appeared to hold less than the runoff from the 5-year storm. In review- ing the possible causes for the failures, the design calculations were one of the first possi- bilities that came to mind.

The original design used an SCS type II storm for 1.8 inches of rainfall over 24 hours. The storms that were causing the breaches were in the range of 0.5 inches to 1.0 inches but lasted less than an hour. In modeling these events using SEDIMOT II, the runoff from the smaller, but intense storms can exceed the design storm runoff but still should be less than the capacity of the combination of the berms and furrows. One of the uses of the automated monitoring system that is described later is to verify the model's predictions to see if curve numbers or anticedent moisture conditions must be changed to account for the rainfall-runoff relationship for the area's intense, brief storms.

If the model is correct then the cause of the breaches must be in the construction of the berms. Even after staking the contours some of the berms and furrows are not horizontal. To prevent their becoming channels spir dikes are placed perpendicular to the berm to block flow. These dikes are no more than 200 feet apart and are closer together in critical areas such as drsws. Also, the mine plans to add a device to the hydraulic height adjustment on the disc that creates the furrows to occasionally, briefly raise the disc to block flow along the furrows it makes. These changes should reduce the risk of breaching from off contour berms and furrows.

Another problem that caused breaches is "melting" berms. The bank thrown up by creating the incised portion of the berm contributes to the storage volume and this bank has been prone to failure from piping or infiltration in the loose soil forming it. The best method to solve this problem will be to compact the bank either by modifying the construction method to use the weight of the grader to compact the bank as it is built or to use multiple pass construction techniques. Another alternative is to build a specialized plow or similar device that will dig the trench and compact the bank at the same time. Modified construction methods will be investigated in the next several years, but the present emphasis is on building the larger perimeter berms to meet regulatory deadlines.

Some other problems in berms and furrows have been solved by familiaring the people building the berms with their purpose and design. Some of the early berms failed because they were installed only on the lower slopes. When rain hit the area before the upper berms and furrows could be built, runoff from this area quickly overwhelmed the controls on the lower slope to the extend that the entire hillside had to be regraded and seeded. The lesson is that runoff units must be reclaimed entirely for the controls to be able to have sufficient capacity to perform properly. This means that the grading and top-soiling schedules must consider slopes and drainages as well as mining pit progress.

ALTERNATE SEDIMENT CONTROL SUMMARY

The approach to sediment control at the McKinley Mine, using a variety of techniques and minimizing the use of sedimentation ponds, appears to be workable. Some problems with the use of berms and furrows still need to be solved and design calculations reviewed and verified to determine if standard storm models work for the short, intense storms typical of the mine. Since the sediment control strategy is workable, acceptance of this nonstandard method by the regulatory authorities will depend on showing that the system provides the benefits and avoids the adverse impacts that are claimed. The critical part making the showing is supporting the water quality arguments with streamflow and water quality samples which is the subject of the next part of the paper.

BACKGROUND INFORMATION

McKinley Mine is located in McKinley County, New Mexico approximately 25 miles north-west of Gallup. The mine has been operated by The Pittsburg & Midway Coal Mining Co. (P&M) since 1963. The mine is geologically located in the southwest reaches of the San Juan coal basin. Mean actual rainfall is 15 inches.

High intensity localized thunderstorms during the months of July, August and early September generate flash flooding in the ephemeral drainage channels at McKinley Mine. Runoff volumes varying from a trickle up to peak volumes of 2,000 CFS peak flow may occur during a single event. The flows are turbulent, carrying high concentrations of total suspended solids (up to 250,000 ppm), total iron (up to 6.0 mg/l) and total manganese (up to 2.0 mg/l). Values for iron and manganese are high due to the heavy sediment loading. The pH tends to be slightly alkaline (7.5 to 8.0).[6]

Mass bank caving, extensive headcutting a local refuse disposal habits result in large amounts of vegetative debris and human refuse (everything from household garbage through she metal from junked cars) being carried by runof events. This floatsam carried by the flashy runoffs characteristic of the area creates a sampling environment that is incapable of bein monitored by conventional monitoring equipment

PREVIOUS MONITORING EFFORTS

From 1979 until 1983 conventional surfa water monitoring equipment and facility in-stallations were deployed in the ephemeral drainages at McKinley Mine. Instrumentation a 13 locations included single stage sediment samplers (12 bottle levels mounted on two incl by 12 inch by 10 foot boards cemented into th wash three to four feet), and crest stage gag (two inch steel pipe cemented three feet into the wash floor). At two locations, three foo culvert stilling wells equipped with Stevens stage height recorders and flow activated Man S4040 samplers were maintained.

Attempted use of these installations th four runoff seasons dictated that alternate methods of deployment and equipment sampling methods would be required if acceptable per-centages of data and samples were to be reali The equipment was perpetually clogged with del and silted in by flow events. Masses of vege-tative debris and trash collected on upstream portions of equipment and housings resulting the wash out of the monitoring facilities. Extrapolation of rainfall and flow data[7] for monitoring during the 1983 runoff season indi that less than ten percent of the total poten data and samples for this period were actuall recorded and retrieved.

REVISED MONITORING PROGRAM DEVELOPMENT

Goals

In 1983 P&M decided to develop a surfa water monitoring system that would be as sel contained as possible, reliable, and capable continued operation under the physical condi at the mine. It was also a goal to make the monitoring program more manageable by reduci the total number of stations.

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[6]Erickson, W. R. Unpublished water monitoring data on file for the McKinley Mine, The Pittsburg & Midway Coal Mining Co., McKinley County, New Mexico.

[7]Bean, A. McKinley Mine 1982 Air Quali Report. The Pittsburg & Midway Coal Mining Denver, Colorado.

Regulatory Review and Interpretation

Because McKinley Mine is situated partly on and partly off of the Navajo Indian Reservation, and because the mine has not yet been issued a permanent program mining and reclamation permit, several sets of regulations are applicable. These included the Office of Surface Mining (OSM) 25 and 30 Code of Federal Regulations, The New Mexico Mining and Minerals Division (NMMMD) 79-1 and 80-1 Regulations, and Environmental Protection Agency (EPA) National Pollution Discharge Elimination System (NPDES) regulations. The monitoring and reporting requirements of all of these regulations were analyzed to determine the most stringent set of performance requirements for surface water monitoring. The revised surface water monitoring system was approved by both the OSM and the MMD prior to manufacturer and erection.

Specific Mine Site Problems and Needs

Problems and needs unique and/or specific to the McKinley Mine of potentially significant economic impact were then added to the regulatory requirements for the monitoring system. Items and issues included more accurate estimation of erosion at the mine, procurement of adequate baseline information for upcoming mining areas, and the establishment of a constant reference point for tracking of long term hydrologic trends at the mine, particularly concerned with bond releasal.

Since the McKinley Mine lease covers approximately 27,000 acres, it waa also important to minimize the total number of station locations required for monitoring. An additional problem was encountered by the requirement to monitor water upstream and downstream of the permit area. McKinley Mine lies at the top of the regional watershed. This problem was solved by installing monitoring stations in the four major washes containing land to be disturbed by mining during the next 15 years and through the eatablishment of a background monitoring station on Coal Mine Wash just west of the permit area. Lands within this wash's drainage will remain undisturbed by mining for the life of the mine. In this way a comparison point was established and approximately 90 percent of runoff from active areas at the mine were included in the monitoring program system.

Passive vs. Automated Monitoring Program Costs

An economic analysis of the cost for construction and operation of a passive monitoring network and an automated monitoring network was performed. Initial construction of an automated network was estimated to be five times greater than passive network costs. However, costs of manpower requirements for repair, maintenance, servicing and operation activities for the passive system were estimated to be $150,000.00 dollars more than for the automated station over a ten year operational period.[8] Initial construction costs were included in this estimate.

Additional intangible economic benefits would be realized with the use of washout proof structures. The increase percentages of data retrieved coupled with the long term nature of the stations is expected to prove invaluable in establishing records for water quality and quantity, regional geomorphological trends and bond release for reclaimed lands. No attempt to quantify these items was made in the economic analysis.

REVISED SURFACE WATER MONITORING STATION HOUSINGS

Submergent vs. Emergent Housings

The most crucial design decision encountered in the program revision was whether to use a watertight, submergible housing or an emergent one not subject to immersion during flow events. Submergent housings were being used at Peabody Coal Company's Black Mesa/Kayenta Mine. These installations were located in washes five to seven times wider than those at the McKinley Mine. One benefit of the submerstet housing was the fact that lift capacitiea of sample retrieval pumps was not of concern.

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[8] Erickson, W. R. November 1982. Surface Water Monitoring Program McKinley Mine. Internal company report. The Pittsburg & Midway Coal Mining Co., Gallup, New Mexico.

However, in order to provide adequate room for the monitoring technician and equipment, submergibles would have to be fairly large in size. Structures at McKinley would occupy 20 to 35 percent of the wash cross-sectional volume if erected. Concern that such an obstruction would cause itself to be eroded out of the channel was paramount.

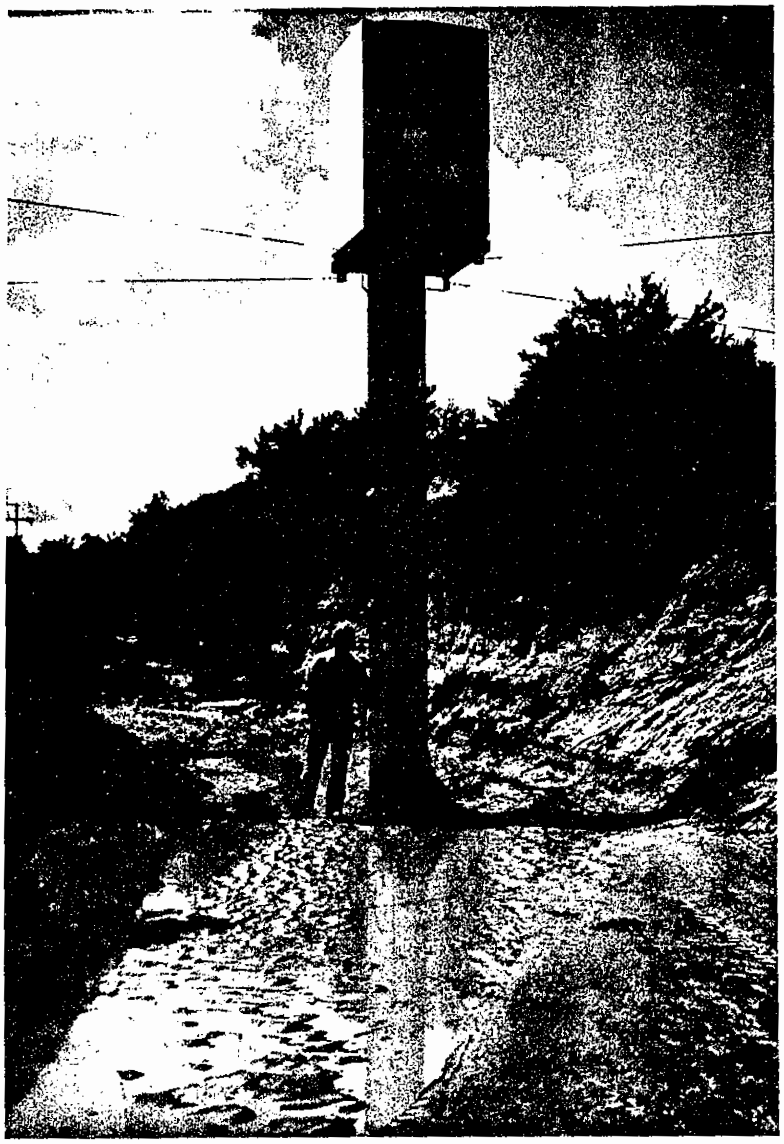

Figure 1.--Surface water monitoring station located in Coal Mine Wash.

With these restrictions in mind, P&M opted to erect the emergent housings (figure 1). Their narrower cross-sectional volumes would impact the channel much less and the chance that leaks could develop in the housing and flood equipment were eliminated. Bouyancy/anchoring problems associated with the submergible housings were also avoided. The principal draw back of these structures was the intake lift limitation of water sampling equipment. It was determined that these problems could be overcome with auxillary pumping equipment and that this limitation represented a much smaller problem.

Housing Pedestals and Anchoring

The principal anchoring component supporting the equipment housing above the wash are three, six inch, schedule 80 steel pipes set into the arroyo to a depth of 25 to 30 feet. No bedrock was encountered when drilling operations were conducted to set the pipes. A coal exploration drill was used to set the pipes. Two inch angle iron forms bracing between the three pipes. The pipes are placed in a triangle in the middle of the wash floor. The narrow end of the triangle points upwash. The triangle formed by the pipes is approximately two feet wide on the downwash side and three and one-half feet on each of the other two sides (from pipe center to pipe center). The pipes were treated with anti-corrosion agents prior to placement.

Four cement footers were placed in a large X on the banks of the arroyos with the station centered in the middle of the X. Three-eights inch anchor cables attach from the corners of the station to the cement footers. Engineering calculations showed the station structure capable of withstanding of flow rate of 2,000 CFS with a safety factor of five.[9]

Steel plate one-fourth of an inch thick encloses the housing pedestal pipes. This plating protects the monitoring equipment which extends down into the wash from the housing and serves to streamline the station profile. Space

[9]Bloom, J. McKinley Mine Water Station Erection Specification No. PM-G383. The Pittsburg & Midway Coal Mining Co., Denver, Colorado. May 1983.

vertically along one upwash side of the plating at six inch intervals are sample intake port attachment holes. The other upwash side has access doors spaced from the wash floor to the bottom of the housing frame allowing for equipment access.

Equipment Housings

Fiberglass housings four feet square and six feet tall are attached on top of the pedestal formed by the pipes. The housing has a sliding door and ventilation is provided by a small fan. Solar panels are mounted on top of the housings and supply power for the monitoring equipment. All of the stations have a small landing platform in front of the door on the downwash side of the station. At the three tallest stations, catwalks with security gates connect the station landing with one arroyo bank. The two shorter stations have a lockable trap door in the landing platform which provides access. A ladder on the platform allows access to the roof of the housing for solar panel servicing.

WATER MONITORING EQUIPMENT

General Description

The present surface water monitoring equipment ia comprised principally of a computerized controller, Stevens Type F stage recorder and Manning S4040 discrete pump sampler. The system is battery powered with solar recharging. A diagrammatic representation of the system and component interaction is presented in figure 2.

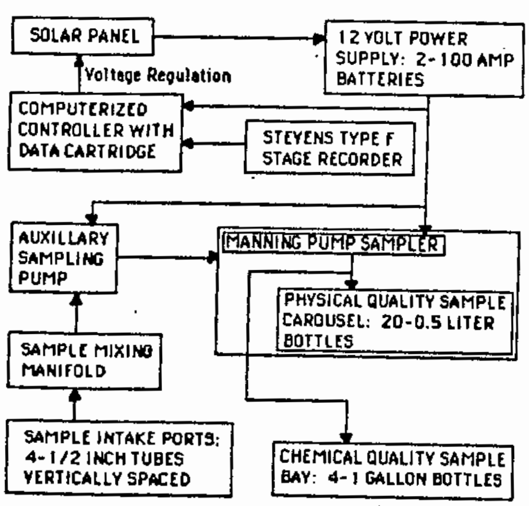

FIGURE 2-SURFACE WATER MONITORING SYSTEM COMPONENT INTERACTION

Measurement of Flow

Cement weirs for channel control and flow measurement were considered for placement in the washes. Conversations with Jack Dewey (USGS-Albuquerque) concerning monitoring installations in other portions of the San Juan Basin indicated that construction of weirs was not necessary to obtain reasonably accurate flow rates. He indicated runoff curves for a given watershed may be developed which estimate flow rate within 90 percent of actual using indirect flow calculations. Verification of flow rate curves would need to be made with direct flow measurements. The large cost of installing weirs and the potential for their erosion out of the channel convinced P&M to utilize the indirect flow measurement methodology as described by the USGS.[10,11]

Indirect flow measurements utilize three channel cross-sections at each station. High water surveys are used in indirect flow rating of channels along with direct measurements for flow curve development and verification. Stage height measured by the station is correlated with the flow curve.

A ten inch PVC pipe is used for the gaging stilling well. It is held in place by plumber's strap towards the back of the enclosure formed between the steel plates surrounding the station legs. The stilling well is vertically adjustable so the level may be moved in response to scour and deposition of sediment in the channel.

Small transmissivity holes were originally drilled into a PVC cap to dampen float chatter. Clogging problems were experienced with this system. To solve the clogging problem the end of the PVC cap was removed. Three one-eighth inch aluminum rods were then inserted into the PVC cap just above the end in an overlapping triangular pattern. The rods form a positive bottoming out platform for the gaging float and allow the stilling well to be self-cleaning. Dampening of float chatter is provided by the computerized data acquisition equipment described in the next section.

A Stevens Type F recorder with a potentiometer is used to measure stage height. The drum chart is used as a backup for the computer system. Gearing for stage height is

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[10]Buchanan, Thomas J. and Somers, William P. "Discharge Measurements at Gaging Stations", Techniques of Water Resources Investigations of the U. S. Geological Survey. U. S. Government Printing Office, Washington, 1980.

[11]Dalrymple, Tate and Benson, M. A. "Measurement of Peak Discharge by the Slope-Area Method", Techniques of Water Resources Investigations of the U. S. Geological Survey. U. S. Government Printing Office, Washington, 1976.

1:10. Time gears used during the runoff season and dry season are eight and 30 days, respectively. The potentiometer sends electronic stage height signala to the computerized controller.

Scour chains are not used in the cross-sections. Since 90 percent of the material suspended in flow events is 65 microns in diameter or smaller, it was decided not to employ these chains. The high labor intensity involved in their use also makes them prohibitive. Should they be deemed necessary during future monitoring their use could be employed.

DATA ACQUISITION EQUIPMENT (COMPUTERIZED CONTROLLER)

General Description

Event sampling activities are based on stage height measurements received by the computerized controller from the Stevens and time measurements. The data acquisition equipment was manufactured to P&M specifications by Creative Systems, Inc., Fort Collins, Colorado. The controller is the brain of the system and coordinates all other activities.

The electronic equipment is mounted in an air-tight metal enclosure. An LED readout and push button control panel allow input and viewing of functions chosen. Replaceable sacks of desaicant in a small PVC tube in the enclosure control humidity in the controller.

The data acquisition equipment records date, time, stage height, time of significant event recognition, and chemical and physical sampling times and bottles filled. Data is transferred from the field unit through the use of a memory cartridge. Data recording time span of the cartridge is variable and depends principally on the frequency that stage height is recorded. At five minute recording intervals the cartridge memory spans about two weeks. The cartridge is read onto P&M's DEC mainframe computer system using a Rainbow PC and special cartridge reader. Analysis and processing of the data is done through available and custom programs. The controller is divided into five functional sections with elements as described in the following sections.

View Set Controls

This section allows the operator to view and change sampling and measurement parameters. Parameters include the following as defined:

Event Height--The level of stage that must be reached for a significant event to be recognized. This level is presently designated as one foot. At this height the water sampling routines are triggered.

Event Wait--Elapsed time period required from the start of a significant event to the allowable of recognition of a subsequent significant event and associated chemical water sample retrieval. This delay period is used to prevent triggering chemical sampling from surges in stage height as runoff from subwatersheds within a station drainage reach the station.

Chemical Delay--This is the amount of time delay after recognition of a significant event that a chemical quality sample is taken.

Stage Recording Time--This is a stage height filter based on algorithms which uses values from zero to ten minutes.

Stage Recording Period--This is the frequency that stage height is recorded in the memory of the controller unit.

Sample "N" Delay--This is the amount of time from the recognition of a significant event that the nth sample is taken.

System Tests

This section allows the operator to perform sampling function operational tests. Functional tests include:

Physical Quality Sample--A one-half liter sample is pumped into the Manning sample carousel.

Chemical Sample--A four liter water sample is pumped into the chemical sample bay.

Find Bottle "N"--The nth bottle in the carousel is located.

Element Tests

This section allows testing of individual components of the system and includes:

Stage Height--The reading sent to the controller by the potentiometer on the Stevens recorder.

Date and Hour--Includes day, month, year and time.

Cartridge Test--Checks for the proper insertion and function of memories in the data cartridge.

Bottle Advance--Advances the Manning filler spout one carousel location.

Several additional tests of values, pumps and compressors are also included.

Special Operations

This section of the memory is protected by an access code. Any functions and parameters from the above sections may be placed in this ction to allow limited accessibility if desired. is must be done during microchip programming.

View Data

This section is memory reserved for the dition of future monitoring programming, if eded.

WATER SAMPLE COLLECTION

A modified Manning pump sampler controlled the data controller retrieves water samples. inline auxillary pump assists the vacuum pump the Manning during sampling. The carousel in e Manning contains 24 sampling locations. The rst four of these locations have been fitted th funnels to route samples to one gallon, emical sample bottles. The remaining locations ll the one-half liter, physical bottles in the rousel.

The intake manifold for sampling has underne several metamorphoses. Initially it was innded that discrete level sampling be conducted. mples were to be drawn from one of four sample rts most closely approximating 40 percent of e total stage height. Problems with vacuum sses in the Manning sample line prevent sampling this fashion.

At the present time four sample ports rtically aligned convey water through nylobraid bing (double-walled, fiberglass reinforced, exible plastic) to a mixing chamber. A one way lve on the exhaust end of the chamber prevents ter samples from entering. Nylobraid tubing is ed to route samples to the Manning. Excess ter drawn up the tube is exhausted back into wash.

Power Supply

Power to run the equipment is supplied by 100 amp, 12 volt, heavy duty batteries. The teries are recharged by a solar panel that is ulated by the data controller. The single gest consumption of power is by the Manning sampler and the auxillary pump during sample rieval. Consumption of power by the remainder he data acquisition equipment is negligible. system can run for several days without any arge from the solar panels.

CONCLUSION

The revised surface water monitoring program at McKinley Mine was designed to withstand the rigors of the sampling environment in which it is placed. The equipment and housings have demonstrated their ability to function in these conditions. The system is not static, but is still undergoing refinement as problems present themselves and solutions are found. The system provides a constant reference point for the long term monitoring of water quality and quantity from "undisturbed" and mining disturbed lands at McKinley Mine. The stations are designed for long term usage and may be relocated upon termination of monitoring at a given location.

DESIGN ACKNOWLEDGEMENTS

During development of this program numerous contacts were made with government agencies, consultants, coal companies and members of the environmental community. Although a complete listing of all of the individuals contacted during development is impractical, acknowledgement for invaluable critique of the system is due those individuals. Mr. Ted Smith of Peabody Coal was particularly helpful with tours of Black Mesa Mine monitoring facilities. His successes in monitoring inspired and convinced those of us who bad searched in knee deep mud for washed out equipment too many times, that it would be possible to establish wash out proof structures in the ephemeral drainages. The time spent reviewing and developing the program with employees of the OSM-Western Technical Center, OSM-Albuquerque Field Office, U. S. Geological Service (Denver and Albuquerque offices) and the NMMMD is appreciated. A special thanks to Ron Lingemann and Joe August of Creative Systems, Inc. for making the electronic portion of the system a reality. Finally, a big thank you to technical, environmental and engineering staffs of P&M 's Denver office, Southwestern Division office and McKinley Mine, including Alan Balok, Allan Bean, Jim Bloom, Bob Davis, John Hinton, Paul Leidich, John Monarch and Ben Wolcott.