Monitoring of Pittsburgh seam mine water and hydrogeology in northern West Virginia (project HRC-5)

Final Report, Project HRC-5

Joseph J. Donovan
David Light

June 2008

West Virginia University
West Virginia Water Research Institute
Hydrogeology Research Center

ABSTRACT

An investigation of mine pools and discharges in the Northern Panhandle was undertaken with the goals of locating mine discharges and gathering information on mine pools in closed coal mines. A new monitoring well was drilled into the Valley Camp #3 Mine in order to investigate the pool within this mine. This well was a replacement for another well, which has been reclaimed. Mine pool elevations were monitored hourly within the Valley Camp #3, Alexander, and Glen Dale mines. Mine discharges within Ohio County, WV were located and mapped with the assistance of personnel from the City of Wheeling, West Virginia Water Pollution Control Division. These discharges were then associated with probable source mines using a geographic information system.

In the Morgantown, WV area, potentiometric elevations within the Fairmont and Morgantown pools were also monitored. The level of the Fairmont pool has remained relatively constant, excepting seasonal variation, throughout the study period. Within the Morgantown pool, a recently initiated pumping and water transfer scheme has caused rapid fluctuations in groundwater pressure head in portions of the pool. Continued monitoring of these wells is necessary as pumping gradually changes the distribution and pressure of mine water in the flooded Pittsburgh mines. In addition, some locally pressurized portions of some coal mines have the potential to discharge to the surface if not carefully controlled.

ACKNOWLEDGEMENTS

The investigators thank the City of Wheeling, West Virginia Water Pollution Control Division, for access to their records and facilities. King Campbell, Director, and Andy Harris and Virgil Smith of the operations staff contributed valuable time and discussion. Frank Borsuk of the USEPA provided assistance surveying discharges to the Ohio River. Don Rigby of the Regional Economic Development Partnership in Wheeling facilitated access to the Millennium Center drillhole location. Bruce Leavitt assisted in design, drilling, and installation of the Millennium Center well. Three-D Drilling of Kingwood, WV, provided drilling and well installation services.

TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

PLATES AND APPENDICES (inset sleeve)

INTRODUCTION

MINE POOLS IN THE PITTSBURGH SEAM

The Pittsburgh coal basin contains the most extensive and continuous economic coal deposits mined to date in Northern West Virginia and southwestern Pennsylvania (Plate 1). It has numerous shallow above-drainage underground mines near its outcrop, as well as much deeper and larger below-drainage mines in the central part of its basin. Many of these deep mines have undergone closure in the last four decades and have been allowed to partly or wholly resaturate (Plate 2). As a result, the Pittsburgh seam today contains large reservoirs of below-drainage mine water, often near currently active mining operations maintained in the dry.

The purpose of this investigation is to compile observations regarding the hydrogeology of mine pools in Northern West Virginia. The focus of the investigation is on two separate areas of the Pittsburgh coal basin in West Virginia: a) the eastern side of the basin from between Fairmont, WV and Mt. Morris, PA, (Monongalia and Marion Counties, WV, plus contiguous mines in Greene county, PA), and b) the western side of the basin (Marshall, Ohio, and Brooke counties, WV, plus contiguous mines in Washington and Greene counties, PA). The eastern area lies fully in the Monongahela River drainage, while the western side lies in the Ohio River drainage.

The objectives in these two hydraulically-distinct study areas were (a) to track water levels in selected flooding or flooded underground mines, (b) to identify locations of mine-water discharge, and (c) to locate mine-water pumping that potentially influences pool elevations.

In Area A (Monongahela drainage), the principal deep mines targeted in this investigation are, from south to north: the so-called Fairmont Pool (Bethlehem #41 and Bethlehem #8 (Barrackville mine), Idamay #44, Jamison #9, Mountaineer #92, and Dakota mines); Jordan; Arkwright; Osage; Pursglove; Humphrey; and Shannopin, which lies just north of the PA-WV border near Mt. Morris. These mines were currently involved in water diversion between mines, intended to route mine water to new and existing large treatment plants in the basin. Deeper mines farther downdip are either active operations (Loveridge, Blacksville #2, Federal #2) or closed mines completely roofed with mine water (Joanne, Barrackville, Federal #1, and Blacksville #1). All these mines possess an updip barrier hydrologically isolating them, to greater or lesser degrees, from shallower flooded mines. The pools in several other large mines are maintained at low levels to reduce the hydraulic pressure on barriers adjacent to active works (O'Donnell, Jamison, Williams).

In Area B (Ohio drainage), relatively less was known at the outset of this investigation regarding the status of mine flooding. In this study, one mine in particular – Valley Camp #3, with its reclaimed main portal near the town of Elm Grove – was thought to represent a potential discharge into Middle Wheeling Creek. To date, no discharge into Middle Wheeling Creek has been found or reported. Therefore, in addition to monitoring, an additional objective in Area B was to ascertain where the saturated zone in Valley Camp #3 lies and when/if it might form a discharge. This involved drilling a new observation well into this mine to ascertain the pool elevation with certainty.

In both areas, data collection allows a further level of synthesis for the hydrogeology of these flooded workings in the Pittsburgh seam. This synthesis includes an assessment of how many of these mines currently have discharges, and which, if any, of these mines will require intervention to prevent future discharges.

METHODOLOGY

WATER LEVEL MONITORING

Water levels in Areas A and B are monitored hourly by pressure transducers installed within wells penetrating the mines, and bi-monthly using a water-level measuring tape. Data processing and storage are via an Access database, while graphical display is via an Internet website. At the beginning of the project, mine pool elevations were monitored within ten mines in Area A and two mines in Area B. Two additional monitoring points were added in Pursglove (Area A) and a new monitoring well was installed into a mine in Area B. During the course of the project, mine-water transfer pumps were installed by a local mine operator (a) into Humphrey Mine to divert water into Pursglove Mine, and (b) into Osage Mine to move water from Osage into Arkwright Mine. The locations of these new pumps as well as the monitoring well locations are shown on Plates 1 and 2. Additional mapping was conducted in the Wheeling area with the location of mine-water discharges to both sanitary and storm sewers. Water level elevations within the mines were established using water-level elevations as well as the structural contours for the base of the Pittsburgh coal.

Two types of pressure transducer were utilized. At the beginning of the project, all of the pressure transducers were Global Water™ WL-15 Water Level dataloggers. This device is a combination vented pressure transducer and datalogger. A cable containing vent tubing and electrical wires connects the sensor and logger. At a pre-programmed interval, the sensor measures the submergence depth, which is stored by the datalogger. Since the sensors are vented to the atmosphere, gage pressure head of water above the sensor elevation (with respect to ambient atmospheric pressure as a datum) is recorded and no atmospheric correction is necessary. The other loggers are Onset Computer Corporation™ Hobo water level loggers. The Hobo loggers are sealed, non-vented units that measure total pressure with respect to an absolute vacuum. To translate these data into pressure head values requires barometric correction. The sensors are programmed to record absolute pressure at hourly intervals and the data are corrected using barometric pressure data collected with a Hobo logger installed at a nearby location. The Onset loggers are a newer design and have been used for instrumentation as well as to replace older logger units that either failed or became insufficient in pressure range to measure the full magnitude of fluctuations observed after mine pumping commenced.

The method for hanging transducers differs for the two types of logger. The Global™ loggers are connected to a computer reading fluid pressure below the potentiometric level continuously, and the sensor is lowered into the well, until the desired submergence depth is achieved. After the sensor depth is set and fixed, the cable connecting the sensor to the logger is suspended from a bolt within the wellhead. The depth to water in the well is measured using a conventional water-level measuring tape. The sensor depth and depth to water are then subtracted from the measuring point elevation to yield the sensor elevation. The sealed Hobo transducer/dataloggers are submerged in the monitoring well at the desired sensor elevation from a 1/16" stainless steel cable (non-electrical) attached to hanging bolts. The cable length is measured manually using a survey tape. The sensor elevation is determined by subtracting the length of the cable from the surveyed measuring point (bolt) elevation.

Pressure data are retrieved from the loggers on a bi-monthly basis. Global™ loggers are connected to a computer via a serial cable and software is used to retrieve the data, stored as comma-separated (CSV) files for processing. Batteries and desiccant are changed during each download period and the sensor is tested to ensure that it is working properly. The Hobo loggers are retrieved from the wells by removing the sensor completely from the well, winding the cable onto a spool. The logger is then attached to a computer and the data are downloaded using an optical USB interface. Following the data download, the logger is lowered back into the wellbore and replaced precisely at the sensor elevation.

Both types of dataloggers are programmed to record at hourly intervals. The Hobo sensors record absolute pressure while the Global loggers record water pressure only due to atmospheric venting. Software for either type of sensor is used to convert the pressure data to water depth and then to hydraulic head of fresh water. The Hobo software subtracts barometric pressure from absolute pressure recorded in the well and then converts the pressure reading to sensor depth. The sensor depth is added to the sensor elevation yielding the mine-water hydraulic head elevation.

A water-level measuring tape is used to manually determine the depth to water below the measuring point during each site visit. The depth to water is then converted to groundwater elevation by subtracting the depth to water from the measuring point. The groundwater elevation is used to establish the installation elevation of the Global Water sensors and also for quality assurance and quality control of the pressure transducer data. The manually determined groundwater elevations are plotted graphically along with the hourly data recorded by the pressure transducers. This allows visualization of any discrepancies in the sensor data. If necessary, the sensor data can then be manually adjusted to fit the manual water elevations. The Global Water sensors tend to be susceptible to varying environmental conditions, so the manual data provides information on the state of the sensor.

At the beginning of the project, water levels in thirteen wells were being recorded by Global Water WL-15 water level sensors. During the course of the project all but three of these probes were replaced with Hobo sensors. The replacements were dictated by both humidity-related sensor failures and to sudden large changes in water level exceeding the range of the WV-15 sensors. The replacement Hobo sensors are sealed (no atmospheric vent) and have the logger as well as the sensor submerged below the water level, eliminating the need for vent tubing/electrical cable between sensor and the surface as well as for desiccant to keep the sensor and logger dry. The Hobo sensors are available in 13, 30, 100, and 250 foot ranges, and longer ranges were selected to accommodate the large head fluctuations observed in the post-flooding mines of this area. Only one of the Hobo sensors failed during the study period. The failure was due to an extreme sudden change in pressure head, which was far in excess of the range of the sensor. The failed sensor was replaced with a suitable range sensor.

DISCHARGE AND POOL MAPPING

AMD discharges in the Ohio Valley area were measured using a handheld WAAS-enabled GPS unit, typically accurate to ±20 feet or better. The AMD locations consisted of discharges into the Ohio River, discharges into other surface water bodies, and discharges flowing into the Ohio County sanitary or storm sewer system. The Ohio River discharges were mapped using a boat. The boat was stopped as near to the discharges as possible and the locations of pipes or other discharges were recorded. The GPS locations were used to create a point file for visualization within a GIS. Similarly AMD discharges within the City of Wheeling, WV were mapped. If the AMD flowed to the sanitary sewer, the location of the manhole closest to the point of AMD entry to the sewer was recorded. The locations of discharges entering surface water were recorded as close to the discharge as possible.

Additional GPS mapping included the location of several mine-water transfer pumps in Area A and a newly installed pumping well. The mine-water transfer pump locations were recorded as close to the pump as possible.

Flooded areas in the various mines are estimated using the water level elevation in monitoring wells penetrating the mines and the structure contours for the base of the Pittsburgh coal. For example, if the water level in the monitoring well is 680 ft AMSL, then the portion of the mine down-dip from the 680' contour is assumed to be flooded. Alternatively, in the northern panhandle, the elevation of discharge is assumed to be the elevation of the pool within the mine. For example if a discharge is located at the 680 ft structural contour for the Pittsburgh coal then the elevation of the pool is assumed to be 680 ft.

RESULTS

MORGANTOWN AND FAIRMONT MINE POOLS

Plates 1 and 2 show the estimated flooding level in the Morgantown and Northern Panhandle areas, respectively, as of May 2007. The flooding levels are developed by interpreting the water levels recorded within the various mines and comparing them to the structure of the Pittsburgh coal. The flooding levels in most of the mines within Area A fluctuate around an average water level as water is moved between the mines and to treatment plants. The exception is the Shannopin mine in which the pool is being lowered to dewater the Sewickley coal. The pool elevation in Osage is also currently well below the previous 24-month average due to the installation of a new transfer pump that moves mine water from Osage into Arkwright. Mine water pool elevations are being maintained by pumping the water to treatment plants.

Water from Shannopin is pumped at Steele shaft and treated (Plate 1). Water from Blacksville #1 is pumped into Humphrey near Brock, PA. Humphrey is pumped into Pursglove at Eddy pump near the Fetty monitoring well. Pursglove is pumped into Osage in the vicinity of Core, WV and Osage is pumped into Arkwright at Statler Shaft. Water is pumped from Arkwright to the treatment plant at Flaggy Meadows. Jordan is pumped at Hagans shaft and treated at Dogwood Lakes treatment plant. The Fairmont pool is pumped to the Llewellyn treatment plant. The Blacksville and Statler Shaft pumps operate continuously while the other pumps are typically run for eight-hour periods everyday to every couple of days.

The pool elevation in Arkwright is maintained at approximately 800 ft AMSL by pumping to the treatment plant at Flaggy Meadows (Figure 1). The pumps are run from one to several days then shut off to prevent dewatering the pumps while the pool recovers. Recent addition of a transfer pump at Statler Shaft, which moves water from Osage into Arkwright has induced shorter recovery periods allowing more frequent pumping to the Flaggy Meadows treatment plant.

Sludge from the Flaggy Meadows treatment plant is injected into River Seam, which is monitored at Flaggy Pond. The pool elevation has dropped during the study period from a high of 860 ft to around 825 ft (Figure 2). As of the close of this project, the monitoring well is currently being used for sludge injection and the old sludge injection well is in the process of being outfitted for monitoring.

The pool elevation at Daybrook remained relatively constant prior to the installation of the transfer pump at Statler shaft, which moves mine water from Osage into Arkwright. The hydrograph for the early portion of the study period shows the effects of pumping at Flaggy Meadows and recovery periods (Figure 3). The later portion of the hydrograph shows the effects of transferring water from Osage into Arkwright.

The pool in Osage is monitored at Willard (Figure 4). The hydrograph for Willard shows a general flooding trend for the early portion of the study period with intermittent pumping events and subsequent lowering of the pool following the installation of the transfer pump at Statler Shaft.

The pool in Pursglove is monitored at Worley (Figure 5), Fetty (Figure 6), and Fetty Core (Figure 7). The Fetty hydrograph shows the effects of transferring water from Humphrey into Pursglove. The effect is somewhat subdued at Worley, which lies at a greater distance from the injection borehole. The effect of pumping is also evident in the Fetty Core monitoring well, but is greatly subdued due to the effects of an internal mine barrier between the monitoring well and the injection borehole.

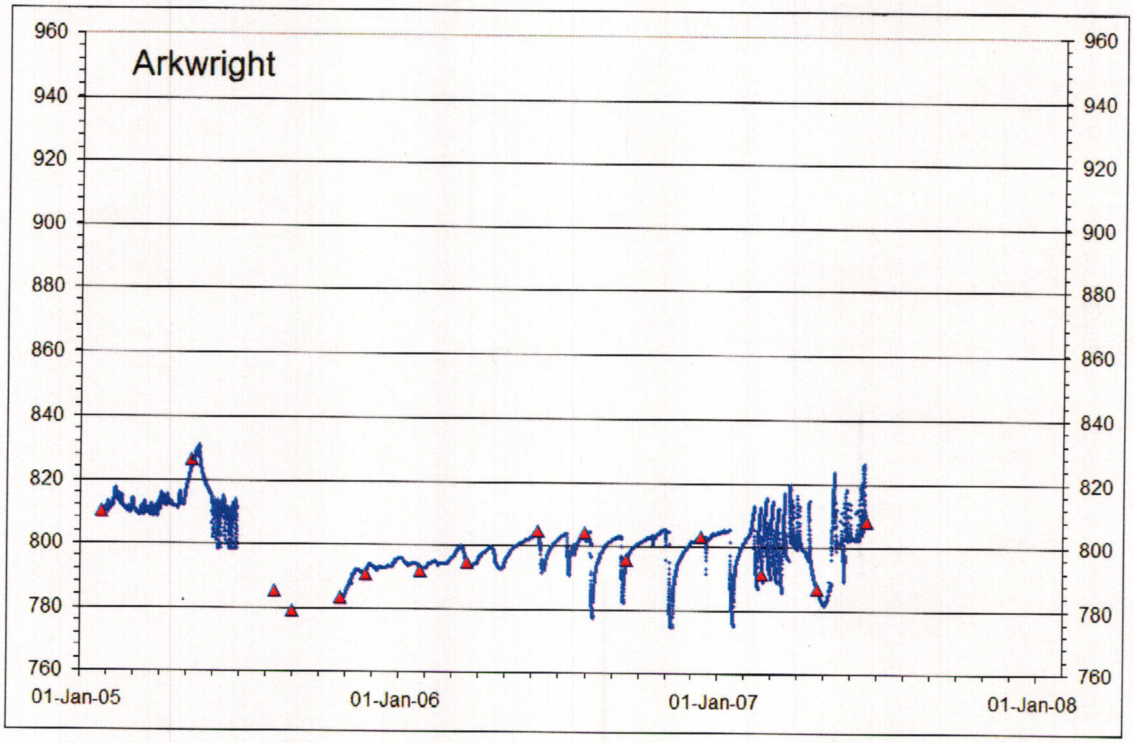

Figure 1: The water level at the Arkwright well is variable.

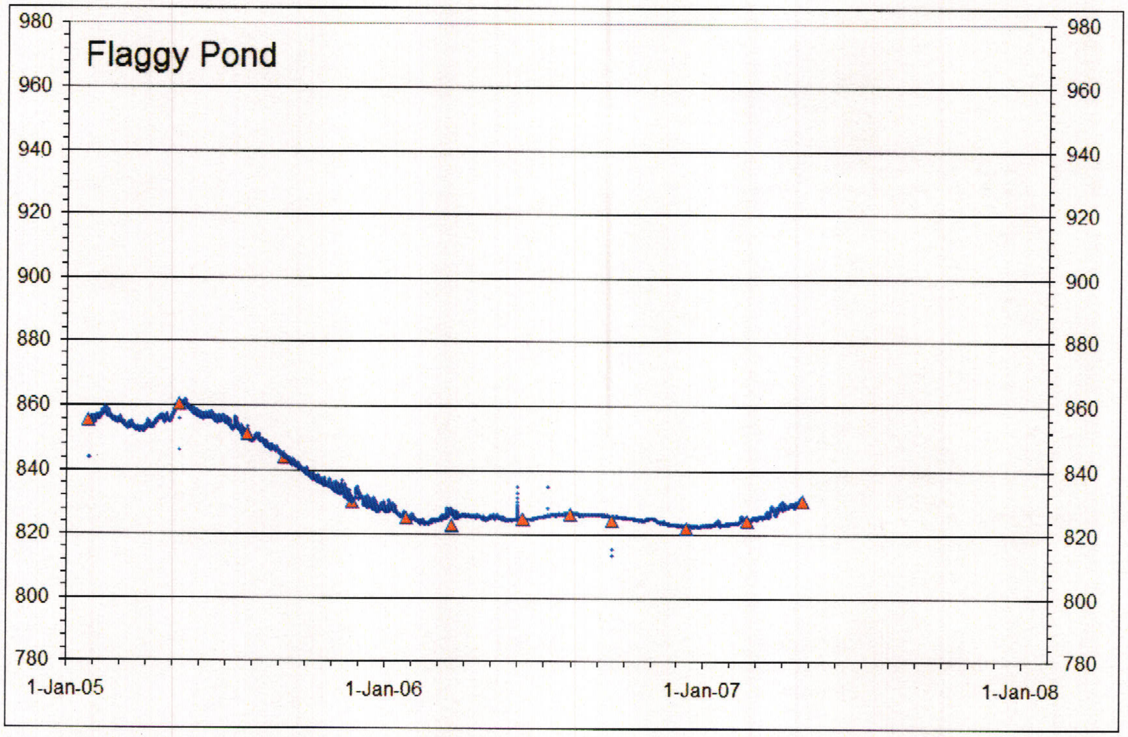

Figure 2: Head at Flaggy Pond decreased over the study period.

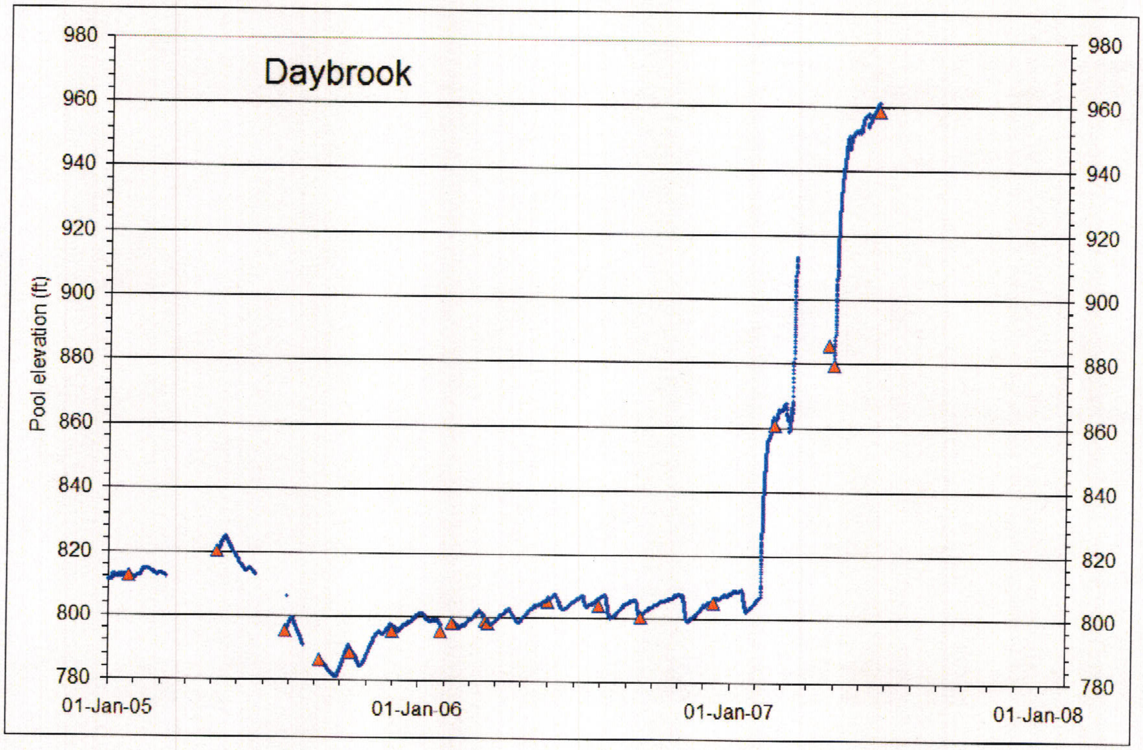

Figure 3: Large head fluctuations were observed during the study period.

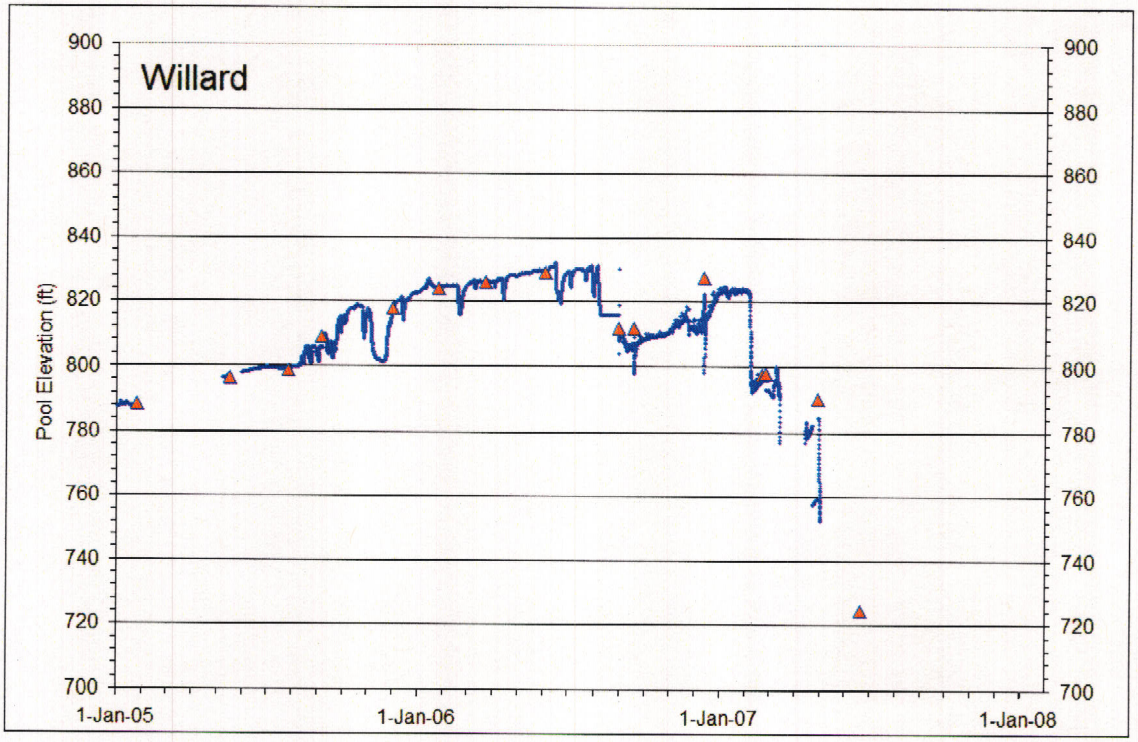

Figure 4: The water level in Osage decreased during the study.

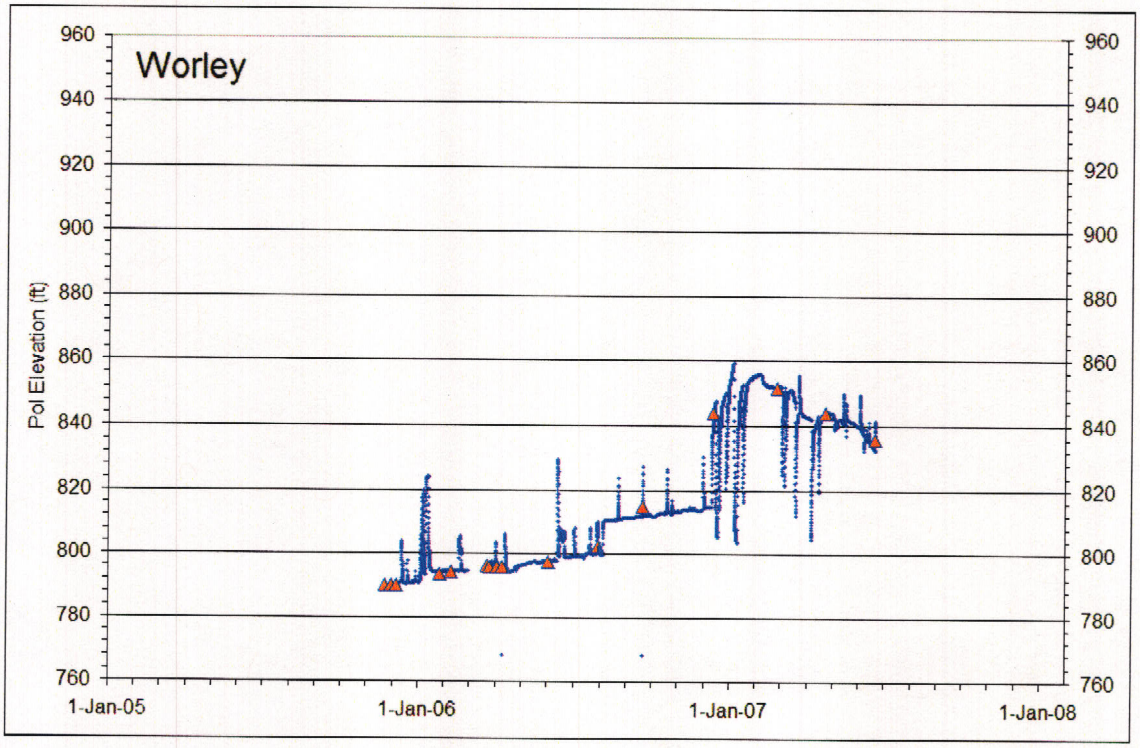

Figure 5: Large fluctuations in water level were observed at Worley.

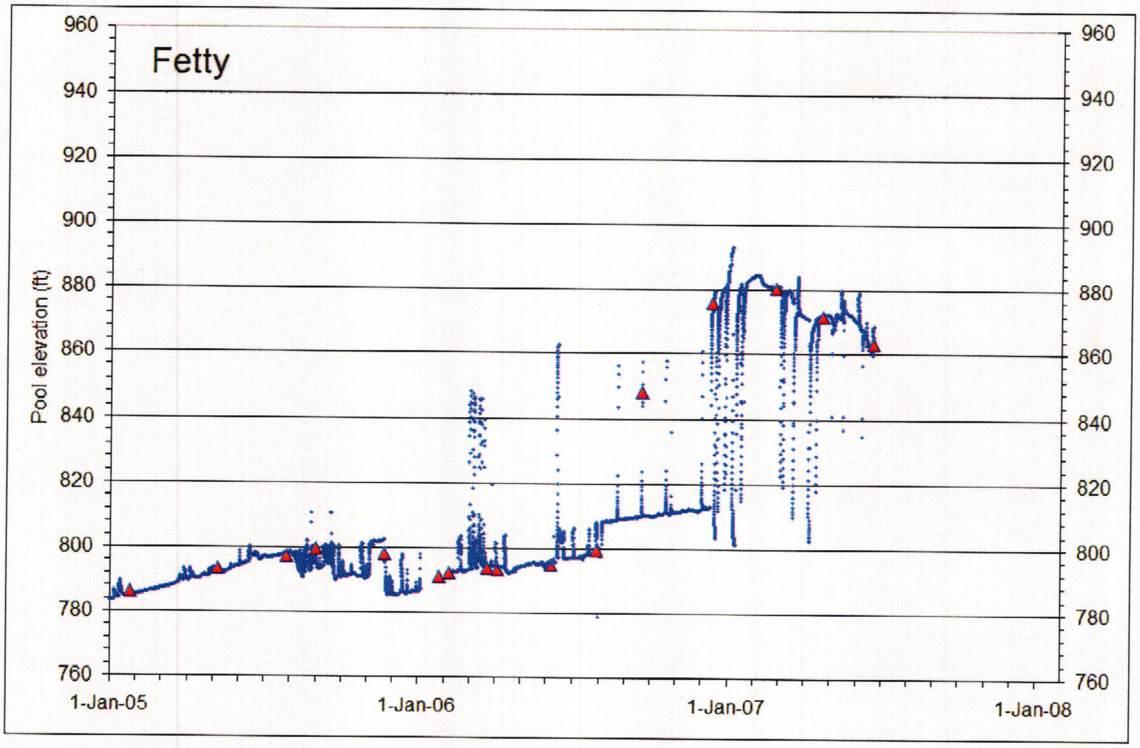

Figure 6: Large water level fluctuations were observed at Fetty.

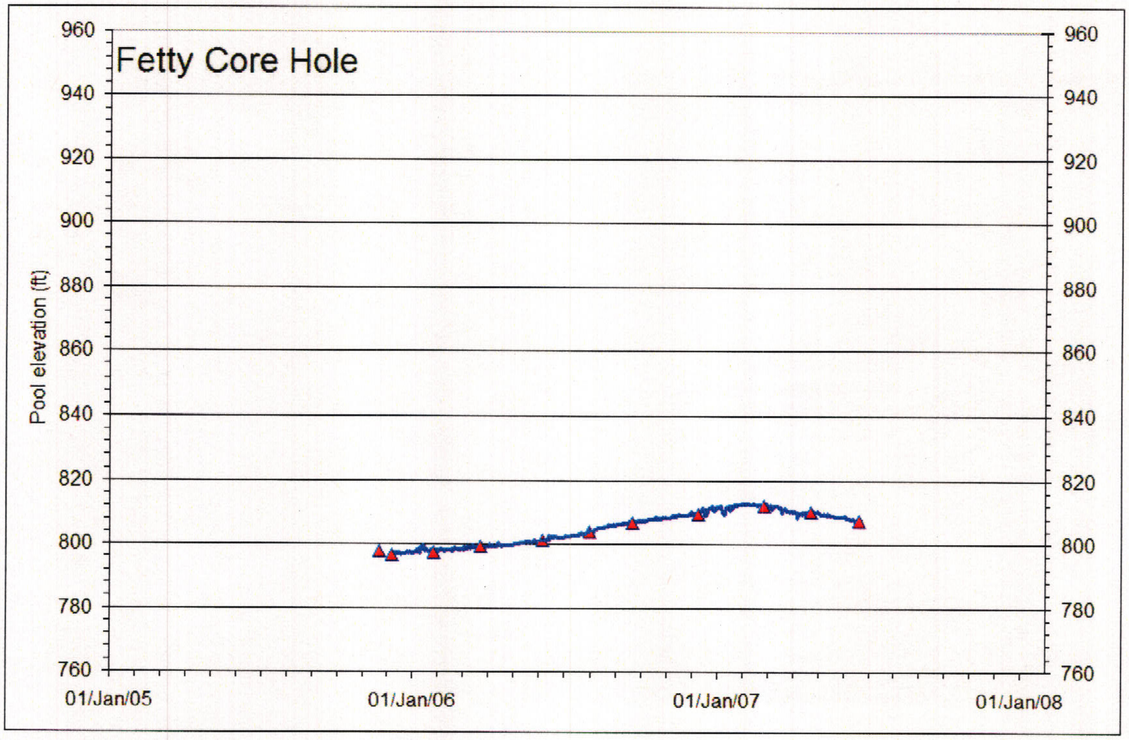

Figure 7: Small water level fluctuations were observed at Fetty Core.

The pool in Humphrey is monitored at Brock and the hydrograph shows the effects of transferring water to Pursglove (Figure 8). The flooding trend has been reversed and the pool elevation is falling.

The pool elevation in Shannopin is recorded at the Shannopin monitoring well (Figure 9). The water level in Shannopin has been steadily declining during the study period due to pumping at Steele Shaft.

The pool elevation in Jordan is maintained by pumping at Hagans Shaft (Figure 10) to the Dogwood Lakes treatment plant. The water level in Jordan fluctuates 15 to 20' around 790' AMSL.

The Fairmont pool is monitored at Penn Overall (Figure 11), Carberry (Figure 12), and Barrackville (Figure 13). The water levels at Penn Overall and Carberry fluctuated around 850 ft AMSL during the study period while the Barrackville water-level elevation fluctuates around 835 ft AMSL.

NORTHERN PANHANDLE MINE POOLS AND DISCHARGES

Interpretation of water levels in the Northern Panhandle shows that Alexander Mine (Figure 14) continues to flood at a rate of approximately three feet per year while the hydrographs for Glen Dale (Figure 15) and Valley Camp #3 (Figure 16) indicate that these two pools have remained constant. Other pool elevations in the panhandle were estimated using the elevation of discharges combined with the structural contours for the Pittsburgh coal. Within each mine containing a discharge, everything down dip from the discharge was assumed flooded. The interpreted extent of flooding in the Northern Panhandle is shown on Plate 2.

AMD discharge locations were mapped both along the Ohio River and within Ohio County. Ohio River discharge locations were mapped on May 24th, 2006 with the cooperation of the USEPA. Ohio County discharges were visited in June of 2007 with cooperation of the City of Wheeling, WV Pollution Prevention and Control Division (PPCD). Seven Ohio River discharges and thirty surface and sewer discharges were mapped in Ohio County (Plate 2).

AMD discharge names and locations are summarized in Table 1. The Ohio River sites are numbered in the order visited while the other surface water and sanitary sewer locations are named by PPCD based on their street address. All of the discharges were observed in late spring and early summer during low flow conditions. Flows varied from 1 or 2 gpm to approximately 25 gpm (Figure 17), although there is significant staining at many of the sites indicating previous large flows (Figure 18).

AMD sludge tends to accumulate in both the surface water (Figure 19) and sanitary sewer (Figure 20) systems requiring frequent maintenance to keep the system

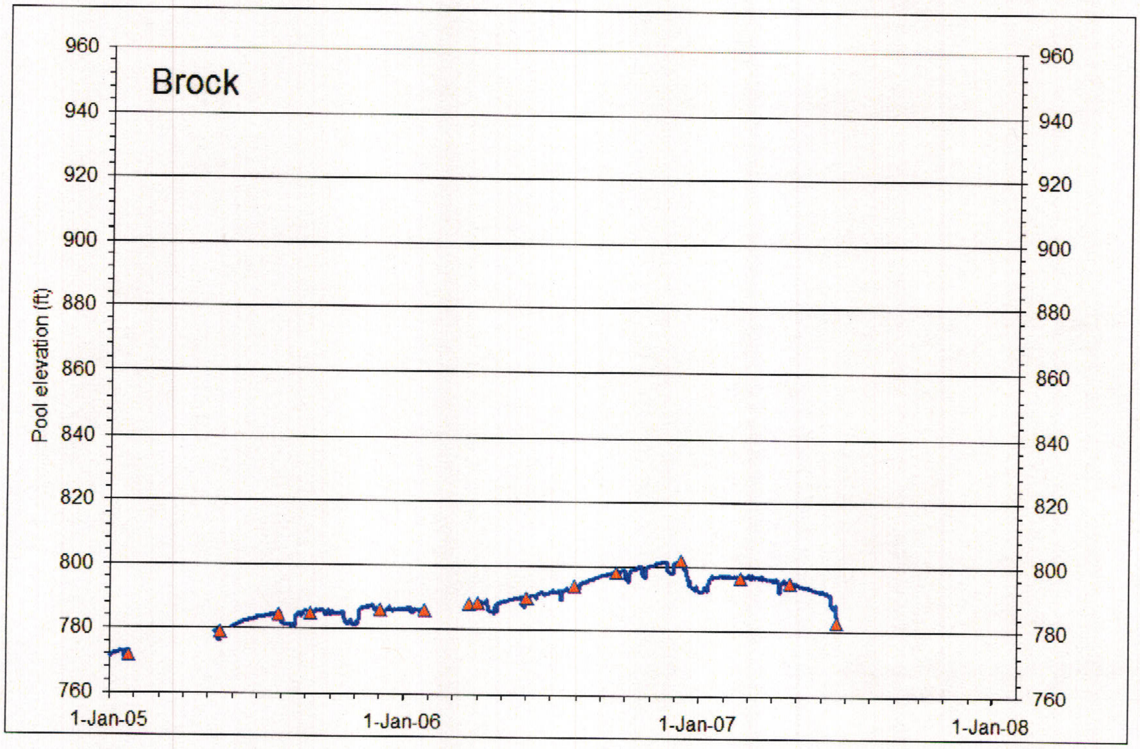

Figure 8: Small water level fluctuations were observed in Humphrey.

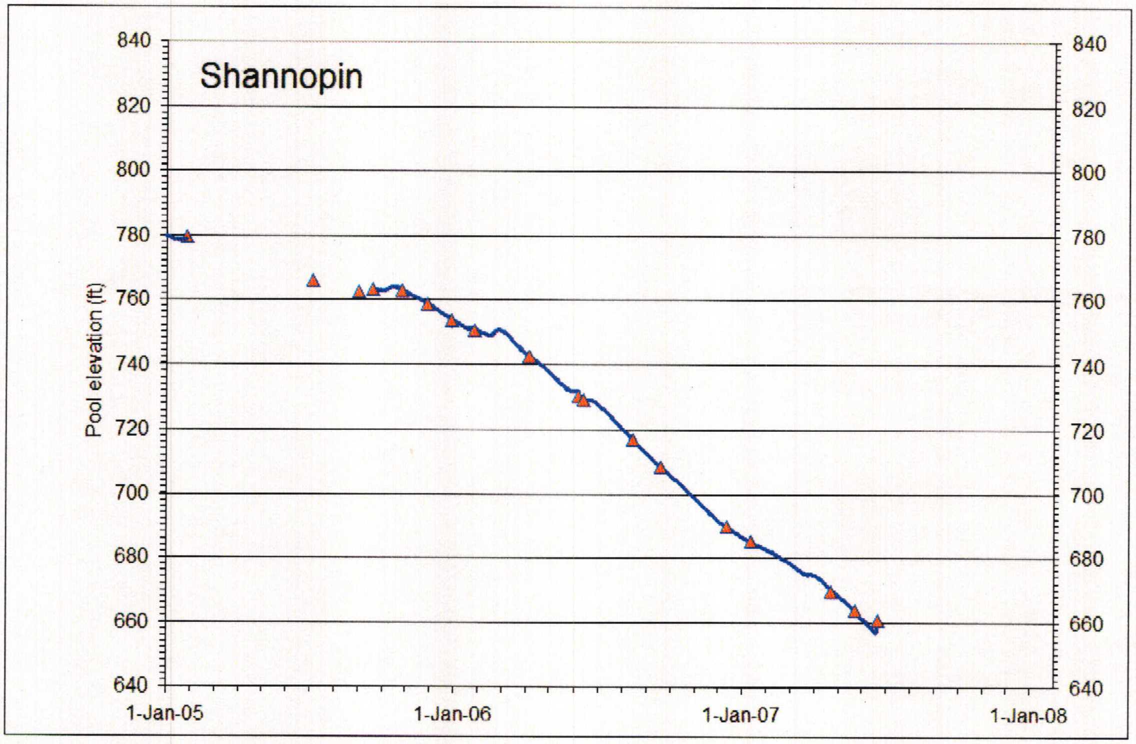

Figure 9: The water level in Shannopin is decreasing.

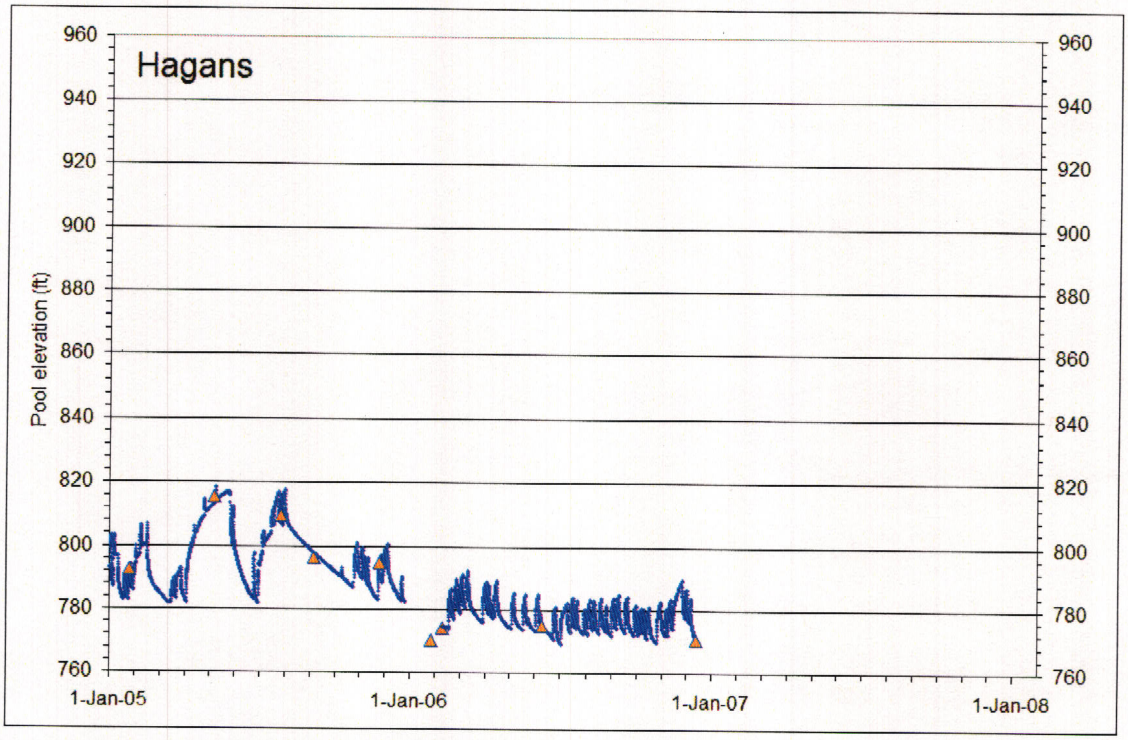

Figure 10: The water level at Hagans dropped during the study period.

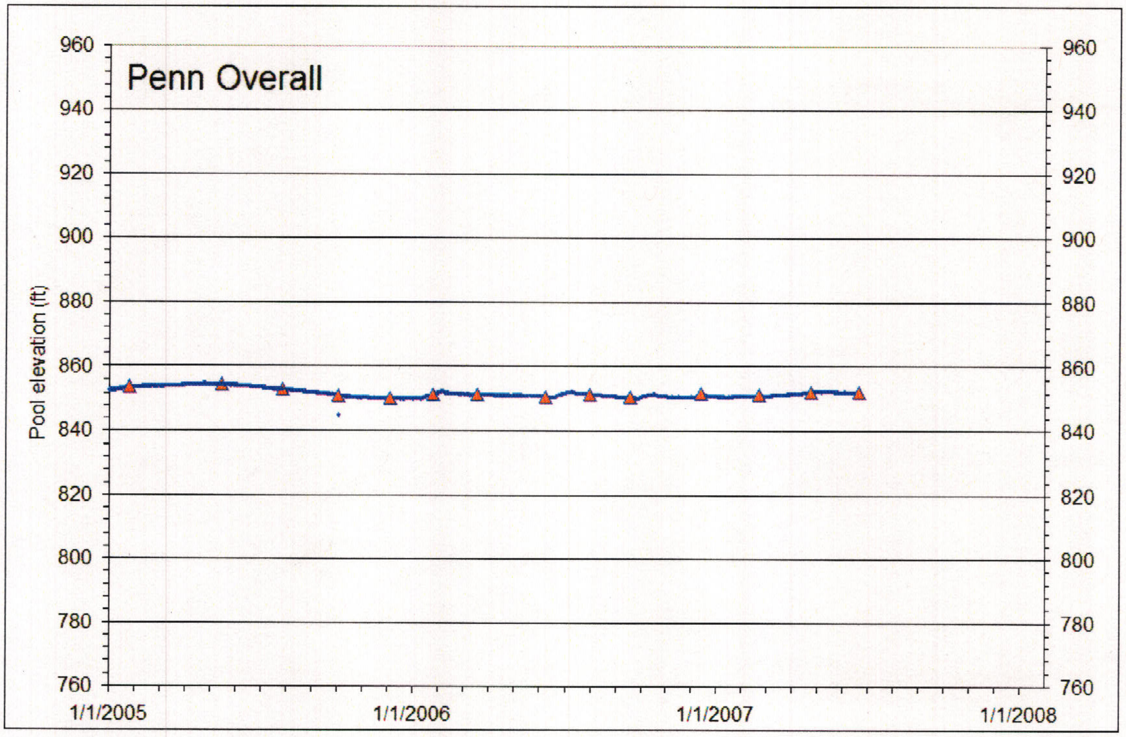

Figure 11: The water level at Penn Overall remained relatively constant.

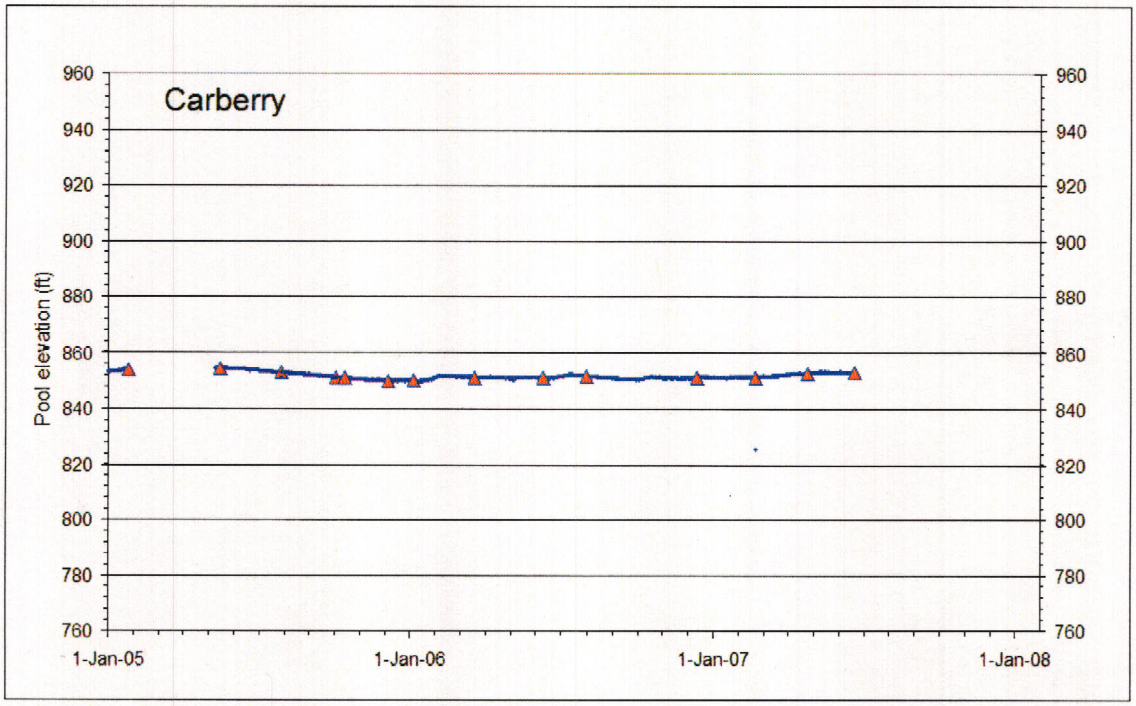

Figure 12: The Carberry hydrograph shows only slight variation.

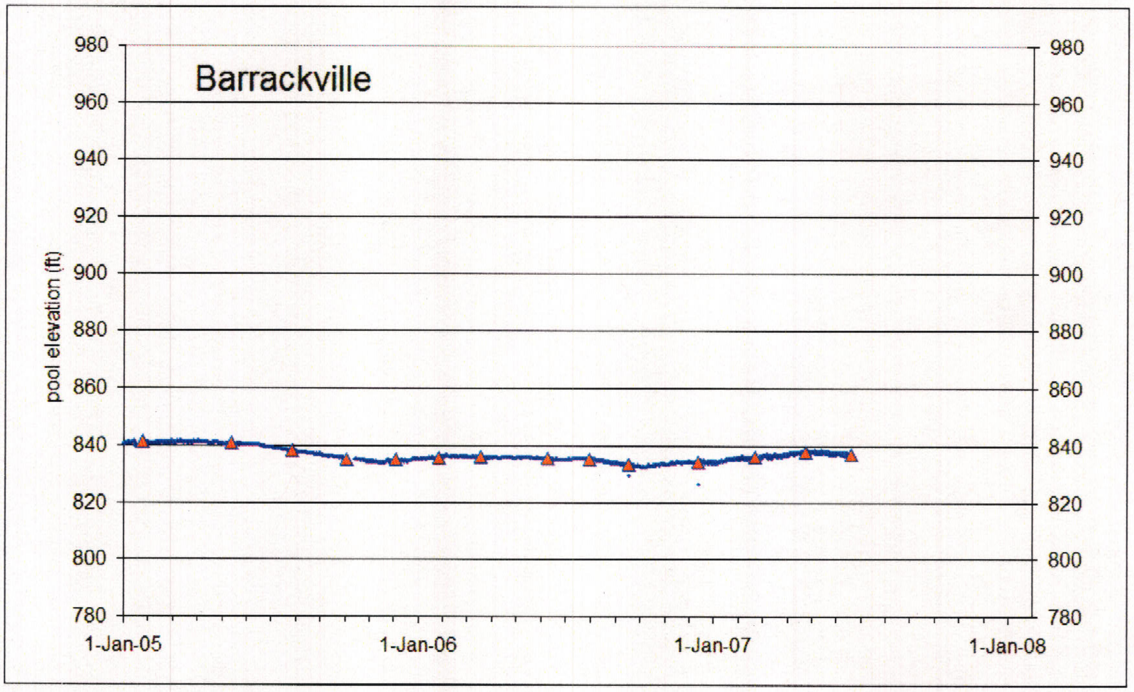

Figure 13: Barrackville shows seasonal variation.

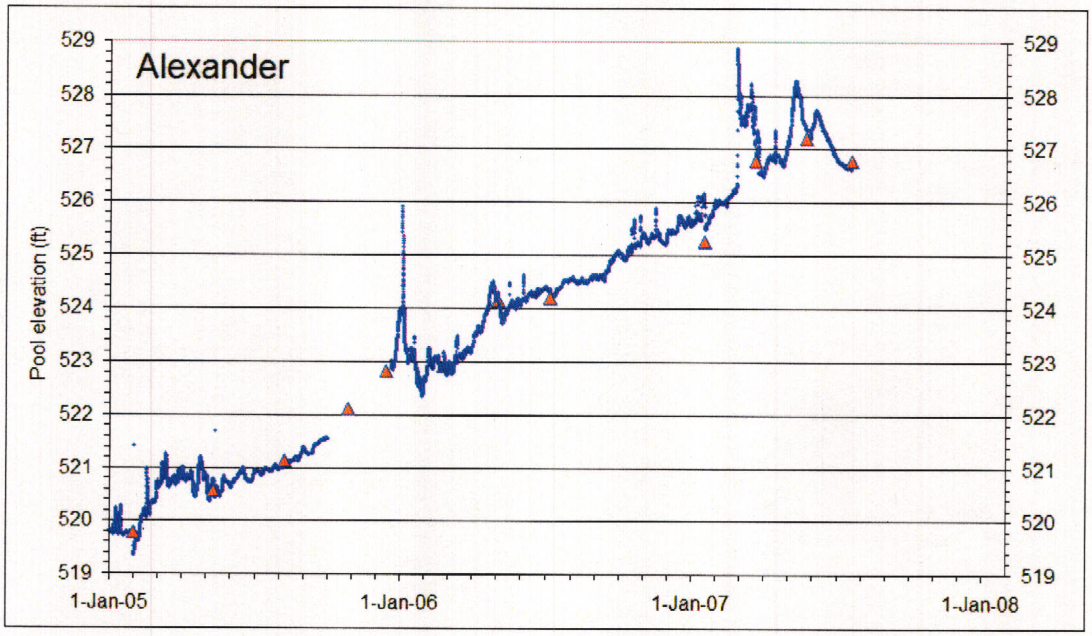

Figure 14: Alexander continues to flood at a rate of approximately three feet per year.

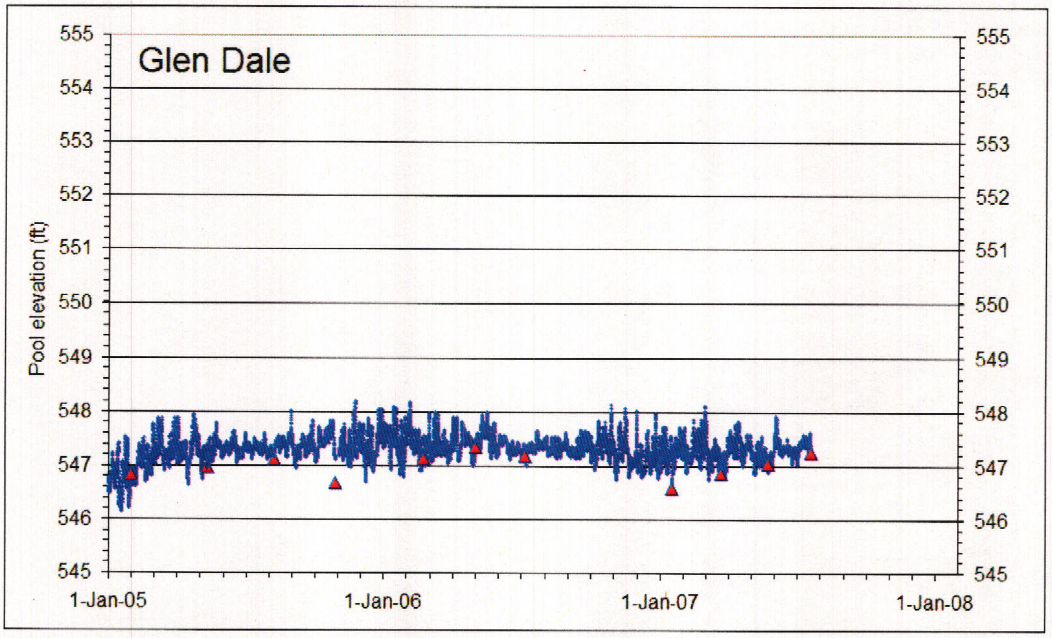

Figure 15: The pool elevation in Glen Dale remained stable during the study period.

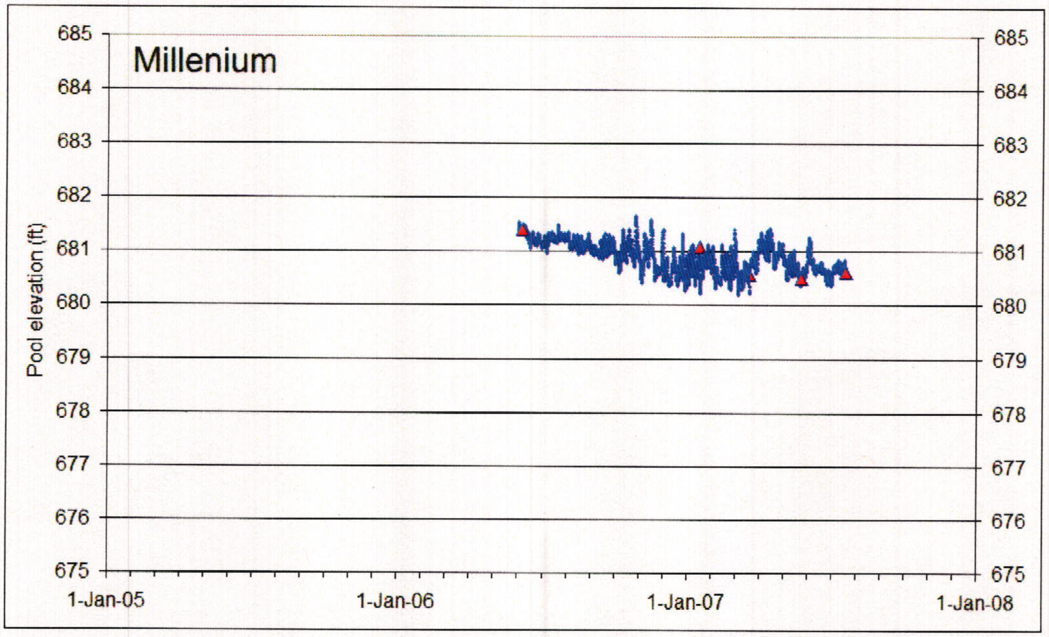

Figure 16: The pool elevation in Valley Camp 3 remained stable during the study period.

TABLE 1. AMD discharges and source mines in Ohio County. See Plate 2 for locations of tabulated Site ID's.

SITE ID	DISCHARGE	RECEIVING	PROBABLE SOURCE MINE
SS1	1030 Chapline St.	Sanitary Sewer	(Downtown Wheeling)
SS2	1029Chapline St.	Sanitary Sewer	(Downtown Wheeling)
SS3	10th & Lind	Sanitary Sewer	(Downtown Wheeling)
SS4	138 GC&P (Troy)	Sanitary Sewer	Richland
SS5	138/150 Pierce St.	Sanitary Sewer	31st St
SS6	3 Economy St.	Sanitary Sewer	Costanzo
SS7	328 Highland	Sanitary Sewer	5th St.
SS8	34 Edgelawn	Sanitary Sewer	Stratford (Pgh-Wheeling)
SS9	54 GC&P/44Brown	Sanitary Sewer	Wheeling Valley (Wheeling Quality)
SS10	59 Elmcrest Ave	Sanitary Sewer	Valley Camp 5
SS11	775 National Rd.	Sanitary Sewer	Dimmgy
SS12	78 Carmel Rd.	Sanitary Sewer	Echo (Edgington, Wheeling Valley, Valley Camp1)
SS13	823 Market St.	Sanitary Sewer	(Downtown Wheeling)
SS14	Peachtree St. (City Operations Center)	Sanitary Sewer	Manchester
SW1	108 National Rd.	Surface Water	Woods
SW2	122 Bethany Pike	Surface Water	Hutchinson
SW3	130 Edgewood	Surface Water	NO AMD
SW4	200/202 Edgington	Surface Water	Storch
SW5	239 River Rd.	Surface Water	Wheeling Glenwood
SW6	2208 Warwood Ave.	Surface Water	Warwood
SW7	2880 Warwood Ave.	Surface Water	Wheeling Valley Coal (Warwood)
SW8	29th St Culvert	Surface Water	31st St., Riverside, (Carter, Southside Steel Works)
SW9	40 Warwood Ave.	Surface Water	Costanzo, 5th St.,
SW10	4521 Wetzel St	Surface Water	Boggs Run
SW11	500 Warwood Ave.	Surface Water	5th St.
SW12	712 Warwood Ave.	Surface Water	Berger (Richland)
SW13	Elm Gove at overflow	Surface Water	???
SW14	Glenns Run	Surface Water	Wheeling Valley Coal
OH1	OH Site 1 (239 River Rd.)	Ohio River	Wheeling Glenwood
OH2	OH Site 2	Ohio River	Wheeling Glenwood
OH3	OH Site 3 (40 Warwood Ave.)	Ohio River	Costanzo, 5th St.,
OH4	OH Site 4 (Glenns Run)	Ohio River	Wheeling Valley Coal
OH5	OH Site 5	Ohio River	Lewis
OH6	OH Site 6 Caldwell Run (29th St.)	Ohio River	31st St., Riverside, (Carter, Southside Steel Works)
OH7	OH Site 7	Ohio River	Boggs Run

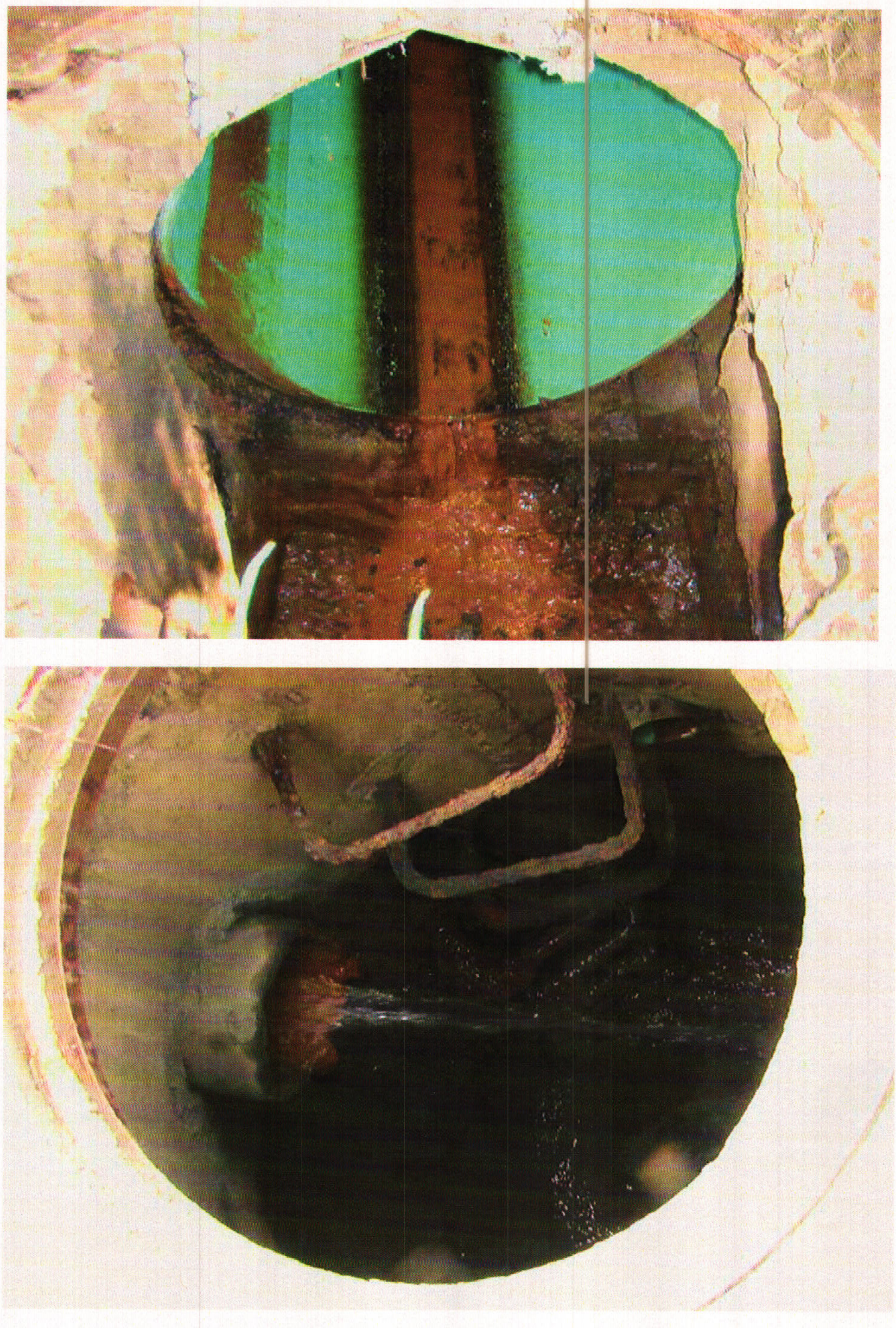

Figure 17: Flow rates varied between 1 to 2 gpm (above) and approximately 25 gpm (below).

Figure 18: Wet-weather high flows are indicated by staining.

Figure 19: AMD sludge is periodically removed from this catch basin on Carmel Rd.

Figure 20: AMD sludge may plug sewer pipes causing overflow.

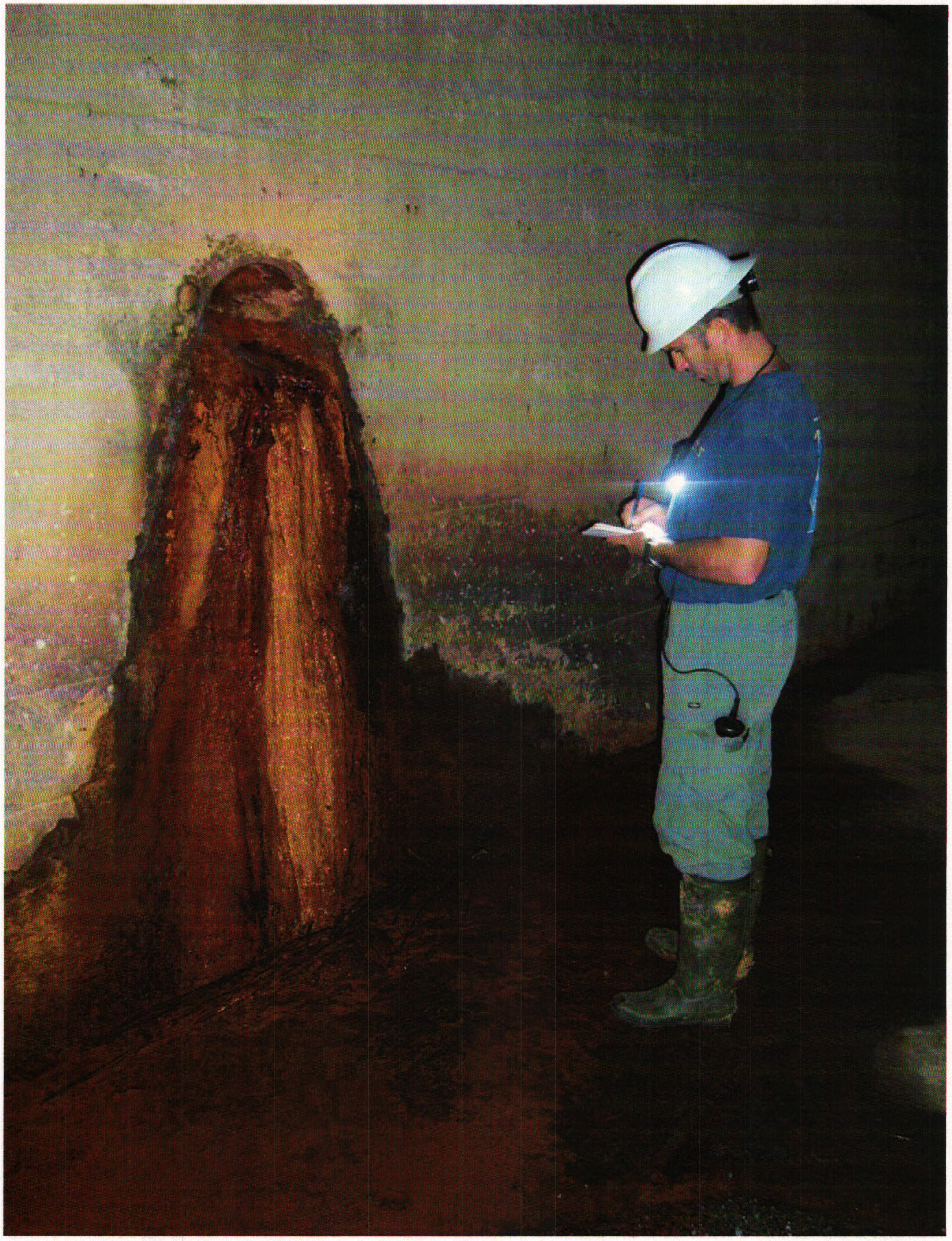

Figure 21: AMD sludge partially fills a 12" culvert in the 29^{th} St. tunnel.

Figure 22: A 12" culvert in the 29^{th} St. tunnel is nearly plugged with AMD sludge.

operating. A large number of the drains entering the 29th St. culvert were either partially or fully filled with sludge (Figures 21 and 22).

INTERPRETED HYDROGEOLOGY OF THE VALLEY CAMP 1, 2, AND 3 MINES

It was an initial hypothesis that water infiltrating into the Valley Camp #1, Wheeling Valley Coal, and Edgington mines flows down-dip across non-intact barriers into Valley Camp #3 (Plate 2). Based on water level measurements in 2003 at a now-destroyed well on Cabela's property in Tridelphia, mine water was hypothesized to pool within the mine below Tridelphia due to a structural high indicated by contours of the base of the Pittsburgh seam. On the other hand, two coal bed methane (CBM) recovery wells in the deepest part of Valley Camp #3 indicated that no water has pooled in the deepest portion of the mine. It was further hypothesized that mine water from the shallow pool is not continuing to folood the mine and must therefore be discharging from Valley Camp #3 to the surface somewhere in the Tridelphia area. I likely location, at the Valley Camp #3 portal near downtown Valley Grove, showed no evident sign of an active modern portal discharge. Subsequent search for mine water discharges in the Tridelphia area, including examining sewer manholes, failed to locate any discharge that might have originated from Valley Camp #3. The well at the Millennium Center was drilled to investigate and confirm the mine pool elevation within Valley Camp #3. Pool elevations in the Millennium well (Figure 16) have been fairly constant throughout the study period, suggesting that the structural high is acting as a dam preventing water from moving to the deepest part of the mine and likely causing water to discharge to the surface at a yet-unknown location. No surface discharge has been located. With continued flooding, mine water may eventually fill these low-lying areas and spill over to inundate the CBM wells. Once the mine fully floods the region of the current CBM wells, methane production from these wells will cease. Such cessation of methane production will then be an indictor of inundation of the mines in the vicinity of these wells.

DRILLING LOG

Permission to install a monitoring well in the parking lot of the Millennium Center was obtained from the Ohio Valley Industrial and Business Development Corporation. The well was drilled on May 9, 2006 by Three D Drilling of Kingwood, West Virginia. The drill was an Ingersoll-Rand T3W using a down-hole hammer bit. The elevation of the well head is 738.5 feet determined from mapping provided by OVIBDC. An 8 inch schedule 40 steel casing was set in a 10 inch hole to a depth of 22 feet through river gravel with sandstone cobbles. Casing hammer was required get the casing to full depth. The casing was set one foot into gray shale. The hole was then advanced using a 7 1/2 inch carbide tipped hammer bit to a depth of 107 ft.

Gray and black shales were encountered to a depth of 36 feet. From 36 to 38 feet the drill cut through a coal seam at 60 feet above the Pittsburgh; this is likely equivalent with either the Redstone or Sewickley coal. From 38 to 98 feet, alternating shale and limestone units were encountered. The Pittsburgh seam was encountered from 98 to 104 feet. The coal is underlain by gray shale, which was penetrated three feet to a total hole depth of 107 feet.

WELL CONSTRUCTION

Five inch PVC casing was set from the surface to the bottom of the hole. The bottom 18 feet is open to the formation using 110 slot. A shale trap was set at 69 feet, and 9.5 feet of bentonite was placed on the shale trap. After the bentonite was allowed to hydrate the hole was cemented using a tremie pipe from 58.5 feet up to 11.75 feet. Seven bags of neat cement grout were used with a mix ratio of 8 gallons per bag. A 12 inch monitoring well cover was cemented flush with the surface of the parking lot. Table 2 shows the lithologic log for the well.

GROUNDWATER OCCURENCE

Groundwater began entering the hole from the alluvial sand and gravel in the upper 21 feet of hole. This water was sealed off using the steel surface casing. Additional groundwater was encountered at a depth of 40 feet in a gray limestone. This flow was estimated to be about 10 gallons per minute. The cementing of the five inch PVC casing sealed this source of water from the monitoring horizon.

The hole location was selected to hit a full-extraction section of the mine. Unfortunately, a coal pillar was hit instead. A quick slug test was performed to see if the well water level would recover quickly from addition of water, which it did. Consequently it is believed to be representative of the water level in the mine. Water in the well stabilized at a depth of 56.24 feet below the surface. This corresponds to an elevation of 682.26 feet above sea level.

SUMMARY AND CONCLUSIONS

Mine pool elevations in the Morgantown and Fairmont pools are believed to have reached the fully flooded stage in about 2005 and are currently being maintained near this condition by pumping to treatment plants. While the Fairmont pool is believed to have reached near-static water level conditions, maintained by pumping and treatment at Hagans Shaft and Booth pump locations in Jordan Mine, water levels in the Morgantown pool continue to fluctuate substantially. The variation is believed to be due to pumping schemes intended not only to maintain pool levels, but also to lower pool elevations in Humphrey, Pursglove, and Osage mines to below the level of intended mining in the overlying Sewickley seam. Therefore, water levels in these mines have actually receding from full-flooding levels.

The apparent focus of pumping activities has been to divert water to centralized treatment facilities at Dogwood Lakes, Flaggy Meadows, Sears, and Steele Shaft treatment plants. This apparent scheme requires that water either flow freely between mines or, if this is not possible, be transferred from mine to mine by transfer pumping over barriers. In the period of this study, such pumping occurred in a number of locations and appeared to be to a certain extent experimental, as the final pumping configuration will likely be determined by trial and error.

Table 2. Millennium Center well log

RESEARCH WELL LOG

Mine Name:	Valley Camp #3
Well ID:	MIL
Date:	5/9/2006
Driller:	Three D Drilling, Kingwood
Logged by:	B. Leavitt
Total Depth:	107 ft.
Static WL:	56.24
MP:	Ground Surface
MP Elevation:	738.5
Head Elevation:	682 ft.
UTM Northing:	4432696
Easting:	532511

Cased Intervals	**From**	**To**	**Material**
	0 ft.	22 ft.	8" Steel SCHD 40
	22 ft.	107 ft.	5" PVC

Grout Intervals	**From**	**To**	**Type**
	0 ft.	1 ft.	Concrete
	1 ft.	58.5 ft.	Cement
	58.5 ft.	69 ft.	Bentonite
	69 ft.	69 ft.	Shale trap

Perforations	**From**	**To**	**Type**
	89 ft.	107 ft.	110 slot

From (ft.)	**To (ft.)**	**Lithology**	**Formation**	**Comments**
0	21	river gravel w/ ss cobbles		
21	33	gray shale		
33	34	black shale		
34	36	gray shale		
36	38	coal		
38	39	gray shale		
39	40	gray limestone		10 gpm
41	42	hard gray shale		
42	56	gray ls w/ interbedded shale		
56	58	dark gray shale		
58	63	lt braown ls		
63	64	dark gray shale		
64	73	lt brown ls w/ interbedded shale		
73	74	black carbonaceous shale		
74	77	gray shale		
77	83	gray ls		
83	85	dark gray shale		
85	89	gray limestone		
89	93	gray shale		
93	98	gray shale w/ black carbonaceous shale		
98	104	coal	Pittsburgh coal	
104	107	gray shale		

One unanticipated outcome of the mine-water transfer pumping has been the apparent development of deep pressurized mine-pool zones within mines into which water is being injected, specifically Pursglove (from Humphrey) and Arkwright (from Osage). In these two mines, injection is taking place at relatively deep-mine locations. These two mines have apparently formed deep pools that are relatively hydraulically insulated from shallow locations within the same mine. The deep pool in Arkwright is currently believed to be between 120-150 ft or so higher in hydraulic head (measured at Daybrook #3 well) than it is in the "shallow pool" near Flaggy Meadows plant (measured at Flaggy Meadows well). Similarly, the hydraulic head values in the deep portion of Pursglove are frequently recorded as 50 to 80 ft above head values for the shallow portion. The origin of these pressurized deep pools is uncertain but is likely related to unintentional closure, collapse, or plugging of the main entries at locations updip of these pools, or alternately to, in the case of Pursglove, elongate strike-parallel internal barriers. Continued monitoring of deep mine pool elevations provides early warning for potential discharges.

In the Northern panhandle, mine discharges have been linked to probable source mines. Roughly half of the discharges mapped in Ohio County flow to City of Wheeling sanitary sewer system at tap locations mapped by the City. The other half flow to storm sewers or surface streams before joining the Ohio River. Similar diversion of shallow-cover mine discharges may exist in other counties north and south of Ohio County. These diversions of pre-law mine discharges have occurred over a long period of time dating back to 1980 or earlier, and most recently during AML reclamation projects. The waste water treatment plant for the City of Wheeling is currently operating well below its design capacity and is capable of treating all of the mine discharge water that currently flows to surface streams. However, removal of AMD sludge from the sanitary sewer is a complex maintenance issue due to fouling of pipe conveyances outside of the City sewerage itself. Mine water in Valley Camp #3 is at an elevation that suggests surface discharge to Middle Wheeling Creek. However, no AMD has been noted in the creek, and the receiving water body for this mine's suspected discharge is not currently known. The base of coal elevation within the mine complex suggests the existence of a structural high which acts as a dam causing pooling in the area of the Millennium well. Given the nearly constant water levels in the Millennium well and the lack of surface discharge, it is probable that discharge is occurring to some location. The unsaturated condition of the deep CBM wells in the deepest portion of the mine suggests it is not flowing to these locations. It is possible that water is pooling in intermediate locations between the apparent dam near the Millennium well and the CBM wells.