

STORAGE OF WET WEATHER OVERFLOWS IN ABANDONED COAL MINES

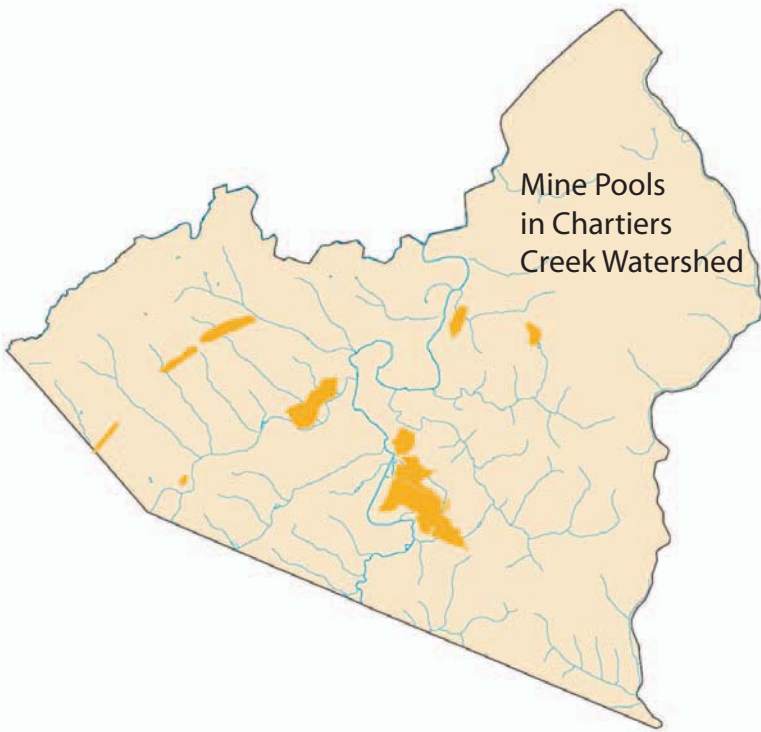
Prepared For:
The Township of Upper St. Clair
Upper St. Clair, Pennsylvania

Prepared By:
GAI Consultants, Inc.
Monroeville, Pennsylvania

and

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Pittsburgh, Pennsylvania

August 2004
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REPORT

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REPORT

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AUGUST 2004

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EXECUTIVE SUMMARY

Wet weather overflows are a common problem of aging municipal sanitary and combined sanitary/storm sewer systems. The problem has received particular attention in Allegheny County, Pennsylvania where wet weather overflows from sewer systems degrade receiving streams. The solution being considered includes improvements to infrastructure and the construction of overflow storage tanks. Large [one million gallon (MG)] capacity tanks will store overflows in wet weather, and release their contents into the sewer system during dry weather. The temporary storage of wet weather sewer overflows is a common control strategy for aging sewer systems. Not all storage tanks are above ground. In Chicago and Milwaukee, overflow storage capacity is being produced through the construction of underground tunnels. The costs of storage facilities is large. The Chicago system has already cost more than \$2 billion and is not yet complete.

Much of Allegheny County lies atop abandoned underground coal mines. The mines contain a substantial amount of void space - in excess of 5 billion gallons. These mines have geological features that generally cause water entering the mines to be trapped and discharge at distinct locations. The discharges from these mines tend to be contaminated with metals and acidity. Recent analyses of surface water conditions in the County have identified wet weather sewer overflows and drainage from abandoned coal mines at the primary sources of pollution to local streams and rivers.

This report investigated the technical feasibility of using abandoned underground coal mines for temporary storage of sewer overflows. The study was conducted in the Chartiers Creek watershed in southern Allegheny County. This watershed has a serious wet weather sewer overflow problem and the local communities, as well as the local sewer authority, the Allegheny County Sanitary Authorities (ALCOSAN), are under court order to correct the problems. The coal geology is well known in this area because of a previous Pennsylvania Department of Environmental Protection (PaDEP) supported mine drainage study. All of the overflowing sewers originate above abandoned coal mines and terminate near the coal crop and the edge of the mines. Some of the mines have distinct pools that contain hundreds of millions of gallons of water. After reviewing the characteristics of each mine pool, two connected pools located beneath the Township of Upper St. Clair and Bridgeville were selected as candidates for wet weather overflow storage. A plan was developed that would allow the storage of 5.5 MG of wet weather sewer overflows in the mine. During the study, wet weather sewer overflows were determined to average less than two percent sewage and more than 98 percent infiltration from surface water. This volume represents both the entire flow from a one-year, one-hour event, and the first flush (ten percent of flow) from a two-year, 24-hour storm event (which contains the major sewer contaminants). The plan involved the following features.

- Storage space would be created by pumping down the mine pool.
- Sewer overflows would be diverted to a solids separation device and then into mine voids.

- The wet weather flow would travel through the mine voids to the mine pool.
- The mine water pumping system would be turned off during the wet weather event and would pump the combined flow back into the sewer system after the wet weather event has passed.

The plan was analyzed from a fatal flow perspective to determine if dangerous or property-damaging consequences could result. The analysis determined the following.

- The plan will not result in the migration of wet weather sewer overflow outside of the targeted coal mine. The Pittsburgh coal seam in this area is underlain by a clay aquatard. This strata currently prevents migration of mine water to underlying aquifers. The mine pools are already contained and lowering them in accordance with this plan would maintain this containment.
- The injection of wet weather sewer overflows is unlikely to cause the production of dangerous gases. The ability of the carbon inputs to support the production of hydrogen sulfide and methane were analyzed. Analyses of wet weather sewer overflows indicate that the carbon loadings are insufficient to support enough sulfate reduction to deplete sulfate levels to a point where methanogenesis would be possible. Any hydrogen sulfide produced would be removed through reaction with dissolved iron. The safety factor for hydrogen sulfide production is at least 16 times (carbon loadings would need to increase by a factor of 16). The safety factor for methane production is about 70 times.
- Changes in the mine pool hydrology caused by the pumping/storage/pumping cycles are unlikely to cause increased subsidence. Increased stresses on coal pillars were calculated as less than one percent. Erosional forces, caused by water flowing past pillars, were about ten times less than established scouring thresholds.

A cost estimate was developed for several alternatives of the plan and compared to the existing alternative which is the construction of 5.5 MG of above ground wet weather sewer overflow storage capacity tank. The model included a present value analysis that incorporated both capital costs and long-term operational costs. The mine-storage alternatives included variations on pumping (pumping water in/out of the mine vs. using gravity to accomplish the transfers) and the treatment procedure (pump water to ALCOSAN or construct satellite treatment system near the mine). All of the mine storage alternatives were less expensive than the above ground storage tank plan. The costs of the alternatives were strongly affected by the cost ALCOSAN charges for treatment of mine water pumped during dry weather periods. The cost of a dedicated satellite plant appeared to be lowest.

In all of the mine storage alternatives, the existing AMD pollution is also eliminated. In the above-ground storage tank alternative, mine drainage pollution still exists.

The next step of evaluation of the use of mine pools for storage is to prove the concept. The project team recommends that a demonstration project be implemented whereby the project would be designed in phases to limit risks and so that all outstanding issues are resolved before the full scale project is put into service.

A demonstration project would serve to either prove or disprove the technology and would prove to the public that projects of this type can be accomplished in a safe manner that protects their health, safety, and the environment, and is cost-beneficial and aesthetically acceptable.

If proven successful, this technology can also be implemented elsewhere. Abandoned mines and sewage system overflows problems are present throughout the Appalachian region and without resolving both issues, the potential for improved stream conditions will not become a reality.

SECTION 1

INTRODUCTION

1.1 Purpose

The purpose of this project is to evaluate the feasibility of temporarily storing sewer overflows associated with wet weather events in abandoned underground coal mines, from which they could be pumped out for treatment after the wet weather events have subsided. This project has been funded by the 3 Rivers Wet Weather Demonstration Program, the Pennsylvania Department of Environmental Protection (PaDEP), the United States Environmental Protection Agency (USEPA), and the Heinz Foundation.

1.2 Background

In municipalities throughout western Pennsylvania, many wet weather events result in the overflow of municipal combined storm water and sanitary sewer systems into local rivers and streams. To address this problem, the USEPA issued a National Combined Sewer Overflow (CSO) Control Strategy in 1989. The implementation of this strategy will impose staggering remediation costs which are a major concern to elected officials at national, regional and local levels as well as the public. It has become a much-discussed problem in Allegheny County that will take more than \$3.0 billion to fix.

There are several corrective actions, or combinations thereof, that are being proposed to deal with wet weather events including increasing treatment plant capacity, repair and replacement of existing sewer lines (including broken pipes), construction of separate sanitary sewer and stormwater systems, and construction of large storage tanks to temporarily retain the overflows. Because of the cost and land requirements associated with these solutions, this study has been performed to evaluate an alternative technology making use of existing underground mines that, if feasible, would be much less costly, use considerably less land, reduce implementation time, utilize an unused asset, and reduce water pollution levels below those achievable through implementation of current alternatives. The proposed technology would provide improved stream water quality by addressing two pollution sources, namely, wet weather sewer overflows and mine drainage. The alternative technology will be to store wet weather sewer overflows in abandoned underground mines, from which the overflow water could be pumped out for treatment after the wet weather event has subsided. The evaluation is focused on Allegheny County, and specifically on the Lower Chartiers Creek watershed, which preliminary research has shown to be a suitable area for evaluating the proposed alternative technology (see Figure 1 for study area location).

The objective of this project is to complete a Feasibility Study, the goal of which is to determine if the storage of wet weather overflows in abandoned coal mines can provide a cost-effective solution to the wet weather sewer overflow problems, and is applicable to the Lower Chartiers Creek watershed communities.

Funding has been obtained for this project through the sponsorship of The Township of Upper St. Clair (Upper St. Clair), and the work is being performed by GAI Consultants, Inc. (GAI), and The Gateway Engineers, Inc. Concurrent, related projects are also underway, the data and results of which are utilized in this evaluation. A mine discharge study in the Lower Chartiers watershed has been completed for Chartiers Nature Conservancy (CNC), from which mine discharge chemistry, flow data, and mine mapping has been used to facilitate the completion of this study (GAI and Hedin, 2003). A research project is also underway at the United States Department of Energy (USDOE) - National Energy Technology Laboratory (NETL) at Bruceton, Pennsylvania, investigating the effects of sanitary sewer wastewater mixed with mine pool water. Data from the NETL study were used in this investigation.

1.3 Overview of Study

This study has been conducted to evaluate the technical feasibility of temporarily storing wet weather overflows in underground coal mines, as well as other factors and constraints associated with the concept. The overall study process consists of:

- Section 2 - site selection - determination of mine sites in the study area to enable a detailed feasibility of the proposed concept;
- Section 3 - technical feasibility determination - evaluation of technical considerations associated with storing wet weather overflows in underground mines, focusing on the specific mines selected;
- Section 4 - evaluation of additional factors and constraints associated with implementing the proposed concept, including regulatory, institutional, legal, environmental, and public acceptability factors;
- Section 5 - development of a conceptual design plan of injection and removal systems to and from the mine, for which preliminary cost estimates could be prepared;
- Section 6 - cost analysis to compare the proposed mine storage concept with currently planned strategies; and
- Section 7 - determination of the feasibility of storing sewer overflows in the mines based on these analyses, and if feasible, providing recommendations for a demonstration project in the area.

SECTION 2

SELECTION OF POTENTIAL SITES

2.1 Introduction

Specific mines and mine pools in the study area were selected to facilitate the detailed evaluation of the proposed concept of storing wet weather sewer flows in abandoned underground mines. Specifically, the selection of individual mine pools in the study area was required to enable the project team to investigate:

- the volumes of void space available and those required to temporarily store wet weather flows;
- fluctuations in mine pool levels anticipated and corresponding impacts (e.g., mine subsidence, surface blowouts);
- physical and hydraulic issues associated with diverting flows from the sanitary sewer interceptors and injecting the sewage into the mine, and removal of wastewater from the mine;
- issues associated with mine pool hydrology, subsurface drainage area, flow paths and conveyance; and
- the possible use of the selected site as a demonstration project.

The selection of specific sites was also performed to enable the project team to identify requirements for analysis, design, and permitting associated with implementing the proposed concept, if determined to be technically feasible.

The methodology used to investigate and select potential sites for detailed evaluation involved:

- collection of historical mine mapping and data;
- development of Geographic Information Systems (GIS) mapping depicting mine workings and boundaries, mine pools, mine discharge points, and inferred mine pool drainage areas, overlain by surface features including streams, roads, topographic contours, sewerage system, etc.;
- evaluation of mine, sewer, and surface features to select one or more sites, i.e., mines, mine pools, and injection locations, for detailed evaluation; and
- selection of recommended sites.

A detailed description of the data collected and the findings of this evaluation are presented in the following paragraphs.

2.2 Coal Mines in the Basin

For many decades, abandoned underground coal mines in southern Allegheny County have polluted the main stem of Chartiers Creek and several of its tributaries. In 2001, the PaDEP provided funding to the CNC for the assessment of the largest deep mine discharges in the lower watershed.

Chartiers Creek is located south and southwest of the city of Pittsburgh, Pennsylvania. The creek flows north from its origination near Washington, Pennsylvania to its confluence with the Ohio River at McKees Rocks, Pennsylvania. The headwaters are primarily in Washington County, while the lower portion of the watershed is in Allegheny County. Nine major mine discharges are located in Allegheny County in the lower watershed. One major mine discharge is located in Washington County in the upper watershed. This discharge is treated by Consol Energy, Inc. (Consol) and was not included in the evaluation. Figure 1 depicts the area considered for this project.

A very limited amount of historical data exists on the discharges evaluated for this report. An Operation Scarlift report was prepared in 1970 for Chartiers Creek by Ackenheil & Associates. However, the Operation Scarlift study (*Chartiers Creek Mine Drainage Pollution Abatement Project, Part of Operation Scarlift*) did not include the eastern side of Chartiers Creek, which contains six of the nine large discharges.

All of the mining associated with the mine discharges in the lower Chartiers Creek watershed was in the Pittsburgh coal seam. The Pittsburgh coal seam outcrops on Chartiers Creek just south of Bridgeville. North of this location, the coal outcrops along the adjacent hillsides. To the south, coal lies below the stream, but rises above the stream as the coal extends under the adjacent hillsides.

The primary mining method to extract coal in this area was deep mining. Where the coal outcrops at the surface a tunnel (or drift entry) was constructed and mining commenced, generally following the coal seam into the ground. This type of mining is present predominately in the northern portion of the watershed. Typically these "drift mines" begin at the lowest coal outcrop elevation on a property and the coal mine is extended updip. In this mining method any ground water encountered will flow down slope on the floor of the mine and out the entry. The mine would then not flood and no pumping would be required to remove water from the mine.

When coal is found below the ground surface, a shaft or slope entrance is used to access the coal seam. These openings are dug through the rock above the coal either vertically for a shaft or on an inclined plane for a slope to reach the coal level. The mines are advanced from one or more of these access points with entries as in the drift mines. Often these mines are below the local ground water table and require pumping to maintain

a workable mine. When the pumps are removed, the portion of the mine below the level of the water table surface fills with water.

In deep mining, the coal is removed by digging additional tunnels parallel and perpendicular to the entry tunnel, and a grid pattern of tunnels (termed "rooms") and solid coal blocks (termed "pillars") is developed. The mines end up with a network of tunnels and remaining coal pillars which support the roof of the mine, this is commonly called "room and pillar mining". In some areas the coal pillars are removed as the mining retracts from a fully developed zone. This type of mining is termed "full extraction mining."

2.3 Mine Pool Discharges

2.3.1 Mine Pool Hydrology. Nine mine discharges and associated underground mines were studied. Locations of the sites are shown on Figure 2. The discharges were monitored for discharge rates and water quality. Mine maps were obtained for the mines underlying the watershed and geo-referenced to correlate them to surface features, in order to form a GIS database. Maps prepared by the Works Progress Administration (WPA) were obtained from the Office of Surface Mining (OSM). They are not detailed and are undated but probably were completed in the 1930s or the 1940s. Maps that originally were prepared by the Pittsburgh Coal Company and titled as K-sheets were obtained from the University of Pittsburgh Library. These maps are generally very detailed, having been drawn on a scale of one-inch equals 100 feet. The southernmost maps have more detail than the northernmost maps, since mining in the area started in the north and extended southward. GAI geo-referenced the maps using structures that existed when the mines were active and are still existing -- such as major roads and streams. Estimated contours of the mine floor elevations were developed by the project team based upon the mine floor elevations shown on the maps or from previously prepared contours shown on the maps by the mining companies.

The mine slope generally follows the base of the coal seam elevation. Good records of these elevations appear on many mining maps since mining engineers use these elevations to plan the mining in order to minimize the requirements to pump water. If no barrier exists in a mine, water will flow along the coal dip to a discharge point at the surface outcrop or water will collect in a low point and form a mine pool. After abandonment, water collects in the lower portions of the mine until it fills to an elevation of an outlet. The outlet could be a shaft to the surface, a drift entry, a man made cut in the mine such as a strip mine or a natural fracture in the rock.

Chartiers Creek dissects the Pittsburgh coal in the study area. Discharges on the east side of Chartiers Creek are hydrologically separated from the discharges on the west side. The discharge points on the east side of the creek are Whiskey Run, Hope Hollow Road, Woodville, Scrubgrass, McLaughlin Run, and Wingfield Pines. On the west side of the creek are the Coal Run, Gladden and Presto-Sygan discharges. These discharge points are shown on Figure 2. Each of the mines that feeds the discharge points were examined to determine if a pool was possible within the mine. The existence of a pool has not been verified by field exploration. Each discharge is discussed individually in the

following paragraphs. A summary of average discharge characteristics (flow and water quality from the mines) is provided in Table 1.

Table 1

SUMMARY OF AVERAGE DISCHARGE CHARACTERISTICS

Site	Flow (GPM)	pH (s.u.)	Net Acidity (mg/L)	Fe (mg/L)	Al (mg/L)	Mn (mg/L)	Acid Load (kg/day)	Fe Load (kg/day)	Sulfate (mg/L)
Whiskey Run	170	4.4	72	20	0.9	0.8	66	18	525
Hope Hollow	250	5.3	123	58	1.7	0.8	347	163	620
Scrubgrass	170	6.1	- 42	67	< 0.5	0.6	- 39	63	604
Woodville	120	6.2	- 34	70	< 0.5	0.9	- 23	47	603
McLaughlin Run	230	5.4	112	66	3.7	0.8	142	84	503
Coal Run	910	6.6	- 357	32	< 0.5	0.5	- 1,767	158	699
Wingfield	1,500	6.7	- 401	14	< 0.5	0.3	- 3,278	114	392
Presto-Sygan	420	5.5	85	40	12.9	1.3	195	92	630
Gladden	1,430	5.8	74	79	0.8	1.0	576	615	761
Totals	5,470	-	-	-	-	-	- 3,781*	1,354	-

Note: * Negative acid load implies positive alkalinity.

2.3.2 Description of Discharges.

2.3.2.1 *Whiskey Run.* Whiskey Run is located in Greentree Borough and is the northernmost mine discharge point in the watershed. On average, the discharge had pH 4.5 and contained 72 mg/L acidity, 20 mg/L Fe, 1 mg/L Al, and 1 mg/L Mn. The chemistry did not vary substantially between sampling events.

The mines that drain into the Whiskey Run discharge point include the Pittsburgh Coal Company's Idlewild, St. Paul Orphanage and Ventura Mine and an Unnamed Greentree Coal Company Mine. Based on the contours of the floor of the mine there is probably no pool in the mine network that is associated with this discharge. The mine mapping is not very good for this mine since the probable mining occurred from the 1800s to the 1910s. In fact, no detailed map was available in the vicinity of the mine discharge point.

2.3.2.2 *Hope Hollow.* The Hope Hollow discharge is located in Scott Township and is approximately 1.5 miles southwest of the Whiskey Run discharge. The Hope Hollow discharge is located on a bench 30 feet above Hope Hollow Road. The discharge flows down a steep embankment to Georges Run. On average the discharge has pH 5.2 and contains 123 mg/L acidity, 58 mg/L Fe, 2 mg/L Al, and

1 mg/L Mn. The discharge chemistry did not vary substantially between sampling events.

The mines that drain to the Hope Hollow discharge include the Pittsburgh Coal Company's Venture, Enterprise and Mansfield Mines and the U.S. Coal and Supply Company's West Liberty Mine. Mine mapping indicates that mining in this area occurred in the 1900s through the 1920s. Based on contours of the floor of the mine, there may be a very small local pool near the discharge.

2.3.2.3 *Scrubgrass and Woodville.* The Scrubgrass and Woodville discharges are located in Scott Township and are approximately one-mile south-southwest of the Hope Hollow discharge. The two discharges are approximately 1,200 feet apart, have similar chemistry and appear to come from interconnected mine entries, although the mine maps are not very detailed in this vicinity. As such, they are discussed as one mine complex. The Scrubgrass discharge is net alkaline with, on average, 66 mg/L Fe, less than 1 mg/L Al and 1 mg/L Mn. The Scrubgrass discharge flows from an apparent mine drain through a treatment system constructed in 1995 by the Scott Conservancy and Scott Township. The Woodville discharge is located adjacent to an active railroad line along Chartiers Creek. The discharge originates from the same hillside as the Scrubgrass discharge. The discharge is net alkaline with 70 mg/L Fe, less than 0.5 mg/L Al, and 1 mg/L Mn.

The mines that drain to the Scrubgrass and Woodville discharges include the Pittsburgh Coal Company's Nixon, Mansfield, Summer Hill, Essen No. 1, and Harrison Mines, the Pittsburgh Terminal Coal Company's Nos. 1, 2, and 3 Mines, and the U.S. Coal and Supply Company's West Liberty and Oak Hill Mines. Mine maps indicate that mining probably occurred in this area in the 1900s through the 1920s. The mines that drain to the two discharge points start in a localized syncline with an axis that runs east-west, counter to the overall dip. A shallow synclinal basin is likely located in the mines that drain to the discharge points and may tie the two discharge points together. This basin is only a few feet deep and may be a small pool, not yet confirmed.

Another mine pool is possible at a location approximately 1.3 miles east of the Scrubgrass discharge point. This internal pool is in a small synclinal basin that could be approximately seven feet deep and covers approximately 40 acres.

2.3.2.4 *McLaughlin Run.* The McLaughlin Run discharge is located in Bridgeville and is approximately two miles southwest of the Woodville discharge. The McLaughlin discharge flows into a pipe that carries the mine water beneath McLaughlin Run Road in a residential neighborhood in Bridgeville to a discharge point directly into McLaughlin Run.

On average the McLaughlin discharge had pH 5.4 and contained 112 mg/L acidity, 66 mg/L Fe, 4 mg/L Al and 1 mg/L Mn. Little variation in chemistry on the

sampling dates was observed. The mine that drains to the discharge point is the Bridgeville Mine. The average flow from this discharge is 230 gpm.

Internal mine drainage originates in Upper St. Clair at approximately elevation 855. The mine drains to the west and discharges from a pipe flowing north into McLaughlin Run at approximately elevation 825. Based on contours of the floor of the mine, the mine is likely to be flooded south of the discharge point to the elevation of the discharge point, or approximately 70 acres.

During the review of the mining maps, there appeared to be another potential discharge from the Bridgeville Mine into Chartiers Creek. A barrier between the Bridgeville and Montour No. 4 mines is shown on the mine maps. If intact, the barrier would separate the mines, creating a pool in the southwest corner of the Bridgeville Mine. A pipe was shown on the mine maps that would have connected the top of this pool to a discharge along Chartiers Creek. A field visit to the probable discharge location did not reveal any discharge. The pipe may have clogged or was never installed. Thus, the drainage into the second pool appeared to overflow into the first pool and subsequently into the McLaughlin Run discharge. There is also a small seep located along Chartiers Creek that may emanate from this pool. The seep was estimated to flow at approximately 20 gallons per minute (GPM) in late November 2003. The one sample collected contained pH 6.6, 194 mg/L alkalinity, 10 mg/L Fe, 0.36 mg/L Mn, and less than 1 mg/L Al.

2.3.2.5 Coal Run. The Coal Run discharge point is located in South Fayette Township and is approximately 0.7-mile southwest of the McLaughlin Run discharge. The Coal Run discharge occurs within the streambed 100 feet west of Route 50 in Bridgeville. One discharge point occurs several inches above the level of base stream flow and was used for collection of undiluted samples. During high flows the discharge could not be sampled. Flows were estimated from the difference of stream flow above and below the discharge zone.

The discharge is strongly net alkaline and contains an average 32 mg/L Fe. Mn was less than 1 mg/L and Al was below detection limits (0.5 mg/L). The alkalinity concentrations, 350-450 mg/L, are very high values for acid mine drainage (AMD).

The discharge was monitored during the Operation Scarlift investigation in the late 1960s. On average the discharge flowed 1,810 GPM and contained pH 6.2, 167 mg/L alkalinity and 59 mg/L Fe. Over the last 30 years, the discharge appears to have become substantially more alkaline, while the iron has decreased by about 50 percent.

The mines that drain to the discharge point are the South Fayette Coal Company's Melrose Mine and the Slope PC Company's unnamed mines. National Mining Company's Mine No. 1 lies to the west and south and probably contributes to this discharge.

Unfortunately, the WPA and K sheet maps that were obtained did not show the full extent of mining in this area and thus the extent of the recharge area and potential mine pool could not be determined. The mining shown on the maps obtained indicate that mining occurred in this area in the 1910s.

2.3.2.6 *Wingfield Pines.* The Wingfield Pines discharge is located in the Township of Upper St. Clair, on the east side of Chartiers Creek. The Wingfield Pines discharge flows from a concrete structure located at the base of a surface mine highwall. The discharge is on property owned by the Allegheny Land Trust. Monitoring was done by a local group, the Citizens for Land Stewardship. Sample analyses were done by the PaDEP state laboratory. The flow rate, 1,500 GPM, was based on a single estimate by a PaDEP mining inspector. The discharge is strongly net alkaline and contains 14 mg/L Fe, less than 0.5 mg/L Mn and Al. The alkalinity, 425 mg/L, is very high for an AMD discharge.

The mines that drain into this discharge are the Pittsburgh Coal Company's Montour No. 4 mine and the Pittsburgh Terminal Coal Companies No. 8 mine. Mining appears to have occurred in the 1930s and 1940s, although the Montour No. 4 mine was active into the 1970s (mostly in Washington County). Internal mine drainage appears to originate in the Township of Upper St. Clair, along Route 19 and at an approximate elevations of 900. The mines drain to the southwest and discharge from an abandoned mine shaft at approximately elevation 832. The top of the pool is probably the same elevation as the discharge point and would therefore cover approximately 270 acres.

It is also the project team's opinion that the Wingfield Pines discharge to the south is separated from the McLaughlin Run discharge by the barriers. The Allegheny Land Trust recently increased the discharge elevation to an approximate elevation of 832 from the previous elevation of 826.5 to determine if the adjacent site could be designed as a gravity fed passive treatment system. This increase in head reportedly had no impact on the McLaughlin Run discharge or to the seep coming out of a hillside alongside of the Bridgeville Mine No. 2 pool.

2.3.2.7 *Presto-Sygan.* The Presto-Sygan discharge is located in South Fayette Township and is on the western side of Chartiers Creek. The Presto-Sygan discharge flows from an old stone structure. The average discharge had pH 5.5 and contained 85 mg/L acidity, 40 mg/L Fe, 13 mg/L Al and 1 mg/L Mn. The discharge has always been a milky white because of the presence of aluminum hydroxide solids. Compared to the other discharges monitored, Presto-Sygan was the most variable both in terms of flow (175 to 775 GPM) and chemistry (19 to 163 mg/L acidity and 8 to 19 mg/L Al).

The discharge was monitored during the Operation Scarlift investigation in the late 1960s. On average the discharge flowed 627 GPM and exhibited pH 5.2, 189 mg/L acidity and 41 mg/L Fe. The pH and Fe concentrations are similar to

those measured in 2002 by CNC. The acidity was approximately 50 percent lower in 2002 than in the late 1960s. The flow rate in 2002 was 33 percent lower.

The mines that drain to the Presto-Sygan discharge are the Panhandle Mining Company's Essen No. 2, Essen No. 3, and Blythe Mines, the McLane Mining Company's McLane Mine, the Pittsburgh Coal Company's National Mine, the Leech Farm Coal Company's Chalfant Mine, and the Fayette Coal Company's Chalfant Mine.

Internal mine drainage originates in South Fayette Township, near Oakdale, at approximately elevation 1020. The mine drains to the southeast and discharges from an abandoned mine slope at approximately elevation 830. The mine complex draining to the discharge point includes a number of drift entries in the northern portion of the recharge area and a shaft at the southern end. The drift entries are located at or near stream level along either the main creek or its tributaries and follow the coal updip to the north and west. The low point of the mine complex is the shaft located in the southeastern corner of the recharge area, with an approximate base of coal elevation of 800.

Based on contours of the floor of the mine and the presence of barrier pillars along the southern limit of the mine complex, a pool appears to be present in the southeastern corner of the mine. The top of the pool elevation should be the same as the discharge point elevation (approximately 830). The pool would cover approximately 200 acres. Within the mine complex, there are two additional areas where mine pools may exist. These areas are two minor synclinal basins located approximately 1.9 miles northwest (updip) of the discharge pool. These pools would be relatively shallow and would be approximately 50 and 100 acres respectively. The 100-acre pool also discharges into Thoms Run, but probably only during high flow conditions. A large pipe was found at this discharge location but was not discharging during the one site visit. However, an orange stain indicative of mine drainage was evident. This discharge should be monitored in future studies.

2.3.2.8 *Gladden.* The Gladden discharge is located in South Fayette Township, approximately three miles southwest of the Presto-Sygan discharge point and less than a mile from the Washington County line. The Gladden discharge is located in a steep ravine along Route 50 at its intersection with Millers Run Road. The discharge flows 200 feet to Millers Run, which flows four miles to its confluence with Chartiers Creek in Bridgeville. Flow rates were estimated from the difference of Millers Run stream flows above and below the discharge inflow. In June 2003 a rectangular weir was installed in the discharge channel. Weir measurements in June averaged 1,300 GPM.

The average discharge has pH 5.8 and contains 74 mg/L acidity, 80 mg/L Fe, 1 mg/L Mn, and 1 mg/L Al. The discharge chemistry was variable, with acidity ranging from 25 to 112 mg/L and Fe ranging 55 to 115 mg/L.

The discharge was monitored during the Operation Scarlift investigation in the late 1960s. On average, the discharge was 1,389 GPM and pH 3.3, 492 mg/L acidity and 75 mg/L Fe. The flow rate and iron concentrations are similar to those measured in 2002 by CNC. The acidity of the discharge appears to have declined in the last 30 years.

The mines that drain to the discharge point are the Pittsburgh Coal Company's Willow Grove and Laurel Hill Nos. 1, 3, and 5 Mines.

Internal mine drainage originates in South Fayette Township, near the North Fayette Township boundary, at approximately elevation 1020. The mine drains to the southeast and discharges from an abandoned mine entrance at approximately elevation 900. The mine maps indicate that a drain was installed at this discharge point but it is uncertain if it still exists. The site terrain was modified substantially during the construction of Route 50, after the last mine map was made. The mine complex draining to the discharge point includes a number of drift entries located at or near stream level along either the main creek or its tributaries, and the entries follow the coal updip to the north and west. The low point of the mine complex is located in the southeastern corner of the recharge area, with an approximate base of coal elevation of 880.

Based on contours of the floor of the mine and the presence of barrier pillars along the southern limit of the mine complex, there is probably a pool present in the southeastern corner of the mine. The top of the pool elevation should be the same as the discharge point elevation (approximately 900). This pool is only about 10 acres. Within the mine complex, there is an additional area where a mine pool may exist. This area is a minor synclinal basin located approximately 1.4 miles northwest (updip) of the discharge point. This pool would be approximately 270 acres.

2.3.2.9 *Summary.* Mine maps were identified for most of the discharges in detail enough that the probable extent of mine pools and the probable in-mine flow paths could be established. These can be seen on Figure 2. The approximate extent of mine drainage zones was also established. Table 1 depicts a summary of the mine drainage in this area.

2.4 Evaluation and Selection of Mine Pools for Detailed Evaluation

2.4.1 Summary of Mine Pools in the Basin. In conjunction with the investigation of mine discharges, the associated mine pools were examined. The mine pools were identified based on the previously-discussed mine maps and on the mine discharge information (location and elevation). Verification of mine pool information was not included in the scope of this study.

Within the Lower Chartiers Creek Watershed, there were 11 separate mine pools identified. Figure 3 shows the pool locations and Table 2 lists characteristics of the mine

pools. There were no pools associated with the Whiskey Run or Hope Hollow discharges. Two potential small pools were found associated with the Scrubgrass and Woodville discharges. One pool was thought to be located at the mine discharge point while a somewhat larger pool may exist within the mine about one-mile to the east of the discharge, probably beneath St. Clair Hospital. For the purpose of this report these pools were named the Mansfield Mine Number 1 and Number 2 pools.

The McLaughlin Run discharge appears to have two mine pools associated with it. A small pool probably exists at the discharge point while another pool is located in the same mine (Bridgeville Mine) less than 2,500 feet to the south. The first pool (Bridgeville Mine No. 1 pool) is only approximately 70 acres and the larger second pool is approximately 120 acres. Based on the mine maps, the second pool (Bridgeville Mine No. 2 pool) appears to overflow to the first pool, where they discharge together into McLaughlin Run.

Adjacent to the Bridgeville Mine No. 2 pool is a large pool associated with the Wingfield Pines discharge. This pool covers approximately 385 acres and is in the Montour No. 4 Mine. A small barrier coal pillar approximately 60 feet thick separates the Montour No. 4 Mine and the Bridgeville Mine. The mine maps also show a connection between these two mines at a higher elevation and thus would indicate that some of the Wingfield Pines discharge water originates in the Bridgeville Mine. The pools, however, appear to be separated by a barrier pillar at pool level. Another large pool exists within the Montour No. 4 Mine-Wingfield Pines pool to the south. This pool is controlled and the discharge treated by Consol in Peters Township, near Canonsburg Dam. The potential interaction between the expected Bridgeville Mine No. 1 and 2 pools and the northernmost Montour No. 4 Mine pool is discussed in detail later in this report.

Six additional mine pools are found on the west side of Chartiers Creek. There is a pool associated with the Coal Run discharge but no mine maps were found to delineate its location or characteristics. A mine pool of about 200 acres exists at the Presto-Sygan discharge. It is in the Essen No. 3 Mine and thus is called the Essen Mine pool. There are two other pools that are within the mine boundaries and may feed the Essen Mine pool. The southernmost of these pools is about 50 acres and is located in the Federal Mine. This is called the Federal No. 1 Mine Pool. The pool north of the Federal Mine Pool is approximately 100 acres and is located in the Federal No. 2 Mine. For the purpose of this report it is called the Federal No. 2 Mine pool.

The Gladden Mine Discharge is located in the town of Gladden, in South Fayette Township. The mine pool associated with this discharge is the Laurel Hill No. 2 Mine. The pool is approximately 10 acres and is called the Laurel Hill No. 2 Mine Pool. To the west of this pool is another mine pool that is located in the Vulcan Mine and is called the Vulcan Mine pool. It is approximately 270 acres.

Table 2

MINE POOL CHARACTERISTICS

Mine Pool	Average Discharge (GPM)	Acres	Associated Discharge	Restricted Discharge	Community	Remarks - Site Suitability for Demonstration Project
Mansfield No. 1	290	Small	Scrubgrass/Woodville	Possibly	Scott Township	Low storage capacity.
Mansfield No. 2	Internal	40	Scrubgrass/Woodville	Not Applicable	Mt. Lebanon	Insufficient information.
Bridgeville No. 1	230	70	McLaughlin Run	Yes - During High Flows	Bridgeville	Low discharge rate.
Bridgeville No. 2	Internal		McLaughlin Run	Not Applicable	Upper St. Clair	Connects to Bridgeville No. 1.
Montour No. 4	1,500	Undetermined	Wingfield Pines	No	Upper St. Clair	High discharge rate.
Essen	420	200	Presto-Sygan	No	South Fayette	Low accessibility to sewer.
Federal No. 1	Internal	50	Presto-Sygan	Not Applicable	South Fayette	Insufficient information.
Federal No. 2	Internal	100	Presto-Sygan	Not Applicable	South Fayette	Insufficient information.
Melrose	910	Undetermined	Coal Run	Yes	South Fayette	Insufficient information.
Laurel Hill No. 2	1,430	10	Gladden	No	South Fayette	High discharge rate.
Vulcan	Internal	270	Gladden	Not Applicable	South Fayette	Insufficient information.
Combined Bridgeville Pools	230		McLaughlin	Yes		

2.4.2 Site Selection. One of the goals of this project was to identify a potential site where wet weather flows could be diverted into an abandoned mine for storage, and later removed from the mine for treatment after the wet weather event had subsided. An additional goal was to select one (or more) potential site(s) that meet the above criteria, could be evaluated in detail to assess the feasibility of the concept, and potentially could be used in a future study as a demonstration site for the proposed technology.

Two critical elements must be determined to verify that the selected mine can be used for storage. The mine must have the capacity to store the expected volume, and the wet weather overflows must be contained within the mine without leaking into adjacent strata.

2.4.2.1 Mine Seals. During closure of mines, engineers can sometimes design mine seals to impound water, and thus, create a storage pool. This technique is often used by mining engineers to mitigate AMD since acidic water does not form in mines that are full of water, and thus, void of oxygen. Mine seals typically entail the design and construction of bulkheads at mine openings (shafts, slopes or drift entrances). Remaining coal barriers that exist between the mined zone and the surface must be large enough and have a sufficiently low permeability so that they can also act as an impounding structure. Older underground coal mines that were not planned to be closed in this manner, as exist in the study area, are normally not capable of being sealed to impound water due to the thin or non-existent barrier pillars that were left by the mining companies.

2.4.2.2 Flooded Mines. On the other hand, mine pools that develop after mining ceases are capable of containing water. Mine entries "below grade" (grade being defined by geologists as the surface elevation over which water flows - such as the local stream bottom) are kept dry during mining by pumping out any accumulating water. Once pumping ceases, the lower elevations fill up with water until reaching a point where they overflow to the surface. The extent of the mine pools can easily be determined when the discharge point is unrestricted and if the elevations within the mine were surveyed during mining and drawn on the maps. For openings that are restricted, such as a small borehole or cracks within the geologic strata, a piezometer can be used to measure the pool elevation. In any case, a mine pool's extent can be established if sufficient data is available. The mine inflow can also be established, by measuring the outflow. Pool levels do not fluctuate substantially unless the discharge point (or points) is restricted.

2.4.2.3 Selection Criteria. Based on the above discussion, the project team established criteria to select an acceptable mine pool for use as a containment structure for this project, and that could serve as a demonstration site for a future study. The selection criteria were:

- sufficient size and volume of pool;
- containment capability;

- location near sewage main pipelines;
- sufficient information available to assess viability of site; and
- discharge rate not excessively high.

All of the previously discussed mine pools were considered by the project team as applicable for this project. Table 2 summarizes the characteristics known about each pool.

In the Chartiers Creek watershed, there are over 50 overflow structures in the shallow cut interceptor owned by Allegheny County Sanitary Authority (ALCOSAN). The shallow cut interceptor extends along Chartiers Creek upstream to Bridgeville, near Millers Run. Numerous other overflow structures exist above the main stem interceptor pipe, within the municipal owned sewer lines. Mapping of the interceptor lines in the basin was overlain on mine pool mapping in order to examine the relative locations of the pools and interceptors, i.e., to observe possible diversion sites.

It was concluded that since the mine pools would be kept below normal pool (via pumping or other means) during dry weather periods, a pool which did not exhibit high discharge rates would be desirable for a demonstration project.

Using the information summarized in Table 2 in conjunction with the mine pool/interceptor mapping, the project team selected the Bridgeville Mine No. 1 pool and the Bridgeville Mine No. 2 pool as the potential mine pools for use in the technical feasibility evaluation. These pools are located near a major sewer network (below the McLaughlin Run interceptor, and upstream of the Chartiers Creek interceptor) and appear to have moderate storage capacities that could be controlled by pumping. Mine maps indicated that the Bridgeville Mine No. 1 and No. 2 pools were interconnected either by the No. 2 pool overflowing into the No. 1 pool or by being only one larger pool. The Bridgeville Mine No. 1 pool, has the lowest discharge volume of all of the discharging pools, and thus, less water would need to be controlled if this pool was used in a demonstration project.

The four remaining internal mine pools were not selected because not enough information was available to evaluate them adequately. The Montour No. 4 and Laurel Hill No. 2 pools were not selected due to their high discharge rates. The Mansfield Mine No. 1 pool was not selected because of its small potential storage capacity and the Essen Mine Pool was not selected because the pool was less accessible to sewer lines and had a large discharge volume.

SECTION 3

TECHNICAL FEASIBILITY EVALUATION

3.1 Introduction

The technical feasibility of temporarily storing wet weather sewer flows in abandoned coal mines was evaluated by the project team. The methodology and results of the evaluation are described in this section. The findings are based in part on detailed evaluation of the selected sites identified in Section 2 of this report, specifically, the Bridgeville No. 1 and No. 2 mine pools. The evaluation was completed to determine if a constructed demonstration project is warranted as the next step in assessing the viability of storing wet weather flows in the mine. The evaluation identifies technical issues, constraints and requirements associated with implementing the proposed concept. The following topics are addressed in this section:

- hydrologic considerations;
- water quality and environmental aspects; and
- mine subsidence considerations.

3.2 Hydrologic Considerations

The Bridgeville Mine pools, existing and potential inflows and requirements for water removal are discussed in the following paragraphs. The focus of this evaluation is to assess the physical and hydrologic viability of storing wet weather sewer flows in the mine pools, and the hydrologic consequences of storing these flows in the mine.

3.2.1 Mine Pool Characteristics and Storage Capacity.

3.2.1.1 Review of Mine Mapping. Figure 4 is a composite mine map of the project area. As discussed in Section 2 the mine maps and the surface elevations suggested that there were three distinct mine pools within the selected area. The Bridgeville Mine was mined in the early 1900s, beginning in Bridgeville and extending eastward under the Township of Upper St. Clair. The mining maps obtained from the University of Pittsburgh Library are at a scale of one-inch equals 100 feet and are remarkably detailed for maps of that era. Reduced copies (one-half size) of the mine maps are included in Appendix A. The mine maps depict the mine entrance locations, the main entryways, the production rooms, numerous bottom of coal elevations, numerous mining dates, details of adjacent mines (including notes where breakthroughs occurred), areas of unmined coal, and areas where full extraction mining occurred. For the reader's information, full extraction mining zones are areas where most of the coal was removed to not only recover the coal, but to induce the roof to cave in, so that weight of the overlying strata being

placed on the adjacent active mining zones was reduced, and thus, improving safety of the miners. This mining practice resulted in a pervious zone of broken rock (that miners term as “gob”) at the mine level and, if shallow enough, numerous surface fractures. Mining in the Bridgeville Mine would have been conducted by hand loading, using the room and pillar mining technique.

To the south of the Bridgeville Mine is the Montour No. 4 mine. This mine was active into the 1970s. An approximately 60-foot thick coal barrier is shown on the mine maps as a separation between the Bridgeville and Montour No. 4 mines. The mining in the Montour No. 4 mine in the area adjacent to the Bridgeville Mine was conducted in the 1940s. One interconnection was shown on the maps between the two mines (see Figure 4). This interconnection could be a borehole drilled to drain a mine pool that would have formed. Without draining this area of the Bridgeville Mine, mining in the Montour No. 4 mine may not have been conducted safely due to concerns of a mine blowout (similar to the recent Quecreek incident). Two large mine pools are associated with the Montour No. 4 Mine. One pool discharges in the Township of Upper St. Clair at the Wingfield Pines discharge, and the second pool is managed (by pumping and treating) by Consol in Peters Township, near Canonsburg Lake.

The two pools in the Bridgeville Mine are formed at the lowest elevations in the mine. Any water percolating through the geologic strata will collect in the mine workings and run downdip along the mine floor, following entry ways for the most part but also through the gob areas entering the mine pool somewhere along a wide area referred to as the “beach”. The beach line is established by the mine floor elevations and the pool elevation. The pool elevation can vary, but not significantly, in the same manner as lakes and ponds vary. As water flows through the unflooded portion of the mine it comes into contact with minerals in the coal and broken strata and becomes polluted with acid, metals and mineral salts. Water is typically contained in the mine until it discharges at a connection to the surface. Water normally does not continue to percolate downward into geologic strata beneath the coal seam because a low-permeability clay bed lies beneath the base of the coal seam.

Water collecting in the two Bridgeville Mine pools appears to originate from the abandoned updip mine workings of the Bridgeville Mine. The highest elevations within the mine occur in the McMillan Road area and drain to the southwest. The large Harrison Mine lies updip of the Bridgeville Mine but doesn't appear to contribute a substantial amount of mine drainage to the Bridgeville pools because of a large barrier that was left between these two mines. There may be breaks in this barrier but if so they would be located in a zone where the Harrison Mine drainage (and possibly drainage from the adjacent Coverdale Mine) would drain to the Wingfield Pines discharge from the Montour No. 4 mine instead of the McLaughlin Run discharge. This is probably the reason that flow from the Wingfield Pines discharge is much greater than the discharge from the McLaughlin Run discharge.

The Bridgeville Mine No. 1 pool (based on the discharge elevation) has a surface elevation of approximately 825. If this elevation controls the mine pool elevation a shallow pool would form at the lowest part of the mine. The mine pool would extend from Spruce Street eastward to near the intersection of the following roads: Chartiers Street, Mayview Road, Bank Street and Lesnett Road. The mine pool would cover about 70 acres and contain approximately 20,000,000 gallons of water. This estimate is based on an assumed void spacing of 25 percent of the area and the mining height of six feet. These values were selected based on previous experience with mine pools. Confirming this porosity estimate would require a drawdown test by pumping through the mine pool. Such testing may be necessary if the project proceeds to design phases.

In the same manner, the Bridgeville Mine No. 2 pool water storage volume was estimated. The pool surface water elevation was estimated to be at elevation 828. At this elevation, based on evaluation of the mine maps, the pool would be expected to overflow into the No. 1 pool. At elevation 828, the No. 2 pool has an estimated capacity of 40,000,000 gallons and covers approximately 120 acres. The mine pool extends into the Township of Upper St. Clair, under Mayview Road (see Figure 4). Mine pool stage-storage curves, based on the estimated contours, are shown on Figures 5 and 6.

3.2.1.2 Borehole Data. To further estimate the pool elevation, extent of pool and mine pool chemistry three boreholes were drilled and mine pool monitoring wells installed in early February 2004. A field report of this activity is included in Appendix B.

Boring B-1 was drilled in the pavement on the corner of Elizabeth Street and LaFayette Street in Bridgeville. This well was expected to intersect the Bridgeville Mine No. 1 pool. The borehole encountered solid coal at the coal seam elevation, which was probably the coal pillar that was shown on the mine map. The base of the coal was found at elevation 809.6, about four feet lower than expected. The water level in this monitoring well was found to be 828.7 feet on February 23, 2004 and also on March 15, 2004 (after the wells has stabilized for over a week), almost four feet higher than anticipated.

Boring B-2 was drilled in the green area of a cul-de-sac on Langport Drive in the Bridgeville Mine No. 2 pool. This boring encountered a small (two-foot) void and a variety of soft and hard rock at mine level, indicating a mine opening with a collapsed roof (as expected) according to the mine maps. The base of the coal was estimated to be at 816.7 feet or about three feet lower than anticipated. The water level in this boring was found to be at approximately 832.5 feet on February 23, 2004 and at 832.9 feet on March 15, 2004 or about 4.5 to 5.0 feet higher than anticipated.

Boring B-3 was drilled in an open field along Mayview Road in the Township of Upper St. Clair, on the Boyce-Mayview Park property, into the Montour No. 4

mine pool. Several fractures and voids were found during the drilling of this borehole and the rock was very broken, indicating a probable gob area, again as expected conditions according to the mine map. Some methane was encountered during the drilling of this borehole. The base of the coal was estimated to be at approximately 804.9 feet, the same as was expected (805 feet) from the elevations on the mine map. The water elevation in this pool was measured to be 831.1 feet on February 23, 2004 and 830.8 feet on March 15, 2004 or very close to the anticipated level of 831.3 feet.

3.2.1.3 *Discharge Sampling and Analysis.* During February 2004, water samples were obtained from the mine discharges and boreholes in order to compare chemical characteristics of the pools and discharges. The results obtained are provided in Table 3.

Table 3

MINE POOL COMPARISON

Parameter	Bridgeville Mine No. 1 Pool		Bridgeville Mine No. 2 Pool		Montour No. 4 Pool	
	McLaughlin Run Discharge	Borehole B1	Small Discharge near Bridgeville No. 2 Pool	Borehole B2	Wingfield Pines Discharge	Borehole B3
pH (s.u.)	5.5	ND ⁽¹⁾	6.58	7.25	6.65	7.64
Alkalinity (mg/L)	-	ND	178	223	382	377
Acidity (mg/L)	78	ND	-	-	-	-
Fe (mg/L)	61.4	ND	9.5	0.2	14.6	0.4
Mn (mg/L)	0.9	ND	0.3	0.2	0.3	0.2
Sulfate (mg/L)	196	ND	52	36	116	37
Top of Pool Elevation (feet)	825	828.7	ND	832.5	831.3	831.1

Note:

(1) Not determined.

The water elevations of the monitoring wells and the chemistry of the samples were compared to see if they could be used to verify that the Bridgeville Mine No. 2 pool was separated from the Montour No. 4 Mine pool. Measured pool elevations were also expected to be useful to determine the extent of the mine pools and to estimate their storage capacity. The findings are described below.

The Wingfield Pines discharge elevation closely resembles the Montour No. 4 pool elevation. Both the pool and the discharge are alkaline, but the iron content of

the pool at the borehole location is substantially lower than the discharge. This could be due to the borehole being located in an area of the mine where the pool is stagnant and not flowing toward the discharge.

The Bridgeville Mine No. 2 pool resembles the adjacent small discharge, but again, the iron levels are substantially different. A similar explanation, as described above, may also apply at this borehole. At the measured elevations it would be expected that the Bridgeville Mine No. 1 and No. 2 pools would have combined and have similar elevations. The higher elevation at Borehole B-2 could be due to a phreatic (groundwater saturation zone) head differential within the mine. The chemistry, however, is different. The McLaughlin Run discharge is acidic and has an extremely high iron content while the No. 2 pool is alkaline, with a low iron content. They could still be connected, considering that the No. 2 pool could be stagnant near Borehole B-2, and most of the discharge water being generated from the unflooded portion of the Bridgeville Mine north of the discharge. This could be the case since the expected inflows would be higher in these areas due to lower overburden thicknesses.

With the Bridgeville Mine pools being larger than anticipated and appearing to be connected, the available storage area would increase. At measured pool elevation (elevation 828.7), the No. 1 pool would contain about 38 million gallons (MG), while at the No. 2 pools measured pool elevation (elevation 832.5) would contain about 72 MG. Combined they would contain about 110 MG.

To further assess the isolation of the Bridgeville Mine from the Montour No. 4 Mine it is suggested that additional drilling and hydrological testing be undertaken. Additional holes may be needed and a drawdown test performed. The discharge elevation at Wingfield Pines could be lowered by removing the pipe cap or removing a section of concrete pipe. As the pool lowers, the elevations of the monitoring wells could be measured and recorded. The interconnections between the pools would be confirmed. This test is beyond the scope of this study, but should be conducted if the project moves into a design phase.

3.2.2 Wet Weather Flows into the Mine. A “design storm” storage volume needs to be chosen so that the selected mine pool can be evaluated to determine if it provides the required storage capacity for wet weather overflows. The following paragraphs describe the methodology by which a design volume was computed for the study area.

Upper St. Clair, in collaboration with the Municipality to Bethel Park, evaluated an alternative to manage the wet weather sanitary sewer overflows in McLaughlin Run in 1996. The proposed concept was to construct a basin/tank for storage of overflows. The design was to be based on a 2-year, 24-hour storm event (*McLaughlin Run Watershed Equalization Facilities Sizing and Siting Analysis Report*, August 1996).

The project team decided that, after review of the Rouge River National Wet Weather Demonstration Project designs (USEPA, 2004), a 2-year, 24-hour storm was

much higher in storage needs than would be feasible, given restrictions within the sewershed (flooding in McLaughlin Run would be significant). Also, the project team has experience with the Local and State Regulatory Authorities who suggest that the 2 year 24 hour may be the best design option. The basins and respective storm events in the Rouge River report were based on much lower design storms, i.e., Rouge River basin, 10-year, 1-hour; the Birmingham basin, 1-year, 1-hour; the Acacia Park basin, 1-year, 1-hour; and the Seven Mile basin, 1-year, 1-hour. Based on these design storm event sizes, the design of the basin using a 2-year, 24-hour storm was thought to be impractical.

However, through a separate 3RWWDP Grant, the Township of Upper St. Clair utilized a dynamic hydraulic model to simulate and determine what volume of a storage tank would be needed. This study involved more flow metering and a higher computation power to do what was otherwise outside of this projects scope of work. It was in the modeling project in which the team found that a hydraulic condition occurred at the projects critical flow meter. It was realized that when the flows reached above approximately 10 MGD the recorded flow rates, and subsequently volumes became drastically higher than actual rates. In the one metered event the error is suspected to be on the order of 10 times.

The size of a 2-year, 24-hour storm event, 52.9 MG, was determined by a rainfall-dependant inflow and infiltration (RDII) analysis and the use of the above erroneous data. When the volume was recalculated using data known to be accurate then it was determined to be 8.46 million gallons. The RDII analyses included the creation of a typical dry weather flow pattern. A typical dry weather day is determined by first reviewing the site-specific data. Flows influenced by wet weather events are measured. Wet weather flows are removed from the total flows, and all dry weather days are averaged (based at 8:00 a.m.). This dry weather average flow is then subtracted from the flow recorded during a wet weather event to determine a volume of water that is solely dependent on the amount of rainfall.

When it was thought that the initial volume was 52.9 MG, it was thought impractical to store the entire volume. So it was determined that the alternative would be to store only the first flush of such an event. The first flush was proposed to be the first 10 percent of the volume of flow generated by the 2-year, 24-hour storm or 5.29 MG. This would have been roughly equivalent to all of the overflow from a 1-year, 1-hour storm and this volume was roughly equivalent to that which was ultimately used for the storage tank volume in the 1996 report, and therefore, facilitated comparison of the two concepts.

Once the report for with the dynamic modeling results came into the light then it was taken from that report that the appropriate size of a tank would be 5.5 MG and not our earlier volume of 5.29MG. This still allows the two techniques to be compared and solidifies the proposed volume needed in the mine.

The above mentioned RDII analysis was performed on six separate meters in the McLaughlin Run interceptor for a precipitation event that occurred on September 19, 2003. A per equivalent dwelling unit (EDU) flow value was created for each site. These values were compared and generally fell within 10 percent of each other and thus were accepted

as representative. Application of the RDII volumes was therefore applied to the 12 trunk lines on the interceptor that were not monitored, by multiplying the per EDU volume by the number of EDUs in a particular subshed. A subshed is a number of homes whose sewage drains through a common pipe, or trunk line, into the interceptor. In this case, 12 subsheds drain into the interceptor. The calculated flow from the combined 12 subsheds was then compared with the measured flow from the area.

The flow data from a wet weather event on September 19, 2003 was used as a basis to analyze the storage needs. The precipitation from that event was approximately 1/8 that of the 2-year, 24-hour storm. In order to estimate the flows that would be generated by a 2-year, 24-hour storm event, the RDII that was recorded on the September 19, 2003 event was multiplied by eight (100 percent divided by 12.5 percent). In this manner the total volume of flow for the 2-year, 24-hour event was estimated to be approximately 52.9 MG. The first flush (10 percent of a storm event) is approximately equal to the 1-year, 1-hour event or 5.29 MG. The peak discharge calculated for the first flush was estimated to be approximately 28,000 GPM.

During our project, the hydraulic model was used in lieu of the described procedure because of the issues spoken above.

3.2.3 Base Flow Rate into the Mine. The base flow rate into the mine pool (i.e., mine flow without wet weather overflow component) is in essence the same as the mine discharge rate. The average of measurements taken over a five-month period in 2002 and 2003, determined that the base flow rate into the Bridgeville Mine pool is 230 GPM. This average flow would need to be pumped from the mine pool on an ongoing basis to maintain the pool level at a point to eliminate the discharge and to provide storage for wet weather overflows. The wet weather flow rate from the Bridgeville Mine pool was recently measured to be on the order of 500 GPM. Because this comprises a continuous source of inflow to the mine, this higher flow would need to be pumped from the mine pool during or after wet weather events. Additional monitoring of discharge is recommended to better define the average discharge flows and its variation.

3.2.4 Post-Event Pool Drawdown. After wet weather events have subsided the mine pool would need to be drawn down to enable the mine to store future events. The drawdown must include removal of the stored wet weather overflow and the base flow rate into the mine. For the purpose of this report, it is assumed that ALCOSAN would not accept withdrawal from the mine for two days and then allow two days to withdraw the overflow and mine flow. The actual design rate can be altered as desired in the design phase of the project. Further discussion of pumping is provided in ensuing sections.

3.2.5 Mine Pool Management. This project assumes that both Bridgeville Mine pools will be utilized. There is still some uncertainty regarding the interaction of the two pools or even if there are two pools. Thus, by planning to use both pools, this uncertainty will not be an issue. All of the pollution emanating from the No. 1 pool would also be eliminated and about 5,000 feet of McLaughlin Run would be restored to a non-polluted condition.

A stage-storage curve was prepared for each of the expected two Bridgeville Mine pools. The Bridgeville Mine Pool No. 1 was estimated to contain approximately 20 MG of water and the beach would be located at elevation 825. The No. 2 pool was estimated to contain approximately 40 MG. Its beach elevation is expected to be at elevation 828. If the two pools are combined as suggested by the water levels in the monitoring wells, the volume of one large combined pool would be 110 MG and covers approximately 325 acres (see Exhibit 1). Due to the head differential within the mine, the water level in the No. 1 pool would be a few feet lower than the water level in No. 2 pool. This is not uncommon in mine hydrogeology. However, additional wells may be necessary to fully understand the pools' interaction. Water in the pool must be contained within the pool limits so that it does not contaminate waters in the adjacent strata. The overflow exiting the mine along Maple Street in Bridgeville, and the seepage near the No. 2 pool would be eliminated if the pools were maintained at a lower level of pumping. The condition and suitability of the 60-foot barriers shown on the mine maps between the Bridgeville and Montour No. 4 Mines would, however, need to be evaluated in a project design.

The project team proposes to manage the mine pool in a manner similar to other mine pool sites that are currently being pumped and treated by industry or government agencies. The pool would be lowered by pumping so that no uncontrolled discharges would occur. It is planned that two feet of freeboard below the Maple Street discharge point would be maintained at all times. The storage volume would come from reducing the pools further so that a minimum of 5.3 MG of wet weather overflow storage space would be available. Another 1.5 MG of storage space would also be available to contain a high rate of mine inflow during a wet weather event (estimated at a two-day period). A contingency storage space of 0.2 MG would also be included. Thus, a storage volume of 7 MG is proposed. Lowering the No. 1 pool below the Maple Street discharge point would separate the two pools. Using the Pool No. 1 stage-storage curve, approximately 26 MG would need to be pumped to create the two feet of freeboard below the discharge point. Another foot of water (4 MG) would need to be withdrawn to create 3.5 MG of wet weather storage (50 percent of the required 7 MG). In the same manner the No. 2 pool would have to be reduced to elevation 826 to create the two-feet of freeboard below the overflow elevation to pool. This would require pumping out 40 MG of water. A storage volume of 3.5 MG can be obtained by further reducing the pool by less than one-foot. Maintaining the pool at elevation 825 would, in fact, provide 5 MG of storage. Thus, it is proposed to maintain the No. 1 pool at elevation 822 and the No. 2 pool at elevation 825 during dry weather. At these elevations, no water from the pools should discharge into Chartiers Creek or its tributaries. The discharge into McLaughlin Run along Maple Street would be eliminated, as well as the small seep from the No. 2 pool. The pumping layout and operation is discussed in Section 5 of this report. Figure 7 is a conceptualized schematic of the proposed plan.

3.2.6 Injection Point Analysis. For a mine to be used to transport and store the proposed sanitary sewage overflows, a suitable injection point must be determined and the flow path of the injected water within the mine must be estimated. As discussed in Section 3.2.2, it was estimated that 5.3 MG of storage capacity would be needed to store

the design volume. The highest flows to be diverted into the mine during the wet weather event were estimated to 28,000 GPM.

Selecting an optimal injection point requires the consideration of several important factors: location of the mine pool within the mine, coal floor contours, mine passageways in the dry portion of the mine, porosity of mine passageways, and the location and porosity of mine gob areas. An appropriate location for injecting wet weather sewer overflow water would be from a location directly above the mine pool. This would eliminate the need for wet weather overflow to flow through the mine but would only be possible when the injection point is directly above the mine pool. Pumping of sewage from the wet weather sewer overflow point to an injection point above the pool is possible but would add substantial expense to the project. Alternatively, removing sewage flows at a suitable mine injection point upstream of the wet weather overflow location would either reduce or eliminate the wet weather sewer overflows.

The McLaughlin Run Sewer interceptor line was selected as a candidate site for this project. This line was the basis for the volume and flow rates discussed previously. The injection point of wet weather sewer overflows into the abandoned mine was initially considered near the intersection of McLaughlin Run Road with Lesnett and McMillan Roads. This location was chosen because:

1. primary mine development passageways were found near this location; and
2. preliminary review of mine contours suggested that injected wet weather sewer overflows at this location would flow by gravity to the Bridgeville Mine No. 2 pool.

A more detailed examination of mine maps was then conducted to verify these assumptions.

Mining at this location took place in the 1910s. The nearest mine feature would be the intersection of No. 1, 2, 3 and 4 Mains with No. 10 and 11 Face entries (see Exhibit 1). Mines were laid out during the non-mechanized hand-loading era to be parallel to the coal cleavage planes. Mining in these directions made breaking the solid coal easier for the miners. Thus, a square pattern of mine development passageways was utilized. The mine was developed in a rectangular pattern where development entries were mined to provide access routes for men, materials, ventilation and coal transportation. These entries were planned to be maintained for a longer period of time than production zones. Passageways were approximately 12 feet wide and 6 feet high. Passageways mined along the coal butt cleavage plane were termed Butt entries and those mined along the perpendicular face cleavage plane were termed Face entries. They were numbered sequentially starting from the main mine entrance.

Production rooms were developed perpendicular to the development passageway. These rooms had a narrow connection to the development entry but were widened-out to be about 20 feet in width. This provided a two-man hand loading crew with working more

room. Track was laid in each room and cars were individually loaded one at a time. Mules or horses were used to pull the cars. A thin pillar of coal was left between rooms to support the roof. After the room was extended to its expected length, the thin pillar of coal, referred to as a support pillar, was removed as mining retreated, referred to as full extraction mining. The roof would collapse - leaving broken rock that the miners termed as gob.

The intersection of McLaughlin Run Road with Lesnett and McMillan Roads is located near the Bridgeville Mine's intersection at No. 1, 2, 3, 4 Mains with No. 10 and 11 Face entries. Water percolating into the mine (or injected) would flow along the paths of coal contours in a manner similar to surface drainage. However, there are impedances within the mine that must be considered when predicting flow paths. The main entrances were protected from extensive caving by leaving the adjacent pillars unmined. Local rock falls may block these passageways but the rock falls would probably be porous and not totally impede flows in the direction of the floor grade. The remaining pillars would, however, impede the flow and act as barriers. The gob areas would still be porous but less than the development passageways. For the purposes of this report, the project team delineated the mine into specific mining zones: 1) development entries, 2) gob area, or 3) barrier pillars. Each of these areas were assigned expected porosity values. These porosity values were used along with the known mine gradients to predict the expected flow path. These are estimated since actual conditions are unknown.

The estimated flow path from the area beneath the intersection of McLaughlin Run Road with Lesnett and McMillan Roads was expected to flow into to Bridgeville Mine Pool No. 2 based on its location and mine level contours. However, detailed review of the primary flow path, along No. 6, 7, 8 and 9 Face entries indicated that most of the wet weather sewer overflows would probably flow to the Bridgeville Mine section of the Montour No. 4 mine pool and thus to the Wingfield Pines discharge. Because the wastewater would not be expected to flow to selected mine pool, alternate discharge locations were evaluated.

The McLaughlin Run sewer interceptor line flows towards Bridgeville. The next possible injection site along McLaughlin Run is about 800 feet downstream of the intersection of McLaughlin Run Road with Lesnett and McMillan Roads. At this location, injected wet weather sewer overflows could be placed directly into the No. 7, 8, and 9 Face entries and again would flow in the same direction as discussed in the previous paragraph. This flow path was also unacceptable.

Another 700 feet downstream, a potential injection point was identified in the No. 5 and No. 6 Face entries. A mine shaft was shown on the maps at this location. It was located along an unnamed tributary to McLaughlin Run. This location was visited by the project team but no visual indication of the shaft was found. However, the location was in a wooded area that has not been associated with any surface development. The flow paths for wet weather sewer overflows injected at this location were estimated to flow primarily into the Bridgeville Mine No. 2 pool but with the possibility of a portion of the flow going to pool No. 1. This is the selected injection location and is shown on Exhibit 1.

3.3 Water Quality and Environmental Aspects of the Combined Wet Weather Overflow and Mine Water

3.3.1 Biogeochemical Processes in Mine Pools.

3.3.1.1 Mine Water Characteristics. The mine proposed to be used for temporary storage of wet weather sewer overflow is the Bridgeville Mine, located in Upper St. Clair and Bridgeville. The mine is flooded and currently discharges to McLaughlin Run in the town of Bridgeville. The chemistry of the discharge is assumed to represent the average chemistry of the mine pool. The discharge was monitored between February 2002 and January 2004 by the CNC as part of an assessment of deep mine discharges in the Chartiers Creek watershed. Water samples were collected from a pipe that carries the water from the abandoned mine to McLaughlin Run. Ten samples were submitted to the PaDEP State Laboratory for analysis of standard mine drainage parameters. Flow rates were measured five times using the timed-volume method. Table 4 shows the results of the CNC/PaDEP sampling. The discharge was also sampled in February and April 2004 by USDOE personnel who submitted the samples to NETL for analysis of standard mine drainage parameters and a suite of trace metals. Personnel from DOE also measured Eh and chemical oxygen demand (COD). The DOE results are shown in Table 5. The results of the USDOE analyses were similar to the CNC/PaDEP results.

Table 4

AVERAGE FLOW AND CHEMISTRY OF THE BRIDGEVILLE MINE DISCHARGE

Parameter	Unit	Result
Flow, Average	GPM	287
Flow, High	GPM	500
pH	s.u.	5.7
Alkalinity	mg/L as CaCO ³	49
Acidity	mg/L as CaCO ³	111
Fe	mg/L	66
Mn	mg/L	1
Al	mg/L	4
Sulfate	mg/L	515

Table 5

CHEMICAL CHARACTERISTICS OF THE BRIDGEVILLE MINE

DISCHARGE AND WET WEATHER SEWER FLOW (MCLAUGHLIN RUN)

Parameter	Unit	Sample Collected and Date(s)			
		Mine Water 02/04/04 ⁽¹⁾	Mine Water 04/14/04 ⁽²⁾	Wet Weather Sewer Flow 04/14/04 ⁽³⁾	Wet Weather Sewer Flow 04/14/04 ⁽⁴⁾
BOD5	mg/L			31	
COD	mg/L	15	11	93	48
Color, Apparent	CU			35	
Cyanide, Total	mg/L			< 0.005	
Cyanide, Weak Acid	mg/L			< 0.005	
Fecal Coliform	per 100 ml			280,000	
Oil and Grease	mg/L			10	
Phelolics	mg/L			0.005	
Residual Chlorine	mg/L			< 0.01	
Surfactants	mg/L			1.32	
ORP	meV		- 120		- 237
Total Suspended Solids	mg/L			27	
Total Dissolved Solids	mg/L			686	
Total Kjeldahl N	mg/L			9.72	
Ammonia N	mg/L			1.73	
Nitrate-Nitrite as N	mg/L			2.79	
Organic N	mg/L			7.99	
Phosphorous (P)	mg/L			1.31	
Total Organic C	mg/L			9.4	
pH	s.u.	5.5	5.69	7.7	7.2
Alkalinity	mg/L CaCO ₃	37	5		149
Acidity	mg/L CaCO ₃	78	67		- 147 ⁽⁵⁾
Calcium	mg/L	116	127		105
Magnesium	mg/L	47.1	43.9	20.5	21.6
Potassium	mg/L	4.3	3.84		5.0
Sodium	mg/L	239	196		44.7
Iron	mg/L	63.6	50.3	0.368	0.215
Iron, Dissolved	mg/L	61.4		0.051	
Aluminum	mg/L	5.14	5.07	0.296	0.677
Bromide	mg/L			1.95	
Fluoride	mg/L			0.36	
Sulfate	mg/L	603	620	85	88
Sulfide	mg/L		< 1	< 0.05	< 1
Sulfite	mg/L			< 2	
Antimony	µg/L			< 100	

Table 5 (Continued)

Parameter	Unit	Sample Collected and Date(s)			
		Mine Water 02/04/04 ⁽¹⁾	Mine Water 04/14/04 ⁽²⁾	Wet Weather Sewer Flow 04/14/04 ⁽³⁾	Wet Weather Sewer Flow 04/14/04 ⁽⁴⁾
Arsenic	µg/L	24	15.5	< 5.0	< 8
Beryllium	µg/L	1	1.3	< 5.0	0.11
Cadmium	µg/L	< 0.05	< 0.5	< 5.0	< 0.5
Chromium	µg/L	25	6.6	< 10.0	3
Chromium, Hexavalent	µg/L			< 10.0	
Copper	µg/L	< 1	45.6	17.5	92.8
Lead	µg/L	< 5	< 5	< 100	< 5
Mercury	µg/L			< 0.2	
Nickel	µg/L	110	116	< 10.0	8.9
Selenium	µg/L	< 7	< 8	< 5.0	< 8
Silver	µg/L			< 10.0	
Thallium	µg/L			< 100	
Zinc	µg/L	154	639	43.4	605
Barium	µg/L	10		60	68.5
Boron	µg/L			< 10.0	
Cobalt	µg/L	49	41.7	< 10.0	1.1
Molybdenum	µg/L	< 2.5	< 2.5	< 100	7.6
Manganese	µg/L	899	793	67.7	44.7
Tin	µg/L			< 100	
Titanium	µg/L			< 10.0	
Vanadium	µg/L	< 1	< 1		< 1

Notes:

- (1) Mine water sampled by USDOE and Hedin Environmental and analyzed by USDOE.
- (2) Mine water sample collected and analyzed by USDOE.
- (3) Wet weather sewer flow sample collected by Gateway Engineers and analyzed by Microbac Laboratories, Inc.
- (4) Wet weather sewer flow sample collected and analyzed by USDOE.
- (5) Calculated from alkalinity and metal concentrations.

The mine contains water with pH 5 to 6 and moderate concentrations of bicarbonate alkalinity. The water is contaminated with iron and, to a lesser extent, aluminum. These acidic metals give the water a net acidic character. Manganese concentrations are low, always less than 1.0 mg/L. The dominant non-contaminant cations are sodium, calcium, and magnesium. The trace metals present at more than 40 ug/L are zinc (154 to 639 ug/L), nickel (110 to 116 ug/L), and cobalt (42 to 49 ug/L). These three metals are commonly present in coal mine drainage at concentrations similar to those reported in Table 5.

3.3.1.2 Wet Weather Sewer Overflow Characteristics. Wastewater from Upper St. Clair and Bethel Park is carried in a sewer interceptor line along McLaughlin Run into the town of Bridgeville, where it combines with a sewer trunk line owned by ALCOSAN. The McLaughlin Run sewer line is located above the portions of the Bridgeville Mine. Flow in the line was sampled during a wet weather event on April 14, 2004. Two sets of samples were collected. A sample was collected by Gateway Engineers and submitted to Microbac Laboratories (Warrendale, PA) for analysis of wastewater parameters and metals. A sample was also collected by USDOE personnel and submitted to the PETC Laboratory for analysis of metal concentrations and several mine drainage parameters. The wastewater results are presented in Table 5.

3.3.2 Implications of the Storage Proposal for ALCOSAN.

3.3.2.1 Hydrologic Considerations. The use of abandoned mines for temporary storage of sewer overflow is being considered as an alternative to the use of constructed storage tanks. The only significant hydrologic difference of these plans is that the mine pool alternative requires the pumping of water during dry weather in order to maintain the storage volume. Constructed tanks will, presumably, not require continuous pumping to keep them empty during dry weather. The pumping of stored wastewater to ALCOSAN that occurs after a wet weather event is common to both alternatives.

These extra waters that will be treated as a result of the mine water pumping is a small fraction of ALCOSAN's capacity. The average dry weather flow rate to the ALCOSAN plant is 176 MGD. During the two-day, post-event drawdown, 4.1 MGD of flow would be pumped to the plant. This flow would increase the average dry weather flow by 4.1 percent. Of this amount, 3.4 MGD is wastewater and will be pumped to the treatment plant regardless of the temporary storage medium. During the drawdown, and during the dry weather storage maintenance periods after the storm, 0.7 MGD of water will be pumped to ALCOSAN for treatment. This flow would increase the current dry weather hydrologic loading by 0.4 percent.

3.3.2.2 Treatment Process Considerations. The mine drainage would have negligible effect on the operation of the wastewater plant. The ALCOSAN treatment process involves oxidation and settling. Treatment of the mine drainage is achieved by similar oxidation and settling processes. The COD of the mine water, 11 to

15 mg/L, is less than a quarter of the COD of the wet weather wastewater, 48 to 93 mg/L (Table 5). The mine water will not create a treatment burden for the facility.

The mine drainage does not contain any toxic trace metals that would interfere with the waste water treatment process or cause compliance issues with the treatment plants National Pollutant Discharge Elimination System (NPDES) permits. Mine discharges similar to the Bridgeville Mine flow are legally discharged at dozens of permitted sites in Pennsylvania following neutralization, oxidation, and settling. Treatment with the ALCOSAN process will have the same effect.

Treatment of the mine water will result in the precipitation of iron oxide, FeOOH. The Bridgeville mine produces an average iron load of about 83,000 lb/yr of dissolved iron. Assuming that the collected FeOOH is 25 percent solid (and 75 percent water), then the discharge would produce approximately 260 cubic yards of iron oxide sludge per year. This is expected to be only a minor addition to the sludge currently produced by the treatment facility.

Treatment of the acidic mine discharge requires neutralization. In this case, the neutralization will be provided by the alkaline wastewater flow. The wet weather sewer flow had a net alkalinity of approximately 150 mg/L as CaCO₃. A 1:1 mixture of mine water and wastewater will yield a neutralized solution. During storm events, there will be approximately 3.5 gallons of wet weather sewer overflow per gallon of mine water. During dry weather, the mine drainage will be neutralized by wastewater flow in the McLaughlin sewer and by wastewater at the ALCOSAN facility. As noted in the hydrologic calculations above, the dry weather ratio of wastewater to mine water is approximately 240:1. In all cases, there will be a great surplus of neutralizing alkalinity provided by the wastewater flows.

3.3.3 Implications of the Storage Proposal for the Bridgeville Mine Pool.

3.3.3.1 Microbiochemical Changes to the Mine Pool During Storage Events. The injection of wet weather sewer overflow to the mine pool will change the chemistry of the pool and potentially affect the biochemistry of the pool. Two negative consequences that should be evaluated are:

- the production of hydrogen sulfide gas as a result of bacterial sulfate reduction; and
- the production of methane gas as a result of bacterial methanogenesis.

The possibility that injection of wastewater into the mine voids is evaluated below.

3.3.3.2 Expected Conditions in the Mine Pools. The mine pools associated with the Bridgeville mine are anoxic (water with no dissolved oxygen content) with low redox conditions. Measurements made by the USDOE indicate that the pool

has an Eh value of -120 meV (Table 5). This Eh indicates anoxic conditions. If the injection process injects oxygen into the pool, it will be quickly consumed by microbial and chemical reactions. At the circumneutral pH values present in the pool, the inflow of dissolved oxygen would cause ferrous iron to rapidly oxidize to particulate ferric oxyhydroxide.

In the absence of oxygen, a series of microbially-mediated geochemical processes occur. Figure 8 shows the processes that are dominant on Earth. Table 6 summarizes several reactions that are pertinent to this discussion. The occurrence of the processes in a particular system is dependent on the presence of the necessary reactants and the absence of inhibitors. The rate of the reactions is dependent on the energetics of the process. Even with an excess of reactants, poor energetics will result in slow rates of chemical processes. Table 6 shows the great energetic advantage of aerobic respiration and, once oxygen is consumed, denitrification.

Table 6

**BIOGEOCHEMICAL PROCESSES THAT COMMONLY
OCCUR IN AQUATIC AND MARINE ENVIRONMENTS**

Reaction	Generalized Reaction	Kcal/equiv.
Aerobic Respiration	$\text{CH}_2\text{O} + \text{O}_2 \hat{=} \text{H}_2\text{O} + \text{CO}_2 + \text{Energy}$	- 29.9
Denitrification	$\text{CH}_2\text{O} + \text{NO}_3^- \hat{=} \text{HCO}_3^- + \text{H}_2\text{O} + \text{N}_2$	- 28.4
Fermentation	$\text{C}_6\text{H}_{12}\text{O}_6 \hat{=} 2\text{CH}_3\text{CH}_2\text{OH} + 2\text{CO}_2$	- 6.4
Sulfate Reduction	$2\text{CH}_2\text{O} + \text{SO}_4^{2-} \hat{=} 2\text{HCO}_3^- + \text{H}_2\text{S}$	- 5.9
Methanogenesis	$\text{CH}_2\text{O} + \text{CO}_3^- \hat{=} \text{CH}_4 + \text{H}_2\text{O}$	- 5.6

Once these high-energy reductants are exhausted, fermentation reactions are initiated that break down glucose into low-carbon compounds (such as ethanol). These low-carbon organic compounds can be further oxidized by sulfate reducing bacteria using sulfate as the reductant. In the process, sulfate is reduced to hydrogen sulfide and released into the water column. Sulfate reduction requires low-carbon compounds. In the case of wastewater, low-carbon compounds are not likely present, and sulfate reduction will be largely dependent on the ability of fermentative organisms to break down the complex carbons compounds present.

Sulfate reducers and methanogens use the same low-carbon compounds. However, sulfate reducers competitively inhibit methanogens as long as sulfate concentrations are greater than 20 mg/L. The reason for the competitive exclusion is the more favorable energetics and the fact that sulfate reducers make more

efficient use of low-carbon compounds than methanogens. If sulfate concentrations drop below 20 mg/L, the efficiency of sulfate reduction lessens, and methanogens are able to successfully compete for carbon compounds.

Existing evidence from many sites indicates that abandoned mine pools do not support high rates of sulfate reduction. The limiting factor for bacterial sulfate reduction is likely the supply of suitable low-carbon compounds. Abandoned mine pools do not normally have large quantities of low-carbon organic compounds or more complex organic compounds that can be degraded through fermentation processes. Mine pools with theoretical retention times of months retain high sulfate concentrations, an indication that sulfate reduction is not occurring. Methanogenesis under these high-sulfate conditions is not expected and, indeed, it has never been reported.

Wastewater contains organic carbon and its addition to a mine pool should stimulate microbial processes. If low-carbon compounds are present, they should be initially utilized by denitrifying bacteria. Once nitrate is depleted, the compounds should fuel sulfate reduction. If sulfate is depleted, then methanogenesis could occur. How far this sequence develops depends on the availability of reactants and time. The data available for the wet weather wastewater indicates that carbon limitations will prevent sulfate reduction from proceeding very far. In no reasonable scenario would sulfate concentrations decrease to a point where methanogenesis could occur.

Table 7 shows mass calculations for the mine pool after it has been pumped full with wastewater. The masses were calculated from the hydrologic loading assumptions presented above (and in Table 7) and from the sulfate, organic carbon, iron, and acidity data provided for wastewater and mine water in Table 5. The wastewater only contains 9 mg/L organic carbon. If this carbon is available in a low-carbon form, it should first be used by the denitrifying bacteria. Denitrification of the 2.8 mg/L nitrate-N present will require 2.4 mg/L organic carbon. Only 7 mg/L organic carbon is potentially available for sulfate reduction. This amount of carbon can only support the reduction of 28 mg/L of sulfate. (two moles of carbon support one mole of sulfate reduction; 24 grams of carbon supports 96 grams a sulfate reduction). As shown in Table 7, if all of the organic carbon supports sulfate reduction (a very conservative assumption), 700 kg of sulfate will be removed from the mine pool. The wastewater contains 1,700 kg of sulfate, so sulfate removal will not deplete this sulfate source. The mine pool is estimated to contain about 53,500 kg of sulfate. The estimated sulfate reduction potential only decreases the sulfate mass by one percent.

Table 7

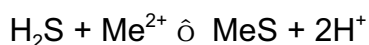
MASS CALCULATIONS FOR THE OVERFLOW STORAGE SITE

Description	Gallons	Acid (kg)	Fe (kg)	Sulfate (kg)	Organic C (kg)
Pool, Drawdown ⁽¹⁾	26,760,000	11,242	6,684	52,163	0
Wet Weather Storm Inflow	5,300,000	(4,192)	< 1	1,706	181
MD Storm Inflow	1,440,000	302	180	1,403	0
Full Pool, End of Storm	33,500,000	7,352	6,865	55,272	181
Sulfate Reduction Scenarios ⁽²⁾					
• Assumed to be Limited by Measured Organic C	33,500,000	(754)	(422)	(724)	(181)
• Reactants Necessary to Consume 95 Percent of Sulfate		(54,608)	(30,629)	(52,508)	(13,127)
• Reactants Necessary to Deplete Fe		(12,239)	(6,865)	(11,769)	(2,942)

Notes:

- (1) Pool is assumed to be full of mine water at drawdown condition.
- (2) Sulfate reduction stoichiometry is assumed as $2\text{CH}_2\text{O} + \text{SO}_4^{2-} + \text{Fe}^{2+} \rightarrow \text{FeS} + 2\text{CO}_2 + 2\text{H}_2\text{O}$; every gram of sulfate removal yields 1.04 grams of acidity neutralization.

The sulfate reduction that occurs will produce hydrogen sulfide. The minor amount of hydrogen sulfide that is generated will be readily removed from solution through the precipitation of insoluble metal sulfides. A generic reaction is shown below:



The mine water contains a high concentration of ferrous iron, which will act as a significant sink for hydrogen sulfide. If, as outlined, about 28 mg/L of sulfate reduction occurs, then 10 mg/L of H₂S should be released. This amount of sulfide will precipitate 16 mg/L of ferrous iron. In a mass perspective, the removal of 422 kg of Fe (as particulate FeS) is expected. The mine pool contains an estimated 6,800 kg of dissolved ferrous iron.

It is possible that the wastewater inflow to the mine will contain higher organic carbon concentrations than were measured in our sample. The large safety factors present in the mine assure that methanogenesis will not occur and that all the hydrogen sulfide will be precipitated by reaction with iron. Removal of 95 percent of the sulfate will require a wastewater inflow containing 13,100 kg of organic carbon or a concentration of 654 mg/L. Removal of the all of the iron, so that hydrogen sulfide potentially degasses, would require an inflow containing 2,900 kg of organic

carbon or a concentration of 147 mg/L. These concentrations are 16 to 70 times higher than measured in this study. Even these calculations are conservative because not all the carbon will be convertible to low-carbon compounds (at least one-third of the carbon is lost as CO₂ during fermentation) and the rates of sulfate reduction necessary to achieve the conditions outlined above are likely not achievable in the mine pool environment.

Methane has been found in active and abandoned coal mines. When methane is combined with oxygen, the resultant gas is explosive when the methane concentration is within the range of five percent to fifteen percent. Methane is lighter than oxygen and can be easily controlled through dilution. Confined, unventilated, spaces such as abandoned mines can accumulate methane and can cause dangerous situations if it leaks from the mine in an uncontrolled manner.

Methane is generated by an anaerobic biodegradation of organics and is commonly associated with coal seams, particularly deep coal seams where the methane is trapped by geologic barriers. Most in situ methane would be liberated during mining. However, small amounts of methane can still be generated in abandoned mine workings.

Methane production from the anaerobic biodegradation of organics being introduced into the mine in the diluted sewage is a slight possibility. As discussed earlier, desulfurization will occur instead of methanization at somewhat higher redox potentials. Therefore, methane production should not occur when sulfate-oxygen is available. Sufficient mixing of the wet weather overflows with the mine pool water would be needed so that localized sulfate deficiencies can be avoided, and thus, limit methanization. This may not always be the case. However, injection and removal locations may be selected in some projects to minimize localized stagnant areas so that desulfurization may occur.

Three boreholes were drilled in the project area. Boreholes B-1 and B-2 were drilled into the Bridgeville Mine. Methane was not encountered in either borehole. Borehole B-3 was drilled into the Montour No. 4 Mine and did encounter methane. The area where this borehole was drilled had severe cracking in the strata above the mine and thus created a higher elevation pocket for methane to accumulate.

In May of 2003, an explosion occurred at a residence on Chestnut Street in Bridgeville. Occupants were injured and the house caught on fire. It was determined by the investigation officials that the source of the methane was from a leaking casing in a nearby active gas well. The methane initiated from the leaking well and migrated through fractured bedrock on the abandoned mine.

Control of methane gas should be considered in the design of the proposed project. Even though the generation of methane is not thought to be a major issue it can easily be controlled through monitoring or vent boreholes placed at approximate locations.

3.3.4 Potential Groundwater Impacts.

Potential impacts to groundwater could be either physical or chemical. The physical impacts will be related to the fluctuations in mine levels, while chemical impacts will be related to the changes brought forth by the mine water quality. The following paragraphs describe the potential impacts.

3.3.4.1 Physical Changes. The proposed concept will direct diluted sewage into the horizon of the mined out Pittsburgh Coal. The openings created by the mining will act as a transport mechanism and as storage for these waters during wet weather, until such time that the combined mine water/diluted sewage can be pumped out of the mine back into the sanitary sewer system.

Prior to directing the diluted sewage into the mine, the existing mine pool will be lowered so that when the wet weather overflow is added to the pool, it will not raise the pool level to an elevation that will cause a discharge. This drop could lower the surrounding groundwater levels. The manipulation of the elevation of the pools should prevent the development of seeps in areas where seeps were not previously observed. Although minimal, the decreased head in the mine would decrease any vertical migration of water through the mine floor, thereby decreasing the possible movement of mine water to deeper aquifers.

The addition of high volumes of water into and out of the mine voids was thought to have the potential accelerate weathering and erosion of the pillars. This was evaluated and discussed in Section 3.4 and found not to be an issue of concern.

Groundwater use in the area is limited by an Allegheny County law that requires building systems be connected to available public systems where public water systems are within 250 feet. The Pennsylvania Groundwater Information System (PAGWIS) was researched to determine if there were any wells in the project area or vicinity. Two wells were identified; one located to the southwest of the project area in South Fayette Township on the western side of Chartiers Creek, south of the Mayview State Hospital, and the other well was located in Bethel Park. Neither of these wells are located close enough to be impacted by the project. Additionally, Upper St. Clair had no knowledge of any groundwater supply wells in or around the project area. The lack of groundwater users in the area significantly reduces concerns of impacting the yield of private wells, or commercial/industrial users.

Thus, the physical impacts to groundwater should be insignificant.

3.3.4.2 Chemical Changes. Possible contaminants in the sewage injected into the mine include bacteria and coliforms. It would be a concern if these contaminants move out of the mine and into the surrounding and underlying strata. A limited amount of the water may seep through the mine floor into the strata below,

as well as the units that are in contact with the mine pool perimeter. A limited amount may seep through the coal barrier to the pool in the Montour No. 4 Mine to the south. Neither of these flow paths are expected to be significant compared to the volume that will flow from the mine pool discharge.

Since there were no groundwater users identified, the anticipated impacts to groundwater quality should not be significant to human receptors. However, the introduction of sewage may increase coliforms and bacteria counts in the mine pool and the flow path. This may need to be monitored as the project progresses. The research being conducted at USDOE-NETL (see Appendix C) should provide the needed input relative to the expected contaminants and their potential public health concerns.

3.4 Subsidence and Flow Path Evaluation

The term “subsidence” as used in this report is defined as the settlement of the ground surface in response to underground coal mining. It is the result of high extraction mining practices and the occasional (relatively infrequent) result of partial extraction mining practices. A discussion of subsidence methodology for non-technical readers appears for their information in Appendix D.

It is envisioned that the wet weather sewer overflows will be introduced to the underground mine workings near the mine shaft located at the north end of the No. 5 Face Entry. Two injection points are planned: one each into No. 5 and No. 6 Face Entries. Injected wet weather sewer overflows will flow by gravity through the workings to the two mine pools located approximately 3,000 to 3,500 feet south. Some of the wet weather sewer overflows may flow through the gob areas, but the majority is expected to flow along paths of the anticipated least resistance, the orthogonal system of culvert-like entries (face entries and butt entries) that subdivide the mine workings into a series of 10-acre to 25-acre rectangular mine panels. Three sets of face entries (1-2, 3-4, 5-6) and seven sets of butt entries (4-6, 10, 11-12, 13-14, 21-22, 25-26, and 33-34) lie within this section of mine, all of them consisting of at least two, 12-foot wide by 6-foot high mine headings and one of them (4-6) consisting of three headings.

The face and butt entries are supported by relatively large coal pillars (“chain pillars”), which, according to available mine maps, were left in place when the mine was abandoned and are believed still to be standing. In the full extraction mining zones (the mine panels) where the coal was extracted decades ago by pillar retreat methods, the mine roof and overlying rock strata likely have come to rest on the mine floor. Planned subsidence would have occurred decades ago at these locations, concurrent with mining, and therefore, further subsidence would not be expected.

Any loss of support from crushing, punching or compression of the chain pillars along the face and butt entries would be the result of changes in the stress on the coal pillars or from degradation of the supporting rock or coal pillars.

Changes in vertical stress on the pillars and the gob materials was evaluated for this project with regard to the No. 2 pool being lowered from elevation 832.5 to elevation 825 and then temporarily raised to elevation 826 in response to a charge of wet weather sewer overflows from a storm event. Similar conditions would be expected for the No. 1 pool. The affected areas are shown on Exhibit 1. The changes in vertical stress due to the new conditions were calculated at various locations using accepted engineering methods. Overburden thicknesses, seam thickness and height of the mine pool were considered in the calculations. The computed vertical stress at the top of the coal seam was unchanged while at the base of the coal seam increased by zero percent to 0.81 percent. All were less than one percent. On this basis, changes in vertical stress on the chain pillars due to fluctuations of the mine pool are insignificant and would not be expected to induce failure of the chain pillars, the mine floor or the mine roof.

Potential degradation of the chain pillars was evaluated with regard to the flow of water through the mine. The expected mine flow direction was inferred from contour elevations of the mine floor shown on the mine maps. The thickness of overburden and size of coal pillars were also factors that were considered. The various components of each segment lengths, grade and number of mine entries in the flow routes, were identified. A single mine entry has approximately 72 square feet of area or roughly equivalent to a pipe that would be 9.6 feet in diameter.

Considering the wet weather sewer overflows through the mine in terms of flow through a straight section of pipe, the computed velocity of a 28,000 GPM discharge put through a single mine entry is 0.87-foot per second. Assuming the friction factor for the walls of mine entry to be on the order of 0.133, the shear stress along the wall of the entry is estimated to be on the order of 0.024 psf and the head loss along the entry is estimated to be on the order of 1.2×10^{-3} foot per foot of entry. Considering the wet weather sewer overflows through the mine in terms of open channel flow governed by the Chezy equation, and assuming a Manning's n of 0.041 (corresponding to the friction factor of 0.133) and channel slopes of between 0.0046 ft/ft and 0.02 ft/ft, consistent with the maximum and minimum entry slopes based on coal elevations, it is estimated that a single entry could pass the entire 28,000 GPM flow to the mine pool by gravity. The computed Froude number, which is on the order of 0.022 to 0.048, appears to be considerably below the 0.35 value cited by the USBR as being a threshold for scouring an earth channel. The permissible design velocity with regard to erosion of an unlined channel assuming an erosion coefficient of 2.5 (as for silty clay; soft rock such as shale is above 3) and a flow depth of six feet, is approximately 3.9 feet per second. A velocity of 0.87 ft/sec is considerably below this value, and thus, severe erosion of the coal pillars should not be a problem. During the design process, an energy dissipator will be designed to reduce the flow velocity as the water leaves the injection manholes.

These preliminary findings are based on the wet weather sewer overflows traveling through a single mine entry characterized as a single straight pipe or open channel. In fact, the flow of wet weather sewer overflows would be through a complex of mine entries connected at right angles and at various slopes. Flow conditions would not be uniform or

steady. Under such circumstances, flow conditions and erosional effects could conceivably develop that are not apparent from the preliminary analyses.

SECTION 4

ADDITIONAL FACTORS AND CONSTRAINTS

4.1 Regulatory

Because the proposed project is an innovative approach to alleviate existing wet weather overflows, collaboration between several federal, state, and local regulatory agencies will be necessary to define the regulatory requirements and permits needed for construction, operation, and maintenance of the proposed system. Also, thorough evaluation and coordination with ALCOSAN, Pittsburgh Water and Sewage Authority (PWSA), and various natural and cultural resources agencies, such as the United States Fish and Wildlife Service (USF&WS), the Pennsylvania Fish and Boat Commission (PAFBC), and Pennsylvania Historical and Museum Commission (PHMC) may be appropriate.

Potential agencies that permits/approvals will be required from include:

- Federal: USEPA, United States Army Corps of Engineers (USACE) and USF&WS;
- State: PaDEP (Office of Water Management, Bureau of Mining, Bureau of Air Quality, Bureau of Land Recycling and Waste Management), PAFBC and PHMC; and
- Local/County: The Township of Upper St. Clair, other municipal governments, county government [Allegheny County Department of Health, Allegheny County Conservation District (ACCD)], and ALCOSAN.

Following is a list of potential permits/approvals that would be required, depending on the scope, location, and agency findings on a project implementing the proposed technology:

- Land Disturbance: An Erosion and Sedimentation Control Plan approved by the ACCD would be required for land disturbances associated with the diversion/injection system construction and the removal system, pump stations, and other related construction. Should the land disturbance exceed one acre, a NPDES Permit for Stormwater Discharges Associated with Construction Activities would be required.
- Discharges: The anticipated method of treatment for wastewater pumped from the mine is through the ALCOSAN treatment plant. However, with the emergence of new technologies, it is possible that satellite treatment plants could be utilized to treat the wastewater, and ultimately discharge into nearby

surface waters. Such systems would require a NPDES permit with PaDEP and Allegheny County Health Department approval.

- **Water Encroachments:** Construction of the diversion/injection systems, pump stations, and tie-in to the ALCOSAN interceptors would potentially involve work in streams and wetlands, which would require PaDEP Chapter 105 and USACE Section 401 and Section 404 permit approval.
- **Environmental Impact Assessment:** The environmental impacts of the project would have to be determined and assessed in order to obtain funding and implement the project, including all areas affected by construction, as well as the mine. This would involve investigation and assessment of archaeological and cultural/historic resources, threatened and endangered species, air quality and noise impacts, hazardous wastes, socio-economic impacts, wetlands, and groundwater and surface water impacts.
- **Mining:** It is anticipated that construction of the injection system and associated erosion/energy dissipation protective measures in the mine entries will require permitting approval by the PaDEP, mining and reclamation.
- **Local Permits:** Permits from Upper St. Clair and Bridgeville would be required for grading, building, roadway occupancy, and other construction activities, as applicable.

As part of the completion of this study, meetings will be held with representatives of various government agencies in order to further refine the list of permits and approvals that would be required as part of the implementation of this project. This list will be updated accordingly in the final version of this report.

4.2 Institutional

Institutional support for the project is critical to establish administrative, funding, and operation and maintenance components. Specific targets for institutional support include quasi-government agencies such as ALCOSAN, which could benefit from this type of innovative project, and inter-municipality agreements that bind participating communities within a common sewershed to cooperate in funding and managing a system that benefits each.

As part of the future operation of the project, it is proposed to continue to establish and implement lines of communication with these types of institutions. Individuals within the organization will be responsible for the continuation or establishment of relationships with appropriate agencies to obtain funding to bring together regional agencies under a cohesive plan.

Potential funding sources that can bring together regional support include:

- federal/state government grants;
- municipal bonds;
- loans;
- matching local funds;
- increased rates to customers; and
- environmental trust funds.

USEPA has developed a comprehensive management framework called Capacity, Management, Operations, and Maintenance (CMOM) to assist municipalities in developing more comprehensive sanitary sewer system management programs. The CMOM approach based on the EPA-recommended model to abate sanitary sewer overflows can be adapted into specific program elements that will help to alleviate sewer overflows in the project sewershed.

The organization/authority must specifically identify major program goals, consistent with environmental and human health protection rules and policies as stated in the Storm Sewer Overflow Rule.

Specific CMOM elements include:

- Goals, Organization and Legal Authority;
- Measures and Activities;
- Design and Performance Provisions;
- Monitoring, Measuring and Modification;
- Overflow Response Planning; and
- Program Audit.

4.3 Legal

Legal involvement will be necessary for investigation into the ownership of existing mine voids. The need to establish legal agreements regarding ownership of the void(s) and of the mixture of wet weather overflows discharged into the voids with existing AMD will also be required prior to implementation of the project. Responsibility for the surrounding area for possible offsite contamination will also need to be established.

In addition, the potential liability associated with subsidence, odor, methane generation, or other effects from the storage of wet weather overflow in underground mines will have to be established and addressed by the implementing authority.

SECTION 5

CONCEPTUAL PLAN

To allow comparison of the proposed concept with a conventional project approach, a conceptual plan of the proposed system of diverting wet weather sewer flows into the Bridgeville Mine pool for temporary storage was prepared. A brief overview of the proposed plan is described the following paragraphs. The discussion addresses the conceptual design of the system to divert and inject the wet weather overflow into the mine, as well as the system to remove the wet weather overflow/mine water mix from the mine.

5.1 Diversion/Injection System

The proposed system consists of a diversion structure or a series of diversion structures to divert wet weather overflows into the abandoned coal mine for storage during a high precipitation storm event. The diversion structure will utilize electronic flow meters and electrical valves to divert up to the design flow of 28,000 GPM by gravity to the mine pool for storage until the storm event subsides or until the design volume of 5.3 MG has been diverted (estimated to be the first flush). The diversion control will be automated based on sewer flow rates and the mine pool level, such that it will close once the design volume in the pool is reached. Solids removing devices such as swirl separators or other comparable structures are planned to be placed between the diversion structure and the mine injection point to reduce the amount of solids and floatables being transferred into the abandoned mine. These structures would be periodically cleaned out so that they function properly to remove solids from the diverted flow.

The preliminary anticipated location for the diversion structure is adjacent to McLaughlin Run, approximately six-tenths of a mile toward Bridgeville from the intersection of Lesnett and McLaughlin Run Roads. The existing sewer which runs along McLaughlin Run is both 27 and 33 inches in diameter (depending on location) and runs directly above abandoned mine works, for a portion of its route. The preliminary, conceptual design diverts the existing wet weather sewer flows into the mine in the area shown in Exhibit 1. The selected location must have adequate land area available for a diversion structure, solids removing devices, and injection holes. The conceptual system is shown on Figure 9.

5.2 Removal/Discharge System

Analysis of the mine pools in the proposed project area indicated that two pumping locations would be required so that the wet weather overflow/mine water mixture would be reliably removed from the two mine pools, thereby enabling adequate control of the mine pool elevations. The area proposed as a pumping station to pump water from the Bridgeville Mine No. 2 pool is located approximately 6,000 feet west of the diversion structure, in a ravine north of the Wingfield Pines discharge. The second proposed pumping station, from the Bridgeville Mine No. 1 pool, is located in Chartiers Community Park. See Exhibit 1 for the proposed preliminary locations.

Each proposed pumping system will utilize three pumps to pump the water mixture of from the mine pool (Figure 7). Water which is pumped from the mine will be discharged into existing manholes down-gradient of the pump station locations. Once the water is pumped into a manhole the discharge will flow by gravity to the main interceptor, and ultimately to the ALCOSAN wastewater treatment facility. Only two of the three pumps at each pump station will be utilized at any one time and the pumps will alternate with each pump cycle. These pumps will be automated to run only during times of non-wet weather events and via float controls in the mine pool.

SECTION 6
COST ANALYSIS

The costs to implement and operate a system for storing wet weather overflows in abandoned coal mines was estimated based on the selected site and the conceptual plan described in Section 5. Costs for the project include excavation, backfill, compaction, pumps, valving, controls, piping, manholes, valve pits, two pump station buildings, gated access roads to the two pump stations, land acquisition, vegetation, legal/permitting costs, construction monitoring, three mine pool monitoring wells and two methane monitoring relief wells, and other incidentals required to operate the system.

The estimated costs (in 2004 dollars) for this system are summarized in Table 8. Estimate background information is located in Appendix E.

Table 8

MINE STORAGE SYSTEM CAPITAL COSTS

Item	Cost
Diversion System	\$ 180,000
Two Pump Stations	520,000
Monitoring Wells	30,000
Engineering Costs (design, permitting, etc.)	250,000
Legal Costs	75,000
Property Acquisition	200,000
General Services/Inspection	100,000
Subtotal	\$1,355,000
15 Percent Contingency	205,000
Total Estimated Cost	\$1,560,000

To determine the economic viability of the proposed concept, the cost difference between diverting the wet weather overflows into the abandoned mine and the conventional practice for mitigating wet weather overflows was compared. Excerpts from an August 1996 report by Chester Engineers entitled "McLaughlin Run Watershed Equalization Facilities Sizing and Siting Analyses" are included in Appendix F. Several alternatives were considered in the report for the same sewer interceptor system that was evaluated for storage in the mine. The third alternative, which was the recommended solution, was used for comparison purposes. This alternative consisted of two tanks: an upper tank at 7.5 MG

capacity and a lower tank at 1.5 MG capacity. The cost estimated was inflated using ENR's Construction Cost Index (based on the April 2004 index divided by the August 1996 index, a 1.25 factor). The estimated costs are as shown in Table 9:

Table 9

TWO TANK CONVENTIONAL SYSTEM CAPITAL COST

Item	Upper Tank	Lower Tank
Construction Cost	\$3,750,000	\$2,625,000
Engineering Cost	225,000	157,500
Legal Costs	62,500	50,000
Property Acquisition	250,000	187,500
General Services/Inspection	156,250	156,250
Subtotal	\$4,443,750	\$3,176,250
15 Percent Contingency	666,600	476,400
Total	\$5,110,350	\$3,625,650
Grand Total	\$8,763,000	

It was assumed that most operating expenses would be same for both the abandoned mine storage and conventional systems. Additional costs for the abandoned mine storage system would be the pumping and ALCOSAN's costs to treat the base mine flow. The treatment cost is based on the 2004 ALCOSAN treatment rate of \$2.50 per 1,000 gallons. (Typical mine drainage treatment costs using a chemical treatment system would be less than \$0.75 per 1,000 gallons). This estimated cost based on the ALCOSAN treatment rate (in 2004 dollars) is as shown in Table 10:

Table 10

ABANDONED MINE STORAGE SYSTEM
ANNUAL TREATMENT COST

Item	Annual Cost
Pumping	\$ 3,000
Treatment	302,000
Engineering	50,000
Subtotal	\$355,000
15 Percent Contingency	53,000
Total Annual Cost	\$408,000

For comparison purposes, the treatment cost was inflated annually at three percent and discounted using a seven percent discount factor to develop a percent worth of estimated cost differential. This value is estimated to be \$5,545,000. Thus, combining the capital with the present worth of the operating cost, the mine storage project cost would be \$7,105,000. The alternative two tank solution was estimated to cost \$8,763,000 or approximately \$1,700,000 more than the mine storage concept as shown in Table 11.

Table 11

COST COMPARISON

	Two Tank Storage System	Mine Storage/Dumping ALCOSAN Treatment
Capital Cost	\$8,763,000	\$1,560,000
Annual Cost	Not Considered	408,000
Project Work	8,763,000	7,105,000

The above analyses compared two similarly sized systems. No attempt to optimize the mine storage concept was made. The two tank system was optimized as other alternatives were considered and estimated. Optimizing the mine storage concept could save substantially more money. For example, if a chemical treatment plant was found to be viable to treat the combined water and to treat the mine water, the annual cost to treat the pumped water would decrease substantially. Instead of \$2.50 per 1,000 gallons the cost would be in the order of \$0.75 per 1,000 gallons. This cost saving could be achieved for an additional capital cost of between \$250,000 and \$300,000. Another alternative that could be considered is the use of a gravity discharge system at the current McLaughlin Run discharge location. Since there is an outflow restriction at this location, the site currently impounds as much as 50 million gallons of water. If the restriction is eliminated, the pools could be drained by gravity to the elevation of the discharge pipe. A valved pipe could be constructed to carry the discharge to the ALCOSAN truck line. This pipe would be shut off during wet weather events and the system would impound up to 50 million gallons - almost the size of a full 2-year, 24-hour storm event. The two pump stations would be eliminated as well as their operating costs.

Another consideration that is not included is the treatment of the discharge from the Bridgeville Mine that pollutes McLaughlin Run. Since the discharge is located in a residential area there is essentially no place to develop a treatment system without piping the flow downstream. Passive treatment systems can be utilized for this discharge. We have assumed that an anoxic limestone drain and ponds and wetlands would be required and that the treatment site could be located at the mouth of McLaughlin Run in Bridgeville above its confluence with the back channel of Chartiers Creek (~9,000' downstream of the discharge). The capital cost for this system would be on the order of \$800,000 and cost

approximately \$25,000 annually for maintenance. Adding this cost to the two tank containment system increases the total cost to \$9,563,000 and the present cost to \$9,903,000.

Table 12 summarizes the various options. The lowest cost option (No. 6) is the mine storage system and a local chemical treatment plant to treat both the mine drainage and the wet weather sewer overflow.

Table 12

COST SUMMARY

Option	Two Tank Storage without Mine Treatment	Mine Storage/ALCOSAN Treatment with Pumping	Two Tank Storage with Mine Treatment	Mine Storage/ALCOSAN Treatment without Pumping	Mine Storage/Local Chemical Treatment System with Pumping	Mine Storage/Local Chemical Treatment System without Pumping
Capital	\$8,763,000	\$1,560,000	\$9,563,000	\$ 960,000	\$1,710,000	\$1,660,000
Annual	Not Considered	\$ 408,000	\$ 25,000	\$ 400,000	\$ 160,000	\$ 150,000
Present Worth	\$8,763,000	\$7,105,000	\$9,903,000	\$6,381,000	\$3,886,000	\$3,700,000

SECTION 7

CONCLUSIONS

The possibility of using abandoned coal mines to store wet weather overflows has many potential benefits. This solution will definitely result in cleaner streams than a storage tank system due to the dual benefits of reduced wet weather sewer overflows and reduced acid mine drainage to streams. A wet weather project to store wet weather overflows in abandoned coal mines will also result in a much lower life-cycle cost than a storage tank system. To successfully implement a project of this type, an underground mine must be found that has adequate storage capacity, the drainage within the mine and all discharges must be controllable, and all pollutants must be contained within the zone that is controllable. The sewer interceptor must be located in close proximity to the abandoned mine and preferably high enough so that a gravity flow connector to the mine can be utilized. Environmental regulations must be met and the health and safety standards of the community must be maintained. Finally, the community, governmental authorities, and regulatory agencies must accept the project, legal rights must be obtained, and compliance with the USEPA regulations concerning sewer overflows must be met.

If the project can meet the above criteria, several benefits could be obtained, including cleaner streams, elimination of unsightly storage tanks or the required enlargement of interceptor pipes (which could also disturb stream habitat), and less land area would be utilized.

Taking into account the preceding discussion the major findings of this report are summarized below:

- Nine mine discharges in the Lower Chartiers Creek area were identified and characterized. Eleven separate mine pools, feeding seven mine discharges were evaluated.
- All eleven mine pools were considered possible for storage projects. The two Bridgeville Mine pools were selected for a feasibility evaluation based on their location near a major sewer interceptor, the pools' discharge rates were lower than other candidate pools, and the pools were found to have adequate potential storage capacity.
- The two Bridgeville Mine pools were investigated by installing monitoring wells, one into each Bridgeville Mine pool and one into the adjacent Montour No. 4 pool, which is separated from the Bridgeville Mine by a 60-foot thick coal barrier pillar. Based on water level readings in the wells, it was determined that, the two Bridgeville pools were at higher elevations than originally thought, and when combined as a single pool contain about 110 MG of storage capacity.

- The project team evaluated the McLaughlin Run sewer interceptor pipe and determined that a storage requirement of 5.3 MG would be needed. This volume would store the first flush from a 2-year 24-hour storm event (approximately 10 percent of its total volume) in the watershed, with an estimated peak flow of 28,000 GPM. This storage volume is also approximately equal to that of a 1-year, 1-hour storm.
- The base flow into the mine was determined to be approximately 230 GPM, based on average outflow measured at the McLaughlin Run discharge. The flow rate used during storm events was selected based on a recent measurement of 500 GPM taken after a wet weather event.
- Managing the mine pool was determined to be possible. The pools would be lowered by pumping to eliminate the discharge and create a storage volume for 7 MG of water, including 5.3 MG for wet weather overflow volume, 1.5 MG for mine inflow (two days of the high mine inflow), and 0.2 MG of contingency storage. In addition, the full pool storage capacity would be maintained at two feet below the McLaughlin Run discharge elevation.
- It was determined that a suitable mine injection point could be located along McLaughlin Run Road in the Township of Upper St. Clair, in a wooded area near an unnamed tributary. The injection point would be established into the No. 5 and No. 6 face entries of the Bridgeville Mine.
- Subsidence potential was evaluated relative to the mine flow path and the mine pool beach zone fluctuations. Increased potential for subsidence was found to be remote. The mine openings were evaluated using open channel flow methodology and it was determined that the mine openings could carry all of the anticipated waters flows without causing significant erosion to the pillars and result in subsidence.
- The mine water has a pH between 5 and 6 and an average net acidity of approximately 110 mg/L. The mine water is contaminated with iron, and to a lesser extent, aluminum. The wet weather overflow from a sample collected in April 2004 had a pH between 7 and 8 and a net alkalinity of approximately 150 mg/L. The COD and biochemical oxygen demand (BOD) values were low and the fecal coliform concentrations were average for raw sewage.
- Methane production from anaerobic geodegradations of organics may be a slight possibility, only if the wet weather overflow becomes stagnant in a localized zone and doesn't mix with the mine water. This probably should not occur, but if it would develop, it could be controlled by strategically placed vent boreholes to vent the methane.

- The addition of the mine drainage to the ALCOSAN treatment plant would have a negligible effect on the operation of the plant.
- There are no groundwater users identified in the project area and thus there should be no groundwater impacts to human receptors.
- A conceptual design plan was prepared. During a large wet weather event, a diversion structure would direct up to 5.3 MG (the first flush) into the mine at two manholes located near each other. After the wet weather event has subsided or when the ALCOSAN treatment system can take additional flow, water would be pumped from the mine (at two locations) into existing manholes downgradient from the mine and the existing treatment facility.
- The cost for the construction of a base case mine storage system was estimated to be \$1,560,000. The cost to construct a similarly sized two-storage tank base case system was estimated to be \$8,763,000. There is an operating cost differential between the mine storage and two tank systems. This differential cost is associated with pumping and treating the base mine flow and is estimated to be \$408,000 annually. For comparison purpose, a present worth of the operating costs for the mine storage system was estimated to be \$5,545,000 for 20 years. Including the capital and operating costs, the mine storage system was estimated to be almost \$2 million less than the two-storage tank alternate.

This cost differential would be much higher if an independent chemical treatment plant was utilized at the mine pumping stations in place of ALCOSAN treatment and if a treatment system for the AMD discharge was added to the cost of the two storage tank system.

- As summarized in Table 12, several alternatives were considered and preliminary cost estimates prepared for comparison purposes. The lowest cost approach would be to use the Bridgeville Mine to store wet weather overflows and to treat the mine water/sewage mixture at a dedicated facility in the Bridgeville area. Without pumping, this alternative would result in a savings of about \$5,000,000 over the two tank system (without mine treatment).

The above summarizes the findings of this evaluation. Based on these findings it appears that storing wet weather sewer overflows in abandoned mines can be accomplished technically without endangering the public or the environment. The cost analyses indicate that the project is also economically feasible.

The site evaluated is considered to be a viable candidate site for a demonstration project. Other sites may also be appropriate but these sites would have to be evaluated in a manner similar to the site presented in this report.

SECTION 8

DISCUSSION AND RECOMMENDATIONS

The feasibility of temporarily storing sewer overflows associated with wet weather events in abandoned underground coal mines has been investigated. This concept is a novel approach to a difficult technical and economic problem. Conventional solutions - including new pipes, repairing leaky pipes, storage tanks and increased treatment capacity are extremely expensive and would take away valuable financial resources from other community needs. Conventional solutions also do not solve the clean stream problem when abandoned mine drainage pollution is in the same watershed. The conceptualization of this project has already fostered new opinions in mine drainage mitigation planning - abandoned mine pools are now being considered as assets by some government agencies. For example an agreement was recently signed by the Governor of Pennsylvania to allow treated mine pool water to be used as cooling water at a power plant.

A team of specialist with extensive expertise in the subject areas was assembled to address the problem. GAI and Gateway Engineers have served as the principal coinvestigators. Hedin Environmental and the University of Pittsburgh have provided expert technical consultation. The Township of Upper St. Clair provided project sponsorship and technical advice. The USDOE-NETL provided valuable treatability investigation results through a Cooperative Research and Development Agreement (CRADA) with GAI. Funding for the project was provided by the Three Rivers Wet Weather Demonstration Project, the PaDEP, the USEPA and the Heinz Foundation. Representatives of the above organizations, agencies and ALCOSAN served on a technical advisory committee. The collective expertise of these groups was used to identify key technical and environmental issues.

The project team considered several sites before selecting the candidate site for evaluation. This selection was based on the site's geologic framework and its location near large sewage transport lines. Much information was obtained on the site's conditions that will be useful if the project proceeds to final design and construction.

The goal of environmental regulations for wet weather overflows is clean water. A 2002 report by the Southwestern Pennsylvania Water and Sewer Infrastructure Project Steering Committee states: "Abundant water is one of southwestern Pennsylvania's greatest assets. The quality of that asset has improved steadily in recent decades, as the region has worked hard to reduce industrial water pollution. Unfortunately, the discharge of sewage into the region's waterways and groundwater, and the lack of water and sewer infrastructure in many communities, mean that the region can't fully enjoy the benefits of this important natural asset."

The Chartiers Nature Conservancy, a local environmental organization, recently completed a Rivers Conservation Plan for the Lower Chartiers Creek Watershed. The plan identified pollution from abandoned coal mines as a primary problem in the watershed.

Based on the above two reports, it is obvious that both pollutant sources, mine acid drainage and sewage, must be resolved to reach the goal of having clean streams. Solving one or the other problem does not resolve the entire issue in many streams. This project provides another avenue to reach the result expected.

The novelty of the concept was a challenge to the project team. The wet weather flows are high and conventional solutions are very expensive. Working in an urban setting also is difficult, considering the competition for available land. Using passive treatment systems to resolving the mine drainage pollution, as is used in most abandoned mine drainage mitigation projects, also requires large tracts of land, primarily flat land near streams. These are the same lands envied by sewer authorities and others, such as sports clubs, naturalists, developers, and industry. The City of Chicago is resolving its urban sewer overflow problem by using underground construction techniques (see Appendix G) to develop tunnels for use to store and to convey wet weather flows. This project is in operation and portions are still being constructed. The Chicago project cost is enormous, estimated at \$3 billion plus. The tunnels are constructed using equipment developed and used in the mining industry. The tunnels have not caused a health or safety problem to the public. The Chicago project has resulted in major improvements to the city's rivers and streams.

The proposed demonstration project is technically, environmentally and economically feasible. Since 1977, mining companies and state agencies have successfully managed mine pools. The pools have proved to be containable and the treatment systems employed are proven. The injection techniques have been proven in the Chicago project. Additional research to determine the interaction and the treatability of the wet weather flows and the mine drainage mixture needs to proceed. This research has been started by the USDOE-NETL and the initial results are optimistic.

Most of the water in wet weather sewer over flows is surface water infiltration, approaching 98 percent, based on data collected by Gateway Engineers. One sample of sewer flow during about weather event was analyzed. Fecal coliform was the only tested parameter that was found to be at a significant level. Additional sampling is recommended. The authors are confident that the high fecal coliform treatment can be resolved.

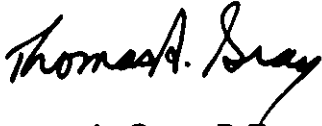
A procedure for regulatory agency approval of the demonstration project does not exist. This could be resolved within the framework of the consent order currently being negotiated between ALCOSAN, 3 Rivers Wet Weather, the Municipalities of Allegheny County, and USEPA. We recommend that a demonstration project be implemented whereby the project would be designed in phases to limit risks and so that all outstanding issues can be resolved before full scale projects are put into service. A demonstration project would serve to either prove or disprove the technology and would prove to the public that projects of this type can be accomplished in a safe manner that protects their health, safety, and the environment, and is cost-beneficial and aesthetically acceptable.

If proven successful, this technology can also be implemented elsewhere. Abandoned mines and sewage system overflow problems are present throughout the

Appalachian region and without resolving both issues, the potential for improved stream conditions will not become a reality.

The authors of this report have reviewed the issues and in our professional opinion, consider that the technology can be implemented successfully and recommend that the investigated project site be developed into a demonstration project.

Sincerely,



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SECTION 9

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