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UNITED STATES
DEPARTMENT OF LABOR
MINE SAFETY AND HEALTH ADMINISTRATION

COAL MINE SAFETY AND HEALTH

REPORT OF INVESTIGATION

Surface Impoundment Facility

Dam Failure Accident (Drowning)

November 30, 2012

Nolan Run Slurry Impoundment
Impoundment Site I.D. No. WV03-00161-00
Robinson Run No. 95 Mine
Consolidation Coal Company
Near Lumberport, Harrison County, West Virginia
Mine ID No. 46-01318

Accident Investigators

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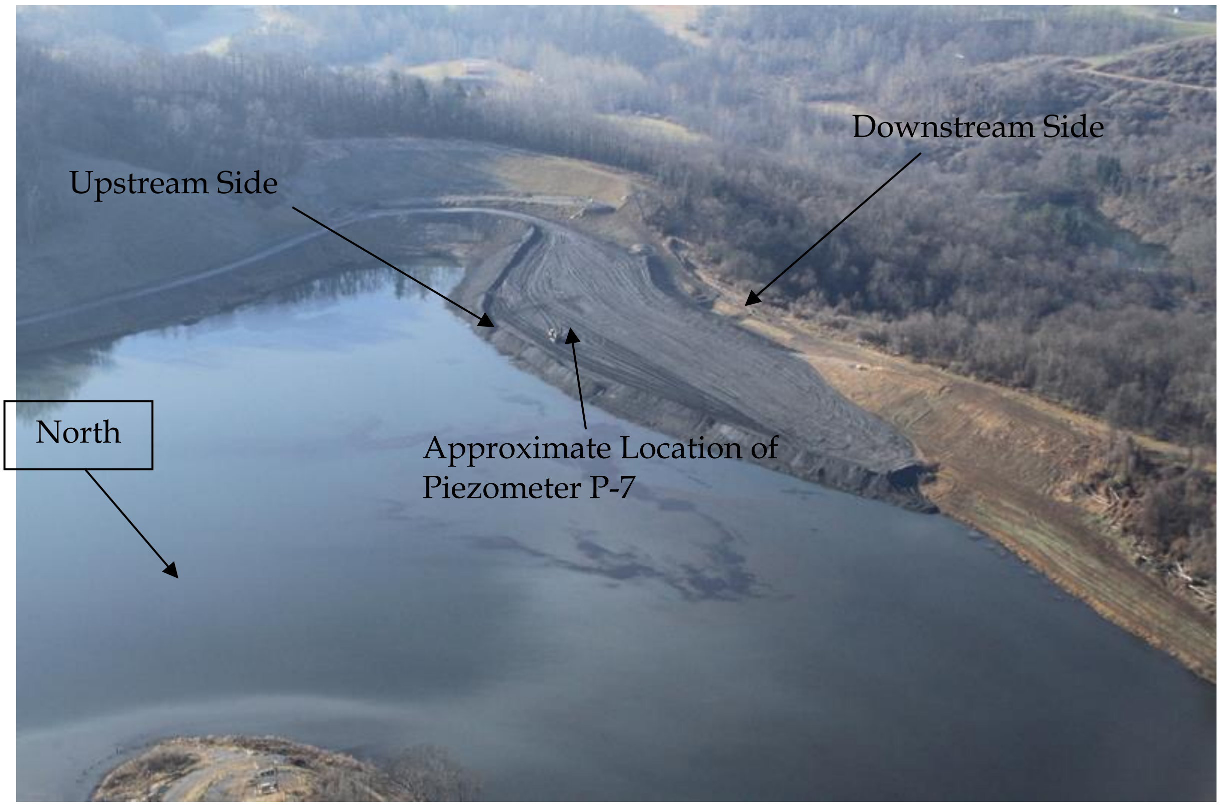
OVERVIEW

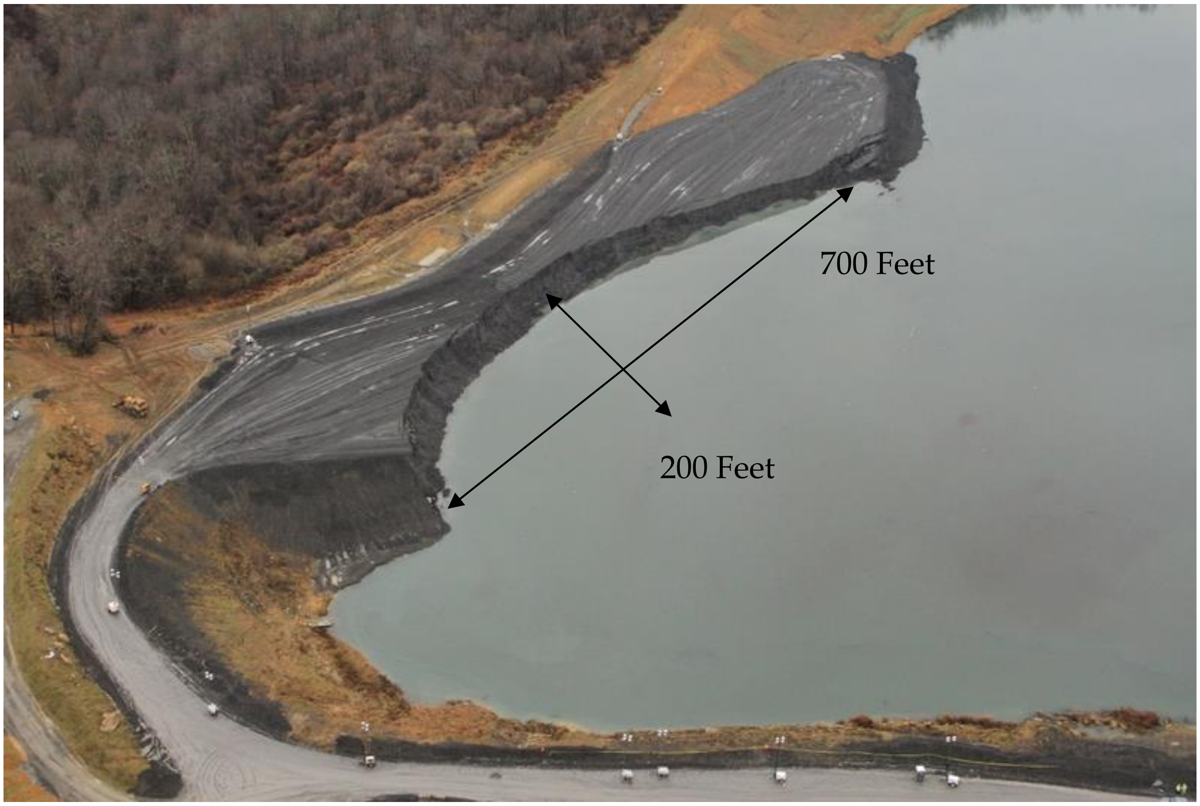
On Friday, November 30, 2012, at approximately 12:15 p.m., a massive upstream slope failure occurred on the Western Saddle Dike (dam) of the Nolan Run Slurry Impoundment, (see Figure 1 and Photographs 1 and 2) resulting in the death of one miner. The victim was a 58-year-old Mobile Equipment Operator, Markel J. Koon (see Appendix A), who was cutting the upstream slope (water side) to final grade. The bulldozer he was operating was carried into the pool area where it went underwater. Two other miners, P. Stuart Carter, Project Engineer, and Michael Friedline, Impoundment Construction Foreman, were also standing on the portion of the saddle dike that collapsed. Friedline was able to reach to natural ground safely. Carter was rescued from the pool by a local volunteer fire department rescue boat. The initial failure was 80 to 130 feet wide (measured east-to-west). Subsequent failures and toppling coarse coal refuse (CCR) further widened the affected area to approximately 200 feet wide. The length (north-to-south) of the failure was approximately 700 feet, or approximately 850 feet along the former perimeter of the upstream slope (See Photographs 1 through 3).

It was determined that the bulldozer was located beneath 25 feet of coal refuse, using remote sensing technology. The mine operator contracted salvage divers to recover the victim. On December 14, 2012, the divers maneuvered a steel pipe down through the material from a barge platform, cut an opening in the operator's compartment of the bulldozer, and removed the victim. The dike failure occurred because the load of the embankment exceeded the strength of the foundation materials. The CCR embankment was raised faster than the strength of the fine coal refuse (FCR) could increase in order to stabilize the dike.

SITE PHOTOGRAPHS



Photograph 1: Western Saddle Dike prior to failure



Photograph 2: Western Saddle Dike after failure.

Photograph 3: Nolan Run Impoundment main embankment

GENERAL INFORMATION

The Robinson Run No. 95 Mine was operated by Consolidation Coal Company with the primary portal located outside Mannington, Marion County, West Virginia. At the time of the accident, this underground coal mine was owned by Consol Energy, which has been acquired by Murray Energy. The mine accessed the Pittsburgh No. 8 coal seam by two portals: the Camp Run Portal and the Margaret Slope Portal. Coal was transported via overland conveyor belt from the slope to the Robinson Run Preparation Plant, located near Lumberport, Harrison County, West Virginia. The current preparation plant began operation in 2009. It was built adjacent to the old structure, which was removed after being decommissioned.

Coal was mined from the 64-inch-thick seam by four continuous mining machine sections and one longwall section. The Robinson Run No. 95 Mine employed 426 underground miners and 54 surface employees, with an average production of approximately 18,000 tons per day. The mine typically operated eight-hour production shifts, three shifts a day, six days a week. The mine was ventilated with six main mine fans. Coal was transported from active workings to the Margaret Slope Portal by a conveyor belt system and brought to the surface via a slope belt. Battery- and diesel-powered rail-mounted vehicles were used to transport supplies and mine personnel. The mine liberated approximately 5.4 million cubic feet of methane every 24 hours.

The Western Saddle Dike was constructed by pushing CCR into the water and onto settled FCR in the impoundment. The hydraulically placed fines were to be the foundation of the Western Saddle Dike. The larger-sized waste material, the CCR, was transported from the preparation plant via a belt conveyor to a bin. The material was then transferred to pans (also referred to as scrapers) and articulated haul trucks and driven to Nolan Run Slurry Impoundment for disposal. The FCR was pumped from the preparation plant to the slurry impoundment in suspension. Clarified water in the impoundment was pumped back to the plant to be reused in the cleaning process.

The mine was beginning to construct Stage 4 of the impoundment, according to the approved impoundment plan. MSHA had reviewed and approved the design plans for this and all previous stages. The Stage 4 design report was prepared for the mine operator by Alliance Consulting, Inc. (Alliance) of Beaver, West Virginia.

At the time of the accident the mine operated and maintained one slurry impoundment, two freshwater impoundments, three Acid Mine Drainage (AMD) treatment facilities with impoundments, and a dry refuse pile.

The principal company officers at the time of the accident were:

Mike Smith……………...Superintendent

Todd McNair…………….Assistant Superintendent
Mike Nestor……………..Safety Supervisor

MSHA completed a regular Health and Safety Inspection (E01) on September 29, 2012. Another E01 inspection was ongoing at the time of the accident. The Non-Fatal Days Lost (NFDL) incidence rate during calendar year 2011 for the mine was 1.23 compared to the national average of 1.82 for 2012.

DESCRIPTION OF ACCIDENT

On Friday, November 30, 2012, Mike Friedline, Impoundment Construction Supervisor, started his day by conducting a pre-shift inspection of the Nolan Run Slurry Impoundment, MSHA Impoundment Site I.D. No. WV03-00161-00. He inspected the main embankment and Western Saddle Dike prior to the other miners starting work. Friedline did not note anything out of the ordinary at that time. The shift started with a safety meeting in the preparation plant prior to the miners going to their assigned work areas.

Koon was operating a Caterpillar D6T low-ground-pressure model bulldozer (dozer), working on the main embankment of the impoundment. Afterward, he moved the dozer to the Western Saddle Dike to continue grading the upstream slope. Daniel Krivosky and Mark Wentz were operating pans used to transport the CCR from the refuse bin to the impoundment for placement. Danny Stonebreaker and Craig Carpenter were operating smooth-drum vibratory compactors, and Joshua Dean was operating various pieces of mobile equipment. Later in the shift, Stonebreaker used another dozer to start building up a berm along the downstream edge of the saddle dike. Carpenter left the site to get the water pan.

Jeff Cox, Impoundment Inspector, contracted through Forquers Contracting, arrived at the site at 10:00 am to complete a required seven-day impoundment inspection. Cox recorded a pressure of 15 pounds per square inch (psi) on the P-7 Pneumatic Piezometer, located below the Western Saddle Dike. Since the reading was greater than the hydrostatic pressure acting alone on the instrument, it indicated that excess pore water pressures had developed. Cox had been instructed to notify Consol personnel if the piezometer reading showed excess pore pressure. This was the second consecutive weekly reading of the piezometer that indicated the pore water pressure was greater than the hydrostatic pressure. Hydrostatic pressure is the pore water pressure that is due to the difference in elevation between the pool and point of measurement. P. Stuart Carter, Project Engineer for Consol Energy, was immediately notified of the reading and he traveled to the site.

Friedline met Carter on the saddle dike at approximately noon. They parked their trucks near Piezometer P-7. After discussing the piezometer reading, they walked to the edge of the upstream slope on the saddle dike near the water surface. Carter noticed islands of FCR which had formed above the water surface in the pool, south of their location. Friedline told Carter that the islands were not present during his preshift inspection prior to 8:00 a.m. During Carter and Friedline's inspection, approximately 15 feet out into the pool, the water started bubbling at the pool surface. Carter informed Friedline that the saddle dike was starting to settle and everyone needed to get off of it. Suddenly, a large crack formed across the saddle dike behind Piezometer P-7 and the pickup trucks as water sprayed into the air from the crack. Miners operating equipment nearby felt a sudden jolt from the saddle dike area. Koon radioed, "What was that?" The dozer Koon was operating was located on the front slope of the dam with the front of the dozer pointed up toward the working surface. Koon attempted to maneuver the vehicle out of the pool as it slid with the failed material into the pool area. The dozer eventually submerged with Koon still in the cab. Stonebreaker drove his dozer off the saddle dike onto natural ground. Krivosky had just left the saddle dike in his pan and saw the events occurring in the pan's mirror. Dean witnessed the dam failure from an articulated haul truck near the emergency spillway on the main embankment and immediately called for help over the radio. Both Dean and Krivosky returned to the saddle dike area as quickly as possible.

Friedline and Carter looked up and saw a 12-to 15-foot-high, nearly vertical, slope of CCR in front of them and realized the section of the embankment where they were standing was sinking rapidly. The failure sent a wave of water to the other side of the impoundment. Friedline and Carter were not able to reach the remaining portion of the dike before being engulfed by water. Friedline swam and waded to the southern corner of the remaining dike as it continued to break off. Dean, Krivosky and Stonebreaker were able to pull him to safety. Carter fell down as the water rushed around him. The momentum of the failed material and the current of the water carried him away from shore. He grabbed a wooden crib block to help him stay afloat. Large slabs of the CCR embankment continued to fall into the pool. Carter floated past his partially submerged pickup truck, from which he obtained a lifejacket. However, the momentum of the failure pushed Carter farther toward the center of the impoundment, where he was able to climb onto material that had heaved above the water surface level. He was rescued by a boat operated by the Winfield District Volunteer Fire Department.

INVESTIGATION OF THE ACCIDENT

Greg Fetty, District 3 Staff Assistant, was notified of the accident on November 30, 2012, at approximately 12:49 p.m. by Mike Nestor, Safety Supervisor of Robinson Run No.95 Mine. Nestor informed Fetty that a failure had occurred at the Nolan Run Slurry Impoundment and that a miner was trapped in a submerged dozer and two other miners were unaccounted for. Fetty issued a 103(j) order verbally to ensure the safety of all persons during the recovery of the victim and accident investigation. MSHA personnel were immediately dispatched to the accident location. Michael Stark, Mine Safety and Health Specialist, traveled to the site and was met by Michael Evanto, Impoundment Group Supervisor, and Fetty. An investigation started immediately in conjunction with the West Virginia Office of Miners' Health, Safety and Training, the West Virginia Department of Environmental Protection, Consolidation Coal Company, and the United Mine Workers of America.

Upon arrival at the site, Stark spoke with General Preparation Plant Superintendent, Rocky Cianfrocca. Stark was informed that two miners, Friedline and Carter, were rescued and en route to the hospital and Koon was still missing.

The rescue effort started with a local dive team associated with the Winfield District Volunteer Fire Department. Numerous other fire departments and emergency services personnel arrived throughout the day to assist with finding and recovering the victim. Since the dozer was located with remote sensing technology underneath 25 feet of a mixture of CCR and FCR, the mine operator used a contractor to locate the dozer. The local dive team was replaced by a professional diving contractor. The contractor, River Services Company, Inc., is a salvage recovery company experienced in using a method called "pipe diving." This method is used on the Mississippi River to protect the divers from the fast moving current of the water. The mine operator brought several barges from its river division to the accident site. These barges were connected and used as a work platform on the water. The 42-inch-diameter steel pipe that the divers worked in was fitted with a series of air and water jets and a vacuum pump to remove the material on top of the dozer. The recovery operations were hampered because the divers had to continuously fight through shifting refuse, with near zero visibility and difficulty orienting the dive pipe to determine the location of the bulldozer operator's cab. The divers cut an opening in the cab, through which they removed the victim on December 14, 2012, 14 days after the accident.

Informal interviews were conducted at the mine site on December 3, 2012. Formal interviews were conducted January 13-16, 2013, at the MSHA Bridgeport Field Office and January 31, 2013, at the MSHA District Office in Morgantown, WV. Appendix B includes a list of interview participants.

A subsurface exploration program was conducted by the operator as part of the accident investigation. The program included geophysical exploration, geotechnical drilling and sampling, in situ (in place) material testing, and laboratory testing (see a portion of the boring location map in Figure 2).

DISCUSSION

Nolan Run Impoundment History

The Nolan Run Slurry Impoundment is classified as a high hazard potential facility. This classification defines for sites where failure of the dam would cause the probable death of persons downstream of the impoundment, regardless of the condition of the dam. The impoundment is capable of storing and discharging runoff associated with the Probable Maximum Flood through an open-channel, grouted-rip-rap-lined, emergency spillway. The normal pool level is maintained by a system of pumps which allows water to be returned to the preparation plant or to be stored in the adjacent Robinson Run Freshwater Impoundment.

The Nolan Run Slurry Impoundment design plan was originally submitted by the operator in 1977. The design was prepared by Bowser-Morner Testing Laboratories, Incorporated. The 75-foot-high, Stage 1 embankment is a zoned rock fill with a clay upstream face. The Pittsburgh coal seam, located at approximately the same elevation as the downstream toe of the impoundment, was contour strip mined as part of the impoundment construction. The mining provided additional volume to store the FCR and the strip soil was used to construct Stage 1. The Stage 1 crest elevation was 1215 feet. The plan, as modified, was approved by the District Manager on September 25, 1978.

The design plan for Stages 2 and 3 was prepared by Almes and Associates, Incorporated. The mine operator submitted this plan to the MSHA District Manager on February 17, 1999. MSHA approved the plan on March 7, 2001, following modification to address technical issues. Stage 2 consisted of a 15-foot-high crest raise to an elevation of 1230 feet. Stage 3 consisted of a 40-foot-high crest raise built to an elevation of 1275 feet using the upstream construction method. The term "upstream construction" typically identifies portions of the CCR embankment that are constructed on settled FCR. The term "settled" FCR refers to the particles of the slurry that have dropped out of suspension, but the term does not imply any particular level of consolidation or strength. The construction technique for each stage of the impoundment is based on the geometry of the valley and the refuse disposal requirements. Both stages were constructed using CCR generated from the preparation plant. During Stage 3, the Eastern Saddle Dike was constructed. A saddle dike is a dam constructed to fill a low area, or saddle, on the perimeter of an impoundment.

The Stage 4 design plan was originally submitted on February 1, 2007. The plan was prepared by Alliance. A seismic liquefaction report, prepared by Civil & Environmental Consultants, Incorporated, dated June 7, 2007 supplemented the plan. Stage 4 consisted of raising the crests of the main embankment and Eastern Saddle Dike by 40 feet using the upstream construction method to an approved Stage 4 final crest elevation of 1310 feet.

The Stage 4 plan included the construction of a Western Saddle Dike (Figures 3 and 4). The upstream construction method was also utilized to construct the Western Saddle Dike due to the elevation of the FCR and the narrow width of the ridgeline at the saddle location. The modified Stage 4 plan was approved by the District Manager on April 15, 2009, and construction of the Western Saddle Dike began in April 2012.

The mine operator submitted two additional plan modifications. The first modification, titled "Procedural Guidelines for Implementing the Upstream Construction of the Nolan Run Slurry Impoundment," was approved on June 16, 2011. This modification included the following provision: *"The placement of coarse coal refuse for upstream construction should initiate with advancement of a thick layer (typically 4 to 6 feet thick) of coarse coal refuse onto the exposed fine refuse delta. Placement of the initial lift of coarse will begin along the embankment upstream slope and gradually advance upstream over the fine refuse*." This required that a slurry delta be maintained in the area of the push-out. No exposed delta of larger, heavier, slurry particles was formed prior to the initial push-out of the Western Saddle Dike. A delta is a build-up of sediment that generally forms at the discharge location of a slurry line due to the larger particles settling sooner than the finer particles suspended in the slurry. Since deltas are composed of the coarser portion of the FCR, they are more permeable and have the ability to consolidate more rapidly than finer FCR. In addition, the weight of the delta consolidates the underlying material, strengthening it. Figure 5 shows an exposed delta at the main embankment of the impoundment, which was constructed in accordance with the approved plan.

The second modification, titled "Intermediate Stage – Nolan Run Slurry Impoundment Robinson Run 95," was approved on April 11, 2012. This intermediate stage was not reached.

In addition to the design plans, MSHA regulations required the mine operator to submit an engineering certification every twelve months. The operator complied with this requirement. MSHA also received a copy of the annually updated "Monitoring and Emergency Warning Plans and Procedures" required by the West Virginia Department of Environmental Protection.

Geology

The Western Saddle Dike of the Nolan Run Slurry Impoundment is constructed along the western ridge of the Nolan Run watershed. The adjacent watershed forms an unnamed tributary to Jones Creek. The impoundment is located within the Appalachian Plateau physiographic province, which is comprised of bedrock of the Upper Pennsylvanian Period of the Paleozoic Era. Specifically, the bedrock underlying the Western Saddle Dike belongs to the Monongahela Group. The Monongahela Group consists of alternating sequences of shale, sandstone, siltstone, claystone, coal, and underclay. The upper and lower portions of the Monongahela Group contain sandstone, shale, and claystone. The bottom of the Pittsburgh coal seam is the base for this group. The bedrock dips approximately 50 feet per mile towards the west. The site is located on the western limb of the north-south trending Wolf Summit Anticline, and is approximately 4 miles west of the Shinnston Syncline and 7 miles east of the Robinson Syncline.

The soils in the Nolan Run watershed have been mapped by the Natural Resources Conservation Service as part of the National Cooperative Soil Survey. The hillsides around the impoundment are predominantly Westmoreland silt loams. The silt loams present in the vicinity of the Western Saddle Dike occur on 15 percent to 35 percent slopes. The surficial (relating to the surface) soil is classified as fine-loamy residuum weathered from interbedded sedimentary rocks such as claystone, siltstone, sandstone, and limestone.

Location of Equipment

Koon was operating a Caterpillar D6T low-ground-pressure model dozer on the upstream outslopes of the Western Saddle Dike at the time of the accident. The victim was working on the upstream slope approximately 500 feet south of the northern end of the saddle dike. The dozer was oriented upslope, facing the west. Witnesses observed the dozer sinking into the impoundment until it was submerged. At the time of the recovery, the dozer was oriented facing the northwest (Figure 2). The top of the cab of the dozer was at a depth of approximately 25 feet. The dozer was not removed from the impoundment.

The pick-up trucks that Friedline and Carter had driven to the Western Saddle Dike were parked on its surface near Piezometer P-7. During the failure of the saddle dike, both vehicles were swept into the impoundment pool and subsequently removed after the recovery operation.

Dike Construction

The upstream push-out for the Western Saddle Dike began in April 2012. A sounding conducted in May 2012 determined the elevation of the settled FCR at the western region of the pool to be at an elevation of 1247 feet. The pool water elevation at the time of the initial push-out was approximately 1255 feet. There was a maximum of eight feet of water above the settled FCR at the saddle dike. CCR was pushed into the pool of the impoundment to establish the footprint of the dike.

The leading edge of the push-out progressed eastward into the pool of the impoundment during the spring and summer without the delta required by the plan modification approved June 16, 2011. The height of the dike surface above the pool water level was reported to be approximately 4 feet during the push-out. The designed lateral extents of the dike were reached by mid-September of 2012. At this time, the elevation of the settled FCR in front of the dike was approximately 1251 feet. The recorded pool elevation remained at approximately 1255 feet. The estimated surface elevation was approximately 1259 feet at the upstream edge of the embankment.

The haulage equipment used to transport CCR to the Western Saddle Dike included pans and off-road haul trucks. During construction of the pushout, a dozer was used to spread the material across the surface and push it over the edge and into the impoundment. The slopes were initially constructed at a steeper grade than required by the plan. As the height of the pad increased, the slope required material to be removed in order to meet the 2.5 horizontal to 1 vertical design grade specified in the approved design plans. Records indicate that approximately 500,000 tons of CCR were used to construct the saddle dike prior to the failure.

Compaction testing using a nuclear density gauge was conducted at the Nolan Run Slurry Impoundment weekly by a technician contracted through Triad Engineering, Inc. (Triad). Samples of the CCR were collected for laboratory testing in order to determine the moisture content. A series of fifteen compaction tests were completed each week. The most recent compaction tests that took place on the Western Saddle Dike were conducted on November 20, 2012. The compaction testing conducted during the preceding four weeks took place on the Western Saddle Dike surface. The CCR was to be compacted to at least 95% (per cent) of the maximum dry density, as determined by the American Society of Testing and Materials (ASTM) Standard D698 (standard Proctor compaction test). All compaction test records for the Western Saddle Dike showed that compaction met the specifications.

The mine operator continued to place CCR material on the Western Saddle Dike after the initial pad was completed in late September, prior to installing the P-7 pneumatic piezometer as required by the plan. Page 7 of the Alliance Report, titled "Report Expansion Plan – Stage IV MSHA I.D. NO. 1211WV300161-00" states on page 7, "*Instrumentation … the pneumatic piezometer (P-4, P-5, P-7) shall be installed once an adequate embankment pad has been established on the fine coal refuse surface….*" Accident investigation interview statements indicated that the mine operator added material to raise the pad between mid-September and late October, raising the surface an average of less than one-half foot per week. Records and interview statements indicated placement rate was significantly higher in November. The rapid loading of FCR deposits during upstream construction may lead to an unacceptably low factor of safety against failure through the FCR underlying the embankment. Piezometer P-7 was installed on November 16, 2012, and at that time, the elevation at its location was recorded to be 1264.5 feet, which would be 4 to 5 feet higher than the initial pad elevation. The surface elevation at the Piezometer P-7 location on November 30, 2012 was estimated to be between 1268 and 1269 feet. This is consistent with an interview statement that estimated placement rate, during November, of 2 feet per week.

Instrumentation

Pneumatic Piezometer P-7 was installed at the saddle dike on November 16, 2012, by Triad. The location of this piezometer is shown on Figures 3 and 4. The purpose of a pneumatic piezometer is to monitor the pressure in the pores of fine-grained material, such as FCR, during embankment construction. Pneumatic piezometers respond much more quickly to pressure changes than standpipe piezometers, and are often used in upstream construction. Tolerable excess pore pressures predicted in the design can then be compared with the monitored pore pressures. During material placement on soft, saturated, fine-grained soils, the load is initially carried by the water. The CCR being pushed out onto FCR through upstream construction is similar to building an island on top of mud; the weight of the CCR drives the water from the pores of the underlying material. This consolidation of the underlying FCR and clay occurs at a slow rate due to the low permeability of the material.

A more technical explanation of elevated (excess) pore pressures follows: Excess pore pressures generated by the loading of the CCR during saddle dike construction delay the increase in effective stresses in the FCR and thereby delay the increase in strength. The CCR must be placed on top of the FCR at a slow enough rate for the pore water pressures to dissipate without causing significant instability.

A chart, titled "Maximum Allowable Pneumatic Piezometer Readings, PSI" was included in the Stage 4 design plans. The chart correlated the saddle dike pad elevation to the calculated pore water pressures associated with a slope stability factor of safety (FS) of 1.5 in order to limit the rate of construction. The chart had the work surface elevation in feet on the vertical axis and the piezometer reading in pounds per square inch (PSI) on the horizontal axis. Anything to the left or above the line was a factor of safety of 1.5 or above and was acceptable, while anything below or to the right of the line representing P-7 indicated the factor of safety may have been reduced to below 1.5 (See Figure 8). When the factor of safety fell below 1.5, the plan required the mine operator to contact Alliance and have the slope stability re-analyzed. The plan did not require construction to stop.

The first reading of Piezometer P-7 took place during the morning of November 23, 2012. Jeff Cox, Impoundment Inspector, contracted through Forquers Contracting, recorded a pressure of 15 psi. Since the reading was greater than the hydrostatic pressure acting alone on the instrument, it indicated that excess pore water pressures had developed. Cox had been instructed to notify Consol if the piezometer reading showed excess pore pressure. At the time of this inspection, the dike surface elevation was approximately 1266.5 feet at the location of the piezometer. The pool elevation was recorded as 1255.4 feet.

Prior to leaving the mine on Friday, November 23, 2012, Cox spoke with Len Roman, Prep Plant Maintenance Foreman. At 11:28 a.m. Roman emailed Friedline and Carter the following, "*Forquer just pulled their first reading on the P-7 Piezometer. The phreatic surface is 4' higher than the pool elevation. Pool El. 1255.6 P-7 1259.65 Just wanted to make you are aware.*" On Monday, November 26, 2012, Carter informed Fred Vass, Principal Engineer for Alliance, via email of the piezometer reading. The same day, both parties discussed the piezometer reading by telephone. The piezometer reading exceeded the allowable pressure indicated on the design plans by approximately 2 psi. As specified on the plans, the slope stability was re-analyzed. At 3:21 p.m. on November 27, 2012, Vass replied via email the following: "*…the preliminary stability looks like your current measured pressure in ok, but can you tell me the elevation of the fines adjacent to the slope of saddle dike so we can finish evaluating it….*" Ten minutes later, Carter replied that the FCR surface elevation was 1254 feet. On November 28, 2012, Vass emailed, "*…attached please find a preliminary revised graph for the allowable readings for Pneumatic Piezometer P-7. Note the graph provides guidance for two adjacent fines levels, Elevation 1254 (current level) and 1256. Also note that we have plotted 1.3(sic) and a 1.5 factor of safety line for each level. Please contact me for a more complete explanation….*" The revised graph indicated that the 15 psi reading acquired on November 23, 2012, correlated to a slope stability factor of safety between 1.3 and 1.5. Construction continued after the initial piezometer reading and miners were not withdrawn from the saddle dike. Section 6.6.4.2.1 of MSHA's Engineering and Design Manual Coal Refuse Disposal Facilities Second Edition, dated May 2009, includes the following: "A minimum factor of safety of 1.3 is recommended for analyses based on intermediate configurations where material strengths are supported by laboratory and/or field testing and undrained strength parameters are used." The designer did not conduct additional laboratory and/or field testing, or use undrained strength parameters in the analysis. Selection of an acceptable factor of safety for the design of an embankment depends on the degree of uncertainty and the consequences of failure. Elements affecting the selection of an appropriate factor of safety include:

- The type and extent of sampling and testing to determine material strengths;
- The variation of materials in the embankment and impoundment;
- Uncertainties of embankment geometry;
- The type of embankment (e.g., constructed by upstream method or downstream method);
- The level of uncertainty concerning the location of the phreatic level and related excess pore-water pressures;
- The accuracy of the stability analysis method(s) used; and,
- Potential for loss of life and/or property damage.

If these uncertainties and conditions are well-defined, or if conservative assumptions have been made, a lower FS may be acceptable. Conversely, when many assumptions are made relative to forces and material strengths, a higher FS is appropriate. This is particularly applicable for upstream construction due to the potentially unstable nature of the slurry foundation.

On November 30, 2012, Cox returned to the Nolan Run Slurry Impoundment to conduct the weekly impoundment inspection and monitor all instrumentation. He arrived at the Western Saddle Dike at approximately 10:00 a.m. to obtain the Piezometer P-7 reading. Friedline accompanied him to observe the reading. The dike surface elevation was between elevation 1268 and 1269 feet. The pressure reading was 15 psi, same as November 23, 2012. The events during this inspection, immediately preceding the accident, are contained in this report in the section titled, "Description of Accident."

The design plans, details, and assumptions pertaining to the piezometer installation were reviewed as part of the investigation. Several factors were identified that could have adversely affected the ability of Piezometer P-7 to observe the critical excess pore pressures:

- The Piezometer P-7 tip elevation of 1225 feet was designed to be placed in FCR approximately seven feet above the clay of the submerged natural hillside. Pore pressures dissipate as water is squeezed from the FCR. The clay exhibited a lower permeability that would impede drainage from the bottom of the FCR. Therefore, excess pore pressures would be expected to increase with depth in the FCR and the maximum pore pressures observed would be at the bottom of the FCR deposit. All analyses conducted by Alliance assumed that the CCR constructed as part of the saddle dike penetrated into the FCR to a bottom elevation of 1250 feet. However, Triad's driller's log listed the material above elevation 1234.5 feet as "moist CCR," and below this level the material is listed as "slurry." The drillers continued drilling to elevation 1225 feet and installed the piezometer. Also, the subsurface exploration conducted as part of the accident investigation encountered FCR containing CCR as low as elevation 1216 feet in front of a portion of the dike which did not fail. As the bottom of CCR approaches the piezometer sensor elevation from above, excess pore pressures observed at the piezometer sensor (elevation of 1225 feet) would dissipate at a faster rate due to the shorter drainage path to the overlying, more permeable materials.

- The Piezometer P-7 auger hole was backfilled only with cuttings obtained during the installation. Triad's driller's log indicates that the cuttings were predominately CCR. The permeability of the backfill material is likely to have been much higher than the permeability of the consolidating FCR surrounding the borehole. The manual published by the piezometer's manufacturer, Slope Indicator Company, states that the installation of pneumatic piezometers should include a bentonite seal and bentonite-cement grout, both of which are very low permeability materials, placed above the piezometer.

- MSHA conducted independent finite element consolidation analyses to estimate the pore pressures beneath the Western Saddle Dike. The staged-construction consolidation analyses suggest that a layer more permeable than FCR, such as a mixed zone of CCR and FCR would need to extend to nearly an elevation of about 1225 feet for the total pore pressure to be 15 psi at the piezometer tip.

As a result of the above factors, the pneumatic piezometer showed lower readings than MSHA believes were present in the FCR deposit a short distance away. While more accurate readings may have further warned the operator, the results were still sufficiently high to show that a potentially unsafe condition existed.

Subsurface Investigation

An extensive subsurface investigation was conducted as part of the accident investigation. A post-failure cross-section of the impoundment in the saddle dike area is shown on Figure 6. Geotechnical drilling and sampling was completed at the main embankment, the remaining portion and area surrounding the Western Saddle Dike, and in the impoundment pool. Boring locations in the saddle dike area are shown on Figure 2. The investigation included cone penetration testing (CPT), standard penetration testing (SPT) with split-spoon sampling, sonic drilling, field vane shear testing, rock core drilling, collection of undisturbed material samples (Shelby tubes), and test pits. Samples obtained from the subsurface investigation were tested to determine material classifications, strength properties, consolidation characteristics, densities, and permeabilities. The operator developed a drilling and sampling plan which was approved by MSHA and the West Virginia Office of Miners Health, Safety & Training to assist in the investigation. Both agencies provided oversight of the drilling operation and the laboratory testing.

The subsurface investigation produced data on the material in the vicinity of the saddle dike. The drilling program found that the natural hillside is composed primarily of brown clay underlain by bedrock. Laboratory testing concluded that the strength parameters of the clay sampled during the accident investigation were similar to those used in the design. Testing also demonstrated that the FCR in the vicinity of the saddle dike area is much finer than the FCR in the vicinity of the main embankment. This is expected due to the fact that the saddle dike is a considerable distance from the slurry discharge spigot at the main embankment. FCR is a combination of sand-sized particles, silts, and clays, which are removed during the coal preparation process.

When the FCR is transported hydraulically as slurry, the heaviest particles settle near the slurry discharge and the finer particles are carried in suspension farther into the impoundment. Only the finest portion of the material will remain in suspension until it reaches the rear of the pool (the saddle dike area). Laboratory testing completed as part of the investigation shows the strength of the FCR located in the vicinity of the saddle dike was less than assumed in the design plan. Compaction testing, performed by Triad Engineering, Inc., as required by the impoundment design plan, indicated that the CCR placement met the minimum level of compaction required by the plan, so it is likely that the compacted CCR strength was approximately what was used in the design analysis. Additional technical information is provided in Appendix D.

MSHA Post-Failure Analyses

There are many factors that can affect the short-term stability of an upstream stage, such as material strength and consolidation properties, the depth and drainage conditions of consolidating layers, the construction technique and rate of construction, and the embankment and foundation geometry. MSHA reviewed topographic drawings, the boring logs, in situ testing, and geotechnical laboratory testing reports generated from the subsurface investigation; performed evaluations and calculations to characterize the material properties; estimated consolidation and strength parameters; conducted analyses to estimate in situ pore pressures; and evaluated potential failure scenarios.

The cross-section of the dike that was judged to be the most critical to slope stability was chosen based on the widest upstream pushout and steepest natural ground surface. Calculated excess pore pressures in the FCR, due to the rate of construction, were determined to be higher than those assumed in the design. MSHA conducted slope stability analyses using undrained strengths for the fine-grained materials and estimated excess pore water pressures yielded a factor of safety less than 1.0, indicating that failure could occur. Additional technical information is provided in Appendix D.

Weather

The National Weather Service reported no precipitation on November 30, 2012, in Clarksburg, West Virginia. The rainfall for the month of November was 0.28 inches. The temperature on November 30, 2012, ranged from 26 °F (Degrees, Fahrenheit) at approximately 7:53 a.m. to 55°F at 1:53 p.m. The temperature reported at 11:53 a.m. was 52° F. The wind speed was 10.4 miles per hour from the southwest. The temperature and rainfall were within normal ranges and would not have any adverse effects on the impounding structure.

Seismic Activity

The United States Geological Survey National Earthquake Information Center maintains a database of earthquakes in the United States. The center also keeps records of seismic events induced by mining activity, such as explosions and roof falls. In the week prior to the accident, no events greater than a magnitude 3 were reported within a 1000-mile radius of the Nolan Run Impoundment. The records do not show any activity within a 1000-mile radius of the site on November 30, 2012. Seismic activity does not appear to be a contributing factor to the accident.

Mine Workings

Surface and underground mine workings are located in the vicinity of the Nolan Run Slurry Impoundment. The potential role of breakthroughs and subsidence-related events in the saddle dike failure were evaluated. Abandoned underground mine workings are present approximately 800 feet south of the Western Saddle Dike (See Figure 7). Discharge from the reclaimed portals of the abandoned workings was observed for signs of a hydraulic connection to the impoundment pool. The drainage was clear and no contamination due to FCR was observed in the discharge or drainage channels. Therefore, there was no evidence in the portal discharge that a hydraulic connection between the workings and the pool had been established.

Portions of the Nolan Run valley have been contour strip-mined; both within the impoundment area and downstream of the main embankment. The strip mining within the impoundment was completed concurrently with the initial construction of the embankment. Contour strip and auger mining were also completed south and west of the impoundment.

Borings were drilled through the underlying Pittsburgh coal seam south of the impoundment. The minimum recovery of the seam was 97 per cent, indicating that no abandoned workings were present at the boring locations. In addition, electrical resistivity testing was conducted to determine if unrecorded abandoned mine workings are present to the west or south of the saddle dike. Six resistivity profiles were developed. Anomalies observed by the test method indicate that unmapped abandoned workings may be present west of the saddle dike, but are not observed closer than approximately 750 feet from the saddle dike. The subsurface investigation indicates that subsidence due to unknown workings below the saddle dike is unlikely.

The impoundment pool level for the months preceding and immediately following the failure was reviewed. Records do not indicate a notable change in the pool elevation near the time of the failure. Therefore, there is no evidence of a direct hydraulic connection to underground mine workings below or adjacent to the impoundment.

Mining does not appear to be a contributing factor to the accident. Additional technical information is provided in Appendix D.

Gas Characterization

Following the accident, bubbles were observed at numerous locations within the impoundment pool in the area of the Western Saddle Dike. Gas samples of the bubbles were collected by the mine operator and the accident investigation team from the pool on February 25, 2013, and April 4, 2013. The gas content samples analyzed by MSHA exhibited high levels of methane. The geochemical composition of the methane was compared to samples collected from other potential local sources during the investigation. Laboratory testing indicated that the samples obtained from the impoundment pool exhibited similar chemical and isotopic characteristics to samples desorbed from CCR.

Observations were also made on the main embankment of the impoundment where upstream construction was also completed. In numerous locations, bubbling was observed through the FCR. Based on visual observations and geochemistry of the gas, the bubbling observed in the impoundment pool appears to be originating from the CCR push-out for the saddle dike and the volume of CCR submerged in the pool as a result of the failure. Therefore, the bubbles observed in the pool do not appear to be a contributing factor to the accident. Additional technical information is provided in Appendix D.

Training

Koon received Part 48 surface training on March 24, 2009 and annual refresher training on June 11, 2012. He was last task trained on the bulldozer operation on July 25, 2012.

ROOT CAUSE ANALYSIS

An analysis was conducted to identify the most basic causes of the accident that were correctable through reasonable management controls. During the analysis, root causes were identified that, if eliminated, would have either prevented the accident or mitigated its consequences.

Listed below are the root causes identified during the analysis and their corresponding corrective actions to prevent a recurrence of this type of accident:

Root Cause: The construction of the Western Saddle Dike was not performed in accordance with the approved plan. The initial pushout of CCR was not placed on an exposed fine refuse delta and the operator continued to place fill on the completed pad prior to the installation of the piezometer.

Corrective Action: The mine operator will perform construction in accordance with the approved plan. Additionally, all surface foremen who oversee work at the Nolan Run Slurry Impoundment will be trained in the requirements of approved impoundment plan design plan, revisions, and modifications. MSHA will verify that the training has been completed.

Root Cause: The mine operator's plan did not have procedures in place to stop construction once pore pressure readings exceeded the allowable pressure in the approved plan.

Corrective Action: The mine operator was required to develop an action plan to address "level of safety" below that specified in the approved impoundment plan. Specifically, the mine operator must stop construction if conditions indicate a "level of safety" lower than what is specified in the plan. Additionally, all surface foremen who oversee work at the Nolan Run Slurry Impoundment will be trained in the requirements of approved impoundment plan design plan, revisions, and modifications. MSHA will verify that the training has been completed.

CONCLUSION

A failure occurred on the Western Saddle Dike of the Nolan Run Slurry Impoundment because the load of the embankment exceeded the strength of the foundation materials. The CCR embankment was raised faster than the strength of the FCR could increase. Following completion of the footprint (pad), the mine operator continued to place CCR on the saddle dike for approximately two months prior to installing a pneumatic piezometer to indicate the strengthening of the FCR by measuring pore pressure. The mine operator did not follow the approved impoundment plan, which required the pneumatic piezometer to be installed once an adequate embankment pad has been established on the FCR surface. After the piezometer was installed, the readings exceeded the maximum allowable pore pressure stated in the plan. The mine operator continued to place fill on the saddle dike after additional stability analyses indicated a factor of safety lower than that specified in the approved plan. The mine operator's design plan did not require stopping placement of additional material once excessive pore pressure readings were observed.

William M Sergent

William M. Sergent
District Manager

Date 3-14-2014

ENFORCEMENT ACTIONS

1. A 103(k) Order was issued to Consolidation Coal Company to ensure the health and safety of all miners until an examination and an investigation could be completed.

An accident occurred at this operation on November 30, 2012, at approximately 12:30 pm. As rescue and recovery work is necessary, this order is being issued, under Section 103(j) of the Federal Mine Safety and Health Act of 1977 to assure the safety of all persons at this operation. This order is also being issued to prevent the destruction of any evidence which would assist in investigating the cause or causes of the accident. It prohibits all activity at The Nolan Run Slurry Impoundment, MSHA I.D. No. WV03-00161-00, except to the extent necessary to rescue an individual or prevent or eliminate an imminent danger until MSHA has determined that it is safe to resume normal mining operations in this area. This order applies to all persons engaged in the rescue and recovery operation and any other persons on-site. This order was initially issued orally to the mine operator at 12:52 pm and has now been reduced to writing.

2. A 104(a) Citation was issued for a violation of 30 CFR § 77.216(d). The high hazard potential Nolan Run Slurry Impoundment was not constructed in accordance with the design plan approved by the District Manager. The mine operator failed to follow the approved plan as stated on page 7 of the Alliance Report titled "Report Expansion Plan – Stage IV MSDAH I.D. NO. 1211WV300161-00" states on page 7 "*Instrumentation … the pneumatic piezometer (P-4, P-5, P-7) shall be installed once an adequate embankment pad has been established on the fine coal refuse surface….*"

The modification submitted by P. Stuart Carter, P.E. on May 19, 2011, and approved by the District Manger on June 16, 2011, states on page 3, item Number 6 *"The placement of coarse coal refuse for upstream construction should initiate with advancement of a thick layer (typically 4 to 6 feet thick) of coarse coal refuse onto the exposed fine refuse delta. Placement of the initial lift of coarse will begin along the embankment upstream slope and gradually advance upstream over the fine refuse*." Information gathered during the fatal accident investigation, including soundings completed by the operator in September 2011, May 2012, October 2012, and January 2013, indicate underwater settled fine coal refuse (slurry) elevations were well below the water surface. Testimony of witnesses concurs with this.

3. A 104(a) Citation was issued for a violation of 30 CFR § 77.216-3(b)(1): A potentially hazardous condition was allowed to develop on the Western Saddle Dike of the high hazard potential Nolan Run Slurry Impoundment. A condition existed where the structure was overloaded with the construction material, not allowing enough time for the excess pore water pressure to dissipate.

The excess pore water pressure reading was also affected by other factors which resulted in a misleading reading. The Pneumatic Piezometer P-7 was not installed according to the Manufacturer's Recommendations. The pneumatic piezometer was not installed at the proper time to get a base-line reading, (Pushout completed in September but the piezometer was not installed until November 16, 2012). Some construction had taken place on the Western Saddle Dike which likely would have increase pore pressure). The tip location of the pneumatic piezometer had not been placed in the optimal location to sense the critical pore pressure. MSHA's own analysis indicates that the pore pressures would have been as much as 10 times greater just a few feet away in a solid FCR deposit and not in a mix zone.

4. A 104(a) Citation was issued for a violation of 30 CFR § 77.216-3(b)(2): The mine operator did not notify the District Manager when a potentially hazardous condition developed on the saddle dike, contributing to the fatal accident.

The mine operator continued to place coarse coal refuse (CCR) on the saddle dike after the stability factor of safety had fallen below 1.5, which indicated that the weight of the CCR was overloading the fine coal refuse foundation. The mine operator was made aware of this potentially hazardous condition by the high pore pressure readings from the P-7 pneumatic piezometer obtained on November 23, 2012, and on the morning of November 30, 2012, prior to the accident. The readings obtained exceeded the allowable pore pressure limits set forth in the plan approved by the District Manager on April 15, 2009, at revised Figure 10. This potentially hazardous condition required the mine operator to notify the District Manager, who, through the District's Impoundment Group, would have directed the mine operator to cease operations on the saddle dike until a new stability analysis had been completed showing a stability factor of safety at or above 1.5 in accordance with the approved plan.

APPENDIX A – VICTIM INFORMATION

Accident Investigation Data - Victim Information

Event Number: 6 2 6 0 6 0 0

U.S. Department of Labor
Mine Safety and Health Administration

Victim Information: 1

1. Name of Injured/Ill Employee: *Markel J. Koon*	2. Sex *M*	3. Victim's Age *58*	4. Degree of Injury: *01 Fatal*

5. Date(MM/DD/YY) and Time(24 Hr.) Of Death: a. Date: 12/14/2012 b.Time: 17:00

6. Date and Time Started: a. Date: 11/30/2012 b.Time: 8:00

7. Regular Job Title: *068 Bulldozer/tractor operator*

8. Work Activity when Injured: *047 Operate bulldozer*

9. Was this work activity part of regular job? Yes X No

10. Experience

	Years	Weeks	Days
a. This Work Activity:	2	28	0
b. Regular Job Title:	2	28	0
c: This Mine:	37	36	0
d. Total Mining:	37	36	0

11. What Directly Inflicted Injury or Illness? *126 Water*

12. Nature of Injury or Illness: *110 Asphyxia/strangulation/drowning/suffocat*

13. Training Deficiencies
Hazard: New/Newly-Employed Experienced Miner: Annual: Task:

14. Company of Employment: (If different from production operator) *Operator*
Independent Contractor ID: (if applicable)

15. On-site Emergency Medical Treatment
Not Applicable: First-Aid: CPR: EMT: Medical Professional: None:

16. Part 50 Document Control Number: (form 7000-1) *220123540016*

17. Union Affiliation of Victim: *2555 United Mine Workers of Amer.*

APPENDIX B – LIST OF PERSONS INTERVIEWED

Consol Energy

P. Stuart Cater, P.E	Project Engineer	December 3, 2012 January 14, 2013 January 31, 2013
Michael Friedline	Impoundment Construction Foreman	December 3, 2012 January 14, 2013
Rocky Cianfrocca	Preparation Plant Superintendent	January 15, 2013

United Mine Workers of America, Local 1501

Daniel Krivosky	Mobile Equipment Operator	December 3, 2012 January 14, 2013
Daniel Stonebreaker	Mobile Equipment Operator	December 3, 2012 January 14, 2013
Mark Wentz	Mobile Equipment Operator	December 3, 2012
Joseph Skelly, Jr.	Mobile Equipment Operator	January 14, 2013
Joshua Dean	Mobile Equipment Operator	December 3, 2012 January 14, 2013

Forquers Contracting

Jeffrey Cox	Impoundment Inspector	January 16, 2013

Alliance Consulting, Inc.

Fredrick Vass, P.E.	Principal Engineer	January 15, 2013

Triad Engineering, Inc.

Alan Kennedy	Quality Control Technician	January 16, 2013
William “Bill” Frantz	Driller	January 31, 2013

APPENDIX C – PERSONS PARTICIPATING IN THE INVESTIGATION

CONSOL ENERGY COMPANY OFFICIALS

Todd Moore…………………….……Consol Corporate Safety, Director Safety Awareness
Chris Pence………………………..…Attorney / Hardy Pence, PLLC
Charlie Johns…………………………Attorney / Steptoe & Johnson

MINE SAFETY and HEALTH ADMINISTRATION

Edward J. Arnold……………………….Industrial Hygienist
Bob Cornett………………………………District Manager
Joshua Falk………………………………SOL/MSH Division
Greg Fetty………………………………..Staff Assistant
Eric J. Gottheld, P.E………….…………Civil Engineer, MSHA Technical Support
James M. Kelly, P.E……………………. Civil Engineer, MSHA Technical Support
Megan N. Lavage, EIT.…………….......Civil Engineer, MSHA Technical Support
Paul Marone……………………………USDOL RSOL, Region III
Sandin E. Phillipson, Ph.D……………..Geologist, MSHA Technical Support
Gregory M. Rumbaugh, P.E.…………..Civil Engineer, MSHA Technical Support
Michael Stark……………………………Mine Safety & Health Specialist - Impoundments
Thomas A. Tamasco, P.E………………Civil Engineer, Impoundments Group
Matt Taylor…………………………….. Mine Safety & Health Specialist - Impoundments
Steve Vamossy, P.E…………………......Civil Engineer, MSHA Tech Support

UNITED MINE WORKERS OF AMERICA (UMWA)

Ron Bowersox………………....UMWA International Safety
Mike Shearer…………………..UMWA Local 1501
Ann Martin…………………….UMWA Local 1501
Chuck Ceinawski……………..UMWA Local 1501
Chuck Donnelly……………….UMWA Legal Department
Timothy "Toad" Toothman….UMWA Local 1501
Bruce Vernon………………….UMWA Local 1501

WEST VIRGINIA OFFICE OF MINERS', HEALTH, SAFETY, & TRAINING (WVOMHST)

William Tucker…………………Administrator
Monte Heib……………………..Chief Engineer
Barry Koerber………………….Attorney
John Meadows…………………Assistant Inspector at Large

Mike Southern …………………District Inspector
James Stuckey………………….District Inspector

WEST VIRGINIA DEPARTMENT OF ENVIRONMENTAL PROTECTION

Jim Pierce…………………………….Engineer

APPENDIX D – TECHNICAL INFORMATION

Subsurface Investigation

The subsurface investigation produced extensive data on the material in the vicinity of the saddle dike. Aerial topographic mapping compiled in approximately 1980 and 1999 were used to estimate the original ground surface below the dike. The 1999 drawing only included elevations above 1192 feet, which was the pool elevation at the time it was generated. Above the elevation of 1192 feet, the topographic features are similar. However, the 1999 drawing depicts an access road cut into the hillside below the current location of the dike. The road traverses the hillside approximately parallel to the elevation contours between elevations 1195 feet and 1202 feet.

The natural hillside is composed primarily of brown clay underlain by bedrock. The extent of disturbance within the clay was evaluated in order to determine the likelihood of the failure surface extending through the material. The results of the drilling indicate that the surface of the natural hillside generally corresponded to the surface elevations indicated on the topographic drawings. The borings and CPT tests indicate differences up to 8 feet between the aerial mapping surface elevations and the natural ground elevations observed during the subsurface investigation.

Three of the borings within the impoundment encountered clay displaced from the natural hillside. The clay was observed above and below the CCR failure mass that slid into the pool. The thicknesses ranged from 1.2 feet to 8.9 feet. The thickness does not necessarily indicate the depth of clay that was removed from the natural hillside, since the orientation may have changed as it traveled through the impoundment pool. These lenses detected in the borings were above significant depths of coal refuse.

Laboratory testing concluded the strength parameters of the clay sampled during the accident investigation were similar to what was used in the design. Specifically, average and minimum effective shear strength friction angles of the clay tested during the accident investigation were found to be 25.2° and 22.4°, respectively. The slope stability analyses conducted by Alliance assigned a value of 24° to the clay. Field vane shear tests were also performed on the submerged in situ clay, and the average and minimum peak undrained shear strengths found were 2629 and 1337 pounds per square foot (psf), respectively. Borings were also drilled at one location through the remaining portion of the dike, and both field vane shear tests and pocket penetrometer tests were performed on the 12.5-foot layer of clay. The material was classified as very soft to very stiff. The pocket penetrometer tests indicated undrained shear strengths averaging 369 psf. The field vane shear tests yielded average undrained shear strength of 1870 psf, with a minimum value of 1065 psf.

A test pit was excavated north of the saddle dike at an elevation of 1261.3 feet. It encountered seven feet of stiff to very stiff clay underlying one foot of silty clay with trace organics. The average shear strength of the upper 6.5 feet of this material, as estimated by pocket penetrometer tests, was 1900 psf, and the lowest 1.5 feet was estimated at approximately 4000 psf. Underlying this clay was 5.7 feet of weathered claystone. The bottom 1.2 feet of the weathered claystone was very soft. South of the dike, at elevation 1257.8 feet, a test pit was hand-dug through clay to a depth of 4.2 feet. The first six inches was classified as stiff-to-hard and the material below as very stiff. The average shear strength of this material, as estimated by pocket penetrometer, was 2675 psf.

During the Stage IV design phase, a 15.5-foot-deep test pit had been dug near the centerline of the dike, at elevation 1248 feet. The pit identified 8 feet of highly plastic (fat) clay at the surface, with 4 feet of clayey sand directly below it, which was underlain by 3.5 feet of sandy fat clay. No other soil characterization was included on the log. The material from this pit was tested for grain size and Atterberg limits (a basic measure of the critical water contents of a fine-grained soil, such as its shrinkage limit, plastic limit, and liquid limit).

The fine coal refuse (FCR) sampled during the investigation in the vicinity of the saddle dike area unaffected by the failure was much finer than the FCR tested for Stage 4 design. All FCR tested for the Stage 4 design was obtained from the main embankment area. Therefore, this is expected due to the fact that the saddle dike is a considerable distance from the slurry discharge spigot at the main embankment. Only the finest portion of the material would remain in suspension before settling in the rear of the impoundment pool (the Western Saddle Dike area). Laboratory sieve analyses indicate that the FCR tested during the Stage 4 design had an average of 45.5 percent passing the #200 sieve. The FCR sampled during the investigation in the area of the saddle dike had an average of 96.4 percent passing the #200 sieve. The effective shear strength parameters of the saddle dike FCR also varied from those used in the design. The previously tested FCR from below the main embankment had effective shear strength friction angles ranging from 32.3 to 37.0 degrees. A value of 30 degrees was used in the upstream stability analysis associated with the original design for the saddle dike. FCR effective shear strength friction angles determined from this investigation ranged from 24.9 to 30.1 degrees, with an average of 27.4 degrees. The friction angles associated with the total shear strength envelope ranged from 11.0 to 12.4 degrees, with an average of 11.7 degrees. The cohesion intercept associated with the total shear strength envelope ranged from 245 to 410 psf and the average was 323 psf.

Stage 4 Design Stability Analyses

The method of calculating the values shown on the P-7 Warning level chart was evaluated during this investigation. Alliance used an effective shear strength method and assumed distribution of pore pressures in the FCR materials. In this method, the shear strengths of FCR decrease as the pore water pressure (the pressure in the water between the particles) increases. Rather than adding the excess pore water pressure to the hydrostatic water pressure due to the pool, the submitted method of analysis used a pore pressure parameter to calculate the maximum allowable pore pressure in the FCR. In this method of analysis, the pore pressure is determined by multiplying the total vertical stress (due to the weight of the material above any point) by a pore pressure parameter.

The excess pore pressure action levels were not derived from a consolidation analysis. The action levels were back-calculated based on the value of the pore pressure parameter determined from the slope stability analyses. The pore pressure parameter was varied until a factor of safety of 1.5 was obtained. A factor of safety of 1.5 means that the computed resistance of all the soils involved is 50 percent greater than what it needs to be to prevent the slope from failing. The corresponding pore pressure at the location of Piezometer P-7 was then computed from the resulting pore pressure parameter for various overburden conditions due increasing the height of the embankment. These pressures were then plotted on a chart versus the dike surface elevation. The analyses used the same material densities and strength parameters that had been used in the design of previous stages for the main embankment. The analyses were performed on the cross-section of the main embankment.

On Wednesday morning, November 28, 2012, Alliance emailed to Consol a "preliminary revised graph" for allowable Piezometer P-7 readings. As did the previous chart, it shows maximum allowable piezometer pressures as a function of embankment surface elevation. However, this revised chart included piezometer pressure levels that corresponded to slope stability factors of safety of 1.3 and 1.5 and for slurry top surface elevations (in front of the dike) of 1254 and 1256 feet. Consol had previously provided Alliance a current slurry elevation of 1254 feet. Assuming an elevation of FCR of 1254 feet and the surface elevation at Piezometer P-7 on the day of the failure, the graph predicts that the 15 psi pressure measured at Piezometer P-7 corresponds to a factor of safety between 1.3 and 1.5.

The analyses that Alliance used to develop the new graph were based on the dike cross-section from the design drawing (Figure 4), rather than the main embankment cross-section that was previously analyzed. Below an elevation of 1224 feet, topographic drawings show steeper slopes than portrayed on the design dike cross-section. The pore pressure in the FCR below the dike was calculated by adding the hydrostatic pressure to an excess pore pressure determined using a pore pressure parameter. As before, the pore pressure parameter was varied to result in the factors of safety of 1.3 and 1.5. Maximum allowable pore pressures at the elevation of the Piezometer P-7 tip were then computed from the revised pore pressure parameters and plotted on the graph.

MSHA Post-Failure Analyses

There are many factors that can affect the short-term stability of an upstream stage, such as material strength and consolidation properties, the depth and drainage conditions of consolidating layers, the construction technique and rate of construction, and the embankment and foundation geometry. MSHA reviewed the boring logs, in situ testing, and geotechnical laboratory testing reports generated from the subsurface investigation; performed evaluations and calculations to characterize the material properties; estimated consolidation and strength parameters; and conducted consolidation analyses to estimate in situ pore pressures; and evaluated potential failure scenarios. MSHA performed numerous engineering analyses to evaluate the upstream stability of the saddle dike embankment construction and gain insight into the conditions that contributed to failure.

The cross-section of the dike that was judged to be the most critical to slope stability was chosen based on the widest upstream pushout and steepest natural ground surface from a 1999 topographic drawing that shows elevation contours down to elevation 1192 feet (the pool elevation at that time). MSHA's analyzed cross-section was slightly south of the section used by the designer. In the elevation range of 1202-1224 feet, the topographic drawings show steeper slopes than the cross-section analyzed by the designer in the week prior to the failure.

Extensive in situ and laboratory testing was performed on the FCR in the area of the saddle dike. Representative permeability, consolidation, and undrained shear strength parameters were developed by MSHA from the results of laboratory testing of FCR samples. These values were also compared to values computed in different ways from the laboratory testing for validation, compared to in situ testing and correlations with in situ testing, and judged against typical values for FCR with special consideration for the higher fines content. The mixed zone was modeled using material characteristics similar to the in situ FCR, but modified to account for the addition of CCR, using various typical values for loose CCR and CCR with grain size finer than average. Although consolidation parameters were developed for the natural clay soil under the saddle dam, the stability analyses used undrained shear strengths for the clay, with no normalization, based on in situ measurements, primarily from field vane (FV) shear tests, in lieu of the laboratory testing. The consolidation parameters and hydraulic functions for the mixed zone were estimated from various typical values for loose CCR and CCR with grain size finer than average. Its void ratio was estimated from unit weights and specific gravity of CCR and FCR, and its permeability was estimated between that of the in situ FCR and typical finer CCR.

For the investigation analyses, the strength of the mixed CCR/FCR zone and the FCR were characterized as having undrained shear strengths that would have been mobilized during failure. Undrained shear strengths were determined to be more appropriate than effective (drained) shear strengths due to these properties more closely resembling the field conditions. The undrained strengths were normalized based on vertical effective stresses. They were then used in the analyses with the static pore pressure from the pool and the excess pore pressures from construction loading that were estimated from the finite element (FE) consolidation analyses. MSHA estimated the undrained strength of the FCR from three consolidated undrained (CU) triaxial tests. The undrained strength of the clay determined from the FV tests was deemed appropriate for use in the analyses. For the FCR in front of the dike, an undrained strength-to-depth relationship was developed from the results of the FV tests. The FV tests were correlated to the CPT results performed in the FCR in front of portions of the dike that did not fail.

The degree of consolidation can be monitored by excess pore pressures in the consolidating materials. Piezometer P-7 was installed to monitor the pore pressure at one location in the FCR. However, pore pressures measured at Piezometer P-7 do not appear to be commensurate with the average or maximum pore pressures in the FCR zone estimated by the MSHA analyses. MSHA performed 1-dimensional (1-D) and 2-dimensional (2-D), FE consolidation analyses for the staged construction that estimated significantly higher pore pressures in the FCR than measured in Piezometer P-7. The 1-D consolidation analysis (neglecting the mixed zone and assuming FCR in the mixed zone) estimated average excess pore pressures in the FCR that were on the order of 5 times greater than the piezometer reading. The 2-D FE consolidation analysis estimated excess pore pressures in the FCR (neglecting the mixed zone) that were on the order of 10 times greater than the piezometer reading.

The bottom of the upstream stage (the zone of mixed refuse below the pool) was considerably lower than assumed in the design. The investigation determined that the uncompacted CCR and mixed CCR/FCR zone were significantly thicker, and the FCR layer beneath the pushout appeared to be significantly thinner than shown on the design drawings. MSHA estimates that the Piezometer P-7 sensor was in or very near the mixed CCR/FCR zone. Since this zone is better drained than the FCR and consolidates faster, the pore pressures in the mixed zone are lower than the pore pressures in the FCR. However, this mixed zone can still be under-consolidated. MSHA performed 2-D, FE consolidation analyses for the staged construction with and without a mixed CCR/FCR zone. The FE consolidation analyses with a mixed zone extending to the bottom of the piezometer sensing zone appear to support the relatively low pore pressures measured in Piezometer P-7. MSHA believes this change in geometry, and the presence of the mixed zone near the piezometer tip, led to the relatively low pore pressure readings from Piezometer P-7.

A more rigorous 1-D consolidation analysis was performed to estimate the variation of pore pressures with depth. The results indicated that the relatively low pore pressures measured by Piezometer P-7 were possible only if the upper drainage boundary of the

FCR was lowered to near the piezometer sensing zone. This analysis suggested that the CCR zone had to be no more than 2 feet above the piezometer tip to obtain the measured pore pressures. However, the driller's log from the piezometer installation reports CCR to an elevation 1234.5 feet and "slurry" down to the piezometer tip elevation of 1225 feet. This is the zone that the authors believe is the mixed CCR/FCR zone. The 2-D FE consolidation analysis with uncompacted CCR extending from elevation 1255 down to elevation 1235 feet and a mixed CCR/FCR zone from elevation 1235 to 1225 feet was adopted for the general geometry. The piezometer readings together with the 1-D consolidation analyses were also used in judging the validity of certain 2-D FE consolidation analyses that were used for the stability analyses.

The factor of safety was determined from limit equilibrium slope stability analyses with pore pressures generated from the 2-D consolidation analyses. Several analyses were performed to evaluate variations in material properties, pore pressure distributions, and minor modifications to the subsurface geometry. A minimum factor of safety near 1.0 is what should be expected after the last stage of the consolidation analyses, which is when the failure occurred during saddle dike construction. Stability analyses using peak effective shear stress strength parameters for the CCR, Mixed zone, and FCR generated erroneously high factors of safety. Using the undrained strength of the FCR consistent with direct shear values, the stability analyses resulted in a minimum factor of safety near 1.0; and adopting the peak undrained strength for the FCR in triaxial shear for the mixed zone reduced the factor of safety to less than 1.0. These general results were similar for both of the consolidation analyses.

Mine Workings

Surface and underground mine workings are located in the vicinity of the Nolan Run Slurry Impoundment. Abandoned underground mine workings are present approximately 800 feet south of the Western Saddle Dike. The potential role of breakthroughs and subsidence-related events in the saddle dike failure were evaluated. Mine mapping obtained from the West Virginia Geological and Economic Survey refers to these workings as the Catom Mine No. 3 operated by the Catom Coal Company. The Catom Mine No. 3 extracted coal from the Pittsburgh seam in the 1960s using room-and-pillar methods. Recorded drawings indicate that these workings were previously operated by the Warjean Coal Company and Ramey Coal Company in the 1950s and 1960s. The portals associated with the mine were reclaimed by the West Virginia Department of Environmental Protection (DEP) Division of Land Restoration. The design plans and as-built drawings associated with the reclamation, titled "Jimtown Tipple," were provided by Consolidation Coal Company. Drainage from the portals is discharged through three pairs of 12-inch-diameter PVC pipes into a rip-rap-lined channel. MSHA personnel observed the drainage from the reclaimed portal area on May 20, 2013. The drainage was clear and no contamination due to FCR was observed in the discharge or drainage channels. Therefore, there was no evidence in the portal discharge that a hydraulic connection between the Catom Mine No. 3 and the Nolan Run Slurry Impoundment had been established.

Nine borings were drilled on the southern side of the Western Saddle Dike access road. Borings BH-100 through BH-107 and BH-110 each obtained rock core through and below the Redstone and Pittsburgh coal seams. The Redstone coal seam was observed at a bottom elevation ranging from 1106.4 to 1089.1 feet and the height was less than 1.5 feet. The elevation of the bottom of the Pittsburgh coal seam ranged from 1079.1 feet to 1059.5 feet, and the average height of the seam was 7.1 feet. The minimum recovery of the core runs sampling the Pittsburgh coal seam was 97 per cent at Boring BH-102. All other borings achieved 100 per cent recovery of the seam. The results indicate that no abandoned workings were present at the boring locations.

Electrical resistivity testing was completed to determine if unrecorded abandoned mine workings are present to the west or south of the Western Saddle Dike. Six resistivity profiles were developed. One line was conducted over an area containing known, mapped Catom No. 3 mine workings south of the impoundment. The results indicated that the method could detect flooded mine workings, but would not detect the workings if they were dry. A line was completed south of the access road to the Western Saddle Dike. No anomalies were observed from the testing indicating abandoned mine workings. Four profiles were conducted west of the saddle dike. The profiles were oriented in the north-south direction. Three anomalies possibly representing flooded mine workings were observed on the western-most profile approximately 800 feet from the saddle dike. One anomaly was observed in the northern end of the profile located approximately 750 feet west of the saddle dike. The profiles located approximately 250 and 450 feet west of the saddle did not exhibit any anomalies indicative of flooded mine workings. The resulting interpretation of the electrical resistivity testing is that unmapped abandoned workings may be present west of the saddle dike, but are not observed closer than approximately 750 feet from the saddle dike. The subsurface investigation indicates that subsidence due to unknown workings below the saddle dike is unlikely

Portions of the Nolan Run Valley have been contour strip-mined both within the impoundment area and downstream (east) of the main embankment. The strip mining within the impoundment was completed concurrently with the initial construction of the embankment. Aerial mapping conducted in 1980 indicate that the elevation of the top of the highwall resulting from the strip mining is approximately 1175 feet. The Western Saddle Dike upstream slope, prior to the failure on November 30, 2012, was located approximately 200 feet west from the top of the highwall. A boring drilled within the strip-mined area encountered very soft to soft FCR extending to an elevation of approximately 1080 feet.

Contour strip mining and auger mining were also completed south and west of the impoundment. Mapping compiled by the West Virginia Geological and Economic Survey indicates that strip mining took place approximately 1,300 feet west of the saddle dike. Records also indicate that strip and auger mining was completed along the hillsides south of the Catom Mine No. 3 portals.

The impoundment pool level, for the months preceding and immediately following the failure, was reviewed. Records do not indicate a change in the pool elevation near the time of the failure. Therefore, there is no evidence of a direct hydraulic connection to underground mine workings below or adjacent to the impoundment. Mining does not appear to be a contributing factor to the accident.

Gas Characterization

Bubbling was observed in the pool following the accident. Samples were collected by MSHA and the operator in order to conduct laboratory testing. The analyses indicated that methane was present in the composition of the gas. Methane monitoring was implemented as part of the drilling and sampling plan during the accident investigation. Methane gas was observed on March 14, 2013, during drilling on the main embankment at Boring BH-11. The hollow-stem augers had been advanced to a depth of 120 feet. A gas analysis conducted by MSHA on two samples collected from the augers indicated methane concentrations ranging from 85.6 per cent to 89.1 per cent.

Cone penetration tests (CPT) took place in the pool area from a barge in the vicinity of the failure. Hollow-stem augers were used to case the CPT rods as they were advanced through the zones of the failed CCR embankment in the pool. During multiple occasions, gas was observed being released from the stem of the augers or from the center point rods after advancing the augers. Samples from borings CPT-14, CPT-6, and CPT-28 were collected on April 4, May 6, and May 10, 2013, respectively. Gas analyses conducted by the operator and MSHA determined methane contents ranging from 7.5 per cent to 76.9 per cent.

As a means to potentially determine a probable source of the gases encountered on-site, samples of coal from the Pittsburgh and Redstone seams were collected from Borings B-107 and B-110. CCR was also collected from the Robinson Run Mine Complex Dry Refuse Pile located approximately 1.5 miles east of the Nolan Run Slurry Impoundment. The samples were placed in aluminum desorption canisters for determination of hydrocarbon content. The gas obtained from the Pittsburgh coal seam had a high dilution and low sample volume. Therefore, the results of the characterization of the Pittsburgh coal were inconclusive.

The element Carbon (C) includes two stable isotopes, ^{12}C and ^{13}C. The element Hydrogen (H) includes two naturally-occurring stable isotopes, ^{1}H and ^{2}H, the latter being known as Deuterium and referred to with a capital "D." The ratio of concentrations of heavy to light isotopes is called a fractionation factor and is reported in per mil, or parts per thousand (‰), relative to the heavier isotope, and is designated by the Greek letter "δ." The hydrocarbon contents and stable isotope ratios of the gas encountered from within the impoundment pool during the drilling program and from desorption canisters were compared and plotted on discrimination diagrams to determine the sources. The stable isotope contents for methane desorbed from the Redstone coal seam indicated a $\delta^{13}C$ value of -67.65‰ and a δD value of -262.8‰. The stable isotope contents from a sample set comprised of gases from five bubble locations, the desorbed CCR, two borings on the main embankment, and one boring on the dry refuse pile ranged from $\delta^{13}C$ values of -43.69‰ to -46.43‰ and δD values of –200.6‰ to –193.8‰. The sample collected from the tooling at CPT-28 on the main embankment indicated a $\delta^{13}C$ value of –52.02‰ and a δD value of –204.0‰. Therefore, the samples obtained from impoundment pool and drilling equipment are chemically and isotopically very similar to the sample collected from the desorbed CCR.

Observations were also made on the main embankment of the Nolan Run Slurry Impoundment, where upstream construction was also completed. In numerous locations, bubbling was observed through the FCR. Based on visual observations and geochemistry of the gas, the bubbling observed in the impoundment pool appears to be originating from the CCR push-out for the saddle dike and the volume of CCR submerged in the pool as a result of the failure. Therefore, the bubbles observed in the pool do not appear to be a contributing factor to the accident.

Figure 1
Plan View of Stage 4 Construction
"Expansion Plan – Stage IV"
Drawing No. B05-022-E2, Figure No. 3
Dated February 7, 2007

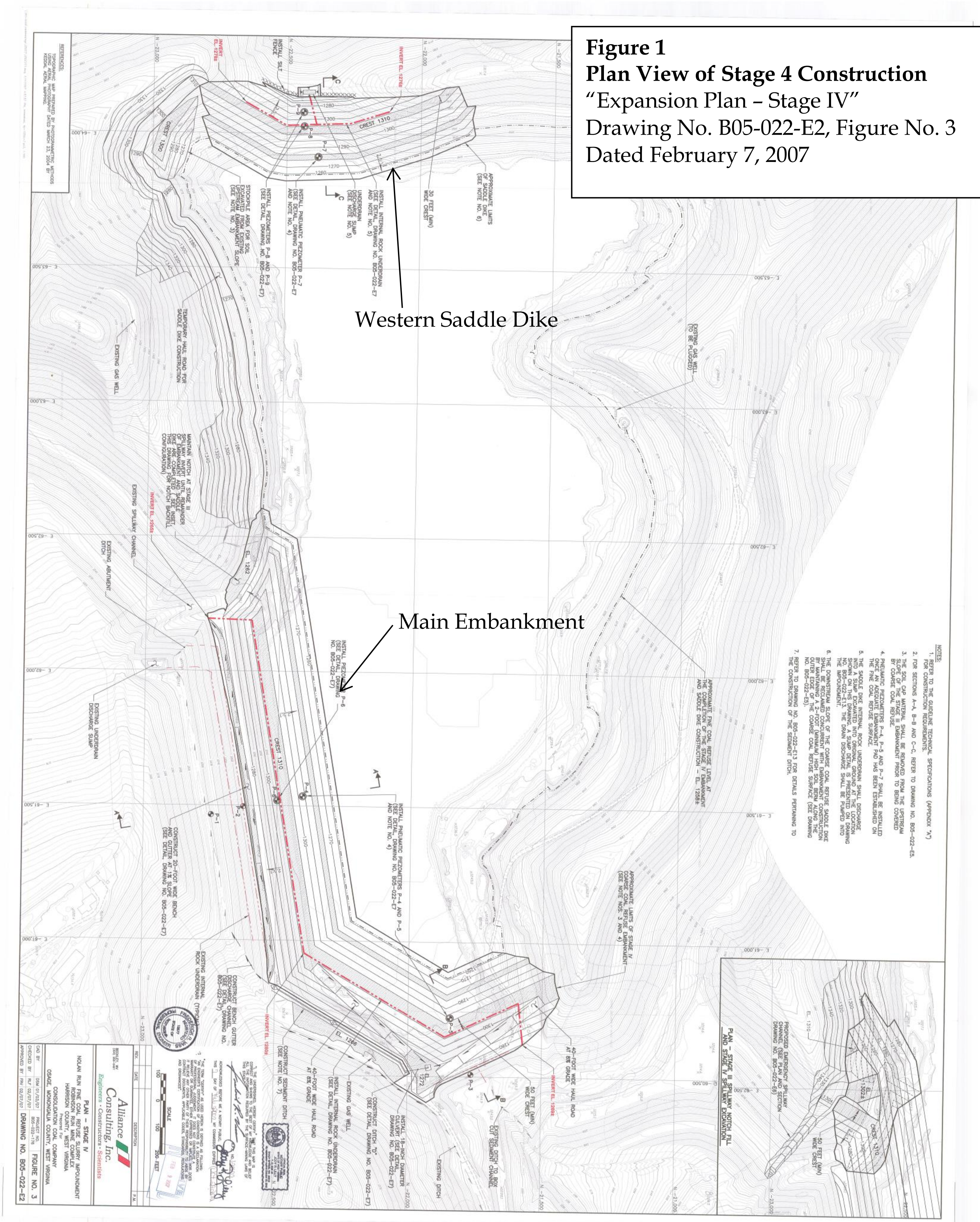
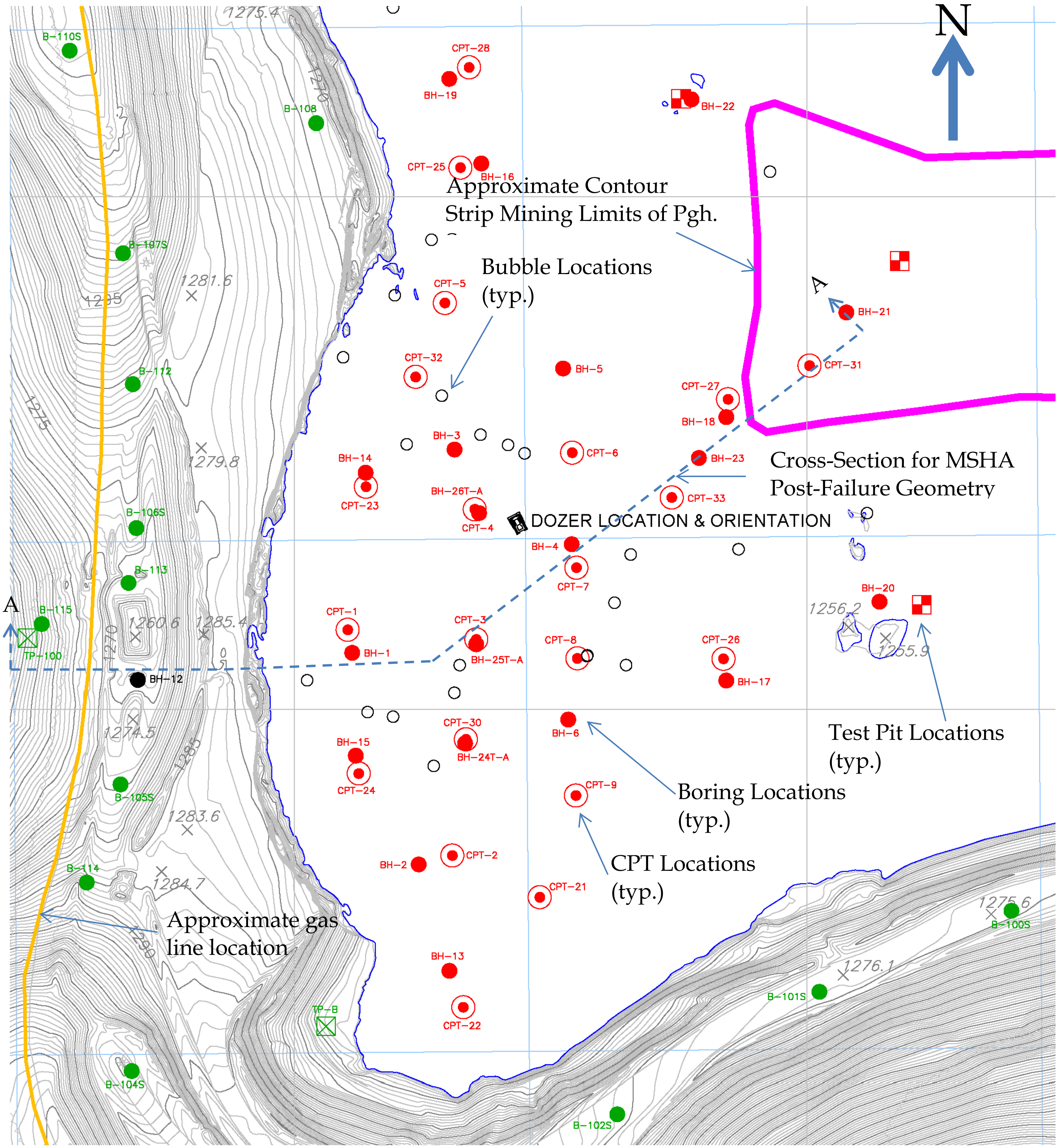


Figure 2
Boring Location Plan
Portions of "Boring Location Map"
Drawing No. B12-594-E4
Revision Date: December 3, 2012



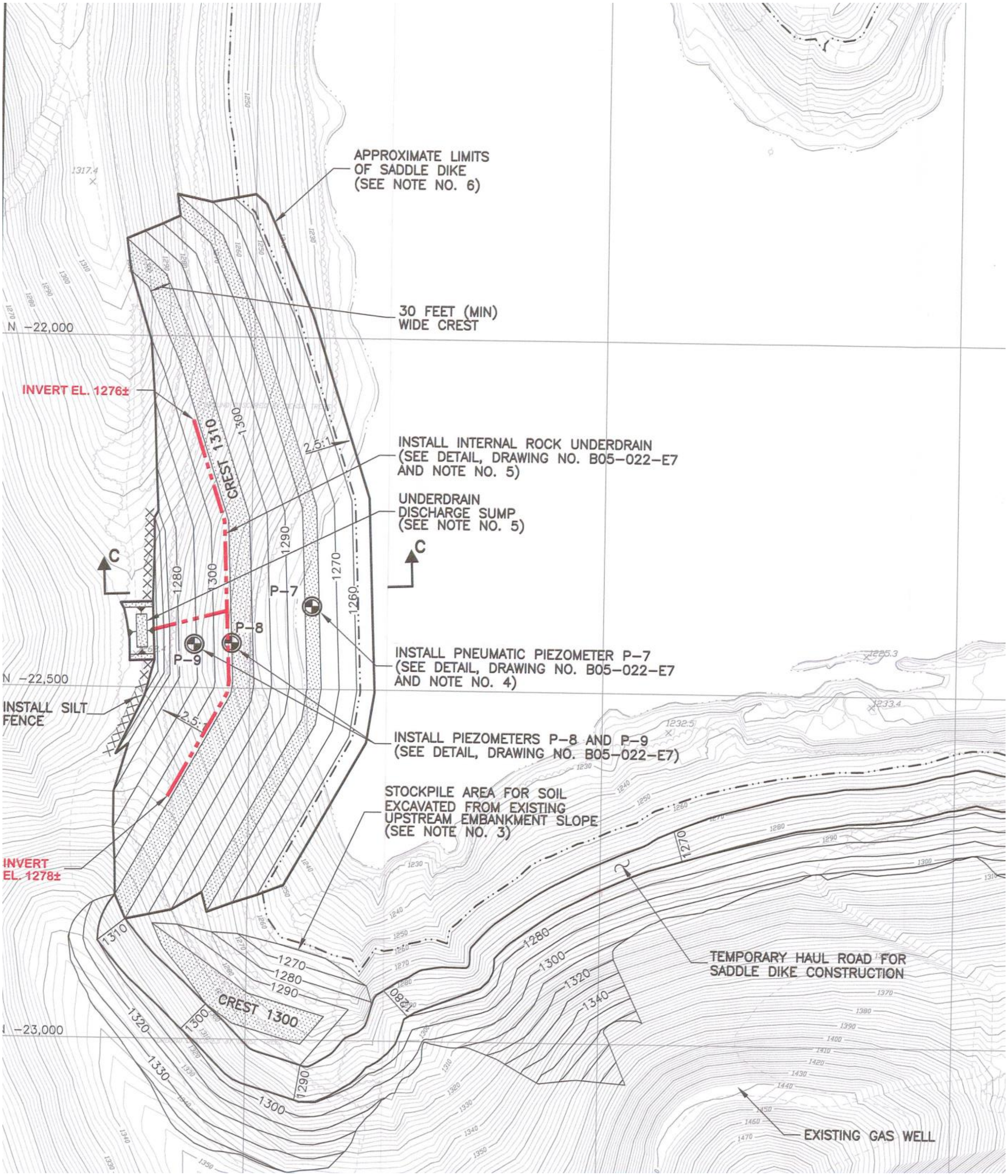


Figure 3
Saddle Dike Design: Plan View
Portion of "Expansion Plan – Stage IV" Drawing No. B05-022-E2 Figure No. 3, Dated February 7, 2007

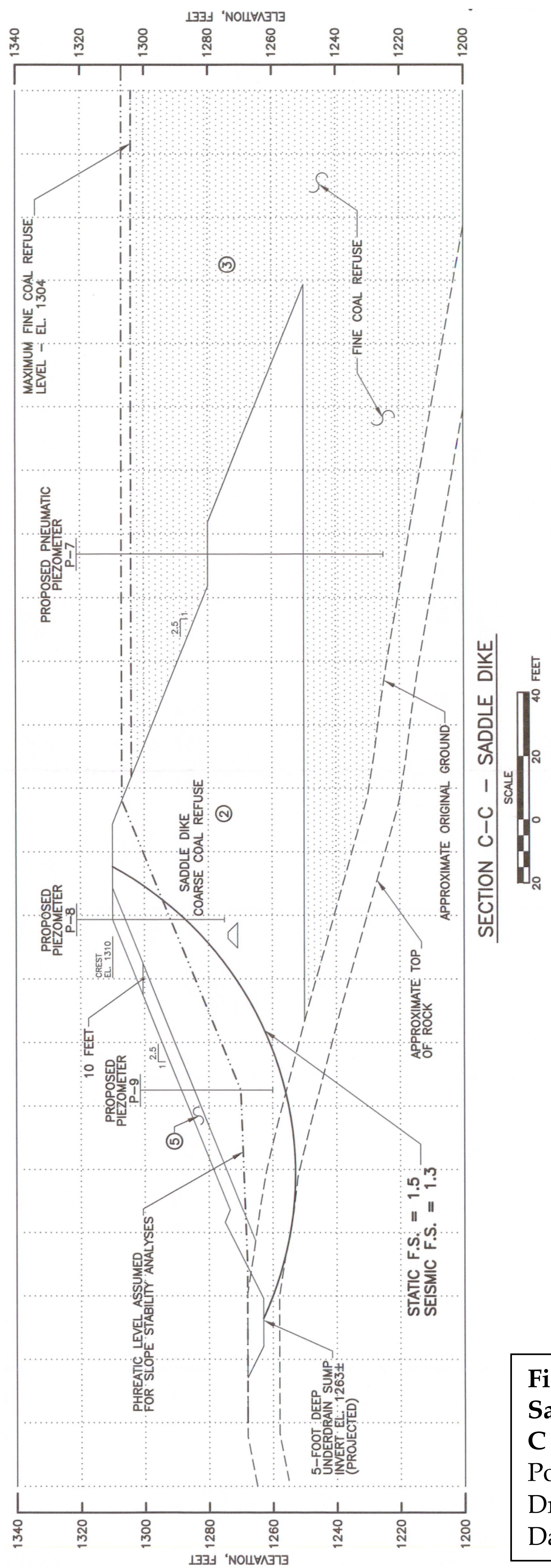


Figure 4
Saddle Dike Design: Cross-Section C-C
Portion of "Expansion Plan – Stage IV"
Drawing No. B05-022-E4, Figure No. 10
Dated March 24, 2008

Figure 5
Satellite Imagery of the Nolan Run Slurry Impoundment
Photograph date: July 1, 2011
Retrieved December 13, 2013 from Google Earth

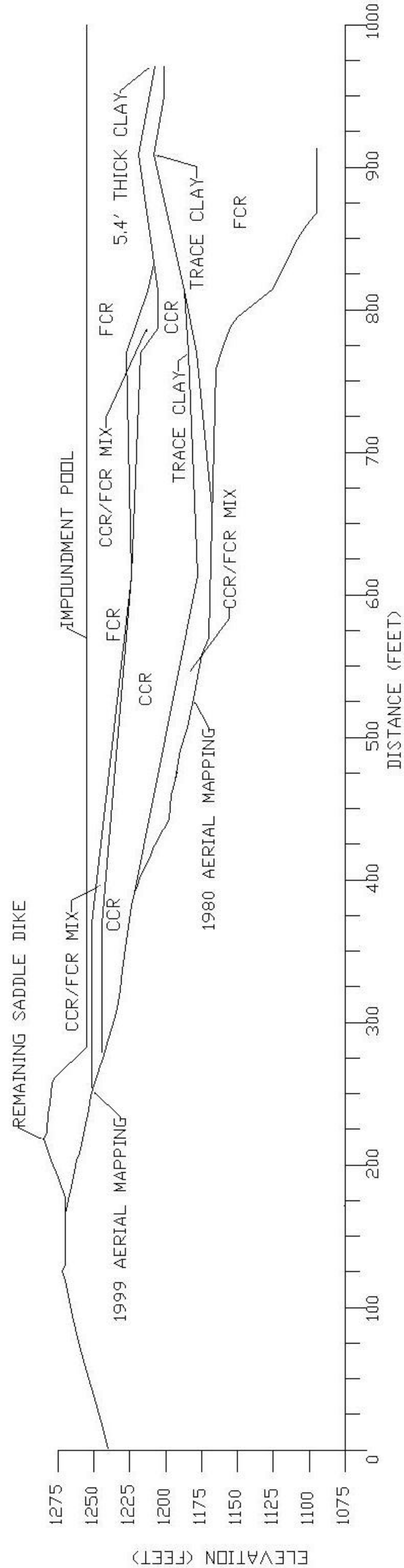
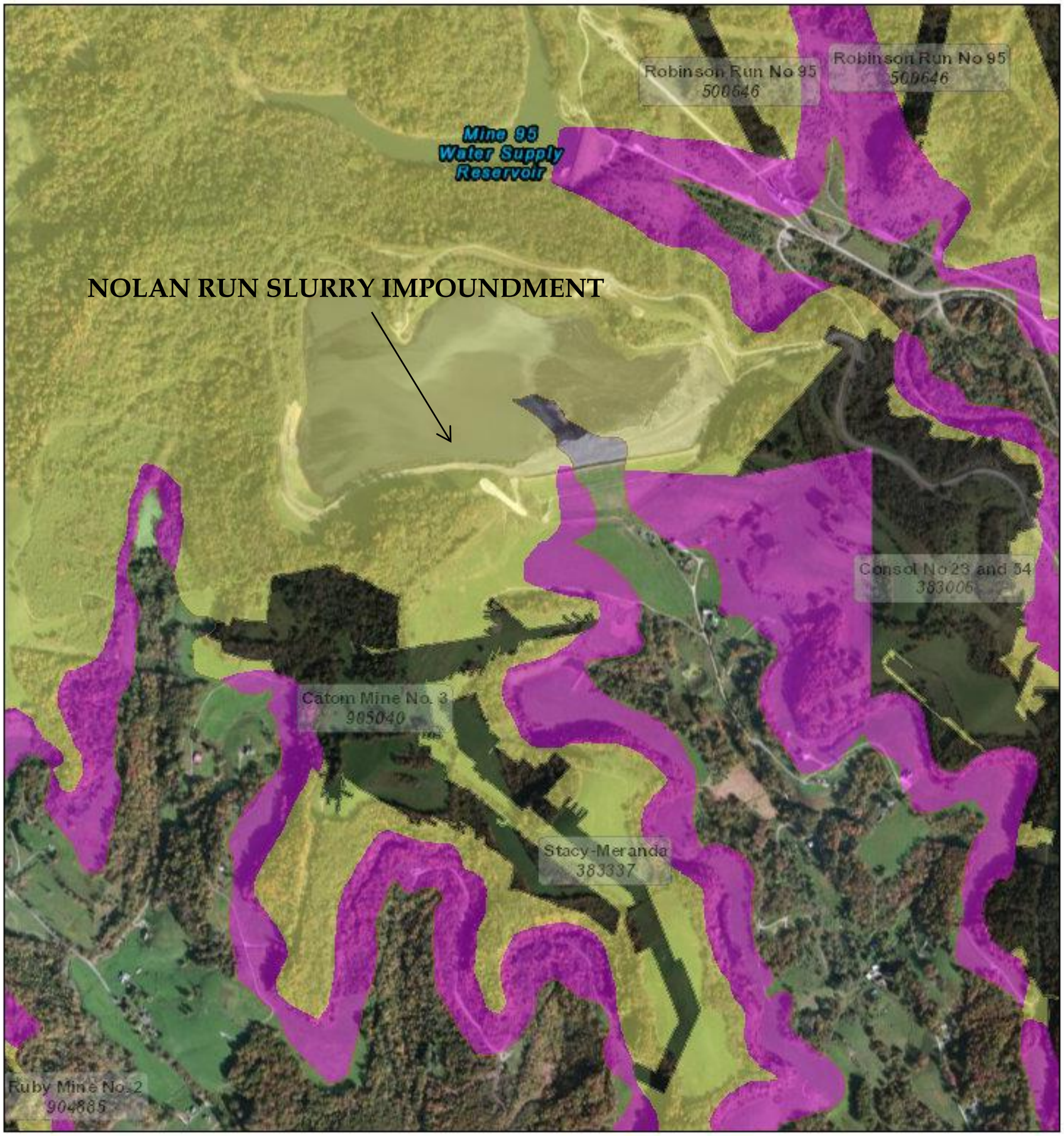
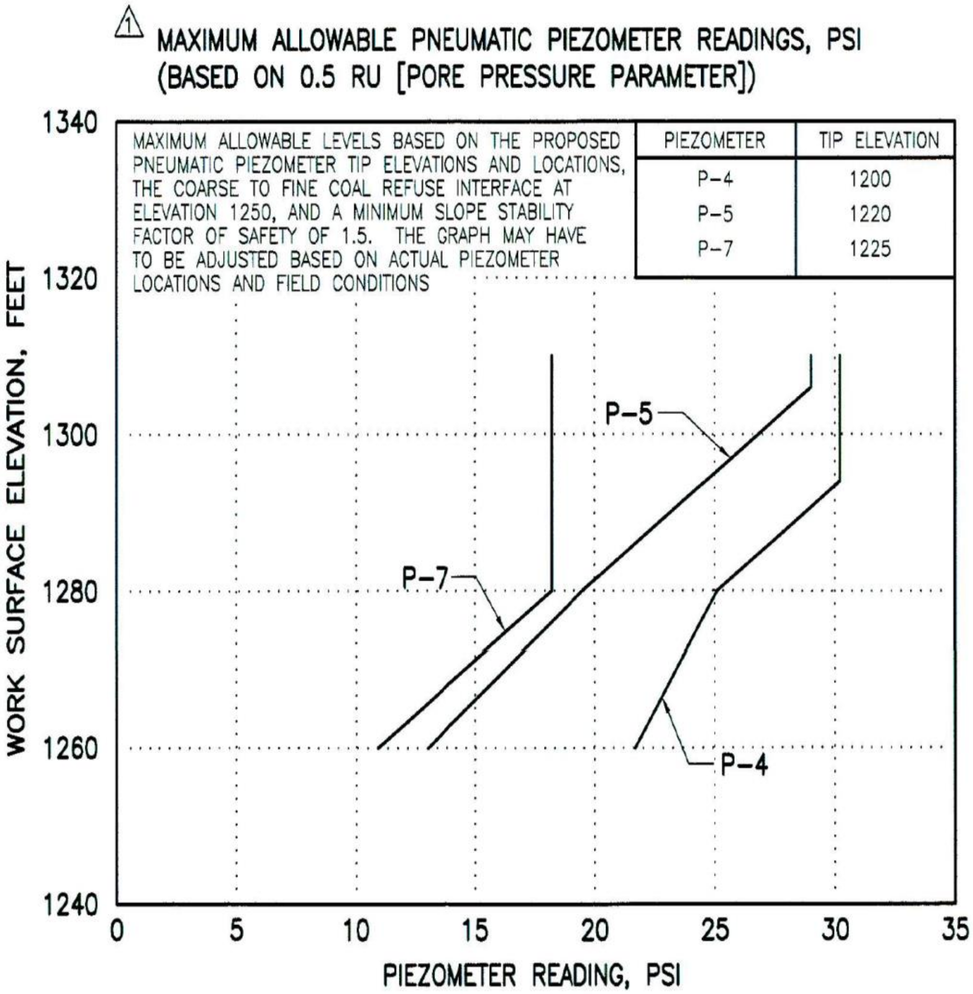


Figure 6
Sketch of Post-Failure Subsurface Geometry
Note: Refer to Figure 2 Cross-Section A-A



Color Key:
Purple- Surface Mining
Yellow- Remaining Coal
Black- Underground Mine Workings

Figure 7
Mine Working in the Pittsburgh Coal Seam
Adjacent to the Nolan Run Slurry Impoundment
Retrieved from the West Virginia Geological and
Economic Survey Coal Bed Mapping Project



THE PNEUMATIC PIEZOMETERS ARE TO BE MONITORED DURING CONSTRUCTION OF THE EMBANKMENTS. EXCEEDANCE OF THE PIEZOMETER READINGS DOES NOT NECESSARILY MEAN THAT THE SLOPE STABILITY FACTOR OF SAFETY HAS BEEN REDUCED TO LESS THAN 1.5. IT DOES MEAN, HOWEVER, THAT THE PORE PRESSURES ARE HIGHER THAN ASSUMED IN THE STABILITY ANALYSES. THEREFORE, IF ANY OF THE READINGS EXCEED THOSE VALUES, THE SLOPE STABILITY SHOULD BE REANALYZED. THE PIEZOMETERS MAY BE ABANDONED UPON COMPLETION OF EMBANKMENT CONSTRUCTION PROVIDED EXCESS PORE PRESSURES HAVE DIMINISHED.

Figure 8
Maximum Allowable Pore Pressure Reading
"Expansion Plan – Stage IV"
Drawing No. B05-022-E4