UNITED STATES
DEPARTMENT OF LABOR
MINE SAFETY AND HEALTH ADMINISTRATION

COAL MINE SAFETY AND HEALTH

REPORT OF INVESTIGATION

Underground Coal Mine

Noninjury Mine Fire/Explosion Accident
June 22, 1999

Loveridge No. 22 Mine
Consolidation Coal Company
Fairview, Marion County, West Virginia
I.D., No. 46-01433

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Table of Contents

OVERVIEW 1

GENERAL INFORMATION 2

DESCRIPTION OF THE ACCIDENT
- Activities Prior to Discovering the Fire 3
- Discovery and Attempted Fighting of the Fire 5
- Mine Evacuation and Sealing 7

MINE RECOVERY
- Phase I – Starting the Sugar Run and Harvey Run Fans 10
- Phase II – Examining from Sugar Run to Miracle Run 10
- Phase III – Examining from Miracle Run to 8-North Plugs 11
- Phase IV – Examining from Miracle Run to St. Leo 12
- Phase V – Examining the 8-North Submain to Inby the 2-Left Fire Area 14
- Rehabilitating the St. Leo Air Shaft and Starting the St. Leo Fan 15
- Revised Plan for Rehabilitating the 8-North Submain and the St. Leo Bleeders 16
- 9-South Exploration Between the 1D and 2D Entries 16
- 8-North Exploration Between the 2-Left and 6-Left Entries 17
- 9-South Exploration Inby the 2D Entries 18
- 6-Left Exploration to the Longwall Section 18
- Bleeder System Improvements 19
- Recovering the 1D and 2D Entries 19

INVESTIGATION OF THE ACCIDENT 20

DISCUSSION
- Ventilation and Bleeder System 21
- Origin and Propagation of the 2-Left Fire 24
- Origin, Flame, and Forces of the 9-South Explosion 25
- Potential Ignition Sources 26
  - 2-Left Fire Ignition Sources 27
  - 9-South Explosion Ignition Sources 31
- Decision to Evacuate and Seal the Mine 36

CONCLUSION 37

ENFORCEMENT ACTIONS 38

APPENDIX A - Investigation Participants 41
APPENDIX B - Persons Interviewed 42
APPENDIX C – Dust Sample Analysis Results 43

FIGURES

OVERVIEW

At approximately 12:50 a.m., on June 22, 1999, a mine fire was discovered at an approach to a worked-out area off the 8-North Submain, in the former belt conveyor entry of the mined-out 2-Left longwall panel (refer to Figure 1). A foreman discovered the fire while checking on a work site where cutting and welding operations had been performed during the previous day shift. When approaching the work site, he observed an orange glow near a permanent stopping across the former 2-Left belt entry, immediately inby the location where cutting operations were last performed. The stopping separated the 8-North intake air courses from the adjacent worked-out area. He then traveled to the 8-North track entry to obtain fire-fighting equipment and to report the fire. Four other foremen, including the shift foreman, were working nearby and soon joined him. The five men then gathered fire extinguishers, traveled to the fire area and immediately discharged three 20-pound fire extinguishers at the base of the stopping. When vision cleared, an orange glow was still present near the corners of the stopping. They next connected fire hose to a nearby water line and sprayed water onto the stopping. However, an orange glow was still visible through holes in the bottom left and both top corners of the stopping. The shift foreman then realized that there was a large fire on the inby side of the stopping, within the worked-out area, and sent one of the foremen to a nearby mine phone to inform all underground personnel to report to 2-Left to help fight the fire. An attempt to gain better access to the fire was then made by opening a personnel door in the stopping at the fire location. However, burning debris was tightly packed against the door from a roof fall on the other side of the stopping. They then attempted to access the fire through a personnel door in the adjacent entry. Evidence of heat was present as they approached the stopping and very dense black smoke was observed on the inby side of the stopping when the personnel door was opened. Based on these conditions, the shift foreman determined that the fire was too close to this stopping for safe access from this approach. The stopping at the remaining approach to the fire also showed signs of extreme heat on its inby side. Meanwhile, water was being continually applied to the fire through the holes in the stopping at the initial fire location. However, the roof fall made it impossible to apply water to the base of the fire and the mine roof at this location continued to deteriorate. At 1:45 a.m., with no remaining approaches to the fire and with worsening conditions at the fire fighting location, the shift foreman ordered all personnel to evacuate the mine. The evacuation was completed by 2:15 a.m. By 6:30 a.m., mine management decided to minimize the spread of the fire by sealing the surface openings as quickly as possible. While sealing progressed, all shaft and slope openings were monitored. The entire mine was sealed by 9:50 p.m.

On June 26, 1999, at 3:20 a.m. (78 hours after ventilation was stopped), an underground explosion occurred. Explosive forces exited the mine at the St. Leo Shaft, destroying the fan and damaging the shaft partition. There were no injuries as a result of the explosion. The most likely ignition source of the explosion was an electrical arc from a battery powered locomotive, located near the inby end of the 9-South Submain, which ignited methane that had accumulated after the mine was sealed. Recovery of the mine was initiated in July 2000 and required approximately one year to complete.

GENERAL INFORMATION

In 1956, the Loveridge No. 22 mine, I.D. 46-01433, was opened into the Pittsburgh No. 8 coal seam at a location near Fairview, in Marion County, West Virginia. Consolidation Coal Company operated the mine using three continuous mining machine sections to develop entries for a single longwall unit, producing 5.5 million tons of coal annually. However, coal production had been idled since February 28, 1999. Since that time, only general maintenance work was being performed. At the time of the accident, employment consisted of 99 underground and 19 surface workers. During full production periods, the mine employed 440 persons.

The mine was accessed by a dual compartment slope located at the Sugar Run Portal (containing a conveyor belt and a track compartment) and five shafts. The St. Leo, Miracle Run, and Harvey Run airshafts contained shaft partitions which separated intake and return airways. Separate intake and return shafts were provided at the Sugar Run Portal. Workers entered the mine by elevators at two portals: the Sugar Run Portal, where the supply yard and preparation plant were located, and the Miracle Run Portal, from which the active sections were accessed. Ventilation was provided by four main mine fans exhausting a total of approximately 1,600,000 cubic feet of air per minute (cfm). At the time of the accident, the mine liberated 5,829,447 cubic feet of methane every 24 hours. The methane liberation rate, which was higher during coal production, was measured at 8,785,668 cubic feet per day during the first calendar quarter of 1999. The immediate mine roof consisted of 6 to 12 inches of coal below 8 to 20 feet of shale. The main roof consisted of 5 to 30 feet of sandstone.

At the time of the accident, the 6-Left Longwall, the last panel in the 8-North Submain, had been retreat mined to approximately one half of its length (Figure 2). The three continuous mining machine sections were located in the 9-South Submain. Methane-air mixtures from the pillared worked-out area associated with the 6-Left Longwall were directed into bleeder entries before being coursed to return entries near the St. Leo airshaft. A total ventilating pressure differential of 15.6 inches water gage (in-wg) between the longwall face and the St. Leo return entries was used to move 170,000 cfm of air through the highly restrictive worked-out area. At the time of the accident, methane concentrations in the air flowing from the bleeder entries was 1.1 percent, measured immediately before mixing with the St. Leo return air courses. The pressure drop across the stopping where the fire was discovered, from the 8-North Submain toward the worked-out area, was 4.8 in-wg.

The principal officers for the Loveridge No. 22 mine at the time of the accident were:

J. N. Magro	Vice President Operations, Group 1
John T. Higgins	Superintendent
Mark Watkins	Assistant Superintendent
Dave Clise	Mine Foreman

An MSHA Safety and Health Inspection (AAA) was completed on April 12, 1999, and another was ongoing at the time of the accident. The Non-Fatal Days Lost (NFDL) incident rate during the previous quarter was 8.18 for underground mines nationwide and 3.50 for this mine.

DESCRIPTION OF THE ACCIDENT

Activities Prior to Discovering the Fire

At the start of day shift on Monday, June 21, 1999, Dave Clise, Mine Foreman, assigned a crew to recover a belt conveyor take-up unit from the old 2-Left belt entry off the 8-North Submain. The crew was also to prepare the equipment for transport to the surface (Figure 1). Jeff Myers, Belt Foreman, and Mike Tatterson, Maintenance Foreman, supervised the crew. The remaining crewmembers consisted of the following miners: Leo McIntosh, Mechanic; Larry Straight, General Inside Laborer; and Linz Booth, General Inside Laborer. The crew entered the mine at the Miracle Run Portal and traveled, via rail-mounted personnel carriers, to the 2-Left work site, arriving at approximately 8:30 a.m. Myers examined the work site and determined that additional bagged rock dust was needed for fire protection prior to cutting and welding. Tatterson traveled to the 6-Left entries to obtain the rock dust, while the remaining crew members began cleaning and loading previously disassembled components of the belt conveyor system onto rail-mounted flat cars.

By 10:00 a.m., Tatterson had returned to 2-Left and the crew had loaded several flat cars with components of the belt take-up. Two motormen arrived at that time and pulled the loaded flat cars out of the 2-Left track spur and parked them on the 8-North track. Tatterson and McIntosh then began spot welding the equipment to the flat cars in order to stabilize the load for the five-mile trip to the surface via the slope at the Sugar Run Portal. This task was completed by 10:30 a.m., at which time the motormen stored the loaded flat cars in a track spur located near the outby end of the 8-North Submain. Tatterson and McIntosh returned to the old 2-Left belt entry to assist in recovering the remaining sections of the take-up unit.

At approximately 11:00 a.m., Clise and Mark Watkins, Assistant Superintendent, arrived at 2-Left and briefly observed the recovery work. They then walked outby in the old belt entry where they found and fixed a leak in the water line near the former location of the 2-Left belt drive. At 11:20 a.m., Clise was informed that the motormen were ready to begin moving the loaded flat cars to the Sugar Run Portal. The crew disconnected the cutting torch hoses from the tanks and traveled to the mouth of the St. Leo Headings, into a split of intake air from the St. Leo Shaft. They ate lunch at this location until the equipment move was completed.

After the equipment move, the 2-Left crew returned to their work site to finish removing the last section of the take-up. The inby end of this structure was located approximately 5 feet from a stopping that had been built across the old 2-Left belt entry. This stopping, which contained a personnel door, separated the intake air ventilating the 2-Left track spur from a worked-out area where second mining had been conducted by retreat longwall mining. To minimize leakage, the stopping had been completely covered with a layer of Tyvek (a flame-resistant fabric similar to "house wrap" which is designed to prevent airflow through walls). This fabric also covered the personnel door. The last section of the take-up had been secured to the mine floor by eight, 2-inch diameter, all-thread rods which were anchored in concrete. Tatterson checked for methane as other crew members prepared acetylene torches to cut off the 2-inch rods. They began by

digging around the four outby rods which had been covered by approximately 8 inches of dried muck and rock debris. Cutting on these rods began at approximately 1:30 p.m. Any loose heated materials were picked up and put onto metal plates, which the crew had placed on the floor near the rib. Water was then poured onto these materials for cooling. Once cutting was completed, water was also poured into the holes that were dug around the four outby rods.

McIntosh next cut the four anchor rods at the inby end of the take-up. These rods were easier to cut than those were at the outby end, since they were exposed above the floor level (this end of the take-up had been pulled up by approximately two inches, leaving a space between the mine floor and the structure). However, cutting above ground level resulted in sparks being cast over a larger area than while cutting the previous set of rods.

Cutting was completed at approximately 2:00 p.m. and water was poured over and around the cut surfaces. Tatterson checked for hot spots while the crew loaded the take-up section onto the scoop. The scoop with the take-up section was then parked in the crosscut immediately outby the recovery site, between the old 2-Left belt and track entries. Myers then made an additional check of the work site, including digging around the rods, and found no evidence of heating. The crew departed from the 2-Left area at 3:00 p.m., after stowing their equipment on the personnel carrier. Approximately 15 minutes later, Dave Frazier, Longwall Foreman, traveled to the end of the trolley wire in 2-Left while conducting a preshift examination of the 8-North track haulageways. He did not notice anyone in the area, nor did he notice any hazardous conditions or signs of fire.

Once outside, Tatterson informed an employee assigned to the oncoming afternoon shift, Jim Welch, Maintenance Foreman, of the cutting activities in 2-Left and recommended that the location be checked at the start of the shift. Myers offered a similar recommendation to Walt Simatic, Afternoon Shift Foreman, and Warren Richardson, Longwall Foreman. Simatic then assigned Clarence Moore, Longwall Foreman, to check the area in 2-Left where cutting had been performed.

Moore and Richardson traveled to 2-Left, arriving at approximately 4:30 p.m. Richardson remained in their personnel carrier while Moore walked to the previous shift's work site via the 2-Left track entry. He noticed that some of the areas surrounding the cut anchor rods were still damp. He tested for methane, detecting a concentration of 0.1 percent, but he did not have a sensor for detecting carbon monoxide. Finding no evidence of fire, Moore returned to the personnel carrier and traveled with Richardson to the 6-Left Longwall Section, leaving 2-Left at approximately 4:45 p.m.

At 9:00 p.m., Moore began a preshift examination of the 8-North track haulageways, reaching the 2-Left area by 9:30 p.m. This was the same type of examination as conducted by Frazier during the previous shift, and was not intended as a check for fire at the site where cutting was performed. As required, Moore traveled to the end of the 2-Left track spur, approximately one crosscut outby the scoop that was parked in the crosscut between the Nos. 1 and 2 entries. He noticed nothing different from his earlier examination and departed from the 2-Left area at approximately 9:40 p.m.

At 11:30 p.m., Jim Ammons, Fireboss, entered the mine at the Sugar Run Portal to begin his assigned examinations (Figure 3). He started his examinations at the Motor Barn checkpoints, before traveling a return air course to the 1-South Seals. Ammons was then scheduled to examine the 1-West Seals and the 3-North daily checkpoints. The remaining employees assigned to the June 22, 1999, midnight shift began work at 12:00 a.m.

Arthur Reeves, Midnight Shift Foreman, entered the mine from the Miracle Run Portal at 12:15 a.m., along with Rod Pitman, Assistant Shift Foreman, Leroy Cook, Belt Foreman, and Tom Osborne, Foreman. This group was intending to check belt splices and to assess the work requirements for scheduled maintenance on the 8-North conveyor belt system. They first obtained tools and supplies near the Miracle Run shaft bottom before traveling to the 8-North Submain via a track mounted vehicle. Foremen assigned to examination duties in the 9-South and St. Leo areas also entered the mine from the Miracle Run Portal at this time, including Rick Campbell, Mike McCue, Mike Basnett, and Tom Chickerell.

Discovery and Attempted Fighting of the Fire

Steve Harris, Longwall Foreman, and Ed Gum, Foreman, entered the mine from the Miracle Run Portal at 12:30 a.m., where they obtained a rail-mounted personnel carrier. Gum was assigned to conduct examinations in the Main West entries. Harris dropped off Gum at the 8-North belt transfer point before traveling east to Crosscut 85 in the Main West entries, where he left Gum's lunch bucket and jacket near a track switch. He then returned inby to meet with Reeves, who had parked his personnel carrier at the 3-Left track switch and was working with a group of foremen near Crosscut 29 in the 8-North Submain. While en route, Harris decided to check the 2-Left take-up recovery work site before meeting with Reeves. Harris had parked his personnel carrier and was walking in the 2-Left track entry toward the recovery work site when he detected the faint smell of burned coal or wood. He spent several minutes checking the scoop parked in the crosscut immediately outby the recovery site before continuing into the old 2-Left belt entry. When Harris looked inby in the former belt entry, toward the take-up recovery site, he saw an orange glow from behind a pile of debris that had formed at the inby end of the take-up structure. He also noticed an orange glow at the bottom left and top right corner of the stopping located inby the take-up recovery site. Harris then traveled back to his personnel carrier to report his observation and to obtain fire-fighting equipment.

By 12:55 a.m., Harris had returned to his personnel carrier and was calling for Reeves on the trolley radio. Receiving no immediate response, Harris began driving toward 3-Left. Meanwhile, Reeves and Cook were walking toward the 8-North belt entry when they heard Harris yelling on the trolley radio. Reeves returned to his personnel carrier, from which point he could see the lights of Harris' approaching vehicle. Harris then informed Reeves that there was a fire in 2-Left and that he needed fire extinguishers. Reeves, Pitman, Cook, and Osborne then followed Harris to 2-Left, where they gathered fire extinguishers from the personnel carriers and a nearby power center. Upon arriving at the fire location, some flame was visible near the stopping. The men discharged three 20-pound fire extinguishers near the base of the stopping.

The chemical agent from the fire extinguishers temporarily obscured vision near the stopping. When the air cleared, the orange glow was still visible near the bottom and at the corners of the stopping. Reeves then ordered the others to connect fire hose to a water supply line at the 2-Left battery charging station. Once this task was completed, Osborne used the fire hose to spray water onto the stopping, which extinguished any small flames that may have remained on the intake side of the stopping. Reeves then realized that there was a large fire on the other side of the stopping. The glow from the fire could still be seen through small holes (1 to 2 inches in diameter) in the bottom left and both top corners of the stopping. Reeves then ordered Cook to go to a phone at the outby end of the 8-North Submain and inform all underground personnel to report to 2-Left to assist in fire fighting. He also requested that someone bring pipe wrenches for connecting additional fire hoses.

The crew fighting the fire then attempted to get a better look at the conditions on the other side of the stopping. Harris stood to the side of the personnel door, with his back to the stopping, while the others watched from a safe distance. When Harris opened the door, they saw debris packed against the stopping from a roof fall. The debris was glowing, reddish-orange in color, and partially melted. Osborne continued spraying water onto the stopping while Reeves, Harris, and Pitman attempted to find another approach to the fire. They proceeded to the adjacent track entry, which contained the only other personnel door in the stopping line separating the 2-Left intake split from the worked-out area. While approaching the stopping across the track entry, they felt an increase in temperature and noticed that the normally white Tyvek covering the stopping had begun to turn brown. When Harris opened the door, they observed very dense, black, billowing smoke immediately behind the stopping, which had covered the inby side of the door with soot. The thick smoke did not clear, even though air was rapidly flowing into the fire area through the open personnel door. Based on these conditions, Reeves determined that the fire was too close to this stopping for safe access through the personnel door. He then traveled outby in the 8-North Submain and opened a personnel door at Crosscut 14 to short circuit track intake air into the left return while Harris rejoined Osborne, who was still spraying water on the stopping in the old belt entry. The combination of effects from the fire and the force of the water being sprayed on the stopping had caused the hole in the top right corner to increase in size to approximately 3-1/2 inches in diameter and the roof was beginning to deteriorate near the holes.

Meanwhile, Cook had contacted Roger Sharp, Yard Foreman, who coordinated communications from the Sugar Run Portal, instructing all underground personnel to report to 2-Left to assist with fire fighting. Sharp first contacted Chickerell and McCue, one of who was with Campbell. He then contacted Ed Gum. Ammons had just finished examining the 1-West Seals and was on his way to the 3-North checkpoints when he heard Sharp paging on the mine phone. When Ammons answered the call, Sharp instructed him to find Lou Tolka, Foreman, and Joe Snoderly, Fireboss, and proceed to 2-Left. Ammons met Tolka at the Motor Barn and Snoderly at the 2-1/2-North entries, getting ready to go to Checkpoint E. The three men then proceeded toward 2-Left to assist with the fire fighting efforts. By this time, all 12 persons working underground had been notified of the fire. Jim Welch and Wyatt Bittinger, Maintenance Foremen, were on the surface at the Miracle Run Portal when they received a call requesting pipe wrenches. They entered the mine, but were delayed for some time before traveling toward 2-Left due to the locks on the tool

storage location. This increased the number of people underground to 14.

When Reeves returned to 2-Left, he attempted to further evaluate the extent of the fire. He and Pitman traveled to the adjacent longwall recovery chute where they encountered a solid stopping with no door. Harris checked the stopping in the crosscut adjacent to the chute and informed Reeves that there were obvious signs of fire behind that stopping. With no remaining approaches to the fire and with worsening conditions in the old belt entry, Reeves decided that the mine should be evacuated.

Mine Evacuation and Sealing

At 1:40 a.m., Reeves began issuing orders to evacuate the mine. By this time, all underground personnel assigned to the Miracle Run Portal had reported to 2-Left, except for Gum. Reeves ordered Harris to oversee the evacuation of all personnel from the fire area. He assigned Bittinger the task of locating Gum. Before leaving the fire, Osborne affixed the hose in such a manner that it would continue spraying water through the hole (which was now approximately one foot in diameter) at the top of the stopping. Reeves also called Sharp and informed him that the mine was to be evacuated. He asked Sharp to contact personnel responding to the fire from the Sugar Run Portal and to have them turn around. Sharp was also told to notify Reeves when everyone was evacuated from the mine. Sharp then contacted Ammons, Tolka, and Snoderly, whom had nearly reached the Main North Junction, and told them to turn around and evacuate the mine. By 1:45 a.m., all underground personnel, except for Gum, had received the order to evacuate. Sharp then began calling persons on the emergency list, starting with Clise.

Bittinger continued searching for Gum while traveling outby from 2-Left. He checked the 8-North belt conveyor transfer, but saw no one. Bittinger then called Sharp to see if Gum had been located. A miscommunication occurred at this time which resulted in Bittinger returning to the Miracle Run Portal without Gum.

By 2:00 a.m., underground personnel were exiting the mine portals. Ammons, Tolka, and Snoderly exited the mine at the Sugar Run Portal. Ammons, an experienced dispatcher, then joined Sharp in the dispatcher's office to assist with communications. All personnel were soon evacuated and accounted for at the Miracle Run Portal, except for Gum. Reeves asked Bittinger if Gum knew about the fire. Bittinger told Reeves that Sharp informed Gum of the fire. However, Reeves could not be certain that Gum was aware of the evacuation order. With all other personnel safely accounted for on the surface, Reeves and Bittinger brought the elevator to the Miracle Run shaft bottom and locked it out. They then searched the bottom area, but could not locate Gum. Reeves then telephoned the dispatcher's office and Ammons answered. Reeves asked Ammons to find out exactly what Sharp last communicated to Gum. Sharp indicated that his last communication with Gum was to report to 2-Left to fight the fire. Reeves and Bittinger then obtained a personnel carrier and traveled back toward the fire. They soon met Gum in the 8-North track entry, outby the 1-Left switch, walking toward 2-Left to fight the fire. The three men then traveled back to the Miracle Run Portal. At approximately 2:15 a.m., Reeves, Bittinger, and Gum were the last persons to exit the mine during the evacuation.

By 2:40 a.m., MSHA and upper mine management had been informed of the evacuation. Cecil Branham, MSHA Supervisory Coal Mine Inspector, notified the mine that a 103(k) Order would be issued. Ammons, a Loveridge Mine Rescue Team member, began preparing the mine rescue equipment while other team members were en route to the mine.

Bittinger was assigned to monitor air quality, every 15 minutes, at the St. Leo fan and to ensure that the fan remained in operation. This fan ventilated the worked out area containing the fire, as well as the 9-South Submain and St. Leo Headings. Bittinger first tested the air quality exhausting from the St. Leo fan at 2:45 a.m. He detected 20% O_2 and 0.7% CH_4. However, the carbon monoxide content was above the upper limits of the sensing range for his detector. The methane readings remained constant during his assignment, but the oxygen content trended downward, reaching 19.2% by 05:00 a.m.

At 5:20 a.m., additional mine rescue teams began arriving from other Consol mines. However, by 6:30 a.m., mine management decided to minimize the spread of the fire by sealing the surface openings as quickly as possible. They also placed a gas chromatograph unit at the St. Leo shaft and began analyzing air samples while both MSHA and Consol employees monitored all mine fans. Meanwhile, Consol was developing a plan to seal the mine at the shafts and at the slope. This plan also proposed to drill holes from the surface into each of the 8-North and St. Leo Bleeder entries for placing a cement/flyash mixture in order to isolate the fire area from the remainder of the mine (Figure 4). Drill holes would also be used to pump inert gases into the mine environment in the fire area. Prior to implementation, this plan was submitted in writing to MSHA and the 103(k) Order was modified to permit sealing in accordance with the operator's plan.

While sealing plans were being developed and mobilized, various monitoring locations were indicating that the fire was affecting a larger area. At 8:07 a.m., the mine monitoring system showed the first indications of carbon monoxide in the 8-North track entry. Other sensors showed carbon monoxide was quickly extending inby toward the 6-Left entries. Carbon monoxide was first detected at the Miracle Run fan at 10:30 a.m., indicating that permanent ventilation controls were being breached, and concentrations continued to increase throughout the morning. Shortly after noon, the Miracle Run fan pressure began to fluctuate, indicating that the fire was affecting the main ventilating current. These fluctuations continued until the fan was shut off later that evening.

Gas analysis showed that the fire was intensifying as sealing operations continued into the evening. Prior to being shut down, carbon monoxide levels reached 7900 ppm at the St. Leo fan and 807 ppm at the Miracle Run fan. Mine fans were shut off and sealed sequentially, beginning with the fan farthest outby the fire, Sugar Run, and progressing inby (Figure 5). This was intended to keep any unburned and potentially explosive distillates, which would have been released from the heated coal, moving away from the fire. By 9:50 p.m., all of the shafts and the slope were sealed and work was being performed at the drill sites. Once sealing was completed, the 103(k) Order required all persons to remain at least 300 feet away from all mine openings.

Tubing was extended from each shaft to permit atmospheric sampling from a safe distance, in accordance with this requirement of the 103(k) Order.

On June 24, 1999, a borehole was completed into the 2-Left fire area; through which nitrogen was pumped into the mine at a rate of 2,000 cfm. By the end of the following day, a total of 2,454,000 cubic feet of nitrogen had been pumped into the fire area. To further prevent oxygenated air from entering the mine, approximately 80 drill/de-gas holes that penetrated other portions of the mine were capped. Drilling continued into the 8-North and St. Leo Bleeder entries.

At 3:20 a.m., on June 26, 1999 (78 hours after ventilation was stopped), an underground explosion occurred which exited the mine at the St. Leo Shaft, destroying the fan and damaging the shaft partition (Figure 6). No injuries occurred as a direct result of the blast. Persons working at the St. Leo Bleeder drill site and at the St. Leo Shaft atmospheric monitoring station, all of who were more than 300 feet from the shaft, reported seeing a narrow blast of fire extending approximately 200 feet above the mine opening. The concrete and steel cap was blown into the air and landed approximately 170 feet from the shaft opening. Although the explosion did not propagate to the Miracle Run Portal, which was located approximately two miles from the St. Leo Shaft, a resulting pressure wave did cause the anti-reversal door on the Miracle Run fan to open, breaking the temporary seal. The explosion also damaged electric power transmission lines, located just uphill from the St. Leo Shaft. This interrupted electrical power to the region, including the Miracle Run Portal, causing the Command Center to temporarily switch to generator power. Consol then proposed a plan to re-seal the St. Leo shaft with a temporary steel and plywood cap. After the plan was approved, prefabricated components of the cap were transported to the site and assembled at a staging area located beyond the 300-foot radius from the shaft. Once welding was completed, the entire assembly was lifted into place using a crane. Mine rescue team members performed necessary manual work nearest to the perimeter of the shaft. This work was completed at 9:20 p.m., on June 26, 1999.

During the next several weeks, work continued at the borehole drilling sites. The 8-North flyash/cement plugs were completed on July 7, 1999, after a total of 1590 tons of material was pumped into these seven entries. The St. Leo Bleeder cement/ flyash plugs were completed on July 13, 1999, with a total of 990 tons of material pumped into these three entries. Nitrogen and carbon dioxide injections ceased on July 14, 1999. A total of 62 million cubic feet of nitrogen and 13 million cubic feet of carbon dioxide were pumped into the fire area. By the week of August 2, 1999, continuous Infrared Monitoring had stopped and gas samples at the boreholes and shafts were being collected on a daily basis. The gas analysis and IR trucks were both returned to the Pittsburgh Safety and Health Technology Center (PS&HTC). Samples were then analyzed in the PS&HTC laboratories. Mine atmosphere sampling and testing continued into the following year to ensure that the fire was extinguished and that the affected area was sufficiently cooled to prevent rekindling upon re-entry.

MINE RECOVERY

On April 25, 2000, Consol submitted a reentry plan that proposed a five-phase plan for systematically recovering the Loveridge No. 22 mine. The Re-entry Plan Map specified the sequence of areas to be explored (identified as Areas A through J), and is shown on Figure 7 of this report. The plan was approved by MSHA on June 14, 2000, pursuant to Section 103(k) of the Act. In the months that followed, numerous modifications to this plan were approved, as conditions warranted, and its provisions were discussed with the mine rescue teams every day before entering the mine.

A waterproof video camera was first used to survey damage in the St. Leo shaft, which showed that all but the top 275 feet of the curtain wall was destroyed during the June 26, 1999, explosion; blocking the bottom of the shaft with a 50-foot deep pile of rubble. This condition prevented the use of the St. Leo Shaft during the early phases of the recovery.

Phase I – Starting the Sugar Run and Harvey Run Fans

Phase I of the approved Re-entry Plan was initiated on July 11, 2000, when concrete was removed from the caps on the Harvey Run and Sugar Run Shafts. Training on the provisions of the approved plan was provided to all mine rescue teams prior to reentering the mine. On July 19, 2000, the Sugar Run and Harvey Run fans were started. This was three days prior to the planned re-entry. As ventilation was restored to this portion of the mine, continuous monitoring of the mine atmosphere showed no evidence of rekindling. After two days of fan operation, the Loveridge Mine Rescue Team opened the airlock doors near the bottom of the slope to provide additional intake airflow. Since fire or explosion damage was not expected in the eastern portion of the mine, normal air flow patterns were anticipated outby the Harvey Run Shaft during this phase of the recovery.

Phase II – Examining from Sugar Run to Miracle Run

Phase II provided for the following steps: reentering the mine via the Sugar Run slope; examining to the Miracle Run Portal; and restoring the elevators at these portals back to service. This included Areas A through E on the Re-entry Plan Map (Figure 7). On July 22, 2000, thirteen months after the mine was sealed, underground exploration began in the Sugar Run slope and shaft bottom area, utilizing mine rescue teams from Consol's Loveridge, Bailey, McElroy, Dilworth, Blacksville, and Robinson Run mines. A member of MSHA's Mine Emergency Unit accompanied each mine rescue team during underground exploration. Water was encountered at several locations near the Sugar Run Portal, including at the elevator landing in the Sugar Run intake shaft (Figure 8). However, the teams were able to navigate around or through these pools. Once an area was deemed safe, following exploration by the mine rescue teams, examinations were conducted on required intervals. This permitted pumps to be operated and repair work to be conducted on underground electrical equipment in the Sugar Run shaft bottom area soon after the initial re-entry of the mine.

By July 26, 2000, teams had advanced to Crosscut 47 in the Main West entries, a distance of approximately 12,000 feet from the Sugar Run Portal. This included Areas A through C on the Re-entry Plan Map (Figure 7). Exploration proceeded quickly in the Main North and 1-North entries, where conditions were fairly normal. However, the Main West entries were flooded by water, 2 to 3 feet deep, over a distance of approximately 4000 feet. Exploration was stopped when high concentrations of methane were encountered on the south side of the Main West entries, just inby the Harvey Run shaft. Since the Miracle Run fan had not yet been restarted, airflow was reversed in the intake entries immediately inby the Harvey Run shaft (Figure 9). The split most affected by this condition was that which normally coursed air past the 6-South seals to the Miracle Run fan along the south side of the Main West entries. At Main West Crosscut 43, where intake air normally split off of the track air course toward the 6-South seals, air containing up to 6.7% CH_4 was now flowing into the Main West track entry. In the track entry, the methane was quickly diluted to a concentration of 0.7% by air from the Harvey Run intake shaft. The combined airflow was then coursed outby in the Main West track and belt entries to the Main North Junction, where it was directed into a return air course. Calculations indicated that the methane liberation rate from this split was higher than would be expected for the seals alone. Therefore, it appeared likely that this split originated from the unventilated area inby the Miracle Run shaft. This unventilated area included the return side of the Miracle Run shaft, which remained sealed and contained methane concentrations ranging from 12% to 23%.

Several weeks were required to rehabilitate the areas explored during the first 5 days of the re-entry. During much of this period, the number of people permitted underground was limited to 20, until a second means of exiting the mine was provided. This restriction was lifted on August 4, 2000, one day after the Sugar Run elevator was returned to service. On August 8, 2000, stoppings were constructed across the Main West intake entries, just outby the Harvey Run shaft (Figure 10). This change prevented methane-air mixtures in the split ventilating the 6-South seals from flowing outby the Harvey Run shaft in the Main West track and belt air course. Staging areas for continued mine rescue explorations could then be established just outby the Harvey Run shaft.

Mine rescue teams resumed exploration of the Main West entries on August 11, 2000, reaching Main West Crosscut 120 on the following day. Explosive concentrations of methane, up to 11 percent, were again encountered in the air course along the south side of the Main West entries. As expected, the source of this methane was the unventilated area inby the Miracle Run shaft. On August 14, 2000, changes to the ventilation system were completed which removed the explosive mixtures of methane from all areas outby Crosscut 120. This permitted rehabilitation work to begin between the Harvey Run shaft and Main West Crosscut 120.

Phase III – Examining from Miracle Run to 8-North Plugs

Phase III provided for the following steps: examining from the Miracle Run Portal to the 8-North plugs; establishing ventilation at the 8-North plugs; and restarting the Miracle Run fan. This work would be conducted in Area F on the Re-entry Plan Map (Figure 7). On August 22, 2000, mine rescue teams examined from Main West Crosscut 120 to the bottom of the Miracle Run

shaft. They also explored to Crosscut 1 of the 8-North Submain, where 31% CH_4 was detected in the No. 8 entry. After exploring the area, the teams adjusted ventilation controls in preparation for starting the Miracle Run fan. The fan was started on the afternoon shift, shortly after the teams and all other personnel exited the mine.

By the morning of August 24, 2000, methane concentrations at the Miracle Run fan had dropped to 1.23% and stabilized. Mine rescue teams then explored from the Miracle Run shaft bottom area to Crosscut 5 of the St. Leo Headings, and to the 8-North plugs at Crosscut 7. Air was flowing inby in the 8-North Nos. 1-7 entries, while air containing 14% CH_4 was flowing outby in the No. 8 entry. The first evidence of the 1999 fire was encountered between the 8-North Nos. 1 and 2 entries, where soot was present at the left return regulator in Crosscut 7. At the time of the fire, a portion of the left return air course was directed toward the Miracle Run fan at this point. The plugs, which were pumped from the surface during fire-fighting efforts, were also accessed. However, the cement/flyash mixture had slumped prior to solidifying and never plugged off the entries as intended. On the following day, teams advanced past the plug locations to 8-North Crosscut 20, where they were stopped by a series of roof falls that spanned the entire width of the submain. Heavy soot deposits were present at the regulator in the 1-Left No. 1 entry and in the 8-North left return inby Crosscut 9. At the time of the fire, most of the air in the 8-North left return was directed into the 1-Left worked-out area through this regulator. Mine rescue teams installed ventilation controls across the 8-North entries, just outby the roof falls (Figure 11). This isolated the unexplored portion of the 8-North entries from the areas being rehabilitated, completing this phase of the recovery.

Phase IV – Examining from Miracle Run to St. Leo

Phase IV provided for the following steps: examining from the St. Leo Switch to the St. Leo plugs; establishing ventilation at the St. Leo plugs; establishing ventilation to and exploring in the 9-South Submain; uncapping the St. Leo shaft; and restarting the St. Leo fan. This included Areas G through I on the Re-entry Plan Map (Figure 7). On August 30, 2000, the teams began exploration of the St. Leo Headings, reaching Crosscut 52 by the end of the day, approximately half way between the Miracle Run and St. Leo Shafts (Figure 12). As the teams advanced, air quantity and quality decreased due to damaged stoppings, open personnel doors, and old electrical equipment vents (approximately 7,000 cfm with 19.2% O_2 and 2.7% CH_4 at Crosscut 45). Some of these controls were repaired as the teams retreated.

On September 1, 2000, mine rescue teams were assigned to explore toward anticipated deep water near Crosscut 58 in the St. Leo Headings, and to advance ventilation to permit pumping. As expected, water was roofed just inby Crosscut 58 (Figure 12). Tests for air quality in the track entry at Crosscut 58 indicated concentrations of 19% CH_4 and 15.8% O_2. Two stoppings were then partially removed at the following locations: Crosscut 58 between Nos. 1 and 2 entries, and Crosscut 56 between Nos. 2 and 3 entries. Stoppings outby those locations were repaired. As a result, the total airflow increased at Crosscut 56 in the Nos. 1 and 2 entries to 28,880 cfm, and a slight increase in air quality was detected in the return air course at Crosscut 23. This also cleared the methane from Nos. 1 and 2 entries, outby Crosscut 56, where pumping would be

initiated.

On September 7, 2000, mine rescue teams were used to install a water discharge line to Crosscut 4 of the 1-Left No. 1 entry in order to facilitate water removal from the areas being rehabilitated. This location was the highest point in the worked-out area associated with the 6-Left longwall panel, which had yet to be ventilated. From here, water would flow to a point where it could be pumped to the surface via a deep-well pump, which was to be installed in the bleeder entries. An air sample collected at Crosscut 4 during this work indicated 40.99% CH_4 and 4.1% O_2. The high concentration of methane in this area also exerted considerable pressure on the 8-North isolation controls, requiring frequent maintenance as water levels dropped. No signs of fire were observed in the 1-Left entries. As pumping continued in the St. Leo Headings, mine rescue teams returned to the 8-North Submain to try and post over the roof falls near the fire area.

On September 18, 2000, the teams entered the unventilated area through air locks and proceeded to evaluate each roof fall for the best path through the affected area. Air quality in this area included concentrations of 74.41% CH_4 and 1.85% O_2 in the 8-North No.7 entry. Each roof fall appeared to be fairly tight, with the exception of that just inby Crosscut 20 in the No. 5 entry, which had a space of approximately four feet between the cavity and the fallen material (Figure 1). At 11:44 a.m., team members began carrying supplies to the No. 5 entry air lock. Steel jacks and wooden posts were used to support the mine roof over this roof fall, which extended for 100 feet. Numerous team rotations were required to complete this task. At 5:40 p.m., they cleared the inby brow of the roof fall in the No. 5 entry and encountered a tight roof fall just outby Crosscut 22. Explorations were then halted for the day, with the last team exiting the air lock at 6:00 p.m.

On September 19, 2000, mine rescue teams began posting over the roof fall in the 8-North No. 6 entry. This roof fall was much tighter than that in the No. 5 entry, requiring team members to remove a considerable amount of fallen material as they proceeded. This work continued from 9:30 a.m. until 6:00 p.m., while setting only 14 roof supports. The teams resumed work on this roof fall the next morning. However, by 1:30 p.m., it was apparent that the roof fall was quite sizeable, approximately 25 feet high, with large slabs of hanging rock that prevented further work in this entry. The teams then moved to the No. 7 entry, where they set roof supports and removed debris until 6:30 p.m. Approximately two feet of clearance existed between the mine roof and the top of the fallen material. Much of the material had to be broken and removed to form a 3-foot high travelway over the roof fall. This work continued during the day shifts on September 22 and 25, 2000, in atmospheres containing up to 98% CH_4.

During the afternoon shift of September 25, 2000, the mine rescue teams resumed exploration of the St. Leo Headings, temporarily halting the work of posting over the roof fall in the 8-North No. 7 entry. Water had been pumped from the swag at Crosscut 58 and a staging area for the teams was established at Crosscut 55. The teams advanced to Crosscut 73, passing ventilation controls damaged by the explosion (Figure 13). The damaged controls disrupted airflow inby Crosscut 67, resulting in high concentrations of methane. The teams reentered the area the following day, repairing ventilation controls as they advanced inby. They explored to St. Leo

Headings Crosscut 83, and to 9-South Crosscut 4. Nearly all ventilation controls in the 9-South Submain and inby St. Leo Headings Crosscut 76 were destroyed, short circuiting ventilation inby this point.

On September 27, 2000, the mine rescue teams reached the St. Leo shaft, where they encountered rubble from the destroyed shaft partition (Figure 14). As one of the teams approached the St. Leo Bleeder plugs, they could feel a smooth surface on the mine floor, beneath the waist-deep water. The plug material was not visible above the water. This indicated that the concrete/flyash mixture also slumped prior to hardening at these locations. Tests for air quality near the plugs showed 20.2% O_2 and 1.2% CH_4. Ventilation controls were generally intact inby the shaft, including those nearest to the St. Leo Bleeders and in the return entries. Finally, the teams examined the 1D entries up to Crosscut 10 and a portion of the 9-South entries to Crosscut 7. Ventilation controls were intact inby 1D Crosscut 2, with personnel doors found open to Crosscut 10. All ventilation controls were destroyed in 9-South, with air quality diminishing toward the south. Extensive damage was observed to the 9-South conveyor belt and track systems (Figures 15-17).

On September 28, 2000, mine rescue teams installed foamed curtains in approaches to unexplored areas along the farthest points of advance. The following day, steel stoppings were installed to replace damaged controls between the St. Leo Headings intake and return air courses, creating an airway around the inside perimeter of the isolation controls (Figure 13). After the ventilation change, maximum methane concentrations in the explored areas dropped from 17% to 1.7%. The temporary controls were systematically replaced over the following week as rehabilitation work proceeded. Also during this period, on September 30, 2000, the cap was removed from the St. Leo shaft.

The St. Leo Bleeder isolation controls were constructed in a flooded area and were particularly vulnerable to changes in barometric pressure, requiring frequent monitoring and repairs. This problem was compounded after the return air course was extended to the inby end of the St. Leo Headings, creating a slight pressure differential between the 8-North entries and the St. Leo Bleeder entries. During this period, air quality in the return air course, downwind of the isolation controls, was constantly monitored at Crosscut 24 in the St. Leo Headings. Air flowed from this point to an overcast at the outby end of the St. Leo Headings, where it passed over a track entry near the Miracle Run Portal. Power was removed from the St. Leo Headings on several occasions during this period when methane concentrations exceeded 2% at this location. Consol also reactivated vertical degas bore holes in the 8-North pillared areas during this period.

Phase V – Examining the 8-North Submain to Inby the 2-Left Fire Area

Phase V, Stage 1, provided for the following steps: breaching the 8-North plugs and exploring to inby the 2-Left fire area; isolating the 2-Left fire area from the 8-North entries; and ventilating the 8-North entries, inby 2-Left. All Phase V work was to be performed in Area J on the Re-entry Plan Map (Figure 7), after completion of recovery work in Area I. However, conditions encountered during the mine recovery prompted Consol to request numerous revisions to their

approved re-entry plan. For instance, the 8-North isolation controls were installed in lieu of the cement/flyash plugs, and were much farther inby than the location of the plugs. In another request, dated and approved on October 6, 2000, Consol submitted a plan for supporting roof falls near 8-North Crosscut 22. The original plan did not provide for re-entering 8-North until after the 9-South recovery was completed. This work would initiate Phase V, Stage 1, while the remainder of Phase IV was placed on hold.

On October 9, 2000, mine rescue teams resumed work to support the roof fall in the 8-North No.7 entry. The teams entered the area through an air lock and into an atmosphere that contained 20.9% O_2 and no methane. The improved air quality was due to leakage through the temporary isolation controls in the 8-North Submain, induced by recent changes to the mine ventilation system. The favorable atmosphere allowed the teams to work barefaced as they used air-powered chisels to remove the material from the top of the roof fall. They continued in this manner, advancing approximately 14 feet per day, until reaching the inby side of the fall on October 12, 2000 (Figures 18-20). A team then examined to Crosscut 25 in the Nos. 5, 6, and 7 entries. Conditions were good inby the roof fall in the No. 7 entry. However, heat from the fire had caused the mine roof to sag in the Nos. 5 and 6 entries, outby Crosscut 23, prohibiting the team from accessing the inby side of the roof falls in those entries. This completed the work approved in the October 6, 2000, plan amendment.

Rehabilitating the St. Leo Air Shaft and Starting the St. Leo Fan

On October 20, 2000, MSHA approved Consol's plan, filed October 18 and revised October 19, 2000, to clean out the St. Leo Shaft. The plan provided for removal of the remaining portion of the curtain wall using hydraulic hammers, a headache ball, concrete saws, and controlled blasts. Debris was then to be loaded into muck buckets and hoisted to the surface for removal. An independent contractor, R. G. Johnson Company, performed this work. Demolition of the shaft partition was completed on Saturday, October 28, 2000. Mucking operations began the following Monday. Also at this time, regulators were constructed in each of the approaches to the shaft bottom to prevent ventilation changes as the material was removed.

As the mucking proceeded, Consol prepared to start the St. Leo fan. Earlier in the summer of 2000, a new fan, capable of delivering a much greater ventilating capacity than its predecessor, was installed adjacent to the St. Leo shaft. In order to withstand the resulting ventilating pressures, numerous ventilation controls near the St. Leo shaft needed to be replaced with more substantial devices. This work was detailed in a plan approved November 8, 2000. The plan provided for the following tasks: building cement block stoppings across the old intake entries leading from the St. Leo shaft; replacing steel stoppings in the St. Leo Headings and 9-South entries with cement block stoppings; and constructing permanent seals across the 1D entries inby Crosscut 9. Explosion-proof steel access panels were included in the 1D seals to facilitate future exploration of these entries (Figure 21).

Provisions for starting the St. Leo fan and for exploring the 8-North and 6-Left entries were approved November 14, 2000. This plan required the fan to be started and monitored remotely,

with re-entry of the mine to be conducted only after the methane in the atmosphere passing through the fan stabilized below 2.0%. The contractor completed mucking the shaft and demobilized from the site on November 20, 2000, as ducts were being installed to connect the St. Leo fan to the shaft. On November 24, 2000, ventilation controls were adjusted, and persons and power were removed from underground areas of the mine. The fan was then started, generating nearly 28 in-wg of ventilating pressure as ventilation was restored to the remainder of the 8-North entries and the associated longwall panels. At 10:30 a.m., gas concentrations at the St. Leo fan included 14.82% O_2 and 17.47% CH_4. Airflow through the fan entered the explosive range within the next hour, and remained explosive until midnight, November 26, 2000. Methane concentrations at the fan remained above 2.0% until the early morning hours of November 28, 2000. Air quality at this location continued to improve through December 3, 2000, when analysis of samples indicated concentrations of 20.3% O_2 and 0.55% CH_4. Afterward, gas concentrations in the St. Leo shaft stabilized, with the oxygen content near 20% and methane concentrations generally ranging between 0.6-0.8%.

Revised Plan for Rehabilitating the 8-North Submain and the St. Leo Bleeders

A revised plan for continued exploration and rehabilitation of the 8-North entries and St. Leo Bleeders was submitted and approved on December 1, 2000. The plan permitted the use of mine rescue teams to enter the St. Leo Bleeders and included provisions to use permissible face equipment to cut and load material from roof falls in the 8-North No. 6 entry. This work was required for establishing a second travelway before work would be permitted inby the 2-Left area. The plan did provide for a one-time event in which mine rescue teams would be used to shut off a water valve at 8-North Crosscut 62. This task was performed on December 2, 2000. The valve controlled water flow through a horizontal borehole drilled between the 8-North entries and an adjacent sealed worked-out area. This flow was hindering water removal efforts in the St. Leo Bleeders. Work to rehabilitate the No. 6 entry, using a continuous mining machine, began December 5, 2000.

On December 9, 2000, mine rescue teams entered the St. Leo Bleeder entries to determine the condition of the plugs. The teams reached the plugs and discovered that the cement/fly-ash mixture slumped less at these locations than those in the 8-North entries did. Only two feet of clearance remained above the plugs, restricting airflow to the bleeder system. The teams then removed internal bleeder ventilation controls to reduce restrictions near the plugs, which increased airflow through the bleeder system from 86,032 cfm to 104,839 cfm. Air quality at the plugs ranged from 16.9% O_2 and 1.3% CH_4 in the No. 1 entry, to 18.3% O_2 and 0.8% CH_4 in the No. 2 entry.

9-South Exploration Between the 1D and 2D Entries

Phase IV exploration was resumed on December 11, 2000 (Figure 22). Mine rescue teams entered an airlock in the 9-South No. 3 entry, located just inby Crosscut 7, into an atmosphere containing 9% O_2 and 55% CH_4. The teams explored to Crosscut 17 in all seven of the 9-South entries. Each of the four 2D entries was also explored, to and including Crosscut 3. All

ventilation controls were destroyed within the explored area and equipment was severely damaged by the forces of the June 26, 1999, explosion (Figures 23-36). The teams worked into the afternoon shift, installing foamed curtains for extending ventilation to Crosscut 12. Airflow was restored to this area during a ventilation change on December 17, 2000. Work to rock dust and improve ventilation controls in this area was then conducted, while mine rescue teams prepared to resume exploration in the 8-North entries.

8-North Exploration Between the 2-Left and 6-Left Entries

By December 20, 2000, the roof fall in the 8-North No. 6 entry had been supported, providing a second travelway inby the 2-Left fire area, and a fresh air base had been established at Crosscut 25. The following day, mine rescue teams examined all previously unexplored portions of the 8-North entries (Figure 1). The conveyor belt was missing or damaged by heat between Crosscuts 24 and 31 (the conveyor belt was covered by roof falls between Crosscuts 21 and 24). There was no direct sign of heat inby Crosscut 31. Heavy soot deposits, up to a foot deep, were encountered up to Crosscut 42 in the intake escapeway air course. Tests for gas concentrations indicated 20.8% O_2 and up to 0.1% CH_4 in the area outby the 4-Left entries. Inby this point, methane concentrations in the 8-North entries increased to a maximum of 0.5% CH_4.

Having completed exploration of the 8-North entries in approximately three hours, a team proceeded into the 6-Left entries. They soon reached Crosscut 29, where they were stopped by water that was over waist-deep (Figure 37). A total of 20,000 cfm of air was flowing in an inby direction through the 6-Left entries. This airflow contained 0.3% CH_4 in most places, with a maximum of 1.0% detected at the farthest point of advance in the No. 2 entry at Crosscut 26. Oxygen content was 20.1% at this location. The team then returned outby and prepared to enter the tailgate travelway, located in the 5-Left No. 3 entry. Upon entering the tailgate travelway, the team encountered 8,500 cfm of air containing 20.4% O_2 and 0.8% CH_4, flowing in an outby direction to Crosscut 5, where it was coursed into the adjacent worked-out area. At 2:10 p.m., the team reached the tailgate end of the longwall face, where they detected 20.8% O_2 and 0.4% CH_4 in the air that was flowing from the longwall face. Of this airflow, 6,110 cfm entered the adjacent worked-out area through the second open crosscut outby the longwall face. The remainder continued outby in the tailgate travelway. A roof fall halted the team's advance immediately adjacent to the longwall face, just inby Crosscut 44.

Later that evening, the 103(k) Order was modified to halt all work inby the 2-Left entries, pending an approved plan detailing the work to be performed in the restricted area. This precaution was taken by MSHA to prevent an unplanned release of methane from the worked-out area as water levels were lowered. Air measurements in the 5-Left and 6-Left entries showed little or no airflow inby the longwall face in the 6-Left entries. Known elevations in the bleeder system also indicated that the inby end of the 6-Left entries was completely blocked by water.

9-South Exploration Inby the 2D Entries

Mine rescue teams resumed exploration in the 9-South Submain on December 29, 2000 (Figure 22). Without the St. Leo shaft intake split, calculations indicated that the St. Leo fan could not provide sufficient ventilation to operate the longwall and the 1D and 2D entries. Therefore, one of this day's objectives was to secure a site for constructing explosion-proof seals across the 2D entries, as was done in the 1D entries. The teams first explored to Crosscut 15 in the 2D entries, where they detected 8.5% O_2 and 6.7% CH_4. A site for constructing the seals was chosen at Crosscut 13, where the 2D entries changed from four to three entries.

The teams then continued exploration in the 9-South entries. By the end of the following day, they had explored each of the 9-South entries to Crosscut 25 and in the No. 3 (track) entry to Crosscut 27. During this time, temporary ventilation controls were installed for the next air change, isolating the 9-South entries just outby the 3D entries. All ventilation controls were destroyed within the explored area, including those in the 2D entries (Figure 27). Numerous pieces of equipment were encountered; most of which were severely damaged by explosive forces. Mine rescue teams were also used to restore ventilation in this area during an air change on January 7, 2001.

On January 21, 2001, mine rescue teams explored the remainder of the 9-South entries, including the 3D panel neck. Air quality at the inby end of the 9-South entries ranged from 17.9% O_2 and 13% CH_4 on the east side, to 14.6% O_2 and 26% CH_4 on the west side. Similar concentrations were detected in the 3D entries. All ventilation controls in the explored area had been destroyed during the 1999 explosion. Temporary controls were installed and the entire area was ventilated during the afternoon shift.

6-Left Exploration to the Longwall Section

Throughout the month of January 2001, Consol submitted and received approval for plans to perform work in the 8-North Submain, inby the 2-Left fire area. This work included the following tasks: roof support work in the longwall tailgate travelway and in portions of the 6-Left entries; splitting blocks for establishing a track entry past the fire area in the 8-North entries; and extending electrical power for pumping water in the 6 Left entries. By January 24, 2001, water levels in the 6-Left entries were low enough to permit mine rescue teams to explore inby Crosscut 29 (Figure 37). The airflow velocities on the longwall face were 240 fpm at the No. 10 shield, and 390 fpm at the No. 121 shield. Water near the tailgate end of the face was too deep to permit travel beyond the No. 121 shield. Roof conditions were promising, with only three of the 171 shields being collapsed on the longwall face. A total of 13, 728 cfm of air was measured flowing inby the longwall face in the 6-Left No. 3 entry. The team continued exploring the 6-Left No. 3 entry, passing several crushed stoppings, before being stopped by waist-deep water, just outby Crosscut 81. Air flowed into the adjacent worked-out area through the damaged stoppings, reducing the airflow in the 6-Left No. 3 entry to 3,380 cfm at the farthest point of advance.

Bleeder System Improvements

During the following weeks, work continued to restore the longwall and outby areas to operational status. However, the minimum airflow requirements for operating the longwall section could not be provided due to restrictions caused by the remaining water and cement/flyash plug material in the bleeder system. On February 12, 2001, mine rescue teams began using air-powered tools to break up the plug material in the St. Leo Bleeders, restoring the entry height to six feet. This work continued through February 14, 2001.

On February 15, 2001, mine rescue teams proceeded into the 6-Left entries to support their way over a roof fall at Crosscut 88 in order to facilitate pumping water from the bleeder system (Figure 37). After posting over this roof fall and removing some of the fallen material, the team encountered a similar roof fall at Crosscut 89. By the end of the day, the team had posted over this roof fall, only to find a larger fall at Crosscut 92. This roof fall was too large for the team's available resources and no attempt was made to support it. Prior to leaving the area, the team moved the discharge line from pumps located outby in the 6-Left entries to Crosscut 91 in order to provide a more direct drainage path to the 6-Left borehole pump located at Crosscut 99.

On February 16, 2001, mine rescue teams entered the bleeder entries from the St. Leo shaft approach. Their objective was to explore as much of the rib-line (most inby) bleeder entry as possible and to adjust ventilation controls in order to improve air quality at the St. Leo Bleeders No. 1 plug location. The team first installed an air-powered water pump inby the plug location and then continued traveling in the rib-line bleeder entry. The team reached the limits of their communication system at Crosscut 15, north of the 2-Left entries. The air at this location contained 19.0% O_2 and 1.3% CH_4. The teams then explored the No. 2 bleeder entry to Crosscut 8, where they detected 15.9% O_2 and 2.5% CH_4. Controls were then installed in this area, to improve air quality at the No. 1 plug. The mine rescue teams removed the remaining plug material during the period from February 19 through 23, 2001. Also, during this period, the 2D seals were completed and the mine rescue teams explored the bleeder entries to Crosscut 28, where they encountered water depths to within 18 inches of the mine roof. Two additional air-powered water pumps were then installed in the bleeder entries.

The St. Leo fan pressure was raised to 32.2 in-wg on February 25, 2001, increasing airflow to the longwall section. Airflow velocities on the longwall face increased from 288 fpm to 675 fpm at the No. 25 shield, and from 305 fpm to 550 fpm at the No. 162 shield. All areas of the mine were then either ventilated or sealed. On February 26, 2001, the 103(k) Order was terminated and coal production was resumed.

Recovering the 1D and 2D Entries

On May 28, 2001, retreat mining of the 6-Left Longwall Panel was successfully completed and a portion of the airflow in the 8-North Submain could now be redistributed to the 9-South Submain, permitting ventilation and recovery of the 1D and 2D entries. Recovery of the 2D entries began on June 26, 2001, when mine rescue teams unbolted and removed the access panels

from the seals, located just inby Crosscut 12, and entered an atmosphere containing up to 90% CH_4. The teams explored and ventilated 4-10 crosscuts at a time, reaching the inby extent of the 2D entries (inby Crosscut 61) on July 2, 2001 (Figure 38). Controls were installed to extend ventilation during each advance, since all stoppings in the 2D entries were destroyed during the 1999 explosion (Figures 39-43).

On July 3, 2001, mine rescue teams removed the access panels from the 1D seals, located just inby Crosscut 9, and proceeded inby. At Crosscut 14, the teams encountered an atmosphere containing nearly 100% CH_4. There was little damage from the 1999 explosion in this area and all ventilation controls were intact. However, water was encountered at Crosscut 20, deepening inby to within one foot of the mine roof near Crosscut 27. Controls were then installed across the entries at Crosscut 20. During the early morning hours of July 4, 2001, after being delayed by a passing thunderstorm, the mine rescue teams restored ventilation to the isolated area. Several days were then required to lower water levels before further exploration and recovery operations could be attempted.

On July 12, 2001, mine rescue teams continued exploration in the 1D entries. They waded through waist-deep water before reaching Crosscut 35, where isolation controls were constructed for the next ventilation change, which was completed later that night. By July 16, sufficient water was pumped to advance the fresh air base and resume exploration activities. Teams entered the unventilated area and explored to Crosscut 46, where they encountered the inby end of the water pool. Consol determined that water would not be present inby these areas at sufficient depths to prevent ventilating the remaining portion of the 1D entries in a single air change. This ventilation change was successfully completed later that day. By noon of the following day, mine rescue teams completed examining the 1D entries to the point of deepest penetration, finding that ventilation had been restored to the entire area, and completing recovery of the Loveridge No. 22 mine.

INVESTIGATION OF THE ACCIDENT

The underground investigation of the 2-Left fire area began on August 29, 2000, after it was determined that the first accessible affected areas were safe. The investigation was conducted by MSHA in conjunction with the West Virginia Office of Miner's Health, Safety and Training (WVOMHS&T). The investigators were accompanied by representatives of Consolidation Coal Company and the United Mine Workers of America. A list of those persons who participated in the investigation is contained in Appendix A of this report.

MSHA and WVOMHS&T conducted interviews of persons with knowledge of the facts surrounding the accident. Interviews were conducted at the WVOMHS&T office in Fairmont, West Virginia. A list of those persons who participated in the investigation is contained in Appendix B of this report.

After each affected area was made safe during the mine recovery, underground investigations of

the accessible areas were conducted. The last portion of the underground investigation was conducted on July 23, 2001, following recovery of the 1D and 2D entries. The investigation team evaluated the areas affected by the fire to determine its probable cause and origin. The team also evaluated the areas affected by the explosion to determine the probable cause and origin of the ignition, the magnitude and direction of explosion forces, as well as the extent and path of flame. The team examined all electrical equipment and circuitry in both affected areas in an attempt to determine the source of the ignitions. A total of 48 rock dust samples were collected and submitted for laboratory analysis to determine percent of incombustible content and/or the presence of coke. Over 600 photographs and digital still images were taken to document fire and explosion damage. Mine monitoring system and examination records were also reviewed. The destruction of the St. Leo fan, as well as other damage caused by the fire and explosion, prevented direct measurement of the pre-fire mine ventilation system. However, MSHA conducted several technical ventilation investigations in the 8-North/St. Leo bleeder system prior to the fire. Information from these inspections, the operator's most recent mine ventilation map, and records of examination were used to evaluate the mine ventilation system prior to the fire.

DISCUSSION

Mine Ventilation and Bleeder System

The mine was ventilated by the four main mine fans as follows:

- The Sugar Run fan ventilated the haulageways and seals in the southeast portion of the mine, including the Sugar Run Portal, 1-North, Main North, and Main South areas.
- The Harvey Run fan ventilated the Main West haulageway and the seals along its north side.
- The Miracle Run fan ventilated portions of the 8-North and 9-South submains, the seals along the south side of the Main West entries, and the St. Leo haulageway.
- The St. Leo fan ventilated the 6-Left Longwall section, including its associated bleeder system, and a large portion of the 9-South Submain, including the 1D and 2D development sections.

A bleeder shaft had also been excavated to the coal bed at the inby end of the 1D entries, but was not yet connected to the mine openings. A line diagram showing the primary ventilation splits for the entire mine is illustrated on Figure 44.

At the time of the accident, all pillared worked-out areas were sealed, except for those associated with the 6-Left Longwall section. Methane was removed from the coal seam, prior to second mining in this area, by drilling numerous horizontal holes into the coal rib of the longwall pillar block. Several holes per longwall panel were also drilled from the surface to within 30-40 feet of the coal seam to remove methane from the overlying strata. Methane within the pillared areas was removed by a bleeder system, which continuously diluted and moved methane-air mixtures away from the active 8-North entries and the 6-Left Longwall face to the St. Leo fan. During longwall coal production, this bleeder system liberated approximately 4.8 million cubic feet of

methane per day (not including methane removed by the degasification program). After mining, methane liberation rates for a given area decreased considerably over time. During coal production, each of the previously completed panels liberated approximately one-fourth the methane of the active panel.

Highly restrictive caved areas and convergence of the mine openings between panels characterized ground conditions in this worked-out area. This was due to geologic conditions, which included a soft shale mine floor, a thick layer of shale directly over the coal seam, and a relatively heavy overburden that ranged in thickness from 1,000 to 1,500 feet. Yield pillars were developed immediately adjacent to the pillared area to protect the tailgate and headgate travel ways. However, roof falls were common in the center headgate entry, inby the retreating longwall face. This further restricted the paths for airflow within the worked-out area. Significant ventilating pressure had to be provided to the bleeder system under these conditions to ensure that methane-air mixtures within the pillared portion of the worked-out area were continuously diluted and moved away from the active workings.

The ground conditions described above meant that the only voids within the pillared area available for significant airflow quantities existed in the rubble zone that extended around the perimeter of the caved area. Consol controlled airflow through these areas by constructing and maintaining substantial stoppings adjacent to the pillared area in the crosscuts between the Nos. 2 and 3 headgate and tailgate entries, and across the old gate entries outby the longwall tear-down faces. These stoppings were removed in the tailgate entry just ahead of the retreating longwall face, introducing the majority of airflow to the worked-out area from the longwall section. These controls also contained the airflow leaving the longwall face to within the rubble zone and the center gate entries, ensuring that these voids were adequately ventilated around the full perimeter of the worked-out area.

The bleeder system design permitted controlling the quantities in each of its two primary flow paths to accommodate both the needs of the longwall face ventilation and the pillared area (Figure 2). The airflow path along the headgate entries and the longwall set-up entries (headgate flow path) ventilated the portions of the pillared area inby the longwall face and controlled airflow losses through the longwall shields. Airflow into the first leg of this flow path was provided by losses through the shields and by leakage from the No. 3 headgate entry. The airflow path which extended along the tailgate entries, across the tear-down faces and into the 1-Left entries (tailgate flow path), ventilated the worked-out areas outby the longwall face and controlled airflow quantities at the tailgate end of the longwall face. The tailgate flow path was longer and more restrictive; therefore, the headgate flow path was regulated at several locations to ensure adequate airflow across the longwall face. The minimum longwall face air velocities approved in the mine ventilation plan were 600 feet per minute (fpm) at the No. 10 shield and 325 fpm within 100 feet of the tailgate. These values were established in January 1998, based on the results of respirable dust samples, which indicated that such levels were necessary to achieve compliance with the 2.0 mg/m^3 respirable dust standard.

The friction losses created by forcing significant air quantities through the restrictive rubble

zones caused large pressure drops from the longwall section to the 1-Left and longwall set-up entries. This caused methane-air mixtures to effectively flow away from active workings at the longwall section and along the 8-North Submain through any minor voids and flow paths that existed within the central portions of the pillared area. This airflow exited the pillared area at any one of the numerous bleeder connectors along the 1-Left and longwall set-up entries. In this way, the 1-Left entries served the tailgate flow path in much the same way as the longwall set-up entries served the headgate flow path. Roof falls in the corners of the pillared area (i.e., the inby end of the 6-Left Panel, or the outby end of the first panel in the longwall district) were less restrictive and tended to develop stronger internal flow paths than in other portions of the pillared area. Leakage through the stoppings separating the pillared area from the 8-North Submain and from the active gate entries provided additional airflow to the rubble zone, replacing any airflow losses from the rubble zone caused by the cumulative effects of the internal flow paths. Leakage through stoppings between the Nos. 2 and 3 headgate entries inby the longwall face provided a similar function in the headgate flow path. Airflow was also introduced to the worked-out area through regulators at the inby end of the headgate entries and at the outby end of the active tailgate and 1-Left entries. This provided a controlled means to ensure adequate airflow throughout the rubble zone without short-circuiting the primary airflow paths from the longwall face.

Several challenges were overcome in maintaining the effectiveness of the active bleeder system prior to the fire. Consol anticipated the restrictive flow paths within the worked-out area and purchased a fan for the St. Leo shaft that should have been more than capable of providing the necessary ventilating capacity to both the active bleeder system and to the 9-South development sections. However, during the summer of 1998, when the fan settings were adjusted to meet increasing mine ventilation demands, it failed to perform according to design specifications. Repairs to the fan were only partially successful at increasing performance. Also, by this time, supplemental roof supports (conventional cribbing) in the 1-Left No. 1 entry had proven insufficient to prevent roof falls and convergence throughout much of this entry, further restricting the tailgate flow path. The reduced ventilating potential of the 1-Left entries tended to decrease oxygen content in the tailgate flow path and weaken airflow on the longwall face. To counter these effects, regulators were tightened on the headgate flow path and improvements were made to the ventilation controls separating the worked-out area from the 8-North entries. These improvements included building a new stopping line across the old 2-Left entries. The stopping at the location where the fire would later be discovered was one of the controls built at this time. Interview statements indicated that this stopping, which included a personnel door, was constructed on a footer, fully plastered, and covered with a nonflammable fabric (Tyvek) to further limit leakage.

Early attempts to improve the effectiveness of the bleeder system were somewhat successful, but failed to keep pace with the increasing rate of methane liberation from the growing pillared area. By September 1998, methane concentrations exceeded 2.0% in the bleeder evaluation points at the cut-through between the inby end of the 1-Left entries and the St. Leo Headings. The operator was then cited by MSHA for failure to comply with 30 CFR 75.323(e) at this location. To abate this condition, Consol submitted to MSHA and received approval for several ventilation

changes to enhance the performance of the bleeder system. These changes included redirecting airflow in the 9-South Submain from the St. Leo fan to the Miracle Run fan and eliminating an intake split in the tailgate travelway. The changes were approved with the stipulation that the total pressure differential across the pillared area be maintained at a minimum of 11.44 in-wg, a value historically shown for this bleeder system to ensure that methane-air mixtures within the pillared area would continue to move away from active workings. These improvements resulted in maintaining the desired airflow paths within the worked-out area while achieving compliance with 30 CFR 75.323(e).

After the mine was idled, the methane liberation rate from the bleeder system gradually decreased. By the time of the fire, 176,600 cfm of air was exiting the bleeder system with a methane concentration of 1.1%. The St. Leo fan was being operated at 21.3 in-wg to provide a total airflow of 377,100 cfm. The pressure drop across the pillared area, from the longwall face to the bleeder evaluation points, was 15.6 in-wg. These airflow patterns should have prevented significant accumulations of methane in the worked-out area near the outby end of the longwall panels where the mine fire was discovered.

Origin and Propagation of the 2-Left Fire

Damage directly caused by the fire occurred only in the 2-Left entries and in nearby portions of the 8-North entries (Figures 40-43). The most significant damage resulted from roof falls, which buried much of the burned material and delayed recovery of the mine. The extent of the roof falls, as shown on Figure 1, roughly corresponded to the locations where fire was present in active areas. These roof falls were caused by the effects of extreme heat on the immediate mine roof. Burned head-coal and wooden roof support materials (crib blocks and header boards) were present in these areas (Figure 45). Locations within the fire area where head-coal had been removed during overcast construction were less affected by roof falls. The old 2-Left belt entry, where the fire was discovered, intersected the 8-North entries at Crosscut 22; the only area where roof falls extended across the entire width of the 8-North Submain. This was the most direct path for flame propagation across the submain, via overcasts where the old 2-Left conveyor belt passed over the 8-North return and track entries.

The fire also propagated through the crosscut immediately outby the location where it was discovered, and into the adjacent former 2-Left track entry. During the investigation, the last section of the belt take-up was found in this crosscut, still loaded onto a scoop and partially covered by a roof fall (Figure 46). This roof fall prevented closer access to the location where the fire was discovered. Several inches of coal ash were present on the mine floor in this intersection and extended outby in the 2-Left track entry to the 8-North entries. The overcast separating the 8-North left return air course and the 2-Left track entry had failed as a result of the fire. The overcast separating the 8-North left return air course and the old 2-Left belt entry was not accessible due to roof falls. This control also likely failed during the fire, as signs of extreme heat was evident in the return entry, immediately downwind of its location.

Several factors were identified which indicated the rate of fire propagation across the 8-North

Submain. Witnesses who fought the fire stated that smoke was flowing into the worked-out area and had not rolled back toward the active workings when they abandoned the area at 1:40 a.m. This was consistent with the 4.8 in-wg pressure drop that existed toward the worked-out area across that stopping. Airflow toward the worked-out area would have increased from both the 8-North belt and track air courses if the size of these openings increased. This airflow pattern persisted as the fire burned along its two intake sources, the 2-Left belt and track entries, toward the 8-North entries. Fire did not reach the 8-North track entry prior to 8:07 a.m., when the mine monitoring system first detected elevated carbon monoxide levels at the 8-North #3 Rectifier. Twenty-seven minutes later, elevated levels of carbon monoxide were first detected in the 8-North belt entry by a sensor located at Crosscut 30. The overcasts separating the 8-North left return and the old 2-Left belt and track entries did not fail until at least 10:30 a.m., when carbon monoxide was first detected at the Miracle Run fan. Heavy soot deposits were present in the 8-North left return (Figure 48), extending downwind from the 2-Left entries to Crosscut 7, due to one or more of these overcasts failing prior to the St. Leo and Miracle Run fans being shut down at approximately 9:30 p.m. The fire breached the stopping in Crosscut 22 of the 8-North belt and intake escapeway air courses prior to the St. Leo fan being shut down, as evidenced by up to 12 inches of soot deposited in the intake escapeway air course, extending downwind to Crosscut 42. Analysis of the Miracle Run fan pressure recording chart (Figure 49) indicated that ventilation was not significantly affected by the fire until after Noon on June 22, 1999. Prior to that time, the fan pressure rose from 6.0 to 6.2 in-wg, consistent with normal daily fluctuations. Between 1:00 p.m. and 4:00 p.m., the fan pressure dropped from 6.2 in-wg to 5.8 in-wg as roof falls occurred and/or ventilation controls failed. This did not necessarily indicate a major change in the overall ventilation system, as calculations showed that a relatively small increase in airflow at the fan would have been sufficient to account for this pressure drop. Soot deposits in the 8-North right return, immediately downwind of the fire area, were found only along the mine roof and upper portions of the ribs, indicating that the fire breached this area after the Miracle Run fan was shut down at approximately 9:30 p.m.

Origin, Flame, and Forces of the 9-South Explosion

Evidence indicating the direction of forces from the June 26, 1999, explosion were used to identify its point of origin, which was located in the 9-South Submain at its junction with the 3D panel neck (Figure 50). Since the 2-Left fire did not propagate outside the 8-North Submain, it clearly did not ignite the explosion (the potential ignition sources are discussed in the next section of this report).

Flame from the explosion extended throughout most of the affected area. Analysis of combustion residue from dust samples collected at numerous locations in the 9-South Submain indicated the presence of an extra-large quantity of coke. Research on coke formation and deposition in experimental explosions has proven that coke indicates the passage of flame. Persons located near the St. Leo shaft at the time of the explosion reported seeing a narrow blast of fire exit the mine opening and extend approximately 200 feet into the air. Signs of heat were also present at the point of deepest penetration of the 2D entries. These factors indicated that flames from the explosion extended from its point of origin throughout the entire length of the 9-

South Submain, to the surface at the St. Leo shaft, as well as along the entire length of the 2D entries.

Damage from the explosion was extensive throughout the affected area. The explosion destroyed all ventilation controls, electrical installations, and conveyor belt systems within the 9-South Submain and the 2D entries. The displacement of these installations provided evidence of the magnitude and direction of forces during the explosion. Also, metal roof support straps, installed throughout the affected area, were readily deformed in the direction of explosive forces. The outby end of the 1D entries and the portion of the St. Leo Headings between the 9-South Submain and the St. Leo shaft incurred similar damage. The top portion of the shaft partition was deflected toward the return side of the shaft, consistent with forces originating in the 9-South intake air courses. The explosive force reaching the surface completely destroyed the portion of the fan housing located nearest to the shaft. It also lifted the concrete and steel cap, which was placed over the St. Leo shaft after the fire, and dropped it approximately 170 feet from the mine opening.

The direction of explosive forces extended out in all directions from the area containing the 3D conveyor belt transfer point (refer to Figure 32 and Figure 50), which was being installed in the 9-South belt entry prior to the accident. The mine roof had been cut to a height of approximately 15 feet at this location to install the 3D conveyor belt discharge assembly. The initial explosive forces extended toward the nearby 3D faces via the 3D belt entry. The explosion intensified as it propagated through the last open crosscut outby these faces. Stronger secondary forces were evident in an outby direction, from the last open crosscut in the 3D entries. The explosion then propagated outby in all of the 9-South entries, where forces were greatest in the belt and track entries. A second leading edge of the explosion developed and propagated into the 2D entries as the other continued outby in the 9-South Submain toward the St. Leo Headings. At the outby end of the 2D entries, signs of heat were greatest in the track entry. However, at the inby end of the 2D entries, the direction of forces indicated that the explosion propagated primarily along the belt entry, splitting into the track entry through each crosscut. There was little evidence of propagation along the 2D return entry, although forces from the explosion reached this entry from crosscuts connecting it to the track entry. At many locations, a rope lifeline, which was hung from the mine roof in the 2D return entry to designate the secondary escapeway, remained intact between crosscuts. From the 9-South Submain, the explosion continued west into the St. Leo Headings to the St. Leo shaft, but did not propagate east from the 9-South Submain. The path of the explosion also continued into the 1D entries for a short distance, where it passed through a connecting set of crosscuts to the St. Leo shaft. The explosion did not propagate in the 1D entries beyond that point.

Potential Ignition Sources

Viable potential ignition sources must be capable of exceeding either the temperature or energy requirements of the fuel. Visual observations of the suspected fire origin were not possible in this case because roof falls blocked access to the immediate area. However, witnesses and other persons with knowledge of the circumstances surrounding the fire have verified the existence of

potential ignition sources through their statements. The entire area affected by the subsequent explosion was accessible during the investigation. Observing the physical effects of the explosion identified the area where the explosion originated. The determination of potential ignition sources for both events was based on several factors, including:

- Identification of the available fuels;
- Ignition temperatures and energies of the available fuels;
- Visual observations;
- Statements from witnesses and other persons with knowledge of the circumstances surrounding each event;
- Location of all ignition sources near the suspected fire and explosion origins;
- The activities that were being conducted at the times of each event;
- The location of all miners in the vicinity of the fire; and
- Subsequent evaluations of ignition sources within the fire and explosion areas.

2-Left Fire Ignition Sources

The available fuels considered for the origin of the 2-Left fire were coal, wood, paper, lubricants, and methane. Methane, which has an ignition temperature of approximately 1000° F, was liberated in significant quantities in the worked-out area west of the 8-North Submain, and would have been ignitable at concentrations between 5% and 15%. However, analysis of the bleeder system indicated that the atmosphere in the portion of the worked-out area nearest to the fire area did not likely contain significant concentrations of methane. Also, witness statements and fan pressure recordings provided no evidence of a methane explosion prior to the fire. Localized fractures in surrounding strata that emit methane into the mine atmosphere (methane feeders) have been encountered in the Loveridge No. 22 mine. The sustained burning of a methane feeder could result in the ignition of other fuels. However, methane feeders were not detected in the vicinity of the fire during the investigation, or when testing for methane during and after cutting operations. Therefore, ignitable concentrations of methane were not likely present at the 2-Left fire origin.

The investigation did not rule out any of the remaining potential fuel sources for the origin of the 2-Left fire. Witnesses stated that dry, loose coal and wood were present on the mine floor, immediately outby the stopping where the fire was discovered. Loose coal was also likely present on the inby side of the stopping due to normal rib deterioration. Additionally, debris remaining from the stopping construction may have been present on the inby side of the stopping. Wooden cribs and posts were also installed in the area as supplemental roof supports. Lubricants that were used to maintain the moving components of the old 2-Left belt conveyor system may have also soaked into the mine floor. Of these potential fuels, coal had the highest ignition temperature of approximately 1300° F.

Witness statements, observations of the fire area, and other information obtained during the investigation were used to identify a general area in which the fire originated. This area included

the 2-Left entries and the adjacent worked-out area. All of the available information concerning possible ignition sources in the 2-Left fire area was examined.

The following ignition sources were considered:

- Electrical circuits;
- Smoking;
- Spontaneous combustion;
- Roof falls;
- Welding operations, and;
- Cutting operations.

Electrical circuits: All electrical circuits identified in the fire area were located in the 8-North track/trolley and belt entries (including the 2-Left track spur), with the exception of two power centers (Figure 47) located in 8-North Crosscut 20, between the Nos. 1 and 2 entries. Immediately before and during the fire fighting efforts, persons traveled throughout the 8-North track entry, the 2-Left track spur, and in the vicinity of the power centers. Several persons were also located in the 8-North belt entry, downwind of the old 2-Left belt transfer point. At that time, no signs of fire were encountered at these locations. The mine monitoring system records also showed that elevated levels of carbon monoxide were not present in the 8-North track and belt air courses during that time. The only other potential path for flame propagation between the power centers and the location where the fire was discovered was through the gobbed room immediately west of Crosscut 20. The portion of this room nearest to the power centers was examined during the investigation and showed no signs of fire. Therefore, electrical circuits and equipment, including the trolley system, are not considered potential ignition sources for the 2-Left fire.

Smoking: Investigators found no evidence to indicate that smoking was the ignition source. Therefore, smoking is not considered a potential ignition source.

Spontaneous combustion: There was no history of the occurrence of spontaneous combustion in the mine. Therefore, spontaneous combustion within the worked-out area is not considered a potential ignition source.

Roof falls: There was no history of roof falls causing sparks to ignite fires in the mine. The immediate mine roof in the area consisted of coal and shale, rather than the type of sandstone that has been associated with this type of ignition source. Also, this ignition source has been primarily associated with the ignition of gaseous mixtures. Therefore, a roof fall is not considered a potential ignition source.

Welding operations: Witness statements confirmed that cutting and welding operations were being performed in the 2-Left entries approximately 11 hours prior to discovery of the fire. These operations would have generated temperatures up to 3,000° F, at which temperature metals melt and vaporize. Such temperatures are well in excess of the ignition temperatures of all

potential fuel sources. When the fire was discovered, flame was not present in or near the track entry where the welding operations had been performed. This was evidenced by the statements of witnesses who traveled throughout the 2-Left and 8-North track entries immediately prior to and while fighting the fire. Also, the mine monitoring system did not detect elevated carbon monoxide levels in the 8-North track air course during this period. Therefore, welding operations are not considered a potential ignition source.

Cutting operations: Cutting operations were conducted in the area where the fire was discovered; the most recent of which was performed at the inby end of the take-up unit, approximately five feet from the stopping separating the old 2-Left belt entry from the adjacent worked-out area. Witnesses stated that hot sparks were widely dispersed in this entry while cutting the inby set of rods. The 4.8 in-wg pressure drop across the stopping would have induced high airflow velocities toward the worked-out area through any holes or other openings that might have existed in the stopping. Smoldering metal sparks landing near any such opening could have been carried into the worked-out area by the resulting high airflow velocities. Possible openings in the stopping included the personnel door and potential holes along the perimeter of the stopping. Such holes often develop due to typical roof and rib erosion, poor construction practices, or rodent activity. Therefore, the potential existed for fire to originate on either side of the stopping as a result of the cutting operations.

The state of the fire, when it was discovered, suggested that it originated on the inby side of the stopping. At that time, the fire was already out of control on the inby side of the stopping, but had just begun to affect the outby side of the stopping. The roof fall would not have been present against the inby side of the stopping when it was constructed, less than a year before the accident. Also, fire was reported throughout the fragmented fallen material, which was packed against the stopping when the door was opened during fire fighting. This condition is consistent with the head coal catching fire before collapsing. Therefore, the fire most likely caused the roof fall. Witnesses who fought the fire stated that the mine roof immediately outby the stopping was just beginning to deteriorate as the fire breached the control, burning toward its intake source. These conditions are consistent with a significant fire that had burned for several hours on the inby side of the stopping prior to being discovered.

Typically, a mine fire will spread most aggressively in an upwind direction, along available fuel sources, toward its source of oxygen. Ventilation controls constructed in a traditionally accepted method, such as the concrete block stopping at the location where the fire was discovered, have shown resistance to fire for a period of at least an hour. During the relatively slow burning of the coal ribs around such a control, flames originating on its intake side would also be expected to intensify in an upwind direction along available fuels. However, interview statements from persons who fought the fire indicated that unburned loose coal and wood were still present on the mine floor, near the fire, on the intake side of the stopping. When the fire was discovered, flames observed on the intake side of the stopping were described as minor and limited to the mine floor, even though the fire was already out of control on the opposite side of the stopping. These factors are more consistent with typical flame propagation patterns if the fire originated on the inby side of the stopping. Observations of the flame propagation path during the

investigation showed that the fire continued to spread upwind toward the 8-North entries from this location.

The results of examinations of the work site before and after cutting operations also indicated that the fire did not originate on the outby side of the stopping. Crewmembers stated that they poured water over the rods after cutting operations were completed. Both foremen searched the immediate area for fire, including digging around and touching the rods for signs of retained heat before leaving the work area. An additional search for fire was completed at this location nearly three hours after the cutting operations ceased. However, the searches for signs of fire were primarily directed at the immediate rod cutting locations and did not include examinations of the area on the inby side of the stopping. Carbon monoxide sensors had not been installed at the St. Leo fan, or at other locations downwind of the worked-out area that could have detected the early signs of the fire.

Based on these factors, the fire origin was most likely located on the inby side of the stopping. In this case, an opening must have existed in the stopping while cutting operations were being performed. During interviews, each member of the cutting crew, including the foremen that performed the searches for fire, stated that they were not aware that the stopping adjacent to the cutting operations contained a personnel door. They stated that the stopping was covered with Tyvek, which obscured the door location. They also stated that no attempt was made to ventilate the area during cutting operations, even though the entry was often filled with smoke and fumes. Fragments of melted fabric were found on the stopping in the adjacent entry during the investigation. Similar stoppings, located at the 1-Left approaches to the worked-out area, were unaffected by heat and were also inspected during the investigation. Individual blocks and general surface features on these stoppings were clearly visible through the fabric, which had been tightly pasted to the controls while exposed to significant ventilating pressure. Therefore, a personnel door should have been evident when examining the stopping's condition.

When the fire was initially discovered, the fabric still covered the entire stopping, except for the door. While this occurrence is consistent with the possibility that the fabric was cut to open the door for ventilating the work site during cutting operations, it could also have resulted from the effects of the fire. The burning, fallen material on the inby side of the stopping was in contact with the doorframe when opened by persons fighting the fire. Since the steel doorframe would have conducted heat faster than the concrete blocks, the fabric would have melted from the door sooner than on the rest of the stopping. The fabric began to melt on the rest of the stopping soon after the fire was discovered.

Persons first responding to the fire observed several small holes along the perimeter of the stopping, including a small hole at its base. The holes adjacent to the coal roof and ribs appeared to have been created by the fire, since they grew larger in size as the fire intensified. However, the hole at the base of the stopping was more likely to have existed prior to the fire, as the mine floor typically consisted of clay or shale. This opening would have been within the range of flying sparks from the cutting operations prior to the fire. A diligent search for fire after the cutting operations should have included all areas that could have contacted the heated metal. An

evaluation of the stopping's condition would have been necessary to determine if a search was needed on its inby side.

9-South Explosion Ignition Sources

The available fuels considered for the origin of the 9-South explosion were methane and coal dust. The ignition temperature for methane is approximately 1000°F. The energy necessary to ignite methane is approximately 0.3 millijoules. Methane is ignitable at concentrations between 5% and 15%. Coal dust layers can be ignited at temperatures as low as 320°F and coal dust clouds can be ignited at temperatures as low as 824°F. The energy necessary to ignite bituminous coal dust is about 60 millijoules. After ignition of a methane accumulation, temperatures within the explosion can rapidly increase to 3000°F or higher. Sufficient heat/energy is available for continued propagation after the methane is ignited and the fireball increases in size. The pressures associated with a methane ignition will place the top layers of dust from the mine floor into suspension along with any dust deposits on the ribs, roof, or equipment. These dust suspensions usually include both coal dust and rock dust. To prevent the propagation of a coal dust explosion, the total incombustible content of mine dust is required be at least 65%. Higher incombustible contents are required in the presence of methane. Layers of coal dust averaging only 0.005 inch thick can propagate an explosion, if suspended. The involvement of coal dust in a burning methane flame can cause temperatures and pressures to increase, can extend the flame, and thus can contribute significantly to the magnitude of the resulting explosion.

By the time of the explosion, 78 hours after mine ventilation was discontinued, methane-air mixtures had reached explosive levels within the affected area. Throughout the evening of June 25, 1999, air samples from the St. Leo shaft contained explosive mixtures of gases (Figure 51). However, approximately six hours prior to he explosion, the St. Leo shaft began ingassing due to rising barometric pressure (Figure 52), which prevented obtaining viable samples of the mine atmosphere. The ingassing event was of sufficient intensity to clear all methane from the fan housing by 10:00 p.m. This could have lowered methane concentrations in areas nearest to the shaft bottom, and may have prevented propagation of the explosion to other areas of the mine, including the 1D entries and the St. Leo Headings east of the 9-South Submain. The effect of the ingassing event on the mine atmosphere at the explosion's origin is not certain, due to its distance from the St. Leo shaft or other borehole sample locations in use at that time.

Several factors indicated that coal dust was involved as a fuel source in the explosion. A total of 48 dust samples were collected at various locations in the 9-South Submain, all of which showed the presence of coke (Appendix C). Coke is not formed where the mine dust initially contained more than 50% incombustible. An extra-large quantity of coke was present in 39 of these samples. Eighteen of these samples were also analyzed for incombustible content, of which 11 showed an incombustible content below 50%, ranging from 20.2% - 49.7%. This amount of incombustible content is not sufficient to prevent the propagation of coal dust explosions in mine atmospheres. On June 21, 1999, the operator's records of weekly examinations reported that the 9-South right return, crosscuts, and the overcast line at Crosscut 20 needed "drug" (an indication

that coal dust was deposited on rock dusted surfaces). No corrective action was reported. However, a crew was assigned to rock dust in the 9-South Submain during the following shift. Bulk rock dusting machines were transported to the 9-South section by two battery-powered locomotives. This equipment was parked in the 9-South track entry, where it remained after the mine evacuation. The investigation found that one set of rock dust pods on these machines had been emptied prior to the accident.

The area where the explosion originated was located at the highest elevation in the 9-South Submain and contained an intersection where the mine roof had been cut to a height of approximately 15 feet. Methane, which is lighter than air, would have accumulated in such high areas after mine ventilation was discontinued. By the time of the explosion, this cavity would have likely contained a richer volume of methane fuel than in the immediate surrounding mine atmosphere. Once ignited, it generated sufficient pressure to lift coal dust from mine surfaces into suspension. The mine atmosphere in the surrounding areas may have contained marginally explosive gas mixtures, resulting in lesser signs of forces, until propagating to the area with a more explosive gas mixture. Therefore, potential ignition sources were considered from throughout the areas adjacent to the 3D belt transfer point. Since this area was in close proximity to two developing face areas and a construction site, potential ignition sources were numerous, as shown on Figure 22. The following ignition sources were considered:

- Underground electrical power transmission circuits;
- Lightning;
- Roof falls;
- Battery-powered hand tools/small equipment;
- Phone systems, and;
- Rail-mounted, battery-powered equipment.

Underground electrical power transmission circuits: The mine monitoring system confirmed that underground electrical circuits were de-energized at 8:25 a.m. on June 22, 1999. Power transmission to the mine monitoring system was interrupted when power circuits were disconnected. Battery backup for these systems would have expired by the time of the explosion. Therefore, underground electrical power transmission circuits, including the mine monitoring system, are not considered a likely ignition source.

Lightning: There were no storms in the area at the time of the explosion, which occurred during a period of rising barometric pressure. Therefore, lightning is not considered a likely ignition source.

Roof falls: There were no roof falls near the origin of the explosion. Therefore, a roof fall is not considered a potential ignition source.

Battery-powered hand tools/small equipment: Numerous pieces of battery-powered equipment were located near the suspected origin of the explosion. Inspection of the permissible face equipment indicated that flame did not originate from these potential sources. Battery-

powered hand tools and equipment were damaged by the explosion and strewn throughout the affected area. However, there was no reasonable cause for these tools to have been actuated at the time of the explosion, therefore, these items are not considered a likely ignition source.

Phone systems: At the time of the mine evacuation, two phone systems were still energized in underground areas of the mine. MSHA evaluated both phone systems for intrinsic safety. Either system could be capable of providing the necessary energy needed to ignite methane when the wiring of the phones was intermixed with other non-intrinsic safe circuits.

One phone system, used for general communications, was a Model LM-101 Loudmouth paging telephone system manufactured by Comtrol, MSHA Approval No. 9B-71-1. This system was a 12-volt battery operated system using multiple dual-polarity phones connected by a single pair of conductors. Each phone contained batteries that powered the system. This system permitted persons to page and communicate with the dispatcher and with other persons at the mine.

The second phone system, for individual communications, utilized Model 491-104, 12 Vdc push-button Mine Dial/Page phones manufactured by Gia-Tronics, MSHA Approval No. 9B-43-04. This system was also connected through a private branch exchange (PBX) to the incoming telephone system equipped with an uninterruptible power supply (UPS) to allow mining personnel to communicate underground with persons away from the mine. The Gia-Tronics system also required that a dedicated pair of conductors be provided to connect each phone to the PBX. This system required power from the mine utility power system and it would not operate during power outages since an UPS for this system was not provided. A bank of protective barriers, consisting of fuses and zener diodes, was installed on the surface to prevent hazardous phone voltages from being transferred into underground areas of the mine.

The conductors for both phone systems entered the mine at the Miracle Run Portal through two 100-pair communication cables that had shielding around the cable assembly. One cable provided phone service outby toward the Sugar Run Portal and the other cable provided phone service inby the Miracle Run Portal. At the bottom of the Miracle Run Portal, the conductors for the Comtrol paging phone system left each 100-pair cable using a telephone cable consisting of single pair of No. 14 AWG black and white conductors twisted together. At approximately every 1000 feet and near several belt drives, a junction box was used to make connections from the main communication cables to individual communication cables for the Gia-Tronics dial/page phones. In addition to about 30 pairs of conductors used for the Gia-Tronics Push-Button phones, the 100-pair communication cables were also used to provide ten (10) pairs of conductors for 120-volt belt control wiring at various locations. Since each pair of the 100-pair cable were not individually shielded and 120-volt control wiring was intermixed with the phone conductors, neither phone system was installed to ensure that the phones would provide protection against methane ignitions in areas where permissible equipment was required.

The Comtrol paging phone system would not pose an explosion hazard since miners were not permitted within 300 feet of any mine portal after the mine was sealed. Thus, no one could activate the paging feature of the phone system. Examination of the phones in the affected area

showed no evidence of short circuits, other than those caused by impact from explosive forces external to the phone units. Also, prior to the explosion, all electrical utility power sources entering the mine were de-energized and disconnected. This would remove any cross-contamination between intrinsic safe wiring and the 120-volt wiring for the belt control system installed in the communication cable underground. The mine utility power for the telephone PBX was de-energized and disconnected. After four to six hours, the UPS for the PBX would have disconnected the Gia-Tronics phone system from the outside telephone system due to a drop in voltage. Ringing signals for underground phones would then stop at the PBX located at the surface portal and not be sent into the mine. Also, there were no roof falls near the initial point of ignition that could have caused a short circuit in the phone lines. Therefore, at the time of the explosion, neither phone system was capable of causing electrical arcing that could provide the energy needed to ignite methane.

Rail-mounted, battery-powered equipment: After the mine evacuation, two battery-powered/trolley-powered locomotives remained parked near the end of the 9-South track, in the vicinity of the identified explosion origin. Each locomotive had two different voltage sources that could supply sufficient energy to ignite a methane/air mixture with the trolley wire de-energized. An electrical schematic diagram for these locomotives is shown on Figures 53. The main batteries consisted of two trays connected in series to provide 240 Vdc for the power circuits, a 280/37 volt DC Converter to charge the control batteries, and a 280/12 volt DC Converter for the 12 Vdc headlights. The control battery consisted of four 8 Vdc batteries connected in series to provide 32 Vdc to the control circuit.

Each locomotive was equipped with a MAIN circuit breaker (CB-M), a POWER TAKE OFF (PTO) circuit breaker (CB-PTO), a CONTROL circuit breaker (CBD) and a On/OFF control switch (CSW). During the investigation, the CSW control switches were found in the ON positions, and the CB-M and CB-PTO circuit breakers were found in the TRIPPED positions. The CBD circuit breakers are located in the end of the locomotives opposite the operator's deck and are usually left in the ON position so that control power will remain available to keep the air brakes set. The control breaker on one of the locomotives was destroyed during the explosions and its position could not be determined. The CB-M and CB-PTO circuit breakers were equipped with undervoltage releases (relays) which would have tripped the circuit breakers upon loss of voltage from the main battery. Two cases were identified in which the breaker position configurations could have resulted in arcing at the time of the explosion.

Case 1 - With the CB-M circuit breaker on or off, the main batteries supplied power to a voltmeter to indicate battery condition (charge) and the undervoltage release for the CB-M circuit breaker. With the CB-M circuit breaker on and the Drive/Brake drum controller in the off position, the main batteries supply power to the following: Transfer Battery Contactor (TB); Trolley Transfer Relay (TTR); Transfer Trolley Contactor (TT); Compressor Motor circuit (CM); a 0-300 volts voltmeter; Anti-Spark Time Delay Relay (TDR); Sanders Box Heater (SHC) circuit; Control Battery DC Converter circuit; Headlight DC Converter circuit; and Power Take Off (PTO) circuit. The Sanders Box Heaters were probably not needed and may have been disconnected at their respective contactor.

With both the CB-M circuit breaker and the CBD circuit breaker on and CSW control switch in one of its two on positions, the control batteries supplied power to the circuits highlighted on Figure 53. These included the following: a voltmeter to indicate control voltage, the Safety Relay (SR), Brake Control Relay (BCR), Solenoid Valve Brake (SVB), either the Forward Control Relay (FCR) and Forward Contactors (F1 and F2) or Reverse Control Relay (RCR) and Reverse Contactors R1 and R2) depending on the position of the directional switch, the Low Air Alarm signal device (piezo-electric), an Elapsed Time Meter (ETM), the Sanders Heater Contactor (SHC), and the Compressor Control circuit consisting on a Drain Control Relay (DCR), a Solenoid Valve Drain (SVD) and a Compressor Control Contactor (C).

Case 2 - With the CB-M circuit breaker off and the CBD circuit breaker on and CSW control switch in one of its two on positions, the control batteries supplied power to the circuits highlighted on Figure 54. These circuits included the following: a voltmeter to indicate control voltage; Brake Control Relay (BCR), Solenoid Valve Brake (SVB); either the Forward Control Relay (FCR) and Forward Contactors (F1 and F2) or Reverse Control Relay (RCR) and Reverse Contactors R1 and R2), depending on the position of the directional switch; Low Air Alarm signal device (piezo-electric); and Elapsed Time Meter (ETM). The main batteries only supply power to the undervoltage release for the CB-M circuit breaker and to a voltmeter to indicate battery condition.

The three voltmeters, located in the operator's deck, for the main battery and the control battery circuits, do not have any parts that would cause electrical arcing during normal operations, capable of providing the energy needed to ignite methane.

The Undervoltage Release (UVR) for the POWER TAKE-OFF circuit, located in the operator's deck, was de-energized since the PTO circuit was not being used. The Undervoltage Release (UVR) for the MAIN circuit breaker (CB-M), located in the operator's deck, would be energized at all times except when the main batteries were being charged. This device could cause electrical arcing capable of providing the energy needed to ignite methane when the main batteries became discharged after a long period of time. The UVR would also open the MAIN Circuit Breaker (CB-M) to de-energize the two DC Converters, the Transfer Battery Contactor (TB), the Sander Box Heaters (SHC), the Anti-Spark Time Delay Relay (TDR), and the Compressor Motor (CM) circuit. As the circuit breaker opens, electrical arcing from the breaker contacts would occur and be capable of providing the energy needed to ignite methane. An undervoltage conditions would also cause the Transfer Battery Contactor (TB) and the Anti-Spark Time Delay Relay (TDR) to open their contacts with the resultant electrical arcing from the contacts capable of providing the energy needed to ignite methane. Since this would have to occur after the main battery discharged over a long period of time, this would probably not be the cause of the explosion even though the circuit breaker was found in the tripped position. However, these conditions cannot be ruled out as a possible cause of the initial explosion. The Anti-Spark Time Delay Relay (TDR) was located in the compartment with the control batteries and the compressor motor in the end of the locomotives opposite the operator's deck.

Under normal operations, 300-volt battery or trolley power is supplied to the compressor motors for the air braking systems (SVB) on the locomotives. Pressurized air in the braking systems will inevitably leak, requiring the compressor to periodically recharge the system. This cycle could typically occur several times per day. As the air pressure bled off to 70 pounds per square inch (psig) in either of the locomotives' braking systems, a pressure switch (PS1) with a set of normally open contacts would close. This would start the air compressor motor (CM) by closing the electrical contacts of the Compressor Control Contactor (C). After the air pressure was restored to 90 psig, the pressure switch (PS1) would stop the locomotive's compressor by opening the electrical contacts of the Compressor Control Contactor (C). Closing and opening the electrical contacts of the contactor can cause 300-volt direct current electrical arcs. Also, the closing and opening of the pressure switches' contacts can cause 32-volt direct current electrical arcs. Both types of these arcs are considered capable of providing the energy needed to ignite methane.

After mine ventilation was discontinued, methane concentrations increased, while the compressor motors on the locomotives would continue to cycle off and on. After the mine atmosphere reached the lower limits of the explosive range, ignition could occur. The ignition of a richer body of methane near the 3-D transfer point likely resulted from the propagation of a less intense methane explosion that originated at one of these locomotives.

Decision to Evacuate and Seal the Mine

If a fire in the highly volatile Pittsburgh seam is not arrested in its early stage, it soon gets out of control. Fires that get out of control cannot be directly fought effectively and must be starved out by cutting off oxygen by means of sealing. In this seam, fires can rage out of control in 2-3 hours. Therefore, the direct approach to fighting the fire is usually very difficult and hazardous.[1] In the case of the 2-Left accident, the fire had been burning for up to 11 hours. By recognizing the implications of this condition with respect to the well-established nature of mine fires in the Pittsburgh coal seam, the operator's decision to evacuate and seal the mine successfully limited damage directly caused by the fire; while also minimizing the risk of injury to those fighting the fire. The inability to gain access to the fire would have likely resulted in the failure of continued attempts to directly fight the fire. In this case, a failed attempt to further fight the fire would have risked serious injury to miners and resulted in the delayed sealing of the mine. Delayed sealing of the mine would have resulted in additional fire damage and would not have likely prevented the 9-South explosion.

1 "Control of Mine Fires", West Virginia University Mining Extension Service Coal Mining Series, 1969

CONCLUSION

The ignition source for the 2-Left fire was heated metal from cutting operations, which were completed at 2:00 p.m. on June 21, 1999, approximately 11 hours prior to the discovery of the fire. Coal and/or other combustible materials within the worked-out area were most likely ignited after a heated metal spark from the cutting operations passed through an opening in the adjacent stopping. Prior to its discovery, the resulting mine fire propagated to the point where it could not be readily extinguished because a diligent search for fire in all potentially affected areas was not made during and after the cutting operations.

The most likely ignition source of the subsequent explosion was an electrical arc from a battery powered locomotive, located near the inby end of the 9-South Submain, which ignited methane that had accumulated after the mine was sealed. The pressures from the methane explosion caused the suspension of coal dust from the mine surfaces. Coal dust then became involved in the explosion because the incombustible content of the combined coal dust, rock dust, and other dust in the affected area was less than 50%. The involvement of coal dust in the explosion increased the magnitude of the resulting explosion.

After the fire was discovered, injuries were avoided by adhering to well-established best practices for dealing with mine fires. The mine was evacuated as soon as it was determined that the fire was out of control and could not be fought directly. Sealing was completed without delay and in an orderly manner, so as to prevent returning unburned distillates to the fire. After sealing, persons were kept a safe distance from all mine openings while explosive mixtures were present in the mine. Finally, the mine recovery was completed after more than 270,000 man-hours of exposure without any lost-time injuries.

ENFORCEMENT ACTIONS

1. A 103(k) Order was issued to ensure the safety of all persons in the mine, until the mine was recovered and the affected areas were returned to normal.

2. A 104(a) Citation was issued for failure to comply with 30 CFR 75.403. This standard states: *Where rock dust is required to be applied, it shall be distributed upon the top, floor, and sides of all underground areas of a coal mine and maintained in such quantities that the incombustible content of the combined coal dust, rock dust, and other dust shall be not less than 65 per centum, but the incombustible content in the return aircourses shall be no less than 80 per centum. Where methane is present in any ventilating current, the per centum of incombustible content of such combined dusts shall be increased 1.0 and 0.4 per centum for each 0.1 per centum of methane where 65 and 80 per centum, respectively, of incombustibles are required.*

The citation body reads as follows:

> The results of the analysis of the incombustible content of the 16 dust samples collected on 01-23-2001, during the investigation of a mine fire/explosion accident, were less than that required by 30 CFR 75.403. The results of the analysis of the samples are listed below showing the Sample Number, Location, Incombustible Content, and Alcohol Coking Content:
>
> | | | | |
> |---|---|---|---|
> | No. 31 | floor 9-South F entry 25-26 crosscuts | 34.1% | X-large |
> | No. 32 | floor 9-South E entry 25-26 crosscuts | 59.4% | X-large |
> | No. 33 | floor 9-South D entry 25-26 crosscuts | 47.6% | X-large |
> | No. 34 | floor 9-South C entry 25-26 crosscuts | 45.9% | X-large |
> | No. 35 | floor 9-South B entry 25-26 crosscuts | 56.1% | X-large |
> | No. 38 | floor 9-South B entry 27-28 crosscuts | 52.9% | X-large |
> | No. 39 | floor 9-South C entry 27-28 crosscuts | 39.4% | X-large |
> | No. 40 | floor 9-South D entry 28-29 crosscuts | 36.6% | X-large |
> | No. 41 | floor 9-South E entry 28-29 crosscuts | 47.8% | X-large |
> | No. 42 | floor 9-South F entry 28-29 crosscuts | 53.3% | X-large |
> | No. 43 | floor 9-South G entry 27-28 crosscuts | 49.7% | X-large |
> | No. 44 | floor 3-D 9S B entry 2-3 crosscuts | 20.2% | X-large |
> | No. 45 | floor 3-D 9S C entry 2-3 crosscuts | 39.0% | X-large |
> | No. 46 | floor 3-D 9S A entry 2-3 crosscuts | 53.6% | X-large |
> | No. 47 | floor 3-D 9S D entry 2-3 crosscuts | 40.6% | X-large |
> | No. 48 | floor 9-South G entry 25-26 crosscuts | 37.7% | X-large |
>
> The presence of an extra large quantity of coke in these samples indicates that inadequately inerted coal dust significantly contributed to the propagation and intensity of the explosion.

3. A 104(a) Citation was issued for failure to comply with 30 CFR 75.1106. This standard requires that: *All welding, cutting, or soldering with arc or flame in all underground areas of a coal mine shall, whenever practicable, be conducted in fireproof enclosures. Welding, cutting, or soldering with arc or flame in other than a fireproof enclosure shall be done under the supervision of a qualified person who shall make a diligent search for fire during and after such operations and shall, immediately before and during such operations, continuously test for methane with means approved by the Secretary for detecting methane. Welding, cutting, or soldering shall not be conducted in air that contains 1.0 volume per centum or more of methane. Rock dust or suitable fire extinguishers shall be immediately available during such welding, cutting or soldering.*

The citation body reads as follows:

> A diligent search for fire was not made during and after cutting operations, which were performed during the Day Shift on June 21, 1999, in the former 2-Left belt conveyor entry off the 8-North Submain. Statements by persons interviewed during the accident investigation revealed that a search for fire was not conducted on the opposite side of the permanent stopping located immediately adjacent to the area where the cutting operations were performed. The accident investigation concluded that coal and/or other combustible materials were most likely ignited after a heated metal spark from the cutting operations passed through an opening in the adjacent stopping. A mine fire resulted which propagated to the point where it could not be readily extinguished by the time of its discovery at 12:50 a.m. on June 22, 1999.

Respectfully Submitted:

Chris A. Weaver
Mining Engineer, Mining Engineer, Ventilation

Joseph R. Yudasz
Coal Mine Safety and Health Inspector

Approved by:

Timothy J. Thompson
District Manager, District 3

APPENDIX A - Investigation Participants

Mine Safety and Health Administration

Allyn C. Davis, Accident Investigation Coordinator, Coal Mine Safety and Health
P. Michael Hall, Chief, Electrical Section
William A. McGilton, Supervisory Coal Mine Safety and Health Inspector
Ronald L. Sidwell, Coal Mine Safety and Health Inspector, (Electrical)
Daniel L. Stout, Electrical Engineer
Clete R. Stephan, Mining Engineer, Pittsburgh Safety and Health Technology Center
Chris A. Weaver, Mining Engineer, Ventilation
Joseph R. Yudasz, Coal Mine Safety and Health Inspector

West Virginia Office of Miner's Health, Safety and Training

John Larry, Assistant Inspector-At-Large
Brian Mills, Inspector-At-Large
Roger Powell, Inspector-At-Large

Consolidation Coal Company

Charles E. Bane, Safety Supervisor
Dave A. Clise, Mine Foreman
John T. Higgins, Superintendent
Jack A. Holt, Vice President Safety
Richard Marlowe, Chief Inspector

United Mine Workers of America

Mark Cochran, Mine Safety Committee Chairman
Wayne Conaway, Miner's Representative
Rich Eddy, District 31 President
Dennis O'Dell, International Representative
Terry Osborne, Regional Director
Gary Trout, International Representative
Roy Williams, Miner's Representative

APPENDIX B - Persons Interviewed

John T. Higgins, Superintendent
Dave A. Clise, Mine Foreman
Mark Watkins, Assistant Superintendent
Clarence Moore, Longwall Foreman (Afternoon Shift)
Dave Frazier, Longwall Foreman (Day Shift)
Mike Tatterson, Maintenance Foreman (Day Shift)
Linz Booth, General Inside Labor (Day Shift)
Larry Straight, General Inside Labor (Day Shift)
Leo McIntosh, Mechanic (Day Shift)
Walt Simatic, Shift Foreman (Afternoon Shift)
Jeff Myers, Belt Foreman (Day Shift)
Arthur Reeves, Shift Foreman (Midnight Shift)
Steve Harris, Longwall Foreman (Midnight Shift)
Jim Welch, Maintenance Foreman (Midnight Shift)
Wyatt Bittinger, Maintenance Foreman (Midnight Shift)
Terry Osborne, Foreman (Midnight Shift)
Roger Lee Sharp, Yard Foreman (Midnight Shift)
Jim Ammons, Fireboss (Midnight Shift)
Dave Wilson, Electrical Foreman (Day Shift)

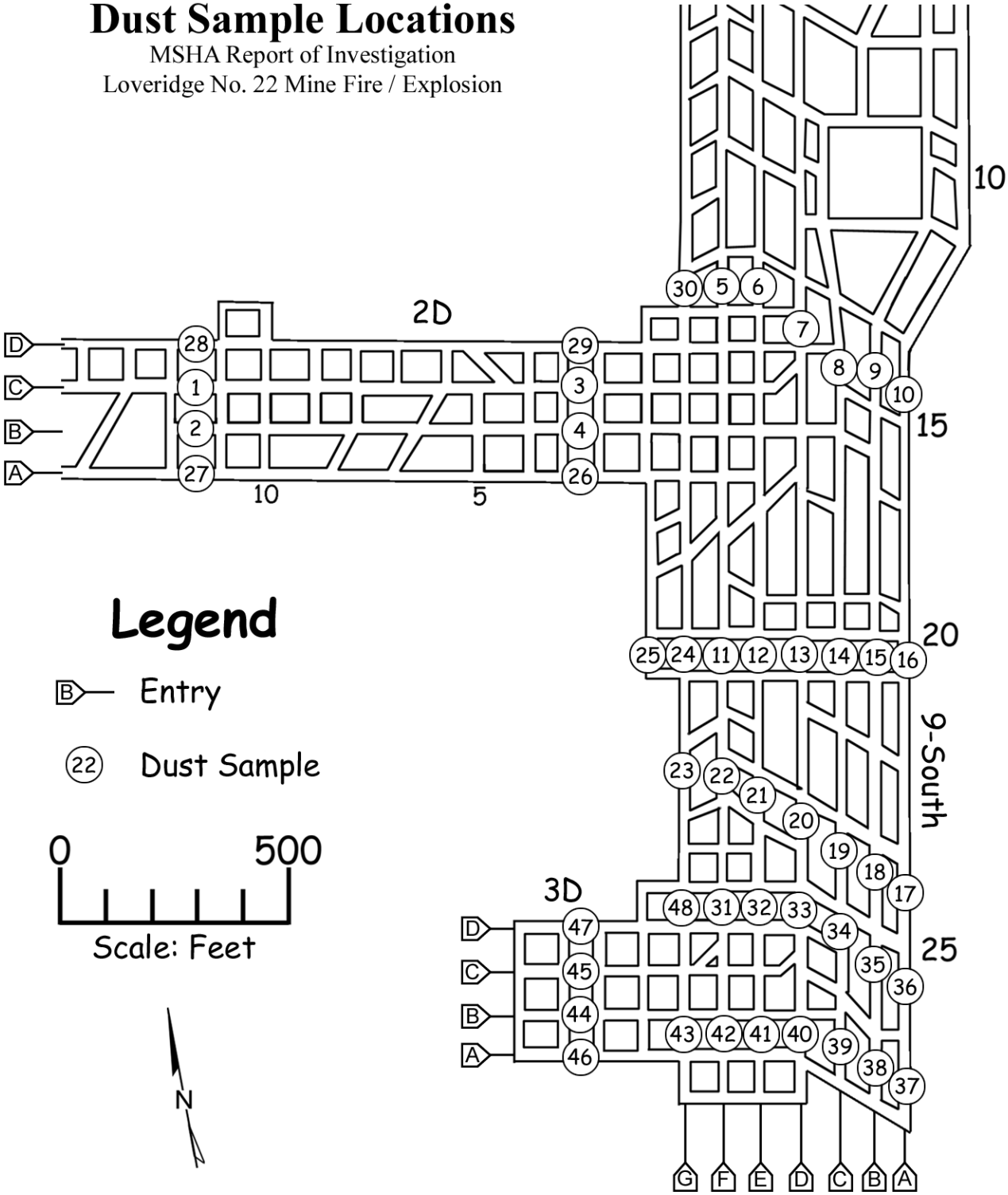
APPENDIX C – Dust Sample Analysis Results

Sample #	Location (refer to map on page 44)	Incombustible Content (%)	Coke Content	Sample Description	Date Collected
1	2D, C Entry, between crosscuts 11-12	Not Analyzed	X-Large	Band	01/08/2001
2	2D, B Entry, between crosscuts 11-12	Not Analyzed	X-Large	Band	01/08/2001
3	2D, C Entry, between crosscuts 2-3	Not Analyzed	X-Large	Band	01/08/2001
4	2D, B Entry, between crosscuts 2-3	Not Analyzed	X-Large	Band	01/08/2001
5	9-South, F Entry, between crosscuts 12-13	Not Analyzed	X-Large	Band	01/08/2001
6	9-South, E Entry, between crosscuts 12-13	Not Analyzed	Small	½ Floor & Left Rib	01/08/2001
7	9-South, D Entry, between crosscuts 13-14	Not Analyzed	Large	Floor & Ribs	01/08/2001
8	9-South, C Entry, between crosscuts 14-15	Not Analyzed	X-Large	Band	01/08/2001
9	9-South, B Entry, between crosscuts 14-15	Not Analyzed	X-Large	Band	01/08/2001
10	9-South, A Entry, between crosscuts 14-15	Not Analyzed	X-Large	Band	01/08/2001
11	9-South, F Entry, between crosscuts 20-21	Not Analyzed	Large	¾ Floor & Left Rib	01/08/2001
12	9-South, E Entry, between crosscuts 20-21	Not Analyzed	X-Large	Floor & Ribs	01/08/2001
13	9-South, D Entry, between crosscuts 20-21	Not Analyzed	X-Large	Band	01/08/2001
14	9-South, C Entry, between crosscuts 20-21	Not Analyzed	X-Large	Band	01/08/2001
15	9-South, B Entry, between crosscuts 20-21	Not Analyzed	X-Large	Band	01/08/2001
16	9-South, A Entry, between crosscuts 20-21	Not Analyzed	X-Large	Band	01/08/2001
17	9-South, A Entry, between crosscuts 23-24	Not Analyzed	X-Large	Band	01/09/2001
18	9-South, B Entry, between crosscuts 23-24	Not Analyzed	X-Large	Band	01/09/2001
19	9-South, C Entry, between crosscuts 23-24	Not Analyzed	X-Large	Band	01/09/2001
20	9-South, D Entry, between crosscuts 23-24	Not Analyzed	Small	Band	01/09/2001
21	9-South, E Entry, between crosscuts 23-24	Not Analyzed	Large	Floor & Ribs	01/09/2001
22	9-South, F Entry, between crosscuts 23-24	Not Analyzed	X-Large	Band	01/09/2001
23	9-South, G Entry, between crosscuts 22-23	Not Analyzed	X-Large	Band	01/09/2001
24	9-South, G Entry, between crosscuts 20-21	Not Analyzed	X-Large	Band	01/09/2001
25	9-South, H Entry, between crosscuts 20-21	Not Analyzed	X-Large	Band	01/09/2001
26	2D, A Entry, between crosscuts 2-3	Not Analyzed	Large	Band	01/09/2001
27	2D, A Entry, between crosscuts 11-12	Not Analyzed	Large	Band	01/09/2001
28	2D, D Entry, between crosscuts 11-12	Not Analyzed	X-Large	Band	01/09/2001
29	2D, D Entry, between crosscuts 2-3	Not Analyzed	Small	Floor	01/09/2001
30	9-South, G Entry, between crosscuts 12-13	Not Analyzed	Small	Band	01/09/2001
31	9-South, F Entry, between crosscuts 25-26	34.10	X-Large	Floor	01/23/2001
32	9-South, E Entry, between crosscuts 25-26	59.40	X-Large	Floor	01/23/2001
33	9-South, D Entry, between crosscuts 25-26	47.60	X-Large	Floor	01/23/2001
34	9-South, C Entry, between crosscuts 25-26	45.90	X-Large	Floor	01/23/2001
35	9-South, B Entry, between crosscuts 25-26	56.10	X-Large	Floor	01/23/2001
36	9-South, A Entry, between crosscuts 25-26	83.10	X-Large	Floor	01/23/2001
37	9-South, A Entry, between crosscuts 27-28	81.00	X-Large	Floor	01/23/2001
38	9-South, B Entry, between crosscuts 27-28	52.90	X-Large	Floor	01/23/2001
39	9-South, C Entry, between crosscuts 27-28	39.40	X-Large	Floor	01/23/2001
40	9-South, D Entry, between crosscuts 28-29	36.60	X-Large	Floor	01/23/2001
41	9-South, E Entry, between crosscuts 28-29	47.80	X-Large	Floor	01/23/2001
42	9-South, F Entry, between crosscuts 28-29	53.30	X-Large	Floor	01/23/2001
43	9-South, G Entry, between crosscuts 28-29	49.70	X-Large	Floor	01/23/2001
44	3D, B Entry, between crosscuts 2-3	20.20	X-Large	Floor	01/23/2001
45	3D, C Entry, between crosscuts 2-3	39.00	X-Large	Floor	01/23/2001
46	3D, A Entry, between crosscuts 2-3	53.60	X-Large	Floor	01/23/2001
47	3D, D Entry, between crosscuts 2-3	40.60	X-Large	Floor	01/23/2001
48	9-South, G Entry, between crosscuts 25-26	37.70	X-Large	Floor	01/23/2001

APPENDIX C

Dust Sample Locations

MSHA Report of Investigation
Loveridge No. 22 Mine Fire / Explosion



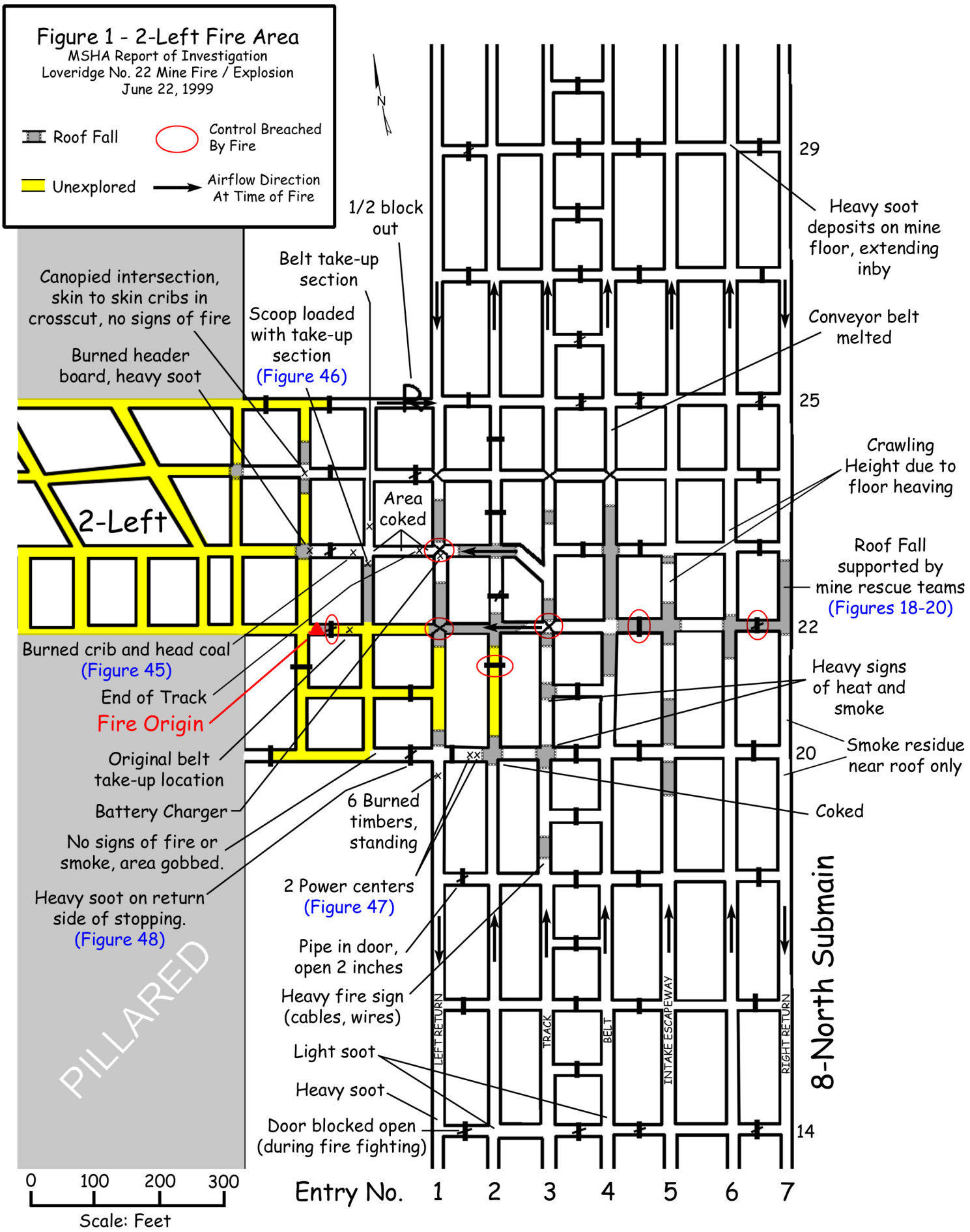
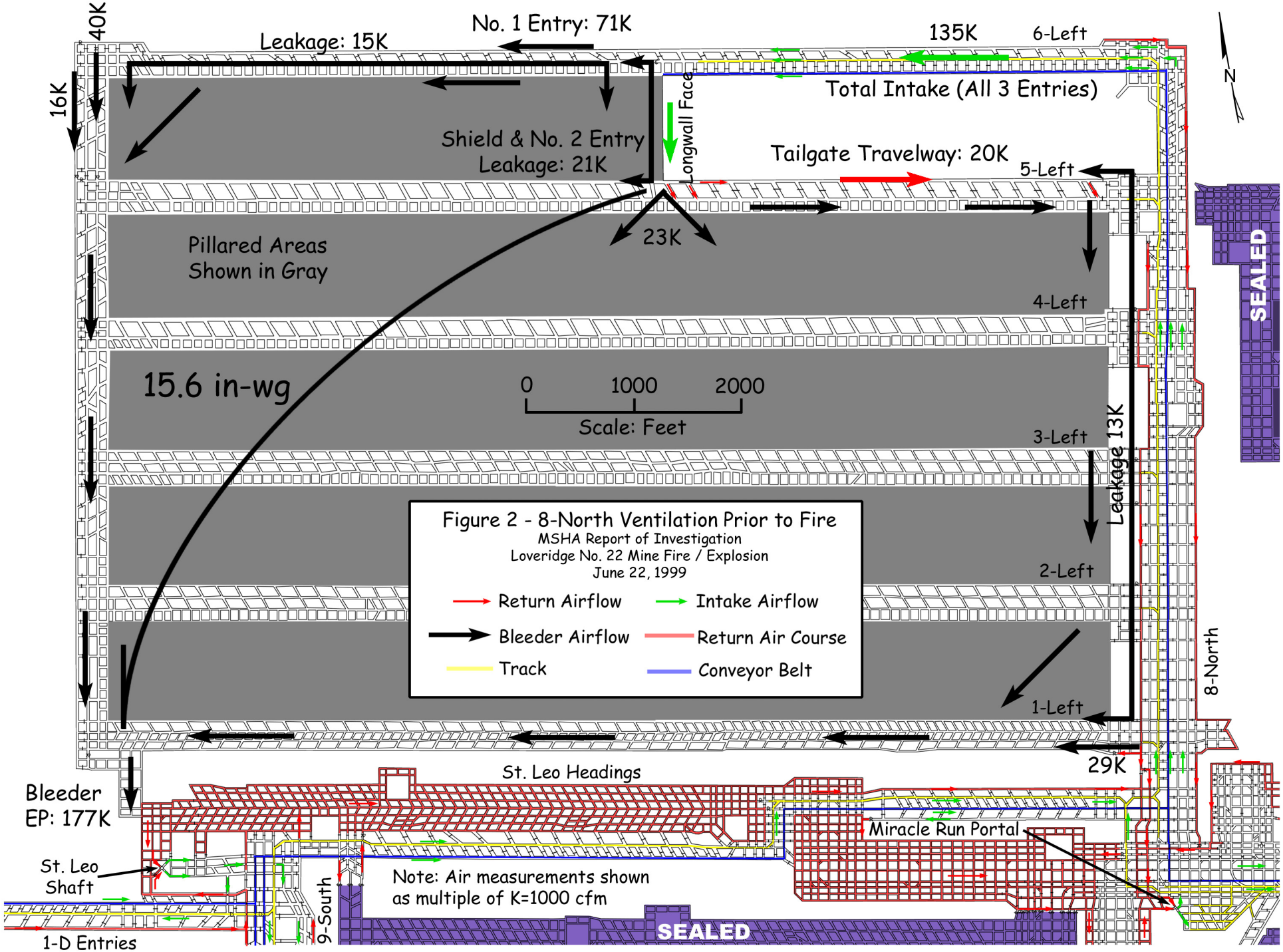


Figure 1 - 2-Left Fire Area
MSHA Report of Investigation
Loveridge No. 22 Mine Fire / Explosion
June 22, 1999
Roof Fall
Control Breached By Fire
Unexplored
Airflow Direction At Time of Fire
N
1/2 block out
Belt take-up section
Scoop loaded with take-up section (Figure 46)
Canopied intersection, skin to skin cribs in crosscut, no signs of fire
Burned header board, heavy soot
2-Left
Area coked
Burned crib and head coal (Figure 45)
End of Track
Fire Origin
Original belt take-up location
Battery Charger
No signs of fire or smoke, area gobbed.
Heavy soot on return side of stopping. (Figure 48)
PILLARED
6 Burned timbers, standing
2 Power centers (Figure 47)
Pipe in door, open 2 inches
Heavy fire sign (cables, wires)
Light soot
Heavy soot
Door blocked open (during fire fighting)
Heavy soot deposits on mine floor, extending inby
Conveyor belt melted
Crawling Height due to floor heaving
Roof Fall supported by mine rescue teams (Figures 18-20)
Heavy signs of heat and smoke
Smoke residue near roof only
Coked
29
25
22
20
14
LEFT RETURN
TRACK
BELT
INTAKE ESCAPEWAY
RIGHT RETURN
8-North Submain
Entry No. 1 2 3 4 5 6 7
0 100 200 300
Scale: Feet


40K
16K
Leakage: 15K
No. 1 Entry: 71K
135K
6-Left
Total Intake (All 3 Entries)
Longwall Face
Shield & No. 2 Entry
Leakage: 21K
Tailgate Travelway: 20K
5-Left
23K
Pillared Areas
Shown in Gray
4-Left
15.6 in-wg
0
1000
2000
Scale: Feet
3-Left
Leakage 13K
2-Left
1-Left
29K
SEALED
8-North
Figure 2 - 8-North Ventilation Prior to Fire
MSHA Report of Investigation
Loveridge No. 22 Mine Fire / Explosion
June 22, 1999
Return Airflow
Intake Airflow
Bleeder Airflow
Return Air Course
Track
Conveyor Belt
St. Leo Headings
Bleeder
EP: 177K
Miracle Run Portal
St. Leo
Shaft
Note: Air measurements shown
as multiple of K=1000 cfm
9-South
SEALED
1-D Entries

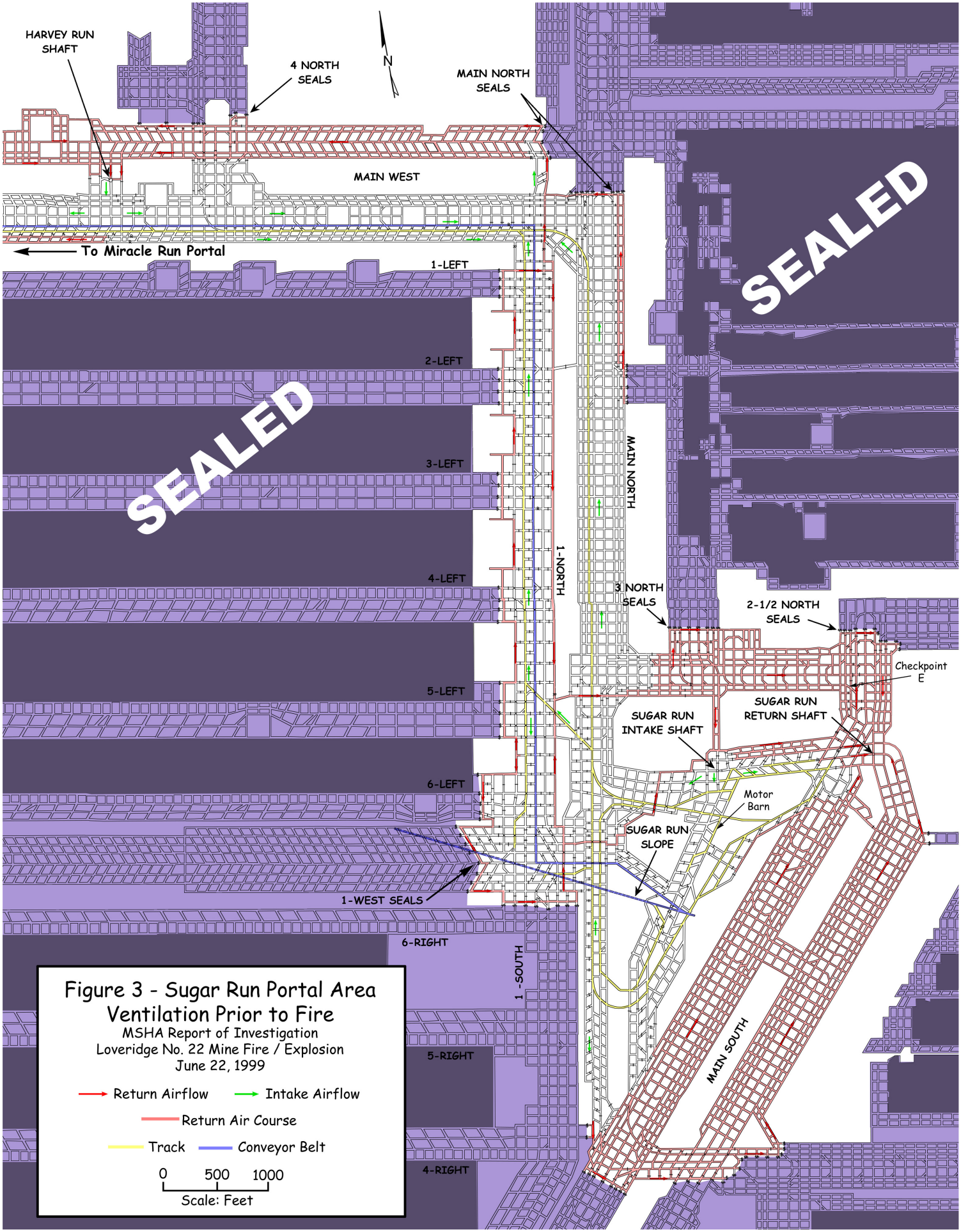


Figure 3 - Sugar Run Portal Area Ventilation Prior to Fire

MSHA Report of Investigation
Loveridge No. 22 Mine Fire / Explosion
June 22, 1999

Return Airflow
Intake Airflow
Return Air Course
Track
Conveyor Belt

0 500 1000
Scale: Feet

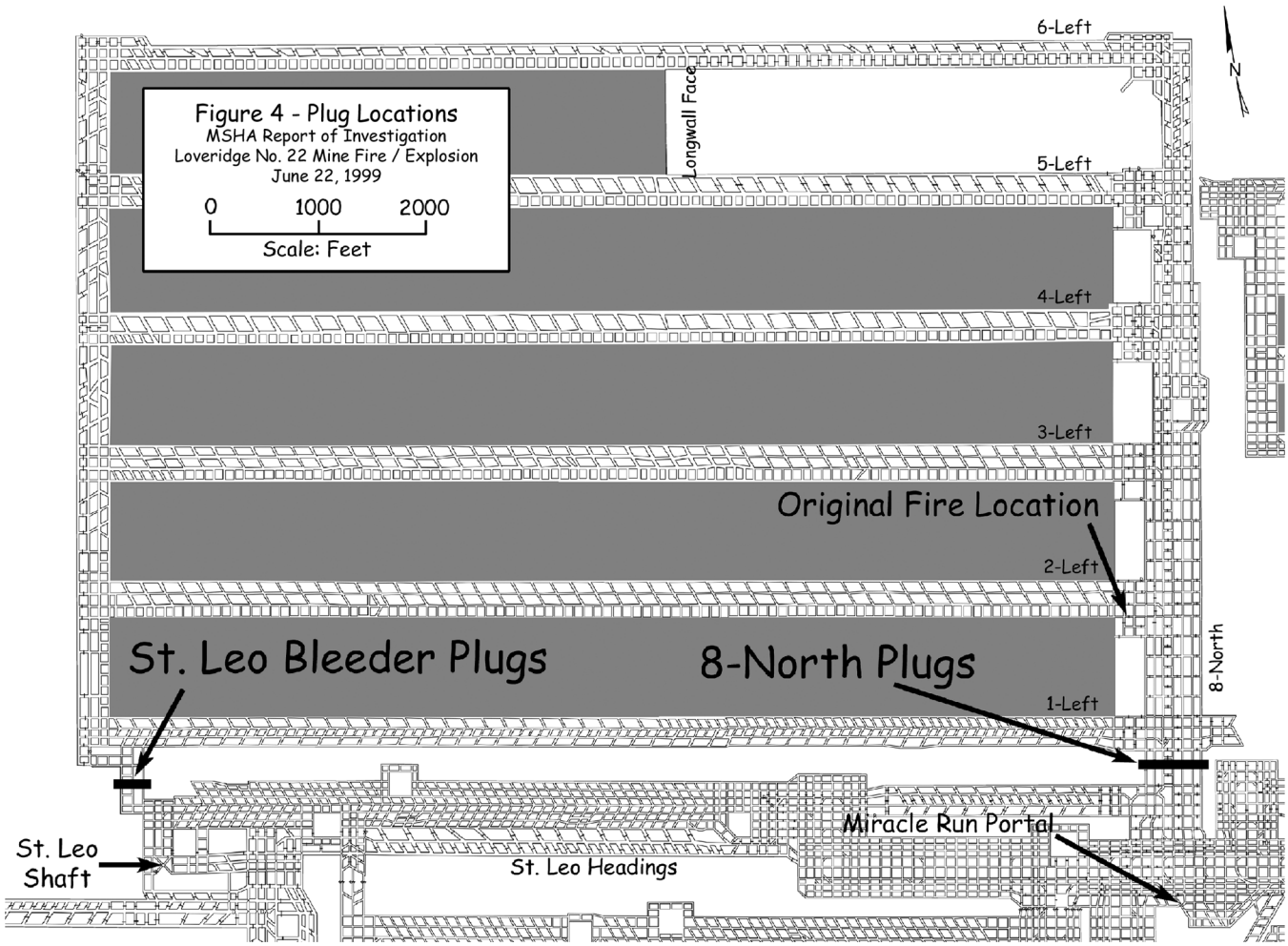


Figure 5 (bottom left): Mine rescue team members apply foam sealant to the St. Leo fan housing on June 22, 1999.

Figure 6 (bottom right): Damage to St. Leo fan and shaft after the explosion on June 26, 1999. The deflection of the top of the shaft partition is visible in this photograph.

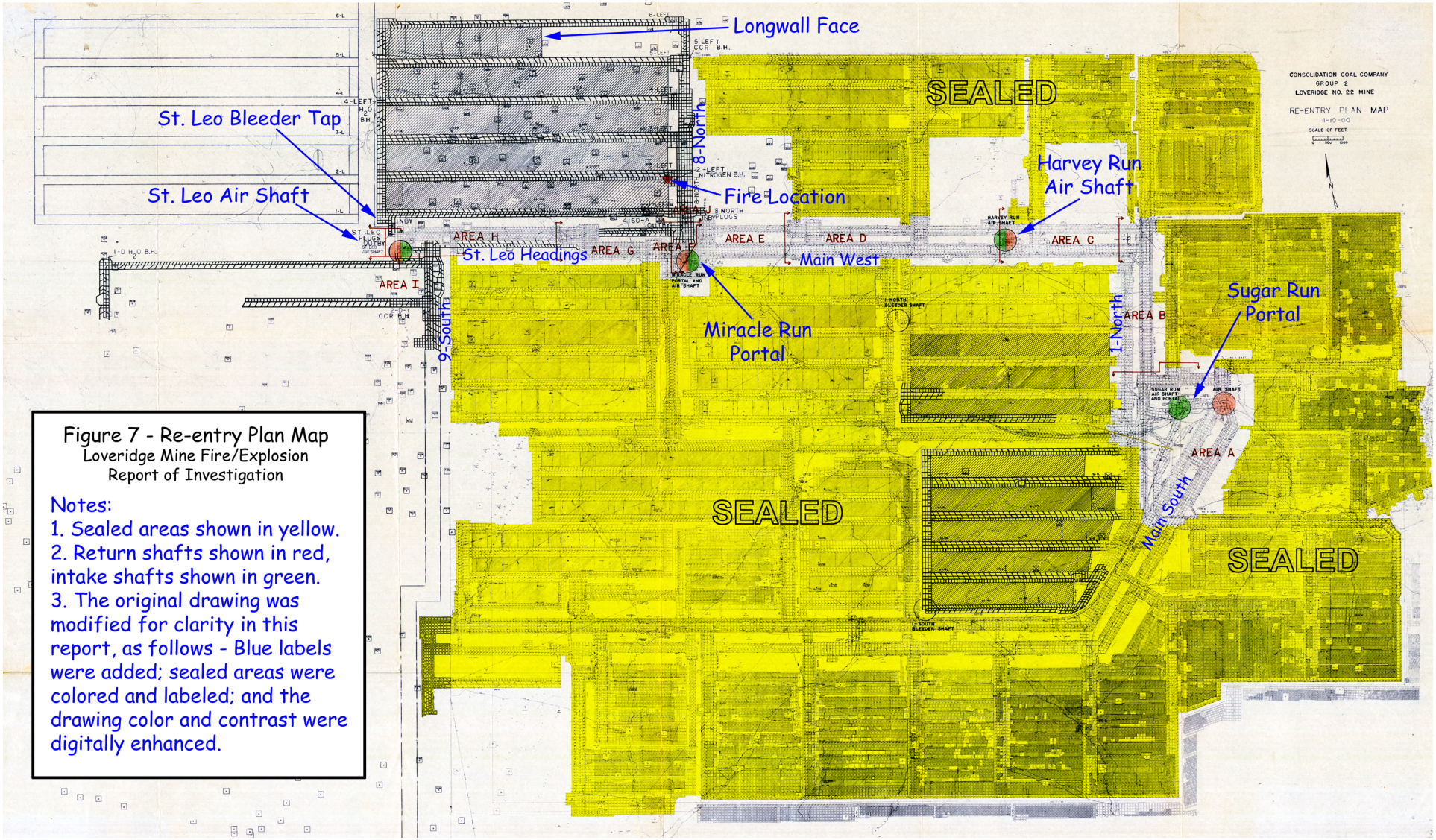


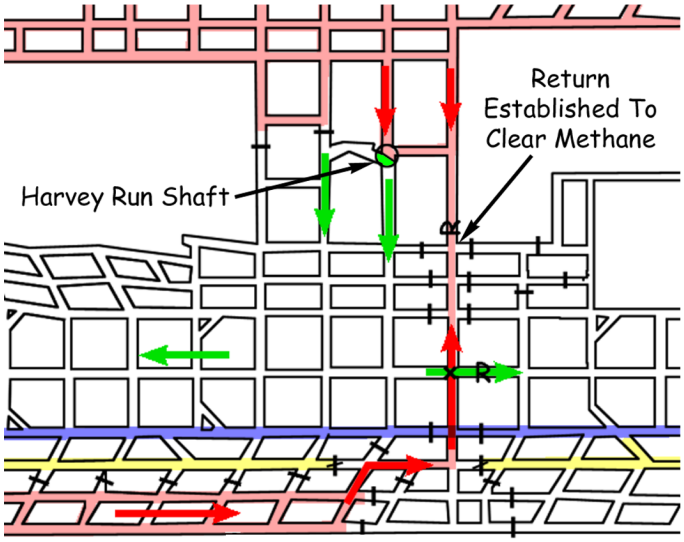
Figure 7 - Re-entry Plan Map
Loveridge Mine Fire/Explosion
Report of Investigation

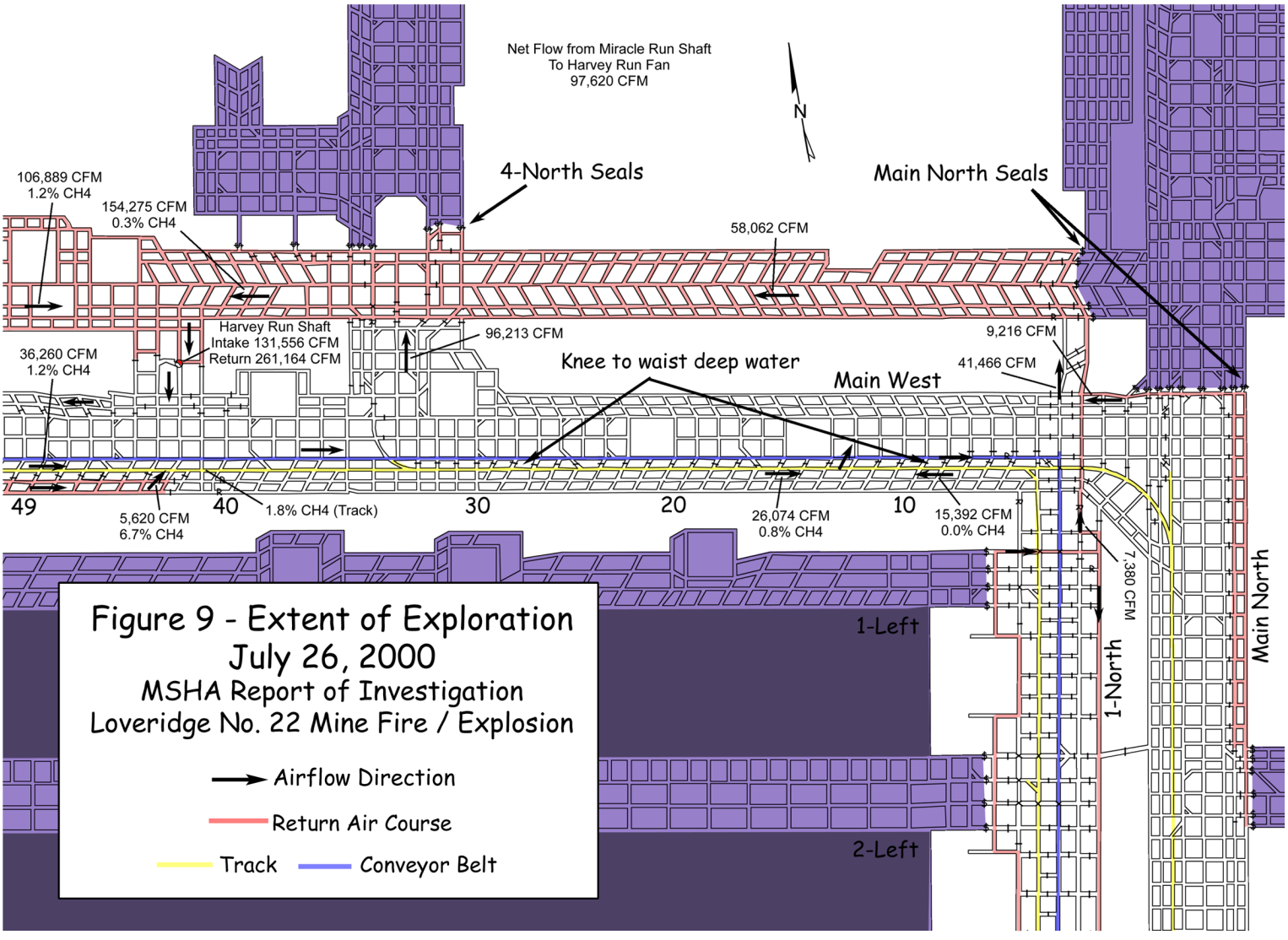
Notes:
1. Sealed areas shown in yellow.
2. Return shafts shown in red, intake shafts shown in green.
3. The original drawing was modified for clarity in this report, as follows - Blue labels were added; sealed areas were colored and labeled; and the drawing color and contrast were digitally enhanced.

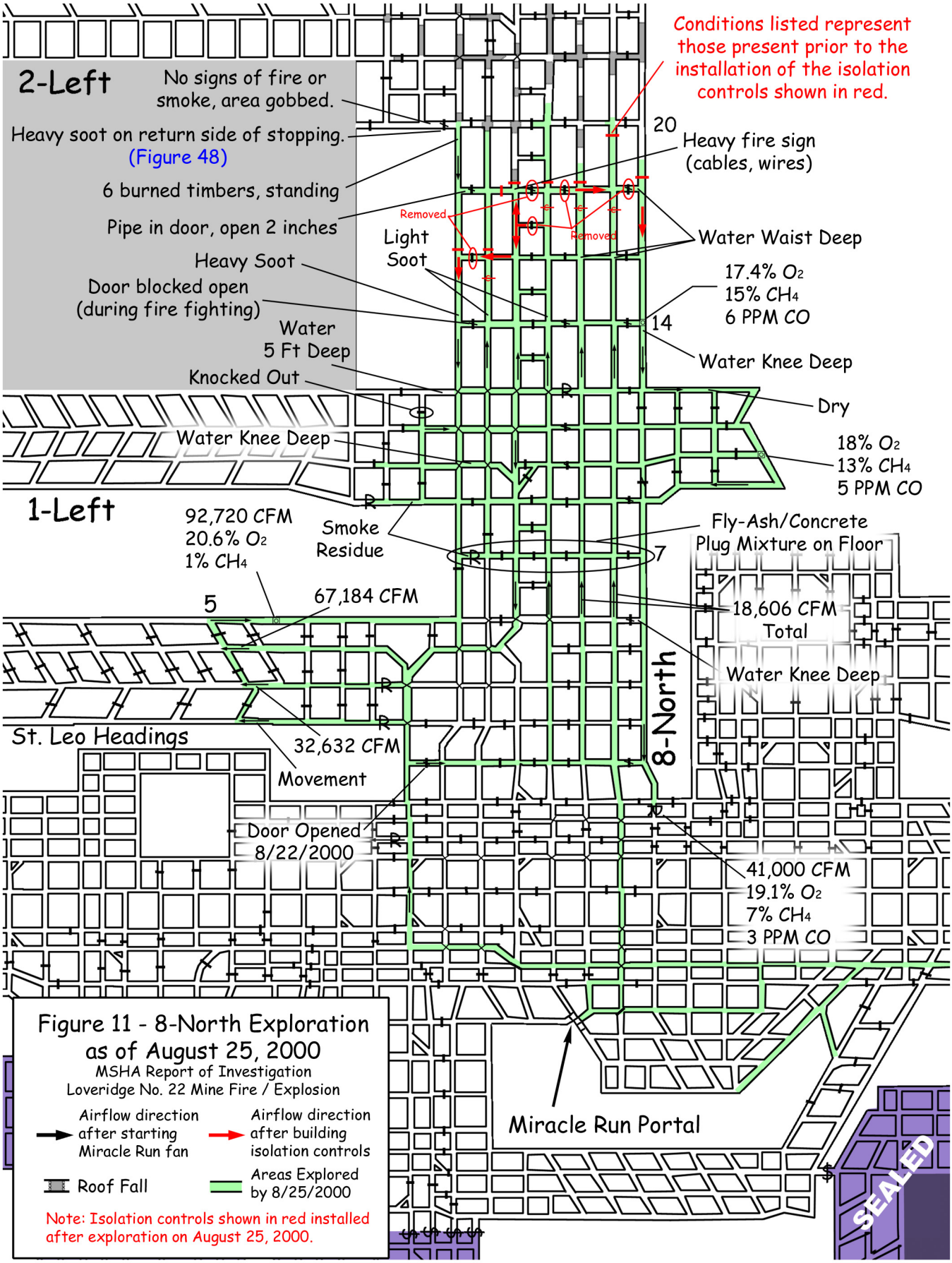
Figure 8 (top left): Flooded elevator shaft bottom at the Sugar Run Portal.

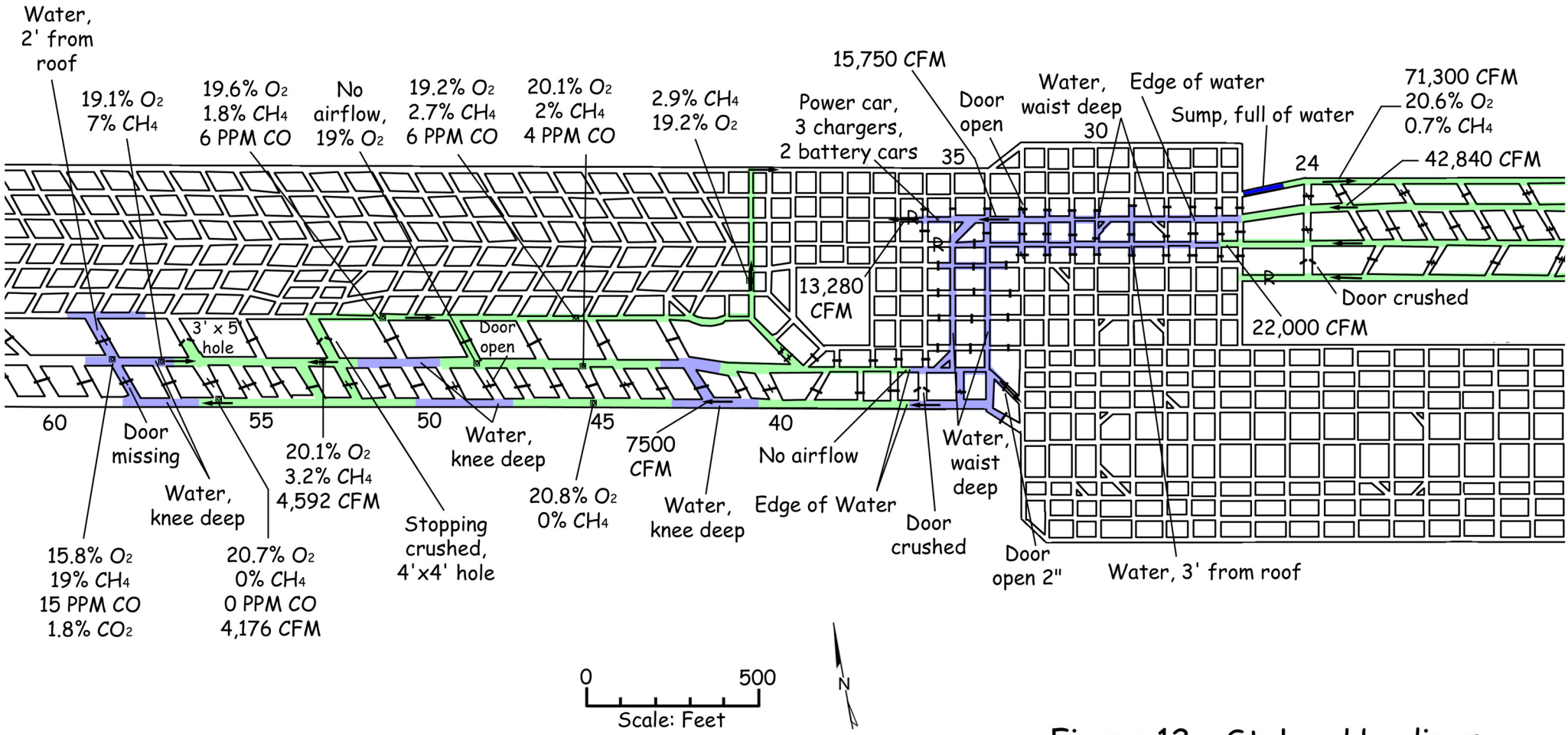
Figure 9: (bottom): Main West conditions during the initial examinations.

Figure 10 (top right): August 8, 2000, air change to clear methane from the south side of Main West.






Conditions listed represent those present prior to the installation of the isolation controls shown in red.
2-Left
No signs of fire or smoke, area gobbed.
Heavy soot on return side of stopping. (Figure 48)
6 burned timbers, standing
Pipe in door, open 2 inches
Heavy Soot
Door blocked open (during fire fighting)
Water 5 Ft Deep
Knocked Out
Water Knee Deep
1-Left
92,720 CFM
20.6% O2
1% CH4
5
67,184 CFM
St. Leo Headings
32,632 CFM
Movement
Door Opened 8/22/2000
Smoke Residue
20
Heavy fire sign (cables, wires)
Removed
Light Soot
Removed
Water Waist Deep
17.4% O2
15% CH4
6 PPM CO
14
Water Knee Deep
Dry
18% O2
13% CH4
5 PPM CO
Fly-Ash/Concrete Plug Mixture on Floor
7
18,606 CFM Total
Water Knee Deep
8-North
41,000 CFM
19.1% O2
7% CH4
3 PPM CO
Miracle Run Portal
SEALED
Figure 11 - 8-North Exploration as of August 25, 2000
MSHA Report of Investigation
Loveridge No. 22 Mine Fire / Explosion
Airflow direction after starting Miracle Run fan
Airflow direction after building isolation controls
Roof Fall
Areas Explored by 8/25/2000
Note: Isolation controls shown in red installed after exploration on August 25, 2000.



Note: Gas concentrations shown represent test results at time of initial exploration of each area. Ventilation was extended after exploring to Crosscut 52.

Areas Explored 8/30 - 9/1/2000
Flooded Areas, also explored
Airflow direction

Figure 12 - St. Leo Headings Exploration 8/30 - 9/1/2000

MSHA Report of Investigation
Loveridge No. 22 Mine Fire / Explosion

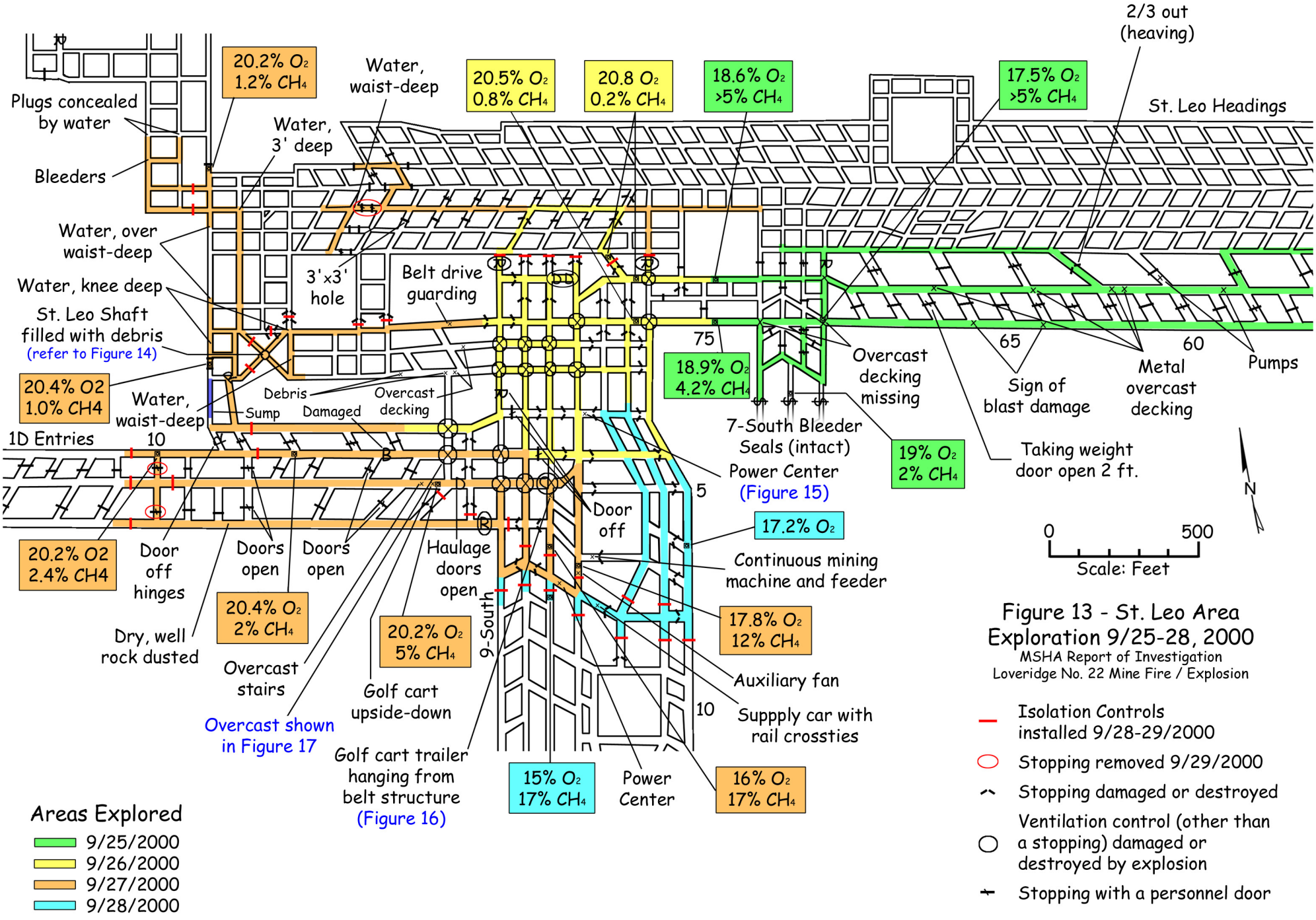


Figure 13 - St. Leo Area Exploration 9/25-28, 2000

MSHA Report of Investigation
Loveridge No. 22 Mine Fire / Explosion

Junction of 9-South & St. Leo Headings

Notes: Nonpermissible photographic equipment was not used in this area until more permanent isolation controls were installed. As a result, Figures 14-17 were taken after rock dust was applied during the recovery operations.

Refer to Figure 13 for the locations of images shown on this page.

Figure 14 (top): St. Leo Shaft bottom, showing concrete and steel rubble from the destroyed shaft partition. This material extended approximately 50 feet up into the shaft.

Figure 15 (center left): Power center in 9-South Crosscut 3. Note the concrete block from the adjacent stopping, which was blown into the power center by the explosive forces.

Figure 16 (center right): Trailer lifted off the floor and transported down the 9-South No. 3 entry during the explosion.

Figure 17 (bottom): Overcast in Crosscut 2 of the 1D entries. Debris was scattered in all directions from the belt entry on the lower side of the overcast.

8-North Roof Fall & 1D Seal

Figure 18 (top): A miner crawls across the top of the roof fall in the 8-North No.7 entry.

Figures 19 & 20 (center): Debris along the left side of the approach to the 8-North No. 7 entry roof fall illustrates the volume of material that was manually removed during the recovery efforts.

Location of Figures 18-20 shown on Figure 1.

Figure 21 (bottom): The 1D seals were equipped with steel access panels that were bolted in place. These panels permitted mine rescue teams to clear methane accumulations from immediately inby the seals upon resuming recovery of the 1D and 2D entries.

Refer to Figure 22 for the location of this seal.

Figure 22 - 9-South Exploration Map

MSHA Report of Investigation
Loveridge No. 22 Mine Fire / Explosion

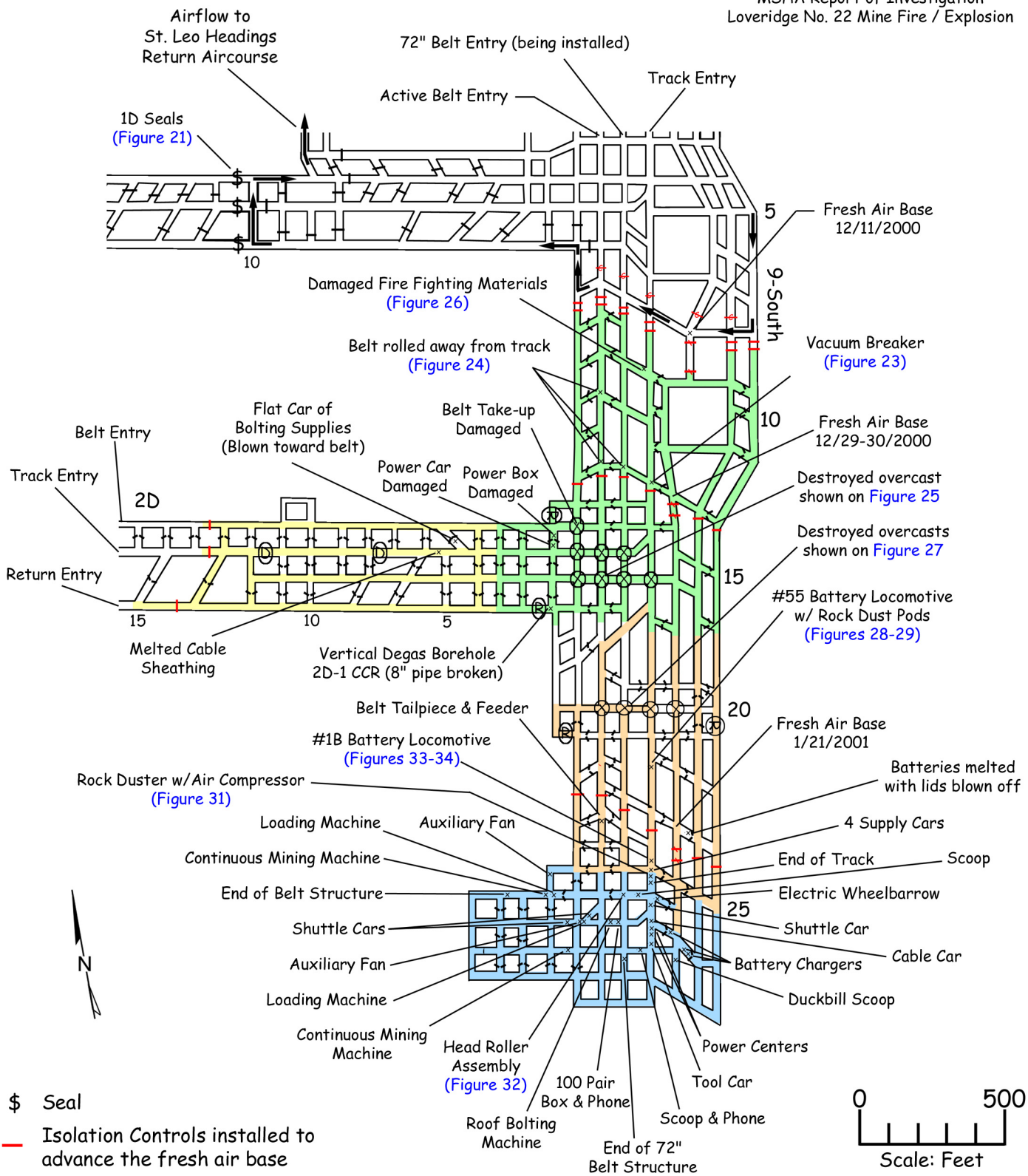


Figure 23 (top): This vacuum breaker box was thrown by explosive forces from the crosscut, on the right side of this picture, and deposited on the track where it was hit by additional forces from an inby direction (photo taken while facing outby in the track entry).

Figure 24 (center left): The smaller temporary belt was rolled away from the track entry (photo looking outby).

Figure 25 (center right): Damage to belt structure at an overcast.

Figure 26 (bottom left): Destroyed fire fighting station.

Figure 27 (bottom right): Investigation team surveys damage to ventilation controls.

Note: Refer to Figure 22 for locations of images shown on this page.

Figure 28 (top): A miner observes the rock dust pods located near Crosscut 21 in the 9-South track entry. The steel pod in the foreground was imploded, while that nearest the miner remained intact.

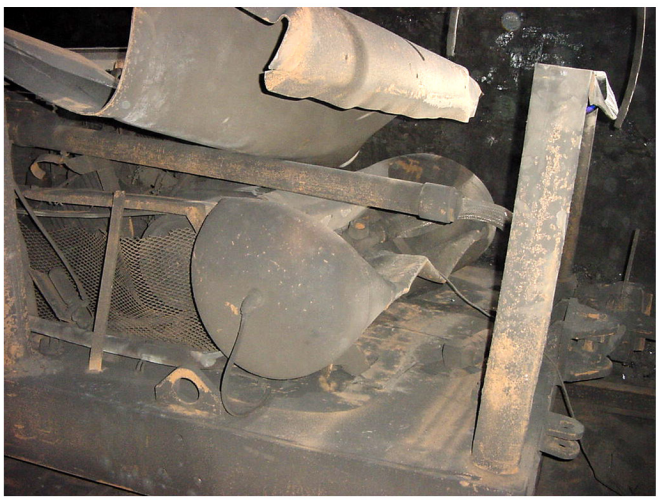


Figure 29 (center left): Outby end of Locomotive #55.

Figure 30 (center right): Inby end of Locomotive #55.

Figure 31 (bottom): Air compressor tank on a rock dusting machine, located at the end of the 9-South track entry.

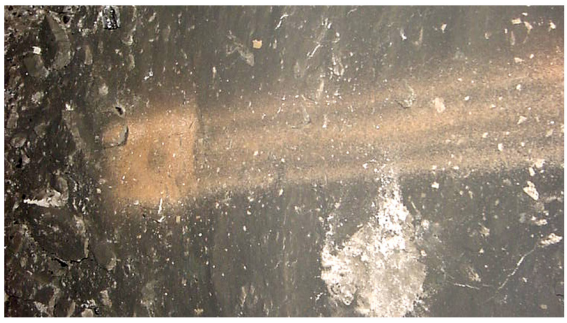
Note: Refer to Figure 22 for locations of images shown on this page.

Note: Refer to Figure 22 for locations of images shown on this page.

Figure 32 (top): Head roller assembly that was being installed at the junction of the 3D and 9-South belt entries. The roof elevation in the adjacent 9-South belt entry is visible in the lower right corner of this image.

Figure 33 (center left): Inby end of Locomotive #1B.

Figure 34 (center right): View across the top of Locomotive #1B.



Figures 35-36 (bottom): Rust particles deposited on the mine floor. These particles dropped 6-7 feet from rusting roof bolt channels, forming detailed images of the channels on the floor throughout 9-South. This indicated that there was no natural ventilation in the submain after the explosion.

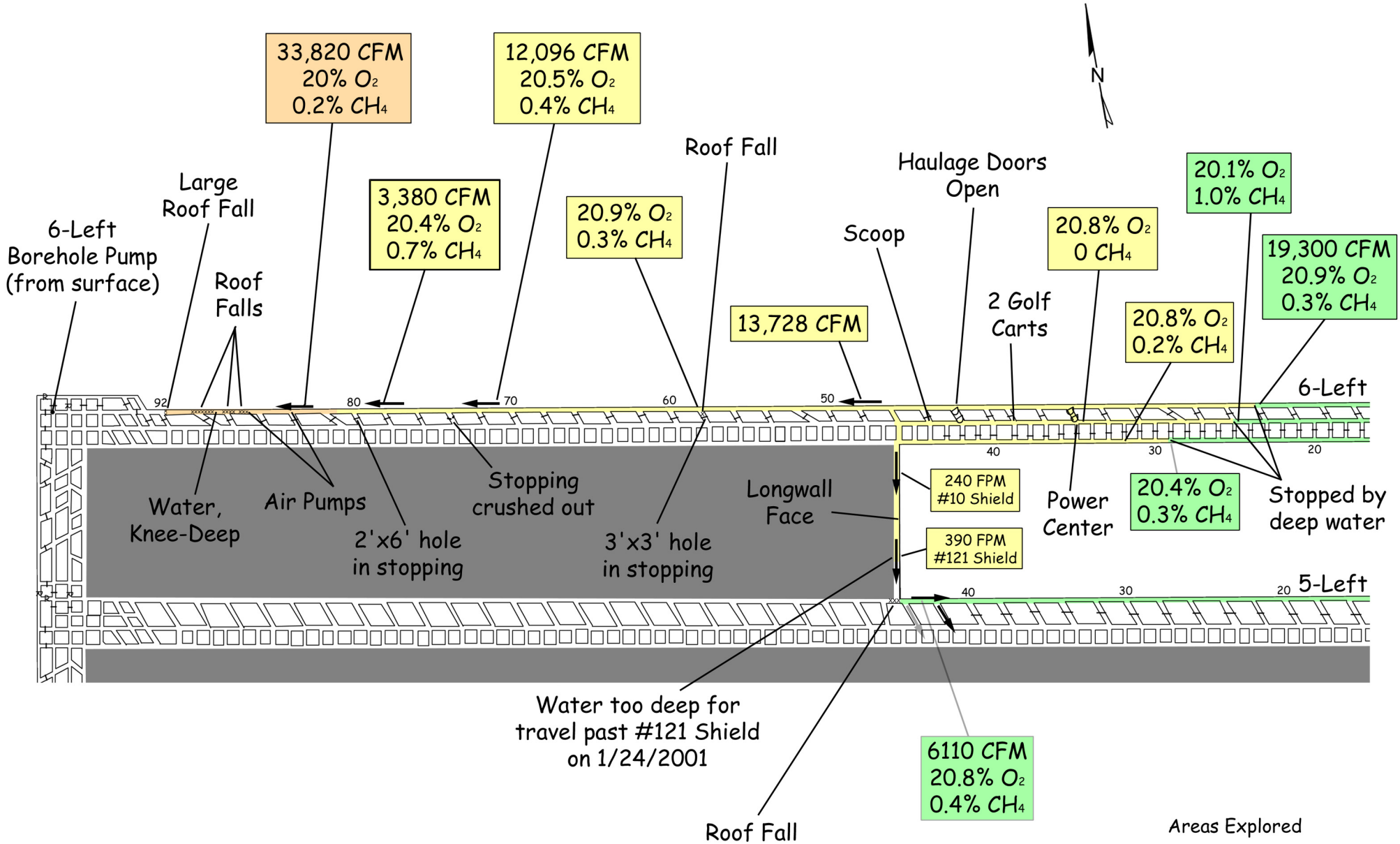


Figure 37 - 6-Left Exploration Map

MSHA Report of Investigation
Loveridge No. 22 Mine Fire / Explosion
June 22, 1999

Note: Air measurements represent values at time of initial exploration.

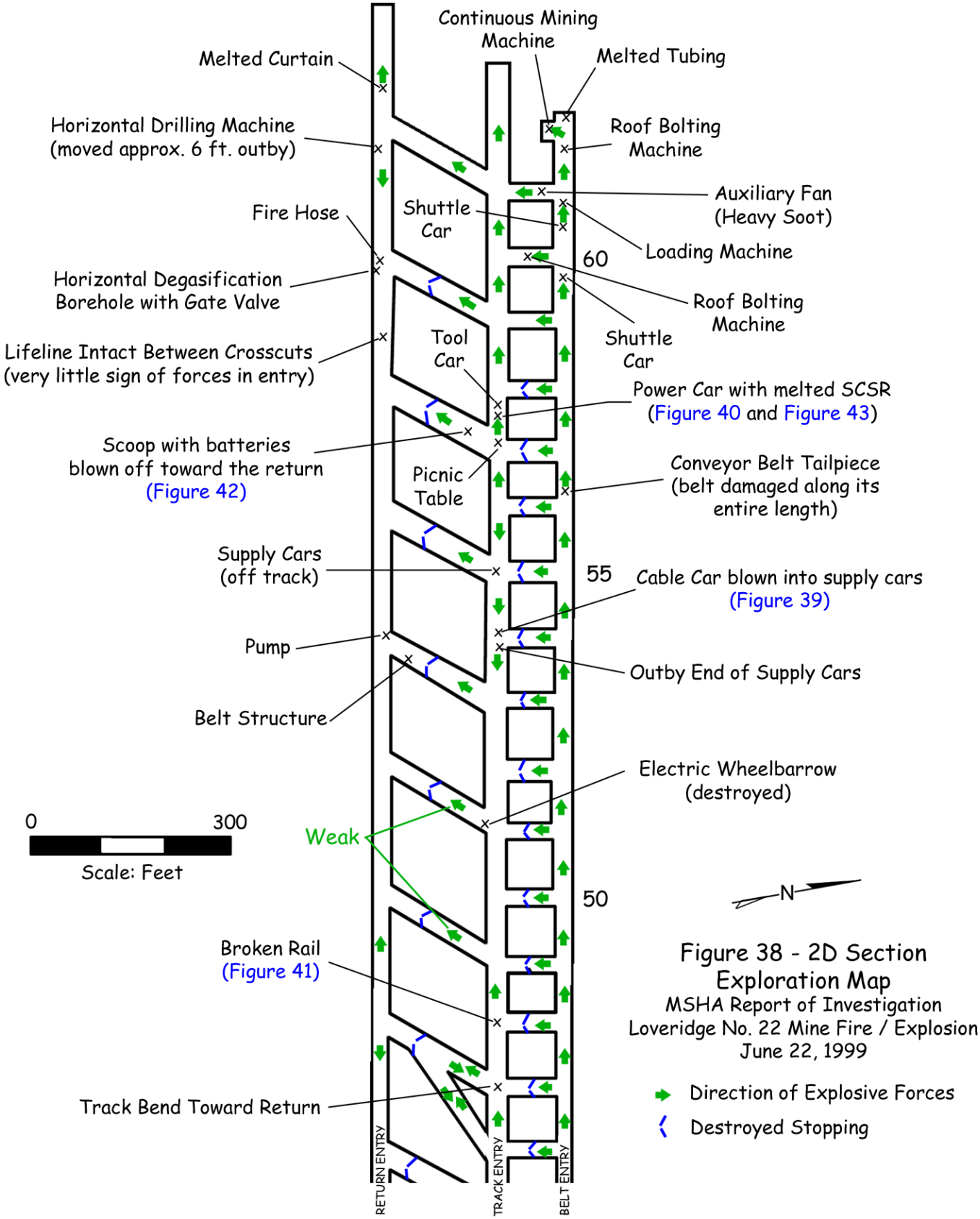


Figure 38 - 2D Section Exploration Map
MSHA Report of Investigation
Loveridge No. 22 Mine Fire / Explosion
June 22, 1999

Direction of Explosive Forces

Destroyed Stopping

2D Section Damage

(images taken after area was rock dusted)

Figure 39 (top): Cable car blown into supply cars by forces from the adjacent belt entry to the right.

Figure 40 (center left): Damaged power car near the end of the track.

Figure 41 (center right): The track was displaced and rail was broken by forces from the adjacent belt entry.

Figure 42 (bottom left): Batteries blown off of scoop.

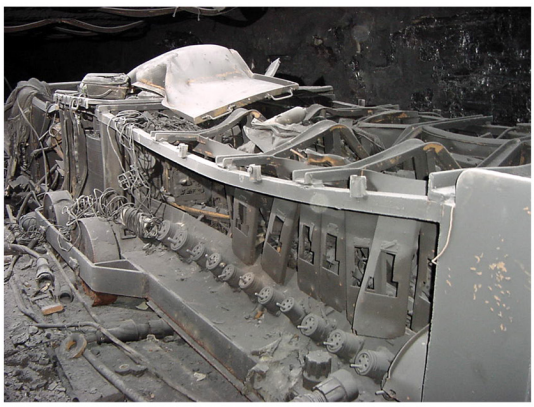


Figure 43 (bottom right): Damaged power car (same as Figure 40)

Note: Figure 38 shows image locations.

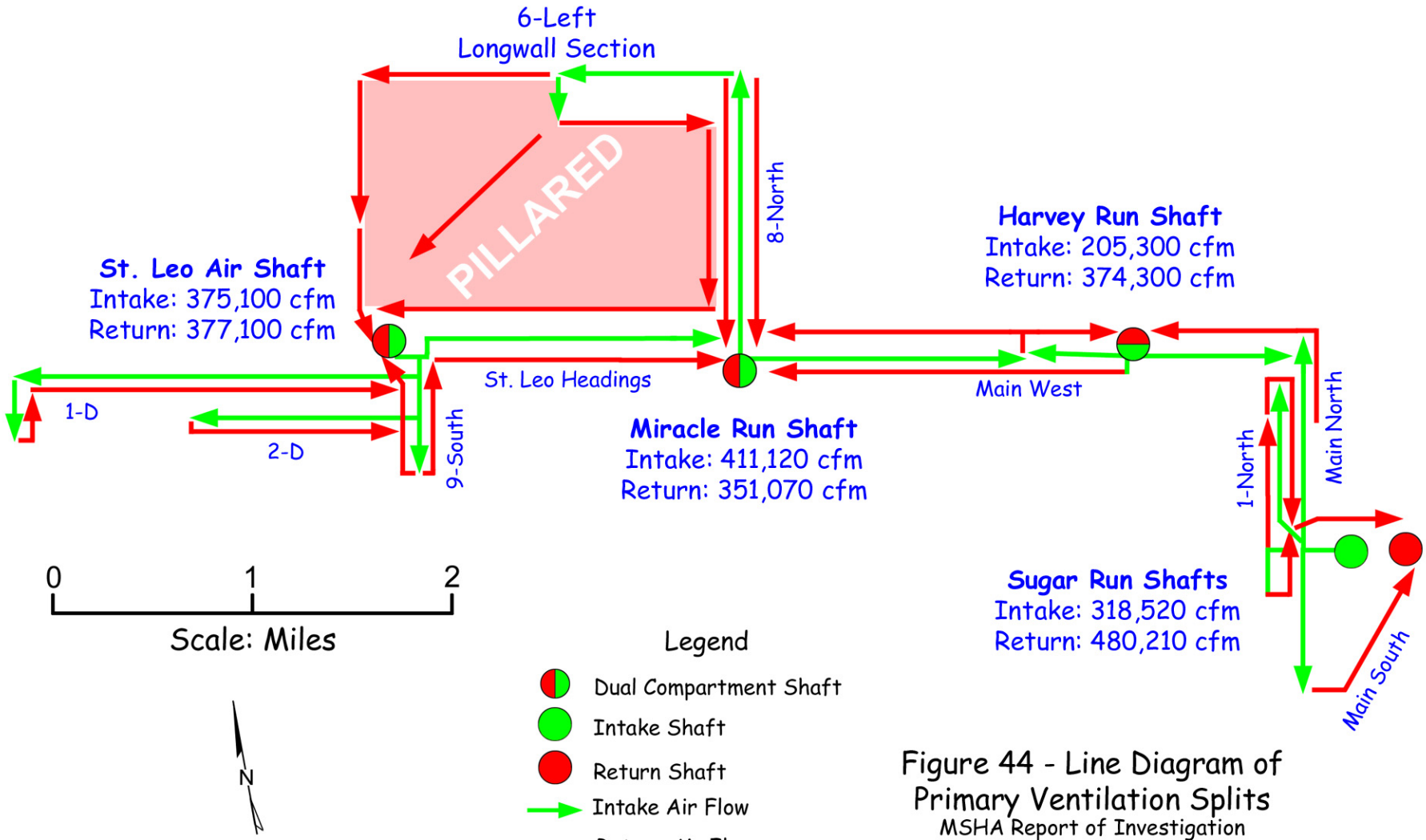


Figure 44 - Line Diagram of Primary Ventilation Splits
MSHA Report of Investigation
Loveridge No. 22 Mine Fire / Explosion
June 22, 1999

2-Left Fire Area

Figure 45 (top): Burned roof coal and cribbing adjacent to a roof fall near the fire origin.

Figure 46 (center): Roof fall covering a scoop that was loaded with the last section of the belt take-up following cutting operations.

Figure 47 (bottom left): Power centers located in the 8-North entries, just outby the fire origin.

Figure 48 (bottom right): Soot deposits a stopping in the return entry immediately downwind of the fire origin.

Note: Refer to Figure 1 for image locations.

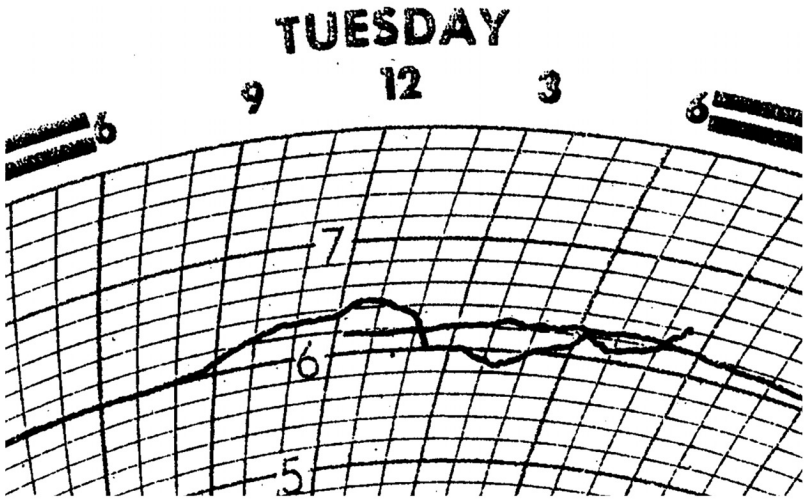


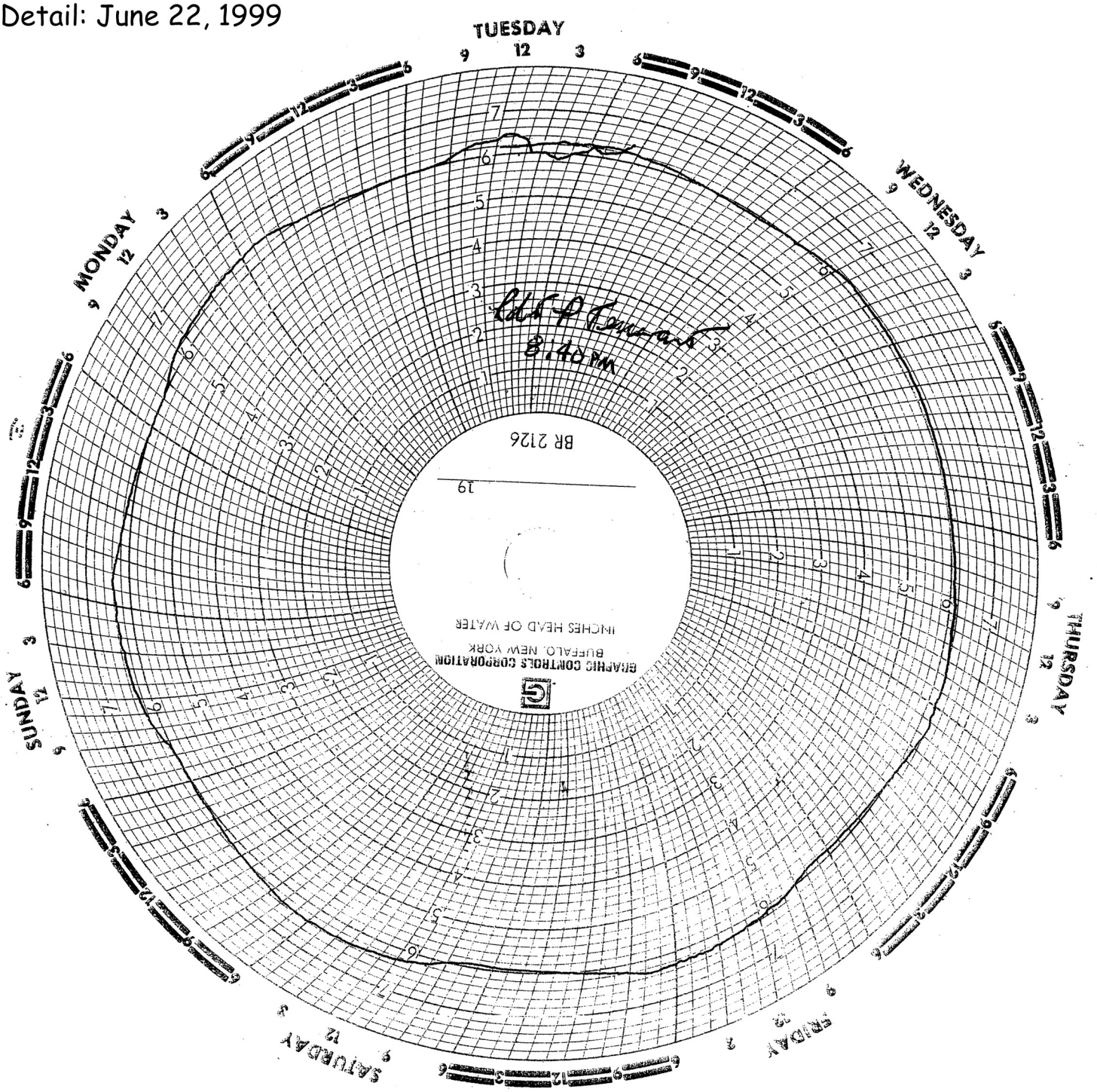
Figure 49 - Miracle Run Fan Pressure Recording Chart

MSHA Report of Investigation
Loveridge No. 22 Mine Fire / Explosion
June 22, 1999

Note: Fan chart recording period:

12:03 p.m., June 15, 1999
to
8:40 p.m., June 22, 1999

Detail: June 22, 1999



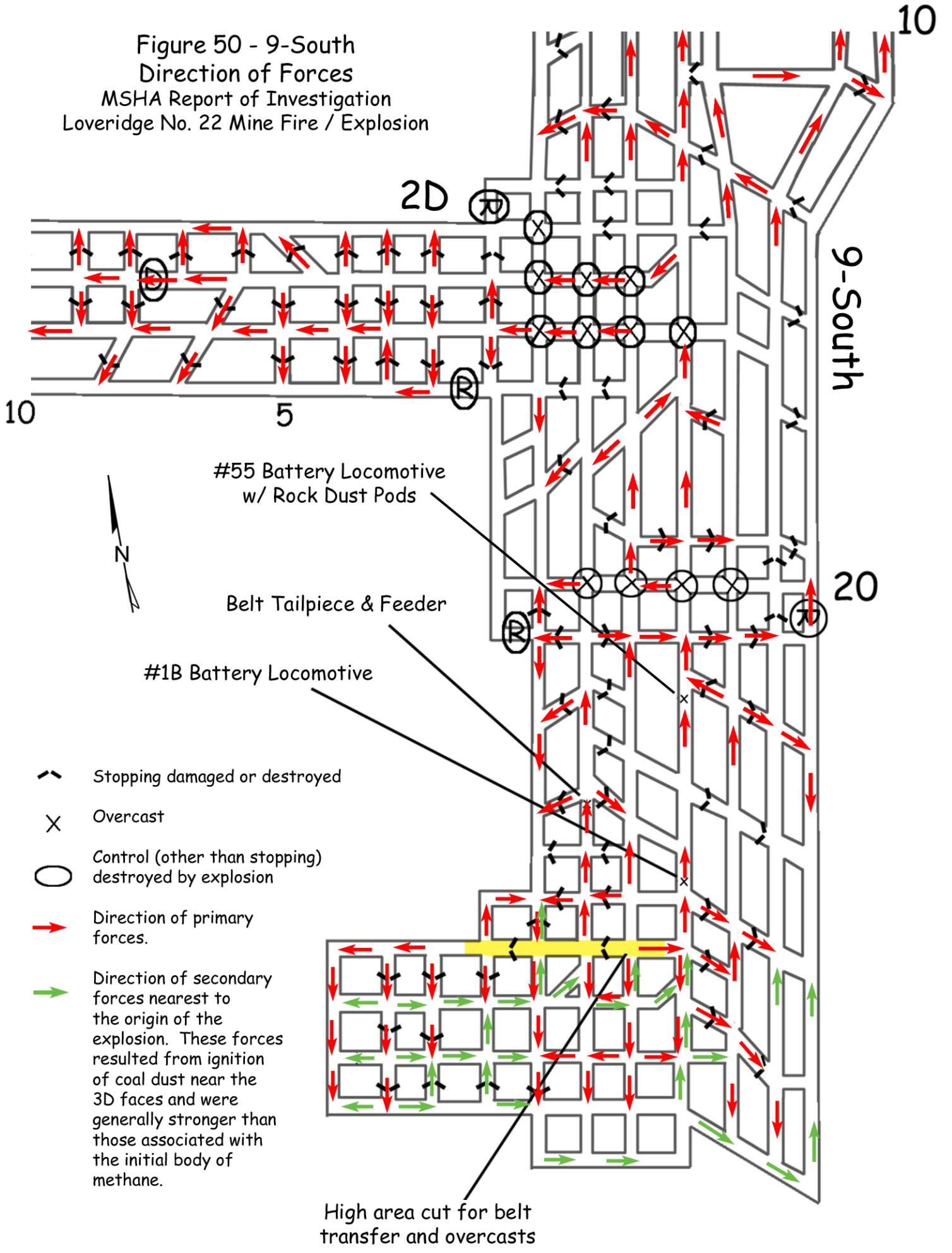


Figure 50 - 9-South
Direction of Forces
MSHA Report of Investigation
Loveridge No. 22 Mine Fire / Explosion
10
2D
9-South
10
5
20
#55 Battery Locomotive
w/ Rock Dust Pods
N
Belt Tailpiece & Feeder
#1B Battery Locomotive
Stopping damaged or destroyed
Overcast
Control (other than stopping)
destroyed by explosion
Direction of primary
forces.
Direction of secondary
forces nearest to
the origin of the
explosion. These forces
resulted from ignition
of coal dust near the
3D faces and were
generally stronger than
those associated with
the initial body of
methane.
High area cut for belt
transfer and overcasts

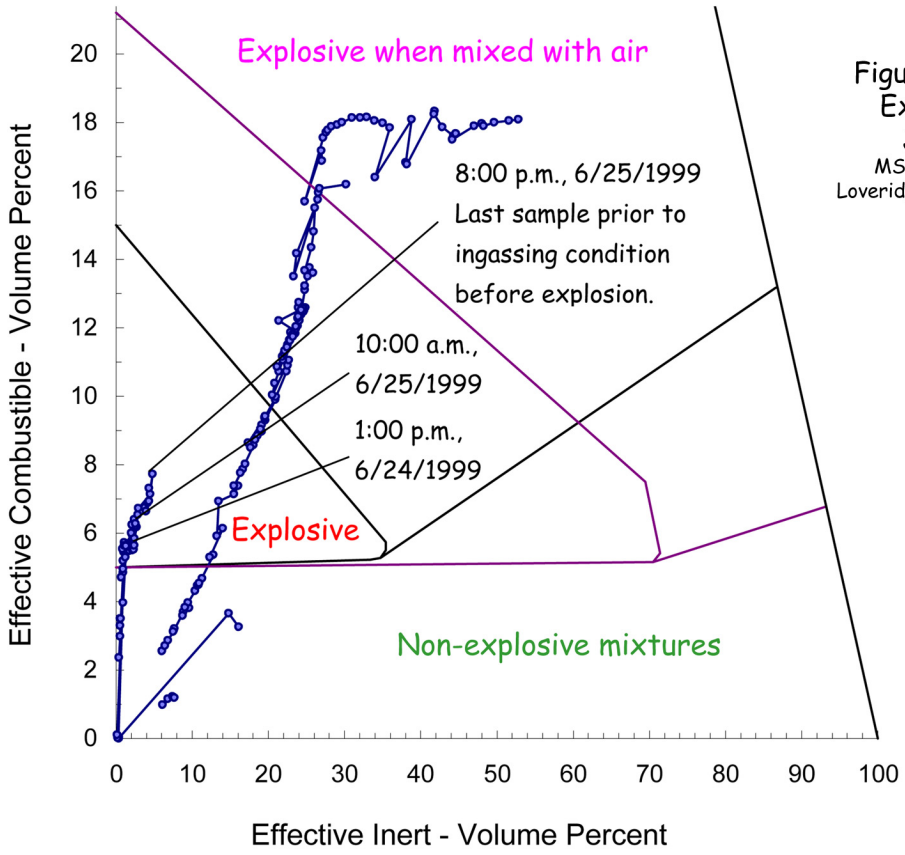


Figure 51 - St. Leo Shaft
Explosibility Diagram
June 22-26, 1999
MSHA Report of Investigation
Loveridge No. 22 Mine Fire / Explosion
June 22, 1999

R = 1.0
R = 0

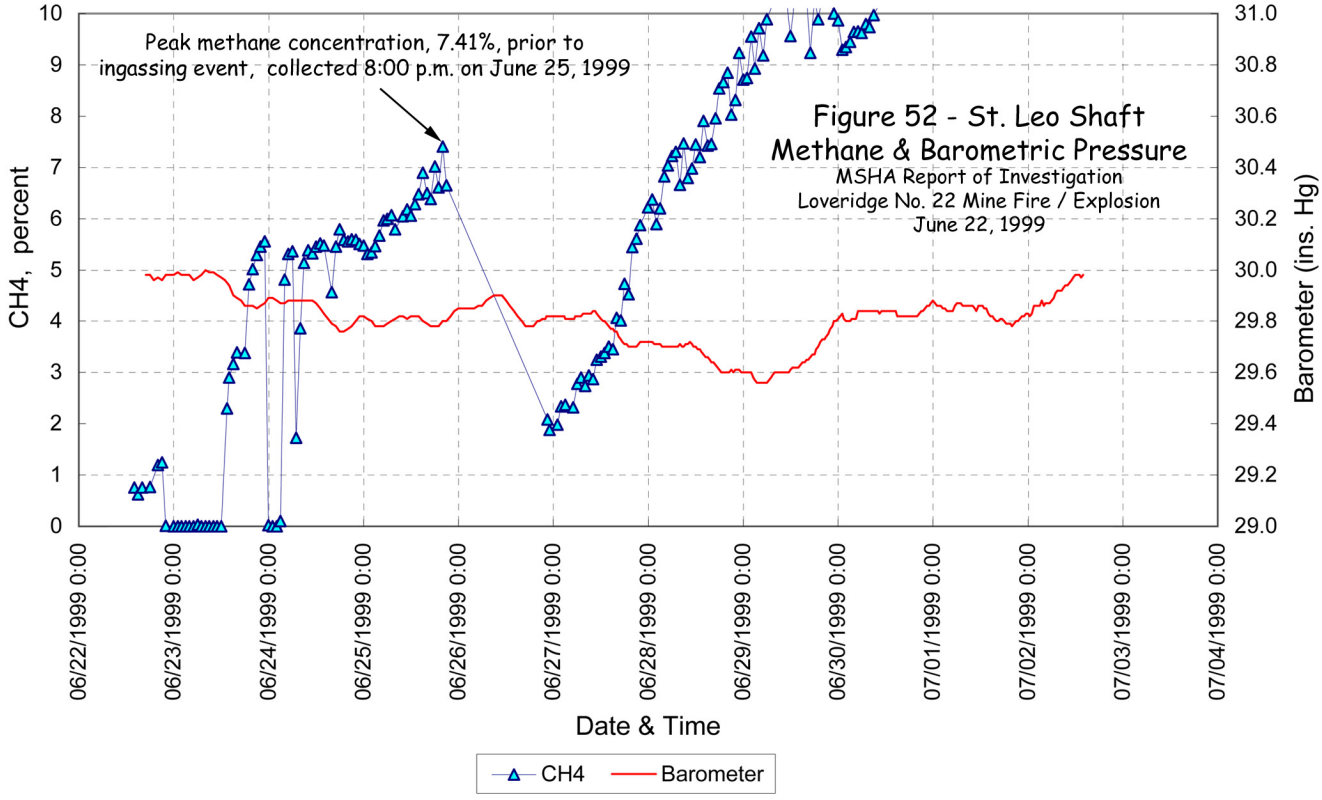


Figure 52 - St. Leo Shaft
Methane & Barometric Pressure
MSHA Report of Investigation
Loveridge No. 22 Mine Fire / Explosion
June 22, 1999

Figure 53
Electrical Schematic Diagram
Goodman Battery/Trolley Locomotive
23 Ton-201

Case 1
Trolley Pole: *Off*
Main Circuit Breaker (CB-M): *On*,
Control Circuit Breaker (CBD): *On*,
and Control Swicth(CSW): *On*

Energized Circuits

Nonenergized Circuits

Not to Scale

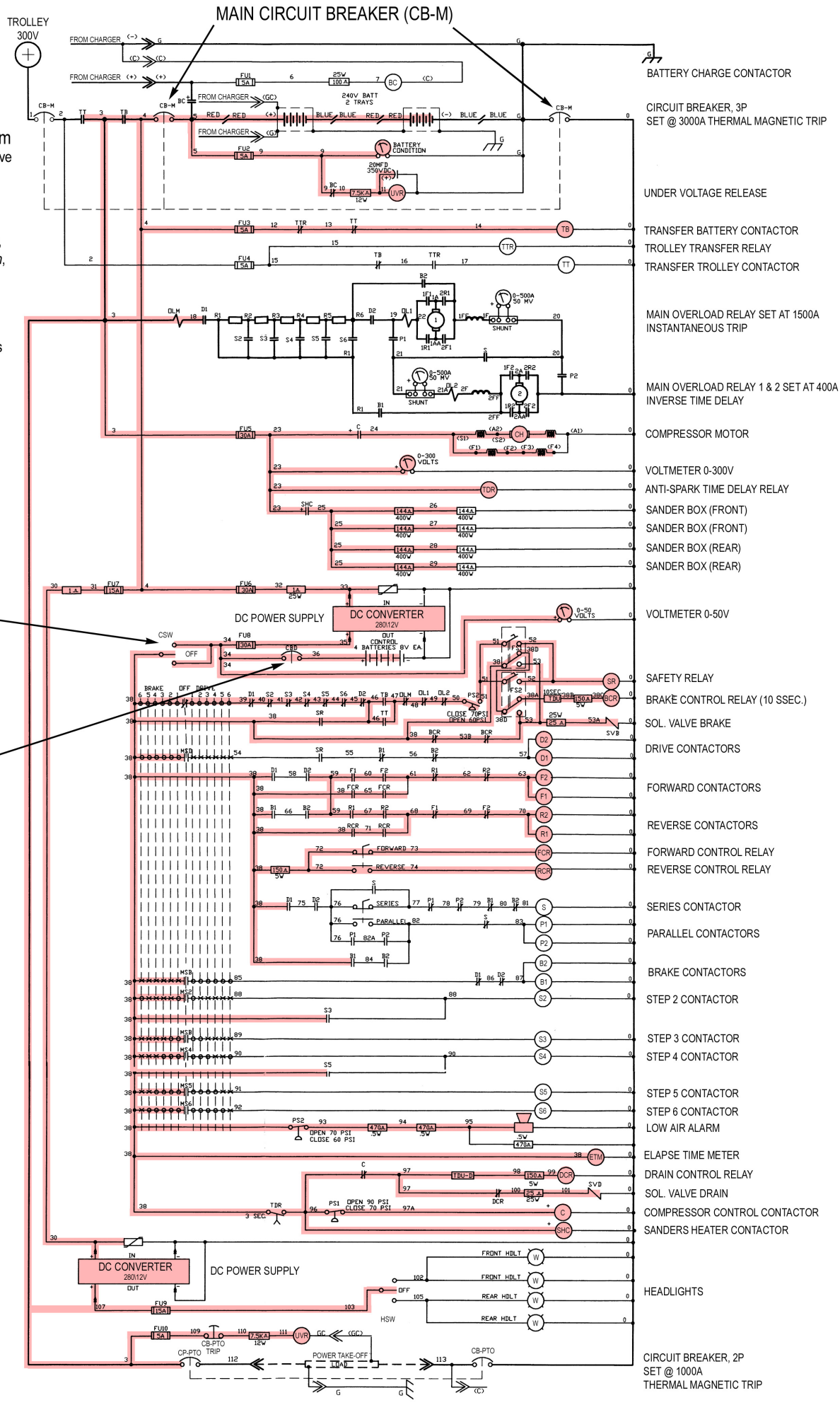
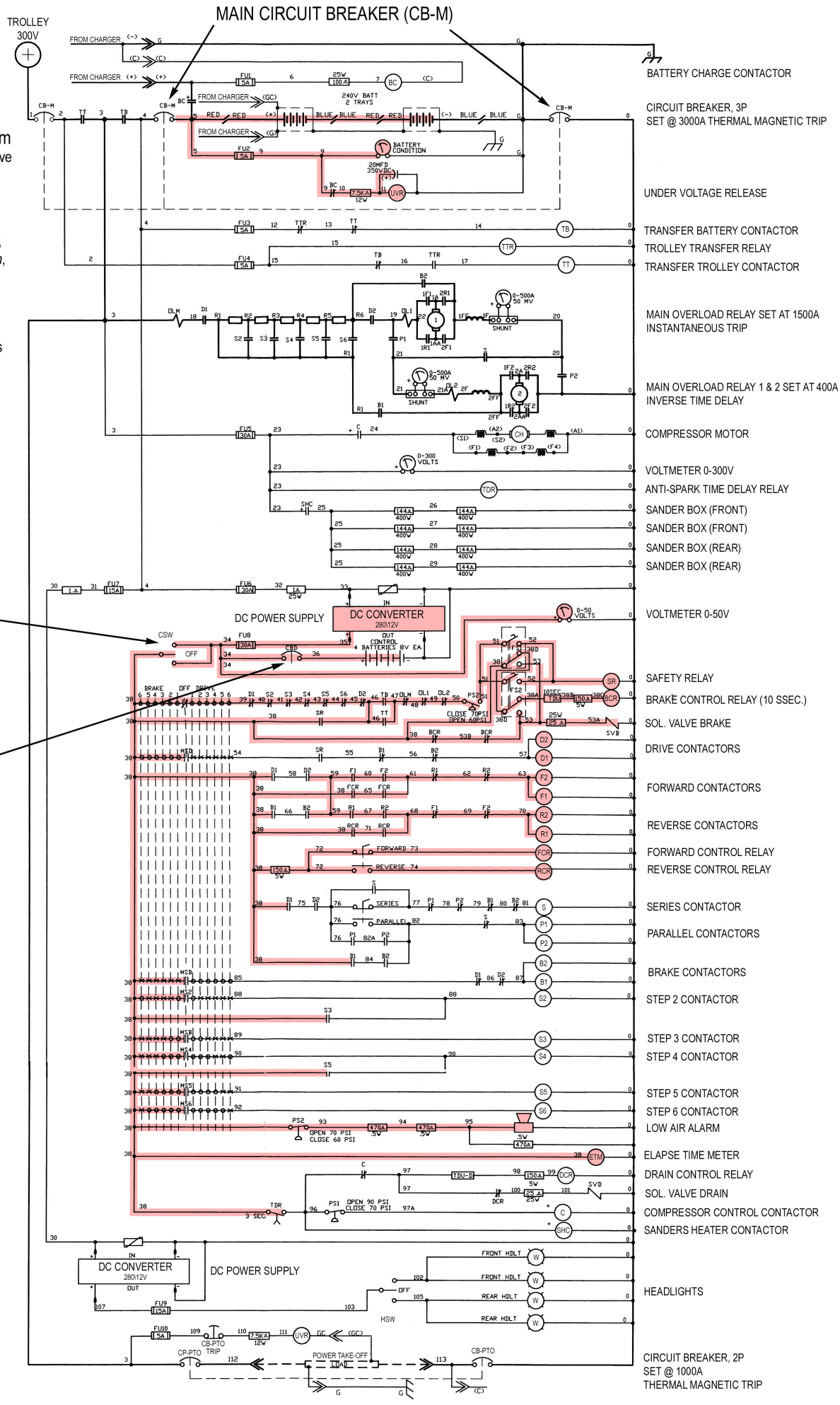


Figure 54
Electrical Schematic Diagram
Goodman Battery/Trolley Locomotive
23 Ton-201

Case 2
Trolley Pole: *Off*
Main Circuit Breaker (CB-M): *Off*,
Control Circuit Breaker (CBD): *On*,
and Control Swicth(CSW): *On*

Energized Circuits

Nonenergized Circuits

Not to Scale