DEEP MINE ABANDONMENT SEALING AND UNDERGROUND TREATMENT TO PRECLUDE ACID MINE DRAINAGE

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BethEnergy's Mine 105W is located in Barbour County, West Virginia, near Buckhannon. The mine was opened by drifts updip into the Pittsburgh Seam in 1971 and operated until June, 1982. Most of the water which enters Mine 105W percolates down from previously mined areas in the Redstone Seam, Mine 101, which generally lies 38 feet above the Pittsburgh Seam. The quality of this water is good as it enters Mine 105W. While operating, the Mine 105W water was segregated by pumping. The bulk of the water was collected in sumps near the main area of infiltration from the Redstone Seam and was pumped to Gnatty Creek Portal where, because of the quality, it was minimally treated and discharged. The remainder of the water flowed to the original West Portal where it was occasionally treated with lime.

When the mine was idled in 1982 and pumping not maintained, not only did the quantity of the water discharging by gravity from the West Portal area increase but also quality rapidly decreased. This problem was initially handled by initiating sodium hydroxide treatment, installing an aerator in the first of two ponds that existed and building two additional ponds to increase retention before discharging to the creek. Due to the increasing volume of water discharging at the West Portal and calculations of water being made by the mine (1000-1200 GPM) it was seen that upon permanent shutdown, the area surrounding

West Portal was insufficient to build a treatment facility capable of handling this volume. This lead to resumption of firebossing and pumping water from Mine 105W while an evaluation of the most cost effective solution to the problem could be developed.

After extensive investigation including discussions with the Surface Mine Drainage Task Force (joint West Virginia University, Department of Natural Resources and Industry) and the Bureau of Mines, it was decided to seal and flood the mine. It was theorized that by flooding the mine with alkaline water, the acid generation could be stopped, and that the exclusion of oxygen would prevent restart of the reaction. As an added precaution, apatite (phosphate) was rockdusted on the underground surfaces that would remain unflooded (the "Beach" area) to help tie up the iron that is necessary to the acid reaction.

In addition to the inadequate area to surface treat the water, the driving force to this solution was the cost of treatment vs. sealing. The annual cost to control water quality while idle was $480,000/year including manpower, pumping, power, and treatment costs. The present value of this annual payout on a 40 year projected treatment cost, was $4.7M (assuming a 10% discount rate). The total cost of sealing and flooding Mine 105W was $1.3M.

To date the purpose of controlling water quality with little or no treatment has been

achieved. Flooding of the mine began September 30, 1984, and by mid December, 1984, the 105W discharge pH had risen from 3.9 to 7.0 (Fig. 1) and has remained above 7.0. The iron decreased from 133 PPM to ± 1 PPM. Other indicators of acid generation have decreased, e.g., sulfates from 2,500 to 1,000 (Fig. 3), calcium from 385 to 120 (Fig. 4), alkalinity from nil to 350 (Fig. 5), and acidity from 470 to 20 (Fig. 6).

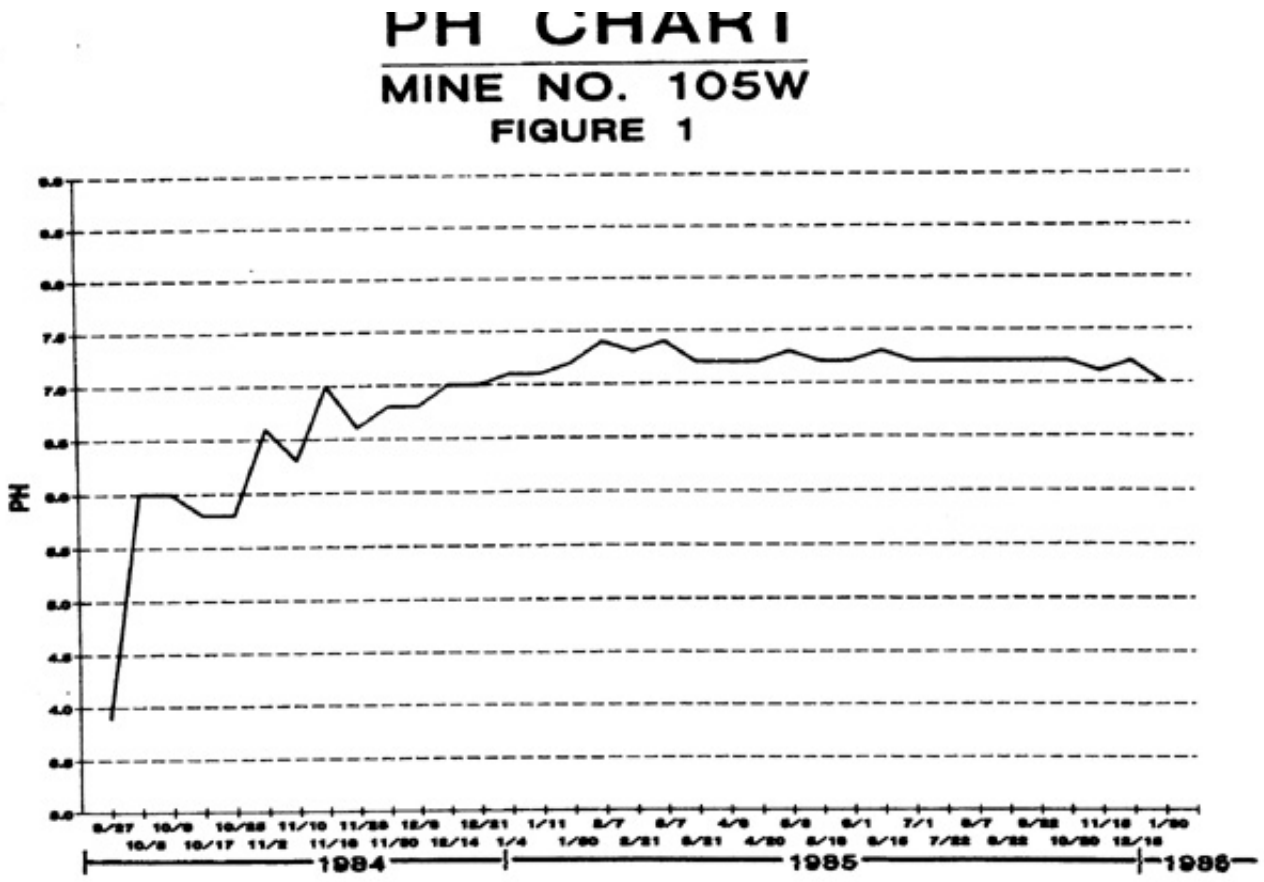


FIGURE 1

IRON CHART

MINE NO. 105W

FIGURE 2

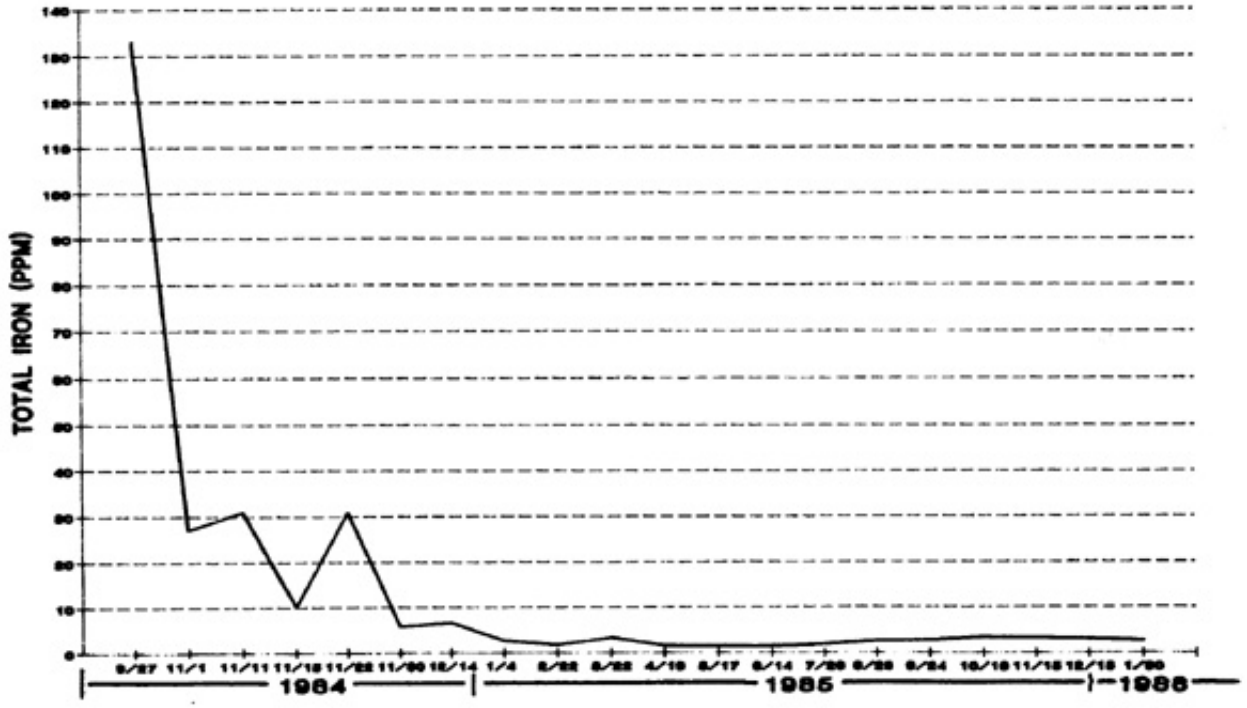


FIGURE 2

SULFATE CHART

MINE NO. 105W

FIGURE 3

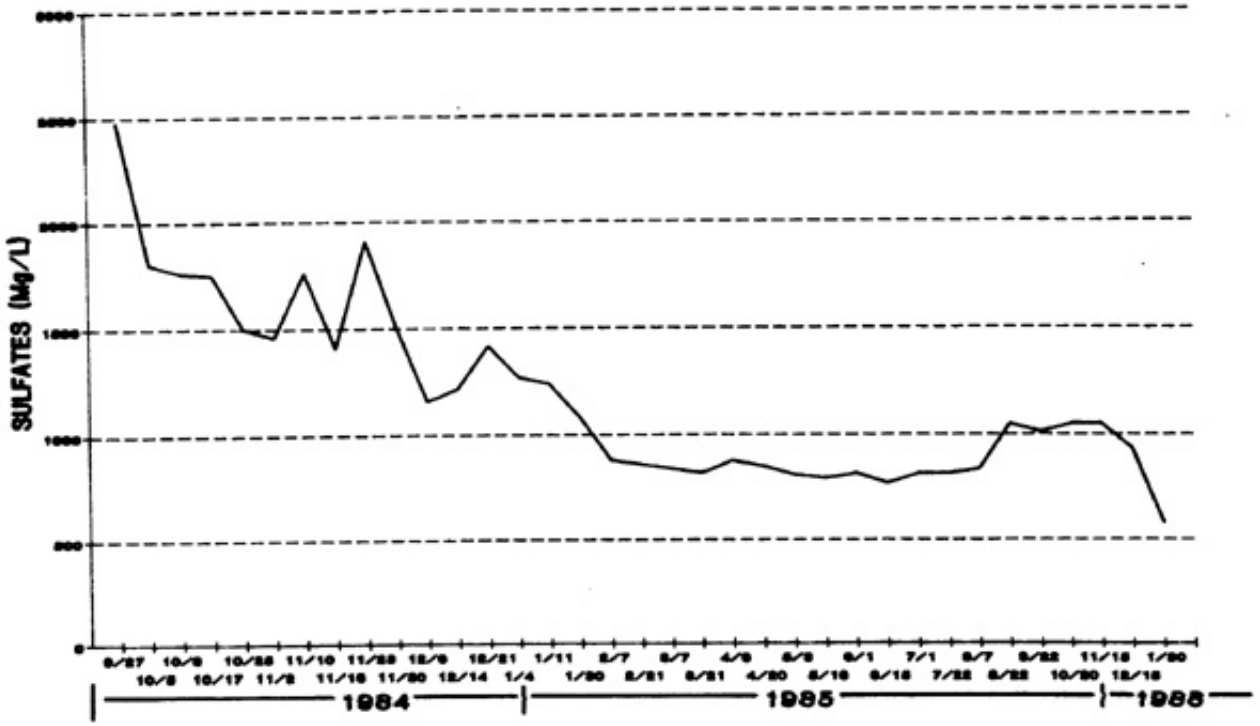


FIGURE 3

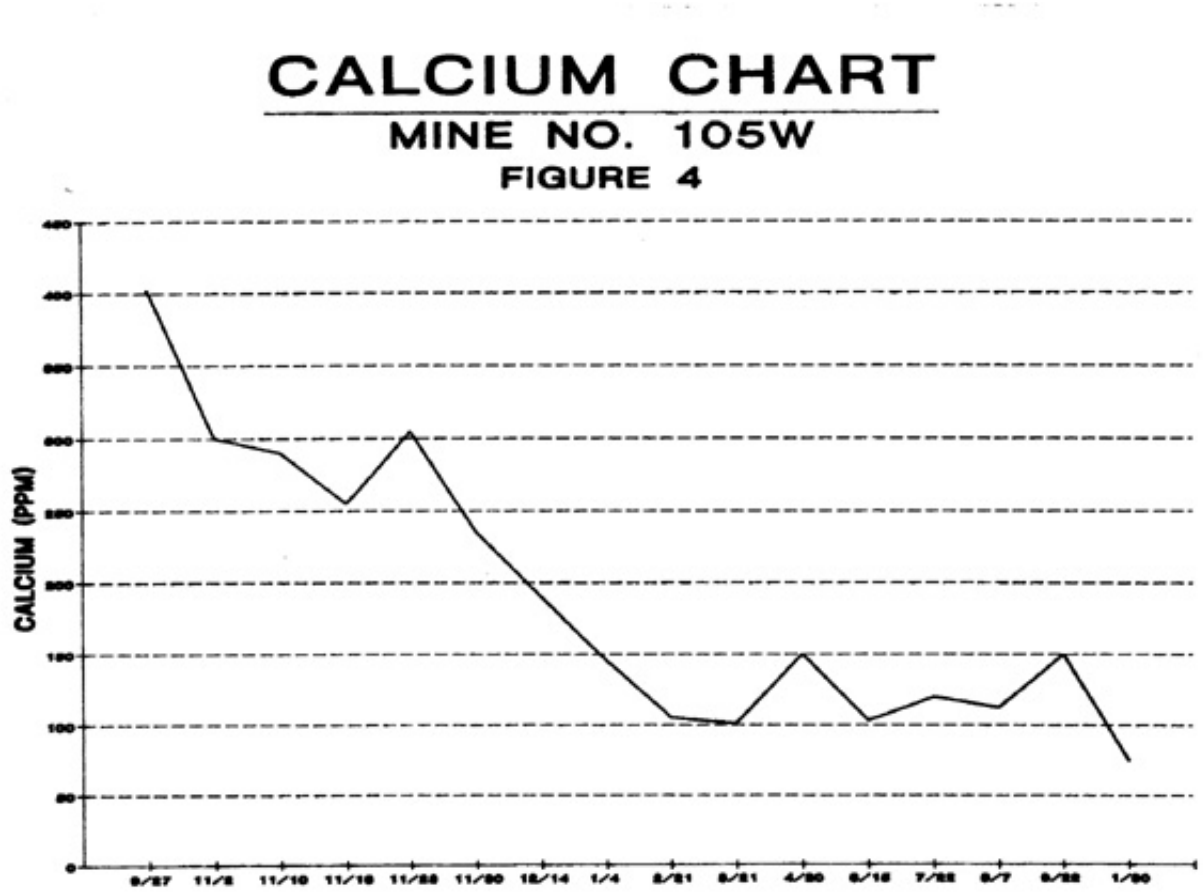


FIGURE 4

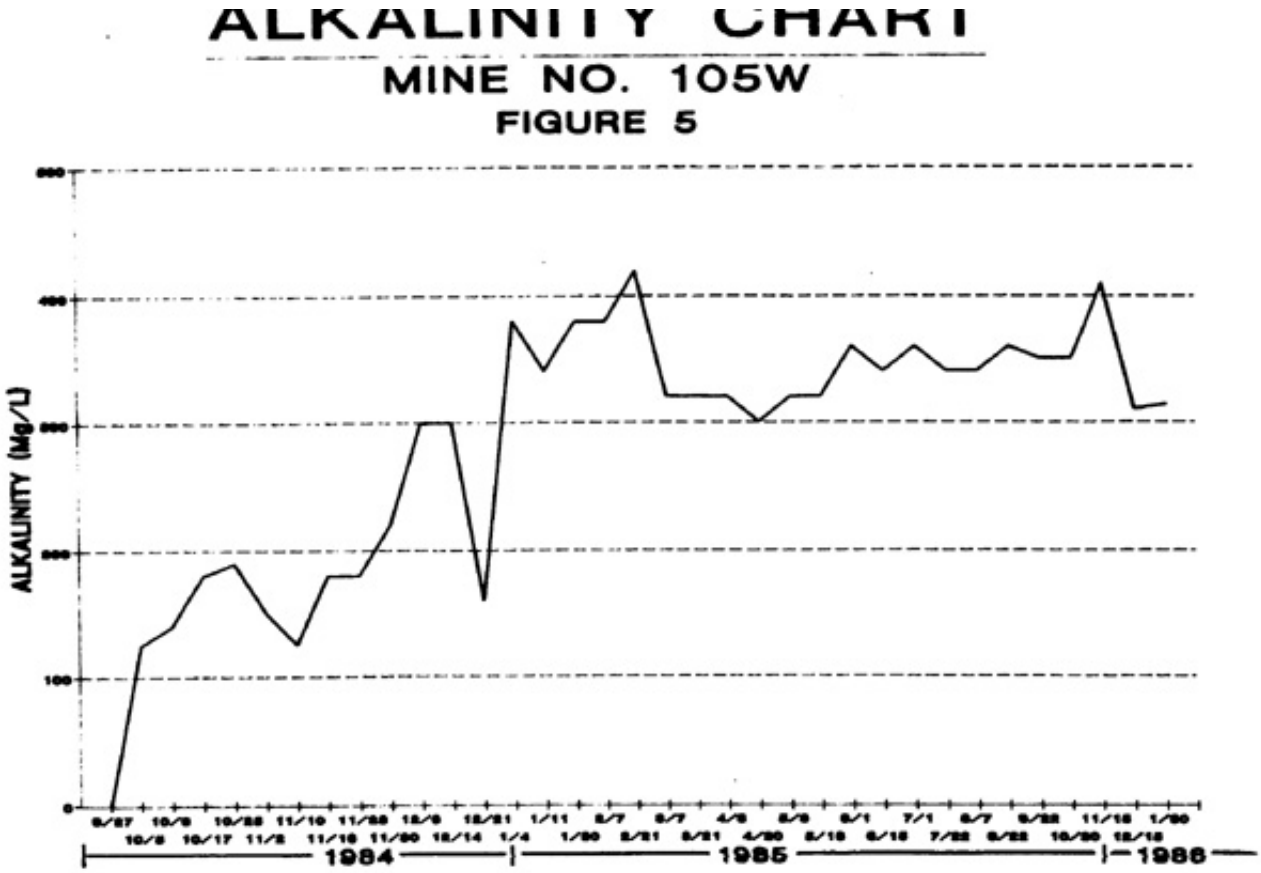


FIGURE 5

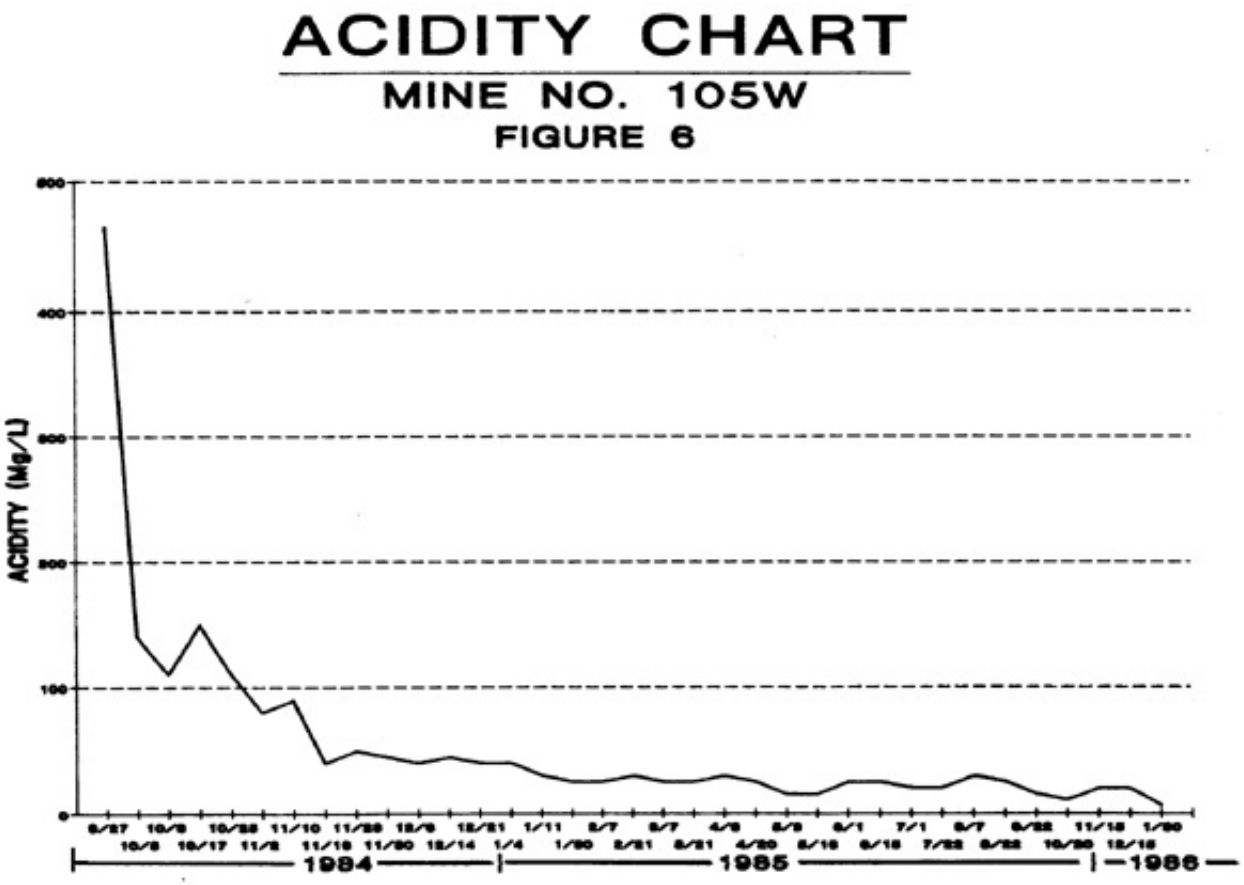
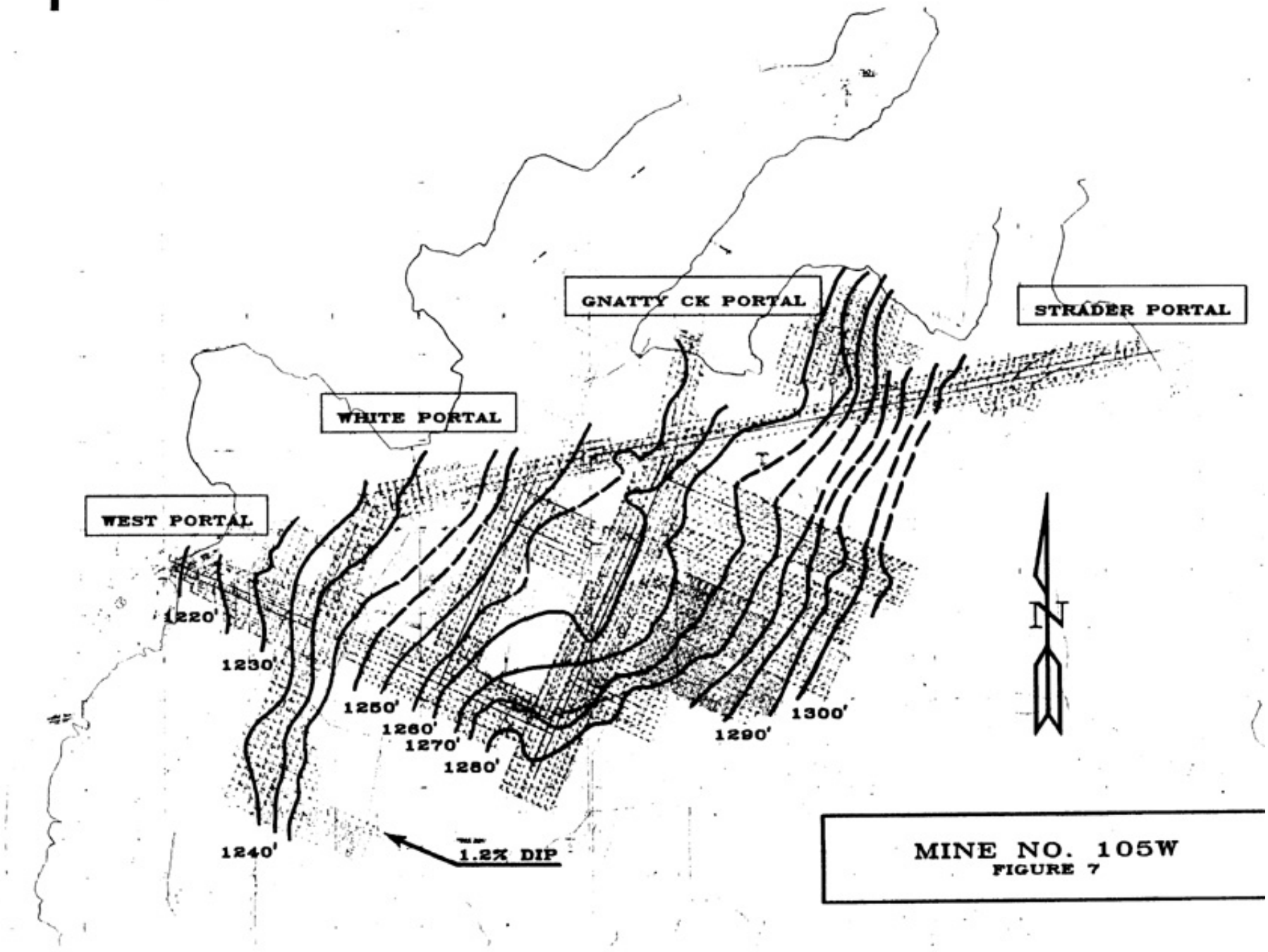


FIGURE 6

Mine 105W (shown in Fig. 7) dips approximately 1.2% to the west. In order to seal the mine, it was necessary to seal the West Portal, White Portal, and Gnatty Creek Portal. Because of different entry conditions and projected water heads, two different types of seals were utilized. On the relatively new entries with low head requirements, a type II Seal (Fig. 8) was used. This consisted of two cinderblock walls separated by 20 feet. These walls were hitched into the roof, floor, and ribs. The roof, floor, and ribs around the walls were injected with expanding polyurethane foam to a depth of ten feet. A 3/4-inch limestone aggregate was pneumatically stowed between the walls and the stowed area was injected with expanding polyurethane grout. The project required five of these seals (one at White Portal, four at Gnatty Creek Portal). The seals were installed by Micon Services, Inc., Pittsburgh, Pennsylvania. The seals have performed well with only minor leakage at White Portal, which was stopped with secondary grouting. This type of seal is preferred when the entry is accessible.

At the West Portal where the entries were older and roof falls had occurred, making the entries inaccessible for the most part, a different sealing technique was utilized. Available technology was reviewed leading to the decision to use a "double bulkhead" Type III Seal (Fig. 9). These seals were installed from the surface by drilling into the collapsed entries and stowing two gravel bulkheads approximately 25' apart in each entry. A cement/fly ash grout is used to stabilize the gravel and upon set up, a grout plug is installed between the two bulkheads. Then the entire area from 10' below the Pittsburgh Seam up to the floor of the

Redstone Seam and 10' to either side of the set of four entries was pressure grouted to form a water tight curtain.


GNATTY CK PORTAL
STRADER PORTAL
WHITE PORTAL
WEST PORTAL
1220'
1230'
1240'
1250'
1260'
1270'
1280'
1290'
1300'
1.2% DIP
N
MINE NO. 105W
FIGURE 7

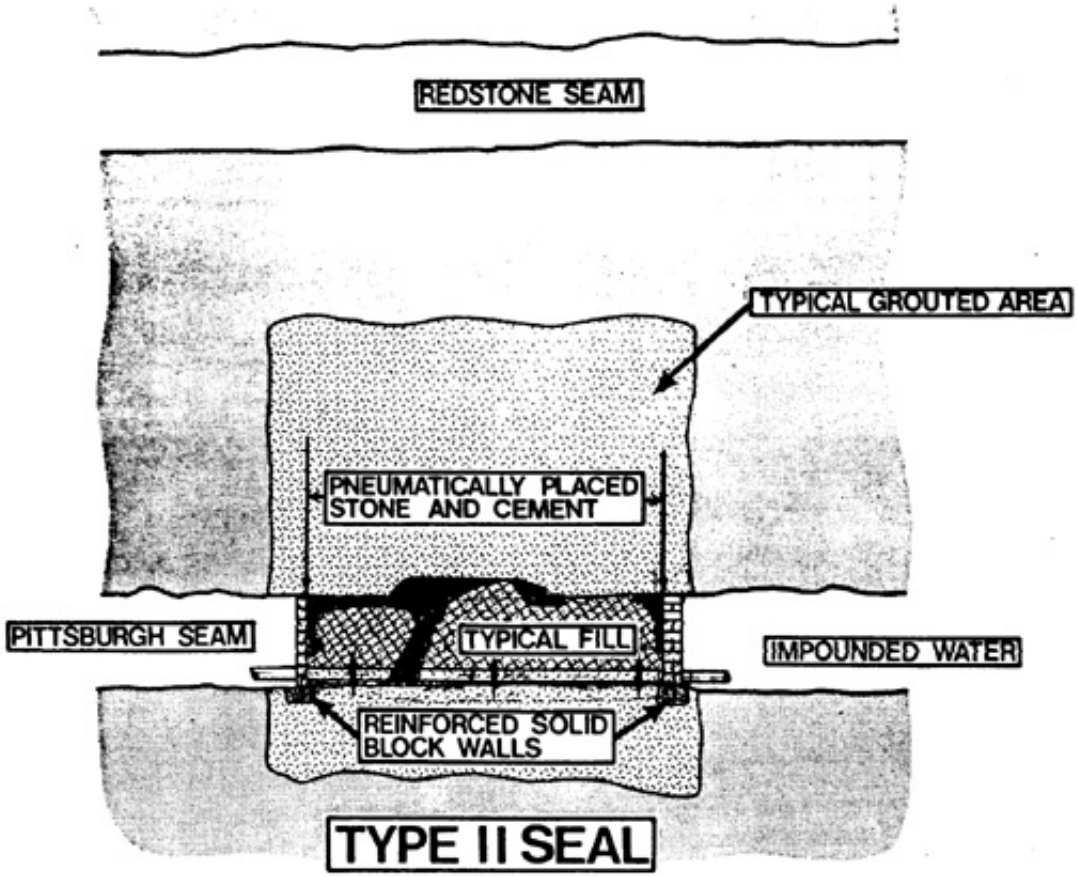


FIGURE 8

FIGURE 8

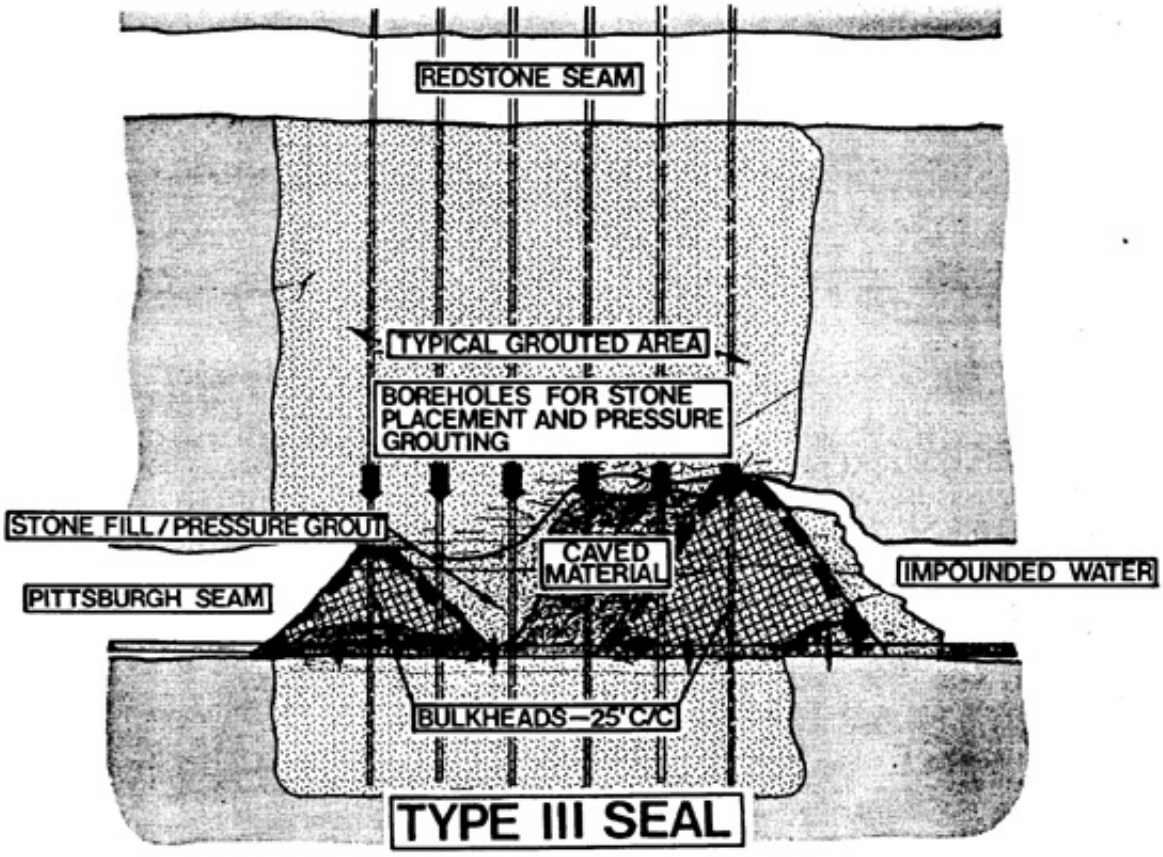
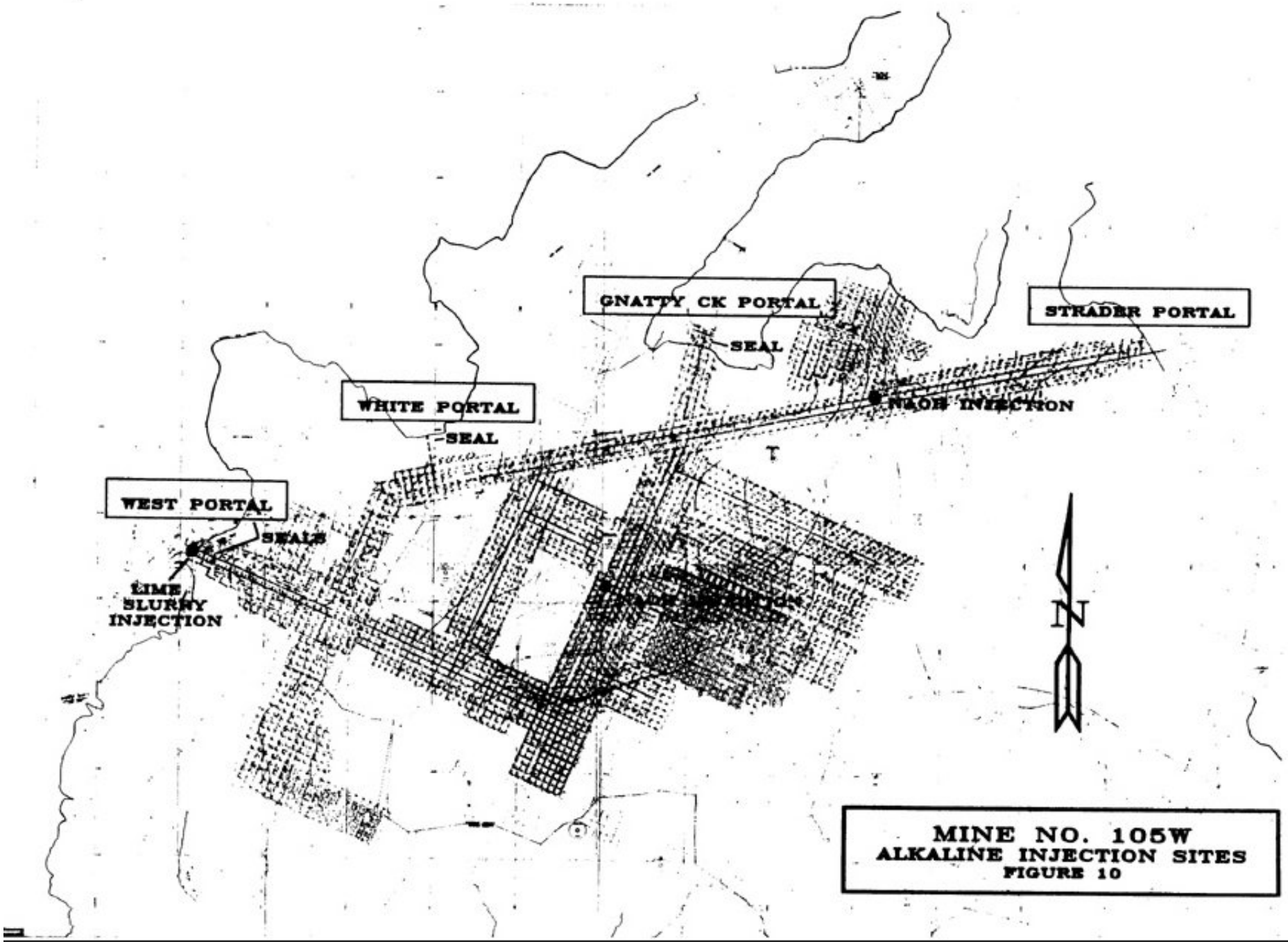


FIGURE 9

FIGURE 9

This method works best on entries that have a definite void area to seal, but on three of six seals at this portal, the entries had collapsed to the point that no large void existed. At this point, a compaction grouting technique was used in which holes were drilled on close center spacing (21-5') and grout pumped in to refusal. This method of sealing can be costly as it is difficult to control placement of the grout. This work was performed by Hydro Group, Inc., Pittsburgh, Pennsylvania.

The flooding of the mine commenced on September 30, 1984. This involved the pumping of lime/water slurry (285 GPM, 580 PPM lime) through a pipe in one of the West Portal seals. At the same time, flow was initiated from two surface injection stations to introduce NaOH through boreholes into the main drainage ways in Mine 105W (Fig. 10). The purpose of this controlled alkaline flooding was twofold: one to neutralize stagnant pools of acid water in the mine and two, to preclude acid formation until the oxygen was sealed out. The NaOH injection period was from September 30, 1984, to February 15, 1985, and lime slurry injection continued into June, 1985. During this time, 120 tons of lime were consumed and 150,000 gallons of NaOH. There has been no treatment since. The mine holds 170R gallons or 520 acre feet of water at the 421 level (Fig. 11). Historically, the mine makes 512M gallons/year, so that to date, there have been approximately four water changes in the mine.

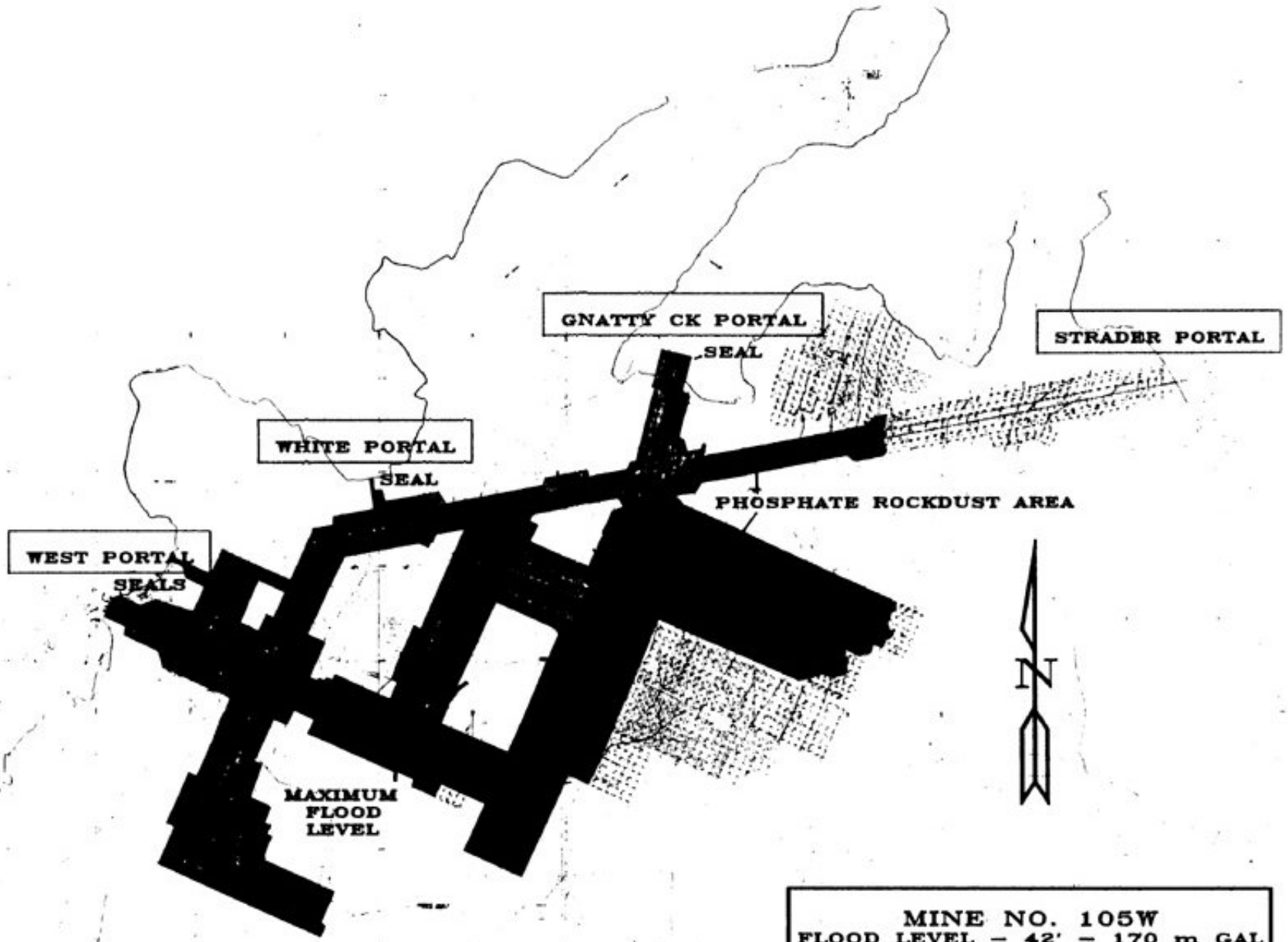


MINE NO. 105W
ALKALINE INJECTION SITES
FIGURE 10

MINE CAPACITY CURVE

MINE NO. 105W

FIGURE 11



MINE NO. 105W
FLOOD LEVEL – 42' – 170 m GAL
FIGURE 12

MINE NO. 105W AMD PROJECT

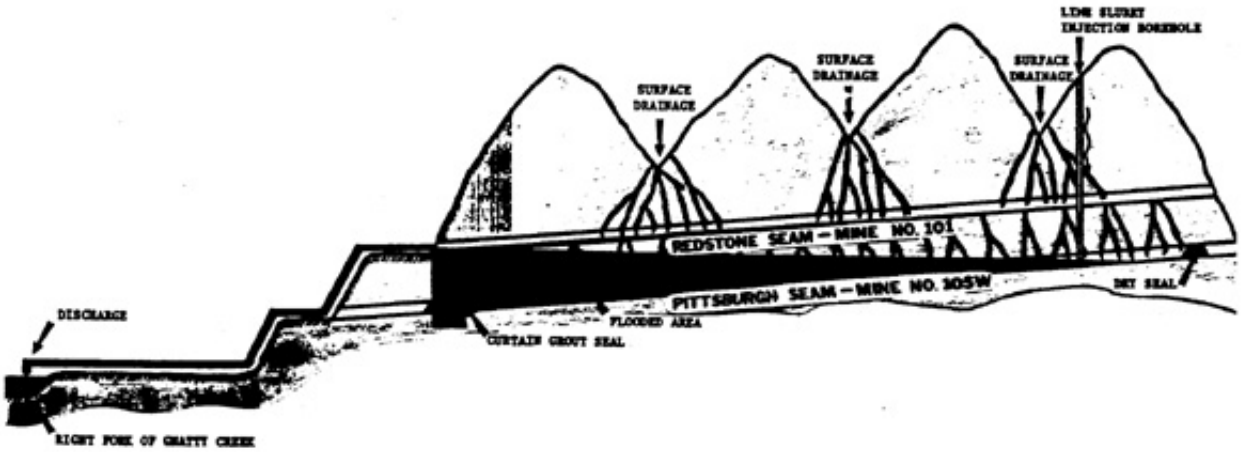


FIGURE 13

As shown in Figure 12, the mine is not completely flooded. This is due to the close proximity of the Redstone Seam (38' above at the West Portal) (Fig. 13). We realized that it was not practical to seal the old Redstone works (Mine 101) so a non-flooded area of Mine-105W was expected to exist after the head in the mine exceeded the interval between seams. The head against the West Portal seals was anticipated to range between 40 and 60 feet. An insurance factor was added to the project by rockdusting all exposed entries of the variable "beach" area with ground apatite rock. Apatite was chosen for its ability to lock up iron in an acidic environment and it relative inertness to leaching. The rock was supplied with the same size consistency of commercial rockdust, by Occidental Chemical Company, White Springs, Florida. The dust was shipped by special pneumatic rail cars to a nearby siding, was off loaded into standard rockdust trucks and dispensed underground with standard rockdusting equipment. In all, 700 tons of apatite were applied.

We wish to specifically thank the Surface Mine Drainage Task Force, West Virginia Departments of Energy and Natural Resources, Mine Safety and Safety and Health Administration, U. S. Bureau of Mines, Michael Baker Engineers, West Virginia University, and a multitude of individuals for their ideas and help in making this project a success.