OFFICE MEMORANDUM

MICHIGAN
STATE HIGHWAY DEPARTMENT

December 8, 1966

To: E. A. Finney, Director
Research Laboratory Division

From: M. G. Brown

Subject: Artesian Flow of Sulfide Water: I 75 over US 25 (I 82191J, C 25).
Research Project 66 G-150. Research Report No. R-616.

During construction operations for the I 75-US 25 interchange, a number of springs or artesian flows of hydrogen sulfide water appeared September 10, 1966, near the west abutment of Ramp D and under I 75 structures after undercutting for southbound US 25. After southbound US 25 pavement was poured through this area on September 15, an additional, isolated artesian flow increased to its present rate. This point of artesian leakage is now primarily up through underlying clay and fill behind Abutment A of the structure carrying the Pennsylvania Railroad over US 25 on the northern side of the interchange area (X02 of 82071A).

At the request of W. W. McLaughlin, flow measurements and sample analyses of the artesian flow were made. Resulting data are to be considered in deciding on a solution to the existing hydrogen sulfide gas problem.

Summary of Inspection Observations

Three sampling and inspection trips were made on October 5, 18, and 26, by W. L. Frederick, J. T. Ellis, and M. G. Brown of the Research Laboratory Division. They were accompanied by A. A. Foster and D. Woodend of the Safety Section, who performed air tests using an MSA hydrogen-sulfide indicating instrument. Highway Department personnel were assisted on these inspections by L. Stelly, H. Tiilikka, and H. Kirchen, Wayne County engineers on the projects involved.

Figure 1 shows relative locations of the four pumphouses that feed the main storm sewer from London-Moore northeast to a fifth pumphouse at Pleasant Ave. where the flow is pumped up and into the Rouge River. Table 1 summarizes chemical analyses and flow measurements of water samples and Table 2 the hydrogen sulfide content of air samples, taken at various points along the I 75 drainage system.

During the first sampling, on October 5, sulfide water was flowing out of the ground immediately west of retaining wall extension of Abutment A, west of

US 25 along the north side of Ramp A. On the same day, tile was installed which conducted this artesian flow into a catch basin in the north curb of Ramp A and through several interconnected tiles into the pumphouse in the southeast quadrant of the interchange. Table 1 indicates the artesian sulfide water to have had about the same composition encountered earlier near Caisson No. 4 of the Rouge River high-level bridge, described in Research Report No. R-509, dated April 15, 1965. Air checks (Table 2) indicated hydrogen sulfide gas in fairly low concentrations (35 to 50 ppm) in the catch basins of the leakage area, but over 500 ppm in the top chamber of the pumphouse. It was noted that paint had blackened on the steel door into the pumphouse's sump section.

More detailed information was obtained on subsequent trips (October 18 and 26), giving a better picture of water flow rates and hydrogen sulfide dissipation through the whole I 75 storm drain system. Data obtained on October 18 were affected by dilution of sulfide water in the I 75-US 25 interchange due to rainfall on that day. October 26 was clear and dry, so the 78-gpm flow entering the Dix pumphouse was probably entirely artesian sulfide water. Note that the concentration of hydrogen sulfide contained in the artesian water drops to about a half at the Dix pumphouse and again almost in half as it enters the storm sewer trunkline. This is indicated by decline of concentrations from 108 to 117 ppm, to 61 ppm, and to 35 ppm hydrogen sulfide. It may be worth noting that it takes slightly more than 3 hr to accumulate 6-1/4 ft of sulfide water in the Dix pumphouse at an inflow of 78 gpm before the first pump cuts on to pump it out at a rate of about 4,000 gpm. Of course, while this 14,700 gal of water is building up, the hydrogen sulfide gas is being released, resulting in 600 to 700 ppm hydrogen sulfide in the air above the sump area. Every three hours (or less) a surge of sulfide water enters the storm sewer at Dix Ave. The Table 2 air checks show that the hydrogen sulfide concentration in the trunkline sewer runs from about 200 ppm in the first manhole at Dix, to about 23 ppm at Champaign Ave. and 5 ppm at Southfield. No hydrogen sulfide problem occurred at any time in the separate motor room at Dix, which is sealed off from the pumphouse proper.

Discussion

It has been suggested that chemical treatment of the sulfide water to prevent evolution of hydrogen sulfide gas should be considered as a solution to the problem. This would assume no possible chance of stopping the present flow by grouting or some other method, and that the present localized flow of about 80 gpm will remain fairly constant. The problem will be greatly complicated if new points of leakage appear or if the present flow increases substantially.

Available literature and sources of information have been reviewed and several possible methods of treatment could be proposed, but all would require expensive initial construction, and fairly costly annual operation and maintenance. Many methods have been used in the petroleum industry, primarily to remove hydrogen sulfide from gaseous mixtures by absorption or scrubbing processes. Water containing hydrogen sulfide has been treated on a large scale primarily in three ways:

1. Aeration in large ponds and spray systems, when release to the surrounding air presents no health or nuisance problems.

2. Oxidation to produce elemental sulfur or stable sulfates. Chlorine, free chlorine containing compounds, and permanganates have been used where low hydrogen sulfide concentrations have been encountered.

3. Treatment with a caustic or basic material such as slaked lime, sodium hydroxide (lye), or sodium carbonate (soda ash).

Information transmitted by G. O. Kerkhoff to W. W. McLaughlin October 17, 1966 contained some cost figures from Wayne County for temporary treatment of sulfide water being pumped from a land tunnel excavation in 1959-60. Over $180,000 was spent on chemicals and equipment in treating 750 gpm between July 5, 1959 and May 17, 1960.

Of the various methods reviewed, treatment of sulfide water with hydrated lime or sodium carbonate appears to have the greatest advantage in cost and ease of operation. A treatment of waste sulfur mine water in Texas was described in detail in an article by Schwab, Edmiston, and McBride in the Proceedings of the 1954 Southern Industrial Wastes Conference published by the Manufacturing Chemists' Association. This involved treatment of about one million gallons per day of waste sulfur mine water containing 270 ppm of hydrogen sulfide. Large concrete and wood reaction chambers, flocculators, and settling basins such as described in this article would be needed to treat the Dix Ave. artesian flow. The needed tanks and equipment would probably have to be installed along the east side of US 25, north of the present pumphouse. For cost estimates of installation or annual operation, a complete design would have to be worked out by water treatment engineers. Initial cost of equipment and chemical storage might possibly run between $100,000 and $200,000. Daily operating cost estimates would require an exact plant design, but it would take about $15 worth of 58-percent soda ash per day to treat 100 gpm of sulfide water containing 120-ppm hydrogen sulfide.

Summary and Recommendations

To summarize, Table 1 and 2 data indicate a continuous dangerous level of hydrogen sulfide gas above the sump area of the Dix Ave. pumphouse, in concentrations of 600 to 700 ppm. Safe maximums of 10 and 20 ppm hydrogen sulfide are currently recognized by Wayne County and the Michigan Department of Health, respectively. Every three hours, or less if it is raining, surges of hydrogen sulfide in the main sewer produce concentrations of from 200 to 5 ppm in the numerous manholes from the Dix Ave. pumphouse to Southfield, with concentrations decreasing with distance from the source.

During the course of this study, contacts with the Soils Division, Safety Section, Office of Maintenance, and the State Department of Health, resulted in formulation of the following recommendations:

1. Chemical grouting. Explore the possibility of stopping the present artesian flow by chemical grouting of an area of about 5 acres in the low part of the interchange. This solution requires an initial outlay, but no subsequent continuing operating expense. However, the possibility of the artesian flow appearing at new locations must be considered.

2. Construction of a separate drain to the existing sewer. Explore the economics of constructing a separate drain from the artesian flow north of Ramp A, to the existing sewer, bypassing the Dix pumphouse. This would require an additional smaller sealed sump and pumphouse of special design, which due to a lower but more steady pumping rate might produce hydrogen sulfide concentrations that could be tolerated in the manholes from Dix to Southfield, as estimated by A. Foster and M. Schuman, District Engineer of the Michigan Department of Health. Some erosion and settlement has occurred at the point of artesian flow, so special permeable fill would be required to maintain flow without erosion.

3. Chemical Treatment. Explore the economics of constructing a chemical treatment plant to neutralize the present artesian flow, with effluent flowing to the Dix pumphouse. The separate drain line and smaller pumphouse just proposed would be needed as part of this treatment system, and thus should be designed for compatibility.

With reference to the Dix pumphouse, it is recommended that a continuous, explosion-proof venting system be installed, to minimize accumulation of hydrogen sulfide gas from sulfide water other than the isolated flow. Preliminary calculations by Mr. Schuman indicate that it would not be feasible to install an adequate venting system to handle the present hydrogen sulfide concentration, but a practical design could be installed if the main artesian flow is bypassed. Need for an explosion-proof venting system has been indicated as a standard design item in all state pumphouses to handle flammable liquid spillage in interchanges, or possible accumulations of noxious gases.

Several persons contacted in the course of the study have also indicated that a separate motor room with an external power cutoff switch should also be a standard design feature on all Michigan pumphouses. Currently, it is reported that a separate motor room is required only within the limits of Detroit.

OFFICE OF TESTING AND RESEARCH

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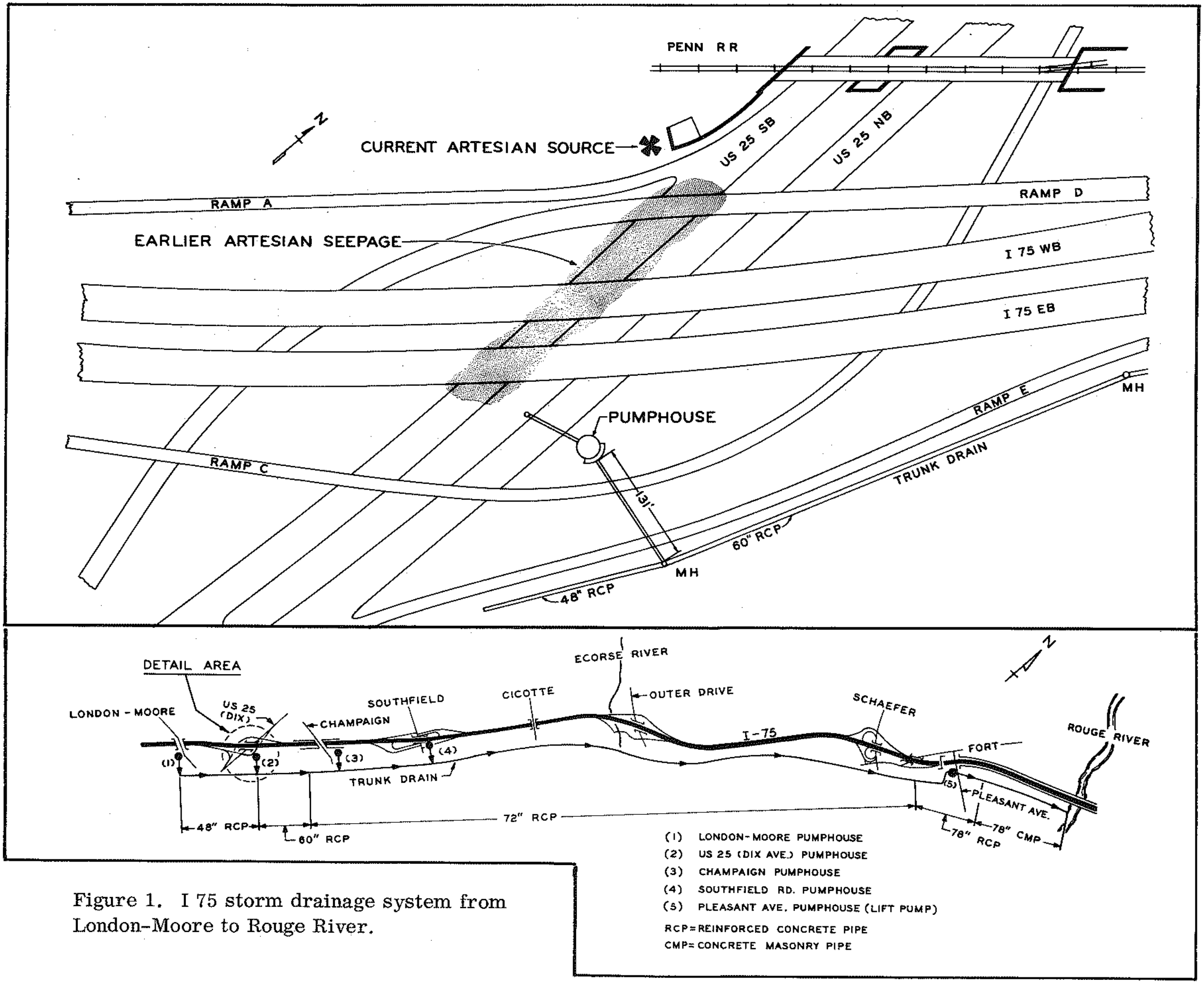

Figure 1. I 75 storm drainage system from London-Moore to Rouge River.

TABLE 1
SUMMARY OF WATER SAMPLE ANALYSES

Location	Sampling Dates		
	10-5-66	10-18-66	10-26-66
I 75 over US 25 (Dix)			
Artesian source (north of Ramp A)	60 gpm (est.) 117 ppm H_2S 1612 ppm $SO_4^=$ Slightly alkaline	108 ppm H_2S Slightly alkaline	
Pumphouse (entering)		152 gpm flow 56 ppm H_2S 1422 ppm $SO_4^=$ Slightly alkaline	78 gpm flow 61 ppm H_2S 1577 ppm $SO_4^=$ Slightly alkaline
Manhole in trunkline (131 ft east of pumphouse)		28 ppm H_2S 1475 ppm $SO_4^=$ Slightly alkaline	35 ppm H_2S 1592 ppm $SO_4^=$ Slightly alkaline
I 75 under Champaign			
Pumphouse (entering)			1-2 gpm (est.) 1 ppm H_2S 1082 ppm $SO_4^=$ Alkalinity not determined
I 75 at Pleasant			
Main pumphouse (entering)			116 gpm flow 0 ppm H_2S 1412 ppm $SO_4^=$ Alkalinity not determined

TABLE 2
SUMMARY OF AIR SAMPLE ANALYSES

Location	Hydrogen Sulfide, ppm		
	Sampling Dates		
	10-5-66	10-18-66	10-26-66
US 25 (Dix)			
Catch Basins			
North of Ramp A	50+		
South of Ramp A	38		
Pumphouse			
Roof level (at grating)	500 (approx.)	500+	600
25 ft below roof		600-250	700
Motor room		0	0
Manhole (131 ft east of pumphouse)*		100-125 (during rain)	200
Champaign			
Pumphouse			
Roof level (at grating)			0
25 ft below roof			5
Motor room			0
Manhole (16 ft northeast)			23
Southfield			
Manhole (to east)			2-5
M 85 (Fort), siphon under street			
Manholes			
North of Fort			0
South of Fort			0
Pleasant (Rouge River)			
Pumphouse			
Sump entrance			0
23 ft below entrance			0
Motor room			0

* During pumping