REC-ERC-85-2

# REHABILITATION OF A CALCIUM CARBONATE CLOGGED DRAINAGE SYSTEM USING SULFAMIC ACID

October 1984

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The restoration of subsurface irrigation drains is a problem when drain water has deposited calcium carbonate scale. Techniques for restoration of these drains such as mechanical routing and sulfur dioxide gas treatment are expensive and dangerous. This report describes a technique in which the drains are flooded with a 10-percent sulfamic acid-sodium chloride solution. The advantages to this technique are cost, less than a fifth of the pipe replacement cost, and simplicity; most irrigation districts can use this method without specialized equipment.

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# Rehabilitation of a Calcium Carbonate Clogged Drainage System Using Sulfamic Acid

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UNITED STATES DEPARTMENT OF THE INTERIOR ★ BUREAU OF RECLAMATION

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# CONTENTS


| | Page |
|---|---|
| Purpose | 1 |
| Introduction | 1 |
| Conclusions | 1 |
| Investigation | 1 |
| Application | 4 |
| Equipment and costs | 7 |
| Discussion | 7 |
| Bibliography | 7 |
| Appendix–Determination and calculation of quantities for treatment mixture | 9 |


## TABLES


| Table | | |
|---|---|---|
| 1 | Relative corrosion rates of 3 percent aqueous solutions of acids at 22 °C (72 °F) | 4 |
| 2 | Results of acid treatments | 5 |
| 3 | Solution pH values before and after treatment | 6 |
| 4 | Costs for drain treatment materials, equipment, and labor | 7 |


## FIGURES


| Figure | | |
|---|---|---|
| 1 | Diagram of treated drains in North Pavillion area of Riverton Unit | 2 |
| 2 | Cross section of calcium carbonate and iron bacteria buildup at pipe joint STA 16+12.4 m (Sta. 52+90 ft) | 3 |
| 3 | Cross section of clogged, 200-mm (8-in) diameter, drainage pipe prior to acid treatment at STA 11+88.72 m (Sta. 39+00 ft) | 8 |

## PURPOSE

Irrigation drainage specialists should know about using a sulfamic acid-sodium chloride solution to break up calcium carbonate deposits in drains. Using the method described in this report is inexpensive, safe, not harmful to the environment, and easy to apply in the field. Chemical treatment using sulfamic acid provides an alternative to other methods of drain cleaning using sulfur dioxide gas and mechanical routing. Applications of this method could be far reaching because clogged irrigation drains occur elsewhere in the 17 Western States.

## INTRODUCTION

During the 1982 irrigation season, two reaches of clay drainage pipe became plugged in the North Pavillion area of the Riverton Project, Riverton, Wyoming (fig. 1). According to the irrigator, 14 hectares (35 acres) of alfalfa and grain were lost from poor drainage which left wet areas in his fields. The Midvale Irrigation District tried to unclog the drain with a high-pressure sewer jet cleaner, but was unsuccessful.

In March 1983, the district tried a chemical treatment as a means of restoring drainage in the pipe. The plugged sections of the pipe were treated with a 10-percent (by weight) sulfamic acid-sodium chloride solution after water quality hazards to the site were carefully evaluated. This evaluation included consideration of the environmentally fragile Pavillion Pond downstream.

After treatment, wet spots around the problem sections dried up and no crop loss occurred during the following irrigation season. While it is possible that the water table was affected by other factors, it appears that the chemical treatment to the drains solved the problem.

This is the first reported use of sulfamic acid to rehabilitate calcium carbonate clogged drains in the Upper Missouri Region. Several years ago, the Lower Missouri Region successfully treated an ocre-clogged drainage system with sulfamic acid [1].[1]

## CONCLUSIONS

The sulfamic acid-sodium chloride method for treating calcium carbonate clogged irrigation drains is both inexpensive and safe. The cost of treating a severely plugged 250-mm (10-in) drainage pipe should range between $3 and $6 per meter ($1 and $2 per foot), less than a fifth of the replacement cost. Also, sulfamic acid is not considered to be a hazardous material when neutralized before disposal, and is available in granular form, making it safe to transport and use.

Drainage systems of Bureau projects should benefit from the acid treatment because the easier and the cheaper a treatment is, the more likely an irrigation district would be to use it. Most irrigation districts could use this method to unclog irrigation drains without help; however, assistance by the Bureau might be advisable depending on the district's experience with chemical treatments and the magnitude of the problem. Since acid directly affects pH, acid treatment should always be cleared beforehand with State environmental authorities.

## INVESTIGATION

On February 8, 1983, the Midvale Irrigation District, in cooperation with the Bureau of Reclamation, made two excavations, 2.4 m (8 ft) in depth, to examine two problem drains. The first excavation was at STA 16+12.4 m (Sta. 52+90 ft) near the upper end of drain 35-4-2-A, while the second site was at STA 2+28.6 m (Sta. 7+50 ft) on drain 35-4-2-A-2.8, about 300 m (984 ft) east-southeast of the first site (fig. 1). At the first site, the interior of the pipe revealed that brown- and blue-colored, mineralized deposits clogged the pipe joints, choking the drainage capacity (fig. 2). There were no deposits apparent in the pipe at the second site. The drains at both sites were installed in 1956 and had been in operation approximately 26 years.

Three samples of the deposits near drain 35-4-2-A were examined at the Bureau's Engineering and Research Center in Denver. One sample was described as a 150-mm (6-in) piece of the spigot end of a 200-mm (8-in) clay drainage pipe. On the inside was a hard, reddish-brown deposit, ranging from 2 to 25 mm (0.1 to 1 in) in thickness. The thickest and most deeply colored deposit was within 38 mm (1.5 in) of the pipe lip. Toward the center of the 1.2-m (4-ft) pipe section, the deposits decreased in thickness and the color faded to an almost clear yellow.

Another sample taken from the excavated pipe section was described as a piece of hard, mineralized deposit. The sample was convoluted and smooth (indicating water formation), and the deposit had to be hammered off the pipe. A third sample, the gravel envelope material, consisted of sand and gravel up to 44 mm (1.75 in) in diameter. The deposits were soft, silty, and deep brown to red in color. Hard, mineralized deposits were attached to some of the

[1] Numbers in brackets refer to items in the Bibliography.

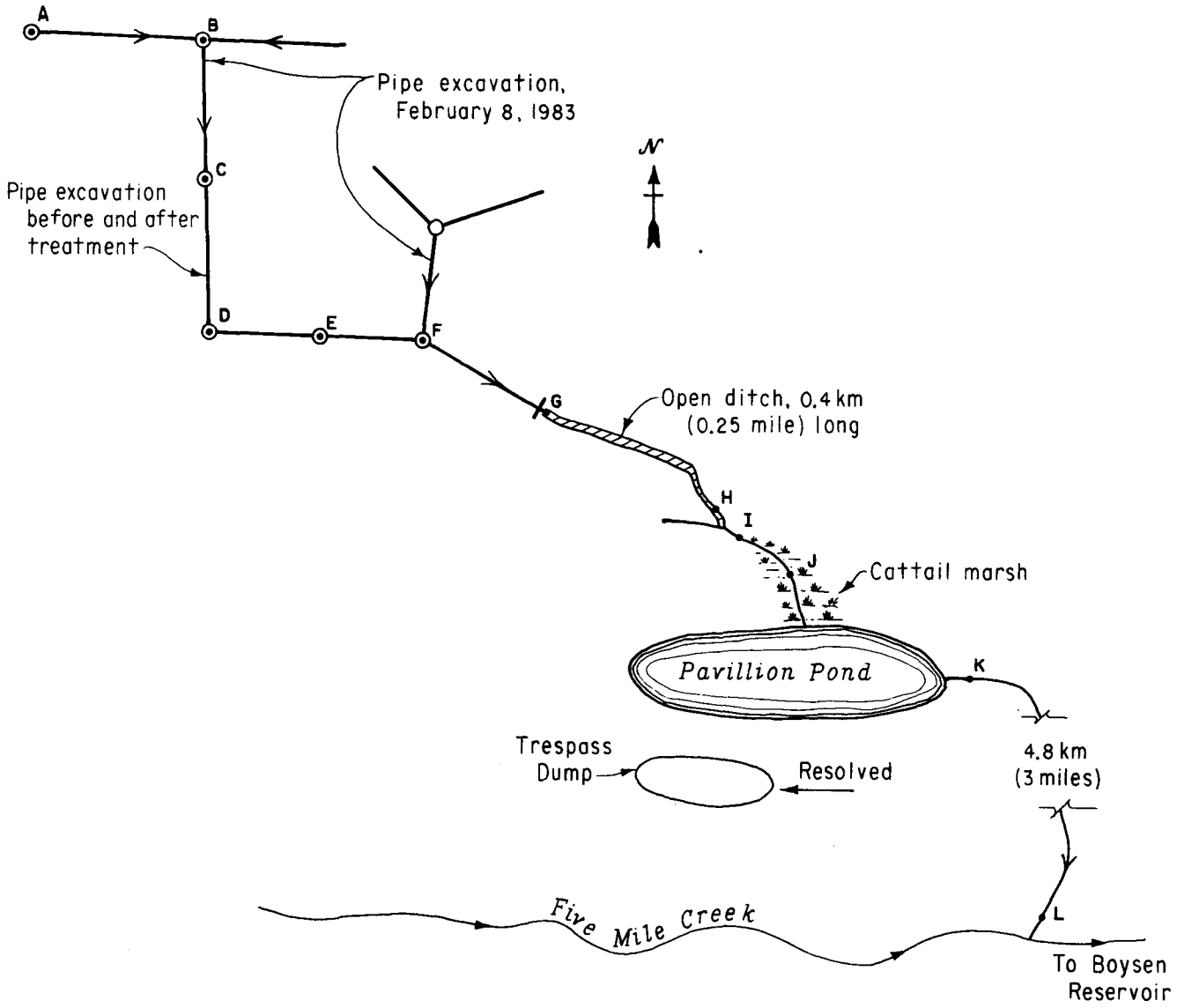


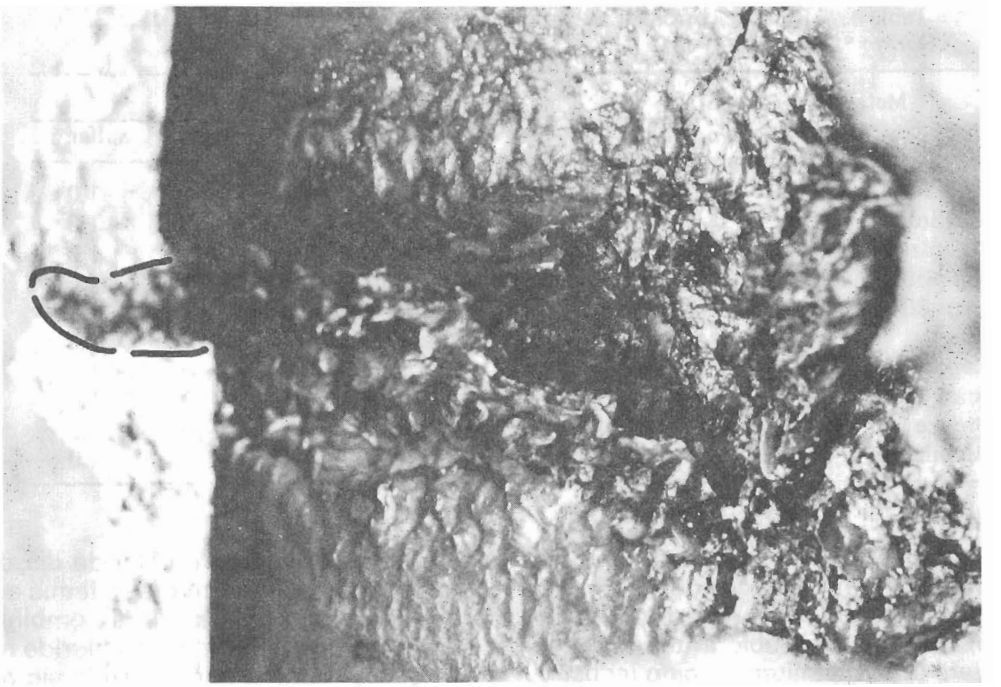

Figure 1. — Diagram of treated drains in North Pavillion area of Riverton Unit.

gravel material. When rinsed with water, most of the color and some of the mineralized deposits were removed.

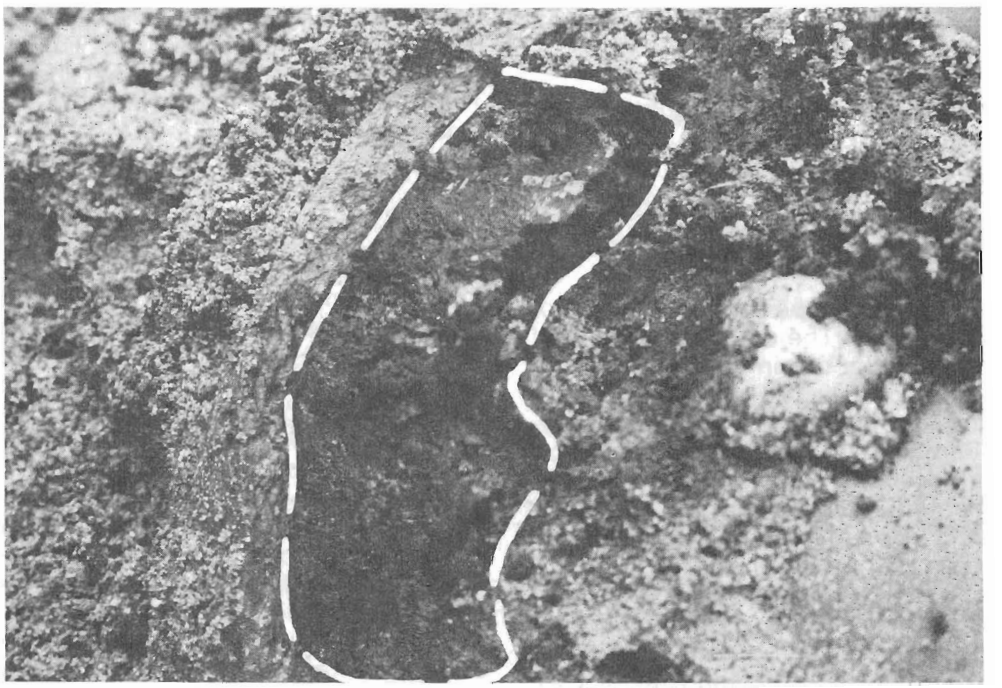
Microscopic examination of the samples identified *Crenothrix* iron bacteria in the reddish-brown and yellow-colored materials. This bacteria produces insoluble hydrated iron and manganese oxide sheaths, which become further mineralized and hard over time. The examined deposits were still soft and easily dispersed with a dilute (0.1 pecent) hydrochloric acid solution, indicating youthful formations.

The hard, mineralized deposits, which have been building up since 1956, were chemically determined to be primarily calcium carbonate, with traces of iron and manganese oxides layered within the thicker carbonate depositions. Also, substantial quantities of fine sand and smaller amounts of detritus were held in the formations.

Samples were tested to determine the effectiveness of hydrochloric, sulfuric, and sulfamic acids in decomposing the mineralized buildup. The deposits and the pipe section were treated with 10 percent (by weight) solutions of sulfuric ($H_2SO_4$), hydrochloric (HCl), and sulfamic ($NH_2SO_3H$) acids to test the effectiveness of these acids in removing the deposits. Hydrochloric and sulfuric acids are strong acids used by industry to remove heavy calcium deposits. Sulfamic acid is the least corrosive to metals of the three acids, see table 1. Formulations containing sulfamic



(a) Interior view showing buildup (outlined by black-dashed line) flaring out from joint. P801-D-80898



(b) Exterior view showing buildup (outlined by white-dashed line) under broken off bell housing. P801-D-80899

Figure 2. — Cross section of calcium carbonate and iron bacteria buildup at pipe joint STA 16+12.4 m (Sta. 52+90 ft).

Table 1. – Relative corrosion rates of 3 percent aqueous solutions of acids at 22 °C (72 °F). From [2].

| Metal | Acid | | |
|---|---|---|---|
| | Sulfuric | Hydrochloric | Sulfamic |
| SAE 1010 steel | 2.6 | 4.2 | 1.0 |
| Cast iron | 3.2 | 3.2 | 1.0 |
| Galanized iron | 63 | Rapid corrosion | 1.0 |
| Tin plate | 81 | 23 | 1.0 |
| Type 304 stainless | 10 | Rapid corrosion | 1.0 |
| Zinc | 2.2 | Rapid corrosion | 1.0 |
| Copper | 1.5 | 6.7 | 1.0 |
| Brass | 1.5 | 2.8 | 1.0 |
| Bronze | 4.0 | 7.0 | 1.0 |
| Aluminum | 0.6 | 5.3 | 1.0 |

acid are used to remove calcium carbonate deposits from boilers, heat exchangers, condensers, and water wells [2]. Sulfuric acid was suggested for testing because it was readily available in the Riverton area from suppliers to the uranium refining industry.

Tests of the three acids considered:

- Effect of 10 percent acid solutions on deposits
- Effect of acids on drainage pipe
- Time required to effectively remove deposits from pipe with diluted acids
- Formation of additional solids resulting from acid treatments
- Cost of acid preparations
- Safety in handling and use of acids

Results of the acid treatments performed in the laboratory are listed in table 2. The dilute sulfamic acid solution was the most effective in removing the calcium carbonate deposits. This acid solution penetrated the iron and manganese oxides overlaying the calcium carbonate in the clay drainage pipe and caused the deposits to separate from the pipe walls. The hydrochloric acid solution only reacted with the exposed carbonate which neutralized the acidity before the acid could penetrate the oxide layers and react with the underlying carbonate deposits. The sulfuric acid solution did not react substantially with the oxides or carbonate deposits on the clay pipe. None of the acids reacted with the clay pipe.

An additional test using a mixture of one-third (by weight) sodium chloride (NaCl) and two-thirds sulfamic acid as a 10-percent solution proved equivalent in effectiveness to the sulfamic acid solution in the laboratory. The sodium chloride dissolves in water and acts in concert with the sulfamic acid on the calcium carbonate deposit. This combination reduces chemical costs since sodium chloride replaces a portion of the more expensive sulfamic acid. Also, the lower concentration of sulfamic acid in the treatment mixture results in less insoluable calcium sulfamate being formed [6].

Sulfamic acid and salt are available as granular solids which are easily transported and handled in the field. Safety precautions such as full eye protection and rubber gloves should be used. The manufacturer's safety handling instruction sheet should be followed. The 1:2 salt/sulfamic acid mixture was used in the field treatment.

## APPLICATION

Environmental effects of acid treatments were considered before field treatment began. Soil and water tests suggested that the acid would be neutralized by the alkaline soils and subsurface drainage before reaching Pavillion Pond, a 30-hectare (75-acre) waterfowl habitat about 914 m (3000 ft) downstream from the clogged drains. Hydrochloric and sulfamic acids are not hazardous to the environment when drain cleaning is followed by neutralizing the remaining acidity with sodium carbonate or lime. Neutralized acid solutions entering waterways may require local permits, and it is advisable to contact the State water quality department when in doubt about requirements. Prior to acid treatment, drainage from the field and pond outfall, about 380 L/min (100 gal/min), had a pH of 7.9. After cleaning, drainage into the pond area had a measured pH of 7.7.

The clogged drains at Riverton were treated with a mixture of 2 parts sulfamic acid, 1 part salt, and 27

Table 2. – Results of acid treatments.

| | Hydrochloric acid (10%) | Sulfuric acid (10%) | Sulfamic acid (10%) | Sulfamic acid and sodium chloride 2:1 (10%) |
|---|---|---|---|---|
| Reactivity on calcium carbonate | Vigorous | Moderate | Moderate | Moderate |
| Persistence of acid attack | Moderate | Poor | Good | Good |
| Time required to remove a 25-mm (1-in) carbonate/ oxide deposit | 6 hours | Not removed after 18 hours | 3 hours | 2 hours |
| Solubility of inorganic calcium salts in water, grams per 100 mL | $CaCl_2$, 90 g | $CaSO_4$, 0.21 g | $Ca(SO_3NH_2)_2$, 79 g | $Ca(SO_3NH_2)_2$, 79 g |
| Effect of acid on drainpipe | No effect | No effect | No effect | No effect |
| Cost of acid per 378 L (100 gal) of treatment mixture | $27.00 | $30.00 | $56.00 | $38.00 |

parts water on March 28, 1983. Eight 1136-L (300-gal) batches of 10 percent solution were used to flood the approximately 366 m (1200 ft) of 250-mm (10-in) drainage pipe. To make the mixture, 68 kg (150 lb) of granular sulfamic acid and 34 kg (75 lb) of sodium chloride were dissolved in 1136 L of water in an aluminum tank. The sulfamic acid dissolved slowly in the 9 °C (48 °F) water, even with vigorous stirring.

The batch solution was pumped into the manhole at the west end of drain 35-4-2-A and flowed in series by gravity into two 182.9-m (600-ft) reaches which were sealed at their lower ends using a junior-sized basketball. The solution remained in the first reach about 5 hours before being released to the downstream reach. In the second reach, retention was not as long due to problems in maintaining the seal at the lower end of the pipe.

The pH of the solution in the pipe was monitored during treatment, see reference [3] for equipment and procedure for pH measurements. The pH of the fresh solution was 0.4. During application, the solution was diluted and partially neutralized by alkaline drainwater and further neutralized by reaction with the carbonate deposits, which increased the pH. The solution had a pH of 7.0 when it flowed into an open ditch about 914 m (3000 ft) downstream from the treated sections. The pH values at locations before and after treatment (fig. 1) are shown in table 3.

A mild reaction of the acid solution at the concrete manholes was observed during treatment. Inspection of the surface of the concrete following treatment determined that the structure was not significantly affected by the acid solution.

About 60 m (200 ft) below the drain outfall, a site was located where a dam could be constructed to hold the used treatment solution for further neutralization by sodium carbonate or diluted. Workers were prepared to construct a small earth dam with a backhoe on short notice during the acid application. As it turned out, the dam was not needed, and no significant environmental impacts to Pavillion Pond occurred.

An hour after the treatment solution was pumped into the upstream manhole, seepage was noted at the effluent pipe in manhole C (fig. 1), indicating that the plug in the upper section of the drainage pipe had broken down on contact with the solution. About 0.33 $m^3$ (11.6 $ft^3$) of sand was observed in the downstream manholes after the treatment, which indicated that the calcium carbonate deposits had contained large amounts of immobilized solids.

On the day following treatment, the district used a sewer jet cleaner to partially flush the treated pipe. The jet hose was worn so the entire reach could not be cleaned, but enough of the drain was flushed to prove that the acid had broken down much of the

Table 3. – Solution pH values before and after treatment.

| Location (fig. 1) | pH values | | | |
|---|---|---|---|---|
| | Before treatment | | After treatment | |
| | Nov. 10, 1982 | Mar. 28, 1983 | Mar. 28, 1983 | Mar. 29, 1983 |
| A | | | 0.4 | |
| B | | | 0.4 | |
| C | | 7.7 | 1.0 | |
| D | | 7.7 | 6.1 | 6.4 |
| E | | | | |
| F | 7.9 | 7.8 | | |
| G | 7.8 | 7.9 | | 7.0 |
| H | | | | 7.7 |
| I | | | | 7.8 |
| J | | | | 7.6 |
| K | 7.9 | | | |
| L | 8.3 | | | |

deposit. Loose material, consisting of sand and gravel, was shoveled from the downstream manholes. On April 28, 1983, the district flushed the entire pipe.

During the 1983 irrigation season, the water table did not back up as it had the year before, and the drainpipe had a continual flow. To determine the full extent of the rehabilitation, the district excavated a section of treated pipe along the second (lower) reach on October 11, 1983. Examination of the pipe revealed that the inside was stripped clean, but the bell-and-spigot joints were still plugged. Also, there were signs that calcium carbonate and iron bacterial buildup was reoccurring.

## EQUIPMENT AND COSTS

The Midvale Irrigation District provided the equipment and manpower for the treatment operation. A Myers MHV6 High Velocity Sewer Cleaner was used to flush the drains the day after treatment. During treatment, the 5678-L (1500-gal) water reservoir on the sewer jet was used for a water source. The 1136-L (300-gal) aluminum tank, used for mixing the treatment solution, and a pump with an attached 5-horsepower gas motor were mounted on a flatbed truck. Two pickup trucks and a backhoe were also used.

The cost for the acid treatment was $1,634.80. Table 4 lists the costs for drain treatment materials, equipment, and labor. Preliminary investigations cost $536.00. The April sewer jet costs ($242.00) would not have been necessary if the jet hose had been in good repair for the March 29 cleanout work. Also, the costs for the cleanout on March 29 would have been cut by 50 percent if the jet hose had been in good repair.

## DISCUSSION

Before acid treatment, portions of the Pavillion area drainage pipe were completely plugged by sand and calcium carbonate-iron bacteria mineralization. Figure 3 shows a cross section of the clogged pipe about a year before treatment and after sand had been washed out of the pipe by flushing. Clogging caused poor drainage and crop loss during the 1982 irrigation season.

Flushing plugged drains with 10 percent sulfamic acid-sodium chloride solution in the North Pavillion area of the Riverton Project was considered successful and is recommended where similar problems occur. Some suggestions for a more effective treatment arose from this experience, and are:

(1) A longer retention time (such as overnight) or a second treatment with a much smaller concentration of acid should be considered to allow for penetration of the treatment solution into the pipe joints.

(2) Warmer water would improve the solubility of the sulfamic acid and decrease the solution preparation time; a larger mixing tank would reduce the number of batches required.

(3) Inner tubes used to seal the 200-mm (8-in) diameter pipe leaked and were judged inadequate. A rubber basketball provided a satisfactory seal, but the ball needs to be braced against the head pressure of the treatment solution.

Further comparison by spraying the solution into the drains with a high-velocity sewer jet as opposed to flooding the drains is recommended. Solution jetting may provide mechanical penetration of the pipe joints, but flooding may still be required as an initial

Table 4. – Costs for drain treatment materials, equipment, and labor[1].

| | | |
|---|---|---|
| *February 8, 1983* (Investigation) | | |
| Material: | 3.05 m (10-ft) section of pipe and 3.8 $m^3$ (5 $yd^3$) of sand/gravel | = $50.00 |
| Equipment: | Drott Backhoe at $30.00/h (6 h) | = 180.00 |
| Labor: | Two laborers at $7.75/h (8 h) | = 124.00 |
| | | $354.00 |
| *March 28, 1983* (Treatment) | | |
| Material: | Sulfamic acid, 544 kg (1200 lb) at $33.00 per 23 kg (50 lb) | = $792.00 |
| | Sodium chloride, 272 kg (600 lb) at $1.75 per 23 kg (50 lb) | = 21.00 |
| Equipment: | Three vehicles at $0.31/mi (60 mi) | = 55.80 |
| Labor: | Four laborers at $7.75/h (8 h) | = 248.00 |
| | | $1,116.80 |
| *March 29, 1983* (Clean out) | | |
| Equipment: | Sewer jet cleaner at $45.00/h (6 h) | = $270.00 |
| Labor: | Four laborers at $7.75/h (8 h) | = 248.00 |
| | | $518.00 |
| *April 28, 1983* (Clean out) | | |
| Equipment: | Sewer jet cleaner at $45.00/h (4 h) | = $180.00 |
| Labor: | Two laborers at $7.75/h (4 h) | = 62.00 |
| | | $242.00 |
| *October 1, 1983* (Investigation) | | |
| Equipment: | Drott Backhoe at $30.00/h (4 h) | = $120.00 |
| Labor: | Two laborers at $7.75/h (4 h) | = 62.00 |
| | | $182.00 |
| | Total | $2,412.80 |

[1] Costs incurred for environmental investigations, technical assistance, and supervision are not included in the costs.

step. If corrosivity of the jetting pump is of concern, the solution could be introduced on the effluent side of the high-pressure pump by aspiration from 568-L (150-gal) stainless steel reservoir on the sewer jet truck. However, reaching the desirable acid concentration may not be possible using aspiration. Since sulfamic acid is less corrosive to most metals than other acids and its saturation concentration in water is comparatively low, 18 percent at 20 °C (68 °F), it may be more practical to add it directly to the sewer jet main water tank and to flush the system after use. If this method is used, consideration should be given to excluding sodium chloride from the mix to reduce corrosion of the tank and pump.

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[2] *Sulfamic Acid Product Information*, E. I. DuPont De Nemours and Co., Inc., Wilmington, DE.

Figure 3. — Cross section of clogged, 200-mm (8-in) diameter, drainage pipe prior to acid treatment at STA 11+88.72 m (Sta. 39+00 ft). P801-D-80900


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## APPENDIX

## DETERMINATION AND CALCULATION OF QUANTITIES FOR TREATMENT MIXTURE

### Determination of Quantities for Preparation of Treatment Mixture

Since 1 L (0.26 gal) of water weighs 1 kg (2.204 lb), 1136 L (300 gal) would weigh 1136 kg (2504 lb). As 6.6 percent sulfamic acid and 3.3 percent salt were needed for the 10 percent chemical mixture, about 75 kg (165 lb) of acid and 37 kg (82 lb) of salt were required for each 1136-L (300-gal) batch. However, the tank was not completely filled each time and, for convenience's sake, 3 bags of acid weighing 68 kg (150 lb) and 1.5 bags of salt weighing 34 kg (75 lb) were used per batch.

### Calculation of Batch Quantities Required for Treatment

The quantity of solution needed was calculated by estimating the volume of the 182.9-m (600-ft) reach of 250-mm (10-in) pipe to be treated by using the standard formula for volume:

$$V = \pi r^2 h$$

where:

$V$ = volume in cubic meters (cubic feet),

$\pi$ = 3.14159...,

$r$ = radius of pipe in meters (feet), and

$h$ = length of pipe in meters (feet).

Therefore,

$$V = \pi\,(0.127)^2\,(182.9) = 9.268\ \text{m}^3 = 9268\ \text{L}\ (2448\ \text{gal})$$

GPO 847 - 150

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