

CHAPTER VIII

THE DUMAN TREATMENT PLANT

BACKGROUND

In July 1969 the Barnes and Tucker Company suspended active operation of the Lancashire #15 mine. Dewatering stations at Dutch Run and Duman's Dam were closed down and the mine began filling with water. The rising pool level gradually extended its reach from the synclinal basin beneath Duman's Dam through the extensive workings of the mine and finally to the west bank of West Branch near Watkins.

The first discharge found flowing from this pool was through the Buckwheat borehole. This discharge was discovered on June 30, 1970 and during the week of July 5, 1970 this borehole was sealed. At that time, treatment was initiated at the Maberry boreholes by the Barnes and Tucker Company (see photos in Figure VIII-1).

On July 22, 1970 a large breakout consisting of numerous seepages was discovered downstream from the Maberry boreholes near Watkins. Since these seeps were at the base of a hillside close to the river and extended over several hundred feet, collection and treatment of this water in situ was impossible. (See photo of part of breakout area in Figure VIII-1).

The company then proposed a plan for resumption of pumping at the Duman's Dam site which resulted in construction of the present Duman treatment plant.

TREATMENT PLANT FACILITIES

The Duman plant is a conventional lime neutralization-sludge settling facility utilizing simple unlined excavated ponds with straight-through flow as settling basins. Flow sheets for the operation are presented in Figure VIII-5a and 5b. Photographs of several sections of the plant are presented in Figures VIII-1, 2 and 3. Location of the plant is shown on the map in Figure VIII-4.

The plant is designed for a maximum pumping and settling capacity of 10 MGD. Aeration (oxidation) capacity, however, is very low, since no adequate power aerator equipment was ever installed.

DESCRIPTION OF UNIT OPERATIONS

a. Pumps

Two 3500 gpm, constant speed Worthington vertical turbine deep well pumps, Model No. 15-H-277, 5-stage, 1760 RPM, provide the capability of delivering a total of 10 MGD of raw water from the mine pool bottom at a depth of 460 feet at 1700' elevation. Each pump has a rated capacity of 2,500 GPM at 500 ft. total dynamic head at 1750 rpm and 80% efficiency. At the 1440 ft. pool operating level, the working dynamic head is 260 feet. This pumping capacity has been adequate for pool level control since the start of pumping operations on October 31, 1970. Pumping records for the year 1971 are included in Appendix C. This data is reproduced in graphical form in Figure VIII-6.

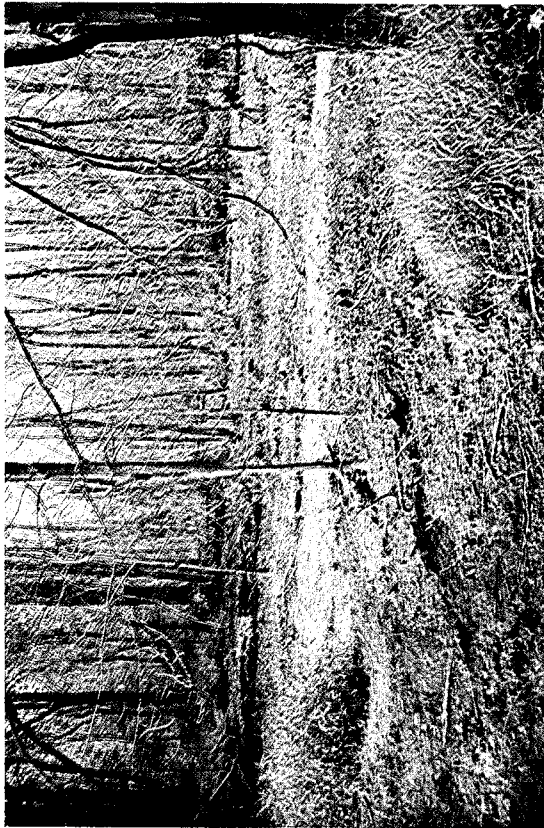
Available data indicates that in one year of operation (from March 1971 through February 1972) the pool level was lowered approximately forty feet at an average pumping rate of approximately 8.7 million gallons per day. It also indicates that maintenance of the pool level at elevation 1480 (low enough to prevent flow from the breakout) required a pumping rate of approximately 7.7 MGD. At this rate, with one pump operating full time, the second pump operated at an average of eleven hours per day.

The pumps have demonstrated that they are capable of controlling pool level at any elevation down to about 1430 feet, so that adequate storage capacity is available in the event of a power failure or other breakdown. A photograph of the pumping station is shown in Figure VII-16 in Chapter VII.

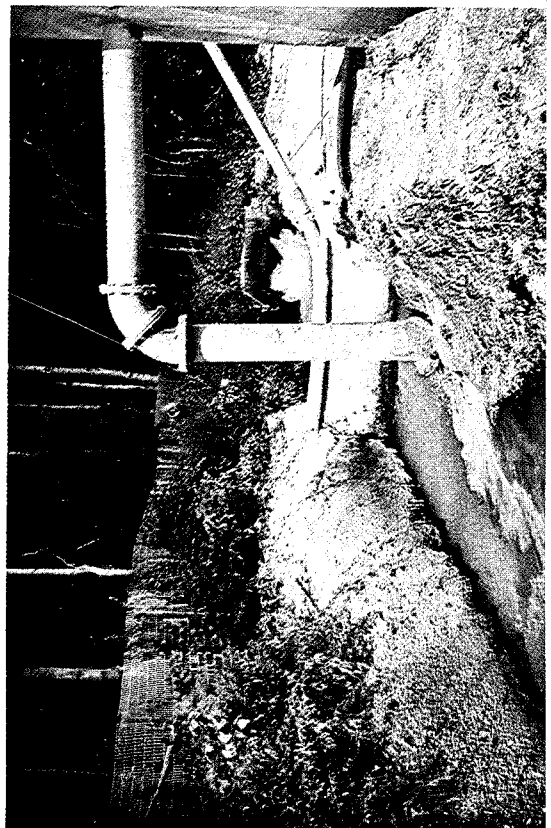
b. Transmission Lines

Two 20" transite pipelines transfer the acid water from the top of the boreholes up a grade for open discharge into the transfer ditch which starts at an elevation of about 40 feet above the pumps and the treatment ponds. The raw mine water has a strong blue coloration and a strong odor of hydrogen sulfide. All raw water (influent) samples were taken at this pump discharge point.

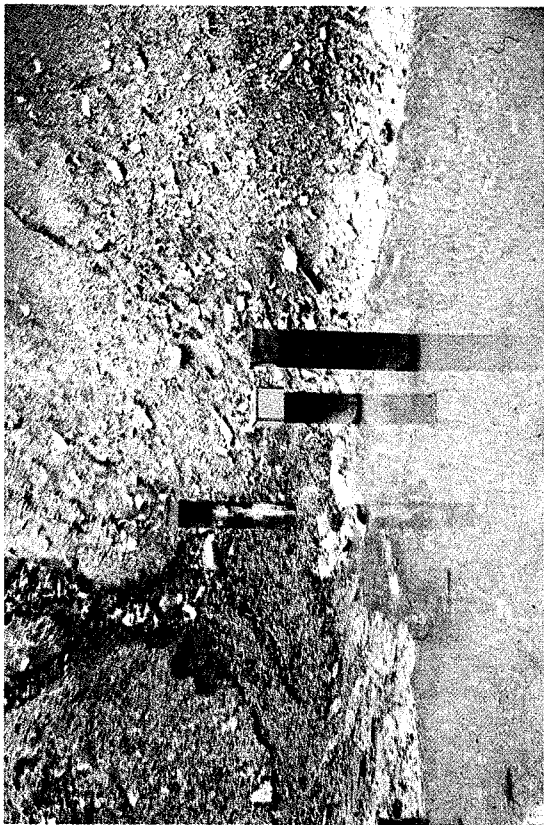
FIGURE VIII-1



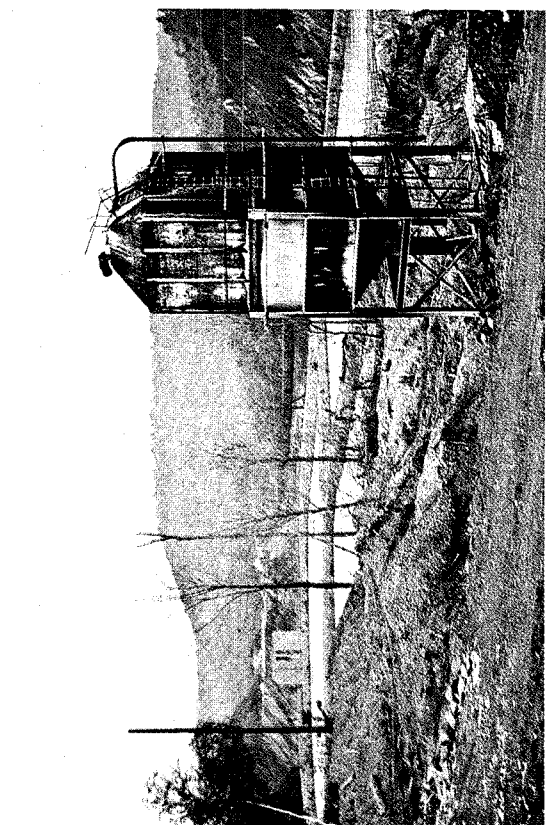
Breakout area near Watkins



Raw pool water pumping at Duman's plant

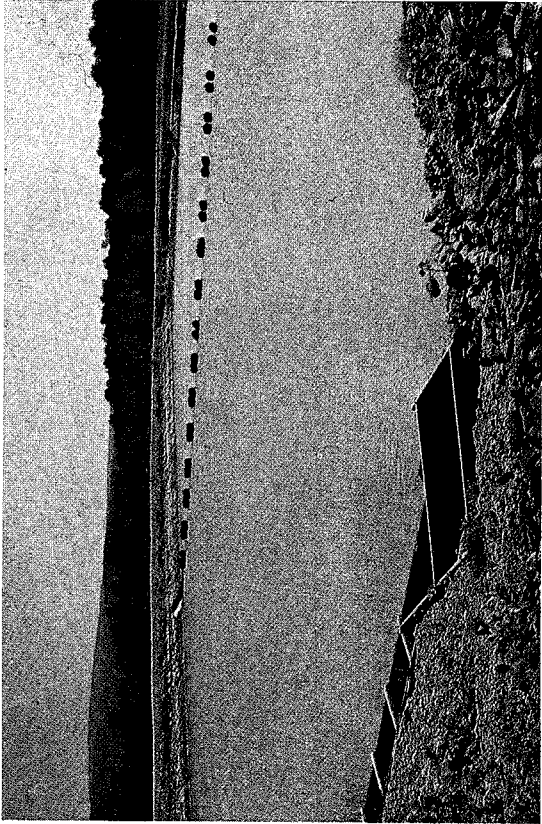


Maberry borehole - Lancashire #15

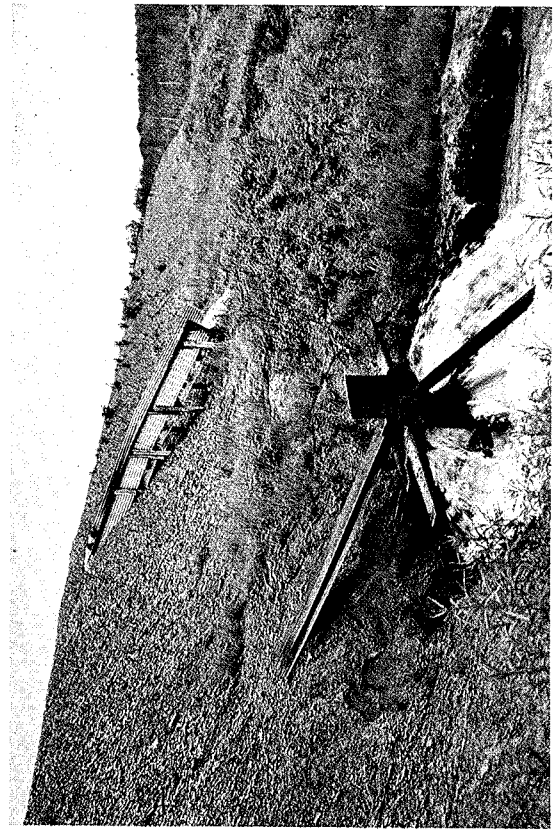


Maberry borehole emergency treatment facility

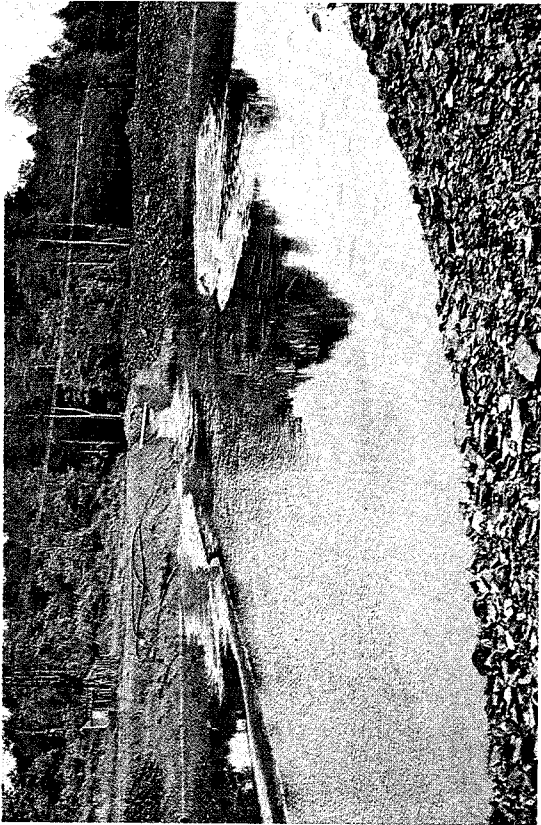
FIGURE VIII-2



Duman's alternate settling pond



Duman's effluent channel into Crooked Run

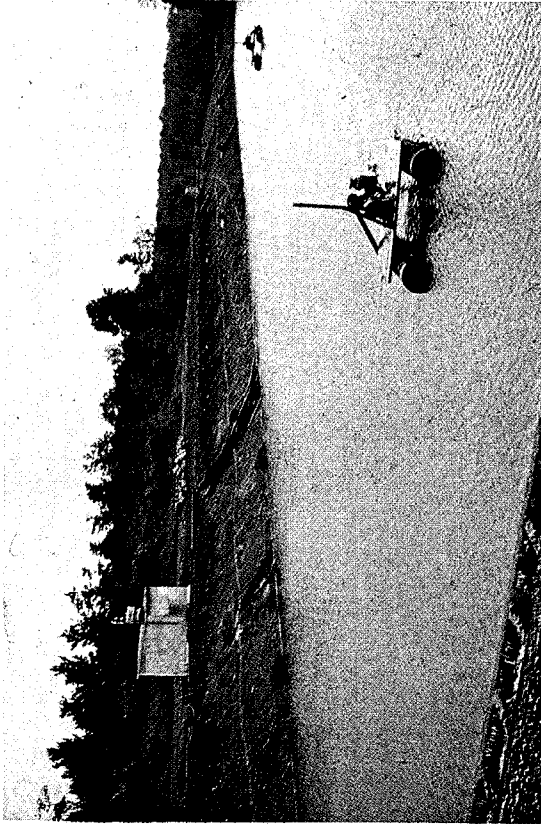


Duman's treatment plant aeration pond

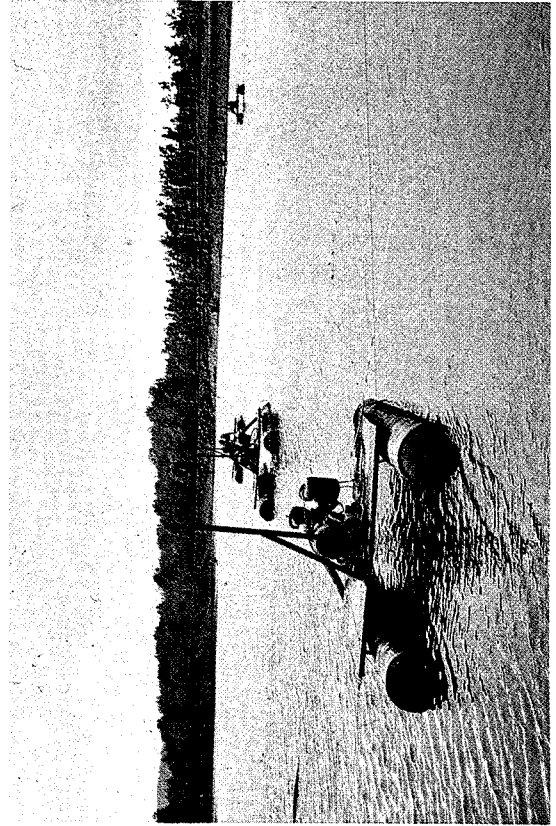


Duman's clarifying pond with a stand pipe

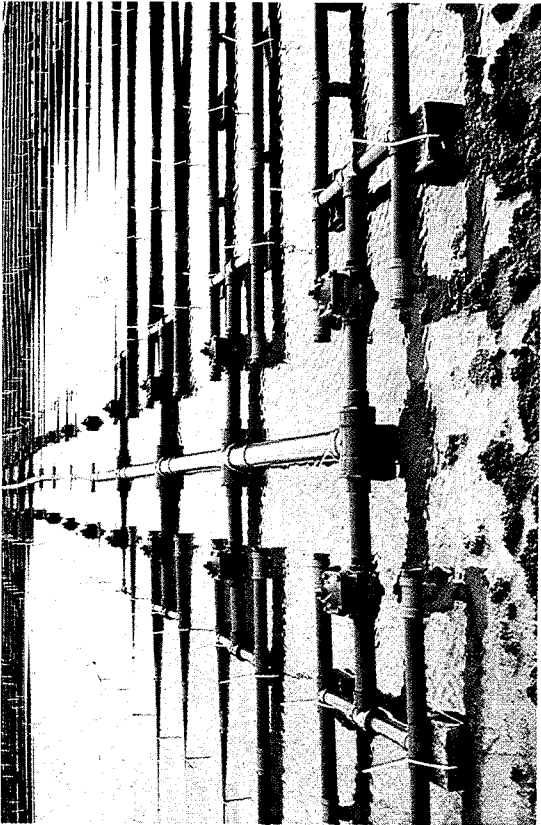
FIGURE VIII-3



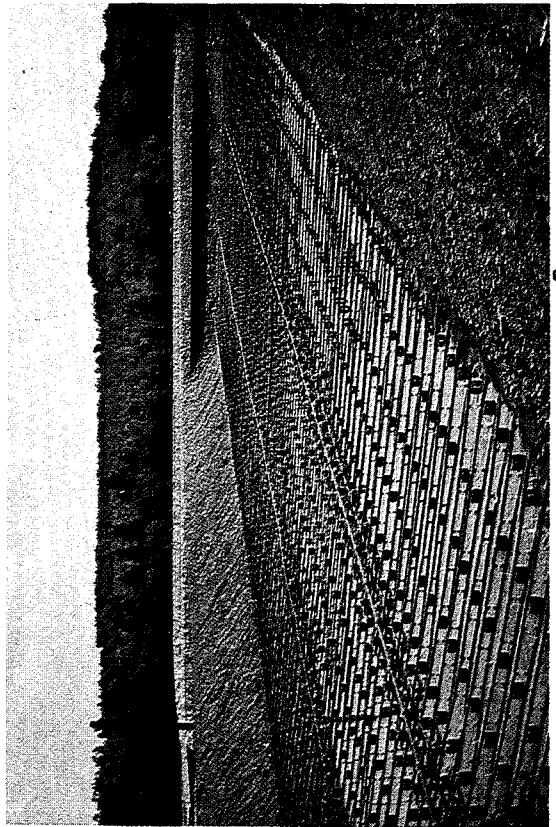
Sludge pumps and booster pump house arrangement



Sludge pump close-up showing positioning cables



Hydra sludge suction pipes and manifolds



Hydra hydraulic rake static thickener installation

c. Lime Handling Facilities

A 100 ton pebble lime storage bin located about 50 feet from the pump discharge supplies a lime feeder having a capacity of 100 pounds per minute or 144,000 pounds per day. Lime is slaked and fed by pipeline into the transfer ditch (see photo in Figure VIII-1). Lime feed capacity is sufficient to neutralize about 230,000 ppd acidity, and has been adequate at pumping rates experienced thus far. Analyses of plant effluent samples taken December 1970 to December 1971 yielded zero (0) acidity in virtually all cases except for a brief period during the summer. There is usually excess alkalinity in the effluent which flows into Crooked Run, the immediate receiving stream.

The lime feeder system equipment requires frequent adjustments and short periods of maladjustment have resulted in plant effluents with high acidities. No automatic pH control facilities are used. Lime is fed normally at a constant rate of about 50 tons per day when the pumping rate is 8 to 10 MGD.

d. Transfer Ditch

Since the company did not own land adjacent to the pumping station, it was necessary to install a 2,800 foot transfer ditch across a right-of-way to reach company property of sufficient acreage to accommodate the settling ponds. This ditch has a gradient of about 10 ft./1000 ft., hence a good flow velocity is maintained throughout its full length while transferring the neutralized raw water to the aeration pond. Several aerating weirs were installed originally near the end of ditch where it discharges into the aeration pond, but these did not prove to be effective. (See photo in Figure VIII-2).

e. Aeration Pond

The aeration pond is an earth excavation with dimensions of 96 feet by 96 feet with a maximum liquid depth of 15 feet and 4 feet of freeboard. This part has an embankment slope ratio of 1:2. Its capacity is 690,000 gallons.

Mechanical aeration was originally attempted with two 10 H.P. floating aerators having a capacity of 68 lbs. O_2 /hour. For a mine water flow rate of 10 MGD

at 1000 ppm ferrous iron, 500 lbs. O_2 /hour are required, which explains the poor oxidation performance obtained. These small aerators were removed after a short period of operation. "Natural" aeration has since been employed. As a result, oxidation of ferrous iron to the ferric state occurs slowly throughout the following settling ponds.

The aeration pond has no sludge removal equipment, but receives the continuous heavy load of precipitated ferrous hydroxide from the transfer ditch. After 18 months of operation, this pond is almost completely full of sludge and is nothing more than a channel through which the neutralized water flows to the settling ponds. (See photo in Figure VIII-2).

f. Settling Ponds

There are two identical settling ponds designed to be used alternately as one or the other requires cleaning. The dimensions are 450 feet long by 220 feet wide with a water depth of 15 feet and 3 feet of freeboard. Inside slopes are at a 1:2 ratio. The capacity of each pond is 9,000,000 gallons. At the maximum flow rate of 10,000,000 gallons per day this allows 21.6 hours detention time. These ponds are provided with half-length influent and effluent overflow weirs on opposite ends. (See photo in Figure VIII-2).

Without power aeration (and the consequent slow continuous oxidation of the iron to the ferric state), the detention time is usually too short to allow good settling of the dispersed oxidized iron precipitate. Most of the settled sludge which is pumped underground is dark green, unoxidized ferrous hydroxide.

Five 300 GPM sludge pumps are floated on the pond and remove sludge from the pond bottom through flexible suction hoses. The pumps are moved by manually pulling attached cables (see photos in Figure VIII-3). The suction lines must be periodically raised by an operator from a boat and moved to a new area of accumulated sludge.

These pumps deliver sludge through plastic pipe to a 800 GPM booster sludge pump located in a small pump building on the pond berm.

Because of the small area and high flow at the sludge suction hose opening, the settled sludge on the bottom of the pond quickly "rat-holes" with the result that a highly diluted sludge is removed from the pond a major portion of the time. This type of sludge handling creates excessive return flow to the underground pool which recycles immediately to increase

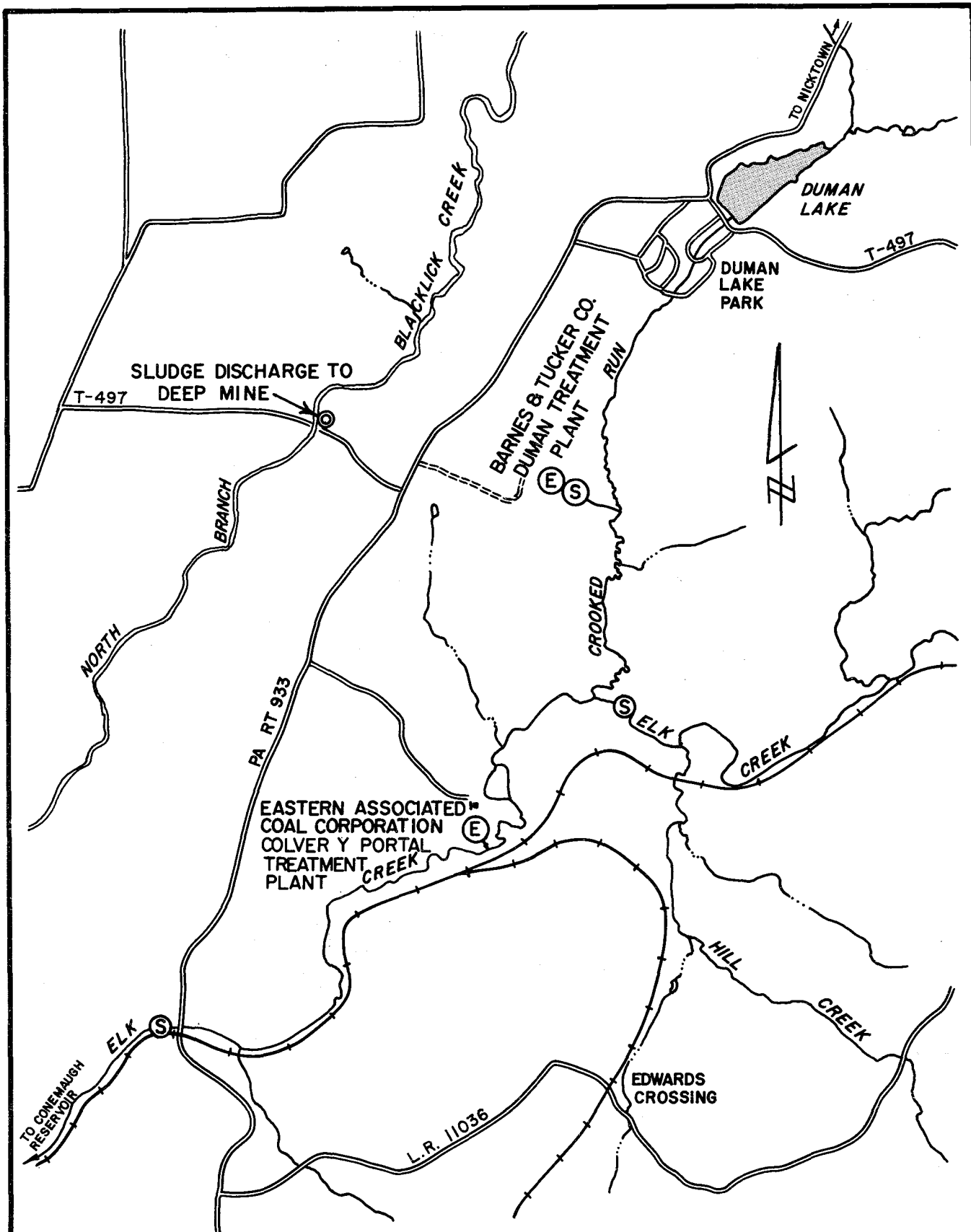


FIGURE VIII-4
WEST BRANCH - RELATED A.M.D.
TREATMENT PLANTS DISCHARGING
INTO THE ELK CREEK DRAINAGE BASIN

LEGEND
 (E) EFFLUENT FROM TREATMENT
 (S) SAMPLING POINT

the load on the neutralization section. Replacement of this system could result in significant savings in overall treatment costs (see further discussion in Recommendation section of this chapter).

g. Polishing Pond

The settling pond effluent flows to a influent distribution weir in a 5,000,000 gallon polishing lagoon. This lagoon is 300 feet long and 255 feet wide with a water depth of 15 feet and 3 feet of freeboard.

At maximum draw from the mine pool of 10,000,000 gallons per day, with 2,000,000 gallons returned as sludge from the settling pond, the flow through the lagoon is 8,000,000 gallons per day. At this flow rate the nominal detention time is 15 hours. However, this pond has been provided with a 24 inch perforated decantation pipe which permits a high degree of short circuiting of both water and solids, thus greatly reducing the pond's settling efficiency. Overflow is handled by two adjacent 12" pipes, which create high inlet velocities entraining appreciable amounts of suspended solids (see photo in Figure VIII-2). The effect of these inadequate overflow facilities is to discharge an excessive amount of suspended, insoluble iron hydrates into the receiving stream, creating a bad visual aesthetic effect. The actual pollutant effect on the receiving stream is insignificant as will be discussed in a later section. The settling efficiency of this pond could be improved greatly by installing a larger diameter solid wall decantor and/or a full length overflow weir at the discharge end of the pond.

h. Sludge Disposal Facility

Sludge is delivered by the floating sludge pumps through flexible plastic lines to a receiving tank which acts as a feed tank for the booster sludge pump. This is a Barrett Haentjens 6" Type VNM pump operating at 1780 rpm using a 100 H.P. motor. The pump discharges into a 6" sludge syphon line which transports the sludge 3000 feet to the borehole. This returns the sludge to a remote corner of the old Lancashire No. 15 workings. The 6" line is Schedule 40 PVC pipe which has withstood working pressures up to 125 psi when the sludge return line was forced to handle 1.5 to 2.0 MGD during 1971. The piping arrangement for the siphon line is shown in Figure VIII-5b.

There is, at present, no means for determining the exact volume of sludge being returned each day to the mine pool.

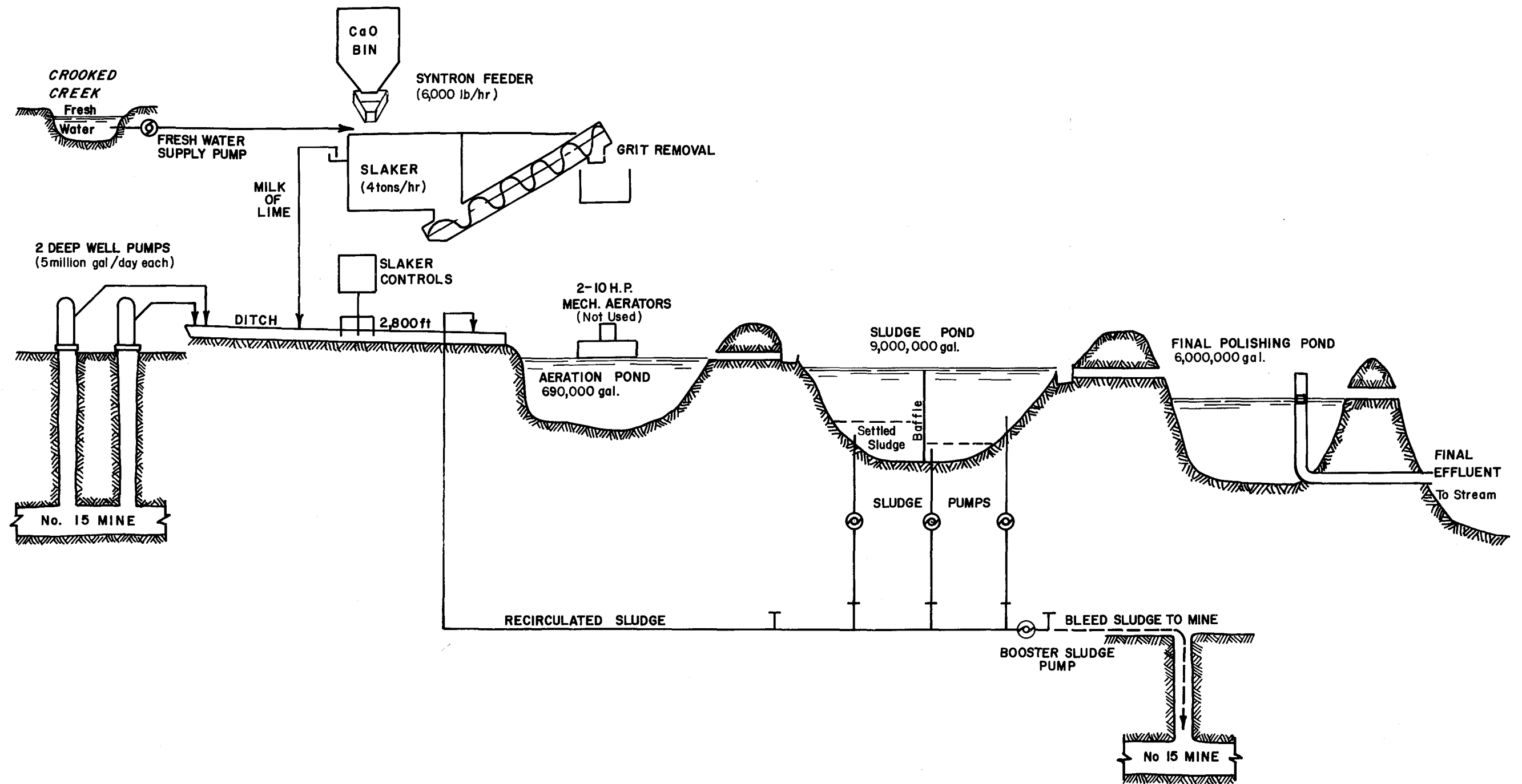


FIGURE VIII-5a
 NO 15 MINE-DUMAN WATER TREATMENT FACILITIES

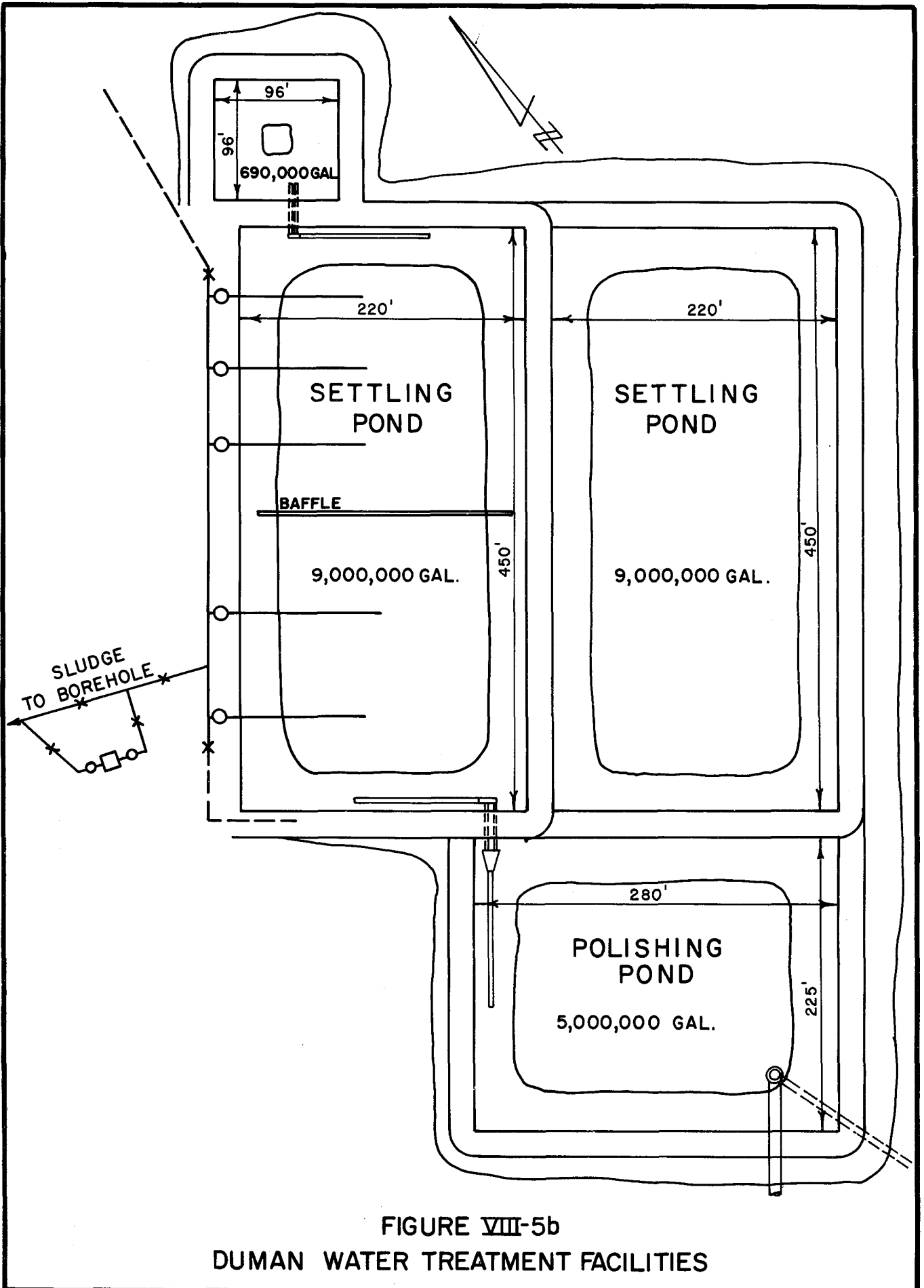
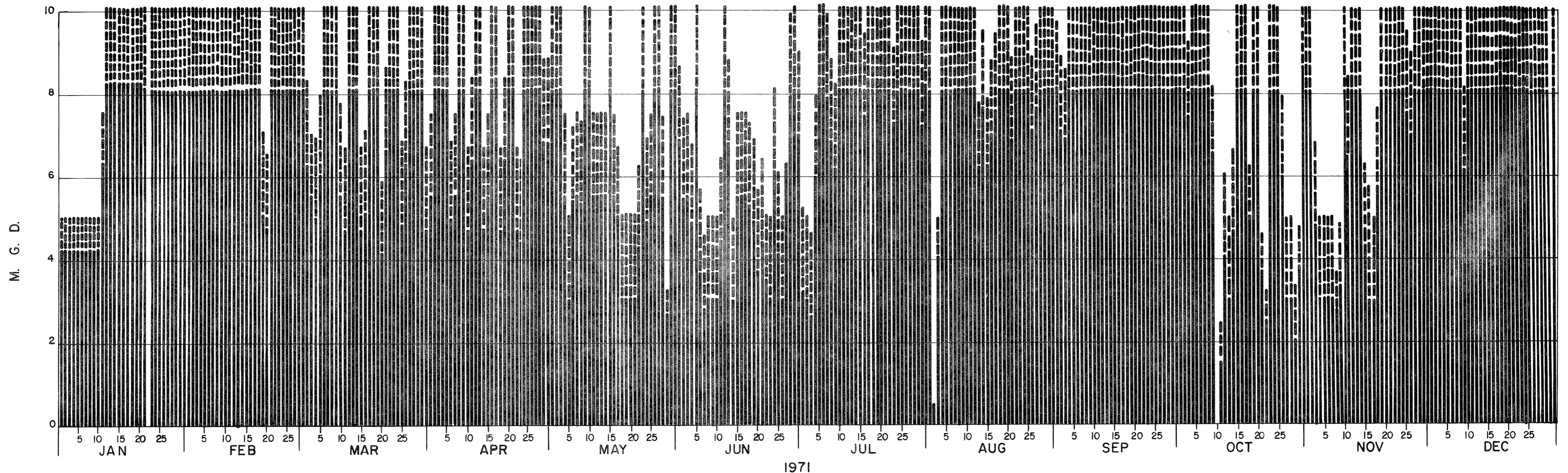


FIGURE VIII-5b
 DUMAN WATER TREATMENT FACILITIES



1971

NET DISCHARGE TO CROOKED RUN-ELK RUN

SLUDGE PUMPED BACK TO MINE POOL

PUMPING FLOW RATE
DUMAN TREATMENT PLANT

FIGURE VIII-6

OPERATING COSTS

During the period March - April, 1971 the Pennsylvania Department of Environmental Resources took over operation of the Duman plant. During this 62 day period, when the plant was operating at an average flow rate of 9 MGD, they compiled the following cost information:

1. Cost of Lime	\$ 95,853
2. Labor	
- Department	17,553
- Contractor	3,999
3. Equipment	
- Department	7,440
- Contractor	13,800
4. Electrical Power	11,680
5. Miscellaneous	<u>77</u>
TOTAL	\$150,402
Average Operating Cost Per Day	\$ 2,426

These costs do not include overhead or depreciation, and hence should be on the low side. The major cost element is the chemical cost (pebble lime at an average consumption rate of 68 tons per day) which is about 64% of total operating expenses.

In various cost discussions throughout this report, a rounded figure of \$2,500 per day has been used as a probable future daily operating cost under present operating conditions. On a 365 day per year basis, this daily cost is equivalent to \$912,500 per year, or \$100,000 per year per MGD treated.

CHEMICAL PERFORMANCE OF THE DUMAN PLANT

Chemical performance of the plant was monitored by taking daily samples of influent and effluent over the period December 29, 1970 through February 26, 1971. Thereafter, samples were taken on a weekly basis until December 2, 1971. The daily and weekly analyses and loadings are tabulated on pages C-1 through C-12 in Appendix C. An analysis of this data indicates the following overall removal efficiencies:

Acidity	98% Removal
Iron	75% “
Sulfate	45% “

These percentages, however, do not provide any real measure of pollution abatement duty performed by this plant. A more objective evaluation is obtained by discussing each item individually.

1. Acid Neutralization - except for the period June - July 1971, the plant did an excellent job of neutralizing all acidity, producing effluents with a pH usually above 8. Even during the abnormal operating periods, the effluent acidities did not exceed those of the receiving stream.
2. Iron Removal - on the basis of total iron analyses, the average iron removal efficiency was not good. The high iron values in the effluent are due largely to the presence of suspended hydrous iron oxides which did not settle out in the settling basins. A few analyses made for soluble iron actually indicate that chemical precipitation of iron was excellent, but physical removal was poor. On a day to day basis, iron removal varied from excellent to very poor. This erratic performance can be attributed to several operating factors:
 - a. when the plant was operating at nominal design capacity (5 MGD) at moderate temperature and wind velocities, performance was usually good, although only partial oxidation of the iron was being attained.
 - b. when the plant doubled its flow to 10 MGD, settling capacity was not sufficient to handle the slow settling flocs that continuously formed throughout the system because of incomplete oxidation in the aeration pond.
 - c. settling of iron flocs was significantly hindered by wind agitation and/or low temperature during the winter seasons.
 - d. The design of the effluent outlets in the final polishing pond was poor, with the result that this large settling area was often essentially ineffective.
 - e. the major difficulty with handling the large mass of iron precipitate involved is the use of the classical straight-through flow settling pond design, which use is unfortunately almost universal. The area provided in the settling ponds (250' x 450') is 112,000 sq. ft. which at a flow rate of 8 MGD (5,560 GPM) provides a nominal overflow velocity of

0.05 GPM/FT. This should permit excellent clarification under all conditions. However, some excellent research has been done in South Africa (16) which proves conclusively (and is borne out by almost everyone's experience) that the settling efficiency of this type of pond declines very rapidly for many obvious reasons in a matter of weeks, resulting in the evolution of a very low capacity settling unit.

The ultimate design for the ideal settling pond is almost identical with that for a conventional thickener. It can often be demonstrated that where high flows of high iron waters are to be neutralized, a thickener will prove to be the most efficient and economical equipment to use. The practicality of replacing these Duman settling ponds with a densifier is discussed in a subsequent section of this chapter.

- f. oxidation capacity in the Duman plant was nil from a power equipment standpoint. Oxidation requirements for each 1000 ppm Fe of a flow rate of 10 MGD are 500 lbs. of oxygen per hour, which would require the use of about twelve 20 H.P. floating aerators. Under the operating conditions existing at the Duman plant, it is really unnecessary (and even undesirable) to oxidize most of the iron. The aeration situation as it affects plant performance is discussed more fully in a later section.
3. Sulfate Removal - sulfate removal, although not important at the Duman plant, is really quite good because the sulfate in the influent usually greatly exceeds the calcium sulfate equivalent saturation level. An interesting observation here is that the effluents exhibit the property of being able to attain various degrees of supersaturation, although many effluent analyses probably reflect the presence of suspended gypsum crystals. An analyses of the typical dark green sludge showed the presence of about 15% $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$.

In general, the Duman plant has done an excellent job in performing its main function, which is to prevent excessive contamination of the upper West Branch by diverting Lancashire No. 15 deep mine water into the Allegheny watershed. It has also done a good job of neutralizing 8 to 10 MGD so that water quality in the Allegheny stream system has not been degraded. Several improvements could be made to attain a more consistent effluent quality which would meet the Clean Streams Act specifications, but the additional costs involved cannot really be justified on a water quality basis in view of the poor quality stream water into which the plant discharges. Several recommendations for improvements or changes made later are based primarily on attaining lower operating costs rather than higher chemical treatment efficiency.

EFFECT OF DUMAN PLANT EFFLUENT ON RECEIVING WATERS

One of the assignments added to this study was that of conducting a short range evaluation of the affect of the Duman plant effluent on the first major receiving stream, Elk Creek. The Duman effluent actually discharges into Crooked Run, a small neutral stream that is the outflow from Duman Lake. Crooked Run flows through a heavily wooded area and joins Elk Creek within a mile of the Duman plant outfall.

Subsequent evaluation of the situation indicated the desirability of having a full knowledge of the potential pollutant effects in the receiving waters downstream as far as Conemaugh Reservoir. This extension of coverage was carried out and has led to the development of information that could greatly affect the mode of operation and the costs of treatment at both the Duman and Eastern Associated plants.

Sampling Program

The effect of Duman's plant effluent on the receiving portion of Elk Creek was evaluated during the period December 29, 1970 through February 24, 1971. During this period, the quality of the Duman effluent underwent a gradual water quality transition from excellent to very bad insofar as total iron content was concerned, although the acidity at all times was zero. The high iron content of the effluent (primarily suspended hydroxide) was the result of increasing plant flow from 5 to 10 MGD, which was more than the settling ponds could handle in cold weather.

The locations of the sampling points were selected by State representatives. These are indicated in Figure VIII-4. The down stream sampling point was at the concrete bridge across Elk Creek on Route 271, about 2 miles north of Belsano. The creek waters at this point include the Eastern Associated treatment plant effluent waters, which were not sampled as part of the program. It was assumed that this plant was producing effluent containing zero acidity and less than 7 ppm total iron, and hence would not influence downstream water quality except for a slight dilution effect.

Individual sample analyses for Duman effluent are tabulated on pages C-1 to C-12 in Appendix C. Analyses for Elk Creek samples are on pages C-13 through C-15 in Appendix C. Average analyses for the Elk Creek and Duman effluent samples during the test period are compiled in Figure VIII-7.

Basic Evaluation of the Elk Creek Sampling Data

These data indicated an average downstream increase of 56 ppm of total iron and 532 ppm of sulfate. Average acidity, however,

FIGURE VIII-7

INFLUENCE ON DUMAN PLANT EFFLUENT ON WATER QUALITY IN ELK CREEK
AND LOWER WATERS

(for period December 29 to Feb. 24, 1971)

AVERAGE ANALYSES - PPM
(for period Dec. 29 to Feb. 24, 1971)

		<u>Upstream From Crooked Run</u>	<u>DUMAN EFFLUENT</u>	<u>Downstream From Crooked Run</u>
Acidity	- average	571	0	215
	range	168 to 1030	-	71 to 442
Alkalinity	- average	0	47	5
	range	0	20-190	0 to 14
Total Iron	- average	160	465	216
	range	54 to 310	0.3-1100	53 to 450
Sulfate	- average	642	2,740	1174
	range	182 to 1258	1700-3800	259 to 2100
pH	- average	3.2	9.54	4.5
	range	2.9 to 3.6	6.1-12.0	2.9 to 6.1

	<u>DUMAN EFFLUENT (June 9, 1972)</u>	<u>ELK CREEK DOWNSTREAM FROM CROOKED RUN (June 9, 1972)</u>
Acidity	62	406
Alkalinity	36	0
Total Iron	57	134
Soluble Iron	0.1	19
Calcium	624	376
Magnesium	83	44
Aluminum	---	25
Sulfate	2600	2330
Hardness	1900	1120
pH	6.4	2.8

	<u>BLACKLICK CREEK (YEAR 1970)</u>	<u>CONEMAUGH RIVER (RESERVOIR INFLOW) (YEAR 1970)</u>	<u>CONEMAUGH RESERVOIR EFFLUENT (YEAR 1970)</u>
Average Total Acidity	257	103	129
Total Acidity Range	128 to 503	23 to 222	51 to 199
Average pH	3.1	3.7	3.5
pH Range	2.30 - 3.35	3.05 - 4.56	2.6 - 4.3

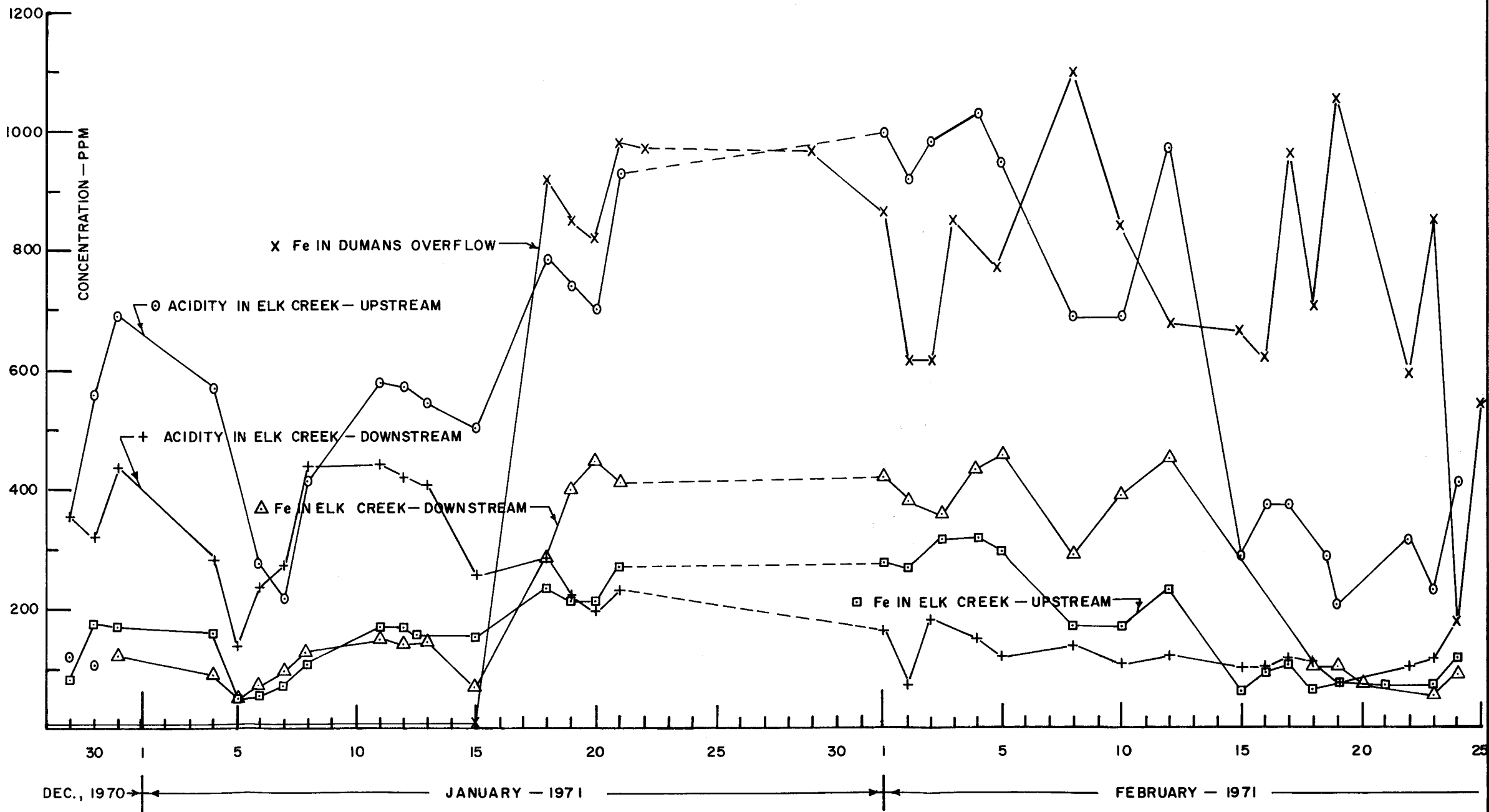
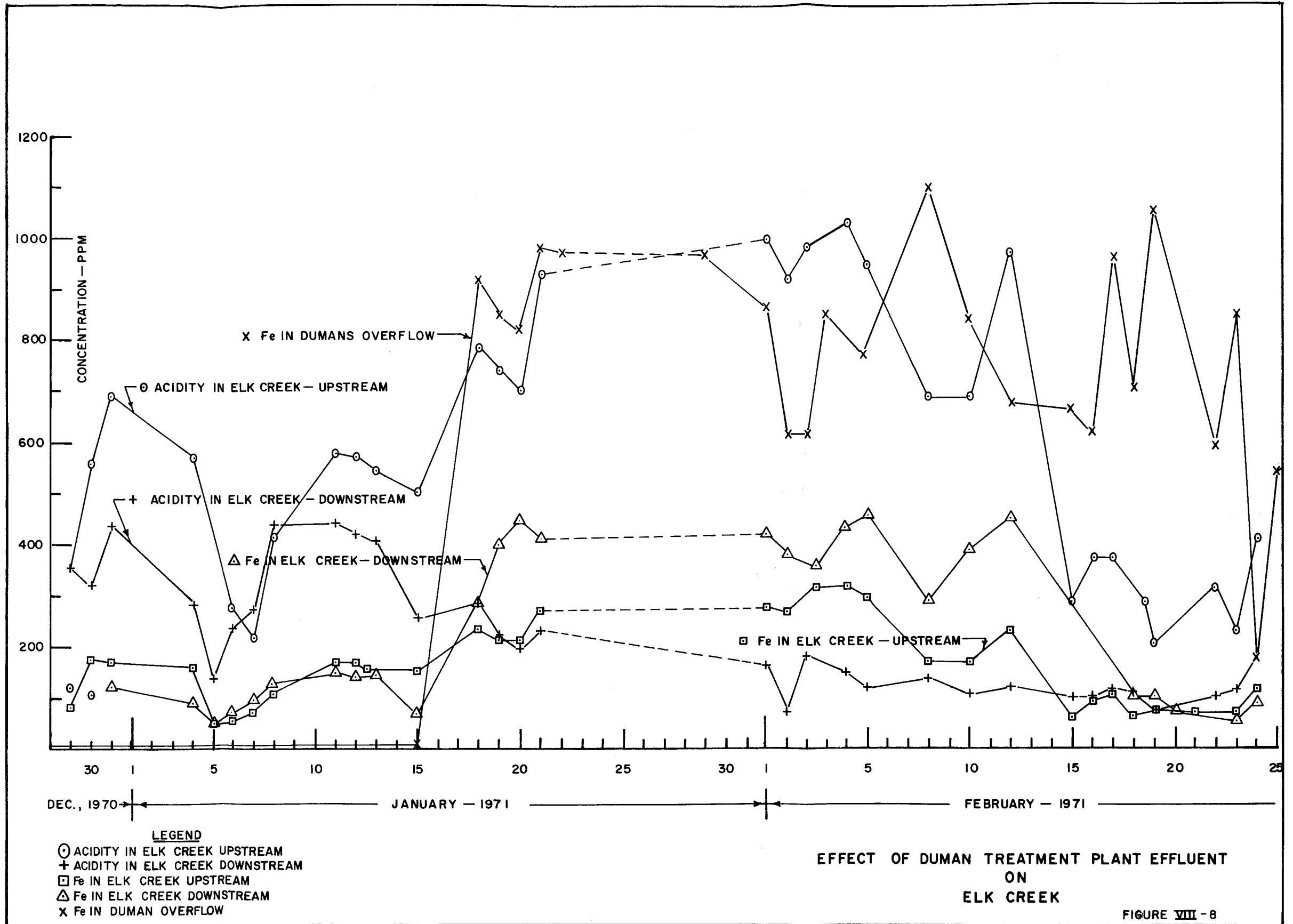
decreased by 356 ppm.

The daily analyses for iron and acidity for all 3 sampling points are plotted on Figure VIII-8. During this period the acidity on all samples of Duman effluent was 0 ppm. The iron plots show that during the period the Duman plant was operating within rated capacity (Dec. 29 through Jan. 13 at 5 MGD), the downstream total iron was usually slightly lower than the upstream values, thus indicating that no significant iron contamination was entering Elk Creek from any sidestream sources. However, when the Duman plant was overloaded (10 MGD pumping rate after Jan. 13), the total iron in the Duman effluent ranged from 600 to 1100 ppm. This was reflected by an apparent increase in total iron in the Elk Creek downstream sample, which averaged about 60 ppm higher than the upstream sample. Toward the end of the sampling period (Feb. 15 through Feb. 24), the downstream iron decreased to the upstream level, even though the iron in the Duman effluent was still greater than 600 ppm.

WATER QUALITY IN ELK CREEK

Before any meaningful evaluation of the impact effects of the Duman effluent on Elk Creek and its lower waters can be developed, it is necessary to characterize the quality of these receiving waters as accurately as possible. A summation of water quality data for the receiving stream system is presented in Figure VIII-7. Three sets of data are tabulated: (1) the average and range values for Elk Creek for the initial sampling period, (2) grab sample data for Elk Creek on June 9, 1972, and (3) data for water year 1970 for Blacklick Creek (the receiving stream for Elk Creek) which becomes a major feed stream for Conemaugh Reservoir. Data is also included for the Conemaugh River which also flows into Conemaugh Reservoir. A stream system schematic indicating stream point acid loadings is shown in Figure VIII-9. This data was furnished by the U.S. Army Corps of Engineers and is presented in its entirety on pages C-16 through 18 in Appendix C.

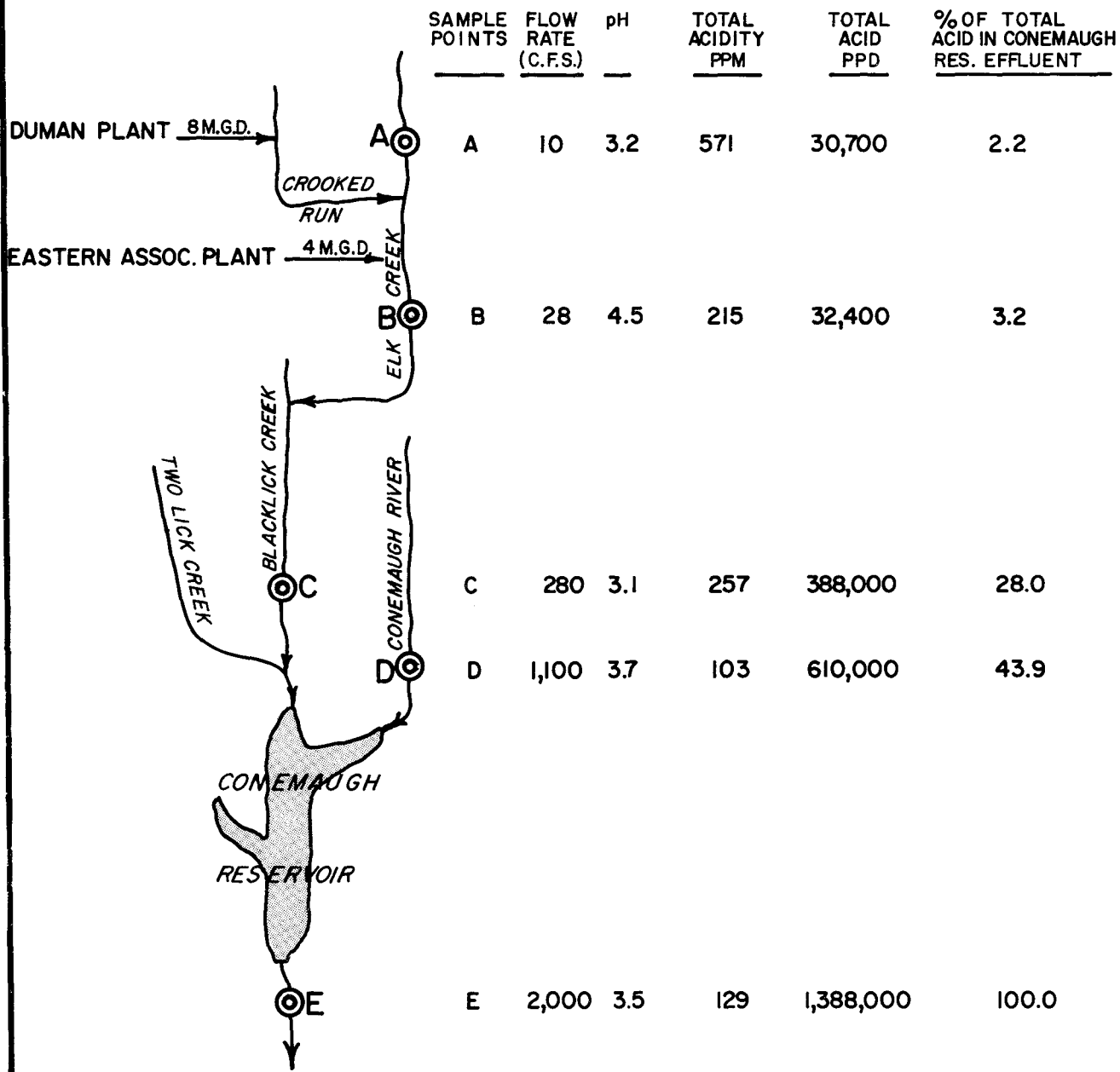
It is apparent from this study that Elk Creek is a very poor quality stream, the pollutant concentrations in which vary over a wide range. Its average acid loading upstream from the Duman plant is 30,000 ppd. Downstream from both the Duman and Eastern Associated effluent discharges Elk Creek merges with the large volume flow (280 cfs) of Blacklick Creek which has an average acidity of 257 ppm and average pH of 3.1. The pollutant loading in Blacklick Creek (388,000 ppd acidity) can easily swamp out any beneficial effects derived from the input of neutral effluent from upstream treatment plants.



LEGEND
 o ACIDITY IN ELK CREEK UPSTREAM
 + ACIDITY IN ELK CREEK DOWNSTREAM
 □ Fe IN ELK CREEK UPSTREAM
 △ Fe IN ELK CREEK DOWNSTREAM
 X Fe IN DUMAN OVERFLOW

EFFECT OF DUMAN TREATMENT PLANT EFFLUENT ON ELK CREEK

FIGURE VIII-8



- NOTES:
1. DATA COMPILED FROM WATER RESOURCES DATA FOR YEARS 1969-1970
 2. TOTAL ACIDITIES AND pH'S ARE AVERAGE VALUES FOR LARGE NUMBER OF SAMPLES.
 3. AN ACIDITY OF 200PPM IN DUMAN PLANT EFFLUENT WOULD GIVE A TOTAL ACID LOADING OF 13,000 PPD = 1.0% OF TOTAL AT CONEMAUGH RESERVOIR EFFLUENT

FIGURE VIII-9
EFFECT OF DUMAN PLANT
ON
ELK CREEK AND CONEMAUGH RESERVOIR

The most obvious pollutant effect in Elk Creek is the presence of suspended ferric hydroxide in the fast moving waters which gives the stream a deep red coloration. The analyses for June, 1972 illustrate an important point in evaluating iron contamination for various streams. On the basis of a total iron determination, both the Duman effluent and the Elk Creek sample show very high iron pollution. The soluble iron analyses, however, are much lower and are the actual significant pollutants. Total iron values in fast moving or turbulent streams is actually a meaningless parameter, since it is largely a measure of turbidity due to local agitation of bottom sediments having no quantitative relationship to any chemical stream balance that one tries to establish for impact evaluation purposes.

Effect of Duman Plant Effluent on Elk Creek and its Lower Stream System

On the basis of the information developed in this study, the following conditions are found to exist regarding the effect of Duman effluent (or Eastern Associated effluent) on Elk Creek.

1. despite the variable operating conditions experienced at the Duman treatment plant during its first two years of operation, the effluent water quality has never been poor enough to degrade the receiving waters in Elk Creek.
2. total iron loadings in Duman effluent as high as 1000 ppm (primarily suspended ferric hydroxide) had no significant effect on total iron loadings in Elk Creek over the two month sampling period. For reasons mentioned above, total iron measurements as an index for contamination in this case are meaningless.
3. using acidity and pH as the most reliable pollutant indices, any plant effluent entering Elk Creek having average acidities, less than 200 ppm will have no effect on water quality in Elk Creek or Conemaugh Reservoir. This is based upon the fact that both Elk Creek and Blacklick Creek have average "natural" acidities greater than 200 ppm.
4. a Duman effluent of 8 MGD at 200 ppm acidity would contain an acid loading of 13,000 ppd. This would increase the acid loading in the effluent from Conemaugh Reservoir by less than one percent.

The generally, poor quality of the water in the receiving watershed should provide a basis from which a much less stringent set of

effluent criteria could be established for Duman and Eastern Associated treatment plant effluents. This possibility, together with its economic ramifications, will be discussed in a subsequent section of this chapter.

RECOMMENDED CHANGES IN OPERATION

Basic Premises

The recommendations for changes in the Duman plant operations are based upon the following assumptions and suggestions which the data from this study indicate are realistic and worthy of consideration:

1. water quality for Duman effluent should not be required to be any better than the average quality of the water in Blacklick Creek. Money spent for attaining a higher quality is a useless waste of funds.
2. under present stream conditions, water quality in Blacklick Creek is very poor, with acidities averaging 257 ppm and total acid loadings averaging 388,000 ppd. Until such time as water quality in Blacklick Creek improves, Duman effluent could be permitted to run as high as 200 ppm acidity without causing degradation to either Elk Creek or Blacklick Creek.
3. the acceptance of the above suggested variance for Duman effluent quality immediately permits consideration of the substitution of limestone for lime as the neutralizing agent at the Duman plant without the need for costly aeration equipment.
4. other phases of this study have indicated several ways in which the quantity of raw water being neutralized can be greatly reduced, and the quality of the influent water improved. These will hopefully be implemented.
5. improvements in sludge handling techniques should result in appreciable savings in labor costs and costs of treating excessive quantities of recycle water.

On the basis of the premises outlined above, the following recommended changes in operations should result in the cost savings of the orders cited.

List of Recommended Changes

The changes suggested are listed briefly on the flow schematic in Figure VIII-10. A more detailed discussion of most of these topics will be found in the following text and under the quick-start projects which involve them.

Benefits to be Derived:

The cost savings and other benefits which may be realized by adopting the above recommended changes are discussed below briefly on a unit operations basis.

Raw Water Pumping:

The potential for decreasing pumping requirements for the Duman plant are discussed fully in Chapter IX and in Quick Start Project No. 2. It appears possible to decrease the amount of water treated by 2 to 3 MGD. The savings to be made by decreasing flow rate are approximately \$90,000 per year per MGD treated.

Neutralization:

Switching from chemical pebble lime (at \$27/ton delivered) to waste limestone product (at \$7/ton delivered) represents a difference in equivalent CaO basicity of about \$13 per ton of pebble lime replaced. At the current lime usage of 50 tons per day, limestone substitution could save a possible \$650 per day or about \$240,000 per year.

Lime neutralization, without the use of special equipment, will not produce water which will meet the Clean Streams Act quality criteria. However, it will produce water which is of a better quality than that in Elk Creek. Thus, if the State will allow a variance on Duman effluent quality of the order suggested, limestone neutralization could be instituted immediately without requiring extra equipment investment.

Limestone usage has two potential valuable secondary benefits:

1. it produces denser sludge having solids contents of 8 to 15%. The production of this type of sludge could greatly reduce the volume of water returned underground for recycle.
2. the sludge produced, if not oxidized, is a mixture of ferrous carbonate, ferrous hydroxide and excess limestone. The return of this chemical composition to the deep mine pool could have ultimate beneficial effects in reducing the rate of pyrite oxidation and acid formation.

The installation of experimental limestone neutralization equipment should be considered to permit determination of methods for obtaining maximum neutralization efficiency. Several promising systems have been developed in England and Canada which have never been given full scale trials in the United States (13, 14, 15).

Transfer Ditch:

There are several possibilities for exploiting the advantages of the 40 ft. head and 2800 foot length to producing aerating and mixing effects. Efforts should be made to convert this ditch into a valuable reactor unit.

Aeration Pond:

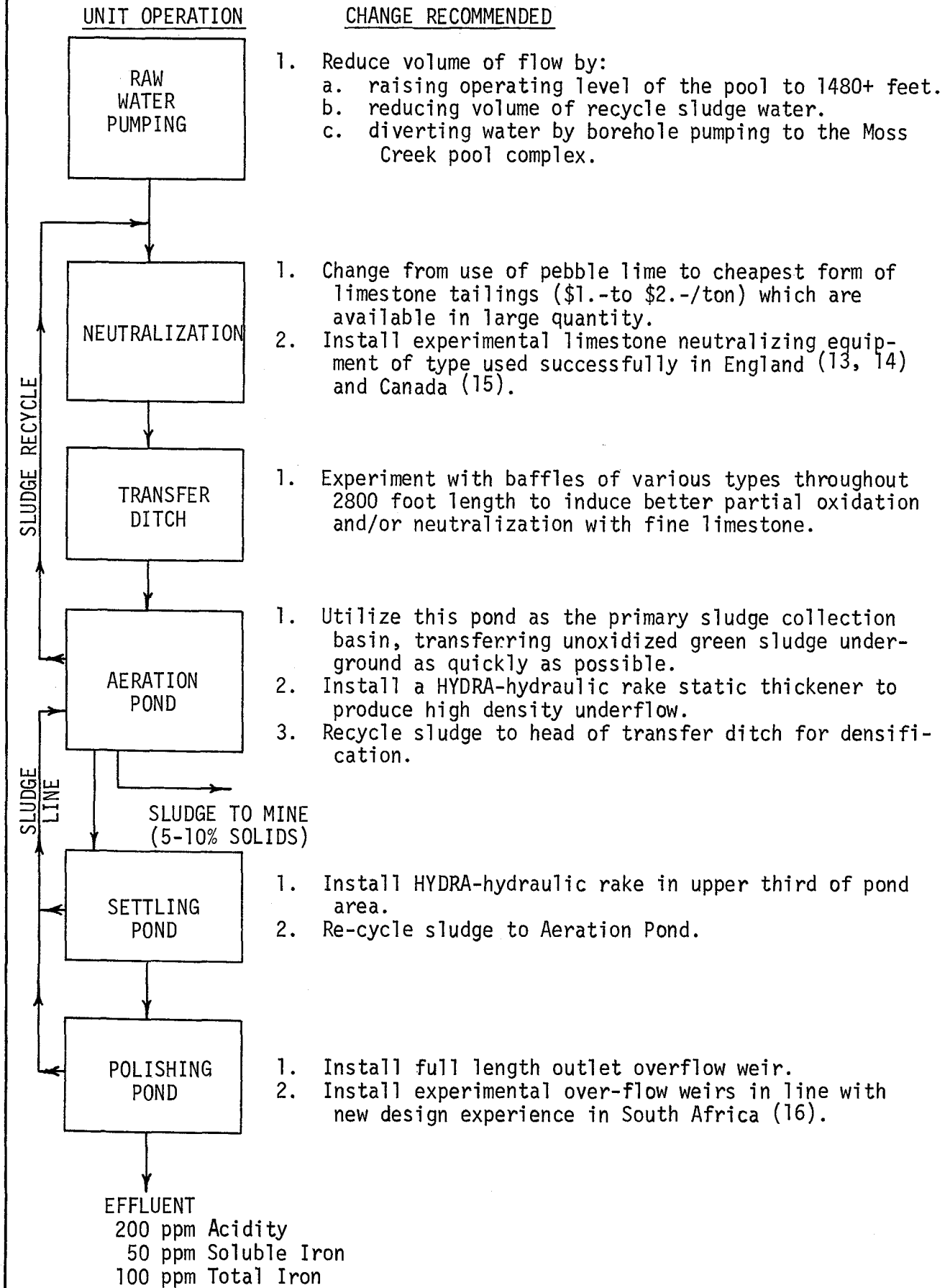
Normal unoxidized limestone sludge entering this pond should have a settling rate of 12 ft./hr. With recycle densification, settling rates could be greater. Under these conditions, the installation of a static thickener could be considered to collect this dense sludge and pump it underground at a high percent of solids. Details for an installation of this type are presented in Quick Start Project Proposal.

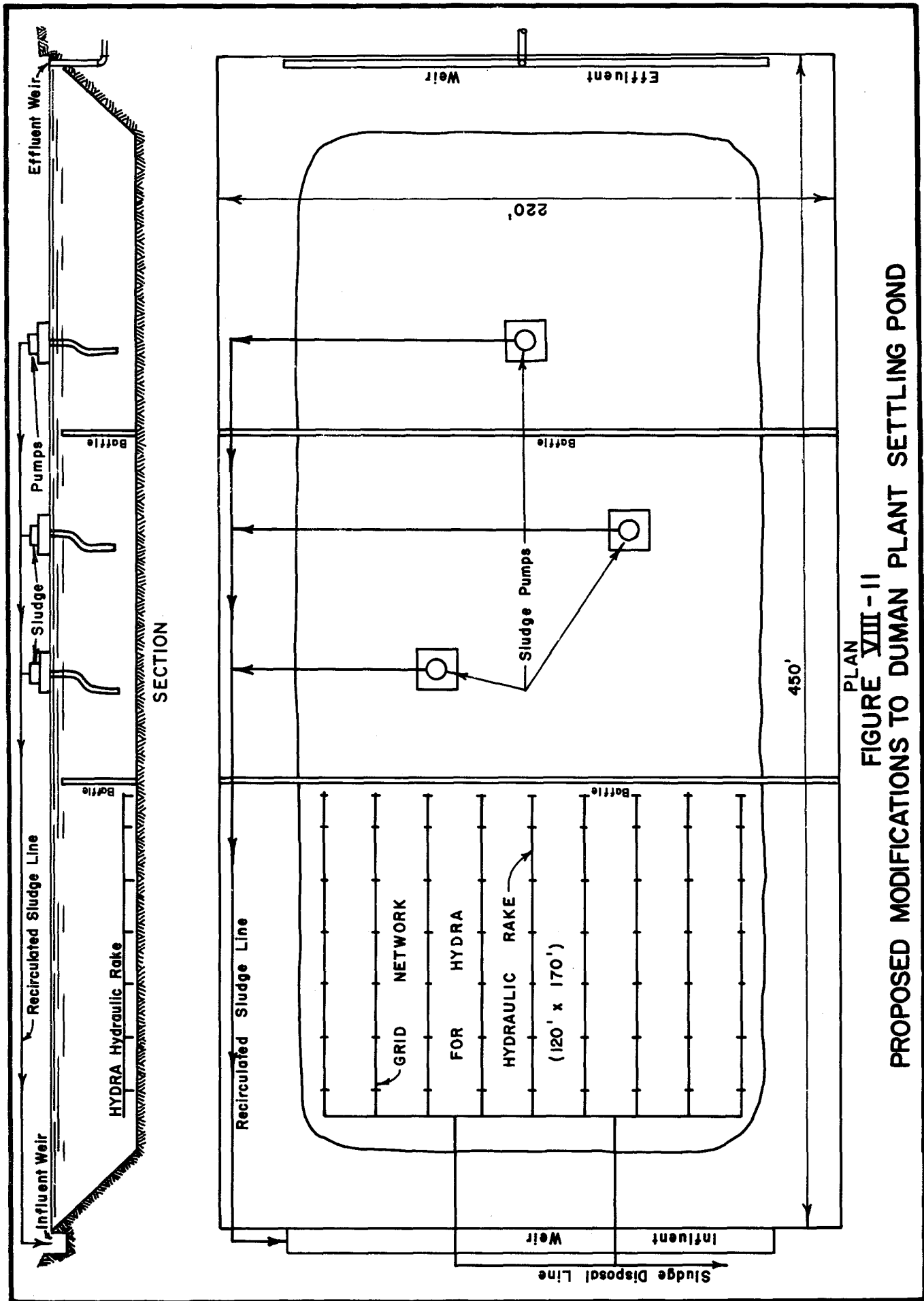
Aeration facilities, with their attendant high capital and operating costs are really not necessary, since there is no useful purpose in oxidizing the major portion of the iron being treated in this plant. The ferrous hydroxide precipitated in the transfer ditch is no longer a source of acid, and is not an oxidizing agent for pyrite. Hence, this is the ideal iron compound to return to the mine. If the ferrous sludge is oxidized, this not only involves costly treatment, but converts the iron to a ferric form which, on return to the acid underground pool, could act as a pyrite oxidant and thus increase the rate of acid formation. Total oxidation facilities, therefore, should not be installed in this plant.

Settling Ponds:

The settling ponds should be modified and operated to produce the highest density sludge possible. One way of producing heavy sludges would be to divide the pond into three compartments as indicated in the schematic in Figure VIII-11. The first compartment (150 feet long) would contain a HYDRA-hydraulic rake installation occupying an area 120 ft. x 170 ft. (20,400 ft.²) at the end of which a transverse sludge retaining wall would be placed having a height of half the pool depth. Photographs of a HYDRA-hydraulic rake being installed at Eastern Associated's treatment plant are shown in Figure VIII-3. This compartment

FIGURE VIII-10
RECOMMENDED CHANGES IN DUMAN PLANT OPERATIONS





PLAN
 FIGURE VIII - 11
 PROPOSED MODIFICATIONS TO DUMAN PLANT SETTLING POND

would be the primary sludge collection basin wherein a maximum sludge depth level would be constantly maintained. Sludge collected in the second and third compartments would be pumped intermittently (by floating sludge pumps) back into the aeration pond for recycle through the first compartment. This system should reduce the sludge recycle stream flow by at least 0.5 MGD and greatly reduce operating labor requirements, especially for second and third shift operations. Overall operating cost savings should be at least \$60,000 per year. Cost of making pond modifications should not exceed \$60,000, hence this improvement would pay for itself within one year.

Another approach to settling pond modification would be to utilize the South African design with or without a HYDRA-hydraulic rake. A schematic for a combination design is included in Quick Start Project No. 1 in Chapter 10.

The Duman plant is actually producing about 80,000 lbs. of iron per day. It is possible that this iron could be recovered as a saleable product. If this option is ever given consideration, the logical sludge handling equipment to install would be a large thickener (Densifier-type) and a rotary vacuum filter. This system would produce an essentially "dry" iron sludge and no mine recycle water.

Polishing Pond:

The installation of a simple, full length overflow weir should help the clarification function of this pond considerably. The perforated standpipe should be eliminated. Accumulated sludge could be handled periodically by a single floating pump which would return sludge to the aeration pond for recycle dewatering.

CONCLUSIONS

This study of the Duman plant operation and its relationship to its mine water sources and receiving stream system has produced information which indicates many techniques for reducing the current high treatment costs at this plant. It has also produced data which should provide a new basis for pollution control criteria for mine water treatment plants discharging into the Blacklick Creek watershed. The implementation of the recommendations made as a result of this study could ultimately result in a lowering of treatment costs at the Dumans plant of \$300,000 to \$500,000 per year.