M. TREATMENT PLANT RECOMMENDATIONS

It has been established that throughout the entire project area conditions are such that only selected mine portals lend themselves to sealing. Because of the poor rock quality, the unknown mine pool potentials, and significant mine seal failures in the past, the feasibility for using chemical treatment on selected acid mine discharge sources was examined.

Five of the largest mines in the region display water quality and geological characteristics which could be fully corrected by treatment. The Proctor No.1 and Proctor No.2 Mines both have high acid/iron concentrations, a limited number of discharging adits, poor or non-existent structural rock and has the potential for developing a large volume of water under high hydraulic head if a seal were placed. The Shawmut No.31 Mine Complex displays similar characteristics and is further compounded by having several discharging sources scattered over an entire watershed.

Both the Tyler Mine Complex and the Shawmut No.41 Mine are similar in their discharge characteristics. Both mine systems display moderately high acid with low iron concentrations. Both of these workings have been totally mined out and because of poor mapping their internal condition cannot be determined. The overburden rock related to both mines is too weak to withstand resulting high pressures due to mine seals.

After a review of the chemical reagents available on the market currently, calcium hydroxide was selected to be most capable of giving the best product for the desired result. Limestone, calcium oxide, and the sodium products were all considered as a reagent but for varying reasons (either chemically, economically or availability) would not meet treatment criteria.

Two types of treatment facility are proposed. Each plant is to be designed to correct the source discharge to meet the criteria established in the Clean Streams Act. For those sources which display high acid, high iron concentrations, a more elaborate treatment will be required and should consist of the following basic stages:

Type I (1) AMD Collection.
(2) Flash Mixing with Reagent.
(3) Aeration.
(4) Flocculation.
(5) Sludge Settlement.
(6) Sludge Drying.
(7) Sludge Transportation.
(8)Clean Effluent Discharge

Those sources which display acid loadings with little or no iron in solution can be treated merely by introducing the reagent into the discharge and allowing the normal stream fall to remove any precipitate, as follows:

Type II

(1) AMD Collection.
(2) Flash Mixing with Reagent.
(3) Aeration by Natural Fall.
(4) Clean Effluent Discharge.

It is proposed that this Type II plant be assembled as a silo type structure which will have its reagent feed assembly in direct contact with the discharge stream.

Two of the Type I treatment facilities are proposed for the study area; one near the Village of Hollywood and the second near the Village of Caledonia.

There are five Type II treatment plants proposed; one for the Shawmut No.41 Mine at Cardiff and four located at key points along the Tyler Mines cropline.

The proposed Hollywood Plant is designed to collect water from the following discharge points (Plate No.71):

Sampling Station	Flow gpm	Acid lbs/day	Iron lbs/day	Sulfate lbs/day
M15	263	5,036	1,510	4,417
P22	12	91	28	138
P22A	315	2,717	682	3,922
P34	665	2,578	405	3,608
SC49	97	114	1	258
SC50	255	221	4	525
Totals	1,607	10,757	2,630	12,868
Composite	2.3 MGD	594 mg/1	136 mg/1	665 mg/1
Design	4.0 MGD	650 mg/1	150 mg/1	700 mg/1

Costs of Proposed 4.0 MGD Treatment Facility at Hollywood.

Capital Cost (1973)	=	$ 2,930,000.00
20 Year Average Cost, 8% true interest	=	385,000.00

<u>20 Year Average Cost at 8% Inflation</u>

Principal and Interest	=	$ 385,000.00
Reagent Cost	=	125,000.00
Operating Cost	=	<u>1,060,000.00</u>
Average Annual Cost	=	1,570,000.00
Average Daily Cost	=	4,300.00
20 Year Accumulated Cost	=	$31,400,000.00
Acid Abated Per Day	=	10,757 lbs/day
Cost Per Lb of Acid Removed (20 Yr.Average)	=	$0.40
1973 Annual Operating Cost Less Principal and Interest	=	$83,000.00

The proposed treatment plant at Caledonia is designed to collect water from the following discharge points (Plate No.C6):

Sampling Station	Flow (gpm)	Acid (lbs/day)	Iron (lbs/day)	Sulfate (lbs/day)
CA99	403	3,294	535	5,182
CA109	420	2,017	221	2,179
CA111	44	190	6	299
CA103	28	221	49	232
CA104	47	171	17	213
CA105	142	958	117	1,144
CA107	138	1,053	157	1,266
CA108	50	839	147	733
CA110	18	24	3	35
Totals	1,290	8,767	1,252	11,283
Composite	1.9 MGD	564 mg/1	80 mg/1	726 mg/1
Design	3.5 MGD	620 mg/1	90 mg/1	800 mg/1

Cost of Proposed Type 13.5 MGD Treatment Facility at Caledonia.

Capital Cost (1973)	=	$ 2,451,000.00
20 Year Average Cost, 8% true Int.	=	318,600.00

<u>20 Year Average Cost at 8% Inflation</u>

Principal and Interest	=	$ 318,600.00
Reagent Cost	=	91,100.00
Operating Cost	=	<u>918,300.00</u>
Average Annual Cost	=	1,328,000.00
Average Daily Cost		3,650.00
20 Year Accumulated Cost	=	26,600,000.00
Acid Abated Per Day	=	8,767 lbs/day
Cost Per Lb. of Acid Removed	=	$0.42
1973 Annual Operating Cost Less Principal and Interest	=	$80,200.00

The Type II plant proposed to treat Shawmut No.41 at Cardiff is designed to collect water from the following discharge points (Plate No.C8):

Sampling Station	Flow (gpm)	Acid (lbs/day)	Iron (lbs/day)	Sulfate (lbs/day)
C56	648	674	20	1,842
C58	331	404	3	898
C59	146	19	T	116
Totals	1,125	1,097	23	2,856
Composite	1.6 MGD	81 mg/1	1.7 mg/1	211 mg/1
Design	2.0 MGD	90 mg/1	2 mg/1	230 mg/1

T = Trace

Cost of Proposed Type II 2.0 MGD Treatment Facility at Cardiff.

Capital Cost (1973)	=	$ 310,000.00
20 Year Average Cost, 8% true Int.	=	40,300.00

20 Year Average Cost at 8% Inflation

Principal and Interest	=	$ 40,300.00
Reagent Cost	=	6,000.00
Operating Cost	=	118,700.00
Average Annual Cost	=	165,000.00
Average Daily Cost	=	450.00
20 Year Accumulated Cost	=	$ 3,300,000.00
Acid Abated Per Day	=	1,097 lbs/day
Cost Per Lb. of Acid Removed	=	$0.41
1973 Annual Operating Cost Less Principal and Interest	=	$18,700.00

The four proposed Type II treatment plants to treat the Tyler Mines Complex are designed to collect water from the following points (Plate No.C5):

Plant	Sampling Station	Flow (gpm)	Acid (lbs/day)	Iron (lbs/day)	Sulfate (lbs/day)
A	TR38	165	444	4	421
	TR39	103	14	T	160
	TR40	100	70	1	201
	TR41	43	34	T	87
		411	562	5	869
B	TR35	261	548	7	796
	TR37	106	287	5	494
		367	835	12	1,290
C	TR42	114	232	2	420
	TR43	124	68	T	304
	TR44	122	82	T	373
		360	382	2	1,097
D	UN180	172	216	2	497
T = Trace					

Design Criteria for Type II Treatment Facilities at Tyler Mines

PLANT		FLOW	ACID	IRON	SULFATES
A	Totals	411 gpm	562 lbs/day	5 lbs/day	869 lbs/day
	Composite	0.6 MGD	113 mg/1	1 mg/1	175 mg/1
	Design	0.7 MGD	125 mg/1	1 mg/1	190 mg/1
B	Totals	367 gpm	835 lbs/day	12 lbs/day	1,290 lbs/day
	Composite	0.5 MGD	189 mg/1	3 mg/1	292 mg/1
	Design	0.6 MGD	210 mg/1	3 mg/1	320 mg/1
C	Totals	360 gpm	382 lbs/day	2 lbs/day	1,097 lbs/day
	Composite	0.5 MGD	88 mg/1	1 mg/1	253 mg/1
	Design	0.6 MGD	95 mg/1	1 mg/1	280 mg/1
D	Totals	172 gpm	216 lbs/day	2 lbs/day	497 lbs/day
	Composite	0.3 MGD	104 mg/1	1 mg/1	240 mg/1
	Design	0.3 MGD	115 mg/1	1 mg/1	260 mg/1

Costs of proposed Type II Treatment Facilities at Tyler Mines

	PLANT A	PLANT B	PLANT C	PLANT D
Capital Cost (1973) 20 Yr. Avg. Cost, 8% Int.	$ 80,000 10,400	$ 95,000 12,400	$ 60,000 7,800	$ 40,000 5,200
20 Year Avg. Cost at 8% Inflation				
Principal and Interest	$ 10,400	$ 12,400	$ 7,800	$ 5,200
Reagent Cost	5,100	7,600	3,400	1,900
Operating Cost	113,900	90,900	90,500	39,100
Avg. Annual Cost	129,400	110,900	101,700	46,200
Avg. Daily Cost	355	304	279	127
20 Yr. Accumulated Cost	$2,588,000	$2,218,000	$2,034,000	$924,000
Acid Abated Per Day	562 Lb.	835 Lb.	382 Lb.	216 Lb.
Cost per Lb.of Acid Removed	$0.63	$0.36	$0.73	$0.59
1973 Annual Operating Cost Less Principal and Interest	$16,800	$15,900	$15,400	$12,400

ABATEMENT COST PROGRAM

To complete the 65 individual projects proposed for the Bennett Branch project area would require $8,062,000 and would abate over 39,700 lbs/day acid (68% of the acid passing Sampling Station BB-136 at Mount Pleasant Church Run). It is apparent that the principal stream will probably always be acidic and will be at best marginal for supporting aquatic life. Because no single project will be capable of significantly reducing the total pollution within the study area, it is recommended to review each sub-watershed and determine its value to the total study area in terms of acid abated, reclamation costs and the degree that tributaries are cleaned after all projects recommended for the watershed have been completed.

The Mt. Pleasant Church Run area has been deleted from this cost analysis in view of the pending surface mine operation which should have a significant effect on existing mine discharges.

Plate No.80 is an acid loading/cost analysis for each watershed within the project which reflects the method in which the acid affects the stream. A direct reading indicates that sources were accurately measured by weirs or gauges. An estimated reading indicates that the loading is based upon the best hydrologic and chemical data available. An Influence reading is that loading which originates beyond a particular watershed's limits, but through surface and auger mining operations allows ground runoff to enter the deep mine working and cause AMD in a separate watershed.

To rate the nine remaining watersheds a series of weighted factors were established based upon, (1) the cost per pound of acid abated, (2) the cost of acid abated per square mile, (3) the watershed involved, (4) total acid abated, and (5) the total cost of all projects.

On a watershed basis, the costs to abate pound/day acid varied from $151 in the Hollywood area to $531 in Trout Run (the project average is $182). The average cost of acid abated per square mile of watershed was $26 and the watersheds ranged from $9 on Kersey Run to $541 on Tyler Run. These unit costs were converted to a non-dimensional factor based upon multiples of the project average (Columns F and G on Plate No.81). These rating factors are then added to factors based on percentages of the three remaining items and algebraically added to determine the priority for the acid abatement projects.

It is interesting to note that two regions; the Hollywood Area and Trout Run, are listed as the two most important regions to consider abatement projects, but for virtually opposing logic. Hollywood covers a small area, has the greatest quantity of AMD and will require the largest percentile of monies spent. Trout Run, on the other hand, has a smaller percentage of acid pollution, will require less money for abatement projects and should open over one-half of the total study area as a reclaimed watershed.

It is also significant to note that with the exception of Trout Run those tributaries on which treatment facilities were recommended as the principal method for abatement are rated higher in priority than those which were basically source correction projects.

The proposed abatement program for Bennett Branch has been divided into two phases. First is to rank those watersheds by priority which were basically planned as source correction projects. The second phase will consider those watersheds which are principally designed to include mine drainage treatment facilities.

*Includes source correction projects within watershed.

PHASE I - SOURCE CORRECTION PROJECTS				
Priority	Watershed	Acid Abated (lbs/day)	Abatement Costs	Rating
2	Trout Run	856	$ 455,000	61
5	Kersey Run	948	467,000	19
6	Moose Run	1,775	711,000	17
8	Mill Run	438	180,000	5
9	Tyler Run	443	170,000	-18
Totals		4,460	$1,983,000	

PHASE II - TREATMENT FACILITY PROJECTS*				
1	Hollywood Area	16,221	$2,659,000	53
3	Dixon Run	11,472	1,869,000	46
4	Tyler Reservoir Run	5,869	1,006,000	20
7	Cherry Run	1,699	545,000	12
Totals		35,261	$6,079,000	
GRAND TOTALS		39,721	$8,062,000	

Phase II costs are based upon total average annual operating costs for treatment.

BENNETT BRANCH COST ANALYSIS FOR WATERSHED ABATEMENT PROJECTS

Watershed	Trib.Acid Loading lbs/day	Source Loading lbs/day			Source Abatement lbs/day				Abatement Costs Dollars			
		Direct	Estimate	Influence	Direct	Estimate	Influence	Treatment	Direct	Estimate	Influence	Treatment
MOOSE RUN	4,168	986	1,890	-	825	950	-	-	437,000	274,000	-	-
MILL RUN (Boreholes Dry)	696	258	370	-	178	260	-	-	30,000	150,000	-	-
TYLER RUN (To T24)	524	401	118	-	361	82	-	-	55,000	115,000	-	-
TYLER RESERVOIR	8,333	1,399	1,043	-	-	-	-	1,397	-	-	-	240,000
Tyler #14		1,891	-	-	1,700	624	-	-	20,000	109,000	-	-
Tyler #8-9	-	598	-	-	-	-	-	598	-	-	-	148,000
Bell Hollow	-	467	-	1,614	420	-	1,130	-	45,000	-	444,000	-
HOLLYWOOD	34,317	10,757	7,003	-	-	3,906	-	10,757	-	643,000	-	1,570,000
Mill Run (Borehole)	Info.only	(5,036)	-	-	-	-	-	-	-	-	-	-
Scattertown	Info.only	(335)	-	-	-	-	-	-	-	-	-	-
Southern Bank	-	678	-	-	610	-	-	-	95,000	-	-	-
Mill Run	-	-	-	1,004	-	-	703	-	-	-	258,000	-
Cherry Run	-	-	-	350	-	-	245	-	-	-	93,000	-
CHERRY RUN	1,361	1,298	184	-	8	149	-	1,097	15,000	265,000	-	165,000
Kersey Run	-	-	-	635	-	-	445	-	-	-	100,000	-
KERSEY RUN	2,127	423	810	-	381	280	-	-	70,000	367,000	-	-
Browns Run	-	-	-	410	-	-	287	-	-	-	30,000	-
DIXON RUN	7,978	62	-	3,046	56	2,132	-	8,767	30,000	368,000	-	1,328,000
Spring Run	-	-	-	738	-	-	517	-	-	-	143,000	-
TROUT RUN	3,584	1,394	-	-	524	332	-	-	167,000	288,000	-	-
TOTALS	Sampling Station BB136 = 58,463 lbs/day				5,063	8,715	3,327	22,616	964,000	2,579,000	1,068,000	3,451,000*

*Twenty year average annual operating cost;
1973 Capital Cost for Treatment = $5,966,000

PLATE NO. 80

ACID ABATEMENT PRIORITY RATING OF BENNETT BRANCH WATERSHEDS

Priority	Watershed	Watershed			Unit Costs*****				F+G	Percentage Rating			
		Area (Sq.Mi.)	Total Acid (lb/day)	% Acid Abated	Cost Per lb/day Abated	F	Cost Per lb/day Sq.Mi.	G		Total Area	Total Acid Abated	Total Costs	Watershed Rating
1	Trout Run	57.27	3,584	24	$ 531	-3	$ 9	+3	0	53	2	6	61
2	Hollywood Area*	0.71	34,317	53	151	+1	151	-6	-5	1	28	29	53
3	Dixon Run	2.42	8,804	100	151	+1	63	-2	-1	2	20	23	46
4	Tyler Reservoir Run**	1.92	10,360	41	209	-1	109	-4	-5	2	10	13	20
5	Kersey Run	30.24	2,127	44	530	-2	17	+2	0	11	2	6	19
6	Moose Run	2.13	4,168	42	155	+1	73	-3	-2	2	8	9	17
7	Cherry Run	4.78	1,364	84	234	-1	49	-2	-3	4	4	7	12
8	Mill Run***	3.93	696	63	410	-3	104	-4	-7	4	2	6	5
9	Tyler Run****	1.71	524	84	384	-2	541	-21	-23	2	1	2	-18
	Mean				$182		$26						

*Includes Southern Bank Sources D212 and D.B. Betta; Proctor No.2 Borehole.
**Includes Bell Hollow Abatement and Tyler Mines Nos.8, 9, 10 and 14.
***Excludes Sampling Station M-15.
****From Sampling Station T-24 upstream.
*****Typical Unit Cost Factor Calculation

Trout Run - Cost Per lb/day = $531 F = -531/182 = -2.9
Mean = $182 Say = -3
(Use negative value when cost exceeds mean)

PLATE NO. 81

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