APPENDIX B

TREATMENT RESEARCH

The research procedure concerned with the project consisted of two main phases; these phases being primary treatment or mine drainage treatment and secondary treatment or potable water treatment. Each phase of the research involved the following steps and combinations:

(1) The treatment of, Kittanning Run

(2) The treatment of, combinations of Kittanning Run and Glen White Run

(3) The primary treatment of combinations of Kittanning Run, Glen White Run and Sugar Run

(4) The secondary treatment of combinations of Kittanning Run, Glen White Run, Sugar Run and Mill Run

(5) The primary treatment of combinations of Glen White Run and Sugar Run

(6) The secondary treatment of combinations of Glen White Run, Sugar Run and Mill Run.

The primary treatment phase of the research project was concerned with the treatment of the acid mine drainage streams with lime or soda ash in order to produce a water having a pH between 6.0 and 9.0, an iron concentration of less than 7.0 mg/l, and the alkalinity exceeding the acidity. This phase of the research was conducted in the laboratory and in part at "Operation Yellowboy." The testing procedures used in the analyses of the samples were in accordance with "Standard Methods For The Examination of Water and Wastewater," Twelfth Edition, 1965. The specific procedures used were as follows:

(1) pH - All pH analyses were conducted on a Beckman Zeromatic pH Meter.

(2) Alkalinity - Phenolphthalein alkalinity and total alkalinity by the methyl orange indicator method.

(3) Acidity - Phenolphthalein acidity at boiling temperature. (4) Hardness - EDTA titrimetric method.

(5) Sulfate - Turbidimetric method using a Hellige Turbidimeter.

(6) Iron - Phenanthrolene method using a Beckman Direct-Reading DU-2 Spectrophatometer.

(7) Manganese - Persulfate method using a Beckman Direct-Reading DU-2 Spectrophatometer.

(8) Total Solids - Total, residue method using both platinum and nickel evaporating dishes

(9) Suspended Solids - Filterable residue using a membrane filter.

The secondary treatment phase of the research project was concerned with the treatment of waters treated in the primary phase and the treatment of combinations of primary phase treated waters and untreated water in order to produce a water meeting the Public Health Service Drinking Water Standard. This entire phase of the research was conducted under laboratory conditions. The treatment procedures investigated were treatment with lime, alum, potassium permanganate and filtration; treatment with soda ash, alum, potassium permanganate and filtration.; and lime-soda treatment with recarbonation and filtration,

Step 1: The Treatment of Kittanning Run

The primary treatment phase for the treatment of Kittanning Run was conducted in the laboratory and at Operation Yellowboy. The results of the investigation indicated that Kittanning Run had the following range and average chemical analyses during the testing period.

Kittanning Run

Analyses	Range (mg/l)	Average (mg/l)
pH	2.8 - 3.2	2.9
Alkalinity	0	0
Acidity, Hot	180 - 455	420
Iron, Total	32 - 117	70
Manganese	4 - 12	11
Hardness	Color interference	
Sulfates	Color interference	
Total Solids	305 - 1200	919
Volatile	115 - 700	267
Fixed	130 - 1020	652
Suspended Solids	4 - 80	14
Volatile	2 - 21	6
Fixed	2 - 56	8

The primary treatment of Kittanning Run consisted of neutralization, oxidation and coagulation process using lime or soda ash as the chemical agents. Aeration was used only during the Yellowboy Operation. The results of the research period indicates that the Kittanning Run primary treatment phase had a lime demand ranging between 280 and 365 mg/l with an average of 316 mg/l; and a, soda ash demand ranging between 400 and 655 mg/l with an average of 528 mg/l. The processed water from this primary treatment had the following range and average chemical analyses.

Kittanning Run - Primary Treatment

	LIME		SODA ASH	
Analyses	Range (mg/l)	Average (mg/l)	Range (mg/l)	Average (mg/l)
pH	6.2 - 6.8	6.5	6.8 - 7.1	6.9
Alkalinity	8 - 11	9	94 - 110	102
Acidity, Hot	6 - 11	7	0	0
Iron, Total	1 - 3	3.0	2.1 - 2.6	2.4
Manganese	8.4 - 9.4	9.0	9.4 - 11.1	9.5
Hardness	548 - 675	592	256 - 260	258
Sulfates	235 - 250	244	240 - 294	270
Total Solids	710 - 1638	1174	972 - 1098	1035
Volatile	94 - 742	418	40 - 42	41
Fixed	616 - 896	756	932 - 1056	994
Suspended Solids	6 - 12	9	7 - 11	9
Volatile	2 - 5	3	2 - 4	3
Fixed	4 - 9	6	5 - 7	6

The results of the research on this phase of the treatment process indicated that Kittanning Run can be treated with lime or soda ash to the criteria as previously stated. However, it appears that lime treatment contributes to the hardness and total solids in the treated water. Soda ash is apparently contributing to the total solids. Its effect on the hardness is not apparent due to the color interference encountered with the raw water. However, it is believed that treatment with soda ash would not contribute to the hardness but lower it to a small degree.

The secondary treatment phase of Kittanning Run was not investigated to any degree due to the proposed flow pattern of the treatment process. There-

fore, the results of a short testing period with lime, potassium permanganate and alum are considered insufficient and are not set forth in the report. However, secondary treatment with soda ash, potassium permanganate and alum indicates the ranges and averages for these chemicals were soda ash 250 to 350 mg/l, average 298 mg/l; potassium permanganate 7 to 11 mg/l, average 9.6 mg/l; alum 35 to 100 mg/l, average 75 mg/l. The processed water from soda ash process for secondary treatment had the following range and average chemical analyses.

Kittanning Run - Secondary Treatment

	SODA ASH	
Analyses	Range (mg/l)	Average (mg/l)
pH	8.9 - 9.2	9.1
Alkalinity	208 - 296	241
Acidity, Hot	0	0
Iron, Total	0	0
Manganese	0	0
Hardness	152 - 184	166
Sulfates	252 - 312	250
Total Solids	778 - 1230	1079
Volalite	12 - 112	63
Fixed	738 - 1152	1016
Suspended Solids	0	0
Volatile	0	0
Fixed	0	0
Color	0	0
Turbidity	0	0

Due to insufficient investigation, the results of secondary treatment of Kittanning Run are considered inadequate for any definite conclusion. However, it is believed that the results obtained at least indicate that Kittanning Run is treatable to the point of meeting drinking water standards when mixed with other water containing lesser concentrations of iron, manganese, hardness and solids.

Step 2: The Treatment of Combinations of Kittanning Run and Glen White Run

The primary treatment of combinations of Kittanning Run and Glen White Run was a lime or soda ash neutralization process carried on at Operation Yellowboy. The research project using Operation Yellowboy was conducted throughout the month of May. The trailer was placed at a point on the by-pass channel near the old existing settling basin site. This site was chosen in order to allow adequate mixing of the streams before treatment. Due to natural runoff process the exact combinations of the streams is not known.

The results of composite sampling during periods of operation show that the stream had the following range and average chemical analyses.

Combinations of Kittanning Run and Glen White Run

Analyses	Range (mg/l)	Average (mg/l)
pH	3.0 - 3.5	3.1
Alkalinity	0	0
Acidity, Hot	220 - 294	255
Iron, Total	44.0 - 49.5	47.8
Manganese	6.8 - 9.8	7.8
Hardness	124 - 188	156
Sulfates	192 - 265	235

Combinations of Kittanning Run and Glen White Run

Analyses	Range (mg/l)	Average (mg/l)
Total Solids	464 - 808	650
Volatile	22 - 340	195
Fixed	398 - 534	455
Suspended Solids	6 - 34	14
Volatile	1 - 8	5
Fixed	3 - 26	9

The primary treatment process at Yellowboy was varied due to the inadequacy in feeding the lime or soda ash in slurry form. However, it was found that a flow of 8 gpm through the plant would provide a detention time of approximately 2.3 hours in the aerator and the thickener, and appeared to be an adequate detention time for settling and for properly feeding both the lime and the soda ash slurries. Operation in the aerator was varied in that some operation, periods were conducted without aeration and some were conducted with aeration at an average aeration rate of 1 cfm. The operation of the aerator with or without air did not appear to have a great effect on the treated waters produced from either the lime or soda ash process.

The chemical results from the primary treatment phase of combinations of Kittanning Run and Glen White Run with the lime and soda ash processes are as follows:

Kittanning and Glen White Run - Primary Treatment

	LIME		SODA ASH	
Analyses	Range (mg/l)	Average (mg/l)	Range (mg/l)	Average (mg/l)
pH	6.2 - 7.0	6.7	6.2 - 7.1	6.7
Alkalinity	6 - 12	9	6.2 - 138	88
Acidity, Hot	4 - 6	5	0	0
Iron, Total	1.8 - 4.2	3.3	1.2 - 5.4	3.2
Manganese	5.3 - 7.4	6.3	6.2 - 11.1	7.6
Hardness	284 - 460	357	144 - 256	202
Sulfates	172 - 242	204	220 - 294	245
Total Solids	544 - 730	607	754 - 1098	875
Volatile	20 - 100	67	36 - 100	59
Fixed	462 - 630	540	674 - 1058	816
Suspended Solids	6 - 14	11	9 - 15	12
Volatile	1 - 6	4	2 - 6	5
Fixed	2 - 11	7	5 - 9	7

The lime feed rate during the primary phase of this step ranged between 161 and 196 mg/l and averaged at 173 mg/l The soda ash feed range between 240 - 402 mg/l and averaged at 396 mg/l. The combinations of Kittanning Run and Glen White Run used in the laboratory in order to establish feed rates ranged from a mixture of 1 part Glen White to 1 part Kittanning to a mixture of 1 part Glen White to 3 parts Kittanning Run.

The secondary treatment phase concerned with combinations of Kittanning Run and Glen White Run during the lime treatment phase of investigation was not extensive enough to report. However, of the few procedures that were

conducted, for secondary treatment with lime, potassium permanganate and alum indicated that the water could be treated to the point of meeting drinking water standards although the final water was very hard. The hardness averaging at approximately 480 mg/l.

The secondary treatment phase during the soda ash treatment process was researched and found to be a valid means of treatment. However, it should be noted that the p4 of the final water is rather high, ranging between 8.9 and 9.5. This high pH range is produced during the manganese removal procedure when the pH is raised to between 9.5 and 10.5 in order to facilitate adequate manganese removal. Although rather large proportions of alum were used in the process in order to aid coagulation and lower the pH of the final water, the results of the research indicate that an excess alum application is not a sufficient method for lowering the pH to a desirable alkaline pH range and that excess alum application does not add sufficiently to the coagulation - settling rate to warrant its high dosage rate.

The results of the investigation for secondary treatment of combinations of Kittanning Run and Glen White Run using soda ash in a range of 250 to 350 mg/l with an average of 300 mg/l, potassium permanganate in a range of 6 to 11 mg/l with an average of 10 mg/l, alum in a range of 30 to 100 mg/l with an average of 65 mg/l and filtration is as follows:

Kittanning and Glen White Runs - Secondary Treatment

	SODA ASH	
Analyses	Range (mg/1)	Average (mg/1)
pH	8.9 - 9.5	9.2
Alkalinity	182 - 296	226

Kittanning and Glen White Runs - Secondary Treatment

Analyses	Range (mg/l)	Average (mg/l)
Acidity, Hot	0	0
Iron, Total	0	0
Managanese	0	0
Hardness	120 - 180	154
Sulfates	235 - 301	267
Total Solids	778 - 1230	1023
Volatile	12 - 114	76
Fixed	730 - 1152	947
Suspended Solids	0	0
Volatile	0	0
Fixed	0	0
Color	0	0
Turbidity	0	0

Step 3: The Primary Treatment of Combinations of Kittanning Run, Glen White Run and Sugar Run

The primary treatment phase for treatment of combinations of Kittanning Run, Glen White Run and Sugar Run using lime as the neutralizing agent was not investigated to any degree due to the similar characteristics of the treatment process as was encountered in the combinations of Kittanning Run and Glen White Run during primary treatment with lime. It is believed that the data gathered during this research phase can be applied to both processes.

The primary treatment phase for treatment of combinations of Kittanning Run, Glen White Run and Sugar Run using soda ash as the neutralizing agent was investigated in the laboratory using stream combinations varying from three (3) parts Kittanning Run to one (l) part Sugar Run and one (l) part

Glen White Run to two (2) parts Kittanning Run, one (l) part Sugar Run and one (l) part Glen White Run, The range and average of the chemical analyses of the raw water of the varying combinations is as follows. As can been seen the chemical results of these combinations are very similar in character to the chemical results of combinations of Kittanning Run and Glen White Run.

The primary treatment phase of these combinations as treated with soda ash under laboratory conditions showed that the soda ash demand varied between 200 and 400 mg/l with an average of 305 mg/l. The results of chemical analyses of final waters from this primary treatment process are as follows:

Combinations of Kittanning Run, Glen White Run and Sugar Run

Analyses	Range (mg/l)	Average (mg/l)
pH	3.1 - 3.3	3.2
Alkalinity	0	0
Acidity, Hot	218 - 304	250
Iron, Total	42.9 - 80.3	57.8
Manganese	5.2 - 8.2	6.4
Hardness	140 - 184	170
Sulfate	215 - 265	231
Total Solids	570 - 822	656
Volatile	48 - 218	119
Fixed	498 - 604	537
Suspended Solids	2 - 9	6
Volatile	2 - 7	4
Fixed	0 - 5	2

Kittanning Run, Glen White Run and Sugar Run - Primary Treatment

SODA ASH

Analyses	Range (mg/1)	Average (mg/1)
pH	6.5 - 7.0	6.8
Alkalinity	44 - 110	72
Acidity, Hot	0	0
Iron, Total	1.0 - 3.6	2.0
Manganese	5.2 - 7.1	6.3
Hardness	180 - 240	190
Sulfates	225 - 260	250
Total Solids	568 - 820	687
Volatile	38 - 80	51
Fixed	526 - 782	636
Suspended Solids	2 - 7	4
Volatile	1 - 5	2
Fixed	0 - 2	2

As can be seen from these results the characteristics of the finished water from soda ash treatment for both combinations of Kittanning and Glen White and Kittanning, Glen White and Sugar Runs are very similar in chemical nature. The final chemical results depending a great deal on the raw water chemical characteristics encountered during research. However, it is believed that there is sufficient evidence to point out that the data from the primary treatment processes for Kittanning and Sugar Runs are comparable to the primary processes for combinations of Kittanning, Sugar and Glen White Runs.

Step 4: The Secondary Treatment of Combinations of Kittanning Run, Glen White Run, Sugar Run and Mill Run.

The secondary treatment of the combinations of Kittanning Run, Glen White Run, Sugar Run and Mill Run involving treatment with lime, potassium permanganate, and alum was not researched to a point that definite conclusions concerning the treatment process can be made. However, the inconclusive results indicate that the lime demand for the process ranged between 55 and 100 mg/l with an average of approximately 60 ppm. The potassium permanganate demand depended on the amount of manganese present in the raw water and was approximately one part of potassium permanganate for each part of manganese. The alum demand ranged between 30 and 70 mg/l.

The secondary treatment phase of these combinations involving treatment with soda ash was investigated extensively in the laboratory. The chemical analyses of the mixtures of six (6) parts of the primary treated water to one (l) part of Mill Run for this phase of the research project are as follows:

Combination of Kittanning Run, Glen White Run, Sugar Run (after primary treatment) and Mill Run

Analyses	Range (mg/l)	Average (mg/l)
pH	6.7 - 6.9	6.9
Alkalinity	40 - 100	69
Acidity, Hot	0	0
Iron, Total	0.8 - 5.4	2.6
Manganese	4.7 - 6.0	5.3
Hardness	136 - 204	175
Sulfates	215 - 260	245
Total Solids	342 - 758	553

Combination of Kittanning Run, Glen White Run, Sugar Run (after primary treatment) and Mill Run

Analyses	Range (mg/l)	Average (mg/l)
Volatile	30 - 55	46
Fixed	53 - 704	507
Suspended Solids	0 - 9	5
Volatile	0 - 5	3
Fixed	0 - 4	2

The secondary treatment process using soda ash, potassium permanganate, alum and filtration showed that the soda ash demand ranged between 100 and 300 mg/l with an average of 200 mg/l, the potassium permanganate demand ranged between 5 and 7 mg/l with an average of 6 mg/l and the alum demand between 35 and 70 mg/l with an average of 50 mg/l. The results of chemical analyses of final waters from this secondary treatment process are as follows:

Combination of Kittanning Run, Glen White Run, Sugar Run and Mill Run - Secondary Treatment

	SODA ASH	
Analyses	Range (mg/l)	Average (mg/l)
pH	7.5 - 9.4	8.8
Alkalinity	124 - 408	182
Acidity, Hot	0	0
Iron, Total	0	0
Manganese	0	0
Hardness	84 - 148	116
Sulfates	200 - 280	243
Total Solids	606 - 1424	846
Volatile	10 - 144	57

Combination of Kittanning Run, Glen White Run, Sugar Run and Mill Run - Secondary Treatment

Analyses	Range (mg/1)	Average (mgl/)
Fixed	550 - 1280	789
Suspended Solids	0	0
Volatile	0	0
Fixed	0	0
Color	0	0
Turbidity	0	0

The results of this phase of the research indicates that combinations of Kittanning Run, Glen White Run, Sugar Run and Mill Run are treatable to the point of meeting drinking water standards using the soda ash, permanganate alum and filtration type of treatment. However, it is believed that a limesoda softening process with recarbonation would lower the total solids present in the final waters, permit lowering of the pH and alkalinity to a more neutral point and produce a water with a lower hardness having a lesser range than was observed during this phase of the research.

Step 5: The Primary Treatment of Combinations of Glen White Run and Sugar Run

The primary treatment phase for treatment of, combinations of Glen White Run and Sugar Run using lime or soda ash as the neutralizing agent was investigated using combinations of one (l) part of Glen White Run to one (l) part of Sugar Run or two (2) parts of Sugar Run to one (l) part of Glen White Run in order to simulate what is expected to be the poorest stream conditions that could exist at this time. The chemical results of the different combinations of Glen White Run and Sugar Run during this phase of the research are as follows:

Combinations of Glen White Run and Sugar Run

Analyses	Range (mg/l)	Average (mg/l)
pH	3.2 - 3.7	3.5
Alkalinity	0	0
Acidity, Hot	78 - 190	175
Iron, Total	4.9 - 14.5	10.0
Manganese	2.5 - 4.2	4.0
Hardness	160 - 276	260
Sulfates	180 - 492	365
Total Solids	414 - 926	800
Volatile	28 - 218	150
Fixed	358 - 760	650
Suspended Solids	0 - 9	9
Volatile	0 - 6	4
Fixed	0 - 5	5

The primary treatment phase for treatment of combinations of Glen White Run and Sugar Run was conducted under laboratory conditions. The results of the research indicate that the lime demand for neutralization varied between 75 and 150 mg/l with an average demand of 100 mg/l. The soda ash demand during the phase of treatment varied between 100 and 285 mg/l with an average of 275 mg/l. As in all primary treatment processes covered during the research period, it was found that a coagulation aid was not necessary. The sludge settled very well within the proposed two hour settling time. Analyses of sludge from both the lime and soda ash process showed that the suspended solids ranged between 980 and 3205 mg/l with an average of 2500 mg/l.

The results of the chemical analyses of the finished water from the lime and soda ash neutralization are as follows:

Combinations of Glen White Run and Sugar Run - Primary Treatment

	SODA ASH		LIME	
Analyses	Range (mg/l)	Average (mg/l)	Range (mg/l)	Average (mg/l)
pH	6.3 - 6.9	6.5	5.3 - 7.6	6.6
Alkalinity	28 - 82	68	6 - 14	9
Acidity, Hot	0	0	0 - 18	4
Iron, Total	1.1 - 4.6	3.0	0.2 - 0.9	0.6
Manganese	2.8 - 3.7	3.7	0.7 - 3.7	3.5
Hardness	160 - 264	250	228 - 440	305
Sulfates	250 - 490	360	210 - 492	360
Total Solids	846 - 1128	980	478 - 1538	777
Volatile	54 - 90	72	38 - 712	165
Fixed	434 - 1040	908	418 - 1384	612
Suspended Solids	8 - 15	11	5 - 17	10
Volatile	5 - 7	5	4 - 7	5
Fixed	2 - 10	6	1 - 13	5

In order to complete the primary phase of research for treatment of waters mixed with Sugar Run, samples from the Impounding Dam were mixed with Sugar Run on a one (l) to one (l) basis. The chemical results of this mixture had the following ranges and averages:

Combination of Impounding Dam and Sugar Run

Analyses	Range (mg/l)	Average (mg/l)
pH	3.4 - 3.8	3.6
Alklainity	0	0
Acidity, Hot	110 - 136	123
Iron, Total	17.4 - 19.0	18.6
Manganese	22 - 24	2.3
Hardness	176 - 184	180
Sulfates	300 - 350	340
Total Solids	552 - 612	582
Volatile	40 - 68	54
Fixed	512 - 544	528
Suspended Solids	2 - 3	2
Volatile	0 - 1	1
Fixed	0 - 2	1

The treatment of the mixtures of the Impounding Dam and Sugar Run were neutralization with lime. The range of lime demand was 90 - 100 mg/l with an average of 98 mg/l. As can be seen the lime demand for treatment the combination of Impounding Dam and Sugar Run is very near to that for the treatment of combinations of Sugar Run and Glen White Run. The finished waters are so similar in chemical characteristic that the chemical results for Combinations of Glen White Run and Sugar Run - Primary Treatment can be used as information reference for this treatment process.

Step 6: The Secondary Treatment of Combinations of Glen White Run, Sugar Run and Mill Run

The secondary treatment phase for the treatment of combinations of Glen White Run, Sugar Run and Mill Run involved three methods of treatment during the research period. The methods. studied were:. (I) treatment with lime, permanganate, alum and filtration; (2) treatment with soda ash, permanganate,. alum and filtration; (3) lime-soda softening, recarbonation and filtration. In order to avoid confusion as to the results obtained from the different types of treatment process, each process has been reported on an individual basis.

(1) Treatment with Lime, Potassium Permanganate Alum and Filtration

Secondary treatment of combinations of Glen White Run and Sugar Run after primary treatment with lime and Mill Run was conducted under laboratory conditions. The mixture to be treated throughout the research period consisted of six (6) parts of primary treatment water to one (I) part of Mill Run. The chemical results of these mixtures during the research period showed the following range and averages.

Mixture of Six (6) Parts Primary Treated Water to One (1) Part Mill Run

Analyses	Range (mg/1)	Average (mg/1)
pH	6.2 - 6.6	6.6
Alkalinity	6 - 30	14
Acidity, Hot	0 - 1	0
Iron, Total	0.5 - 0.7	0.6
Managenese	1.6 - 2.9	2.0
Hardness	136 - 352	300
Sulfates	225 - 480	350

Mixture of Six (6) Parts Primary Treated Water to One (1) Part Mill Run

Analyses	Range (mg/1)	Average (mg/1)
Total Solids)		
Volatile)	Insufficient Data	
Fixed)		
Suspended Solids	2 - 9	8
Volatile	2 - 7	4
Fixed	2 - 8	4

The jar testing procedure for secondary treatment of the above mixtures showed that the lime demand ranged between 5 and 50 mg/l with an average of 25 mg/l; the potassium permanganate demand ranged between 2 and 2.5 mg/l with an average of 2.5 mg/l, and the alum dosage ranged between 2 and 6 mg/l with an average of 4 mg/l. After a settling time which ranged between 1 hour and 2 hours, the samples were decanted. The analyses of this water for suspended solids showed that the total suspended solids going to the filter ranged between 3 and 12 mg/l with an average of 7 mg/l.

The results of analyses of the waters after chemical treatment and filtration are as follows:

Combinations of Glen White Run, Sugar Run and Mill Run - Secondary Treatment - Lime

Analyses	Range (mg/1)	Average (mg/1)
pH	6.2 - 7.0	6.8
Alkalinity	6 - 12	9
Acidity, Hot	0	0
Iron, Total	0	0
Manganese	0	0

Combinations of Glen White Run, Sugar Run and Mill Run - Secondary Treatment - Lime

Analyses	Range (mg/1)	Average (mg/1)
Hardness	224 - 396	350
Sulfates	200 - 475	350
Total Solids	558 - 1400	735
Volatile	36 - 802	153
Fixed	460 - 706	582
Suspended Solids	0	0
Volatile	0	0
Fixed	0	0
Turbidity	0	0
Color	0	0

Mixture of Six (6) Parts Primary Treated Water to One (1) Part Mill Run

Analyses	Range (mg/1)	Average (mg/1)
pH	6.5 - 6.6	6.6
Alkalinity	30 - 68	60
Acidity, Hot	0	0
Iron, Total	0.7 - 3.9	2.7
Manganese	2.9 - 3.5	3.3

(2) Treatment with Soda Ash, Potassium Permanganate, Alum and Filtration

The secondary treatment process for combinations of Glen White Run and Sugar Run after primary treatment with soda ash and Mill Run consisted of mixtures of six (6) parts of the primary treated water to one (l) part of Mill Run. The process involved chemical treatment and filtration as in previous treatment process. The chemical results of mixtures of primary treated water, and Mill Run are as follows:

Mixture of Six (6) Parts Primary Treated Water to One (1) Part Mill Run

Analyses	Range (mg/l)	Average (mg/l)
Hardness	136 - 236	242
Sulfates	250 - 460	345
Total Solids)		
Volatile)	Insufficient Data	
Fixed)		
Suspended Solids	8 - 13	11
Volatile	3 - 8	6
Fixed	5 - 8	5

The secondary treatment process for the mixtures run under jar test conditions showed that the soda ash dosage ranged between 100 and 200 mg/l with 175 mg/l as the average; the potassium permanganate dosage ranged between 4.6 and 5 mg/l with 5 mg/l as an average; the alum dosage ranged between 50 and 90 mg/l with 70 mg/l as an average. The samples were settled for approximately two hours and then decanted. Analyses of the decanted waters indicated that the suspended solids going to the filter ranged between 3 and 11 mg/l with an average of 9 mg/l.

Analyses of the waters after filtration showed that following ranges and averages.

Combinations of Glen White Run, Sugar Run and Mill Run - Secondary Treatment - Soda Ash

Analyses	Range (mg/l)	Averages (mg/l)
pH	7.2 - 8.0	7.7
Alkalinity	60 - 148	120
Acidity, Hot	0	0

Combinations of Glen White Run, Sugar Run and Mill Run - Secondary Treatment - Soda Ash

Analyses	Range (mg/l)	Average (mg/l)
Iron, Total	0 - 0.1	0
Manganese	0 - 0.3	0
Hardness	120 - 232	230
Sulfates	230 - 450	340
Total Solids	406 - 1416	875
Volatile	30 - 692	231
Fixed	388 - 906	644
Suspended Solids	0	0
Volatile	0	0
Fixed	0	0
Turbidity	0	0
Color	0	0

(3) Lime - Soda Softening, Recarbonation and Filtration

The third method of secondary treatment for combinations of Glen White Run, Sugar Run after primary treatment with lime and Mill Run consisted of lime-soda softening process in which the hydroxide and carbonate concentrations are increased in order to remove the hardness causing cations along with the iron and manganese, recarbonation and filtration. The combinations used during this research procedure were two (2) parts of Sugar Run to one (l) part of Glen White Run and one (l) part of Sugar Run to one (l) part of Glen White Run. The primary treatment process consisted of neutralization with lime which gave a primary treated water which averaged as indicated earlier in the report. It was again found that the average lime usage for the primary treatment of combinations of Glen White Run and Sugar Run averaged at 100 mg/l.

The combinations of Mill Run to the primary treated waters used during this phase of the research was varied between six (6) parts treated waters to one (l) part Mill Run and four (4) parts treated water to one (l) part Mill Run. The chemical results for the different combinations used ranged and averaged as follows:

Mixtures of Four (4) and Six (6) Parts Primary Treated Water to One (1) Par Mill Run

Analyses	Range (mg/1)	Average (mg/1)
pH	6.4 - 7.2	6.8
Alkalinity	8 - 10	9
Acidity, Hot	0 - 8	0
Iron, Total	0.4 - 2.7	1.2
Manganese	1.6 - 3.8	2.4
Hardness	332 - 464	375
Sulfates	284 - 492	381
Total Solids	618 - 710	657
Volatile	42 - 96	75
Fixed	556 - 614	584
Suspended Solids	4 - 12	7
Volatile	3 - 4	4
Fixed	0 - 8	3

The secondary treatment process on the. mixtures used consisted of overtreating with lime, then neutralizing the excess lime with soda ash, converting all the causticity to sodium causticity. The soda ash required is that necessary to combine with the non-carbonate hardness of the water and thee excess lime. It was found that in order to get adequate settling of the

the following ranges and averages.

Combinations of Glen White, Sugar Run and Mill Run - Secondary Treatment - Lime - Soda Softening

Analyses	Range (mg/1)	Average (mg/1)
pH	7.1 - 8.3	7.7
Alkalinity	65 - 136	86
Acidity, Hot	0	0
Iron, Total	0	0
Manganese	0	0
Hardness	44 - 116	90
Sulfates	264 - 374	337
Total Solids	550 - 648	582
Volatile	22 - 158	72
Fixed	458 - 528	510
Suspended Solids	0	0
Volatile	0	0
Fixed	0	0
Turbidity	0	0
Color	0	0

In order to complete the research of possible combinations of waters to be treated, water from the Impounding Dam and Sugar Run were mixed on a one (l) to one (l) basis. The primary treatment of these mixtures showed that the lime neutralization dosages ranged between 90 and 110 mg/l with an average of 98 mg/l. The treated water was then mixed with Mill Run using mixtures that varied between six (6) parts treated water to one (l) part Mill Run and four

Conclusions:

The primary treatment or mine drainage treatment phase for Kittanning Run, Sugar Run, Glen White Run or combinations thereof can be accomplished with lime or soda ash neutralization, coagulation and clarification. The primary treated waters should, with proper and adequate treatment, be well within or below concentrations allowable by the mine drainage discharge standards.

The high acidic and iron concentrations in Kittanning Run dictate a high lime or soda ash demand for neutralization and iron removal. Due to the stream quality and the high lime or soda ash usage, which averaged 316 mg/l for lime and 528 mg/l for soda ash during the research period, the quality of the primary treated waters is such that its treatment to potable water standards without mixture with other waters containing lesser concentrations of iron, manganese, hardness and solids is questionable from a treatment procedure and economic standpoint. Due to these factors, it would appear that the best usage for these waters is stream release. However, there is no apparent reason that the Kittanning Run water cannot be used for make-up water when needed. This can be accomplished by mixing Kittanning Run with waters containing lesser concentrations of iron, manganese, hardness and solids ahead of the primary treatment phase or by mixing the primary treated waters from Kittanning Run with treated water from the other sources of supply.

The primary treatment of combinations of Glen White Run and Sugar Run or Impounding Dam and Sugar Run show, that with lime or soda ash neutralization these combinations can produce a finished water well without the allowable limits of mine drainage discharge standards. The research indicates that in order to accomplish this the lime demand averaged at 100 mg/l and the soda

ash demand averaged at 275 mg/l. This would indicate that from an economical standpoint, neutralization with lime is the most desirable means of primary treatment of these combinations. The research also indicated that the floc formed during lime neutralization tended to settle better during clarification and produced a heavier floc which should render itself to a drying process more readily.

The research on primary treatment of the combinations of Glen White Run and Sugar Run or Impounding Dam and Sugar Run indicated that the finished waters produced, although still relatively high in concentrations of manganese, hardness and total solids, can be treated to potable drinking water standards.

Of the three methods of secondary treatment carried on during the research period, it appears that the most desirable method of treatment is the limesoda ash softening with recarbonization and filtration.

In all methods of treatment researched, the waters from Mill Run were mixed with primary treated waters ahead of secondary treatment due to the iron concentrations found in Mill Run during the research period and in order to make use of the dilution effect provided by the water. In most cases this dilution effect helped to increase the pH' and alkalinity and lower the concentrations of iron,. manganese, sulfates, hardness and solids ahead of the secondary treatment, thus lowering the chemical demand for treatment.

In the lime-soda ash method of secondary treatment of the mixtures used during the research, it was found that during the first step of overtreating with lime, the best resulting treatment was obtained when the pH was raised to between 10 and 11. This was accomplished with an average lime dosage of 35 mg/l for mixtures of Glen White Run and Sugar Run and 30 mg/l for mixtures

of Impounding Dam and Sugar Run. The soda ash dosage or lime neutralization stage did not produce an immediate reaction upon mixture. However, with adequate mixing, a well defined calcium carbonate floc was formed. It was found that during the research period the soda ash dosage for mixtures of Glen White Run and Sugar Run averaged at 400 mg/l and for mixtures of Impounding Dam and Sugar Run it averaged at 300 mg/l. The settling of. the calcium carbonate floc was found to be poor. Therefore, it very definitely required a coagulation acid for adequate settling in an allotted hour to two hour clarification retention period.

The lime and soda ash dosages will definitely depend on the non-carbonate hardness present in the primary treated waters and the desired hardness of the finished water. As can be seen from the results of the research for this particular type of treatment process, the chemical dosages were varied and thus varied the hardness of the finished water.

Although the recarbonization process was not easily controlled in the laboratory as was explained earlier in the report, it was found that when the water was carbonated to pH 8.0, the finished water had a desirable alkalinity, hardness and taste. The amounts of carbon dioxide to be used in this process can be readily calculated when the phenothalein alkality and the methyl orange alkalinity of-the water to be treated is known.

The results of the research indicate that the potable water produced by the lime-soda ash softening process, except for the concentrations of sulfates and total solids, is within the standards as set forth by the Public Health Standards and the Pennsylvania Department of Health. The required sulfates

concentrations not exceeding 250 mg/l will be exceeded most of the time due to the sulfates level found in the mine drainage polluted streams which are being treated.

The total solid concentration will exceed 500 mg/l most of the time due to the concentration levels present in the raw waters and due to the methods of treatment although the methods of treatment should not add a great deal to the concentrations.