SECTION III

INTRODUCTION

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A. General

The Carl A. White Water Reclamation Plant, located at Creekside, Indiana County, Pennsylvania presently accomplishes sludge disposal by wasting the sludge back into the abandoned mine workings. This disposal method promotes the occurence of higher concentrations of sludge return in the raw mine water soon after sludge wasting is initiated. This situation has created several process operational problems not anticipated during design of the treatment facility.

As a result, the Commonwealth of Pennsylvania, Department of Environmental Resources, Office of Resources Management has engaged the services of L. Robert Kimball & Associates to recommend a long term solution to the sludge disposal problem. It had previously been established that sludge disposal would be accomplished by dewatering of the sludge prior to landfilling.

The major objectives of this report are: (1) to investigate currently available and developing sludge dewatering techniques and (2) to evaluate those dewatering techniques by performing a costeffective analysis to determine the most economical and functional dewatering technique which can be implemented at the Carl A. White Water Reclamation Plant.

To accomplish the above objectives, a project team was selected with expertise in the areas of environmental and mechanical engineering, operations, water and wastewater quality and economics. Much of the data used to establish the economic base for the cost analysis was obtained from various equipment manufacturers and pilot-plant and laboratory test results. This information was then verified, refined and updated to reflect existing conditions.

B. Literature Review

The "Acid Mine Drainage" published search of the National Technical Information Service (NTIS) of the U.S. Department of Commerce for the period of 1964 - September 1978 presents 270 abstracts on the subject of acid mine drainage in general. An examination of these abstracts indicated that eighteen (18) publications, papers or patents could have elements of interest relating to sludge thickening and/or dewatering.

A closer examination of the above eighteen (18) extractions eliminated three (3) of the items. Of the remaining fifteen (15), eight (8) items were listed as available from NTIS and seven (7) were evidently available from the Government Printing Office (GPO), Washington, D.C.

The NTIS order was placed by telephone on October 3, 1979, under extra cost "fast service" conditions. As a result, the items available (seven) arrived on various dates from October 15 to October 25, 1979. These are the first 7 items in the Section VIII references.

A personal visit was made to the GPO to procure the seven GPO items, but none of these were in print any longer. Other publications of interest, however, were purchased. In addition, a stop was made at the headquarters in Washington, D.C., of the Water Pollution Control Federation. A library perusal there indicated that almost all credible information on sludge dewatering was either ordered or in our offices.

To "double-check" our search, we utilized the OWRT "Acid Mine Water" bibliography taken from a date base of 77,890 abstracts and yielding 365 abstracts. No significant additional information was detected.

C. Research and Pilot Plant Efforts

The major objective of early sludge dewatering study efforts was to determine the most cost-effective technique that should be utilized at the Carl A. White Reclamation Plant. The Commonwealth directive was for land disposal of the sludge from this acid mine water treatment plant. It therefore became necessary to assemble and compare all reasonably available cost, size and performance data on proven sludge dewatering techniques and also to investigate, by means of pilot plant operations at the plant, those most recent proprietary dewatering equipment assemblies that show cost-effective promises.

The owners of two distinctly different assemblies were contacted and contracted. The first unit was the vacuum filter leg of B.B. Barefoot and Associates. This test unit was on the site July 16, 1979, through July 20, 1979. Photographs and results of this pilot operation are presented later in this report, Sections X and V, respectively.

The second unit tried on the site was the L-R-S process which was at the plant from September 6, 1979, through September 14, 1979. Pictures and data for this unit are also presented later in this report. Because of the proprietary nature of the L-R-S equipment little detail of the machinery can be presented.

In addition, late in the study period, Euramca Ecosystems, Inc., exhibited a desire both to test their "ECOPRESS" belt filter press at the plant and to experiment with various polymers. Because of the wide range of anionic, cationic and nonionic organic polymers available and in use it was deemed advisable and timely to permit this third pilot operation on November 8 and 9, 1979. Photos and results follow in Sections X and V respectively. it was also deemed advisable to operate the D.E.R. "Yellowboy" centrifuge at the plant in late March 1980. See Section V.E.

Sharples centrifuge pilot plant testing was observed by representatives of D.E.R. and the Professional on January 31, 1980.

In order to procure the most credible cost, size and performance data on the sludge dewatering equipment that have lengthier histories, the following manufacturers were contacted by L. Robert Kimball & Associates and offered raw water and/or waste sludge samples from the plant:

- B.B. Barefoot and Associates*
- Liquid Removal Services, Inc.*
- Ecodyne, Smith & Loveless Division
- Envirex - a Rexnord Company
- Euramca Ecosystems, Inc.*
- Infilco Degremont, Inc.
- Komline-Sanderson
- Parkson Corporation
- Passavant Corporation
- Bird Machine Co., Inc.
- Sharples-Stokes Division-Pennwalt Corporation

* Pilot Plant Operated in Situ

Five gallon carboys of waste sludge were shipped to L-R-S, Ecodyne, Envirex and Infilco. Ten gallons of sludge were sent to Komline-Sanderson, Parkson and Passavant. 'In addition Komline-Sanderson had requested, and we shipped to them, ten gallons of raw water. Three fifty-five gallon drums of sludge were shipped to Sharples-Stokes.

To establish for proper comparison a uniform sludge quantity and weight solids content our letter of November 13, 1979, to the above manufacturers instructed them, as the result of our plant experiments in efficient operation, to expect 165,000 gallons of sludge per day at a 3% weight solids density to be dewatered to 20% weight solids for truckability and land disposal. A copy of this letter is included in this report as Appendix D.

The solids percentage at the underflows of the plant clarifiers was in the range of 0.9% to 1.4% during this study but experimentation on sludge recirculating, non-operation of of the bottom scrapers and addition of settling aids (polymers) indicated that 3% is an achievable density.

The ultimate 20% weight solids is somewhat arbitrary, originating in discussions with the D.E.R. Solid Waste Division as a good target figure for land disposal of the sludge. Twelve (12%) and more weight solids content would seem to meet all criteria in terms of truckability, non-leaching characteristics, elimination of cover material, general handling, and possible cost-effectiveness, which will be addressed later.

The manufacturers were instructed to use a 20 year design period, three cents per kilowatt hour for power cost and $7.50 per man hour for labor. To assist in the tally and comparison of the laternative sludge dewatering equipment we printed a "Sludge Dewatering Cost Summation Sheet" (Appendix E.) Each sheet summarizes the annual capital, operationg and maintenance costs for a proposed dewatering unit. The sizes of the equipment are very important because of the cost of equipment housing, where required.

The extensive list of manufacturers contacted were intended to provide a representative cost data study on the viable types of dewatering equipment—vacuum filters, centrifuges, pressure filters, belt filter presses, and unique methods.

Following and intimately related to the annual capital, O&M and, in some cases, building costs, the cost of transportation and land disposal of the sludge must be added to some. Needless to say it is at this point that the percentage solids achieved by a particular assembly greatly affects the transportation and disposal costs.

In effect, with transportation and disposal costs being inversely proportional to the percent weight solids achieved, but the O&M costs being directly proportional, i.e., higher percents solids = higher power and/or chemical costs, cost-effectiveness had to be determined via tabulation and plotting as indicated on Figures VII-1 and VII-2 and the table in Appendix C.

Information obtained from research conducted on the treatment of acid mine drainage indicates that certain operating parameters have a significant impact on the overall plant performance. Several of these parameters and a summary of their impact on the overall process, as well as optimum operating range (where applicable) are as follows:

pH

1) The optimum pH operating range is considered to be between 8.0 and 8.5.

2) Higher operating pH's result in increased oxidation rates. This has an impact on the sizing of the aeration vessel utilized.

3) Ferrous iron, although soluble and unstable, can be precipitated by crystallization, without oxidation, to the ferric state by operating at a pH in excess of 9.0. However, this would increase treatment and sludge disposal costs. Ferrous hydroxide sludge is about 1.5 times as voluminous as ferric hydroxide sludge.

4) A minimum operating pH of 8.0 should be employed to assure adequate manganese removal to meet current NPDES discharge criteria to surface waters.

5) Sludge density will increase with decreasing pH. A low pH environment facilitates the formation of crystal ferric hydroxide precipitates generally associated with dense sludges.

Neutralizing Agent

1) Sodium hydroxide (NaOH) is normally used for neutralization when sulfate concentrations in the raw water are sufficient to promote the formation of gypsum ($CaSO_4$).

2) Limestone will produce a denser sludge than lime because of the lower operating pH resulting from its use (see pH - item 5). However, because neutralization and oxidation rates are decreased, the size of the reaction vessels consequently increase. In addition, because limestone is not capable of achieving pH's much above 6.5 without sludge recycle, the effluent pH must first be raised by some other neutralizing agent prior to discharge.

3) Lime is generally the accepted neutralizing agent in AMD treatment plants. It is relatively low cost, capable of attaining a wide variation of operating pH's, and provides for acceptable neutralization rates.

Sludge Recycle

1) Sludge density increases with increased sludge age which is a function of sludge recycle.

2) Optimum sludge recycle is reported to be equal to that which is sufficient to attain a clarifier influent suspended solids concentration of 5,000 to 10,000 ppm.

3) Sludge recycle increases the rate of oxidation due to the catalytic effect of iron precipitates.

4) Exposure of sludge to a high pH during neutralization is reported to enhance the formation of crystalline precipitates which are associated with dense sludges.

5) Sludge recycle does not produce any improvement to plant effluent clarity.

Oxidation Rate

1) If the retention time provided by the aeration vessel is far in excess of that required to perform complete oxidation, the ferric hydroxide flocs formed may be subject to shearing forces which can disintegrate the flocs to small, difficult to settle, crystals. This would result in poor effluent clarity and low sludge densities.

Chemical Conditioning

1) The use of polymers (flocculants) provides for significant improvements in effluent quality and sludge densities.

2) Information obtained from several dewatering equipment manufacturers' pilot plant and/or laboratory studies (see Appendix B – Selected Vendor Data), indicate no singular polymer can be considered to provide optimum results.

Raw Water Characteristics

1) Research indicates that the presence of aluminum in the raw water will interfere with the settleability of the ferric hydroxide sludge. Recent chemical analysis of both the raw water and sludge indicate that appreciable amounts of aluminum are present in the raw water. This situation may very well be contributing to the poor clarifier performance. Aluminum interference can be reduced by implementing a processing scheme in which the aluminum is precipitated prior to aeration at a pH of 5.0. The pH is then readjusted to 8.0 to 8.5 prior to aeration and the resulting ferric hydroxide sludge predipitated in the final clarifiers. Pilot operations employing this treatment scheme would be difficult given the present plant configuration.