PROPOSED ALCOSAN SECONDARY TREATMENT

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Background

The Allegheny County Sanitary Authority was organized in 1946 to comply with the Clean Streams Act passed by the Pennsylvania Legislature in 1945. This Act required all municipalities and industries to cease the discharge of untreated wastes into the streams of the Commonwealth. The Authority is known as "Alcosan". Metcalf & Eddy, Inc. has been consultant to Alcosan since 1947.

Alcosan now serves 72 municipalities plus the City of Pittsburgh. The collection system includes 69 miles of interceptors varying from 10½ ft diameter at the main pumping station at the treatment plant down to 8 in. and 12 in. connecting sewers throughout the system. It generally follows the banks of the three rivers and two large creeks, and is almost entirely gravity flow with the exception of three small pumping stations and three ejector stations. Approximately 30 miles of the collection system is in deep rock tunnel. The collection systems of individual municipalities discharge into, but are not part of, the Alcosan system.

The present treatment process is termed intermediate because of the preaeration channels, but is actually little better than primary treatment. In general, the plant consists of a main pumping station, rack and chlorination building, grit channels, meter vault, preaeration channels and sedimentation tanks, sludge heating facilities, sludge concentration tanks, and incinerators.

All of the existing plant is designed for a peak flow of 300 mgd. All but the primary settling tanks are designed for an average daily flow of 200 mgd. The primary settling tanks are designed for an average daily flow of 150 mgd. However, space was provided in the original design for two additional primary tanks if they should be required by regulatory agencies. The sludge disposal at the present time is by heating, sludge concentration by anaerobic flotation (Laboon process), and flash-drying incineration. The concentrated sludge averages 16 percent solids.

The collection system and treatment plant took 3 years to construct

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and was placed in operation in June 1959. The total cost for engineering, financing and construction was approximately 100 million dollars. The treatment plant cost was approximately $20,000,000.

Future Requirements

In 1965 and 1966, Alcosan and the State Sanitary Water Board held several meetings to discuss new and improved treatment not contemplated by either in the original project. The State Sanitary Water Board issued an order on March 16, 1966 requiring Alcosan to provide additional wastewater treatment. The Authority cooperated by submitting a schedule for reports, plans and specifications, and construction, and has met this schedule to date. Nine years after Alcosan's intermediate wastewater treatment plant was placed in operation, Metcalf & Eddy completed plans and specifications for secondary treatment and additional sludge disposal facilities in order to meet more stringent stream standards and upgraded effluent requirements. The State Sanitary Water Board has approved the plans and issued a permit for construction.

The estimated construction cost of the project is $38,500,000 with a project cost of $49,700,000. Alcosan has applied for federal and state construction grants. If a grant of at least 30 percent is made, construction may start in the spring of 1969, and may be completed in 1970, all on schedule. The Authority needs a large construction grant in order to keep the increase in the service charge rate reasonable. Even with a 30 percent construction grant, the added operation, maintenance, and capital cost may require an increase in the service charge rates. The increased operation and maintenance costs alone are estimated at $1,255,000, about 33 percent of the present operation and maintenance budget.

Fig. 1 shows the population and accounts served. These have increased slowly in the past and, as can be seen, are expected to increase slowly in the future. It is noted that the rate of increase of population and accounts served are approximately the same. Alcosan's present policy is to admit no new participants inasmuch as the collection system is designed to handle only the wastewater flows from the present participants and can be expanded only at a great additional cost.

Fig. 2 shows the average annual wastewater treatment plant flow records and the future trend. Since the records show no trends, the flow has been projected generally in accordance with increases in the population and the numbers of accounts. We expect the average annual flow to increase from approximately 140 mgd to about 150 mgd by 1985.

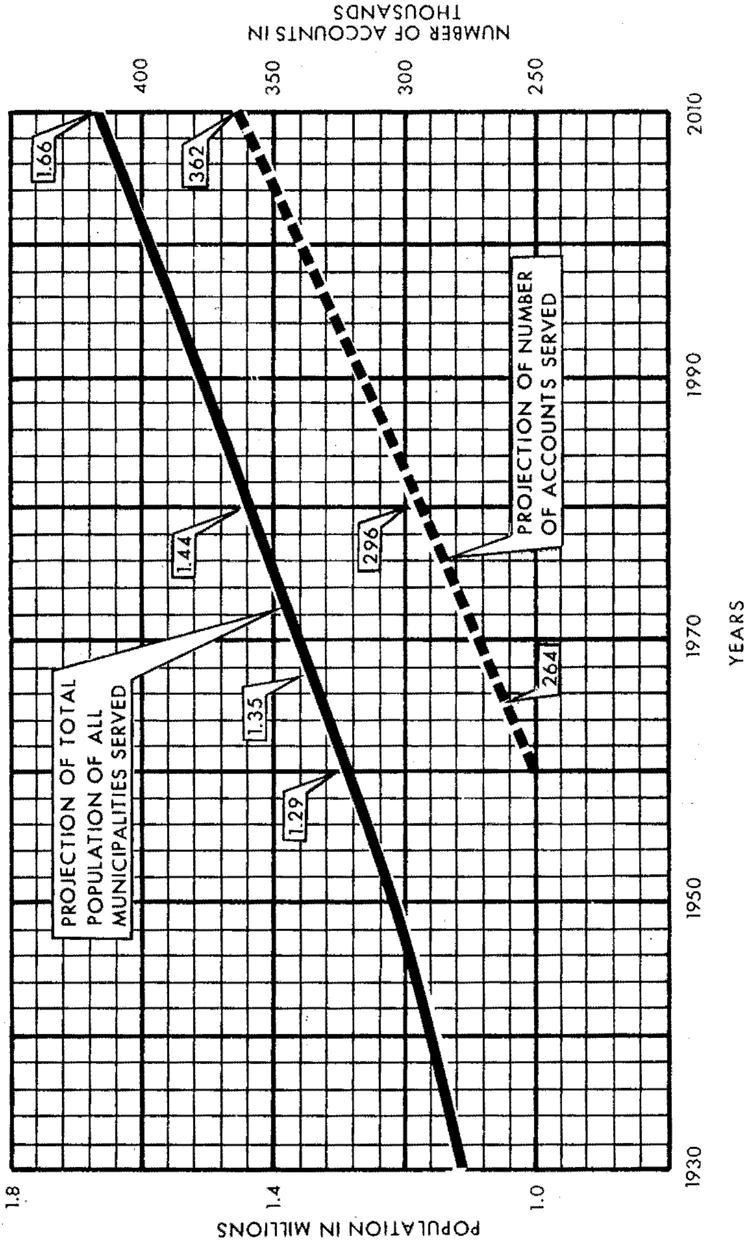

Fig. 1 — Population and accounts trends.

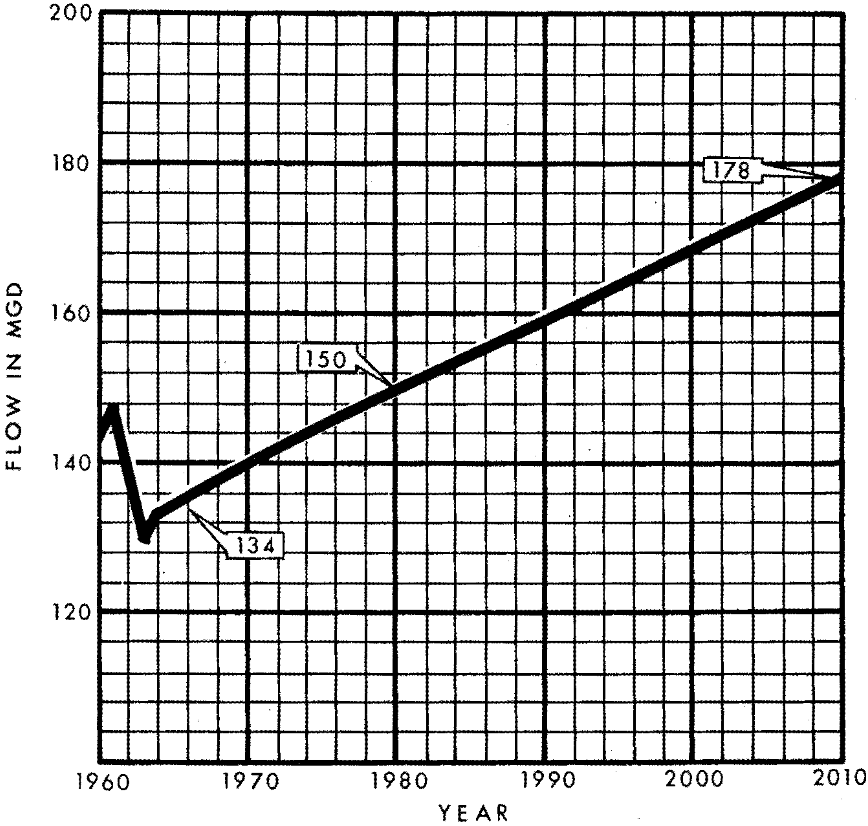

Fig. 2 — Waste water flow trend.

The Pennsylvania Sanitary Water Board order requires Alcosan to discharge less than 60,000 lb/day of 5-day, 20 deg C BOD into the Ohio River. Our computations showed that the Ohio River dissolved oxygen will be in excess of 4.0 mg/L downstream of the Alcosan outfall if not more than 90,000 lb of BOD are discharged into the river each day. In general, removal of 85 percent of the influent BOD is required if the project is to be considered for federal construction grants. We have designed for 90 percent BOD removal.

Fig. 3 shows estimated raw and effluent BOD in 1970 with the existing intermediate treatment, just before the new facilities are placed in operation, and for 1970, 1980, and 2010 with the new facilities in operation. In 2010, the BOD load into the river is expected to be one half of the load allowed by the Sanitary Water Board.

Proposed Secondary Facilities

The proposed plant additions will consist of six aeration tanks, 12 final settling tanks, and two chlorine contact tanks. The existing preaeration tanks will be bypassed and used for partial aerobic digestion of the waste-activated sludge. They can be kept in service as preaeration tanks, if desired. Sludge disposal will be by vacuum filtration and incineration of raw sludge. No additional primary settling tanks are planned up to the design flow of 200 mgd. Although the existing tanks are designed for only 150 mgd, the reduction in efficiency up to 200 mgd is slight and will be compensated for by the secondary treatment. Space has been reserved in this design for two additional tanks if they should be required in the future by the regulatory agencies.

Fig. 4 shows schematically the existing and proposed wastewater treatment. It is noted that preaeration will be eliminated and the tanks used for aerobic digestion of waste-activated sludge.

The six aeration tanks are diffused-air, spiral-flow tanks designed for an average daily flow of 150 mgd, and a design loading of 45 lb of BOD per 1,000 cu ft. It is expected that the loadings can easily be increased to 60 lb of BOD per day per 1,000 cu ft, and that the six tanks will treat an average daily flow of 200 mgd. The air capacity and hydraulic design are such that six aeration tanks will be able to treat an average daily flow of 200 mgd and a peak flow of 300 mgd. The present state standards for design loadings of aeration tanks permit not more than 35 lb of BOD per day per 1,000 cu ft of tank. The use of the 45-lb loading which was approved by the state reduced the size of the aeration tanks significantly. We are confident that op-

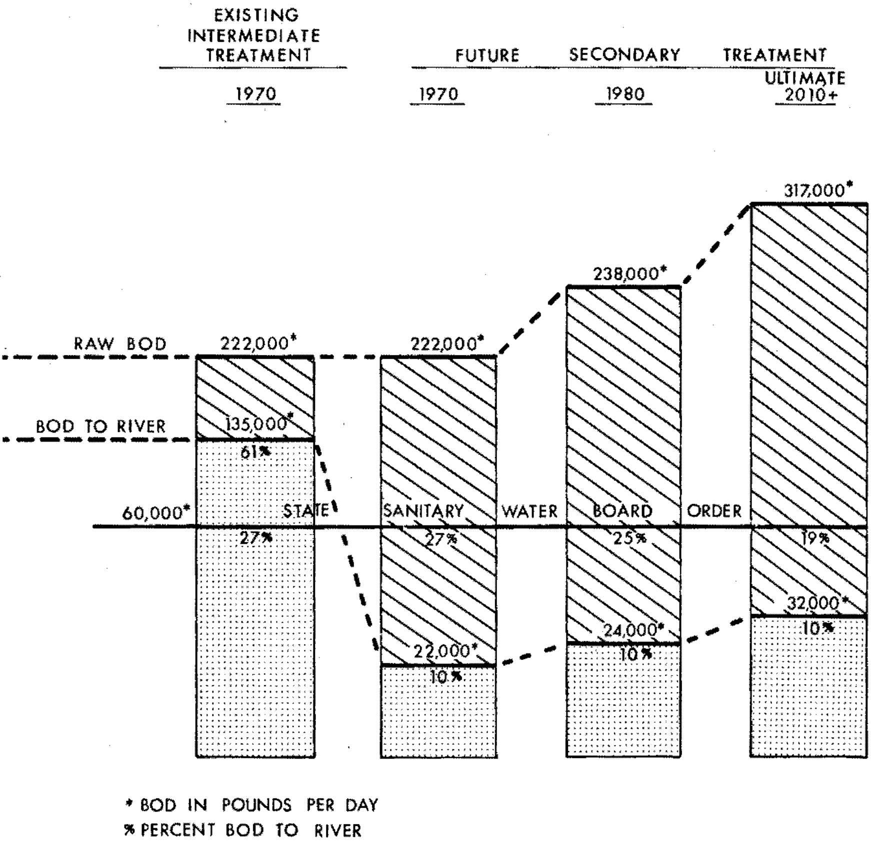

Fig. 3 — BOD information.

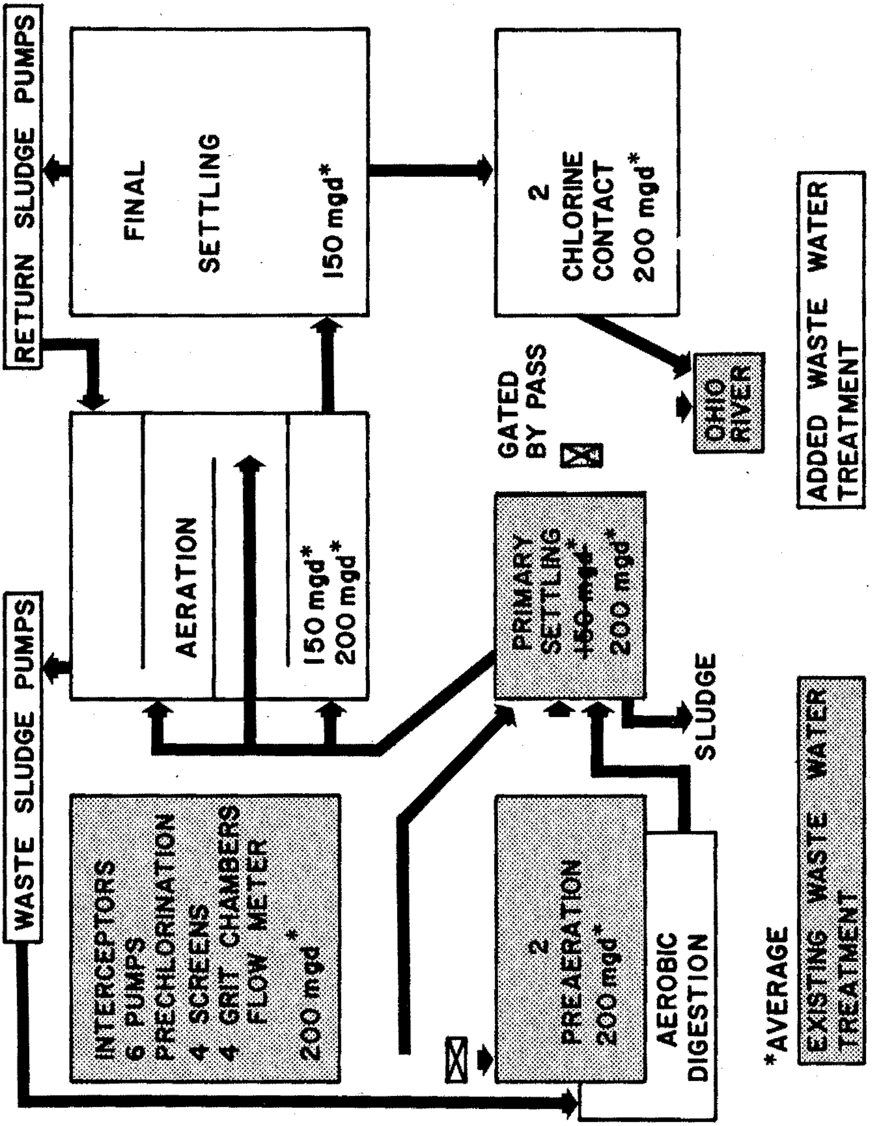

Fig. 4 — Waste water treatment.

eration will prove that the higher loadings of 60 lb of BOD per 1,000 cu ft will provide a 90 percent reduction, and that additional aeration tanks will not be required in the future. However, space was left for two additional aeration tanks if they are required.

The 12 circular final settling tanks, 141 ft in diameter, are designed on the basis of a 1,200-gallon per square foot per day overflow rate for a peak flow of 225 mgd. These tanks will have to be supplemented by two additional tanks as the peak flow increases from 225 mgd to 263 mgd, and by two more tanks as the peak flow increases from 263 mgd to 300 mgd. Space for the four additional tanks has been provided on the site.

The chlorine contact tanks are designed to provide a 15-minute detention at peak flows of 300 mgd.

It is believed that, by the addition of four final settling tanks, the existing and presently proposed sewage treatment plant can provide a 90 percent BOD removal for an average daily flow of 200 mgd and a peak flow of 300 mgd.

A blower building will contain four initially, and room for a fifth, centrifugal compressors, each having a capacity of 60,000 cu ft of air per minute. The air will be filtered through rough filters, electrostatic precipitators, and bag-type filters to reduce the tendency to clog the fine bubble tube diffusers that are specified.

A small new operations building will be constructed next to the blower building. Secondary treatment and final chlorination will be supervised from this building. It will contain a small laboratory for operation control tests; a center for the automatic control equipment; shower, locker, and lunch room facilities; and some storage space.

The operations building is electrically heated, as is the blower building. The large electrical use in the plant makes it economical to use electrical heating. Much of the heat for the blower building will be produced by the blowers themselves although supplemental electrical heat will be required when the number of blowers operating is not sufficient to maintain a reasonable temperature.

The new buildings and structures and existing plant facilities will be interconnected by tunnels and passageways so that the entire plant operation can be observed without going outside in inclement weather. Practically all wire and pipe are installed in tunnels and easily accessible. Most of the power and control wires will be laid in trays.

Sludge Disposal

The sludge disposal for the proposed treatment plant is shown diagrammatically on Fig. 5. It will consist of wasting activated sludge to the existing preaeration tanks, which will be used as aerobic digestion tanks. The partially-digested activated sludge will be discharged into the raw sewage and will be resettled with the raw sewage solids in the present primary settling tanks. The raw sludge containing waste-activated and primary sludge solids will be pumped from the primary tanks through disintegrators into mixing tanks. The sludge will then be pumped to vacuum filters, dewatered, and carried by belt conveyors to the existing incinerators. The incinerator ash will be settled together with residue from two-stage tray scrubbers in the existing ash settling tanks along the river wall. The supernatant from the ash settling tanks will be returned to the raw sewage for treatment. The ash will be handled as at the present time by hauling to a spoil area which the Authority maintains a couple of miles from the treatment plant.

The present incinerators were designed to incinerate sludge concentrated to 16 percent solids. The incinerators actually are evaporators of water, and were designed to evaporate water from sludge containing 84 percent water with the use of supplemental heat. The increased solids concentration in the vacuum filter cake, compared with the present concentrated sludge, will markedly increase the capacity of the incinerators to dispose of solids. Fig. 6 shows the amount of wet sludge which can be incinerated as the sludge solids increase from 16 percent solids to 20 percent solids to 25 percent solids. It is noted that a constant amount of water is being evaporated. Also significant is the marked increase in the pounds of dry solids which can be disposed of through a given incinerator.

The incinerators were plagued for years with deposits on the vapor fan blades, which required that the incinerators be taken off line and solids chipped from the blades at intervals as short as 5 days. Investigation and experimental work by the Authority has proven that a minimum temperature in the drying cycle of 300 deg F will prevent deposits on the vapor fans and will permit the vapor fans to operate almost indefinitely. Incinerator runs now exceed 1,000 hours, or 40 days. Therefore, while in the past it became difficult at times to keep two incinerators on line with a total of four available, three incinerators can now be used most of the time. As a result of the higher solids concentration in the vacuum filter sludge cake, and the solution of the vapor fan problem, the incinerators will have a capacity to handle the primary and secondary sludge from a 200 mgd flow.

Two-stage scrubbers will be added to the incinerators so they will meet the applicable county air pollution codes. The alternative would have been

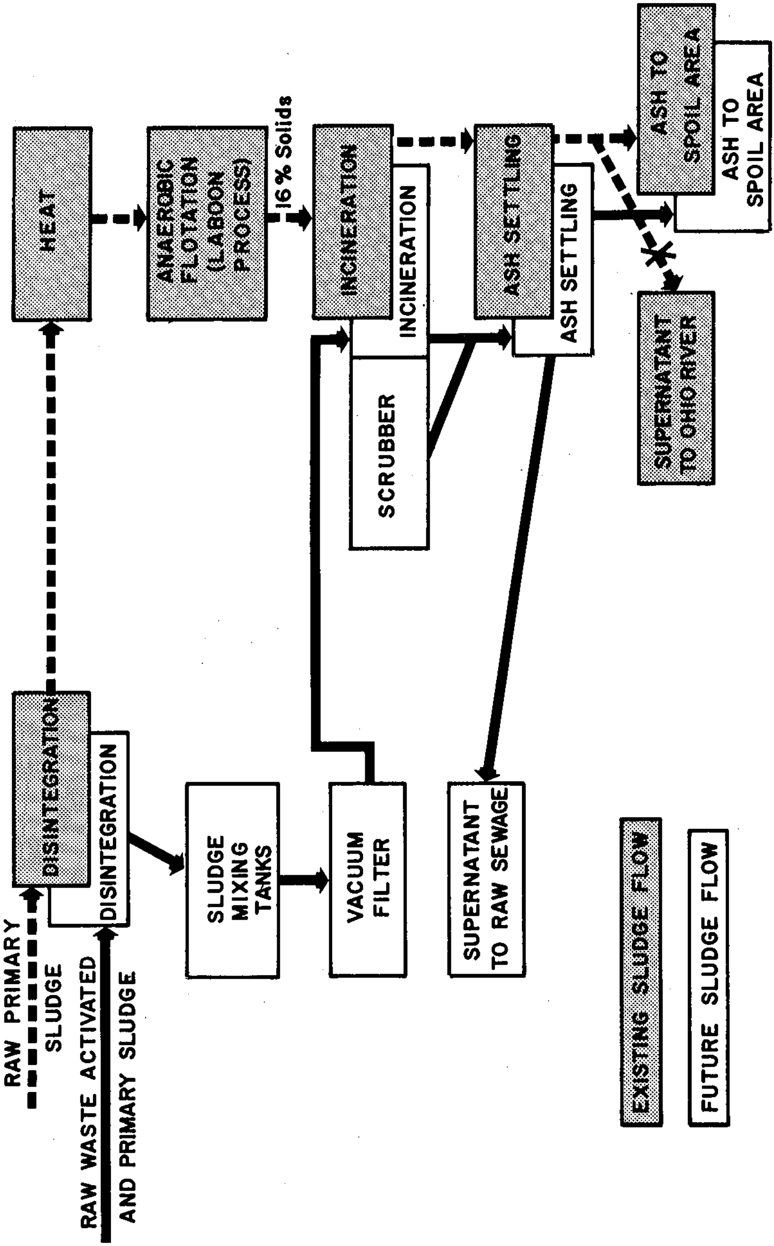

Fig. 5 — Sludge disposal.

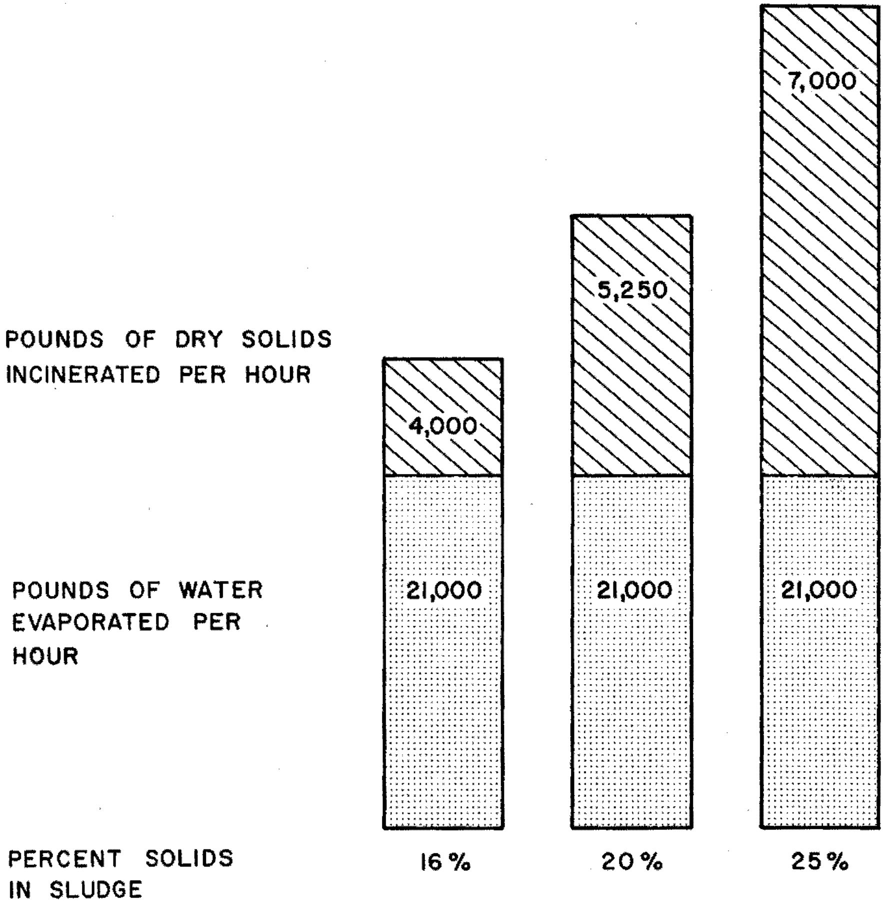

Fig. 6 — Incinerator capacity.

to scrap the existing incinerators and replace them with new incinerators which would give a satisfactory stack discharge into the atmosphere.

Design Features

A few of the interesting features of design are discussed below.

The secondary treatment facilities are designed so that they can be operated as two completely separate plants, or as one plant. Initially, the Authority staff will operate two completely separate plants. They will use different mixed liquor concentrations, dissolved oxygen concentrations, periods of sludge reactivation, points of wastewater application, and BOD loadings to find the optimum operating criteria. Inasmuch as the staff will apply different operating criteria to two portions of the same wastewaters, the operation results will be much more informative than if the different criteria were to be applied to different wastewaters on different days. Once the best ranges of operating criteria are determined, the secondary treatment facilities will probably be operated as a single plant.

The flows from one primary settling tank effluent channel will be discharged into the six, or fewer, aeration tanks. The flows will be measured and regulated by flowmeters and automatic controls so that the primary effluent can be divided evenly between the aeration tanks in operation, or can be divided 60 percent to one side of the plant and 40 percent to the other side of the plant if desirable during the investigations in early years, when the two sides of the secondary treatment plant are operated as two completely separate plants.

A plan of one aeration tank is shown on Fig. 7. It is noted that the sludge follows a U-shaped course. The re-aeration compartment is closest to the final settling tank. Primary effluent can be applied to each or any combination of the second, third, or fourth compartments. This configuration reduces the piping and channels which are required. The actual amount of sewage discharged to each one of the compartments is controlled by manually-operated gates.

Aeration will be automatically controlled. Each compartment of each aeration tank will have three points at which DO analyzers can be installed. Only one DO analyzer is expected to be installed in each compartment of each tank. The best location for control of dissolved oxygen must be determined in the field. In the early stages of operation the DO analyzers will be moved among the three points to find the best location to measure and control the dissolved oxygen. Dissolved oxygen in each of the four compartments of the aeration tank will be controlled separately. The dissolved oxy-

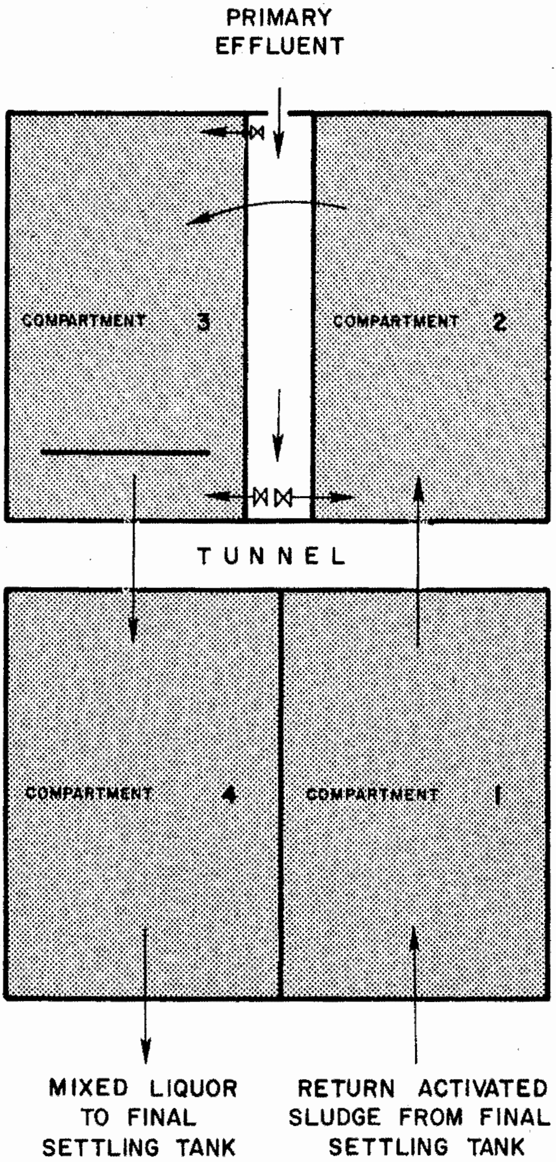

Fig. 7 — Plan of one aeration tank.

gen measured by the DO meter in one compartment will control a butterfly valve in the air header serving that compartment of the aeration tank. The butterfly valve will be controlled in such a way that the minimum discharge to any one section of tank will be kept above the minimum required to keep the tank contents completely mixed. Inasmuch as there are six tanks and four compartments in each tank, this will require 24 dissolved oxygen analyzers and 24 air control points.

The blowers will be automatically controlled to produce the correct amount of air. The control will be based on the blower discharge pressures, which will change as the butterfly valves on the air supply pipes to each compartment open and close to meet the demands for air. This system will provide only the air required to maintain the dissolved oxygen at the optimum level in each compartment. Power saving from supplying just enough air, and better treatment from always supplying enough air, are expected.

The coliform effluent standards permit only 5,000 coliforms per 100 ml. The rate of postchlorine feed will be automatically controlled by a chlorine residual meter to produce a residual chlorine which will reduce the coliforms to the required level. Postchlorination of approximately 10 mg/L will be required.

Fig. 8 "Effluent Chlorination Control" shows that chlorine will be fed into the final settling tank effluent channels immediately ahead of a rapid-mixing chamber. A sample of chlorinated wastewater is taken immediately after the rapid-mixing chamber and pumped to a chlorine residual meter. The chlorine residual reading is transmitted to the chlorinator controller which increases or decreases the rate of chlorine feed to meet the set-point residual. The required residual will probably be in the neighborhood of 5.0 mg/L for the disinfection required. The actual required residual will be determined by comparing coliform counts at the effluent end of the chlorine contact tank with the set-point residual. The set-point residual will be adjusted daily, and then weekly, until a residual is found which will produce a plant effluent containing no more than 5,000 coliforms per 100 ml. Automatic control of chlorination not only saves chlorine but is also more effective.

Prechlorination will be retained and is expected to be used in the summertime to control hydrogen sulfide odors from the raw sewage. Approximately 5 mg/L will probably be used during the warm weather for this purpose.

Experience has shown that sludge disintegrators are very important to the trouble-free operation of plunger sludge pumps. Therefore disintegra-

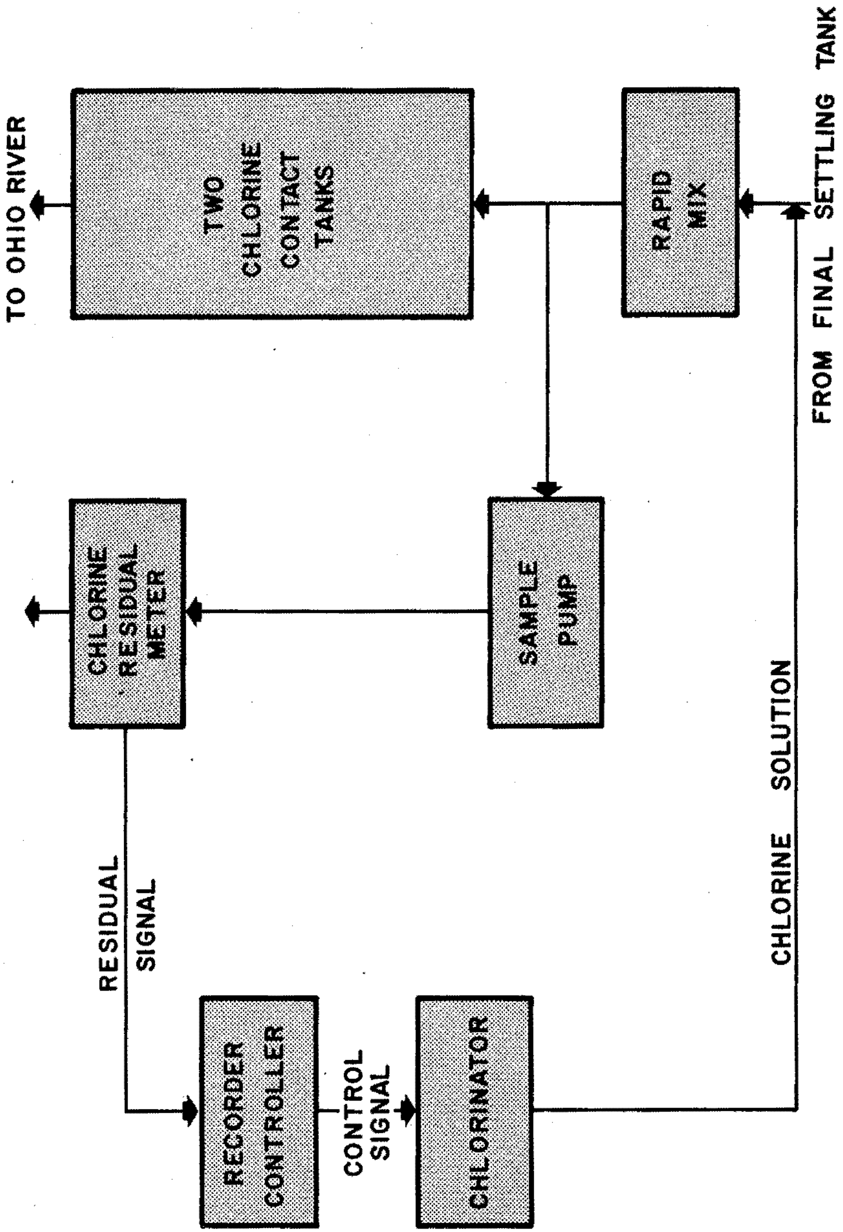

Fig. 8 — Effluent chlorination control.

tors will be provided before the mixture of primary and waste-activated solids is discharged into the mixing tanks. These two mixing tanks are essentially wide places in the sludge lines, with capacity to handle approximately six hours of sludge flow. Mixing will be accomplished with slow-speed mixers to prevent any rapid change in sludge concentration or characteristics. The tanks will also serve as suction wells for the duplex plunger pumps which will pump sludge to the vacuum filters.

Each vacuum filter will be fed by one plunger pump. The plunger pump speed will be controlled by the level in the filter tank.

Facilities are being provided so that sludge can be conditioned with two polymers or with one polymer and ferric chloride. No provision has been made for the use of lime in the conditioning of the sludge. The operator will proportion the amount of each conditioning chemical fed to each filter, and control equipment will automatically maintain this proportion as the sludge pump speed varies to maintain the sludge level in the filter tank.

One console will control four vacuum filters. The filter drum speed will be variable and remotely controlled from the console. Valves are provided on both the pickup line and the drying vacuum line. Each vacuum filter will have its own vacuum pump and its own chemical-feed pumps. In general, each filter will operate completely separately and have completely separate auxiliary equipment. If any part of a filter or its auxiliary equipment requires maintenance, the filter will be taken out of operation and a spare filter placed in operation.

Carbon filters will be used to remove sludge odors from all air which will be discharged to the outside of the vacuum filter building, or recirculated. Two sets of filters will be included, one to take care of the general area, and one to take care of the gases which are pulled out of the filter by the vacuum pumps.

Conclusion

The proposed Alcosan secondary wastewater treatment plant will be a modern semi-automatic facility which will provide a high degree of treatment. It, in conjunction with wastewater treatment facilities to be built by other municipalities and industries, will assure excellent conditions in the Ohio River for years to come.