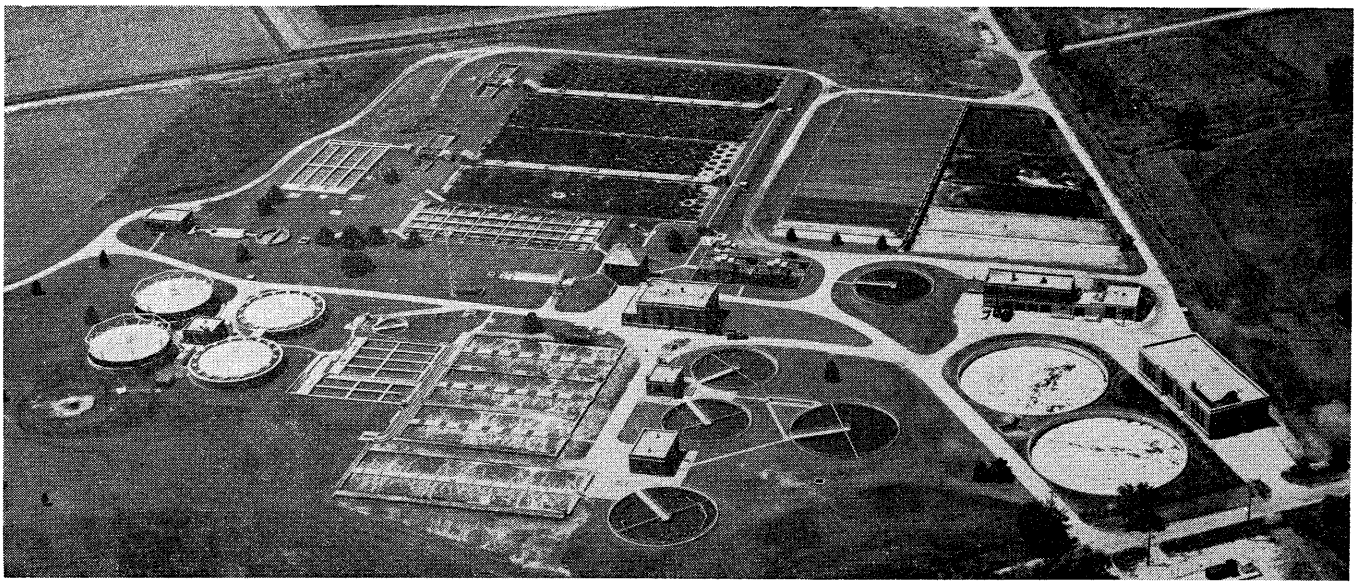

The effluent of the Nine Spring Sewage Treatments Works shown here now flows through an . . .

Outfall Around the Madison Lakes

by JAMES G. WOODBURN, Pres.
Madison Metropolitan Sewerage Commission
Madison, Wisc.

EDITOR'S NOTE: Among the more frequently studied bodies of water in this country are Lake Waubesa and Lake Kegonsa, the lower two of the four so called Madison lakes. The work of Sawyer and others on the fertilizing effect on the algae of these lakes of the nitrogen and phosphorus in the effluent of the Madison plant have been reported in the literature over the years. The construction of an outfall force main and open channel to upper Badfish Creek will now introduce the Madison effluent into the Yahara river below the two lakes as well as most of the dams on the river thus eliminating the problem. Mr. Woodburn in this article describes the construction of this $3 million project.

■ SEVERAL DECADES of discussion, engineering studies, political agitation, public hearings, legislation and court decisions culminated in December, 1958, when the Madison, Wisconsin, Metropolitan Sewerage District began pumping effluent from its Nine Springs Sewage Treatment Works through a pipeline to a channel which bypasses the two lower lakes of the chain of four generally known as the Madison Lakes.

This $3 million project was built pursuant to legislation requiring the District to cease introducing effluent into the lakes unless further treatment were applied to remove the nitrogen and phosphorus which stimulate the growth of algae and other aquatic plants in lakes. No practicable method being known for such removal, the effect of the legislation was to require bypassing the lakes.

The Nine Springs Works provide primary and secondary treatment for all wastes from the metropolitan area of 85 square miles and a population of 135,000. The flow through the works averages about 18 mgd, with occasional peaks of over 30 mgd. Primary treatment consists of screening, grit collection and sedimentation. In the secondary stage, about 5 mgd are treated by the trickling filter pro-

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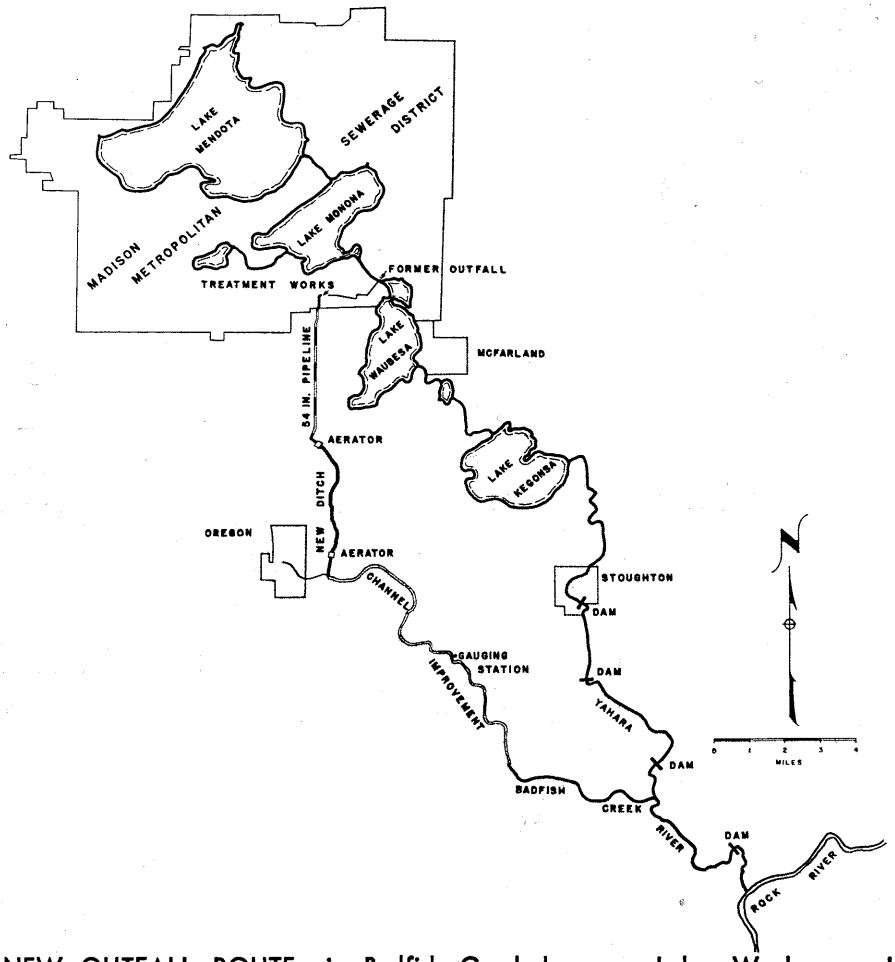


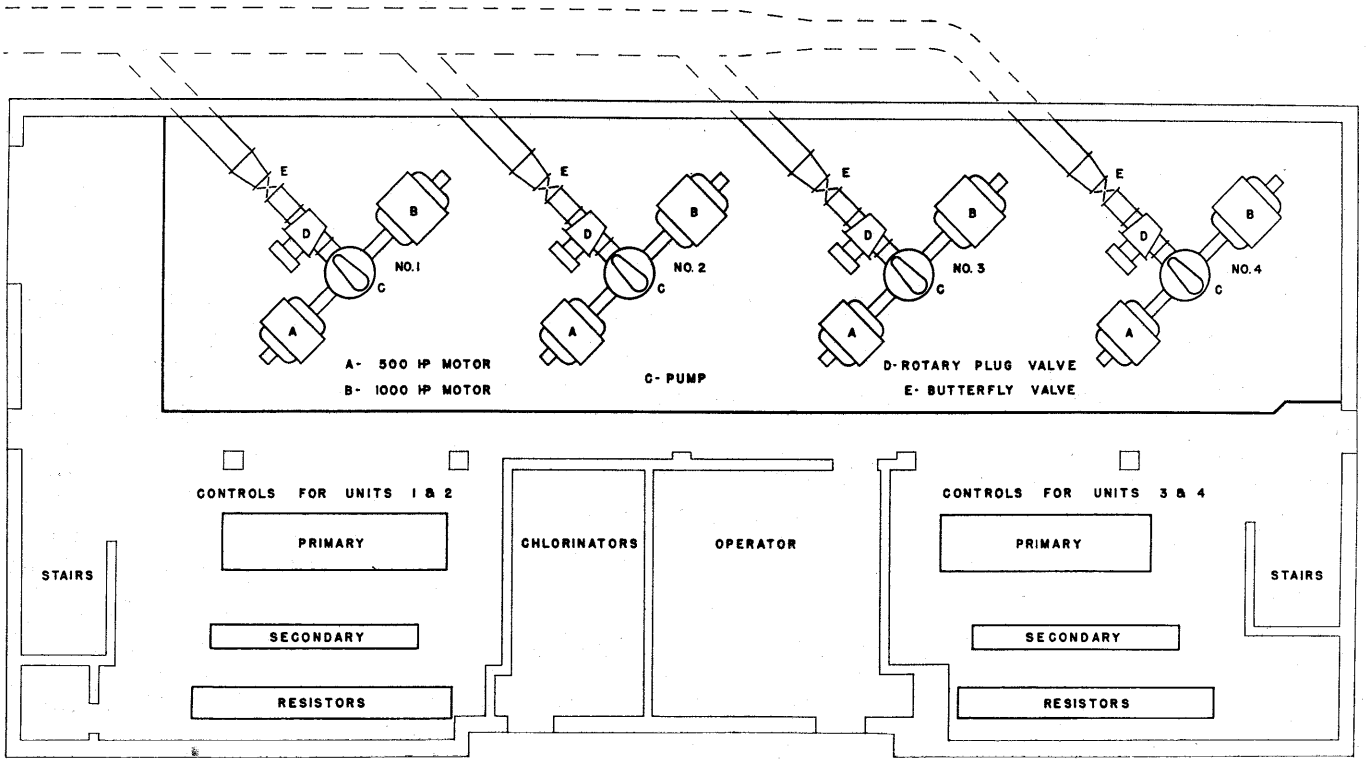
NEW OUTFALL ROUTE via Badfish Creek bypasses Lakes Waubesa and Kegonsa.

cess and the remainder by the activated sludge process. The effluent leaving the final settling tanks generally shows a content of both B.O.D. and suspended solids of between 20 and 25 ppm.

The Problem

Since the opening of the Nine Springs Works in 1928, the effluent has been discharged into the Yahara River about a mile above Lake Waubesa. Four miles below that lake the river enters Lake Kegonsa, from which it flows through the city of Stoughton to the Rock River. In the 19-mile stretch below Kegonsa are four dams which pond water for hydroelectric power plants.

Following the decision by the State Supreme Court holding the legislation valid, the District retained as engineering consultant the firms of Mead and Hunt, Inc., Madison, and Greeley and Hansen, Chicago, to study possible routes for discharge of effluent. From the 14 routes reported on, the District Commissioners selected the "Badfish Creek route" as the best. Although this route involved pumping the effluent over a divide 80 feet higher than the works, the annual cost was found to compare favorably with the least expensive all-gravity route. Weighing heavily in the decision was the fear that introducing the effluent into the Yahara River just below the outlet of Lake Kegonsa, which would have conformed with the statute, might cause the District to be held responsible for any algae troubles that might occur in the series of ponds in the river below that point. The Badfish



DIAGONAL ARRANGEMENT of units in pumping station is economical of space.

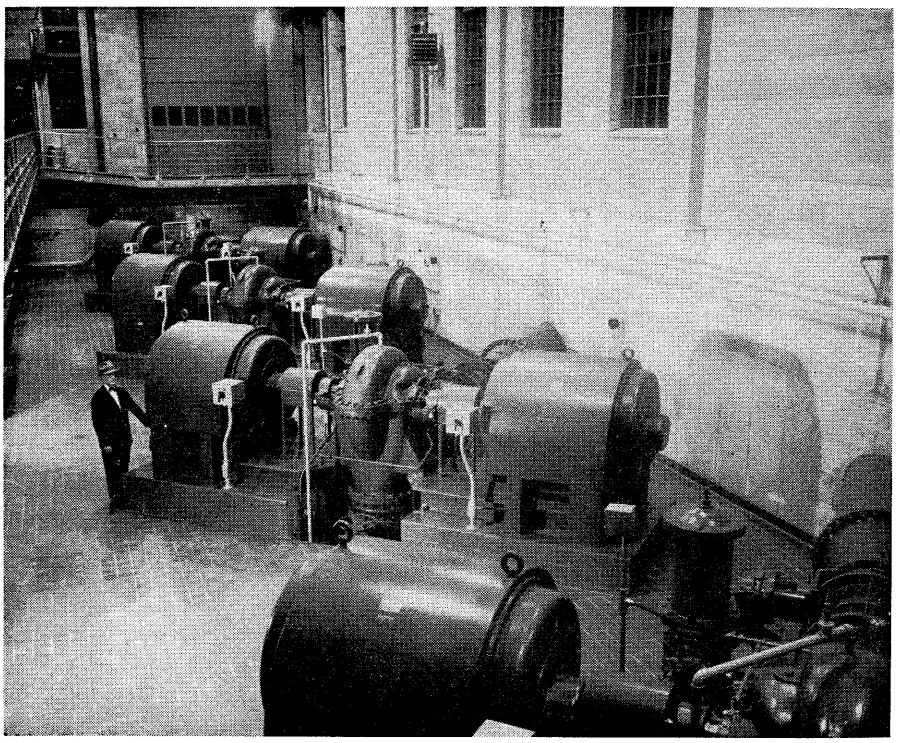
Creek, on the other hand, has an average of slope of over 6 feet per mile and the resulting velocity of flow is expected to inhibit the growth of algae.

The project as constructed includes (1) a pumping plant with an installed capacity of 144 mgd; (2) 5.1 miles of 54-inch concrete pipeline; (3) 3.8 miles of new open channel; and (4) improvement of 10.3 miles of existing channel. Twelve different contracts were let for the work on a combination of lumpsum and unit-price bids. The firm Mead and Hunt, Inc., designed all parts of the project and supervised construction.

Design Features

The facilities provided for the discharge of effluent are considered adequate to handle the expected increase in flow to the year 1990, or a discharge of over three times the present average rate.

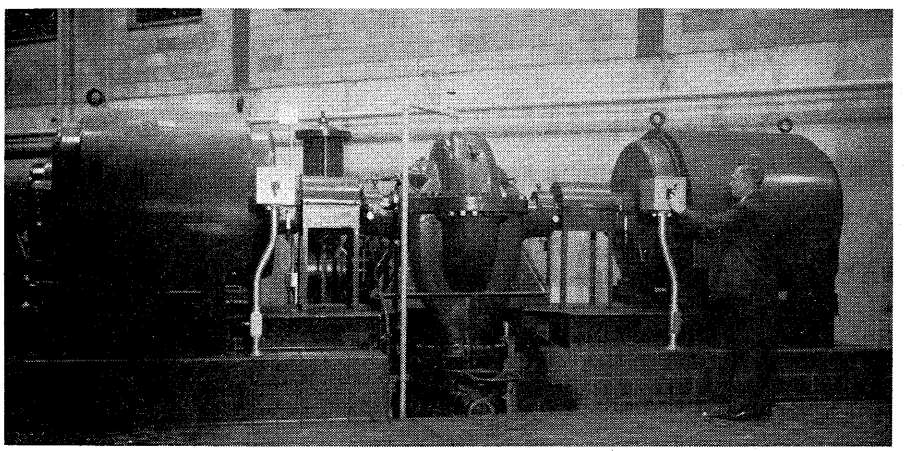
Pumping station. The pumps are located in a new building 121 by 57 feet in plan, and are low enough in elevation to receive effluent under positive head from two new equalizing basins, each 130 feet in diameter. There are four 24-inch single-stage double-volute centrifugal pumps, each with a rated capacity of 25,000 gpm at 110 feet head. Each pump can be driven by either a 500-hp, 700-rpm motor on one end or a 1000-hp, 880-rpm motor on the other. The present average flow can be handled by one pump but two will be needed for peaks. The excess pumping capacity was considered advisable on the theory that if one pump were out of service for repairs or other reason, one would still be available as a spare for additional emergencies. On the discharge side of each pump are an automatic hydraulically-operated cone valve and a manually-operated butterfly value. It requires about four minutes for the cone valve to close after the switch is thrown to cease pumping. During this time the motor and pump continue to operate to prevent backflow. One of the tests made on each motor prior to commencement of regular pumping was to suddenly cut off the power to the motor and determine the maximum reverse speed produced by water from the pipeline flowing backward through the pump while the cone valve is closing. The motors are expected to withstand a 50 percent overspeed, but at no time during the tests did the overspeed exceed 10 percent.



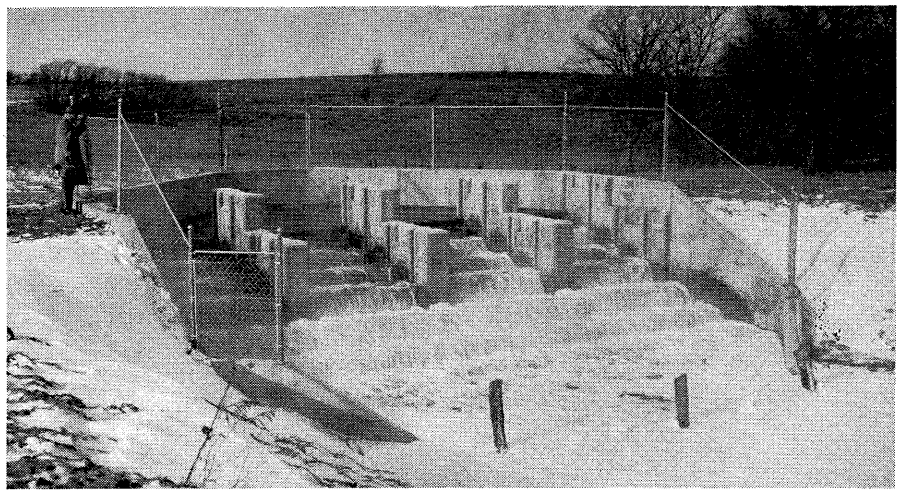
INTERIOR OF NEW PUMPING station.

Adequate chlorination of the effluent was required by the State Board of Health as a prerequisite to the use of the Badfish Creek route. The creek is a fishing and recreational stream and is also, in its lower reaches, open to dairy cattle. Chlorination was therefore considered a necessary safeguard from the health standpoint. The switchboards, chlorination equipment and operator's office are located on the first balcony of the pumping station. On the second balcony are the chemistry and bacteriology laboratories for the treatment works and the offices of the works superintendent.

Pipeline. The pumps discharge into a header leading to the 54-in. pipeline, which consists of 27,000 feet of 100-psi reinforced concrete pipe. The line passes over six summits, at each of which is an air release manhole. In the manholes are a total of 13 6-in. controlled-closing air valves. In addition there are nine blow-off manholes and 10 access manholes. The discharge end of the pipe is 85 feet higher than the pumps. During tests of the pipeline the pressure graphs showed only minor rises due to water hammer when pumping was started or stopped. The air valves functioned properly in opening to admit air and prevent a vacuum in the pipe when pumping was stopped, but it was found that their slow



24-IN. WORTHINGTON PUMP is driven by 500-hp (left) and 1000-hp Marathon motors.



STEP AERATOR AT DISCHARGE end of 54-in. pipe

action in closing when pumping was resumed permitted enough water to escape to erode the drainage ditches down which it flowed. Riprapping or paving the ditches thus became necessary.

New channel. The outfall end of the pipeline is connected to the Badfish Creek by 20,200 feet of new ditch having a bottom width of 16 ft and sideslopes of 1½ to 1 except in rock cuts where the slopes are ¼ to 1. The grade of the channel is 2.6 feet per mile. For a discharge of 18 mgd, assuming n = 0.025, the depth of flow is expected to be 1.1 ft with a mean velocity of 1.5 fps. The channel winds through rolling country and some of the cuts are nearly 30 feet deep. At one point the channel is in fill across a ravine, with the surface runoff carried underneath. Three highway crossings required culverts. Preliminary plans had called for a longer pipeline and less open channel, but further studies showed that substitution of ditch for pipe resulted in a material saving in cost.

To restore oxygen to the effluent after its passage through the pipe, two aerators are provided in the new channel. One is located at the end of the pipe and the other is 3240 ft above the point of discharge into the Badfish Creek. The aerators are, repectively, 35.5 and 30 ft wide and cascade the water in seven and five steps with a total fall of 6.5 and 5.5 ft.

Channel Improvement

Years ago the Badfish Creek in Dane county was straightened and widened to serve as a drainage ditch. It also carries effluent from the sewage treatment works of the village of Oregon. Additional widening and deepening were necessary in order to meet the design requirement that the water level with Madison effluent added be no higher than formerly in order to avoid raising the ground water level in adjacent farm lands. The creek was improved from the end of the new outfall channel to the Dane-Rock county line, a distance of 54,500 ft. For the first 22,200 ft the bottom width was made 16 ft and for the remainder of the distance 20 ft. The average channel grade in these sections is respectively 4.75 and 8.05 feet per mile. One new highway bridge was required and protection was provided for four other bridges. Four new farm bridges were constructed with timber piling and concrete deck.

In 1955, at the request of the District, the U. S. Geological Survey established a stream gaging station on this section of the Badfish Creek with part of the cost borne by the District. In the 2½ years for which records are now available, the flow has averaged 9.6 cfs, with a maximum day's reading of 96 cfs and a minimum of 5.3 cfs. From the Dane-Rock County line to its junction with the Yahara River, the Badfish has a considerably larger natural flow and the channel capacity is sufficient to handle the added effluent without serious increase in depth. Therefore no work was done on that part of the channel.