LAKE AERATION SYSTEM FOR CANYON LAKE, CALIFORNIA

Prepared for:

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EXECUTIVE SUMMARY

Canyon Lake is a monomictic, eutrophic lake that typically stratifies from about late-February/early-March through late-November/early-December each year. The water column is divided into three depth zones, with the deep-water hypolimnion starting at about the 20 to 25 foot depths by mid-summer, with oxygen depletions at or near zero at 16 to 18 feet. The hypolimnion becomes anaerobic and devoid of dissolved oxygen by early summer each year. This anaerobiosis results in releases of dissolved iron, manganese, ammonia, hydrogen sulfide, phosphorus (P) and other substances that degrade potable water quality. Phosphorus release from sediments under anaerobic conditions may increase eutrophication through internal P loading. Artificial destratification by a combination of air injection and axial-flow water pumps should maintain aerobic conditions throughout the water column in the main body of Canyon Lake all year. A well-mixed condition and aerobic conditions in Canyon Lake should achieve expected improvements in water quality including reduced iron, manganese, ammonia, hydrogen sulfide, and phosphorus, with probable reductions in algal densities. This hybrid destratification system includes two axial-flow water pumps (3-HP each) and 400-SCFM of air injection from two air-line diffusers. Total capital and annual operating costs are estimated at $325,000 and $35,000/yr respectively.

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I. INTRODUCTION

Canyon Lake is a eutrophic, monomictic lake located on the San Jacinto River, just upstream from Lake Elsinore (Fig. 1). San Jacinto River runoff enters Canyon Lake, and if sufficient runoff water volumes occurs, overflows the Canyon Lake dam into Lake Elsinore. This is the main source of water for both Canyon Lake and Lake Elsinore.

Monomictic refers to one, prolonged period of thermal stratification during the year. Sustained thermal stratification begins in Canyon Lake probably during February or March and continues into December. Temporary stratification seems to occur even during winter months. The lake was in the process of seasonal destratification (fall "overturn") during our December 4, 2001 visit. The lake is mixed top to bottom at times during December-February. During thermal stratification, the lake is divided into three depth zones (Fig. 2).

Epilimnion. Well-lit surface zone extending from the lake's surface to perhaps 12 feet depth depending on the season. Epilimnion temperatures range from 20 to 30°C.

Thermocline or ***Metalimnion.*** The transitions zone where water temperatures decrease rapidly, separating the epilimnion from deeper waters of the hypolimnion.

Hypolimnion. Dimly lit or dark, deep-water zone below about 20 to 25 feet with water temperatures of about 15°C.

Canyon Lake is highly eutrophic with dense algal populations and occasional surface scum of mostly bluegreen algae (cyanobacteria). Secchi disc water clarity is typically <0.6 to 1.2 m (<2 to 4 feet). As a result of dense algal growths, dissolved oxygen (DO) concentrations are often near or above saturation in the epilimnion during daylight hours, while thermocline and hypolimnion DO concentrations are typically at or near zero (0.0 mg/l) during most of the stratified period. DO depletions at depth are the result of algae and other organic material settling and consuming oxygen as they decompose, plus sediment respiration.

As a result of the anaerobic (zero DO) thermocline and hypolimnion in Canyon Lake, fish and other biota are often limited to shallow depths of less than 15 feet during stratification. In addition, certain substances are generated or solubilized in the hypolimnion that negatively impact potable

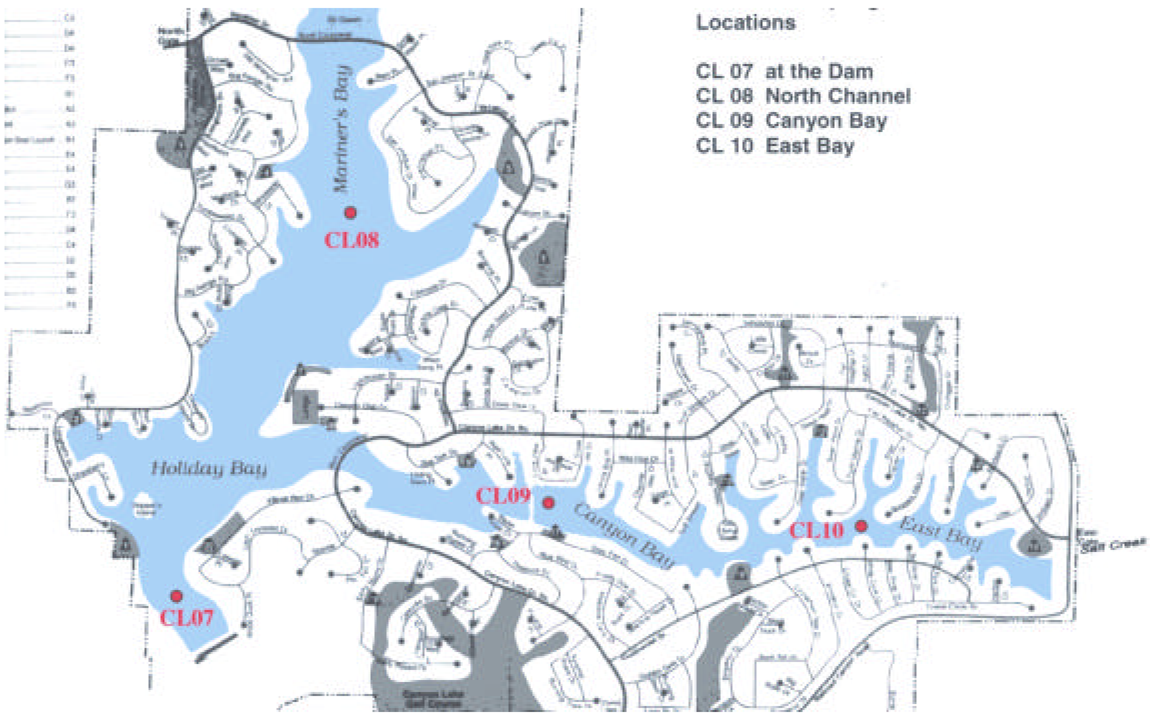


Figure 1. Canyon Lake and surrounding community. The lake impounds the San Jacinto River, the main water source for both Canyon Lake and Lake Elsinore. Canyon Lake is divided into three sections, including; the main body upstream from the dam, a section on the San Jacinto River upstream of Vacation Drive, and East Bay on Salt Creek to the right of the main body. The area surrounding Canyon Lake is a gated community without public access.

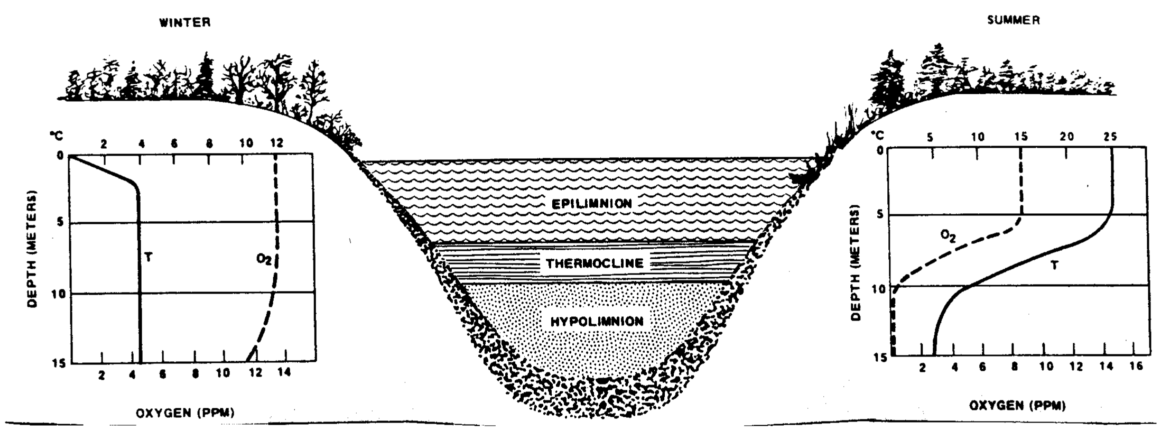


Figure 2. Three depth zones in a thermally stratified, temperate lake, and typical oxygen and temperature profiles in winter (with ice cover) and summer.

and aesthetic water quality. These substances include iron, manganese, hydrogen sulfide, ammonia, phosphate, carbon dioxide and organic compounds. All of these substances can negatively impact potable water quality.

One of the main beneficial uses of Canyon Lake is potable water supply. Water is withdrawn from the lake near the dam by the Elsinore Valley Municipal Water District (EVMWD) water treatment facility. At times, epilimnion waters cannot be used due to excessive algal growth, while thermocline and hypolimnion waters have unsuitable quality as well due to dissolved substances noted above. During these times, the water district must use imported or other water.

Canyon Lake is said to be mostly nitrogen (N) limited with respect to algal growths, but at times could be phosphorus (P) limited (CRWQCB 2001). With N limitation, excessive amounts of P exist relative to N. The N:P ratio in Canyon Lake ranges from 2 to 16.[1] Excessive P concentrations could be due in part to P regeneration in deep waters during anaerobic conditions. This is referred to as internal P loading, as opposed to external P loading from "new" P entering the lake from outside sources. Likewise, anaerobic conditions may reduce N losses from the lake through denitrification since denitrification requires the following processes: organic N => ammonia => nitrate => N_2 (lost to atmosphere). With anaerobic conditions, ammonia is not converted to nitrate. Ammonia then becomes available for plant growth during destratification. Lake aeration may reduce available P (locking P in the sediments) while at the same time reducing N through increased denitrification.

Canyon Lake is essentially divided into three sections that are only slightly interconnected. The main body of the lake extends from the dam up the riverbed to Vacation Drive (Fig. 1). Above Vacation Drive is another lake section that is only connected to the main lake body by drainage culverts under Vacation Drive. A third section of Canyon Lake is East Bay on Salt Creek, again connected to the main lake body through a large culvert. It appears that the two lake areas upstream have minimal connection with the main lake body except during runoff periods when water flows through these upper sections and into the main body.

[1] See Lake Elsinore report (Fast 2002) for discussion on N:P ratios.

A recently constructed depth contour map of Canyon Lake indicates that the hypolimnion exists primarily in the main body of the lake. A small portion of the hypolimnion does exist, however, in E. Bay. Depending on lake elevation, this hypolimnion segment may represent from 1% to 3% of total hypolimnetic water volume.

II. INTENDED AND BENEFICIAL USES OF CANYON LAKE

A lake's intended and beneficial uses are the main issues determining its management needs. These uses form both the underlying conceptual framework for deciding how the lake should be managed, and they also provide a legal basis or justification for government agencies concerned with water quality issues. The RWQCB (2001) identified a number of intended uses for Canyon Lake, including;

♦ Municipal and Domestic (Potable) Water Supply (**MUN**), or drinking water.

♦ Agricultural Water Supply (**AGR**), or irrigation.

♦ Groundwater Recharge (**GWR**).

♦ Body Contact Recreation (**REC1**), or boating, swimming, water skiing.

♦ Non-Body Contact Recreation (**REC2**), including aesthetic enjoyment.

♦ Warm Freshwater Aquatic Habitat (**WARM**), including recreational fishing.

♦ Wildlife Habitat (**WILD**).

Other Uses Include;

♦ Flood Control

♦ Nutrient Trap to reduce nutrient load entering Lake Elsinore (Horne 2001).

All of these intended uses are important and deserve attention. At the same time, it is unlikely that any one lake management approach will result in significant or measurable improvements in all intended uses.

III. CANYON LAKE LIMNOLOGICAL DATA BASES

Canyon Lake has limited limnological data on which to base decision making. I was provided four reports, including the following: Anderson (2000), Horne (2001), CRWQCB (2001), and Anderson (2002). In addition, I was provided a recently constructed bathymetric map of Canyon Lake (Fig. 3), and a copy of an existing area-capacity table (Appendix A).

Area-capacity values are now available for Canyon Lake as shown in Appendix A. Canyon Lake is full and starts to spill over the dam at elevation 1,381.85 feet with about 525 surface acres (A) and 11,920 acre-feet (AF) water volume. Minimum expected water elevation is 1,372 feet with 425 A and 7,154 AF. Canyon Lake homeowners have a contractual obligation to buy water to maintain a lake of no less than 1,372 feet elevation. These area and volume values for Canyon Lake include the main body, East Bay arm and the San Jacinto River arm. If we assume that the surface area for the main body of Canyon Lake is about 80% of total lake area at 1,381.85 feet elevation, then surface for the main body is 420 A.

Although data are limited, it is clear that Canyon Lake is highly eutrophic and has impaired potable water quality due to anaerobic bottom water conditions and excessive algal growths in surface waters. Intended uses of aesthetics and water sports may also be impaired by eutrophication, although flood control and irrigation uses are not.

Figure 3. DRAFT BATHYMETRIC MAP FOR CANYON LAKE

IV. AERATION SYSTEM FOR CANYON LAKE

A destratification system of the design described below should maintain the main body of Canyon Lake in a well-mixed condition all year. This should prevent anaerobic conditions in deep waters, reduce certain dissolved substances (e.g. iron, manganese, hydrogen sulfide, ammonia) below problem levels for potable water. It should also reduce internal P loading and reduce algal densities through a combination of light limitation (see Lorenzen and Fast 1977, pgs. 15-21), and through reduced P availability from sediments. This recommended system would consist of an air injection system with air-line diffusers (Fig. 4) and two axial-flow water pumps (Fig.'s 5 & 6).

Component A. Axial-Flow Water Pumps

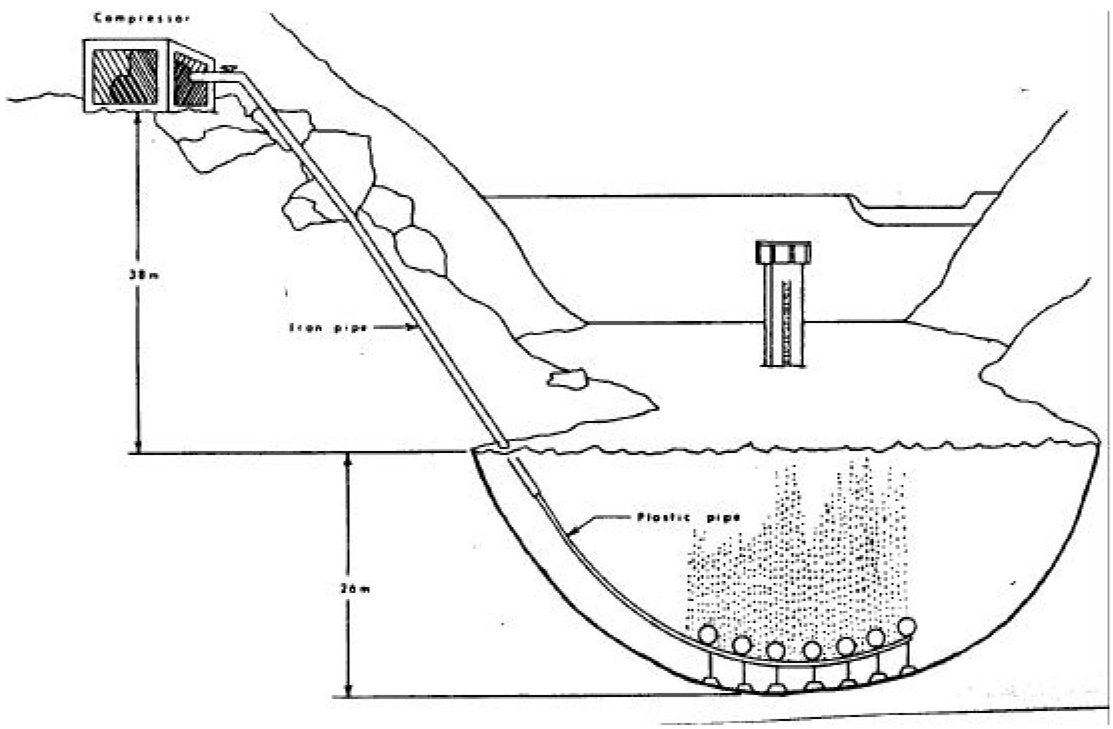
Two axial-flow pumps should be installed in the closed access area near the dam (Fig's 5 & 6). These pumps should each consist of one six-foot diameter blade operated using a 3-HP gear motor; similar to those described in detail for Lake Elsinore (Fast, March 2002). These pumps are commercially available from: E.C. Baker & Sons, Inc., Box 83, Route #1, Sigel, Illinois 62462; telephone (217) 844-2020 (Appendix B).

Estimated costs of these pumps are $25,000 each FOB Sigel, Illinois. This should include complete pump assembly, anchor system and electrical supply line. Additional electrical connections and controls may be required, and perhaps more secure electrical supply cables. Three pumps should be ordered to provide one replacement. The pumps most likely could be installed by a local contractor, or by the pump manufacturer.

Component B. Air Injection System

I recommend an air injection system consisting of a single air compressor of about 400 standard cubic feet per minute (SCFM) operating at about 50 psi. A single stage, rotary dry screw compressor is most appropriate since it provides oil-free air and should result in reduced operating costs compared with double stage compressors, or other compressors operating at pressures greater than 50 psi.

Figure 4. A single air-line destratification system consisting of an air compressor on shore and an air-line extending along the lake bottom. Figure from Fast (1968).



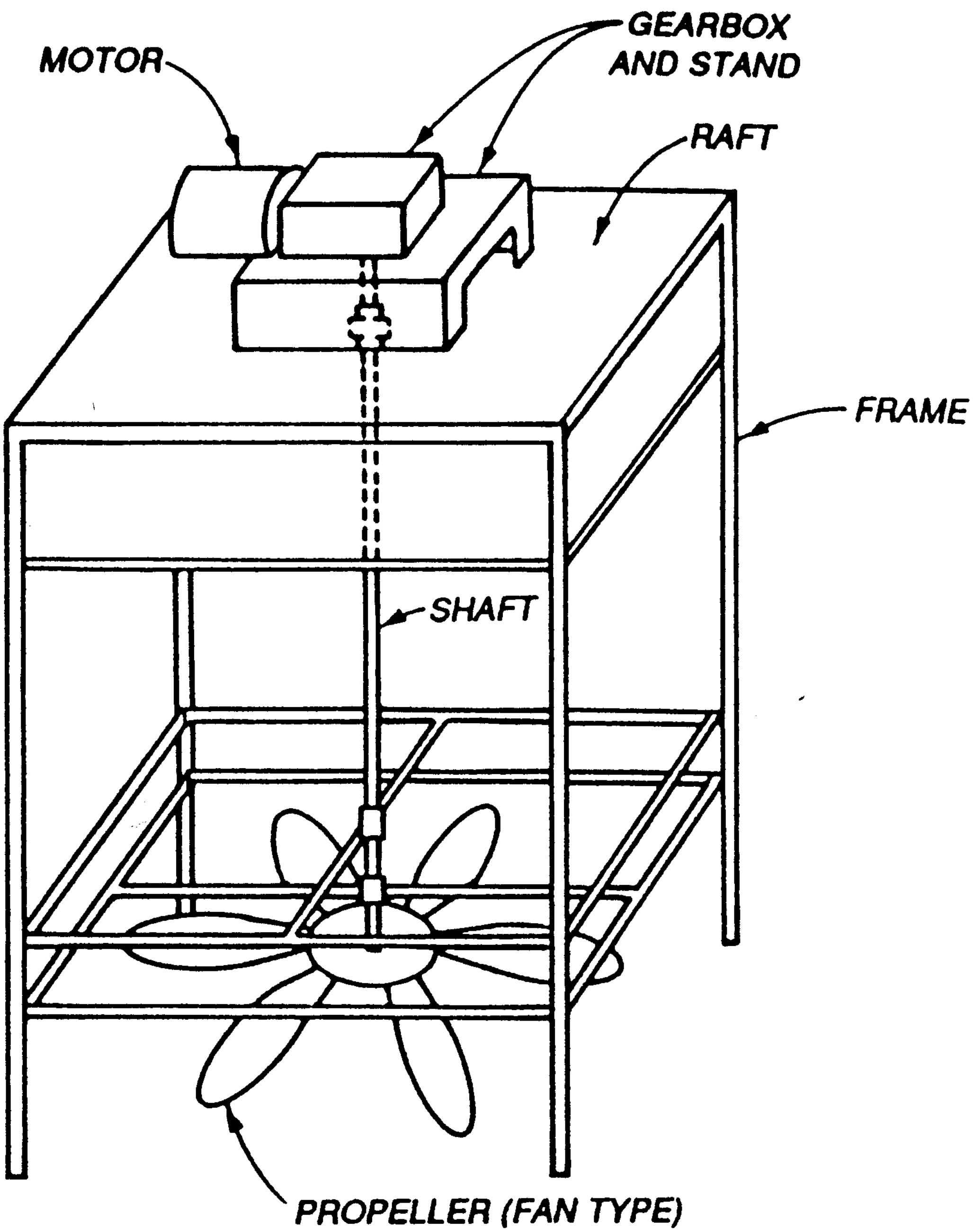


Figure 5. Sketch of axial-flow water pump without shroud or debris shield. Sketch taken from Punnett (1991).

Figure 6. Photograph of a commercially available axial-flow water pump. See Appendix B.

The existing compressor at Canyon Lake can be assessed for possible use, but most likely it will be inappropriate due to its greater operating pressure of 90 psi, which greatly increases operating costs per unit air produced. I have not received any other information on this existing air compressor.

The compressor recommended above could be installed in the same location (inside building at water treatment plant) as the existing compressor and connected to the existing air-lines leading from this building to water's edge. There are several lateral outlets near the shoreline from this air-line. Two of these outlets could be used to install plastic air-lines into the lake.

I recommend two air-lines extending from their connection near the water treatment plant upstream into Canyon Lake (Fig. 7). These air-lines should be at least 3 inch inside diameter, polyethylene plastic pipe. One air-line (air-line B) should extend about 3,600 feet into the lake and have a 200-foot diffuser section along its distal end. The other air-line (air-line A) should extend about 1,300 feet and have a 200-foot diffuser section along its distal end. Approximately equal volumes of air (200 SCFM) should be injected from each air-line (400 SCFM total).

I do not recommend air injection of either the San Jacinto arm or East Bay arm of Canyon Lake. These two arms are relatively un-connected with the main body of the lake except during high runoff periods. Although a small portion of E. Bay around Station 8 (Anderson 2000) does stratify and develop low DO with increased P releases, I feel that air injection is not necessary in E. Bay for the following reasons.

1. Total hypolimnetic benthic areas in E. Bay that could potentially become anaerobic is perhaps less than 10% of the total hypolimnetic benthic area of Canyon Lake. Total hypolimnetic water volume in this E. Bay hypolimnetic segment is probably about <1% to 3% of total hypolimnetic water volume for the lake. I'm basing these estimates on my visual interpretation of the Canyon Lake bathymetric map (Fig. 3).

   It is also worth noting that the portion (%) of hypolimnion water contained in E. Bay will vary depending on surface elevations of the lake. At spill (1,381.85 feet), maximum depth at the dam and at the main body opposite the Lodge (two recommended diffuser locations), are 52 feet each compared with 37 feet at E. Bay Station 8 (Table 1). At minimum

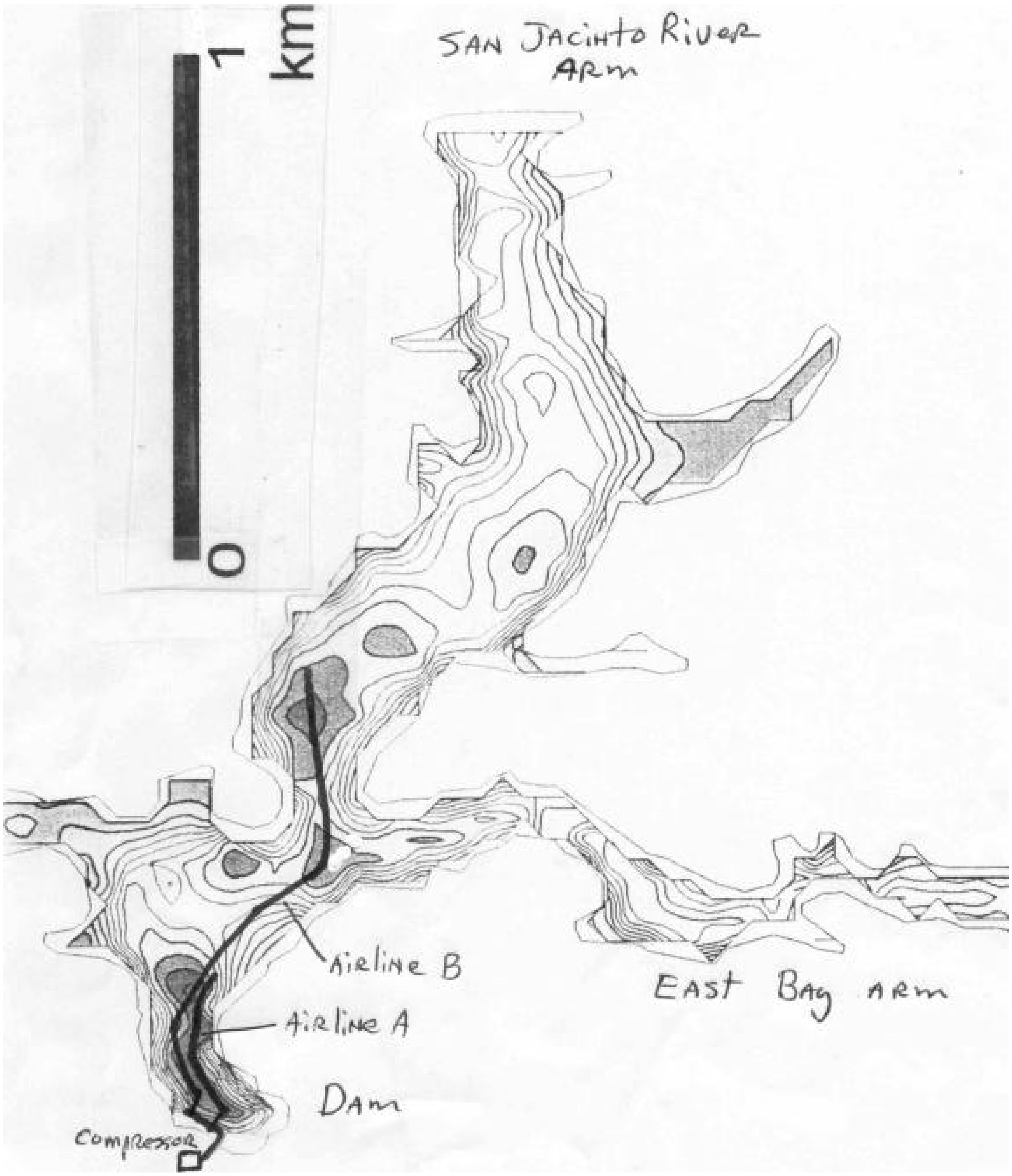


Figure 7. Approximate locations of air compressor and two proposed air-lines (air-lines A & B) at Canyon Lake as part of the lake destratification system for this lake. Two axial-flow water pumps should be located near the dam within the area closed to recreation.

Table 1. Maximum water depths in feet at four locations and at three water level elevations in Canyon Lake.

Locations	Elevations (feet) 1,372	1,377	1,381.85
Dam	42	47	52
Main Body (opposite Lodge)	42	47	52
Main Causeway Sill (E. Bay entrance)	7	12	17
E. Bay (Station 8)	27	32	37

maintenance elevation (1,372 feet), the respective maximum depths are 42 and 27 feet.

2. There is a sill that separates the E. Bay hypolimnion from the hypolimnion in the main body of the lake. This sill ranges from 7 to 17 feet of water depth at surface water elevations ranging from 1,372 to 1,381,85 feet (Table 1). So even when the lake is full (not often), hypolimnetic waters in E. Bay will be separated from hypolimnion waters in the main body of the lake. This means that the main body can be destratified, aerated and water quality improved without influence from the hypolimnion in E. Bay.

3. Aeration of the main body only will meet water quality objectives (as much as possible) for potable water considerations.

4. Although P regeneration from the E. Bay hypolimnion contributes somewhat to internal nutrient loading, my opinion is that this will be trivial compared with the overall P budget.

5. Since water depths at the diffuser depths in the main body are considerably greater than maximum depth in E. Bay, it would be energy inefficient and difficult to balance airflows between the main body and E. Bay from a single compressor air source.

For these reasons, I still feel that the aerator design that I've suggested herein will best meet water quality needs at Canyon Lake.

<u>Component C. Controls and Operations</u>

I believe that manual control of both the axial-flow pumps and air compressors should suffice.

The axial-flow pumps should be operated continuously 12 months per year. The air injection system should be operated continuously from March 1 through October 31 during the first year of operation. At the end of first year's operation, limnological data should be evaluated and consideration given to reducing hours of operation schedule for the air injection system (but not axial-flow pumps) during the second year of operation. For example, it may be possible to reduce hours of compressor operation to 16 hrs or less per day during the second year, thus reducing operating costs. The compressor should be placed on a timer to allow this rescheduling. In any event, the compressor should be operated daily during the months indicated regardless of hours of operation each day.

There have been instances when destratified lakes have experienced very low DO values throughout the lakes during artificial destratification. However, these occurrences are not common and can be minimized by starting air injection in the spring before prolonged stratification develops, while operating the axial-flow pumps continuously, thus maintaining the lake in a well mixed condition all year. On-Off operations of both air injection and the axial-flow pumps should be avoided until sufficient experience is gained using the system. Sediment oxygen demand could be expected to decrease with successive years of aeration, thus reducing risks of water column oxygen depletion after several years' operation. Reduced sediment oxygen demands should result in reduced air injection duration requirements (operating costs), and perhaps reducing nutrient concentrations in lake waters.

Consideration could be given to installing an automated sensor and control system for the air injection system at Canyon Lake; similar to the one proposed for Lake Elsinore. However, I recommend that this be considered only after the Lake Elsinore system has been installed and operated successfully for at least two years.

Capital and Operating Costs

Estimated total capital costs for both air injection and axial-flow pumps are $325,000, including $250,000 for the air injection system and $75,000 for the water pumps (Table 2). Estimated yearly operating costs are $35,000, including $30,000 for the air injection system and $5,000 for the axial-flow water pumps. This includes 7 months operation for air injection (mid-March through mid-October) and 12 months' operation for the axial-flow pumps. During the first two year's operation, however, air injection should extend from early February through November. As noted above, operating times and costs may be reduced after experience is gained with system operation. This may require two or more years experience before any reduction in operating schedules should be attempted.

Table 2. Summary Canyon Lake destratification system estimated capacities, capital costs, and operating costs. The system consists of an air injection system with two air-lines and two axial-flow water pumps.

		Canyon Lake Destratification System	
		Air Injection	**Axial-Flow Pumps**
1. Energy Capacity (HP)		50	6
2. Air Volume (SCFM)		400	N/A[2]
3. Air-line Lengths (feet)	A.	1,300	N/A
	B.	3,900	
4. Estimated Capital Costs		$250,000	$75,000
5. Estimated Operating Costs (continuous operations)		$ 30,000 (7 mo.)	$ 5,000 (12 mo.)

[2] N/A = not applicable.

V. LITERATURE CITED

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APPENDIX A

Area-Capacity Table for Canyon Lake

RAILROAD CANYON RESERVOIR (CANYON LAKE) AREA CAPACITY TABULATION

Water Surface Elev. (USGS Datum)	Surface Area Acres	Average Surface Area Acres	Increment Volume Acre Feet	Accumulative Volume Acre Feet
1380.7	521.61			11291.5
		521.79	52.18	
.8	521.97			11343.7
		522.15	52.22	
.9	522.33			11395.9
		522.51	52.25	
1381.0	522.69			11448.2
		522.87	52.29	
.1	523.05			11500.5
		523.23	52.32	
.2	523.41			11552.8
		523.59	52.36	
.3	523.77			11605.2
		523.95	52.40	
.4	524.13			11657.6
		524.31	52.43	
.5	524.49			11710.0
		524.67	52.47	
.6	524.85			11762.5
		525.03	52.50	
.7	525.21			11815.0
		525.32	52.53	
.76	525.43			11867.5
		525.50	52.55	
.8	525.57			11920.0
		525.75	52.58	
.9	525.93			11972.6
		526.11	52.61	
1382.0	526.29			12025.2

Theoretical Spillway Crest Elevation

which is referenced to copper tack in upstream face of dam 40± feet northeasterly of southwesterly end of southwesterly abutment.

Actual Spillway Crest Elevations

First Spillway from southwesterly abutment = 1382.82

Second " " " " = 1381.85 + NGVD 27A

Third " " " " = 1381.85

Others not determined

See the Field Book No. 9

RAILROAD CANYON RESERVOIR (CANYON LAKE) AREA CAPACITY TABULATION

Water Surface Elev. (USGS Datum)	Surface Area Acres	Average Surface Area Acres	Increment Volume Acre Feet	Accumulative Volume Acre Feet
				9664.8
1377.5	490.36			
		490.99	49.10	9713.9
.6	491.61			
		492.24	49.22	9763.1
.7	492.87			
		493.50	49.35	9812.5
.8	494.12			
		494.75	49.48	9861.9
.9	495.38			
		496.01	49.60	9911.5
1378.0	496.64			
		497.20	49.72	9961.3
.1	497.76			
		498.32	49.83	10011.1
.2	498.89			
		499.45	49.95	10061.0
.3	500.01			
		500.57	50.06	10111.1
.4	501.13			
		501.69	50.17	10161.3
.5	502.26			
		502.82	50.28	10211.5
.6	503.38			
		503.94	50.39	10261.9
.7	504.50			
		505.06	50.51	10312.4
.8	505.62			
		506.18	50.62	10363.1
.9	506.75			
		507.31	50.73	10413.8
1379.0	507.88			
		508.44	50.84	10464.6
.1	509.00			

Water Surface Elev. (USGS Datum)	Surface Area Acres	Average Surface Area Acres	Increment Volume Acre Feet	Accumulative Volume Acre Feet
				10464.6
1379.1	509.00			
		509.56	50.96	10515.6
.2	510.12			
		510.68	51.07	10566.7
.3	511.24			
		511.80	51.18	10617.8
.4	512.36			
		512.92	51.29	10669.1
.5	513.49			
		514.05	51.41	10720.5
.6	514.61			
		515.17	51.52	10772.1
.7	515.73			
		516.29	51.63	10823.7
.8	516.85			
		517.41	51.74	10875.4
.9	517.98			
		518.54	51.85	10927.3
1380.0	519.09			
		519.27	51.93	10979.2
.1	519.45			
		519.63	51.96	11031.2
.2	519.81			
		519.99	52.00	11083.2
.3	520.17			
		520.35	52.04	11135.2
.4	520.53			
		520.71	52.07	11187.3
.5	520.89			
		521.07	52.11	11239.4
.6	521.25			
		521.43	52.14	11291.5
.7	521.61			

RAILROAD CANYON RESERVOIR (CANYON LAKE) AREA CAPACITY TABULATION

Water Surface Elev. (USGS Datum)	Surface Area Acres	Average Surface Area Acres	Increment Volume Acre Feet	Accumulative Volume Acre Feet
1374.3	450.02			8160.0
		450.65	45.07	
.4	451.28			8205.1
		451.91	45.19	
.5	452.55			8250.3
		453.18	45.32	
.6	453.81			8295.6
		454.44	45.44	
.7	455.08			8341.1
		455.71	45.57	
.8	456.34			8386.6
		456.97	45.70	
.9	457.61			8432.3
		458.24	45.82	
1375.0	458.87			8478.2
		459.50	45.95	
.1	460.14			8524.1
		460.77	46.08	
.2	461.40			8570.2
		462.03	46.20	
.3	462.67			8616.4
		463.30	46.33	
.4	463.93			8662.7
		464.56	46.46	
.5	465.20			8709.2
		465.83	46.58	
.6	466.46			8755.8
		467.09	46.71	
.7	467.73			8802.5
		468.36	46.84	
.8	468.99			8849.3
		469.62	46.96	
.9	470.26			8896.3

Water Surface Elev. (USGS Datum)	Surface Area Acres	Average Surface Area Acres	Increment Volume Acre Feet	Accumulative Volume Acre Feet
1375.9	470.26			8896.3
		470.89	47.09	
1376.0	471.53			8943.4
		472.16	47.22	
.1	472.79			8990.6
		473.42	47.34	
.2	474.06			9037.9
		474.67	47.47	
.3	475.30			9085.4
		475.93	47.59	
.4	476.55			9133.0
		477.18	47.72	
.5	477.81			9180.7
		478.44	47.84	
.6	479.08			9228.5
		479.69	47.97	
.7	480.32			9276.5
		480.95	48.10	
.8	481.57			9324.6
		482.20	48.22	
.9	482.83			9372.8
		483.46	48.35	
1377.0	484.08			9421.2
		484.71	48.47	
.1	485.34			9469.6
		485.97	48.60	
.2	486.59			9518.2
		487.22	48.72	
.3	487.85			9567.0
		488.48	48.85	
.4	489.10			9615.8
		489.73	48.97	
.5	490.36			9664.8

RAILROAD CANYON RESERVOIR (CANYON LAKE) AREA CAPACITY TABULATION

Water Surface Elev. (USGS Datum)	Surface Area Acres	Average Surface Area Acres	Increment Volume Acre Feet	Accumulative Volume Acre Feet	Water Surface Elev. (USGS Datum)	Surface Area Acres	Average Surface Area Acres	Increment Volume Acre Feet	Accumulative Volume Acre Feet
1371.1	417.81			6773.8	1372.7	433.01			7454.1
		418.26	41.83				433.52	43.35	
.2	418.71			6815.6	.8	434.03			7497.4
		419.16	41.92				434.54	43.45	
.3	419.61			6857.5	.9	435.04			7540.9
		420.06	42.01				435.55	43.56	
.4	420.51			6899.5	1373.0	436.06			7584.5
		420.96	42.10				436.57	43.66	
.5	421.40			6941.6	.1	437.08			7628.1
		421.85	42.19				437.59	43.76	
.6	422.30			6983.8	.2	438.09			7671.9
		422.75	42.28				438.60	43.86	
.7	423.20			7026.1	.3	439.11			7715.7
		423.65	42.37				439.62	43.96	
.8	424.10			7068.5	.4	440.12			7759.7
		424.55	42.46				440.63	44.06	
.9	425.00			7110.9	.5	441.14			7803.8
		425.45	42.55				441.65	44.17	
1372.0	425.90			7153.5	.6	442.16			7847.9
		426.41	42.66				442.67	44.27	
.1	426.92			7196.1	.7	443.17			7892.2
		427.43	42.76				443.68	44.37	
.2	427.93			7238.9	.8	444.19			7936.6
		428.44	42.86				444.70	44.47	
.3	428.95			7281.7	.9	445.20			7981.0
		429.46	42.95				445.71	44.57	
.4	429.96			7324.6	1374.0	446.21			8025.6
		430.47	43.05				446.85	44.68	
.5	430.98			7367.7	.1	447.49			8070.1
		431.49	43.15				448.12	44.81	
.6	432.00			7410.8	.2	448.75			8115.1
		432.51	43.25				449.38	44.94	
.7	431.01			7454.1	.3	450.02			8160.0

APPENDIX B

Literature for commercially available axial flow water pump.

E. C. BAKER & SONS, INC.
BOX 83 - ROUTE # 1
Phone: (217) 844-2020 SIGEL, ILLINOIS 62462

DATE: March 1st, 1989

Gentlemen:

We thank you for your interest in the destratifiers manufactured by our firm. Photos and information on the destratifier will be found in this booklet.

Users of the destratifiers in lakes, ponds, and reservoirs have noted remarkable improvement in the water quality and reduced cost in the treatment of the water.

If you need additional information, please write or call:

J. Curtis Baker
(Design Engineer)

Vernon Baker
(Sales)

PHONE: 217-844-2020

ADDRESS: BOX 83, SIGEL, ILLINOIS 62462

DESTRATIFIERS

To correct problems with surface

water supplies at the:

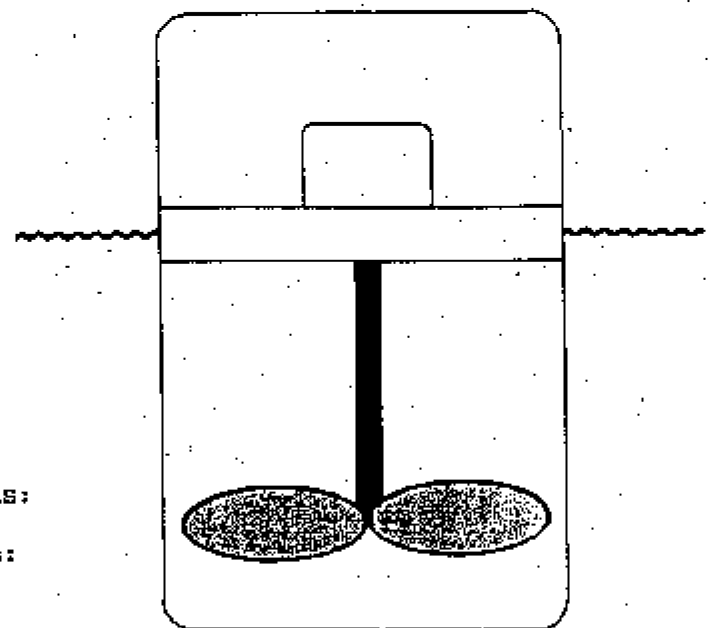
City of Altamont, Ill. (1984)

City of Nashville, Ill. (1986)

S L M Public Water District

Mascoutah, Ill. (1986)

we installed destratifiers.



Additional Destratifier Installations:
City of Greenville, Ill. (1988)
*Illinois Department of Conservation:
Lake Le-Aqua-Na State Park, Lena, Ill. (1988)
*Modification to existing destratifer used in a recreational lake.

The users of destratifiers have noted remarkable improvements in water quality and reduced cost in the treatment of water.

A destratifier installed in your lake, pond, or reservoir will improve water quality and reduce the cost of chemicals needed to treat your finished water.

A destratifier will be installed in May of 1988 for the City of Pinckneyville, Ill.

For additional information and prices contact:

E. C. BAKER & SONS, INC.

BOX 83 - ROUTE #1

Phone: (217) 844-2020 **Sigel, Illinois 62462**

CONDENSED DESTRATIFIER REPORT

ON

LAKE EUREKA, WOODFORD COUNTY, EUREKA, ILLINOIS

A RAW WATER SUPPLY SOURCE LAKE

SIZE: surface area of 36 acres; mean and maximum depths of 6.3 and 18.0 feet, respectively; and a total volume of 227 acre feet.

The installation of a destratifier in May of 1981 in Lake Eureka returned the lake, abandoned in 1979, to a useful water supply. The following water improvements were noted:

* Destratify the lake completely and maintain adequate oxygen levels throughout, even in the deep bottom waters

* Reduce iron and manganese concentrations by 97% and chlorine demand by more than half (Manganese and chlorine demand values were directly correlated with the odor episodes in Lake Eureka)

* Cause a dramatic shift in algal species, replacing problem-causing blue-green algae with diatoms as the dominant species

* Enhance the water quality in Lake Eureka to the extent that it can again be used as a raw water source

* Reduce unpleasant taste and odor

* Reduce operating and chemical costs (The estimated electrical power cost for 1981 - $325 {five and a half months}, 1982 - $650 {nine months}, 1983 - $500 {eight months})

INFORMATION IN THIS REPORT WAS TAKEN FROM THE FOLLOWING STATE OF ILLINOIS, DEPARTMENT OF ENERGY & NATURAL RESOURCES, ILLINOIS STATE WATER SURVEY, CHAMPAIGN, ILLINOIS, CIRCULARS

1 1982 Circular 155 ISWS/CIR-155/182
Aeration-Destratification of Lake Eureka Using a Low Energy Destratifier By V. Kothandaraman and Ralph L. Evans

2 1984 Circular 159 ISWS/CIR-159/84
Aeration-Destratification of Lake Eureka: Second Year Operation By Raman K Raman and Ralph L. Evans

3 1984 Circular 162 ISWS/CIR-162/84
In-Lake Quality Management for Lake Eureka: Highlights of Third Year (1983) Operation By Raman K. Raman and Davis L. Beuscher (Illinois State Water Survey) & Benny R. Arbuckle (City of Peoria)

REPORTS ARE AVAILABLE UPON REQUEST

DESTRATIFIER REPORT
ON
ALTAMONT LAKE, EFFINGHAM CO., CITY OF ALTAMONT, ILLINOIS

A WATER SUPPLY RESERVOIR

SIZE: 56 acres, depth of about 25 feet.

A destratifier was installed for the City of Altamont in their water reservoir in 1984. Below is a listing of the problems needing to be solved and the noted improvements after the installation of the destratifier.

PROBLEMS PRIOR TO INSTALLATION	IMPROVEMENTS AFTER INSTALLATION
40 to 50 phone calls a day from water users complaining of the taste and smell in the water	Eliminated phone calls concerning taste & odor in water
Blue-green algae	Reduced
Low oxygen level in water due to decomposing vegetation	Increased oxygen in water
Spring and Fall lake turnover caused by variation of water temperature	Water temperature stabilized top to bottom of lake
Iron and manganese causing brown water	Eliminated
Copper sulfate needed: 5000 lbs. per year costing $2,000.00	Copper sulfate reduced to: 1000 lbs. per year costing $400.00
	The amount of chlorine & potassium permanganate needed to treat the water was also reduced

CONDENSED DESTRATIFIER REPORT

ON

LAKE OKATIBBEE NEAR MERIDIAN, MISSISSIPPI

A RECREATIONAL LAKE

SIZE: approximately 3800 acres, with a volume of about 42,000 acre feet of water.

INFORMATION IN THIS REPORT PERTAINS TO THE INSTALLATION OF A (GARTON PUMP) DESTRATIFIER IN LAKE OKATIBBEE.

After the installation of a (Garton Pump) destratifier the following improvements were noted:

* Increased oxygen level in the water
* Reduced hydrogen sulfide odor
* Stabilized temperature of the water
* Increased oxygen levels and temperature stabilization were noted in the water released from Lake Okatibbee five (5), thirteen (13), and twenty (20) miles below the dam within a few days after the destratifier was put into operation.

****

The above information was taken from: Supplement to the Technical Completion Report Project C-5228 ←

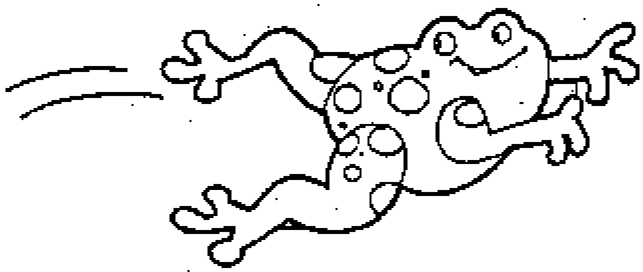
DEMONSTRATION OF WATER QUALITY ENHANCEMENT THROUGH THE USE OF THE GARTON PUMP

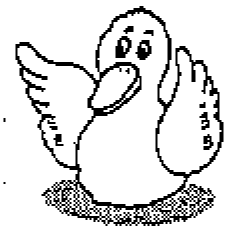
By: James E. Garton and Howard R. Jarrell

Oklahoma State University

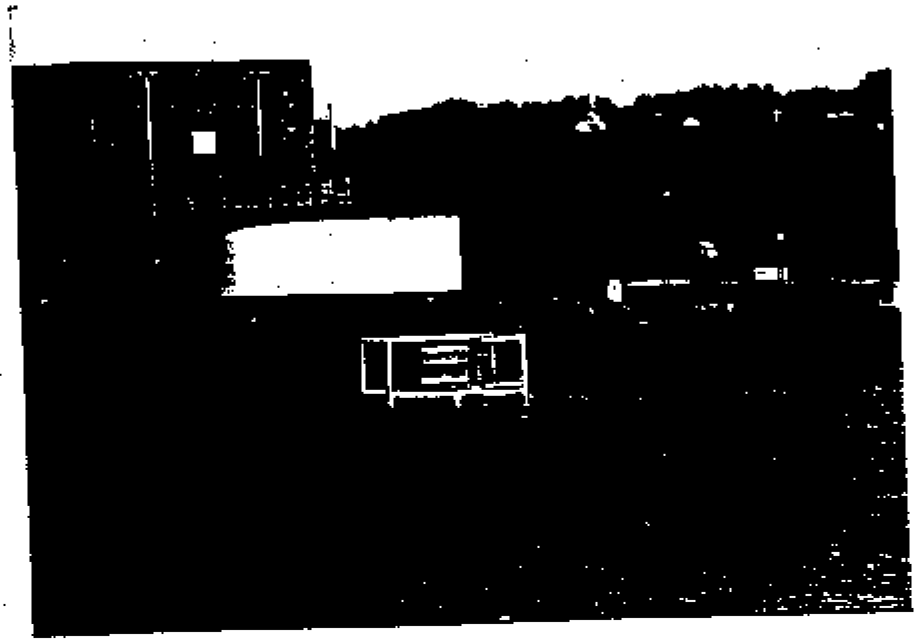
Oklahoma Water Resources Research Institute

THE COMPLETE REPORT IS AVAILABLE UPON REQUEST.





DESTRATIFICATION!   IT'S A NATURAL!

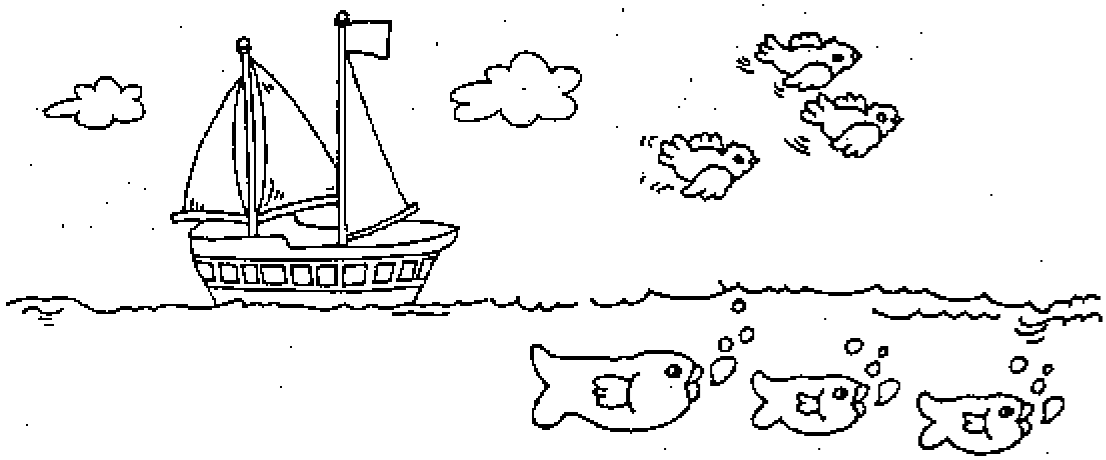


##

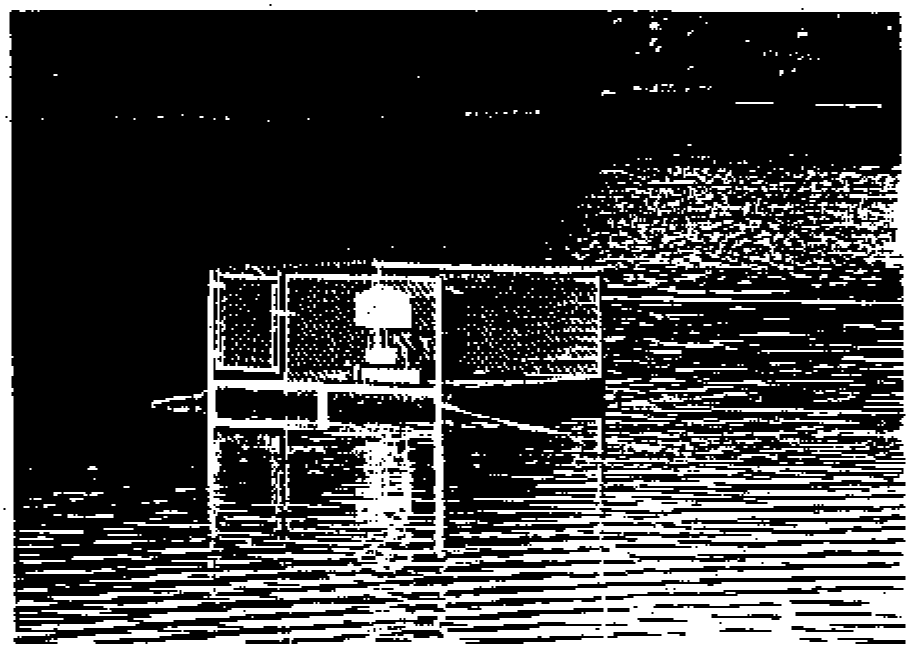
The above photo shows the destratifier that was installed for the *SLM Water Commission at Mascoutah, Illinois.

The destratifier was installed in a five (5) acre holding reservoir in October of 1986.

* SLM Water Commission provides water for Summerfield, Lebanon, Mascoutah, New Baden, Trenton, New Memphis, Freeburg, Smithton, and Hecker, Illinois.



RETURN TO NATURE - DESTRATIFY



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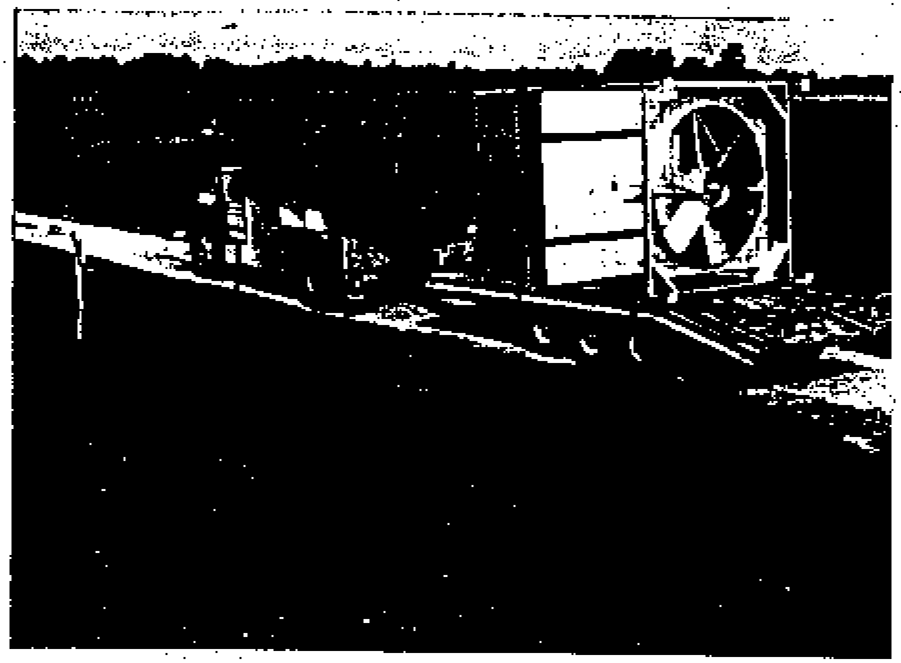
The photo on this page shows the destratifier installed in the City of Nashville, Illinois, (Water Supply Lake).

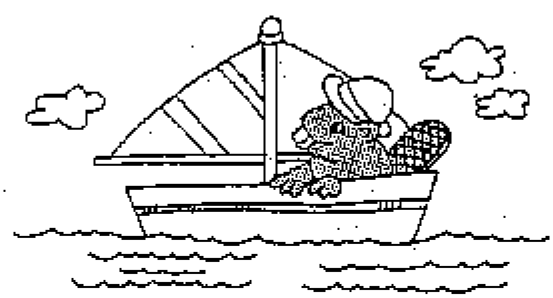
This destratifier was installed in September of 1986.



##

The destratifier photo above shows a destratifier loaded on a trailer ready for installation.

The destratifier in this photo is lying on its side.



HAPPINESS IS - OWNING A DESTRATIFIER!

Join the Recycling Roundup !

DESTRATIFICATION SPELLS CONSERVATION!

##

The above destratifier photo shows the large 72" diameter propeller on the bottom end of the destratifier.

In this photo the destratifier is lying on its side.