American Water Works Association
journal

April 1981

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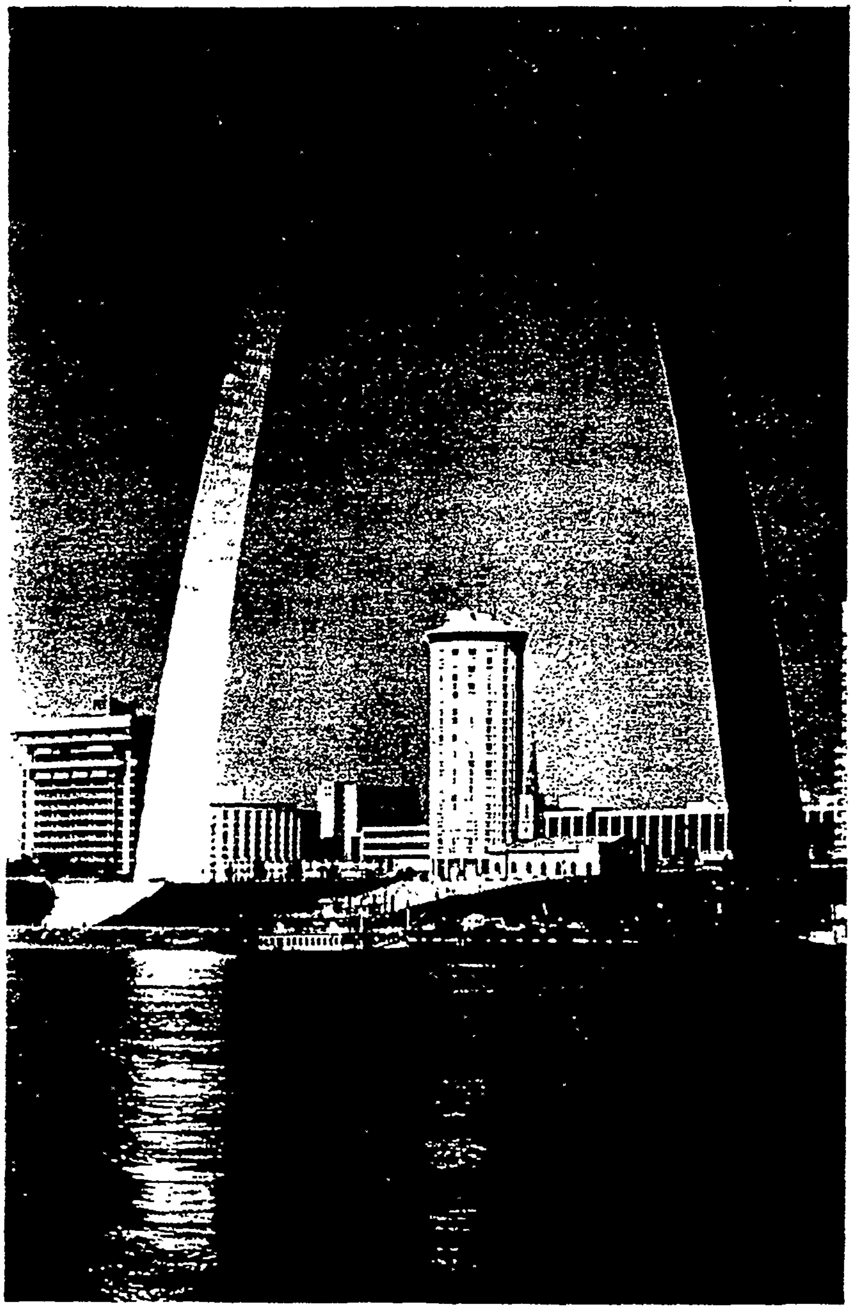

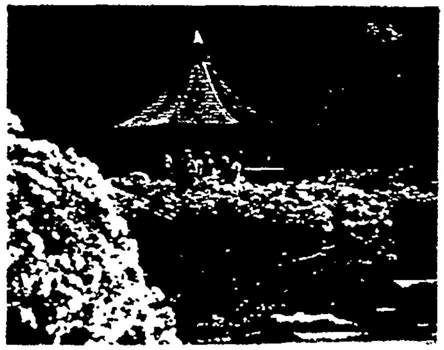

American Water Works Association
Annual Conference and Exposition
Cervantes Convention Center
St. Louis, Missouri
June 7-11, 1981

Another Century of Better Water Quality and Service

Groundwater: An Endangered Resource

CARCO IEN 0020617

On the Cover

St Louis, the site of the Mar. 29, 1881, meeting that formally established AWWA, will host the centennial conference. The theme for this year's meeting is "Another Century of Better Water Quality and Service."

A blue dot precedes articles featuring the theme of this issue.

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American Water Works Association

journal

Vol. 73 No. 4 April 1981

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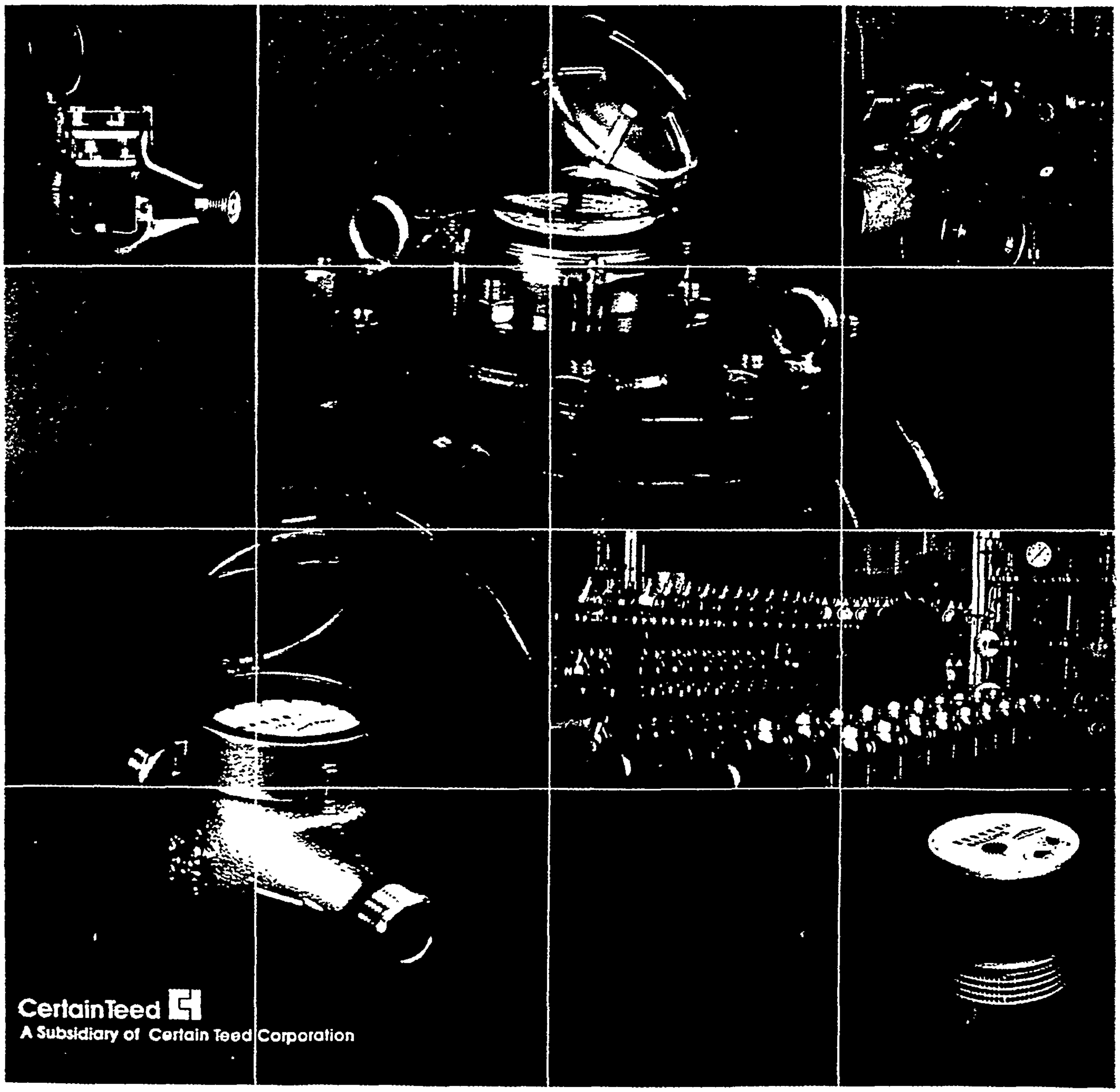

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Briefs and Bios


D.W. Lystra

Page 170 Energy conservation opportunities in municipal water and wastewater systems
Donald W. Lystra, Ashok K. Singhal and Philip N. Loud

Energy is a budget-intensive item for most municipal water and wastewater systems, accounting for 20 percent of their operating expenses. A study of unit processes at four Michigan utilities revealed areas where energy costs could be curbed.

Donald W. Lystra is a graduate of the University of Michigan (Ann Arbor) with BSE and MA degrees. He is currently a senior associate and manager of the energy programs for Ayres, Lewis, Norris & May, Inc. Lystra is a member of IEEE, ISA, and NSPE.


R. Paramasivam

Page 178 Slow sand filter design and construction in developing countries
R. Paramasivam, V.A. Mhaisalkar, and P.M. Berthouex

Recent research has been done to improve traditional slow sand filter design and to discover ways to reduce filter cost. This paper describes how filter dimensions can be selected to minimize construction costs and how system reliability and operating flexibility can be increased at little extra cost by building the proper number of filters. To aid policy makers at the national or regional level and design engineers at the local level, an economic strategy for the design of new plants and future expansions is suggested.

R. Paramasivam received BE, MS, and PhD degrees from the University of Madras. He has served as a consultant to the World Health Organization Reference Center for Community Water Supply in The Netherlands and has 16 years of experience in research and development in environmental engineering, including teaching. Paramasivam is a member of IWWA and IAWPC and has been published by Journal IWWA, Journal IWSA, *and the* Indian Journal of Environmental Health.


E.I. Selig

Page 186 Rights and liabilities of water suppliers arising from groundwater pollution
Edward I. Selig

To steer clear of trouble from contamination, water suppliers should test for priority toxic pollutants and learn both the waste disposal practices and groundwater flow systems of their watersheds. There are many strategies that can be used to maintain a healthy drinking water supply and avoid unnecessary litigation.

Edward I. Selig is a graduate of Yale University (New Haven, Conn.) with a BA degree, of Oxford University (Oxford, England) with an MA degree, and of Harvard University (Cambridge, Mass.) with a JD degree. He is a specialist in environmental, public health, and energy law, and his clients include both industry and government agencies. Selig is a member of the Massachusetts, District of Columbia, and American bar associations.

Continued on page 6

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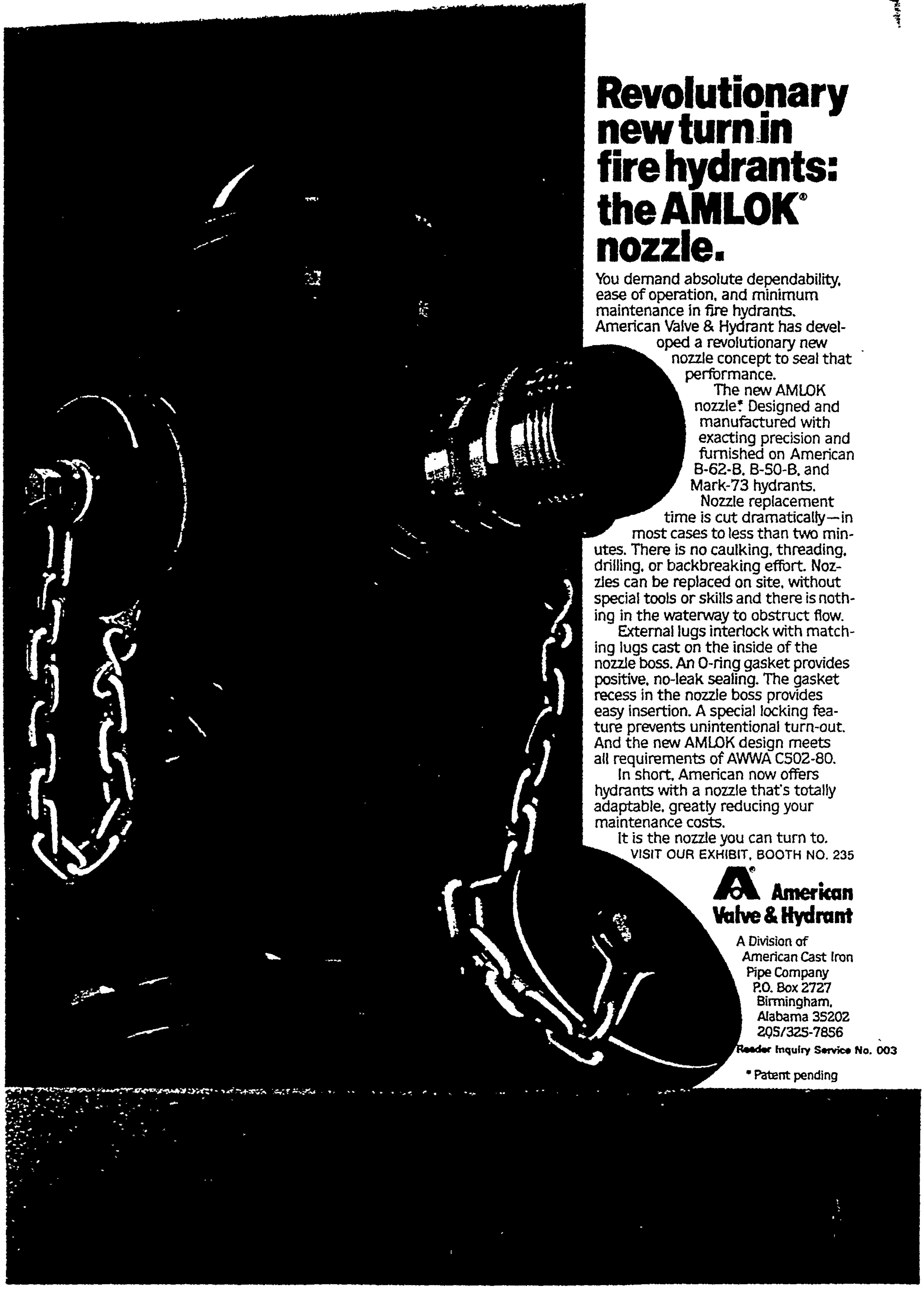

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Continued from page 4


R S. Woodhull

Page 188 Groundwater contamination in Connecticut

Richard S. Woodhull

Cleanup of the widespread organic contamination of Connecticut's groundwaters may be technologically feasible, but the economic repercussions to individuals and towns is prohibitive. This paper explores the possibility of federal assistance for cleanup programs.

Richard S. Woodhull has been with the Connecticut Department of Health Services for 32 years, presently serving as chief of the water supply section. He is a graduate of Tufts University (Medford, Mass.) with a BS in civil engineering and of Harvard University (Cambridge, Mass.) with an MS in sanitary engineering. Woodhull is a member of NEWWA, IWSA, and AWWA and is a recipient of the George Warren Fuller Award. He has been published by Journal NEWWA *and* Journal AWWA.


A.A. Guerrera

Page 190 Chemical contamination of aquifers on Long Island, New York

August A. Guerrera

Aquifers underlying Nassau and Suffolk counties have been classified as the sole source of water supply for Long Island. Therefore, contamination of these underground systems would pose a severe threat to public health. The area has unfortunately been subject to the premature release of information concerning contamination, placing a heavy burden on area suppliers. Not only must they contend with the financial responsibility of cleanup operations but also with consumer fear and distrust.

August A. Guerrera received a BS in chemistry from Brooklyn College (Brooklyn, N.Y.) and an MS in sanitary science from New York University (New York, N.Y.). He has twenty years' experience in monitoring the quality of the New York water supply and has served as a liaison to the US Geological Survey and the US Environmental Protection Agency in matching-fund groundwater studies. Guerrera is currently director of laboratories for the Suffolk County Water Authority.


J.C. Petura

Page 200 Trichloroethylene and methyl chloroform in groundwater: A problem assessment

John C. Petura

Ample funds have been provided for the cleanup of air and water pollution, but groundwater pollution is just beginning to receive much-needed attention. Contamination of wells is a common problem, but only recently has the technology for removing contaminants been developed.

John C. Petura's 13-year career in the water industry has focused primarily on water pollution control, with particular emphasis on the removal of toxic and hazardous substances from water and wastewater supplies. Petura also has an extensive background in the application of activated carbon for removing priority pollutants from water. He is a graduate of Bucknell University (Lewisburg, Pa.) with a BS in chemical engineering and of Drexel University (Philadelphia, Pa.) with an MS in environmental engineering. Petura is a member of NSPE, AAEE, AWWA, AICE, and WPCF.

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F.B. DeWalle

Page 206 Detection of trace organics in well water near a solid waste landfill
Foppe B DeWalle and Edward S.K. C'

Landfills are the primary disposal sites used by municipalities and industries, making the threat of groundwater pollution through leachate migration an immediate concern. A contaminant control program showed that recovery wells can be effectively used to halt plume migration.

Foppe B DeWalle received his MS in environmental engineering from the State University, (Wageningen, The Netherlands) and his PhD at the University of Washington (Seattle). Now associate professor at the University of Washington, DeWalle was a faculty member at the University of Illinois and then at Stanford University.


H.-H. Yeh

Page 211 Selecting polymers for direct filtration
Hsuan-Hsein Yeh and Mriganka M. Ghosh

Determining optimum polymer dosage depends on the molecular weight and charge characteristics of the polymers themselves. Standard jar test apparatus is incapable of providing the necessary G values for mixing most polymers. The optimum polymer dosages based on particle size analysis should be favored over those determined by turbidity measurements in traditional jar tests.

Hsuan-Hsien Yeh is a graduate of the National Cheng Kung University (Tainan, Taiwan) with BS and MS degrees and of the University of Missouri (Columbia) with a PhD. During his studies at Columbia, Yeh conducted polymer-aided filtration research for both surface waters and electroplating wastewater treatment. He has been published by National Science Council Monthly *and is a member of AWWA, ASCE, and the Institute of Chinese Engineers.*


H E. Hudson Jr.

Page 220 Conduct and uses of jar testing
Herbert E. Hudson Jr. and E.G. Wagner

By simulating treatment plant reality, jar tests can quickly and economically produce important data that are directly applicable to plant design, modification, and operation. The procedure offers greater flexibility and economy than does the traditional pilot plant for pretreatment, and it has shown excellent scale-up correlations with plant operating records

Herbert E. Hudson Jr. is a graduate of the University of Illinois (Urbana) with a BS degree in civil engineering He is a member of FASCE, AWWA, and the FAIC. Hudson has been published by Journal AWWA, Journal SED, Water & Sewage Works, *and* Journal ASCE.


R.K. Severson

Page 223 The relationship between asbestos and turbidity in raw water
Richard K. Severson, James Harvey, and Lincoln Polissar

Many studies have attempted to assess the relationship between waterborne asbestos and cancer. Because historical levels of exposure are unknown, data culled from such studies are not considered viable. This paper establishes a significant correlation between turbidity and asbestos levels, possibly providing a means by which historical levels of asbestos could be ascertained.

Richard K. Severson has been studying the relationship between cancer and asbestos in drinking water for the past two and a half years. He is a graduate of the University of Washington (Seattle) with BS degrees in environmental health and mathematics and an MS degree in biostatistics.

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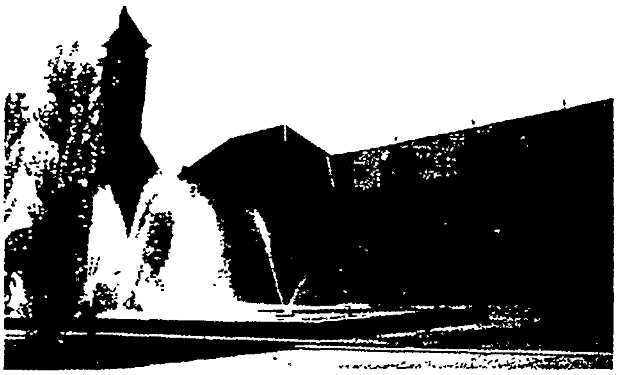

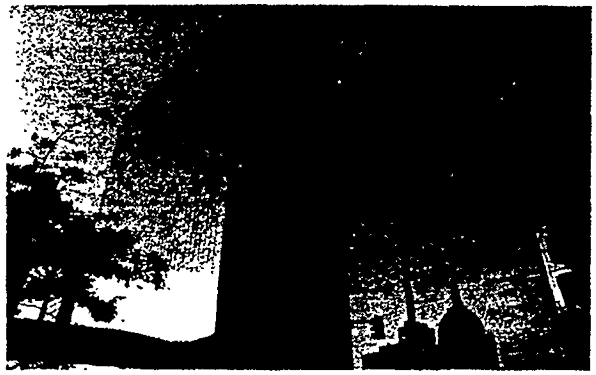

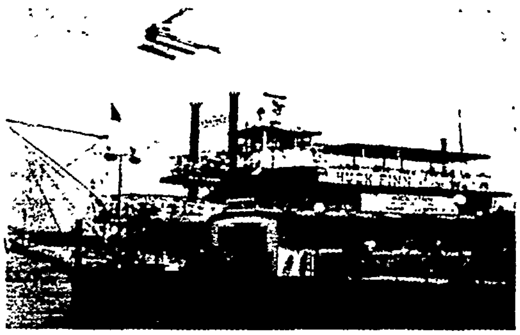

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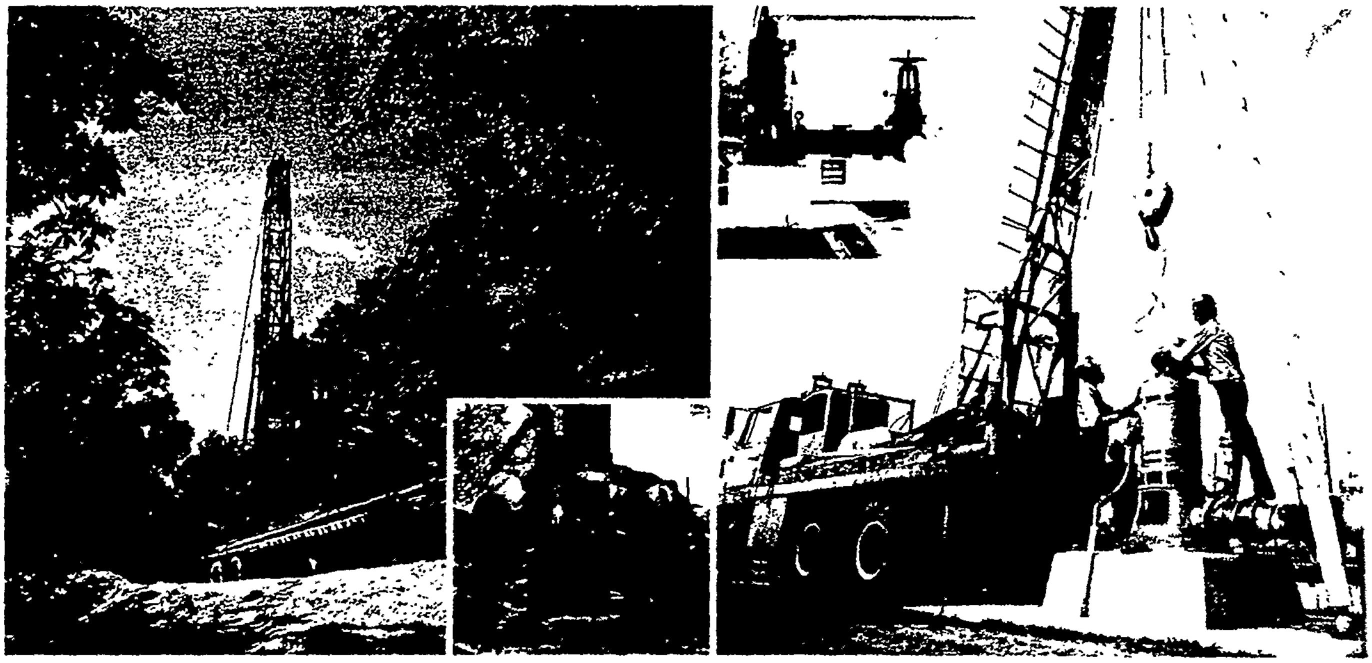

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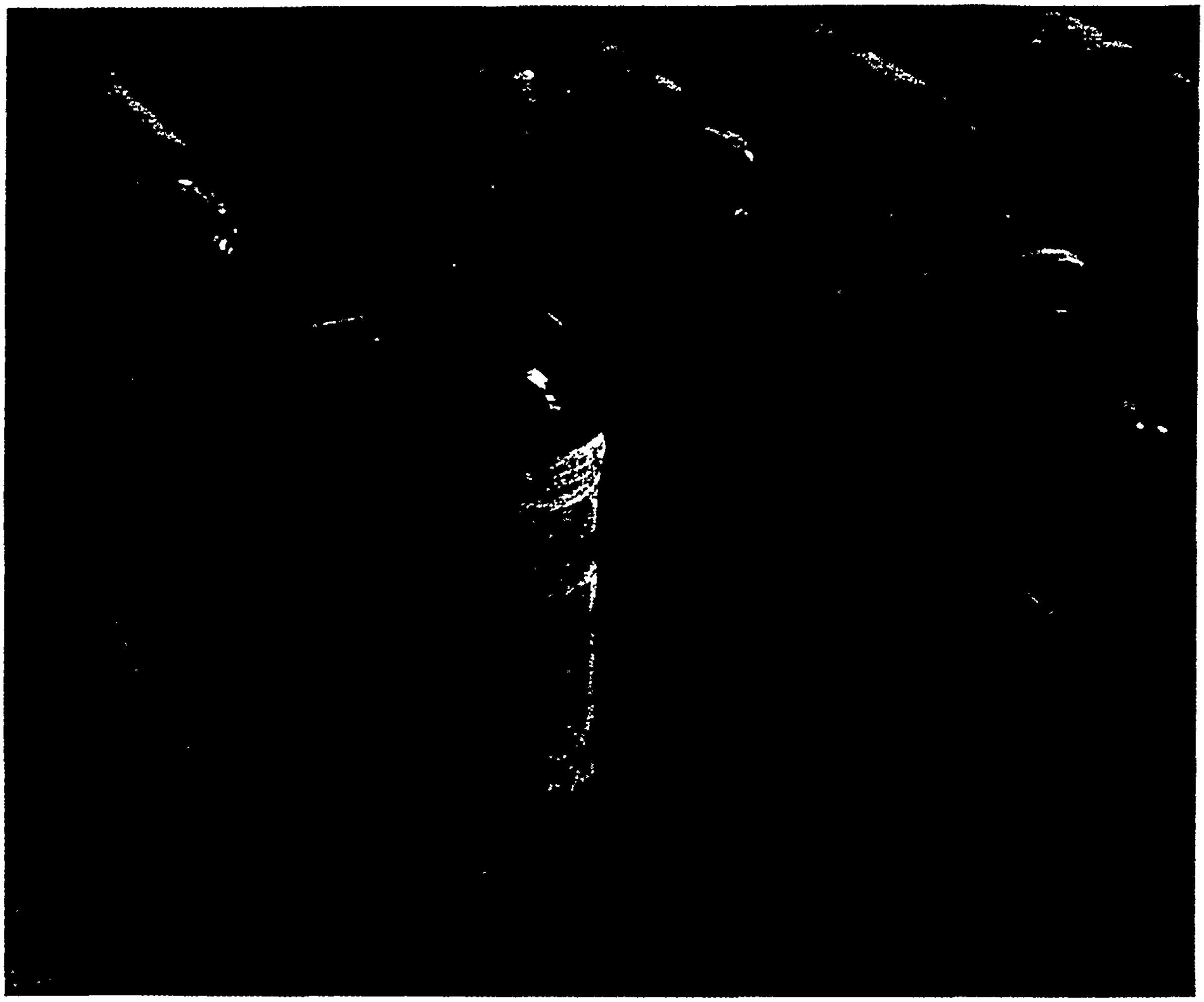

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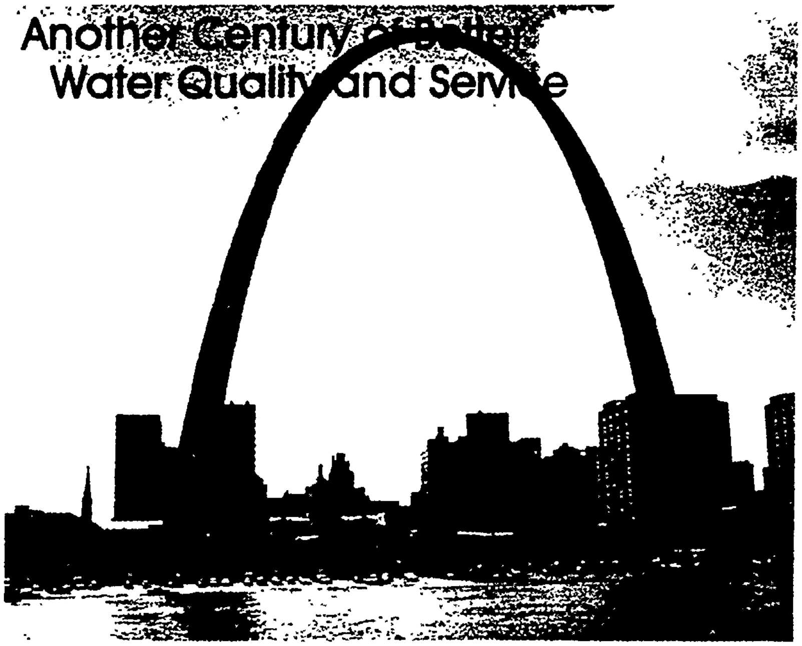
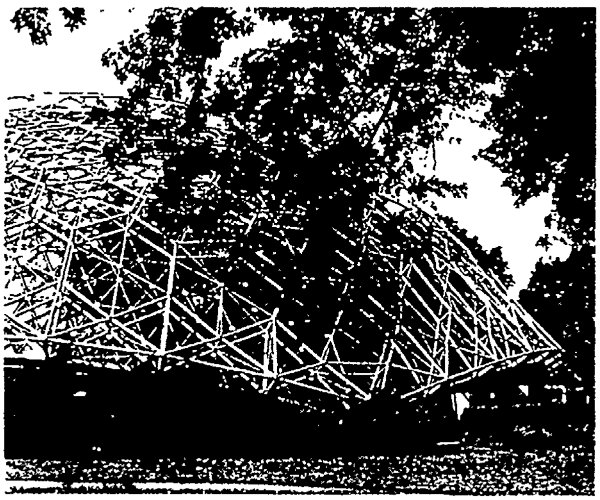
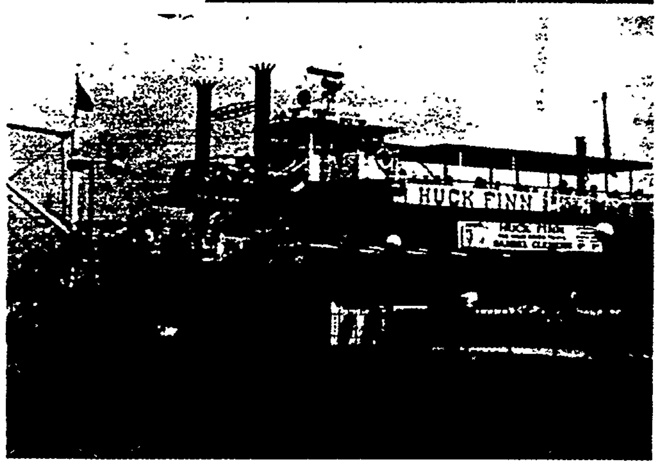
Another Century of Better Water Quality and Service







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It is with great pride and anticipation that I announce the Centennial Conference and Exposition of the American Water Works Association. It will be held in St. Louis, Mo.—the location of the association's founding 100 years ago—from June 7 to June 11, 1981.

The technical program, facilities tours and exposition will provide the latest information on a wide range of technical subjects: contaminant control, utility management, laboratory analysis, operator training, and many more. Our ability to improve the quality and quantity of the water we supply will be further enhanced in meetings with experts from not only our member countries of the United States, Canada, and Mexico but also with others from throughout the world. The centennial conference also will highlight the World Water Decade of the 1980s.

The Missouri Section members have prepared an exciting social and recreational program. The banquet entertainment will feature outstanding performers of the music that accompanied the history of AWWA growth, and you will have an opportunity for individual entertainment, including a baseball game, shopping, and sightseeing.

The conference will be keynoted by an outstanding speaker. These events and many more will make your visit to St. Louis worthwhile. You not only will have an enjoyable experience but also will improve your ability to meet the water service challenge of the next century. Let's help build a stronger association through effective communication between all elements of the industry.

Meet us in St. Louis!

Jerome B. Gilbert
President

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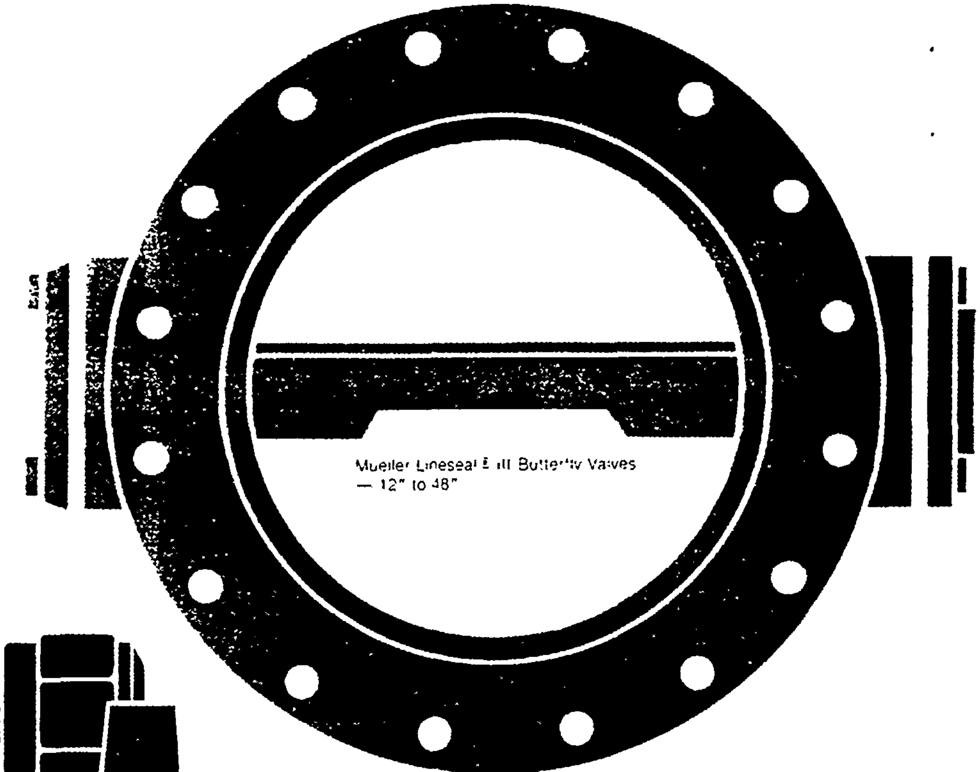

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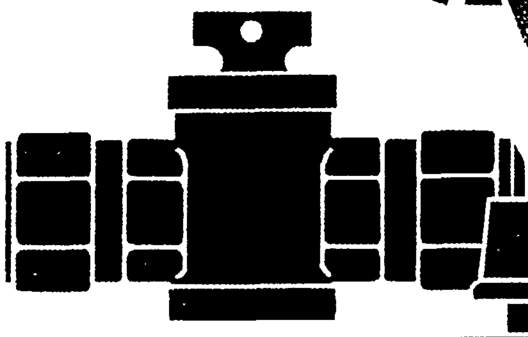

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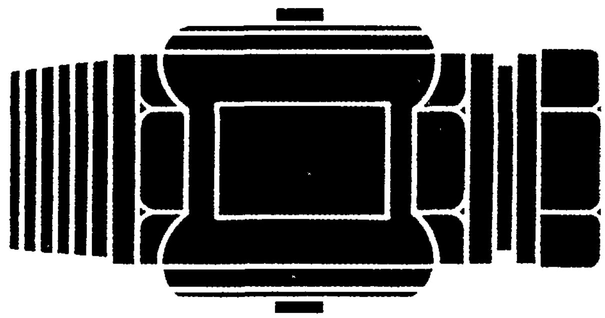

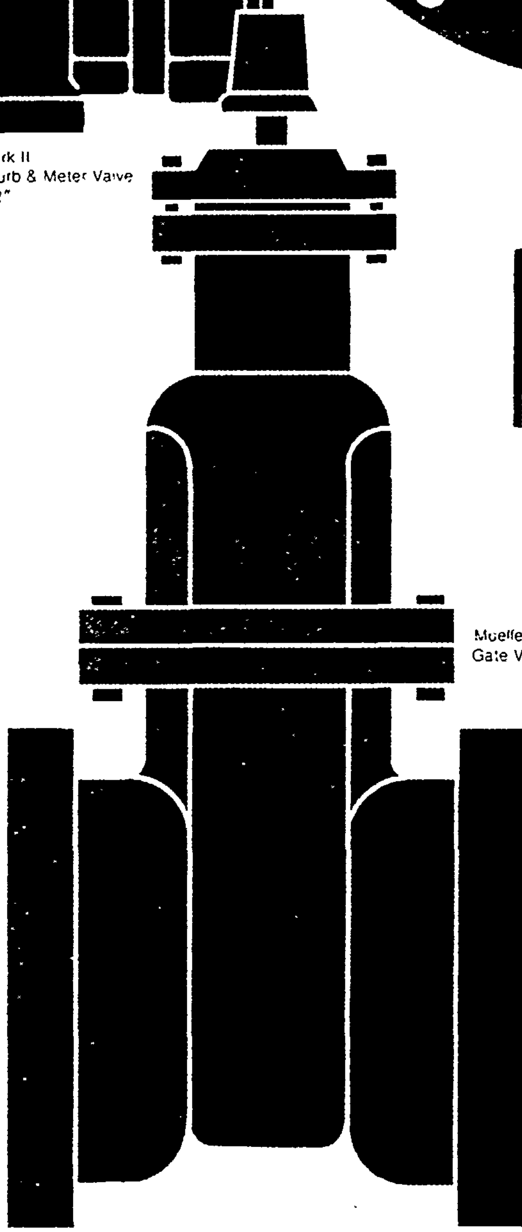

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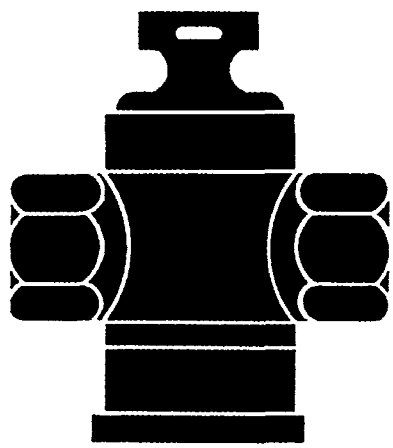

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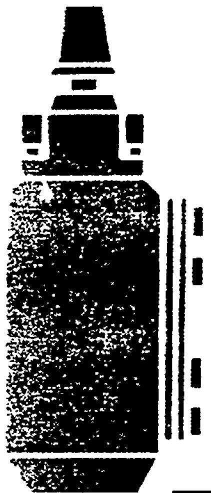
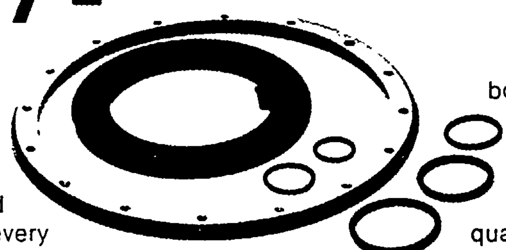
— ¾" to 2"

CAPCO JEN 0020631



Mueller Oriseal® III Curb and Meter Valves — ¾"–1"

Only the Mueller® System offers you bubble-tight valves in sizes from ¾" to 48"



It's the only really complete selection of resilient-seated valves for applications requiring bubble-tight closure. And the only one in which every valve is *pressure tested* for zero leakage before shipment.

Choose from O-ring sealed Oriseal® corporation, curb and meter valves for small size piping. Select and specify the Mueller RSGV with its modified wedge disc, full open flow-way and unique seating design for throttling and other tough applications.

Or specify the Lineseal III®, the better butterfly valve with a unique external operator with one-step adjustment and a body seat ring that adjusts to pressure from either direction.

We make them all with proven Mueller quality. And you can get them all, with prompt delivery, from your Mueller Distributor. He's part of the Mueller System and the only one you need to call for bubble-tight resilient seated valves — in ¾" to 48" sizes. Contact him, your Mueller Representative or write direct to Mueller Co., Decatur, IL 62525.

Each valve is subjected to two hydrostatic tests: one for leakage across the seat and one for leakage from the assembled valve

MUELLER CO.

Reader Inquiry Service No. 042

VISIT OUR EXHIBIT, BOOTH NO. 539

W-8104

CAPCO JEN 0020632

Eliminate "Equipment Shuffle." Switch to the Ford Model 77 Drilling Machine.

Until now, you've needed two or more drilling machines to install ½" through 2" corporation stops.

Not anymore.

With new 1½" and 2" adapter kits, the Ford Model 77 Drilling Machine drills through all these sizes. Eliminating the hassle and expense of equipping your service trucks with multiple machines.

Type of pipe doesn't matter either. The Ford Machine easily handles steel, cast iron, asbestos-cement, or plastic.

And the Model 77's optional chip flushing feature washes chips through the machine and out a hose.

A complete assortment of drills, shell cutters, and special adapters are also available.

Simplify your service installation. For more information on the complete Drilling Machine Kit, or on adapters to update your current Model 77, write or contact your local Ford distributor.

FORD

THE FORD METER BOX COMPANY, INC.
P.O. Box 443, Wabash, Indiana 46992

1½" Adapter 2" Adapter

Reader Inquiry Service No. 02[illegible]

VISIT OUR EXHIB[illegible]

CAPCO JEN 0020633

DATELINE WASHINGTON, D.C.:

AWWA SUPPORTS GORSUCH AND HERNANDEZ APPOINTMENTS. In a letter to Senator Robert Stafford (R-Vt.), chairman of the Committee on Environment and Public Works, AWWA strongly urged confirmation of Anne M. Gorsuch and John W. Hernandez Jr. for administrator and deputy administrator, respectively, of the US Environmental Protection Agency (USEPA). The letter, signed by Water Utility Council chairman W.H. Miller, expressed the association's opinion that Gorsuch and Hernandez offered the country the dedication, knowledge, and experience to efficiently manage the complex issues inherent in the USEPA. AWWA believes that their legal and engineering talents will provide optimum effectiveness in this key regulatory agency. The letter also noted that both recognized the differences among regions of the nation and the need for greater state and local involvement in control of environmental programs. Confirmation hearings are tentatively scheduled for mid-April.

Gorsuch is a former member of the Colorado General Assembly, a graduate of the University of Colorado, and a Fulbright scholar. She has been active in environmental affairs for Mountain Bell, the telephone company in Colorado. Gorsuch is a native of Casper, Wyo.

Hernandez is a professor at New Mexico State University, a civil engineer, and a long-time member of AWWA.

REAGAN DECIDES TO RETAIN THE COUNCIL ON ENVIRONMENTAL QUALITY. Although its budget will be cut by more than 60 percent and its staff significantly reduced, the Council on Environmental Quality (CEQ) will be retained by President Reagan. The administration reportedly considered eliminating the council on the grounds that its functions could be handled by other agencies. Apparently, the decision to retain the CEQ was made to avoid the strong protests of environmentalists. At its reduced size, however, the council will have difficulty carrying out its responsibilities for overseeing federal agency compliance with the National Environmental Policy Act.

NEW DOMENICI-MOYNIHAN WATER RESOURCES BILL INTRODUCED. A bill that would authorize $2.5 billion for water projects construction has been introduced by Senators Domenici (R-N.M.) and Moynihan (D-N.Y.). The legislation provides a different approach for such projects, establishing state block grants and cost sharing and allowing the states to select projects and determine priorities. Cost sharing would be set at 75 percent federal funding and 25 percent state. Projects studied by the US Army Corps of Engineers or other water development agencies would automatically be authorized subsequent to a state's certifying that the project has widespread benefits and is the most economical alternative.

USEPA DISCLOSES PLANS FOR REGULATIONS. The Jan. 14, 1981, issue of the Federal Register contains USEPA's agenda of regulations. There are 183 regulations entries in this document. A large portion, however, are actions required to satisfy agency review procedures in accordance with either statutory or judicial mandates. Two regulations are listed under drinking water, the control of organic chemical contaminants in drinking water by granular activated carbon (GAC) systems and maximum contaminant levels (MCLs) for volatile organic chemicals in groundwater. The USEPA proposes June 1982 as the date for the reproposed GAC regulations; January 1981 was the date for the Advanced Notice of Rule Making for organic chemicals. Recent discussions with USEPA indicated, however, that the latter ruling will not be available until early May. The MCLs for volatile organic chemicals in groundwater could even be delayed until the "new USEPA team" is in place and has provided guidance relative to policy and regulations.

DROUGHT RESPONSE COORDINATION UNDER WAY. Drought response coordination has been assumed by the Federal Emergency Management Agency (FEMA). That agency has prepared a report, soon to be available, relative to drought assistance programs such as those sponsored by the Farmers Home Administration, the US Army Corps of Engineers, and the USEPA. For information concerning this report, write to Federal Emergency Management Agency, Division of Disaster Response and Recovery, 1725 I St., N.W., Washington, DC 20472.
....................AWWA Washington, D.C., office--Cliff Atkinson Jr.

Canadian Update

DATELINE CALGARY, ALBERTA:

According to a report released by Alberta Environment, major steps are needed if water supply and sewage treatment facilities are to keep pace with the growth of the city of Calgary and surrounding communities.

The Calgary Regional Utilities Study reports that many of the treatment facilities were considered in the study. Factors such as projected demand, source of supply, level of sewage treatment, and cost were used to evaluate the various regional, subregional, and individual facility options.

For water supply, the study recommends that the communities of Airdrie, Crossfield, Chestermere Lake, Strathmore, Carseland, Okotoks, High River, Turner Valley, Black Diamond, Springbank Airport, and Cochrane receive their water supplies from the city of Calgary; that Bragg Creek and Redwood Meadows have a joint supply from the Elbow River; that the western irrigation district main canal be used as a source of joint supply for Irricana and Beiseker; that existing facilities at Longview and Cayley be upgraded; and that Blackie continue to be supplied from medium-depth wells.

Recommendations on sewage treatment were to link the communities of Airdrie, Crossfield, Chestermere Lake, Strathmore, Okotoks, Black Diamond, Turner Valley, Redwood Meadows, Bragg Creek, and Cochrane to the city of Calgary's treatment and disposal facilities; to improve existing treatment plants serving Beiseker, Irricana, Carseland, Blackie, High River, Longview and Springbank Airport; and to build a new plant at Cayley.

CAPCO JEN 0020635

Better weed control spells better water control.

Maintaining irrigation and flood control ditches is an on-going effort. That's why so many irrigation and water management districts use Roundup® herbicide.

Roundup can get those weeds *before* they choke off irrigation and drainage water. *Before* the backed-up water overflows, carrying weed seed to spread the problem. *Before* the trouble involves costly dredging.

Just draw down the water from the ditches and apply Roundup to the actively growing weeds. Wait seven days, and then reintroduce the water.

Roundup works inside the weed, so there's no residual soil activity. And Roundup is non-volatile, so it won't vaporize to harm nearby plants. You can even reseed right away—and that means reduced soil erosion.

If you want to get better water control...*and* save time, money and labor...try better weed control with Roundup.

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Nothing works like Roundup.

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Reader Inquiry Service No. 041

Centennial Conferenc

For the AWWA and its members, the spirit of St. Louis encompasses a celebration of the past and a commitment to the future as the association holds its centennial convention, June 7-11, in that city

The theme of the annual conference—"Another Century of Better Water Quality and Service"—was selected to recognize AWWA's past 100 years and to look forward to its goal for the next 100. Even the structure of the conference reflects tradition and innovation.

This year the conference will begin with the customary exposition opening and meet-and-greet function. The opening general session on Monday will include the awards ceremony in addition to an outstanding keynote speaker.

From Monday afternoon through Thursday morning, the divisions and committees of the association will present discussions of emerging technology, research, practical applications, and government regulation. Topics include "Environmental Considerations and Other Delays," "Managing in a Changing Economy," "Small Water Utility Operations and Design," "Better Water Quality and Service Through Training," and "Helen Weren't No Saint."

The annual banquet has been moved to Wednesday night, and the conference will end at noon on Thursday with a special lunch featuring a prominent panel.

The exhibits will be open on Sunday from noon until 5 p.m and from 8 a.m. to 5 p.m. Monday through Wednesday The evenings have been left free for attendees to enjoy the many attractions of the city and the exhibitors' social events.

To amplify the theme, the AWWA Centennial Committee has planned a number of events and souvenirs On Sunday, June 7 the exposition opening will include a birthday party and traditional cake along with period entertainment like ragtime music and German folkdancing.

The theme center, located in the exhibit hall, will present a montage of AWWA history and services as well as water industry accomplishments of the past and directions for the future against a Gay Nineties background. Every technical registrant will receive a copy of the special centennial magazine, with articles and illustrations highlighting the industry's past and future.

Also one of the centennial projects will be a museum display of waterworks equipment and photographs showing the history and development of water supply.

Other traditional events will highlight the conference as well. Three preconference seminars on Sunday will include such timely topics as groundwater contamination, small utility problems, and coagulation and filtration. Facility tours of water systems in the St. Louis area will be offered on Tuesday and Wednesday. The popular golf and tennis tournaments will gather contestants for their once-a-year friendly rivalry.

The ladies' program features a visit to the Missouri Botanical Gardens, with its famous geodesic Climatron, tours of historic St. Louis homes, and a concert by the Saint Louis Symphony. Optional tours, shopping trips, and a fashion show will operate from the ladies' hospitality center, the annual rendezvous for many at the conference.

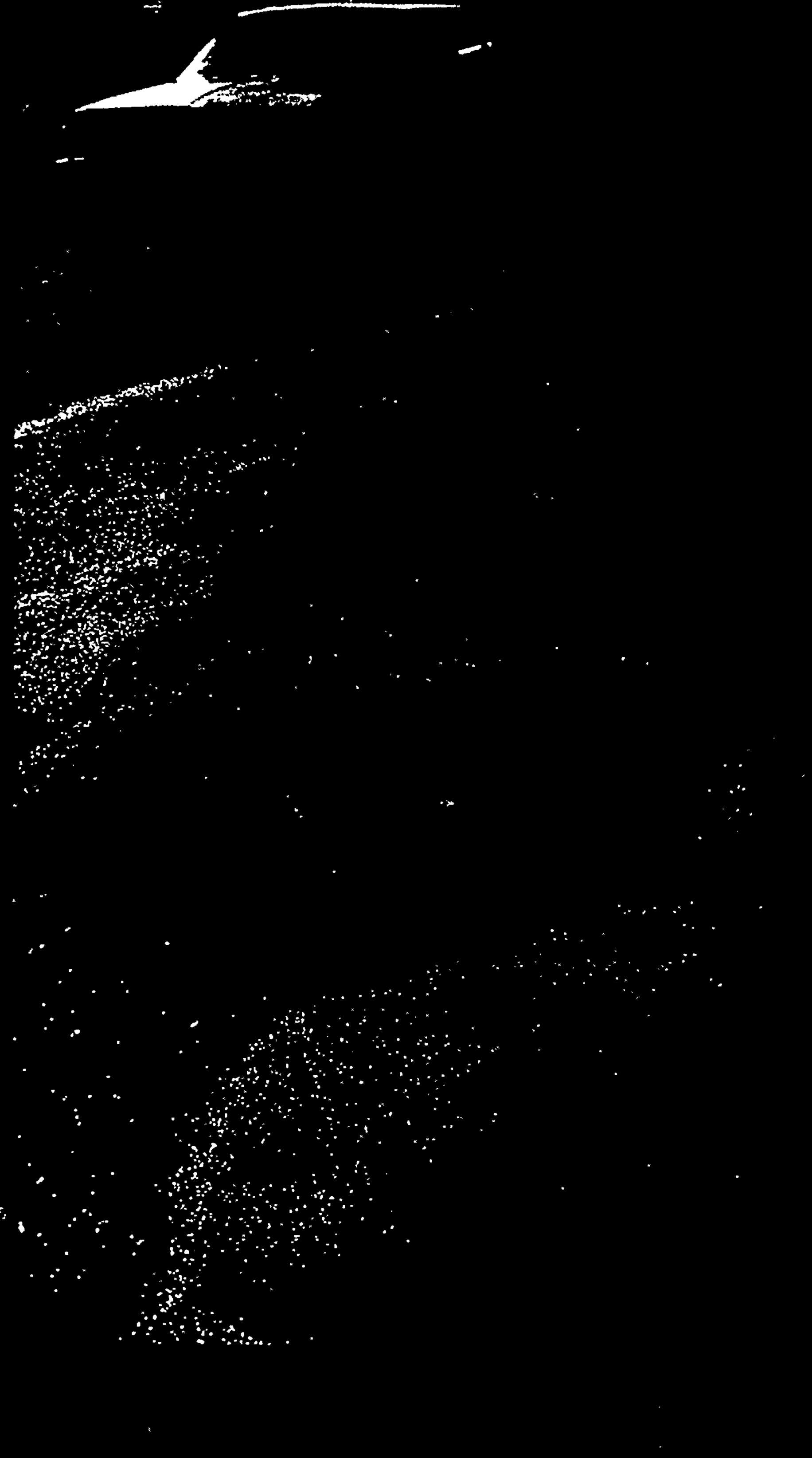
Known as the gateway to the West, St. Louis is a "jumping in" place as well as a jumping off place. The city offers many diversions: riverboat rides on the Mississippi, numerous historical sites, major league sports, the Anheuser-Busch Brewery, and the city's symbol, the famous Gateway Arch. AWWA conferees can jump into the swing with sightseeing and centennial celebrations combined with the best in technical programs.

As AWWA's founding fathers could have said, "Meet me in St. Louie!"

CAPCO JEN 0020637

It *can't* happen here.

It shouldn't anyway.
A failure in any community's pressure pipe system inevitably leads to a series of unpleasant and disruptive events. Pipe costs money and laying costs even more. If unsuitable materials are used, an entire system may have to be replaced, resulting in severe unanticipated expenses.
The answer is to specify permanent material in the first place, ductile *iron from* the McWane Inc. companies . . . Atlantic States Pipe, McWane Pipe and Pacific States Pipe.
When you put pipe into the ground, you *never* want to see it again. That's something you can count on when you specify ductile from McWane Inc.



Atlantic States Cast Iron Pipe
Phillipsburg, New Jersey

McWane Cast Iron Pipe
Birmingham, Alabama

Pacific States Cast Iron Pipe
Provo, Utah

Union Foundry (fittings)
Anniston, Alabama

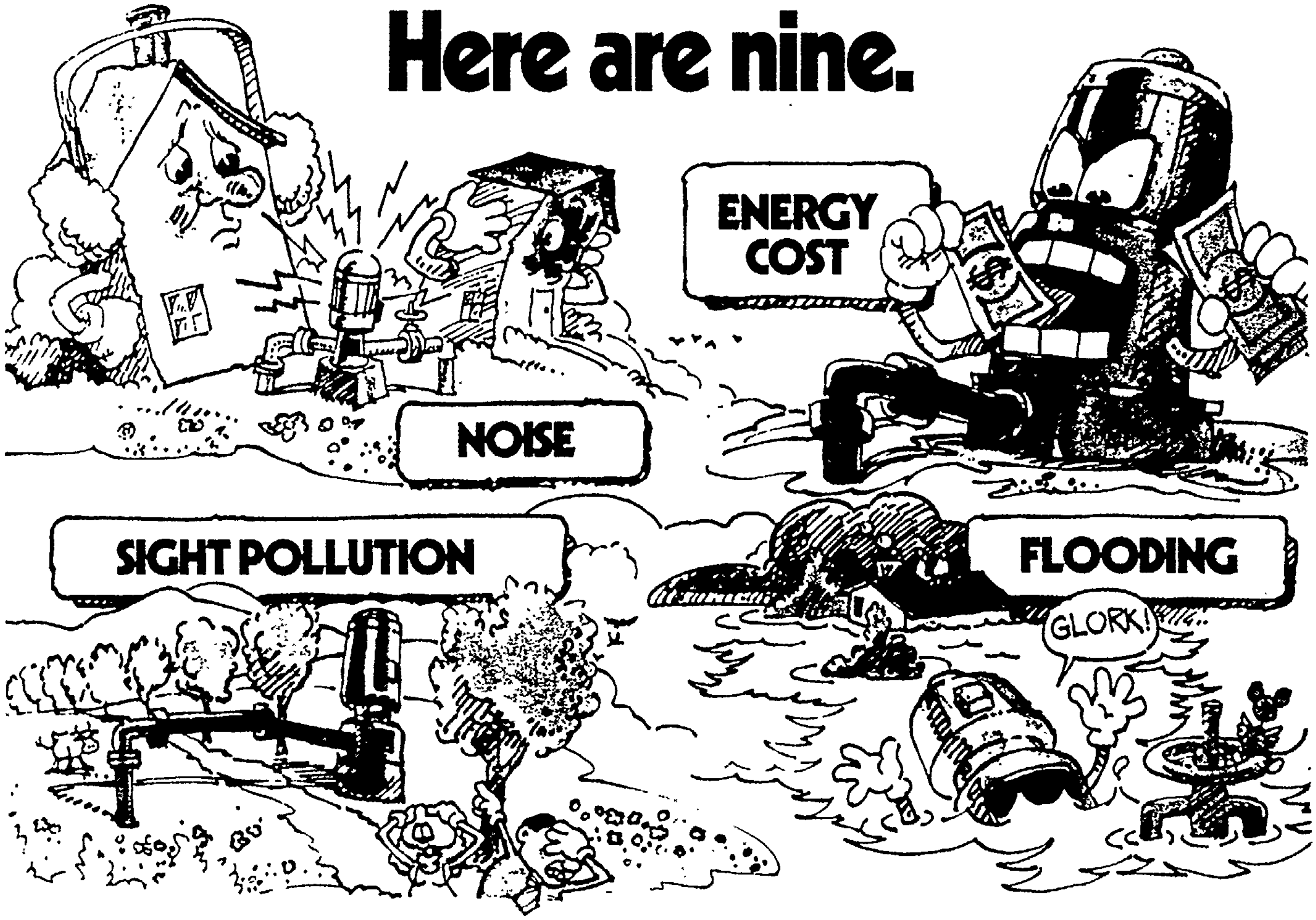
Reader Inquiry Service No. 040

VISIT OUR EXHIBIT BOOTH NO. 645

CAPCO JEN 0020638

You only need one good reason to go submersible.

Here are nine.



Byron Jackson is first in submersibles—and has been ever since 1932. In today's ecology-conscious world, the traditional benefits of submersibles have added meaning. Because the modern Byron Jackson submersible is...

Silent.

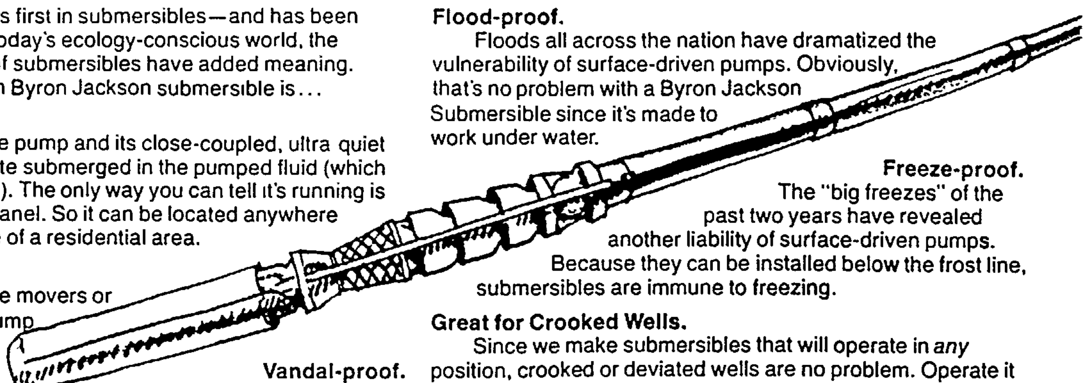
Our submersible pump and its close-coupled, ultra quiet electric motor operate submerged in the pumped fluid (which also dampens noise). The only way you can tell it's running is to read the control panel. So it can be located anywhere —even in the middle of a residential area.

Out of Sight.

No surface prime movers or stuffingboxes. No pump houses. Everything can be under ground. In short, no sight pollution.

Vandal-proof.

Damage to expensive pumping equipment is a growing problem faced by water districts everywhere. Putting pumps underground leaves vandals nothing to vandalize.



Flood-proof.

Floods all across the nation have dramatized the vulnerability of surface-driven pumps. Obviously, that's no problem with a Byron Jackson Submersible since it's made to work under water.

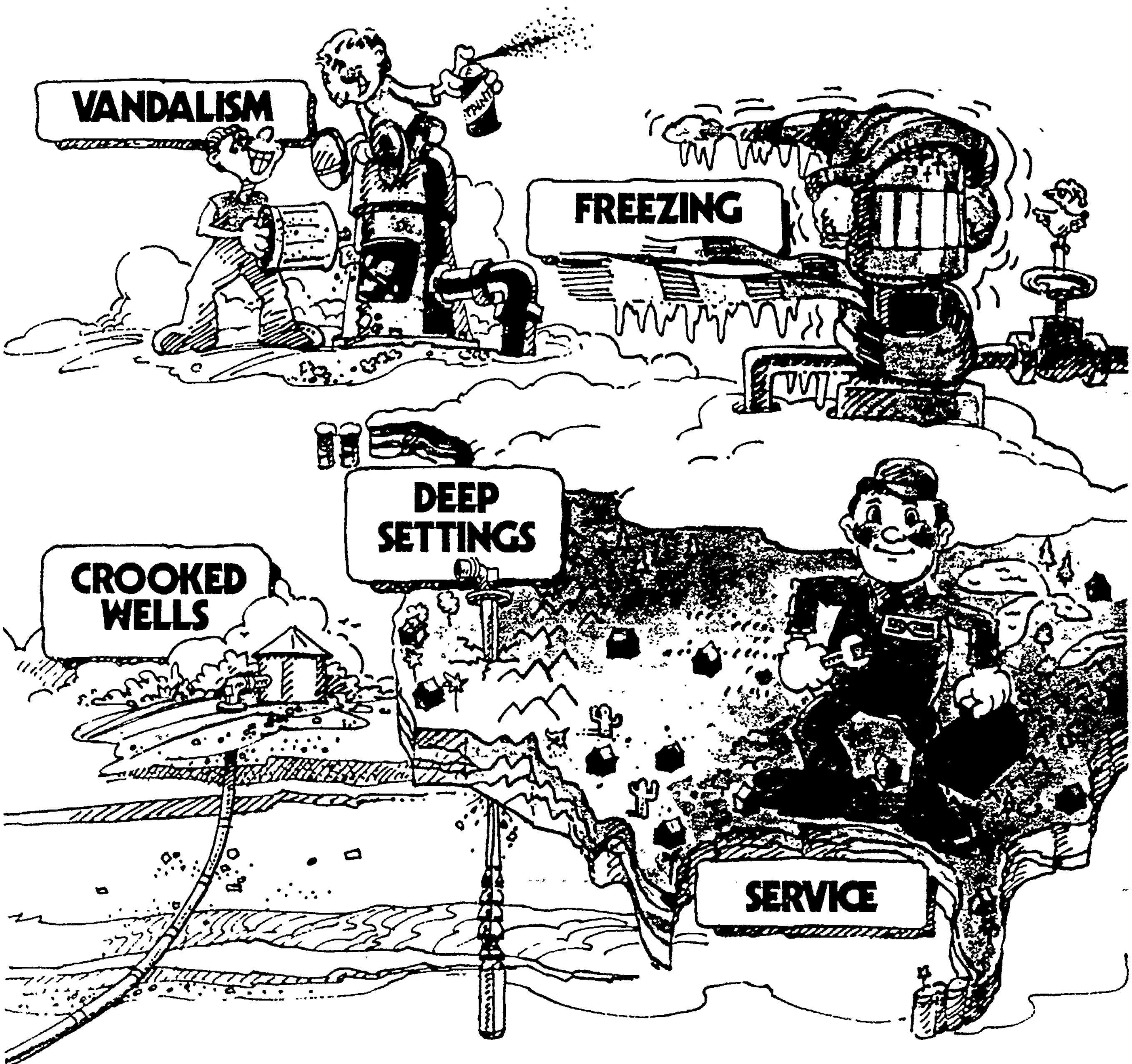
Freeze-proof.

The "big freezes" of the past two years have revealed another liability of surface-driven pumps. Because they can be installed below the frost line, submersibles are immune to freezing.

Great for Crooked Wells.

Since we make submersibles that will operate in *any* position, crooked or deviated wells are no problem. Operate it vertically in primary and booster service—flip it on its side as a transfer pump, or incline it for river water intake. No other type of pump offers such versatility.

CAPCO JEN 0020639



Ideal for Deep Settings.

Your choice of many bowl and impeller designs lets the Byron Jackson Submersible adapt easily to any submerged pumping need. It can be set as deep as you have to go. If you're faced with a declining water table, here is your solution.

Energy Efficient.

The compact, close-coupled submersible is highly efficient in operation. For example, the new municipal water system at Mercer Island, Wash., employs three Byron Jackson Submersibles in conjunction with adjustable-frequency drives and an electronic controller. It is actually paying for itself by *saving 16 per cent in energy consumption* over the noisy, surface-driven pumping system it replaced.

Serviced Nationwide.

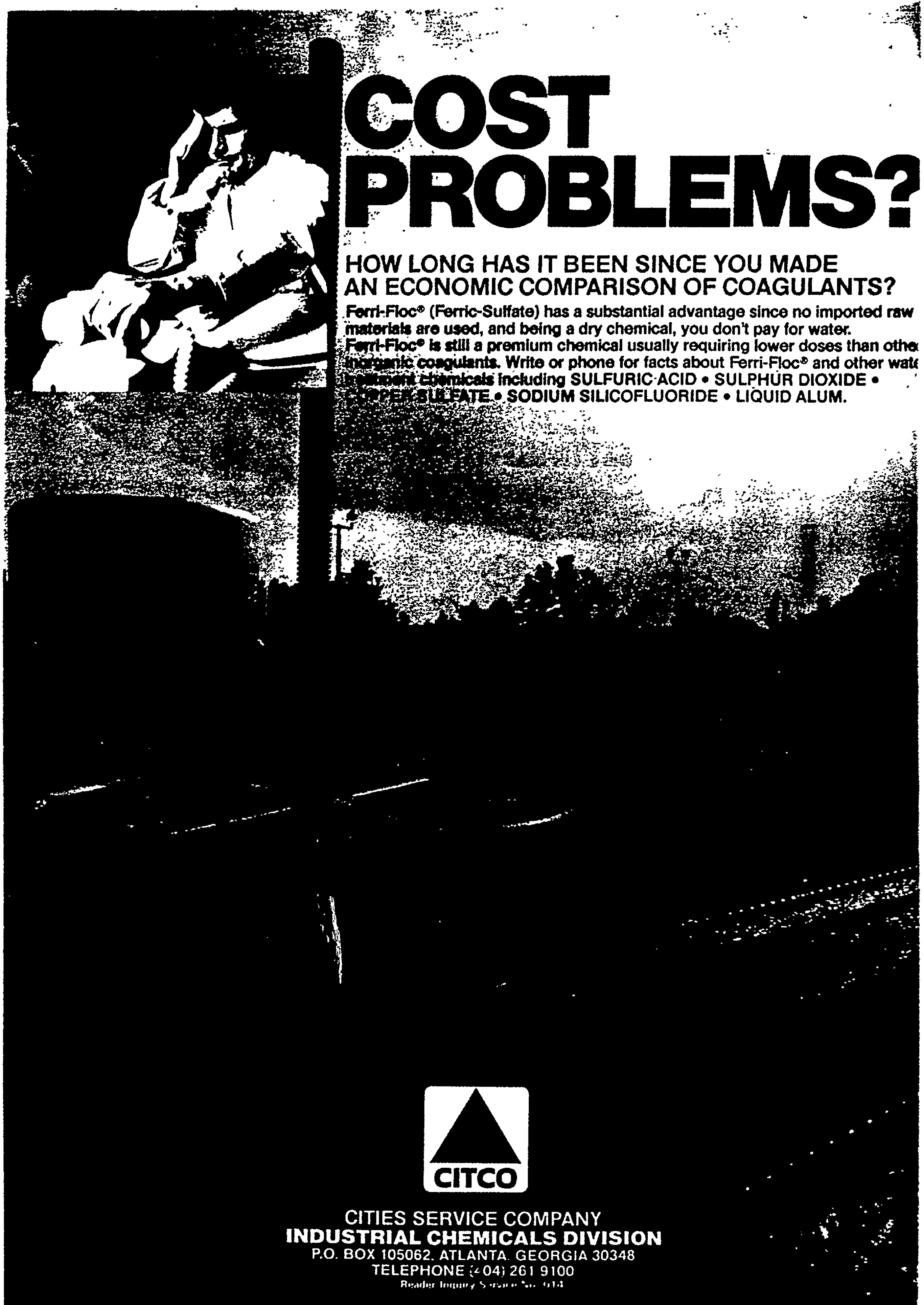
Our submersibles are built to operate unattended for many years of silent service. But should you ever need service, our nationwide network of authorized dealers and factory service centers is on call to meet your installations, parts and service needs 7 days a week.
They're backed up by our factory stock of rebuilt replacement motors, ready for immediate shipment.

For more information and specifications, contact your Byron Jackson dealer today. Or write: Byron Jackson Pump Division, P.O. Box 2017 Terminal Annex, Los Angeles, CA 90051. (213) 587-6171

BYRON JACKSON PUMP DIVISION BORG WARNER®

P.O. Box 2017, Terminal Annex, Los Angeles, CA 90051
Reader Inquiry Service No. 010

CAPCO JEN 0020640



CAPCO JEN 0020641

AWWA ANNUAL CONFERENCE AND EXPOSITION ADVANCE REGISTRATION FORM

June 7-11, 1981 St Louis, Missouri

- Enclose the completed form with payment and mail in the self-addressed envelope no later than May 25, 1981.
- The special rates below apply to registration received by June 1.
- On-site registration rates are 10% higher.
- Your registration will be acknowledged by AWWA.
- Cancellations or transfers will be accepted until the Conference starts.
- Registrant and spouse should register on the same form.
- Sunday Seminar registration should be made on this same form. Lunch is included

Type of Registration

	Sun-Thurs		Ladies		One Day	Student	Exhibit Area Only Sun-Wed	Exhibit Area Only One Day
Member	$100	$70	$80	$50	$32	$5	$10	$4
Nonmember	$130	$100	$80	$50	$45	$9	$10	$4
Includes								
Technical sessions	•	•	-	-	•	•	-	-
General sessions	•	•	•	•	•	•	-	-
Exhibits	•	•	•	•	•	•	•	•
Social functions	•	•	•	•	-	•	-	-
Banquet Wednesday	•	-	•	-	-	-	-	-
Ladies events	-	-	•	•	-	-	-	
Ladies rendezvous	-	-	•	•	-	-	-	-

CUT HERE

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NAME

TITLE

COMPANY

ADDRESS

CITY STATE OR PROVINCE

PHONE ZIP

SPOUSE

USE SAME NAME AS ON THE HOUSING FORM

ADVANCE REGISTRATION

Circle Choice

	Member		Nonmember	
Technical Sessions & Exhibits				
Sun-Thur - with banquet	$100	AA	$130	AC
without banquet	70	BA	100	BD
One Day - Monday only	32	CA	45	CC
- Tuesday only	32	DA	45	DD
- Wednesday only	32	EA	45	ED
Student (college or university)	5	FA	9	FD
Ladies Program - with banquet	80	GA	80	SGA
without banquet	50	HA	50	SHA
Exhibit Area Only				
Sun - Wed	10	IA	10	IA
One Day - Monday exhibit only	4	JA	4	JA
- Tuesday exhibit only	4	KA	4	KA
- Wednesday exhibit only	4	LA	4	LA
Extra Banquet Tickets ___ @ $30 ea	___	MA	___	MA
Facility Tour	15	NA	20	ND
Scientific Luncheon (Thurs.)	10	CA	15	OD
Conference Proceedings	26	PA	52	PD
Sunday Seminars				
Small water system problems	50	QA	70	QD
Coagulation & filtration - back to the basics	50	RA	70	RD
Organic chemical contaminants in groundwater	50	SA	70	SD
TOTAL	$ ______		$ ______	

Are you a member of AWWA?

Yes ______ a No ______ b
(Member No.)

Is your company a member of AWWA?

Yes ______ c No ______ d
(Employees of a member company qualify for member rates.)

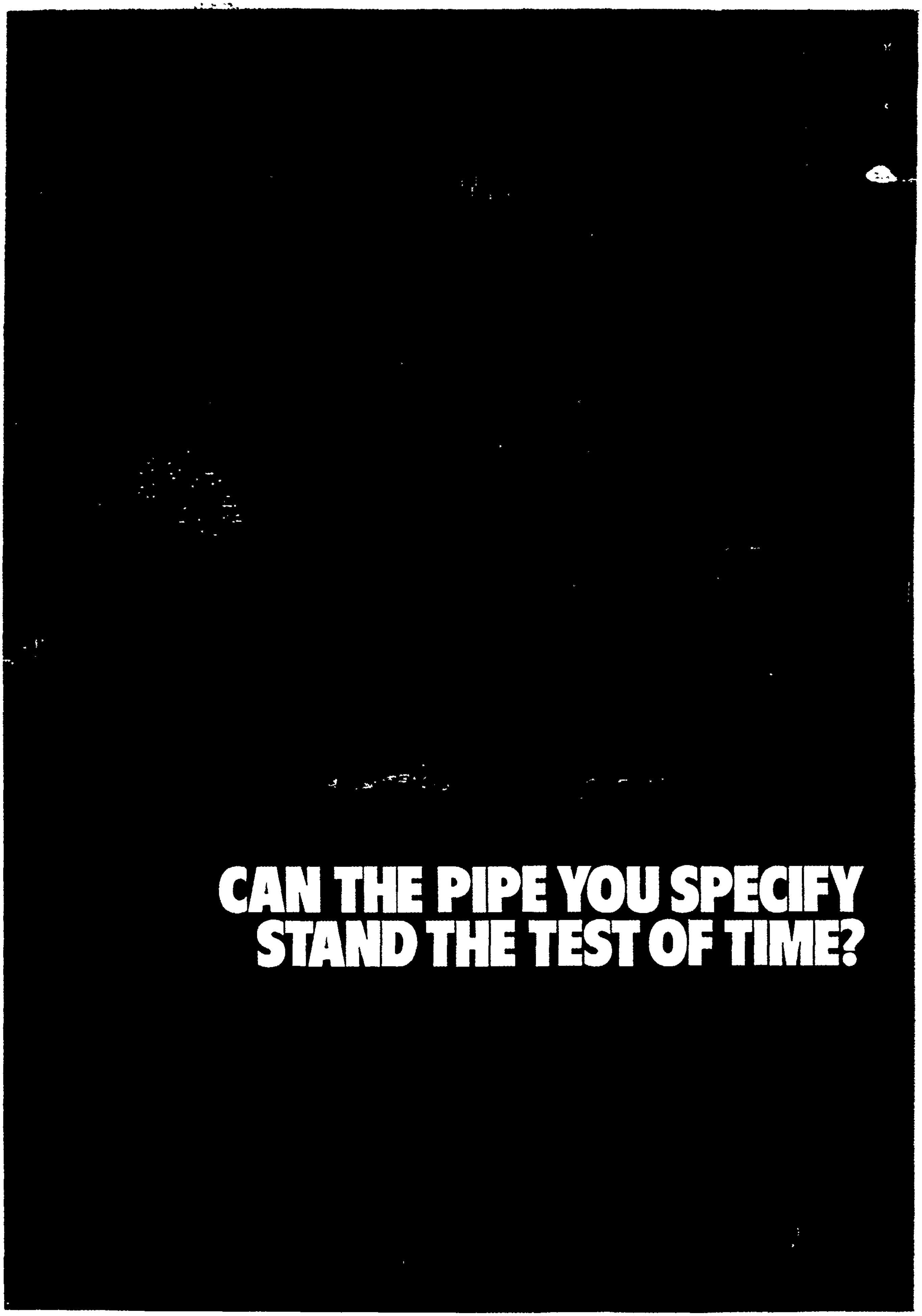
OCCUPATION (circle one)

A Water Utility
B Contractor
C Consultant
D Manufacturer Exhibiting
E Manufacturer Not Exhibiting
F Manufacturer's Representative
G Distributor
H Educator
I Research Lab
J Government-Federal
K Government-State
L Government-Local
M Student
N Other ______

Make check payable to AWWA in US funds
Personal check ______
Company check ______
Date ______

Mail to: AWWA Conference
6666 W. Quincy Ave.
Denver, CO. 80235

CAPCO JEN 0020642



CAPCO JEN 0020643

Some things are built to last. And American Ductile Iron pipe is designed, manufactured and tested to do just that.

Strength, durability and corrosion resistance are characteristics that are built into American Ductile Iron pipe. It's tough enough and versatile enough to stand up to any terrain. Each length is hydrostatically tested (4"-24" sizes at 500 psi; 30"-54" sizes at 75% of yield, usually above 750 psi). And larger than nominal internal diameters provide up to 8% extra flow capacity. It's unexcelled for maintenance free service. All this to meet the unexpected demands of an advancing civilization.

When you need pipe that will stand the test of time, specify American Ductile Iron.

We won't leave you high and dry.

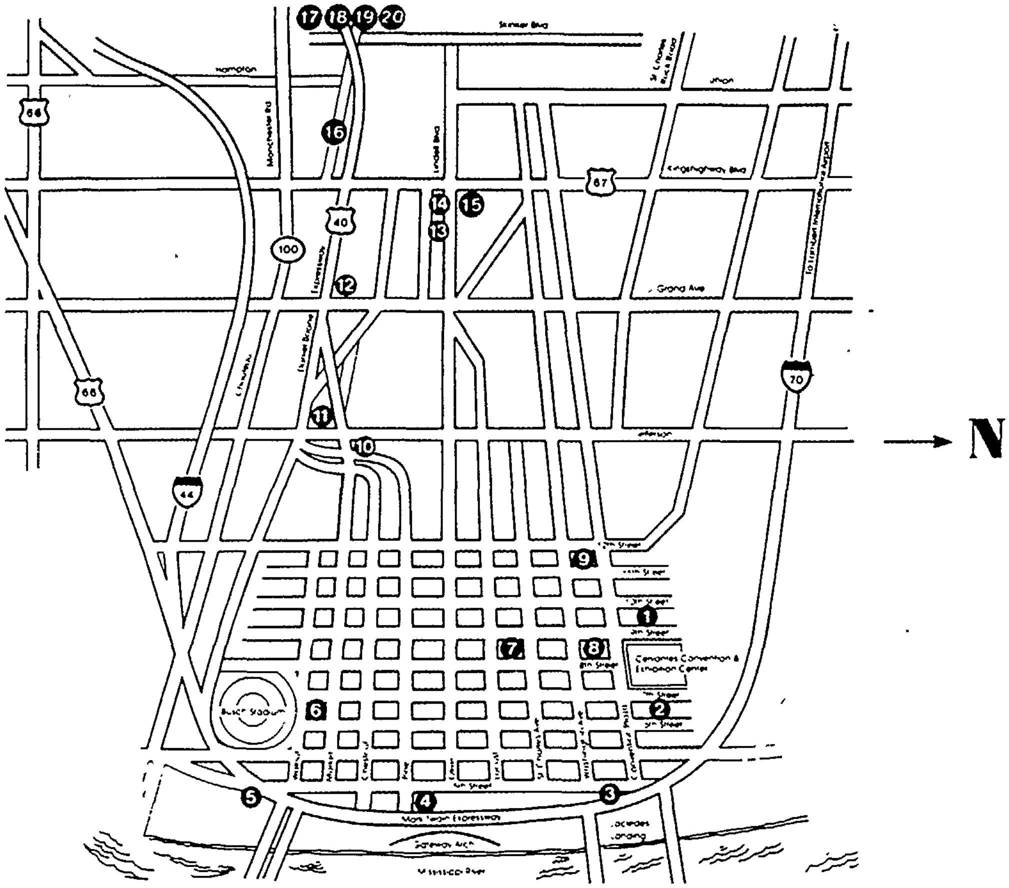
American Ductile Iron Pipe

Corporate Headquarters and Principal Plants
Birmingham, Alabama

Reader Inquiry Service No. 092

CAPCO JEN 0020644

1981 Annual Conference Hotel Locations and Rates



Map No.	Hotel	SGL	DBL	TWIN	EXTRA PERSONS	1 BR SUITE	2 BR SUITE	NO. OF ROOMS RESERVED
1	Radisson-St Louis	50-56	60-66	60-66	–	120	–	200
2	Sheraton-St Louis	55	67	67	10	140-220	–	500
3	Bel Air Hilton	52-62	62-72	62-72	–	150-350	–	100
4	Holiday Inn Riverfront	49-59	58-66	58-66	9	100-110	140-150	300
5	Stouffer's Riverfront Towers	50-52	62-64	62-64	12	175-225	275-300	800
6	Marriott's Pavilion	52	60	60	6	–	–	275
7	Mayfair	41	49	49	–	115-125	250	150
8	Lennox	34-37	38	42	5	55-65	100-130	175
9	Best Western St Louisian	35	45	45	5	70	–	100
10	Holiday Inn—Market Street	33	38	38	–	–	–	150
11	Rodeway Inn—Downtown	38	44	48	6	–	–	200
12	St Louis Ramada Inn	38-40	46-48	46	8	75	–	150
13	Bel Air West	30	32	35	2	–	–	75
14	Forest Park	30-40	35-45	35-45	–	–	–	100
15	Chase Park Plaza	45-65	55-70	55-70	10	–	–	750
16	Quality Inn at Forest Park	35	37	37	–	–	–	100
17	Holiday Inn—Clayton Plaza	42	52	52	–	–	–	90
18	Clayton Inn	48	58	58	–	125	150	100
19	Daniele	65	75	75	–	150-200	–	40
20	Breckenridge Inn—Frontenac	67	78	78	6	–	–	150

CAPCO JEN 0020645

HOTEL RESERVATIONS

AWWA Conference Housing
Bureau
1300 Delmar St.
St. Louis, MO 63103

Hotels

1st choice ______

2nd choice ______

3rd. choice ______

Arrival Date ______ Time ______ AM ______ PM

Names of Occupants

1 ______

2. ______

3 ______

4 ______

Accommodations Requested

- ☐ Single $______
- ☐ Double $______
- ☐ Twin $______
- ☐ Twin Double $______
- ☐ One-BR Suite $______
- ☐ Two-BR Suite $______

Send Confirmation To

Name ______

Company ______

Address ______

City ______ State ______ Zip ______

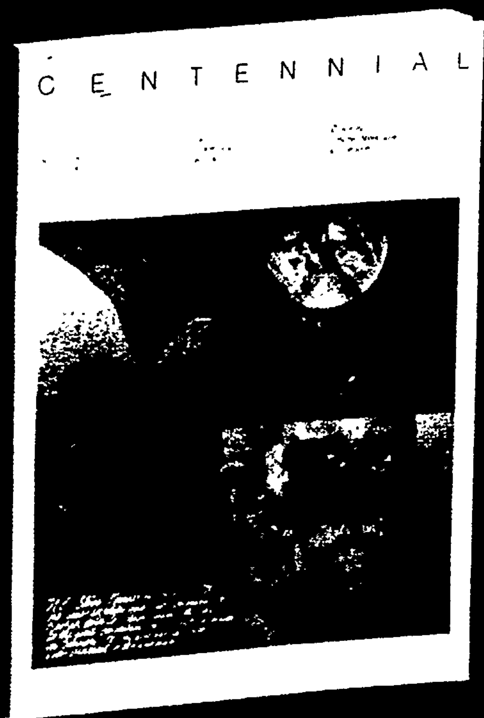
Telephone A/C ______ No. ______

-Important-

1. Reservations must be sent to the AWWA Housing Bureau on official housing forms. Hotels will not accept direct reservations.
2. You will receive acknowledgment of receipt of your reservation request from the Housing Bureau, but confirmation of your reservation will come from the hotel to which you have been assigned.
3. Be sure to list arrival and departure dates and times.
4. Hotel confirmations will indicate late arrival guarantee and deposit policies.
5. Be sure to list names of all occupants of room.
6. If accommodations are not available at the hotels of your choice, comparable reservations will be made at other cooperating hotels.
7. If requested rate is not available, the next available rate will be assigned.
8. Reservations will not be accepted by telephone.
9. Notify the Housing Bureau of CANCELLATIONS. Make CHANGES directly with the hotel.
10. Reservations must be received at the Housing Bureau by May 7, 1981.
11. DON'T BE A NO-SHOW!

CAPCO JEN 0020646

A unique tribute to a once-in-a-lifetime event.



The AWWA Centennial Magazine tells the story of the past, present and future of water service and AWWA. It presents a variety of facts, prognostications, anecdotes and images touching all aspects of the industry.

There's something for everyone in the Centennial Magazine. Technical people, government officals and ordinary citizens will find the articles both informative and absorbing.

The Magazine is sturdily-bound, containing over 100 pages of articles, features, photos and advertising. It's designed in every way to be a comprehensive and long lasting souvenir of the Centennial.

Technical registrants at the 1981 Annual Conference will receive a free copy. Others may purchase copies from headquarters.

Special low rates for advance bulk orders make it possible for companies to purchase complimentary copies for their customers.

ADDRESS

CITY STATE

CAPCO JEN 0020647

1981 Annual Conference Preliminary Technical Program

Monday, June 8—Morning

1 • ANOTHER CENTURY OF BETTER WATER QUALITY AND SERVICE

General Session

Chairman: J.B. Gilbert

Vice Chairmen: K.J. Miller, J.H Stacha, W O. Lynch, D.K. Shine, T.J. Blair III, D.B. Preston

1. INVOCATION
2. WELCOME
3. OPENING REMARKS—*J.B. GILBERT*
4. AWARDS
5. KEYNOTE ADDRESS

Monday, June 8—Afternoon

2 • ENVIRONMENTAL CONSIDERATIONS AND OTHER DELAYS

Distribution Division

Chairman: P E. Pilgreen

Vice Chairman: D.E. Jackson

1. NEGOTIATING FOR INSTREAM WATER—*D.J. CHRISTIANO*
2. ENVIRONMENTAL AND REGULATORY CHESS GAME—*R.L. WUBBENA*
3. PERMIT PROGRAM AS IT AFFECTS NAVIGABLE WATERS—*G.R. ROBERTSON*
4. INSTALLATION PROBLEMS AND SPECIAL TECHNIQUES OF LARGE STEEL MAINS—*S.T. FLETCHER*
5. INNOVATIVE DESIGN TO OVERCOME REGULATORY CONSTRAINTS ON A WATER STORAGE FACILITY—*R.C. HAVEN*

3 • MANAGEMENT CHALLENGES OF THE '80S: PEOPLE AND THE MANAGEMENT PROCESS

Management Division

Cochairmen: C.A. Froman Jr., K.W. Peltz

1. EVOLUTION OF MANAGEMENT AND ORGANIZATIONS—*H.J. GRAESER*
2. CHANGING ATTITUDES AND MANAGEMENT STYLES—*R. BAREFIELD*
3. COMMUNICATION AND RELATONSHIPS WITH CUSTOMERS—*KAY KUTCHINS*
4. THE REGIONALIZATION PROCESS—*C.R. MORRIS*

4 • INTERACTIVE DEVELOPMENT OF SURFACE AND GROUNDWATER SUPPLIES (Panel Discussion)

Resources Division

Cochairmen: F.M. McGowan, W.R. Inhoffer

1. NEED FOR CONJUNCTIVE WATER SUPLIES IN THE DELAWATER RIVER BASIN—*G.M. HANSLER*
2. *D.W. MILLER*

5 • WATER QUALITY: PAST, PRESENT AND FUTURE (Roundtable)

Water Quality Division

Chairman: J.M. Symons

Vice Chairman: J.E. Singley

1. *ABEL WOLMAN*
2. *G.E. SYMONS*
3. *H.E. HUDSON JR.*
4. *C.H. TATE*
5. *V.J. KIMM*

6 • RESEARCH 1

Research T&P Committee

Chairman: P.L. McCarty

Cochairman: P.R. Cairo

(Continued on page 30)

CAPCO JEN 0020648

(Continued from page 29)

1. APPLICATION OF POLYMERS FOR WATER PLANT SLUDGE CONDITIONING—*J.T. NOVAK, MOHAMMAD PIROOZFARD*
2. INTERACTION OF HYDROLYZABLE METAL AND CATIONIC POLYELECTOLYTE COAGULANTS—*R.D. LETTERMAN, P. SRICHAROENCHAIKIT*
3. SOFTENING SLUDGE TREATMENT: STATE-OF-THE-ART—*D.A. CORNWELL; G.P. WESTERHOFF*
4. WATER CLARIFICATION AND DECOLORIZATION WITH THE USE OF REGENERABLE MAGNETIC PARTICLES—*W.G.C. RAPER, N.J. ANDERSON, B.A. BOLTO, D.R. DIXON, L.O. KOLARIK, A.J. PRIESTLEY, D.E. WEISS, N.V. BLESING, P.R. NADEBAUM*
5. THE MECHANICS OF AIR SCOUR DURING FILTER BACKWASH—*A. AMIRTHARAJAH, R.J. MORRISON, S.R. HOLNBECK*
6. HEURISTIC MODEL FOR WATER NETWORK DESIGN—*T.A. RIDGIK; D.T. LAURIA*

Tuesday, June 9—Morning

7 • BUILDING FOR THE FUTURE

Distribution Division

Chairman: K.D. Duke

Vice Chairman: J.H. Wilson

1. SPECIAL DESIGN CONSIDERATIONS ON THE DIEMER PIPELINE PROJECT—*J.J. KINCAID, D.C SCHROEDER*
2. ORGANIZATION AND ANALYSIS OF LEAK AND BREAK DATA FOR MAIN REPLACEMENT DECISIONS —*D.K. O'DAY*
3. STATISTICAL SAMPLING TECHNIQUES FOR CONTROLLING ACCURACY OF SMALL WATER METERS—*PENCHIH TAO*
4. CASE HISTORY OF ASBESTOS-CEMENT PIPE VINYL LINING—*R.S. WOODHULL*
5. AGING WATER SYSTEMS: BOSTON'S APPROACH TO THE PROBLEM—*J.P. SULLIVAN*

8 • MANAGEMENT CHALLENGES OF THE '80S: MANAGING PERFORMANCE

Management Division

Cochairmen, C.E. Woods, W.H. Abbott Jr.

1. IMPROVED PRODUCTIVITY THROUGH WORK MEASUREMENT—*R.C. PARSONS*
2. MANAGEMENT, INFORMATION, AND COMPUTERS—*R.B. CARSON*
3. OPERATING AND FINANCIAL REPORTING SYSTEMS—*W.J. HUELSMAN*
4. PLANNED MAINTENANCE MANAGEMENT—*C.M. BURNEY*

9 • WATER RIGHTS CONTROVERSIES

Resources Division

Chairman: F.G. Honeycutt

1. HIGH PLAINS-OGALLALA AQUIFER SERVES MANY MASTERS—*JOE MOORE*
2. EASTERN STATES TRY TO SHARE WATER—*W.C. WRIGHT, RONNA COHEN*
3. COLORADO WATER RIGHTS ENGINEERING —*G.W. FASSETT*
4. EAST (RIPARIAN) VERSUS WEST (APPROPRIATIVE): HAS THE TWAIN MET?—*T.A. CAHILL*

10 • CURRENT CONCERNS IN WATER QUALITY

Water Quality Division

Chairman: A.F. Hess

Vice Chairman: N.J. Davoust

1. ALTERNATIVES FOR CONTROLLING ORGANICS IN GROUNDWATER SUPPLIES—*J.E. DYKSEN, A.F. HESS*
2. COMMUNITY WATER SUPPLY SURVEY: SAMPLING AND ANALYSIS FOR PURGEABLE ORGANICS AND TOTAL ORGANIC CARBON—*H.J. BRASS; M.J. WEISNER, B.A. KINGSLEY*
3. PROCESS DESIGN CONSIDERATIONS IN RECYCLING PREFORMED FLOCS TO THE COAGULATION- FLOCCULATION PROCESS—*K.B. GUPTA, R.K. HAM*
4. COSTS AND BENEFITS OF DRINKING WATER TREATMENT—*R.M. CLARK, R.A. DEININGER*
5. MEETING THE OBSCURE STANDARDS THAT WERE—*R.E. ZEGERS, MELFORD DAHL*
6. TRANSFORMING CONCEPTS INTO DESIGNS: THE DENVER REUSE PROJECT—*S.W. WORK*

11 • UNIVERSITY FORUM 1

Chairman: J.T. Novak

Vice Chairman: J.F. Ferguson

1. CHEMICAL MODELING OF COPPER CORROSION USING ELECTROCHEMICAL TECHNIQUES—*R.D. HILBURN*
2. A WATER CONSERVATION STUDY IN A WATER-RICH STATE—*JEFFREY LUTZ, ERIC THARP, J.T. NOVAK, J.T. O'CONNOR*
3. FERRIC CHLORIDE AND ALUM AS SINGLE AND DUAL COAGULANTS—*P.N. JOHNSON, A. AMIRTHARAJAH*
4. EFFECT OF SOLUTION CHEMISTRY ON COAGULATION WITH HYDROLYZED Al (III)—*S.G. VANDERBROOK*
5. PILOT DIRECT FILTRATION AND CARBON ADSORPTION TREATMENT OF HIGH-SOLIDS RIVER WATER—*THOMAS GAVIN*
6. RELATIONSHIPS BETWEEN STANDARD PLATE COUNTS AND OTHER PARAMETERS IN WATER DISTRIBUTION SYSTEMS—*M.A. GOSHKO, H.A. MINNIGH, W.O. PIPES, R.R. CHRISTIAN*

Tuesday, June 9—Afternoon

12 • SMALL WATER UTILITY OPERATIONS AND DESIGN (Panel Discussion)

Engineering & Construction T&P Committee

Chairman: G.H. Abplanalp

Vice Chairman: J.L. Cobb

1. VIEWED BY OWNER—*J.A. WADE JR.*
2. VIEWED BY DESIGN ENGINEER—*L.S. WOLFE*
3. VIEWED BY STATE REGULATORY AGENCY—*W.A. KELLEY*
4. VIEWED BY USEPA—*J.W. HOFFBUHR*

(Continued on page 32)

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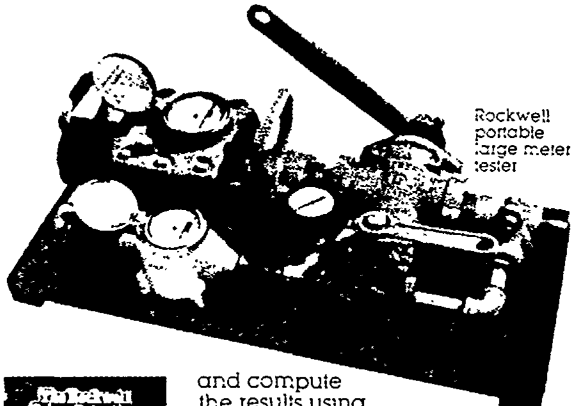

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(Continued from page 30)

13 • **BETTER WATER QUALITY AND SERVICE THROUGH TRAINING (Panel Discussion)**
Education T&P Committee
Cochairmen: J.W. Hoffbuhr, M.J. McGuire
1. TEXAS SECTION—*KAY KUTCHINS*
2. ROCKY MOUNTAIN SECTION—*C.A. LANCASTER*
3. MICHIGAN SECTION—*J.R. VAN DEWEGE*
4. CALIFORNIA-NEVADA SECTION—*M.J. MCGUIRE*
5. ILLINOIS SECTION—*D.C. RENNER*
6. AWWA—*R.W. LEIDHOLDT*

14 • **STANDARDS COUNCIL**
Chairman: J.H. Robinson
Vice Chairman: G.L. Laverty

15 • **INTERNATIONAL AFFAIRS 1**
Chairman: F.W. Montanarí
Vice Chairman: E.A. Merryfield
1. RURAL WATER SUPPLY IN PUERTO RICO—*J.J. MAYOL*
2. REDUCING THE COST AND TIME OF FEASIBILITY AND MASTER PLAN STUDIES IN DEVELOPING COUNTRIES—*H.R. SHIPMAN*
3. ESTABLISHMENT OF WATER UTILITY INSTITUTIONS IN DEVELOPING COUNTRIES—*L.A. FRANCIS*
4. WOMEN, WATER, AND THE DECADE—*MARY ELMENDORF*

16 • **UNIVERSITY FORUM 2**
Chairman: J.K. Edzwald
Vice Chairman: W.R. Knocke
1. SEASONAL EVALUATION OF ORGANICS REMOVAL AT A CONVENTIONAL WATER TREATMENT PLANT—*BENJAMIN GONG, J.K. EDZWALD*
2. DIRECT FILTRATION OF STREAMBORNE GLACIAL SILT—*M.D. ROSS*
3. APPLICATION OF ION EXCHANGE AND ULTRAFILTRATION FOR COLOR REMOVAL FROM GROUNDWATER—*KEITH LOWERY, G.F. MITCHELL, D.O. HILL*
4. AN EVALUATION OF AERATION METHODS FOR THE REMOVAL OF VOLATILE ORGANIC CONTAMINANTS—*M.A. GOERS, S.A. HUBBS*
5. FORMATION AND REMOVAL OF BROMOFORM DURING DESALINATION—*NING-WU CHANG, P.C. SINGER*
6. GRANULAR ACTIVATED CARBON PRETREATMENT FOR THE REMOVAL OF TRIHALOMETHANE PRECURSORS—*K.B.B. CARTER, R.C. HOEHN*
7. OZONATION OF A MUNICIPAL GROUNDWATER SUPPLY TO REDUCE IRON, MANGANESE, AND TRIHALOMETHANE FORMATION—*R.A. STOEBNER, D.A. ROLLAG*

Wednesday, June 10—Morning

17 • **EARLY BIRD**
Management Division
Chairman: H.W. Becker
1. HIDDEN COSTS OF ACCIDENTS—*R.P. VAN DYKE*

18 • **ANOTHER CENTURY OF IMPROVED OPERATION (Operator's Forum)**
Education T&P Committee
Chairman: R.F. Layton
1. *OPFLOW* AND THE OPERATOR
2. WATER METER BASICS—*M.B. YOUNG*
3. TIPS ON PUMP MAINTENANCE—*E.E. ARASMITH*
4. SAFETY AND TRAFFIC ROUTING—*R.L. BEST*
5. CROSS CONNECTIONS: THEIR IMPORTANCE AND CONTROL—*D.C. ANDERSON*

19 • **SECTION OFFICERS' FORUM**
Moderator: A.W. Jorgenson
1. POST EMGM AND WHERE WE GO FROM HERE—*R.S. LANE*
2. DEVELOPING A PROCEDURE MANUAL FOR INCOMING OFFICERS AND COMMITTEE CHAIRMEN—*J.E. KEMPER*
3. OPERATOR TRAINING: PROGRAMS AND MATERIALS —*B.D. HASKINS*
4. TIPS ON CONFERENCE REGISTRATION—*R.E. UHLENBURG*
5. PLANNING A JOINT SECTION CONFERENCE—*R.L. WUBBENA, G. MILLS*
6. DISCUSSION

20 • **INTERNATIONAL AFFAIRS 2**
Chairman: W.W. Aultman
Vice Chairman: W.E. McQueeney
1. AN INTERNATIONAL TRAINING CONSULTANT'S CHARACTERISTICS, A VIEW POINT—*R.F. LAYTON*
2. WATER IN A HURRY FOR THE OIL-FROM-COAL SASOL 2 PROJECT, SOUTH AFRICA—*W.S. LEGGE*
3. NEW EXPERIENCES OF A EUROPEAN SURFACE WATER TREATMENT SYSTEM, ESPECIALLY IN REMOVAL OF ORGANICS—*MAARTEN SCHALEKAMP*
4. NEW DESIGN CONCEPTS IN WATER TREATMENT IN FRANCE—*M.R. RAPINAT*

21 • **WATER UTILITY COUNCIL**
Chairman: W.H. Miller
1. INTRODUCTION—*J.B. GILBERT*
2. OVERVIEW OF THE WATER UTILITY COUNCIL—*W.H. MILLER*
3. WASHINGTON ACTIVITY—*CLIFF ATKINSON JR.*
4. USEPA'S DRINKING WATER PROGRAM
5. SOLVING WATER UTILITY PROBLEMS TODAY (Panel Discussion)

22 • **RESEARCH 2**
Research T&P Committee
Chairman: V.L. Snoeyink
Cochairman: P.D. Foley
1. REMOVAL OF ORGANICS FROM WATER BY AERATION—*P.R. WOOD, JACK DeMARCO, F.W. CURTIS JR., H.J. HARWEEN, R.F. LANG*

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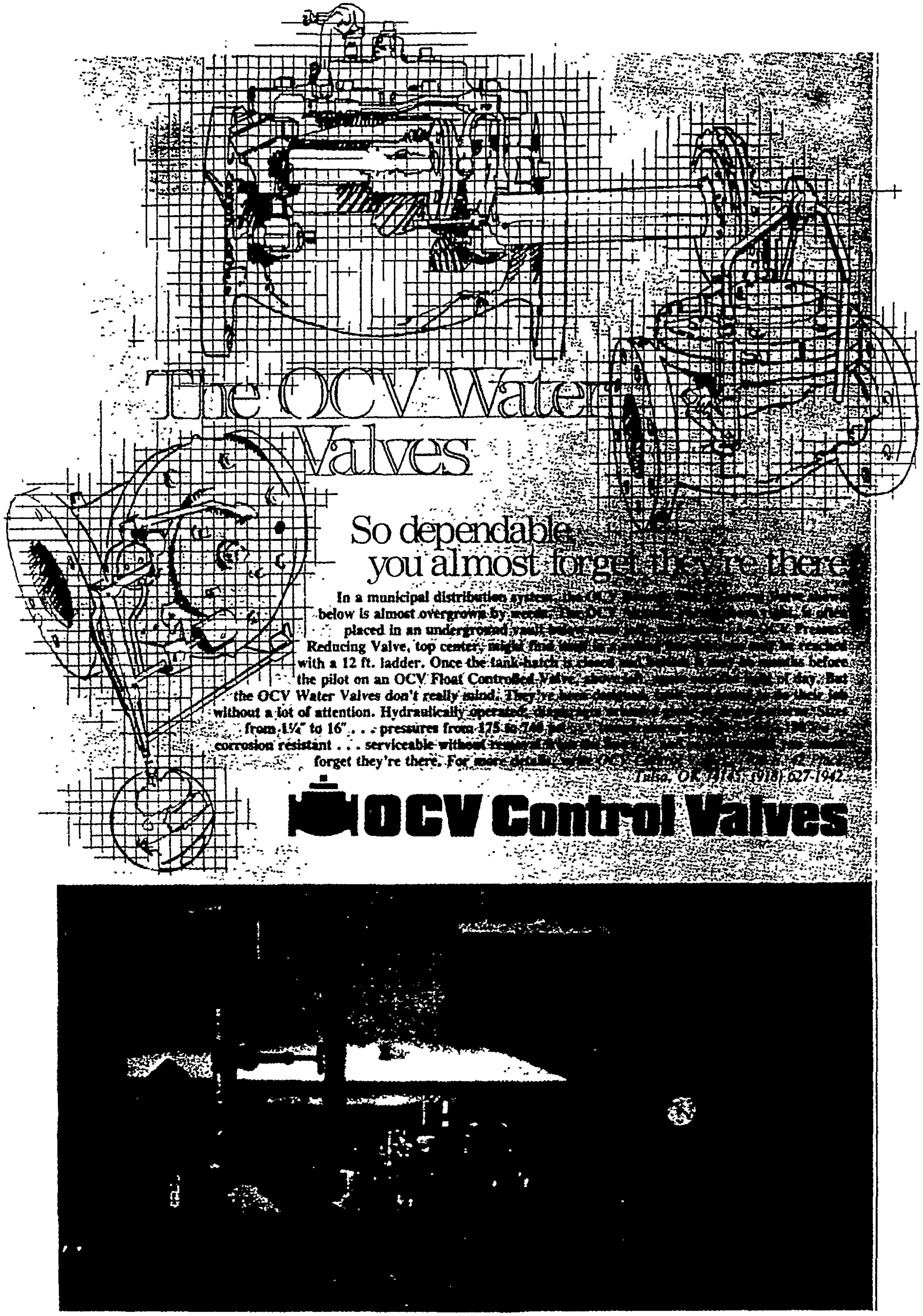

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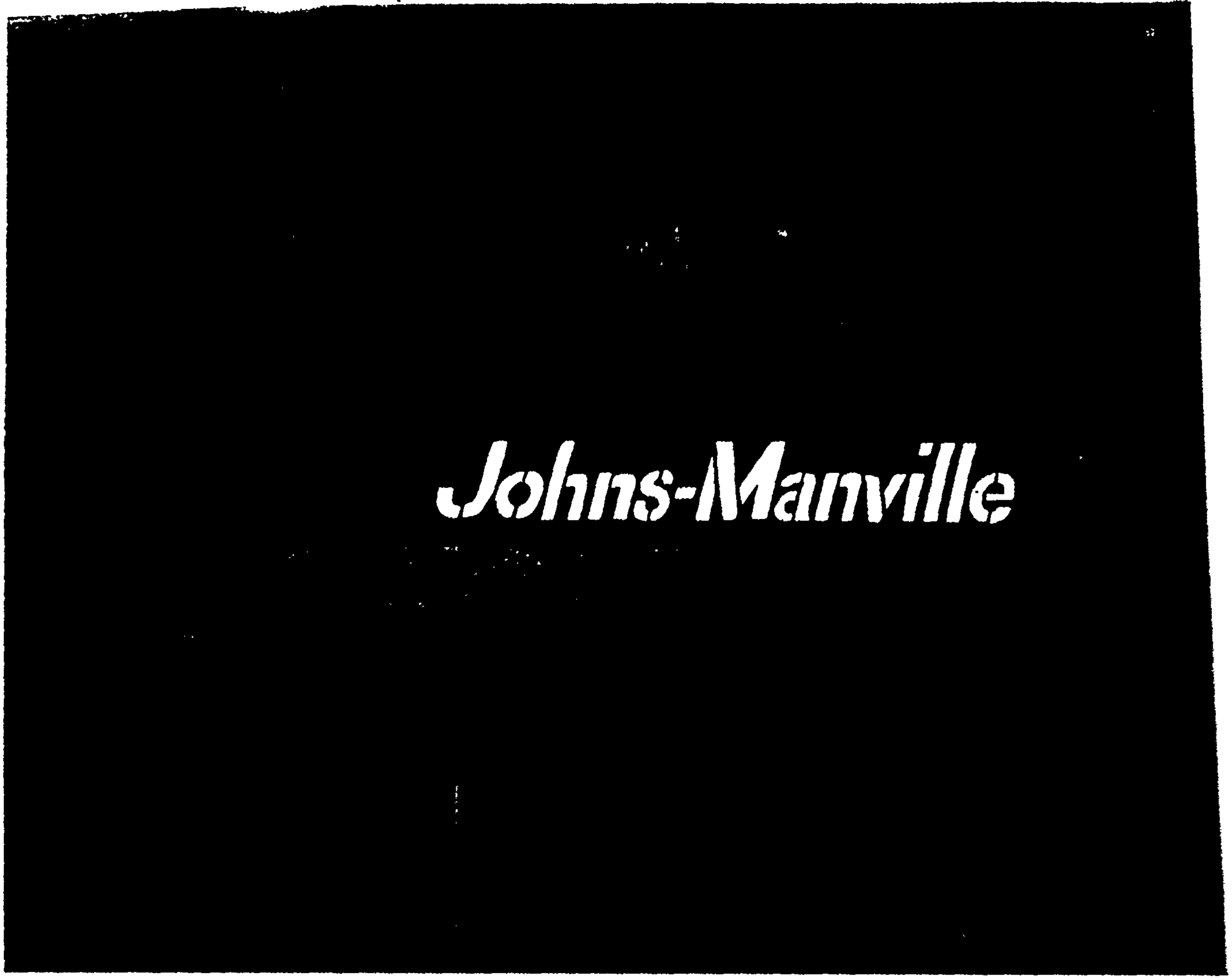

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Continued from page 32

2. INTRODUCTORY STUDY OF THE BIODEGRADATION OF THE CHLORINATED METHANE, ETHANE, AND ETHENE COMPOUNDS—*R.F. LANG, P.R. WOOD, F.A. PARSONS, JACK DEMARCO, H.J. HARWEEN, I.L. PAYAN, L.M. MEYER, M.C. RUIZ, E.D. RAVELO*
3. BIODEGRADATION OF TRACE ORGANICS BY BIOFILMS ON POROUS MEDIA—*RICHARD STRATTON, EUN NAMKUNG, B.E. RITTMANN*
4. REMOVAL OF SOLUBLE ORGANIC CONTAMINANTS BY LIMESODA SOFTENING—*S.J. RANDTKE, C.E. THIEL, M.Y. LIAO, C.N. YAMAYA, D.E. JOHNSON*
5. EFFECTS OF CALCIUM ON THE SPECIATION, ADSORPTION, AND REMOVAL OF FULVIC ACIDS—*B.A. DEMPSEY, C.R. O'MELIA*

Wednesday, June 10—Afternoon

23 • POTPOURRI

Distribution Division

Chairman. J.M Rasberry

Vice Chairman. G.O Muller

1a. AUTOMATION AND INSTRUMENTATION: M2 MANUAL—*J.R. DANEKER*
1b. AUTOMATION AND INSTRUMENTATION: INTERFACE OF INSTRUMENTATION WITH SWITCH GEAR—*O.A. BYRNIE*
1c. AUTOMATION AND INSTRUMENTATION: MASTER METERING—*H.D. GILMAN*
2. TANK INSPECTION, CLEANING, AND MAINTENANCE
3. WORK MANAGEMENT STANDARDS—*D.L. TIPPIN, G.M. BARRON*
4. A PRACTICAL CORROSION CONTROL PROGRAM FOR WATER DISTRICTS—*D.M WATERS*
5. MAINTENANCE OF VALVES AND HYDRANTS—*B.W FRANKLIN*

24 • MANAGEMENT CHALLENGES OF THE '80s: MANAGING IN A CHANGING ECONOMY

Management Division

Cochairmen L.J Hash, R.L Lee

1. ENERGY MANAGEMENT: THREE WAYS TO WIN—*E.A PERSSON*
2. WATER USE MANAGEMENT—*F.P GRIFFITH JR*
3. MANAGEMENT'S OBLIGATIONS IN THE REGULATORY PROCESS—*C.A. BUESCHER*
4. FINANCIAL MANAGEMENT—*G.S. SALEBA*

25 • MATERIAL SPILLS HAZARDOUS TO WATER SUPPLY

Resources Division

Chairman. C H Thompson

Vice Chairman R P McHugh

1. SUPERFUND: WHAT?—*M B. COOK*
2. SYSTEMATIC APPROACH TO CLEANING UP—*J A HARRIS*
3. EAST BAY MUD HAS THE PLAN—*K.B. STINSON*
4. SOME HAZARDOUS TIMES—*C H. THOMPSON, W.C. WESTGARTH*

26 • POTPOURRI

Water Quality Division

Chairman: E.W. Bailey

Vice Chairman: H.E. Pearson

1. INTERRELATIONSHIP OF BACTERIAL COUNTS WITH OTHER FINISHED WATER QUALITY PARAMETERS WITHIN DISTRIBUTION SYSTEMS—*J.K. REILLY, J.F. KIPPIN*
2. BACTERIAL COLONIZATION OF WATER DISTRIBUTION SYSTEMS—*B.H. OLSON*
3. CORROSION CONTROL WITHIN WATER DISTRIBUTION SYSTEMS—*J.J. COSTELLO*
4. ORGANICS REDUCTION BY RIVERBANK INFILTRATION AT LOUISVILLE—*S.A. HUBBS*
5. EFFECTIVENESS OF POWDERED AND GRANULAR ACTIVATED CARBON FOR REMOVAL OF ORGANIC CONTAMINANTS AT NIAGARA FALLS, N.Y.—*J.R WESTENDORF, D.R. WEISS, D.L. BADOREK, L B. SKLARSKI*
6. RESPONSE OF A LOCAL HEALTH DEPARTMENT TO THE PRESENCE OF ORGANICS IN THE DRINKING WATER SUPPLY, NASSAU COUNTY, LONG ISLAND, N.Y.—*G.E. DONOHUE*

27 • RESEARCH 3

Research T&P Committee

Chairman: C.R. O'Melia

Cochairman: P.L. McCarty

1. DESORPTION OF COMPOUNDS DURING OPERATION OF GAC ADSORPTION SYSTEMS—*W.E. THACKER, V L. SNOEYINK, J.C. CRITTENDEN*
2. MICROBIAL ACTIVITY ON GRANULAR ACTIVATED CARBON: AN ASSESSMENT—*F.A. DIGIANO*
3. GAC PERFORMANCE CRITERIA FOR ORGANIC CARBON REMOVAL—*P.V. ROBERTS, R.S. SUMMERS*
4. PRELIMINARY DESIGN OF LEAST-COST FIXED-BED ADSORPTION SYSTEMS USING THE HOMOGENOUS SURFACE DIFFUSION MODEL—*J.C. CRITTENDEN, METIN ARI, M.C. LEE*
5. ADSORPTION OF CARBON TETRACHLORIDE FROM WATER BY ACTIVATED CARBON—*W.J. WEBER JR., MASSOUD PIRBAZARI*

Thursday, June 11—Morning

28 • HELEN WEREN'T NO SAINT

Distribution and Resources Divisions

Chairman J A. Roller

Vice Chairman: R.C. McWhinnie

1. REPORT ON AN EARLY WARNING SYSTEM—*PALMER NORSETH*
2. MUD FLOW PROBLEMS—*L.V. INMAN*
3. MT. ST. HELENS' FALLOUT PROBLEMS—*ROGER JAMES*
4. PUBLIC HEALTH CONSIDERATIONS OF MT. ST. HELENS' ERUPTION—*D.K. SANDER, K.J. MERRY*
5. H-DAY PLUS ONE YEAR—*D.M. THOMAS*

(Continued on page 40)

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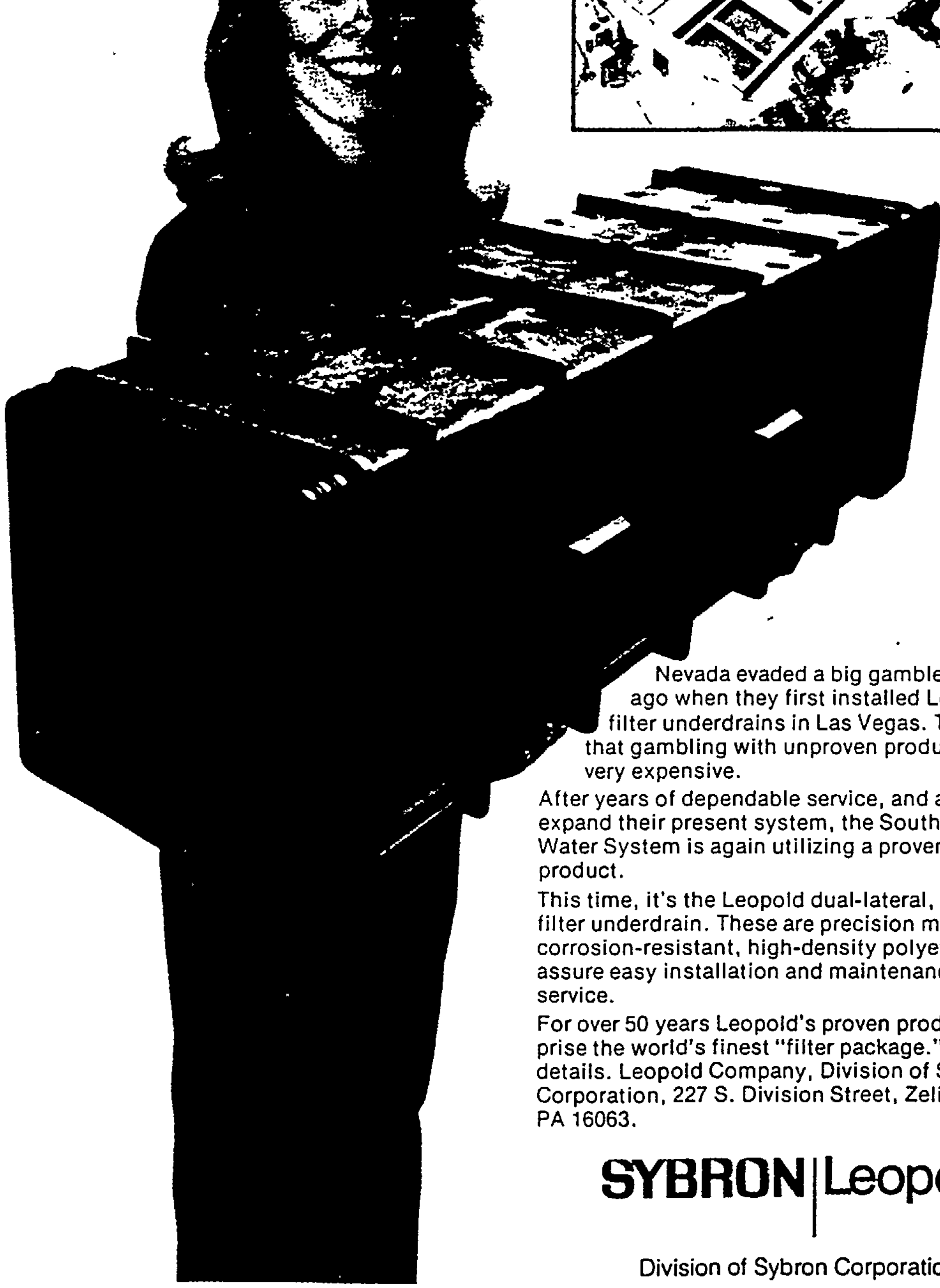
No gambling in Las Vegas



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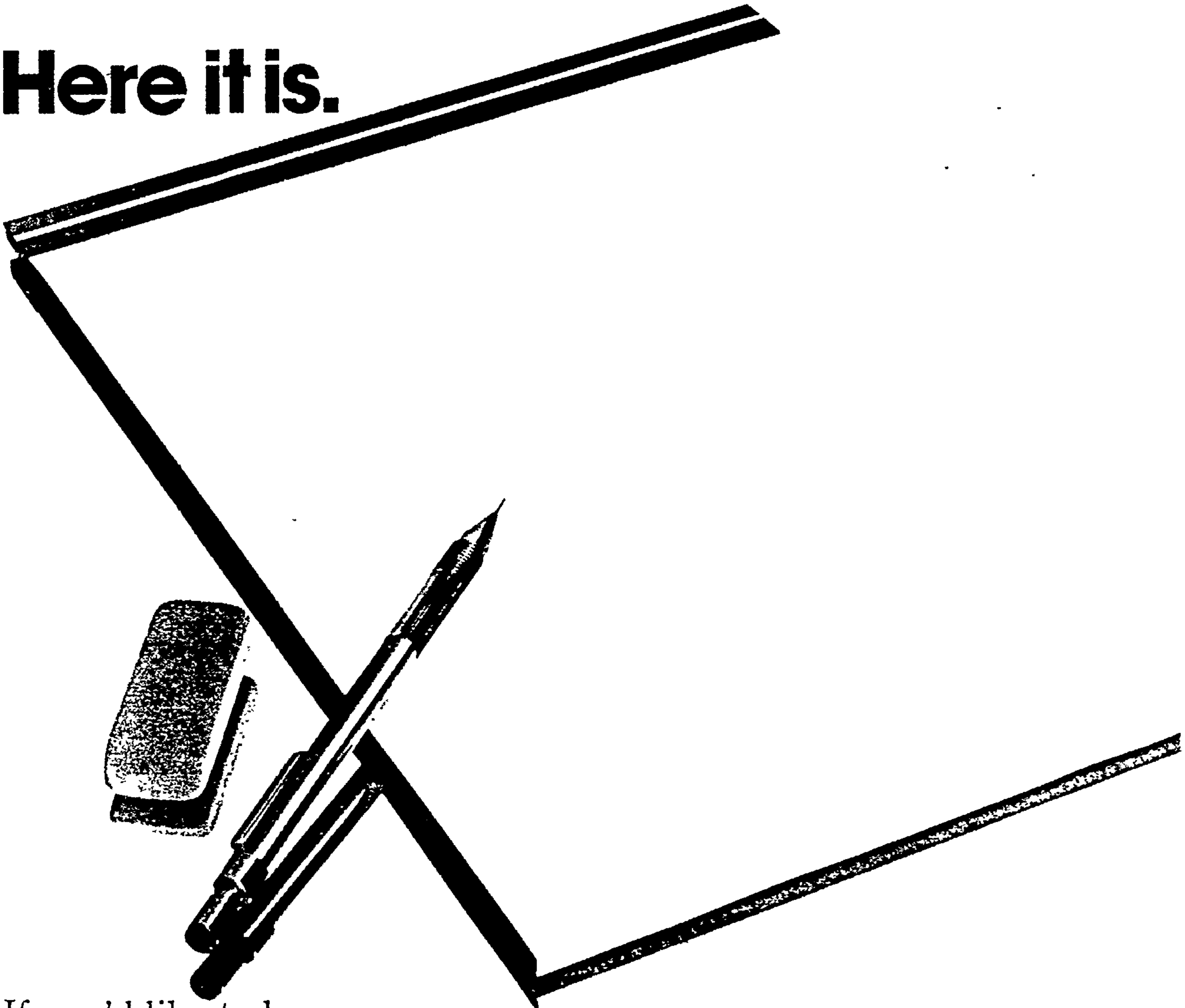

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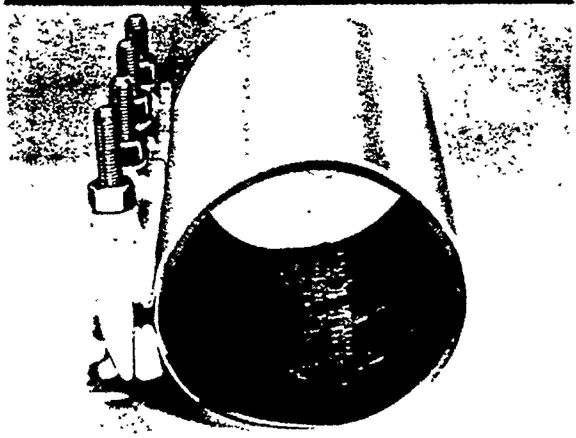

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(Continued from page 36)

29 • **HEALTH EFFECTS OF DRINKING WATER (Miniseminar)**

Water Quality Division

Chairman, J.E Courchene
Vice Chairman, R.G. McCall

1. INTRODUCTION TO EPIDEMIOLOGY—*G.F. CRAUN*
2. INTRODUCTION TO TOXICOLOGY—*R.A. NEAL*
3. ETIOLOGY OF CARCINOGENESIS—*R.A. NEAL*
4. WATER QUALITY AND CARDIOVASCULAR DISEASE—*NATHANIEL REVIS*
5. WATERBORNE INTESTINAL DISEASE—*G.F. CRAUN*
6. TOXICOLOGICAL PROBLEMS ASSOCIATED WITH ALTERNATIVE METHODS OF DISINFECTION—*R.J. BULL*

30 • **WATER TREATMENT DESIGN: PAST, PRESENT, AND FUTURE**

Engineering & Construction T&P Committee

Cochairmen, R Goulding, J.V. Miner

1. EFFECTS OF GOVERNMENT REGULATION—*A.R. HAMMER*
2. PRETREATMENT PROCESSES—*J.D GRIFFITH*
3. FILTRATION PROCESSES—*C.B. HAGAR, D.B. ELDER*
4. DISINFECTION PROCESSES—*R.R. TRUSSELL*
5. WATER SYSTEM CONSTRUCTION: PAST, PRESENT, AND FUTURE—*C.N BOHRER*

31 • **RESEARCH 4**

Research T&P Committee

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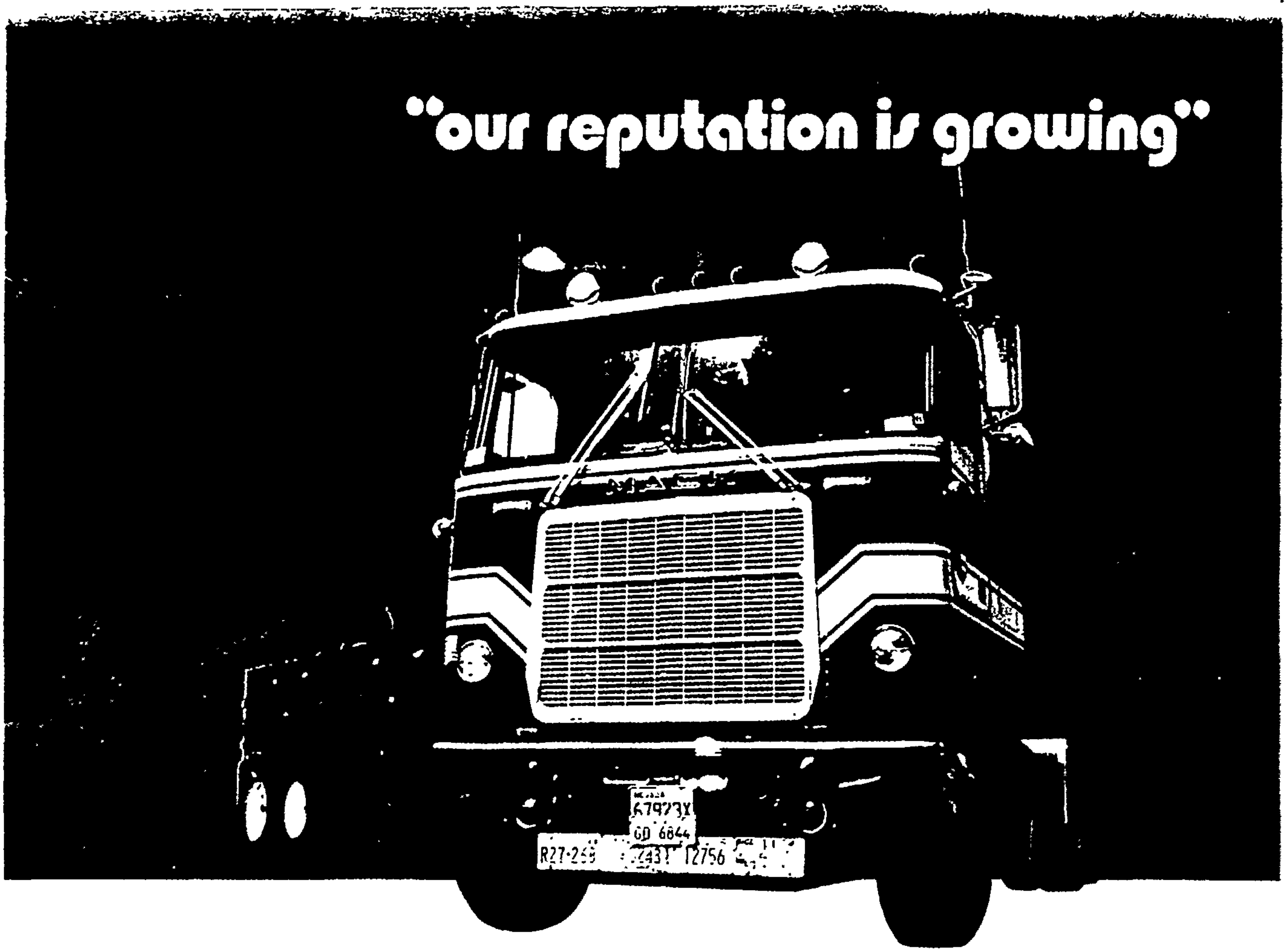
1. COMPARISON OF THE DPD-COLORIMETRIC, DPD-STEADIFAC, AND FACTS TEST PROCEDURES FOR FREE CHLORINE RESIDUAL ANALYSES—*W.J. COOPER, N.M ROSCHER*
2. IMPACT OF WATER TREATMENT ALTERNATIVES ON MICROBIAL BARRIERS—*E E GELDREICH*
3. A PREDICTIVE MODEL FOR CHLOROFORM FORMATION FROM HUMIC ACID—*B A. ENGERHOLM, G.L. AMY*
4. DIFFUSION OF ORGANICS FROM SOLVENT-BONDED PLASTIC PIPES USED FOR POTABLE WATER PLUMBING—*K.D. REICH, A R. TRUSSELL, FONG-YI LIEU, L.Y.C. LEONG, R.R. TRUSSELL*
5. DISCUSSION ON RESEARCH FOUNDATION FUNDING—*J.F. MANWARING*



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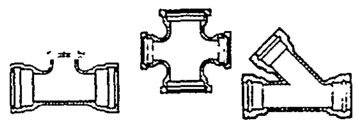

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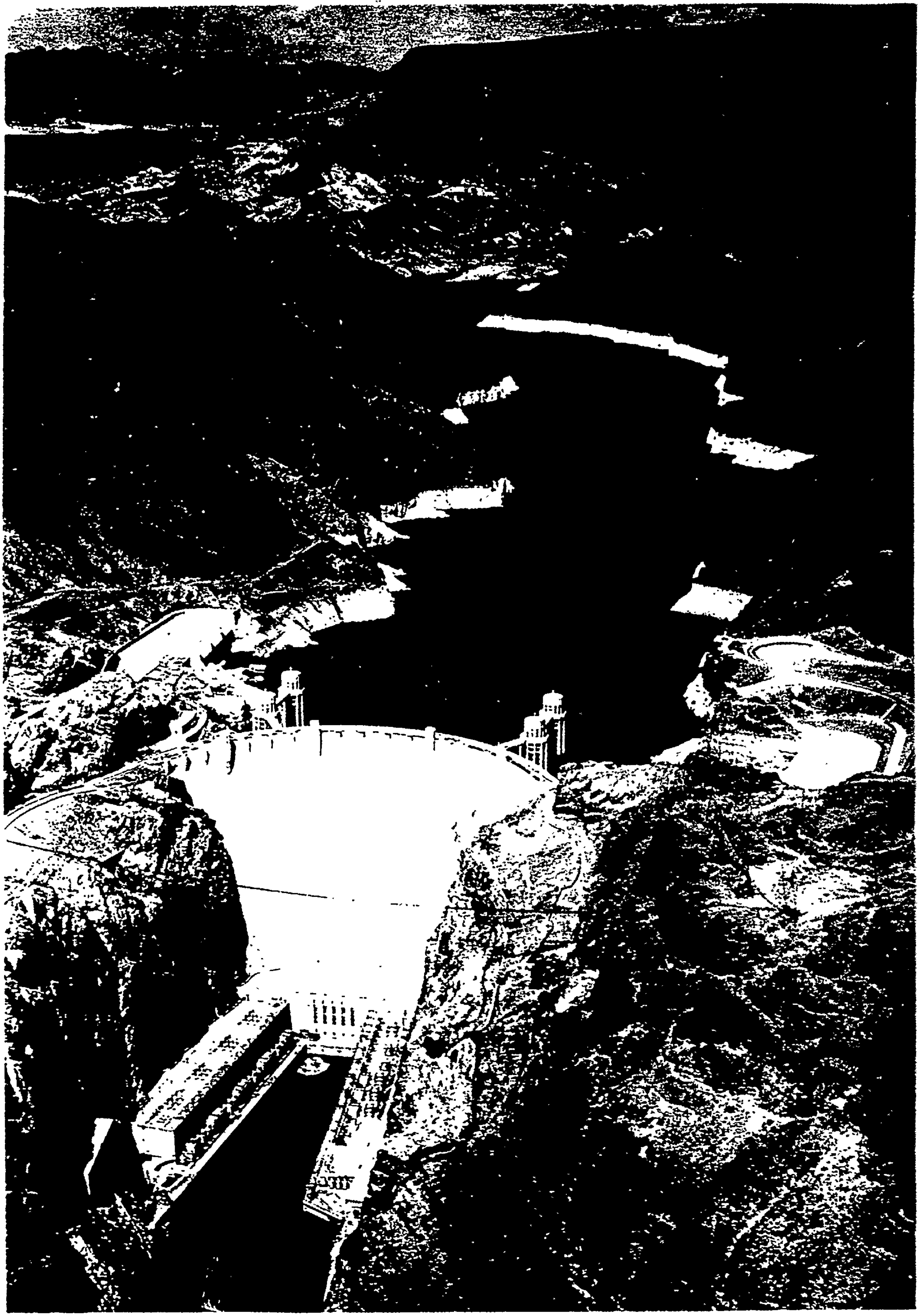

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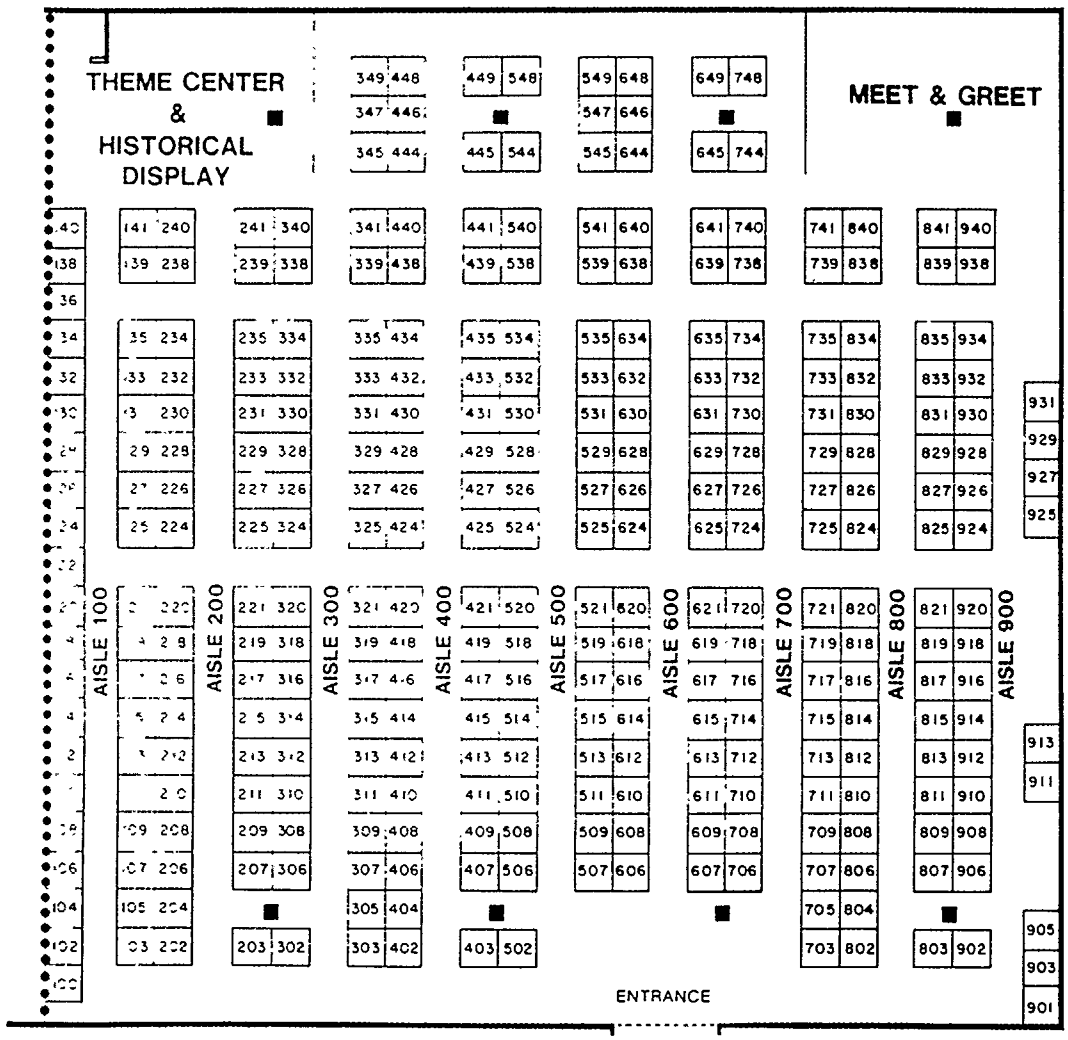

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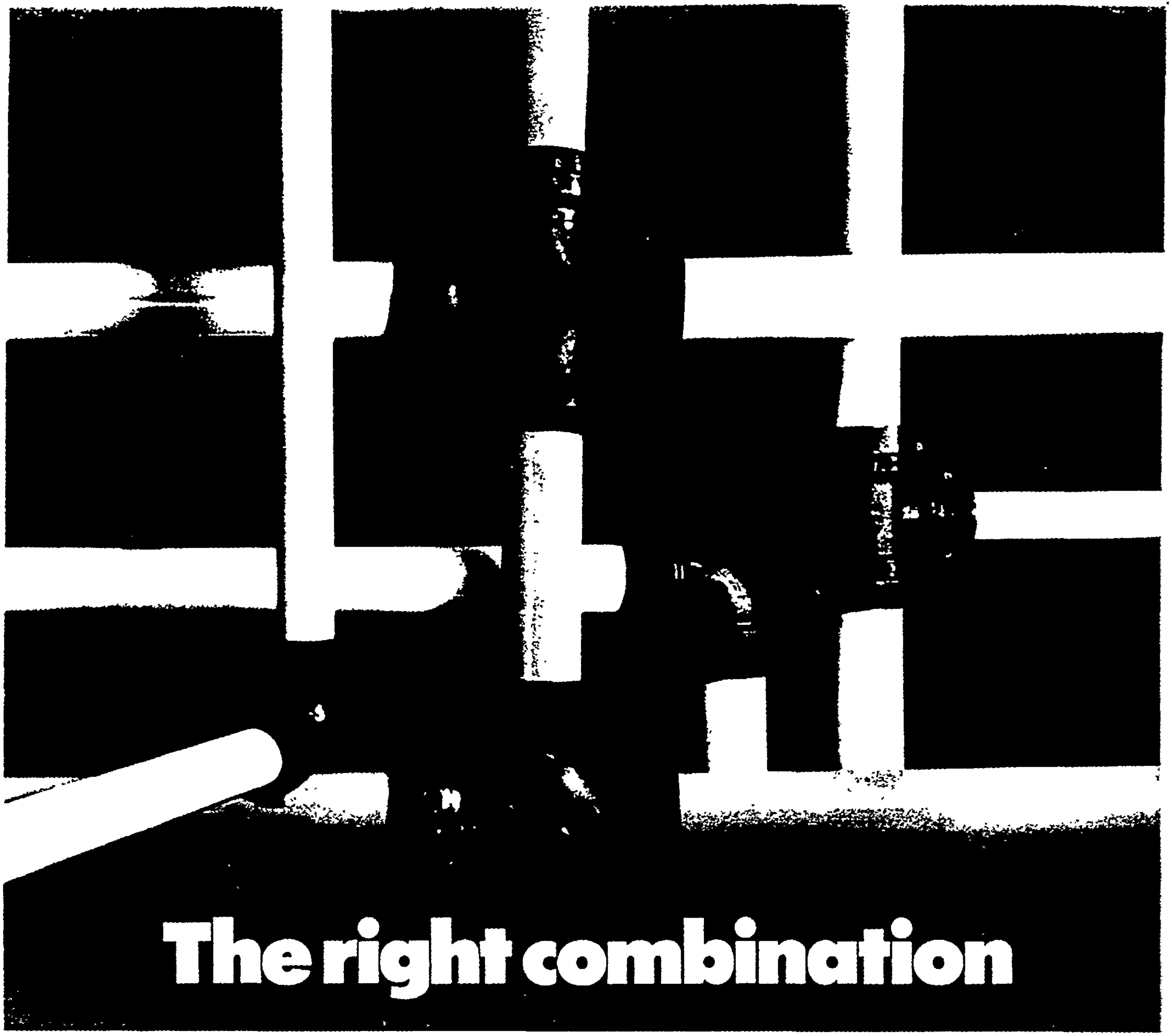

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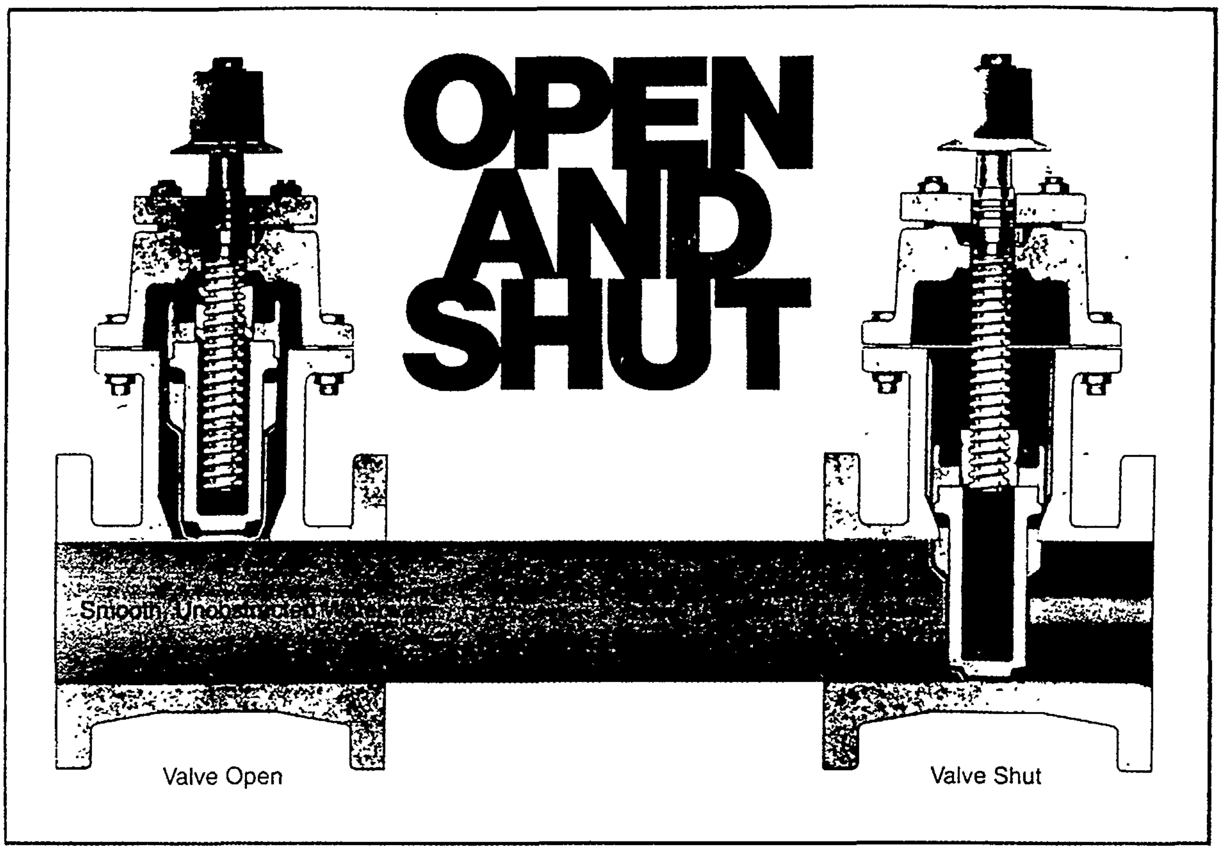

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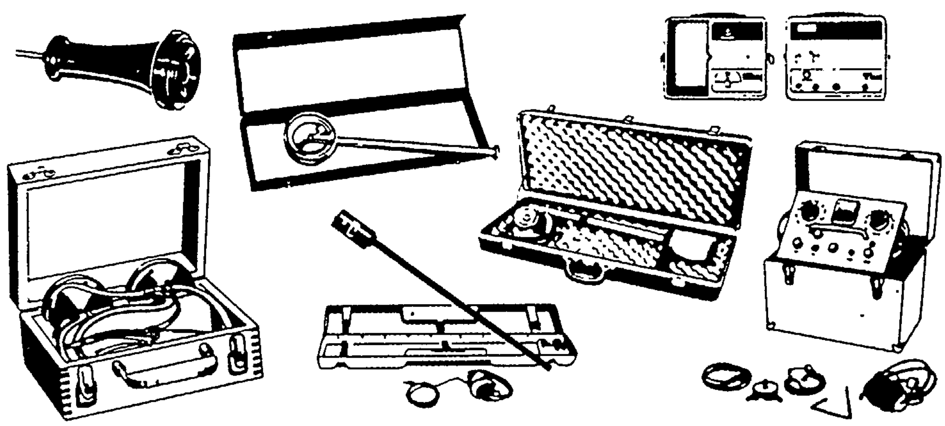

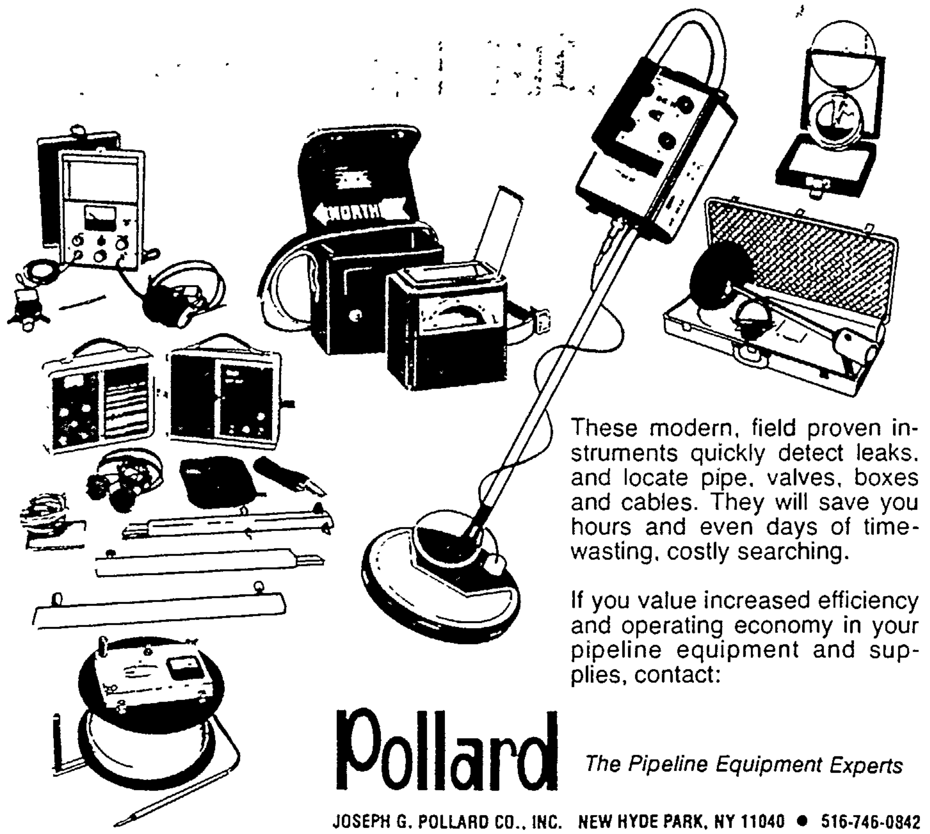

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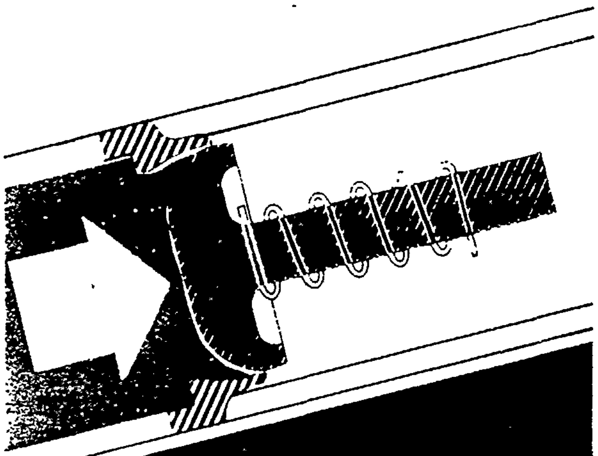

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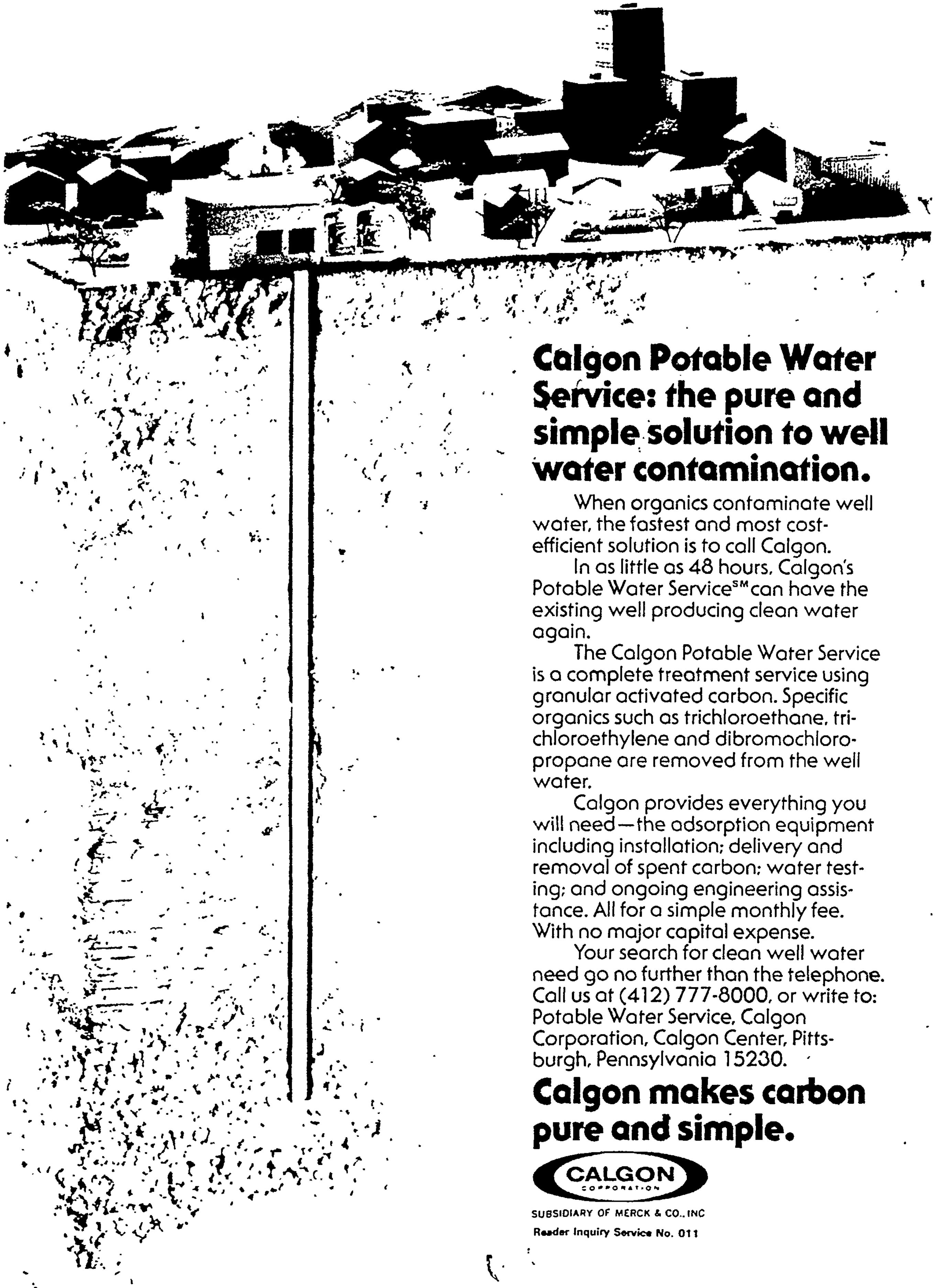

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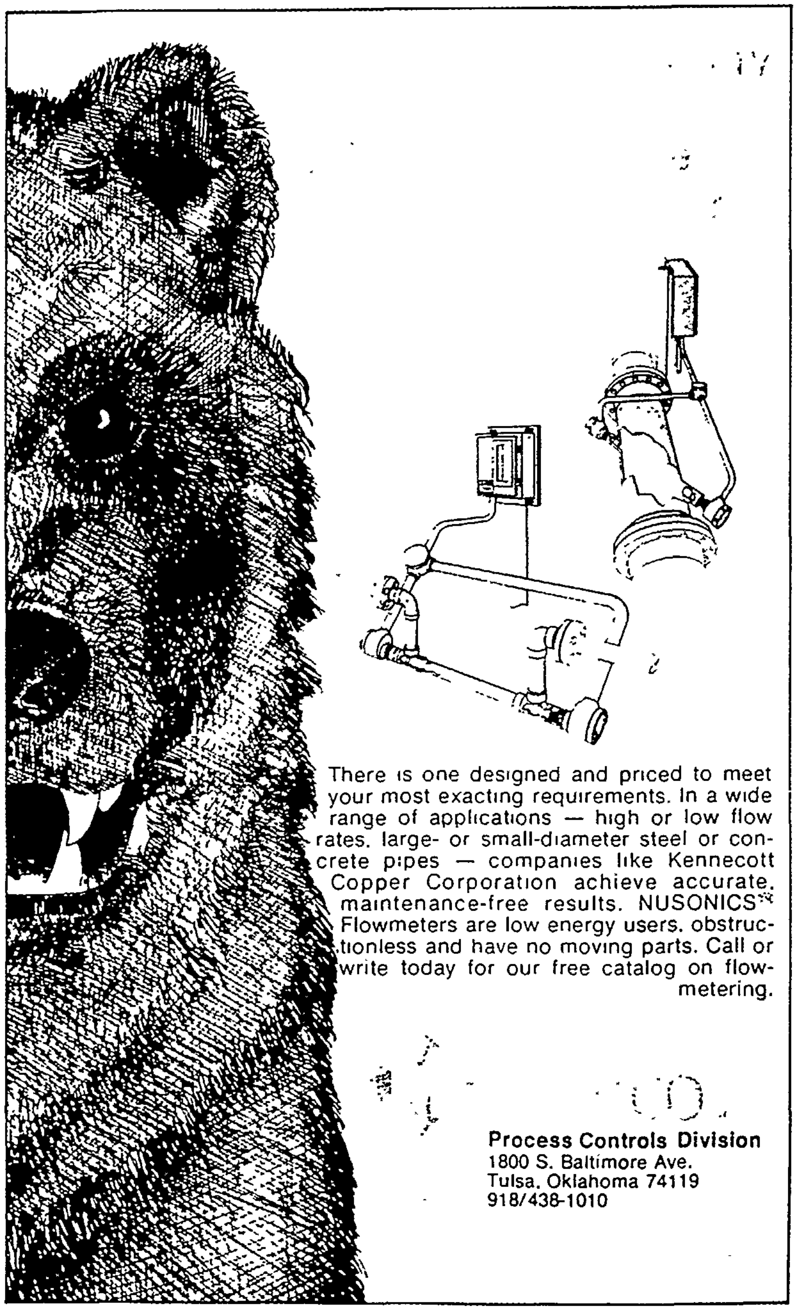
Installation Problems and Special Techniques of Large Steel Mains (2-4)
Maintenance of Valves and Hydrants (23-5)
Mt St Helens Fallout Problems (28-3)
Mud Flow Problems (28-2)



Reader Inquiry Service No 037

Negotiating for Instream Water (2-1)
Organization and Analysis of Leak and Break Data for Main Replacement Decisions (7-2)
Permit Program As It Affects Navigable Waters (2-3)
A Practical Corrosion Control Program for Water Districts (23-4)
Public Health Considerations of Mt St Helens Eruption (28-4)
Report on an Early Warning System (28-1)
Special Design Considerations on the Diemer Pipeline Project (7-1)
Statistical Sampling Techniques for Controlling Accuracy of Small Water Meters (7-3)
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Better Water Quality and Service Through Training: Panel Discussion (13)
Cross Connections: Their Importance and Control (18-5)
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Overview of the Water Utility Council (21-2)
Planned Maintenance Management (8-4)
Reducing the Cost and Time of Feasibility and

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CAPCO JEN 0020677

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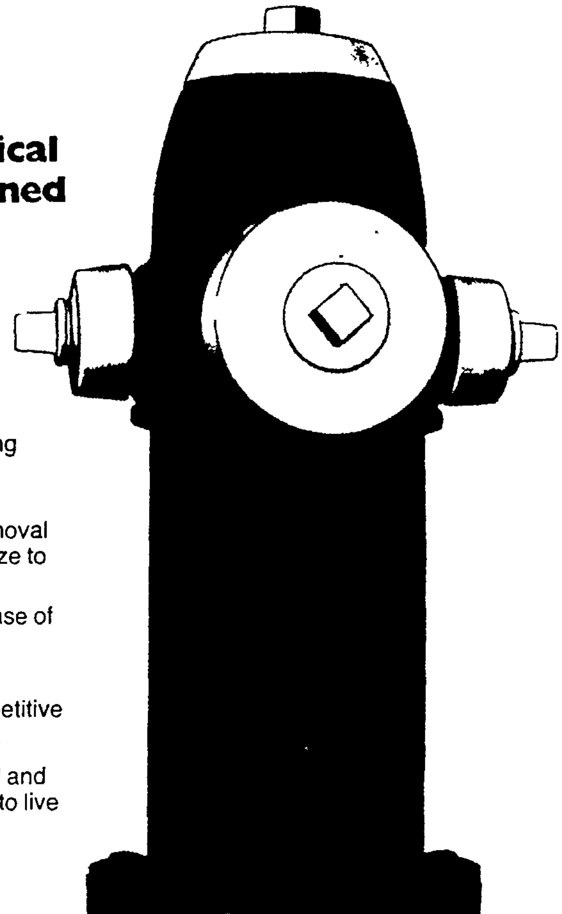

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CAPCO JEN 0020678

(Continued from page 58)

Research

Resources

Water Quality

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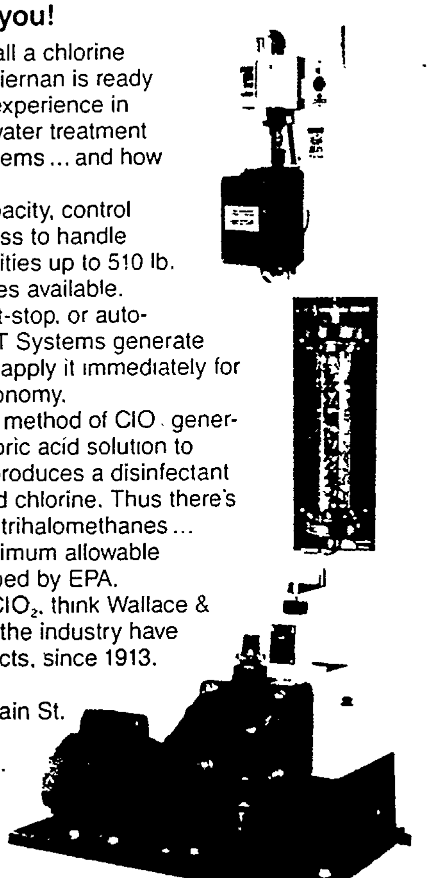

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Reader Inquiry Service No 064

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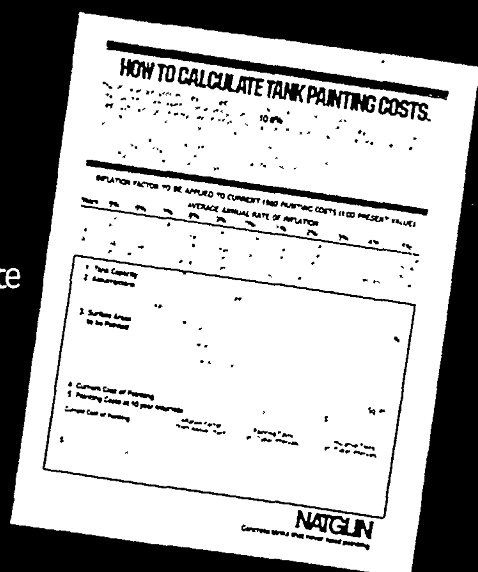

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NATGUN Corporation, Teal Road, Wakefield, MA 01880 Telephone 617-246-1133
Texas: 8111 Preston Road, Suite 820, Dallas, TX 75225 Telephone 214-368-3306
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Reader Inquiry Service No 022

(Continued from page 60)

CAPCO JEN 0020681

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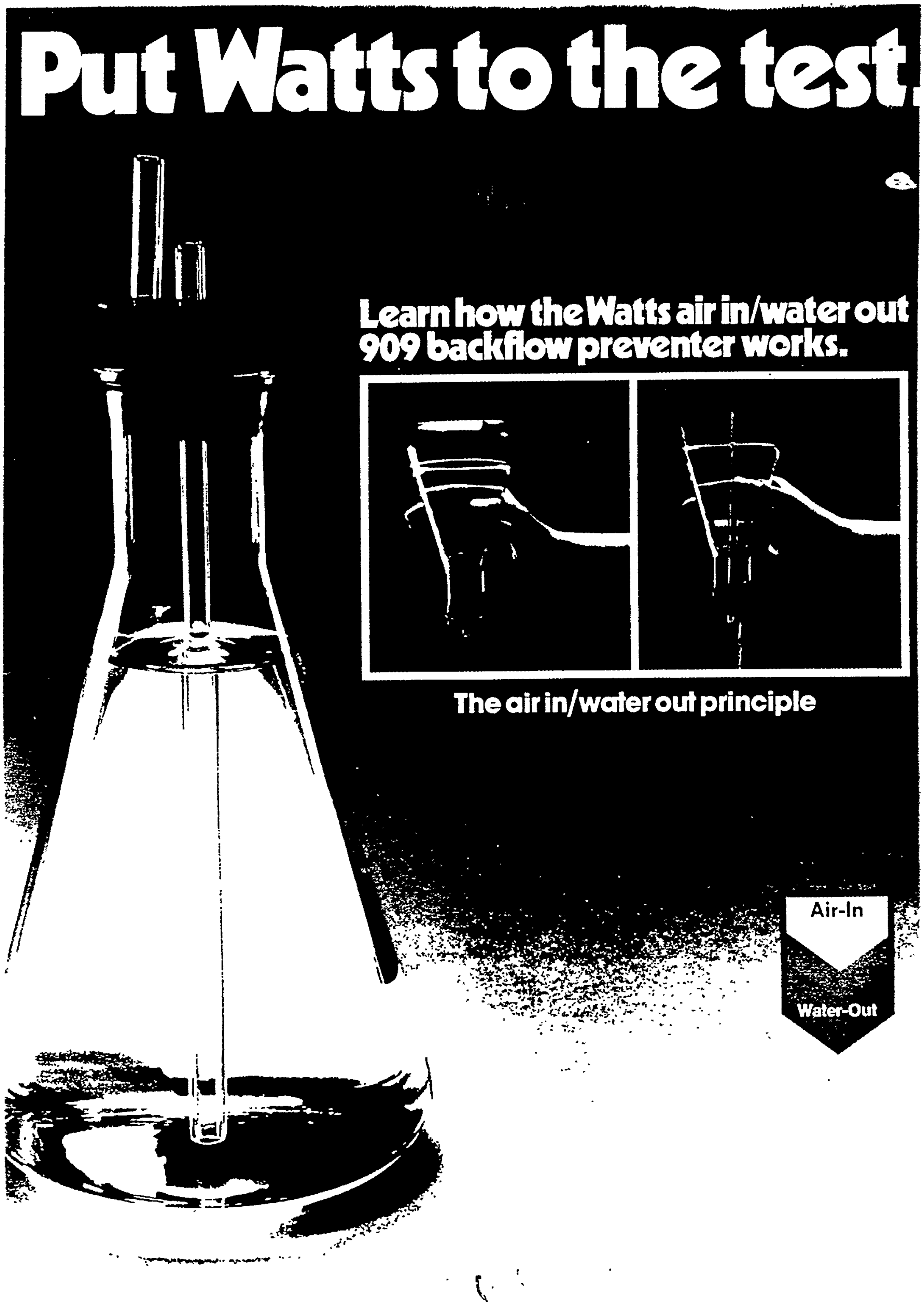
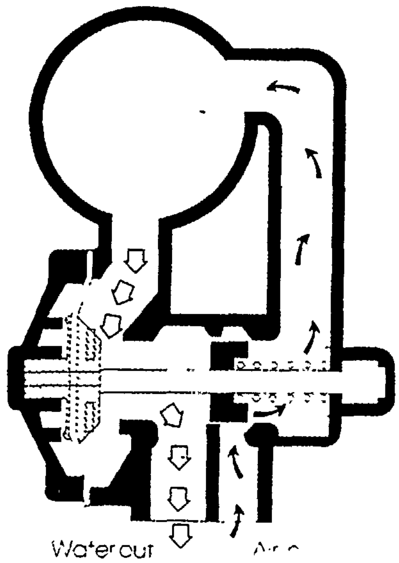
For product specifications and other technical data, look us up in Sweet's Civil Engineering File, Section 15 12 Ce

CAPCO JEN 0020682



CAPCO JEN 0020683



The principle's simple, but we've used it to solve a complex safety problem. It's the only device to provide so much value and so much protection against simultaneous back-siphonage and back-pressure backflow.

Our unique relief valve* is designed around that air in/water out idea. The valve has two channels: one for air, one for water. When the relief valve opens the right-hand channel admits air to the top of the reduced pressure zone. The channel on the left then drains to atmosphere. Therefore if both check valves foul and simultaneous negative supply and positive back pressure develop, the relief valve stops potential backflow.

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- Union ends for simple installation and removal
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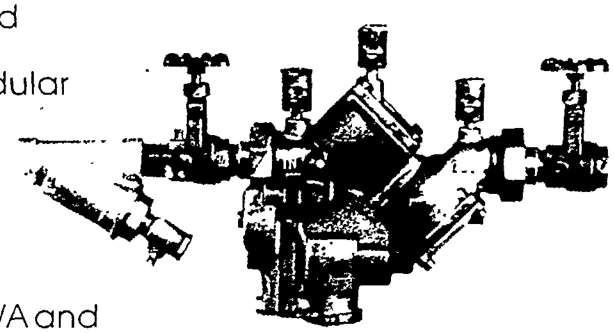
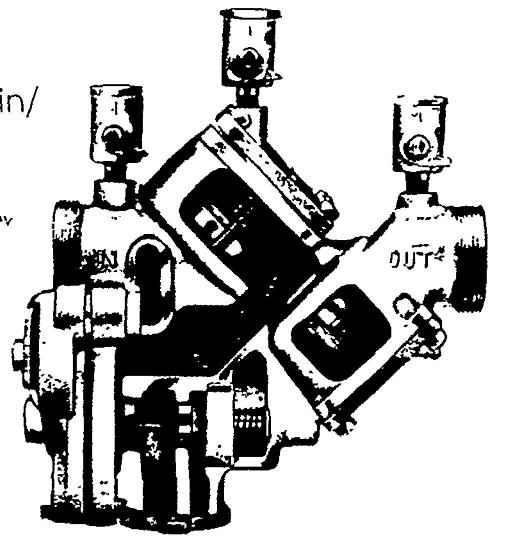
- Tested successfully under ASSE, AWWA and FCCCHR of USC standards for backflow preventers; exceeds performance and design requirements of these specifications.



The Watts 909 Reduced Pressure Backflow Preventer uses the simple-yet-extraordinary air in/water out concept to offer maximum backflow protection with traditional Watts value.



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Reader Inquiry Service No 066

1981 Annual Conference Technical Presentation Abstracts

2-1: Negotiating For Instream Water. A utility decided its next source of water would be a small river, but during the environmental review the US Fish and Wildlife Service had a far different view on how much water could be withdrawn. This paper describes how the utility dealt with the agency's Instream Flow Methodology and successfully reached an agreement.

2-2: Environmental and Regulatory Chess Game. Environmental and land use policies, water quality standards, operational requirements, and the most cost-effective design of water system expansion projects often require a chess game strategy to maintain the original objective. Too often secondary objectives of the environmentalist, the no-growth advocate, or the regulator are not identified or acknowledged as the utility attempts to obtain regulatory approval for new projects.

2-4: Installation Problems and Special Techniques of Large Steel Mains. The failure [illegible] years of [illegible] that was [illegible] the cause [illegible] also provided [illegible] that can be used to [illegible]

2-5: Innovative Design to Overcome Regulatory Constraints on a Water Storage Facility. The Washington Suburban Sanitary Commission was constrained from constructing needed potable water storage because of adverse public reaction to the appearance of existing standpipes and elevated structures. The public opposition led to imposition of regulatory constraints by local governing bodies that dictated that all future water storage facilities would be low profile or subsurface tanks. Through the application of innovative design and engineering WSSC was able to overcome public objections and regulatory constraints and has constructed a decorative globe based on the earth as viewed from a satellite, that provides 2 mil gal (8 ML) of potable water storage.

3-1: Evolution of Management and Organizations. Introduced by a brief resume of the evolution of US urban political structure, the speaker will discuss the growth of the enterprise characteristic of local water utilities. Examples of the evolution of management structures shaped by various political and legislative situations will be given.

3-2: Changing Attitudes and Management Styles. This paper focuses upon changing employee attitudes and managerial styles in the contemporary setting. A comparison will be made between small and large utilities and the paper will be closed by the speaker's assessment of employee attitudes and the most appropriate managerial responses for the decade of the 1980s.

3-3: Communication and Relationships With Customers. Customer communications are becoming more important for all water utilities. The authors cite excellence in customer relations but customers are changing—becoming more directly involved in utility affairs, better educated, and more dollar conscious. Management must develop strategies to mesh employee and customer needs with responsibility for quality water service.

3-4: The Regionalization Process. The presentation briefly traces the evolution of water systems from the individual well to the regulated status now faced by the industry. Included is a discussion of the necessity for conservation of water resources and the efficiencies that can be gained through a larger organization. The current laws that point toward regionalization in some states are reviewed as are the relationship between the water resources systems and the federal planning requirements that exist under current federal law.

4-1: Need for Conjunctive Water Supplies in the Delaware River Basin. Several groundwater supply areas in the Delaware River basin are now stressed to the point where their conjunctive use with surface supplies is necessary. If no additional growth occurred in these stressed areas conjunctive management of water supplies still is required to prevent further lowering of groundwater tables with the attendant reduction in flow of perennial streams.

5-2: Water Quality: Past, Present, and Future (Roundtable). The author reviews water quality developments during the past 40 centuries from the Sanskrit precepts through the dark ages, to the era of safe water and modern problems and techniques. He also comments on his own experiences in the field since 1915 with some special reference to his activities as an AWWA member, section officer, division officer, and association officer.

5-4: Water Quality: Past, Present, and Future (Roundtable). In an era of rapidly changing water quality regulations, water suppliers are faced with tough choices in complying with current standards, anticipating future regulations, and protecting the health of consumers—at a reasonable cost. The role of engineering consultants in evaluating risks and benefits and recommending courses of action is explored.

6-2: Interaction of Hydrolyzable Metal and Cationic Polyelectrolyte Coagulants. The use of cationic polyelectrolytes in combination with hydrolyzable metal coagulants, such as aluminum sulfate, is an effective coagulation technique. This paper describes the results of laboratory studies designed to determine the mode of action of combined coagulants and to delineate the conditions under which the use of combined coagulants is a feasible treatment alternative.

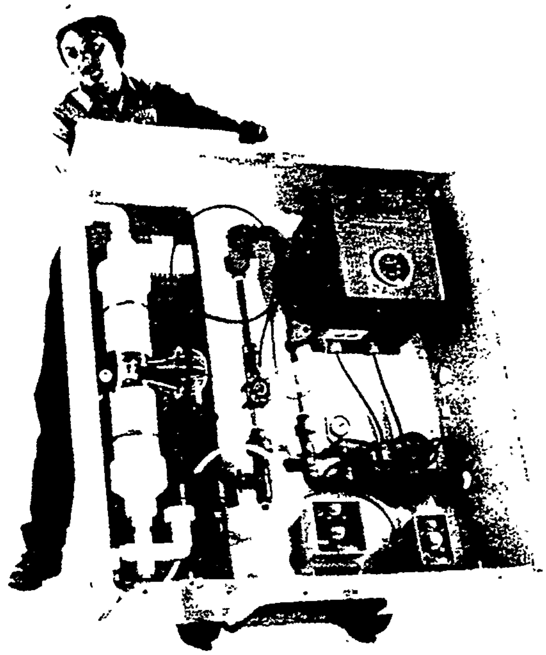
6-4: Water Clarification and Decolorization With the Use of Regenerable Magnetic Particles. A new process, which uses magnetite for the removal of color and turbidity from surface and underground waters, has been developed and a 35-ML/day plant built. Impurities are adsorbed by generation of a positive charge on 1-10-μm magnetite particles. Sedimentation is speeded up by magnetic flocculation. The magnetite is regenerated with sodium hydroxide and reused indefinitely without hydrous sludge production.

6-5: The Mechanics of Air Scour During Filter Backwash. Presented is a theoretical and experimental study of the formation and motion

(Continued on page 68)

CAPCO JEN 0020685

The lowest front-end investment in trihalomethane control may pay the highest dividends.



EPA [illegible] establishing [illegible] trihalomethane [illegible] drinking water will [illegible] control measures in [illegible] of water systems throughout the country.

Substitution of chlorine dioxide for chlorine in the treatment process has been shown to significantly reduce the trihalomethane problem. There are other methods, of course, but chlorine dioxide involves a low capital investment and modest operating costs.

Dividends can go far beyond EPA compliance. Chlorine dioxide also is a more effective [illegible] than chlorine in water [illegible] pH's over 7.0. It is an [illegible] oxidant for iron [illegible] and reacts much faster than chlorine to remove manganese. It controls tastes and odors caused by algae and trace phenol contamination.

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Reader Inquiry Service No 047

CAPCO JEN 0020686

(Continued from page 66)

[illegible]

7-1: Special Design Considerations on the Lemer Pipeline Project. [illegible]

7-2: Organization and Analysis of Leak and Break Data for Main Replacement Decisions. [illegible]

7-3: Statistical Sampling Techniques for Controlling Accuracy of Small Water [illegible]

7-4: Case History of Asbestos-Cement Pipe Vinyl Lining. [illegible]

7-5: Aging Water Systems: Boston's Approach to the Problem. [illegible]

8-1: Improved Productivity Through Work Measurement. [illegible]

8-2: Management, Information, and Computers. [illegible]

8-3: Operating and Financial Reporting Systems. [illegible]

8-4: Planned Maintenance Management. [illegible]

9-3: Colorado Water Rights Engineering. [illegible]

10-1: Alternatives for Controlling Organics in Groundwater Supplies. [illegible]

10-2: Community Water Supply Survey: Sampling and Analysis for Purgeable Organics and Total Organic Carbon. [illegible]

10-3: Process Design Considerations in Recycling Preformed Flocs to the Coagulation-Flocculation Process. [illegible] the presence of recycled preformed flocs

10-4: Costs and Benefits of Drinking Water Treatment. Environmental control costs and their associated benefits have come under increasing scrutiny in recent years Inflationary pressures and a growing concern as to whether the benefits are worth the cost have caused regulated industries and the public to question the usefulness of investing in environmental control measures The purpose of this paper is to develop a framework for the evaluation of the costs and benefits of environmental control and preventative public health practice Using techniques for large-scale data base management, the costs and benefits associated with hardness control are examined Both the costs and benefits of cardiovascular disease and the costs and benefits of technological modifications are evaluated

10-5: Meeting the Obscure Standards That Were. A raw water supply that contains barium radium 226 and high levels of H_2S presents some unique problems The paper discusses problems of supply, treatment and lime residue disposal The paper also discusses treatment of H_2S and the formation of yellow and blue water in the treatment process Marginal lime softening produces 90 percent removal efficiency of barium and radium 226, which creates a disposal problem for the lime sludge contaminated with radium 226

11-1: Chemical Modeling of Copper Corrosion Using Electrochemical Techniques. The aggressiveness of waters with low alkalinity and hardness toward copper varies with chemical composition of the water The effects of pH total carbonate, silicate chloride, sulfate and temperature on the corrosion rate of copper have been investigated to determine which chemical species are the most important in controlling copper corrosion

11-2: A Water Conservation Study in a Water-Rich State. A water conservation program to avoid added capital expenditures for the development of new raw water sources is designed to apply increasingly stringent limits on water consumption This program included a study to determine consumer attitudes to evaluate the use of in-home water conservation devices and to study the impact of water pricing on consumption

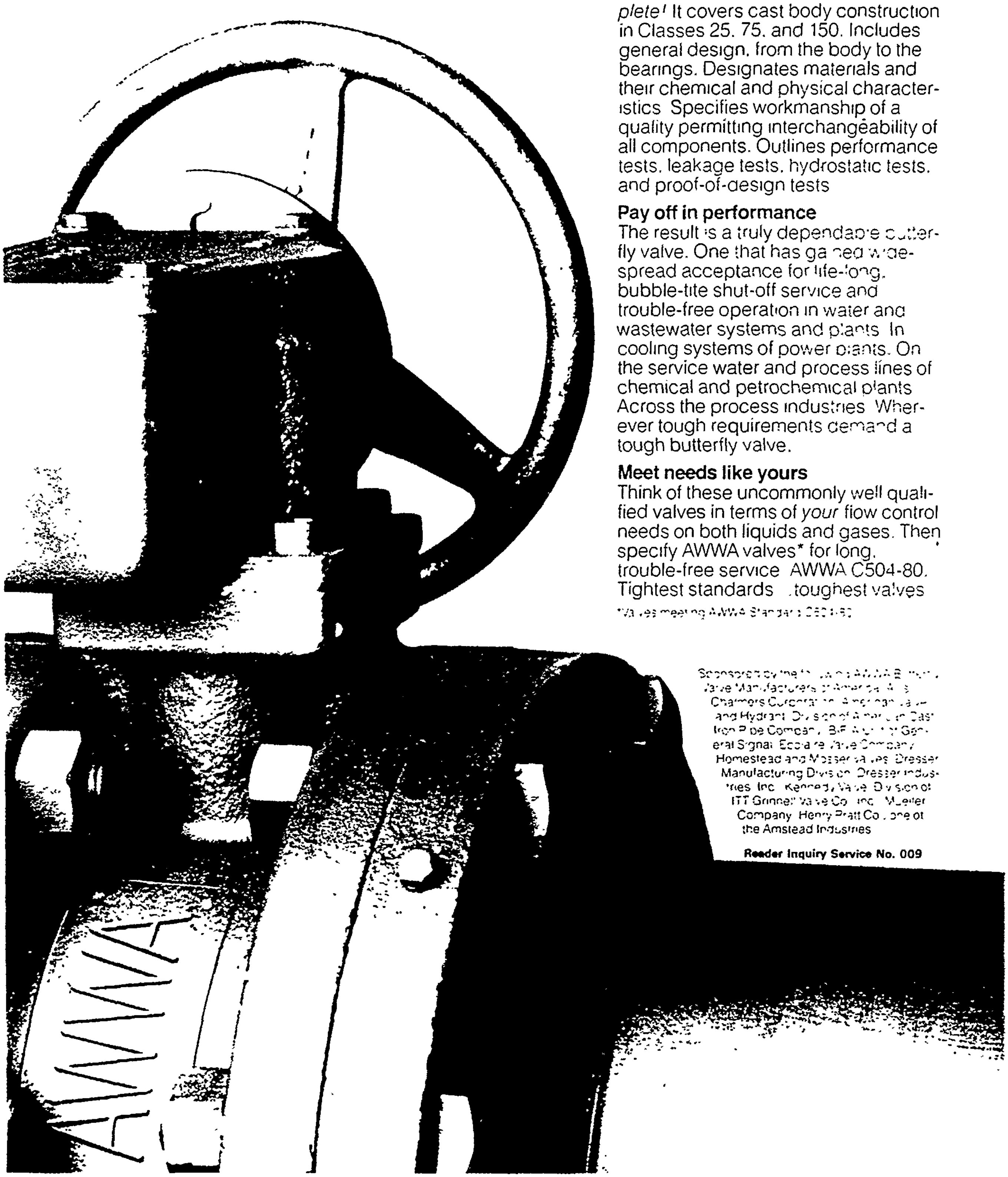
11-3: Ferric Chloride and Alum as Single and Dual Coagulants. Stability-coagulation diagrams for alum and ferric chloride are compared empirically checked, and the conditions under which each coagulant is useful evaluated. The effectiveness of combining the two coagulants in equal molar ratios also is explored empirically in an effort to overcome limitations of the individual coagulants

11-4: Effect of Solution Chemistry on Coagulation With Hydrolyzed Al (111). This study demonstrates that the control of particle surface charge alone is insufficient in determining efficient flocculation when using aluminum salt coagulants Consideration must be given to such solution chemistry variables as pH, anion concentration, coagulant dose, and suspended solids concentration An interpretation of the Smoluchowski equation is presented to define zones of efficient flocculation

(Continued on page 70)

CAPCO JEN 0020687

LETTER-PERFECT



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Reader Inquiry Service No. 009

CAPCO JEN 0020688

Continued from page 68

11-5: Pilot Direct Filtration and Carbon Adsorption Treatment of High-Solids River Water. A pilot study [illegible] for abundant algae growth during the summer and fall.

11-6: Relationships Between Standard Plate Counts and Other Parameters in Water Distribution Systems. Data obtained from intensive sampling of eight small community water systems was analyzed for correlations between standard plate counts and total coliform counts, turbidity, daily water pumpage, and reduced chlorine residual. No such correlations were found. However, correlations were found between these parameters in samples from an experimental system contaminated with sewage.

12-1: Small Water Utility Operations and Design Viewed by Owner. This presentation discusses the problems of small water utility from owner's point of view, including the nature of business, game plan, financing and takes, regulation of rates and health matters, use of outside experts and consultants.

12-2: Design and Operation of Small Water Utility Systems Viewed by Design Engineer. Design and operation of water utility systems in central Iowa communities of 300 to 7000 persons. Topics include evaluation and development of sources, treatment schemes, storage, pumping, distribution, with emphasis on treatment to remove iron, manganese, hardness, nitrates, and radium, storage for [illegible] and fire protection, and constant speed versus variable speed high service pumping.

12-3: Small Water Utility Operations and Design Viewed by State Regulatory Agency. Simple and inexpensive operation is a goal [illegible] facilities that must be balanced against the requirement for a safe and adequate supply of water available to the public on a [illegible] basis. Well-trained operators are [illegible] facilities [illegible].

12-4: Small Water Utility Operations and Design Viewed by USEPA. Small water systems traditionally have had the most problems in meeting drinking water regulations. Although this is because of a number of factors, the major problem is lack of finances to develop new sources or construct and maintain needed facilities. Cooperation between the utilities, consultants, and regulatory agencies is essential to successfully address this problem.

13-1: Better Water Quality and Service Through Training (Panel Discussion): Texas Section. Training is an integral issue in water quality and service. As utilities recognize its importance, they provide opportunities resulting in better service, higher water quality, and career-oriented development for employees. Section programs support proper training needs analysis and involvement enable all utility personnel to improve skills and knowledge.

13-2: Better Water Quality and Service Through Training (Panel Discussion): The Rocky Mountain Section offers operator training through its Action Now program.

13-3: Better Water Quality and Service Through Training (Panel Discussion): Michigan Section. The Michigan Department of Public Health has regulated public water supplies since 1913 and has had compulsory certification of water treatment plant operators since 1942. Training specifically for these operators also began at that time and continues today. With the passage of Michigan's Safe Drinking Water Act in 1976, certification of distribution system operators also became compulsory. Training specifically for these operators was instituted at that time. This paper reviews those training programs.

13-4: Better Water Quality and Service Through Training (Panel Discussion): California-Nevada Section. The responsibility for providing training to water utility personnel can be listed in the following descending order: individual water utility, AWWA section, AWWA, international. The paper explores the roles of people and institutions in providing training for management, treatment, distribution, water quality, safety, and systems control. A review of the role provided by the California-Nevada Section is presented within this framework.

13-5: Better Water Quality and Service Through Training (Panel Discussion): Illinois Style. The water operator training program conducted by the Illinois Section AWWA has followed a simple format of identifying the training need, establishing training guidelines, and instituting a training program based on the needs at a moderate price to the operator.

13-6: Better Water Quality and Service Through Training (Panel Discussion): AWWA. A short presentation will be given on the role of AWWA towards the training of water plant operators through the use of AWWA-prepared materials.

15-1: Rural Water Supply in Puerto Rico. In 1945 the legislature of Puerto Rico created the Puerto Rico Aqueduct & Sewer Authority, a public corporation whose task was to ensure that the whole island would have safe water and wastewater treatment. One main task was to bring water to the countryside, where people often had to walk great distances to find water of questionable quality. Since 1945 the authority has invested more than $162 million and brought service to more than a quarter of a million rural families.

15-2: Reducing the Cost and Time of Feasibility and Master Plan Studies in Developing Countries. Experience in most developing countries shows that to complete master planning and feasibility studies for water and sewerage projects leading to financial appraisal commonly requires lengthy involvement by the consultant at substantial cost to himself and the country. The paper presents causes for the high costs and time requirements based on experiences of firms and agencies involved in international contracts during the past ten years. Actions and policies that can be employed by governments, financial institutions, and consultants to avoid or reduce recurring difficulties are discussed.

15-3: Establishment of Water Utility Institutions in Developing Countries. The establishment of viable water utility institutions in developing countries has been a concern of international lending institutions, the World Health Organization, and bilateral technical assistance programs for more than 40 years. The decade of water and sanitation emphasizes the need for improvement and expansion in existing water utility organizations and formation of new utilities. The author describes several approaches that have been attempted in developing countries—some successful and some unsuccessful.

15-4: Women, Water, and the Decade. This paper points out key roles played by women in traditional societies related to water use and management. It also examines the need for involving women in planning and implementing decade activities so that effective strategies can be developed for reaching as effectively as possible the goals of safe water for all.

16-1: Seasonal Evaluation of Organics Removal at a Conventional Water Treatment Plant. This paper presents the results of a seasonal evaluation of a surface water supply with regard to levels of organic matter and trihalomethane (THM) precursors. A conventional water treatment plant is examined in terms of THM formation and removals of organics and THM precursors. Included are correlations between term total THMs and surrogate parameters such as nonvolatile total organic carbon, UV absorbence, and color.

16-2: Direct Filtration of Streamborne Glacial Silt. A pilot plant study was conducted in Alaska to determine the feasibility of removing streamborne glacial silt using direct filtration. The process consisted of hydrocyclone pretreatment followed by physical–chemical coagulation and filtration through trimedia filters. Alum doses of 7-20 mg/L produced successful results. A maximum productivity of 8000 gal/sq ft (300 m^3/m^2) run was achieved at a loading rate of 5.0 gpm/sq ft (3.4 mm/s).

16-3: Application of Ion Exchange and Ultrafiltration for Color Removal From Groundwater. Ion exchange and ultrafiltration were studied as treatment alternatives for removal of naturally occurring organic color from a groundwater supply. Five strong-base and one weak-base anion exchangers were assessed in both batch and column modes. Batch studies were conducted using a stirred cell unit with Diaflo membranes with molecular weight cutoffs between 1000 and 50 000 g.

16-4: An Evaluation of Aeration Methods for the Removal of Volatile Organic Contaminants. A research program to evaluate various aeration techniques for the removal of trace organic contaminants from chlorinated finished water. The program included investigations with a countercurrent packed column, air-stripping process, a cascade process, and a diffused air aeration process. Experiments were conducted in a 4-in. (100-mm) diameter by 5-ft (1.5-m) long glass column.

16-5: Formation and Removal of Bromoform During Desalination. This paper presents the results of a monitoring program for bromoform production in a desalination pretreatment system and the observation regarding passage of bromoform through reverse osmosis membranes. Also included are the results of a laboratory investigation of the adsorption of bromoform in seawater.

(Continued on page 72)

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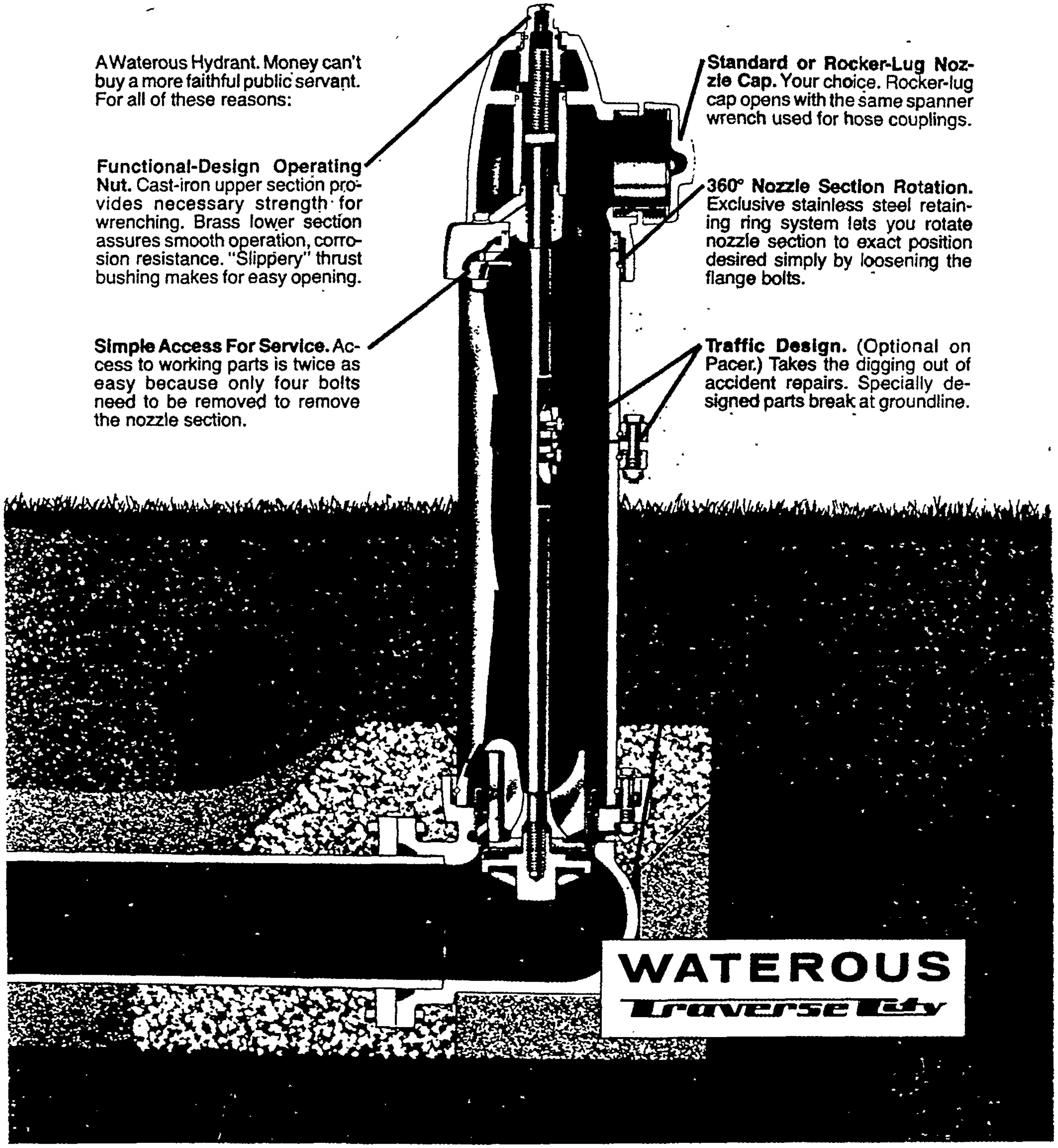

(Continued from page 70)

by activated carbon and its adsorption capacity to desalination system

16-6: Granular Activated Carbon Pretreatment for the Removal of Trihalomethane Precursors. This research project addressed the effectiveness of GAC pretreatment for the removal of THM precursors and the relationship of water quality prior to chlorination to its THM-forming potential (THMFP). A pilot-scale set of three GAC contactors was designed to treat raw water at flow rates of 0.4 and 6 gpm [illegible] 0.2 and 0.4 L/s in an upflow mode

16-7: Ozonation of a Municipal Groundwater Supply to Reduce Iron, Manganese, and Trihalomethane Formation. A pilot study was conducted to investigate the feasibility of using ozonation followed by filtration for removal of iron and manganese from a municipal groundwater supply and for prevention of trihalomethane formation during treatment. The study demonstrated that ozone effectively oxidized the iron and manganese to an insoluble form and that ozone significantly reduced the potential for trihalomethane formation

17-1: Hidden Costs of Accidents. This paper discusses the direct and indirect costs of accidents in an effort to alert management to the fact that it is less costly to prevent an accident than to have one. Dollars spent in the development and implementation of a sound safety program will result in saving several times the amount incurred because of the accidents

18-1: *Opflow* and the Operator. This presentation discusses how to make this popular publication even more useful for the operator

18-2: Water Meter Basics. This paper presents basics of water metering from weirs to ultrasonics, a program designed for operators to review various types of metering devices, their advantages and drawbacks, and developments and experience with the new generation of meters

18-4: Safety and Traffic Routing. This paper [illegible] keep you and your crews safe [illegible] working in and around traffic

18-5: Cross Connections: Their Importance and Control. [illegible] present-day [illegible] in the availability of safe water [illegible] taken for granted [illegible] public water supplies [illegible] complacency [illegible] in the area has [illegible] and that our water supplies have reached the ultimate in safety. This is not true. In order to maintain the level that has been reached, we must now work even harder to improve the present supplies

19-1: Post EMGM and Where We Go From Here. The five-year EMGM membership recruiting campaign was a great success. The association recognized a net gain of nearly 7300 members in that time for an 8 percent growth rate. Our intentions are to keep on growing with other membership campaigns and to increase our growth rate. The end of EMGM only gives us a new starting point. "Onward and upward" is our slogan with special emphasis in the area of member retention

19-2: Developing a Procedure Manual for Incoming Officers and Committee Chairmen. The presentation details the need for a procedure manual for section officers and committee chairmen. The steps in developing and organizing the manual content are outlined as well as the material to be included in a manual of this type. The uses for the manual will also be covered

19-3: Operator Training: Programs and Materials. There are ways of getting around the higher costs of training. Outlined in the presentation are approaches, concepts, and materials that should be considered by sections in achieving their training goals at the least possible cost. Training doesn't have to be expensive to be effective!

19-5: Planning a Joint Section Conference. Joint section meetings provide an opportunity for sharing ideas and expanding opportunities for more technical and educational programs. The British Columbia and Pacific Northwest sections' successful 1980 joint conference will be repeated in 1986

20-2: Water in a Hurry for the Oil-From-Coal Sasol 2 Project, South Africa. When a large scale oil-from-coal production plant was authorized, water of suitable quality had to be transported to the site from a new storage reservoir via two pumping stations and 37 km of canal with a capacity of 15 m^3/s—and be operational within 2 years

20-3: New Experiences of a European Surface Water Treatment System, Especially in Removal of Organics. In the catchment area of the River Rhine most surface water plants possess a seven- to ten-stage treatment system. The ozone and GAC filter stages show the greatest effect in removing organic substances. The removal of organic substances and haloforms through the ozone stage is very good; however, it produces aldehydes. The GAC treatment stage reduces organics and haloforms and causes the aldehydes to vanish completely

20-4: New Design Concepts in Water Treatment in France. This paper presents a survey of design concepts actually in use in France to optimize the treatment scheme of a drinking water plant—in particular, biological means, taking account of the byproducts, accident protection, adjustment, energy savings, networks, evolution, choice of flocculant. Some typical examples of industrial application are given

21-2: Overview of the Water Utility Council. The Water Utility Council has the responsibility of developing response and comment within the framework of AWWA policy on legislative and regulatory matters directly affecting water utilities. The council also has the responsibility of bringing to the attention of other councils and committees of the association policies and procedures that will make possible better water service to the public. Council committees and their responsibilities are explained, and legislative and regulatory challenges of 1981 are examined

22-3: Biodegradation of Trace Organic Compounds by Biofilms on Porous Media. Bacterial films growing on porous media are relevant to today's drinking water supply engineers. These attached microorganisms have the ability to biodegrade extremely low concentrations of organic compounds to a predictable concentration. Removal of an organic below this minimum concentration, called S_{min}, can be achieved by bacteria that employ secondary utilization of a compound not contributing to the cell's long-term growth

22-4: Removal of Soluble Organic Contaminants by Lime-Soda Softening. Lime softening is demonstrated to be effective in the removal of humic and fulvic acids, total organic chlorine, and some—but not all—specific chemicals. Removal is affected by pH, the composition of the precipitate, and the ionic composition of the solution. Removal mechanisms are discussed in light of experimental evidence

22-5: Effects of Calcium on the Speciation, Adsorption, and Removal of Fulvic Acids. Calcium can neutralize part of the negative charge of fulvic acid (FA). Extent of the interaction between calcium and four FA fractions has been measured. Experiments show that this neutralization affects the partitioning of FA between water and solids, such as MnO_2 (solid), $CaCO_3$ solid, and $Fe(OH)_3$ (amorphous)

23-3: Work Management Standards. The Tampa Water Department's distribution division recently implemented a work management system that included development of service levels and performance standards. The development of these standards formed the foundation for an effective work program and budgeting process. Utilization of these standards has helped the division achieve cost savings and increased efficiency

23-4: A Practical Corrosion Control Program for Water Districts. The paper outlines the parameters of a water district's corrosion control program for various facilities. Materials selection, coatings, inhibitors, and cathodic protection are discussed. Slides of specific corrosion problems, causes, and mitigation techniques are set forth, and the paper concludes by outlining the various facets of practical corrosion control programs for water districts

23-5: Maintenance of Valves and Hydrants. Valves and fire hydrants are essential components of a water system and, once installed, are often neglected until called upon to function for system control and fire protection for the community. Maintenance requirements multiply as a distribution system ages, making a regular systematic valve and fire hydrant maintenance program necessary if those components are to perform properly when the need arises

24-1: Energy Management: Three Ways To Win. More than ever, today's waterworks managers must control costs. Escalating energy costs can be counteracted by increasing energy-effectiveness. Three specific ways to accomplish this are to consume energy when it is least costly (time-of-day power rates), to consume less energy for each task (efficiency testing, energy audits); and to produce energy rather than consume it (hydroelectric power generation)

24-2: Water Use Management. Water use management at Fairfax County Water Authority, Virginia, involves a conservation program emphasizing water management by pricing

24-3: Management's Obligations in the Regulatory Process. Management today in-

(Continued on page 74)

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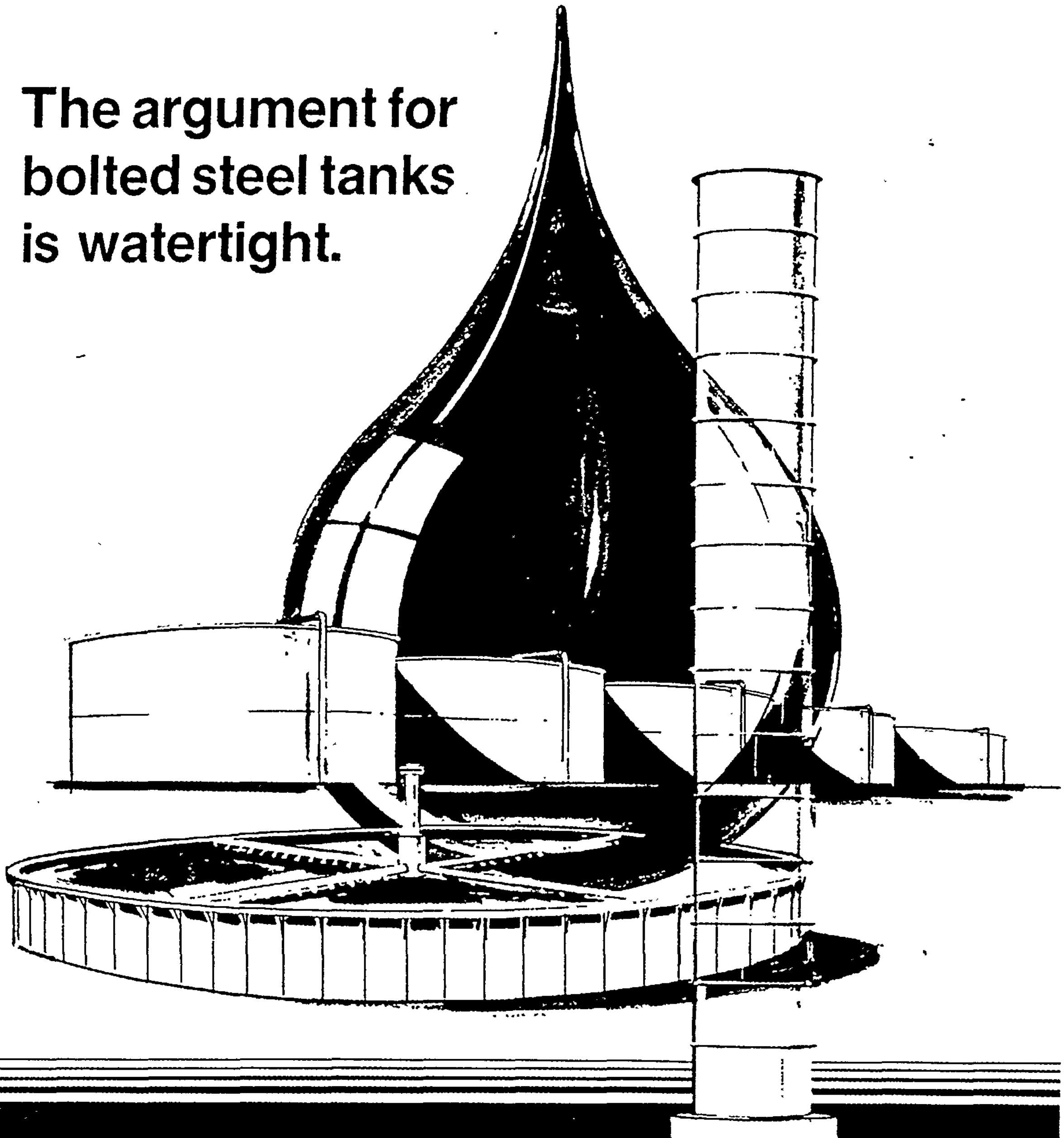

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Continued from page 72

volves the understanding and the control of all factors affecting operations. In recent years new environmental and consumer legislation has brought about a rash of new rules and regulations that have a great impact upon water utilities. Because of this myriad of new regulations, it is imperative that the industry take an active role in the development of all regulations affecting operations. The intent of the paper is to explain the regulatory process and to stress the obligation that management has to review and provide input to this process.

24-4: Financial Management. This paper covers strategies for financial management during periods of inflation—frequent rate increases, accelerated construction, and tight control of wages and benefits. Strategies for financial management during recession times also are covered—lowered construction costs because of competition, generally low interest rates, grants designed to reduce unemployment.

26-1: Interrelationship of Bacterial Counts With Other Finished Water Quality Parameters Within Distribution Systems. Standard plate counts (SPC) exhibited no interrelationship with coliform counts (MF) when the SPC was less than 50 organisms/mL. The frequency of coliform isolation was independent of turbidity and free chlorine. Encapsulated *Klebsiella pneumoniae*, *Enterobacter agglomerans*, *E. aerogenes*, and *E. cloacae* exhibited the ability to survive a free chlorine residual of 0.2 mg/L or more.

26-5: Effectiveness of Powdered and Granular Activated Carbon for Removal of Organic Contaminants at Niagara Falls, N.Y. Pilot and plant scale trials were conducted using granular and powdered carbon to determine their effectiveness in removing organic contaminants from drinking water. Parameters examined included total organic carbon, trihalomethanes, and specific synthetic organic chemicals. Both granular and powdered carbon were shown to be effective, each having its own advantages for particular situations.

26-6: Response of a Local Health Department to the Presence of Organics in the Drinking Water Supply, Nassau County, Long Island, N.Y. The 1.5 million residents of Nassau County, Long Island, depend entirely on groundwater as their source of drinking water. Trace organic contaminants were first found in the water supply in [illegible]. From that time until the present, experience has been gained and procedures developed for coping with the problem. This paper describes the hydrology of the area, provides insight into the effect of contaminants on water quality, and outlines the responses that have been made to the situation.

27-1: Desorption of Compounds During Operation of GAC Adsorption Systems. A verified mathematical model was employed to simulate desorption from carbon beds resulting from a reduction in influent concentration and competition. The influence of various parameters—mass transfer coefficients, process variables, isotherm capacity and slope—on desorption was examined. The significance of the two desorption mechanisms in producing an effluent with a concentration greater than in the influent was evaluated.

27-2: Microbial Activity on Granular Activated Carbon: An Assessment. The present status of microbial activity on granular activated carbon as a method of water treatment and further research needs are presented. Removal of organics at very low concentrations such as are found in water supplies may occur. The support media for microbial growth, i.e., sand grains or GAC, can be an important factor in determining the extent of removal. The important question of whether GAC provides an advantage over sand in promoting biodegradation is discussed in detail.

27-3: GAC Performance Criteria for Organic Carbon Removal. Performance data from 13 investigations on the removal of total organic carbon by granular activated carbon are compared. In all cases there was an initial breakthrough of 10 percent or more of the influent TOC. The fractional removal declined until a steady state was reached, on the average after 10 000 bed volumes were treated. At steady state, 10 to 40 percent of the influent TOC continued to be removed.

27-4: Preliminary Design of Least-Cost Fixed-Bed Adsorption Systems Using the Homogeneous Surface Diffusion Model. Least-cost adsorber operations were determined for adsorbers that were used to reduce the chloroform formation potential to 100 $\mu g/L$. To find the least-cost GAC process configuration, the total costs for single, series, and parallel adsorbers were determined for various empty bed contact times. Several influent concentrations and water plant flow rates were used to evaluate cost reductions that may result from pretreatment or increasing water plant size.

27-5: Adsorption of Carbon Tetrachloride From Water by Activated Carbon. Adsorption by activated carbon has been shown effective for removal of many organic compounds from water. The performance of this process is strongly dependent upon the particular organic compounds in question and upon a variety of other system-specific factors. The research described in this paper focuses on evaluation of the effectiveness of activated carbon for removal of carbon tetrachloride from water and on identification and quantification of process variables with significant impacts on water treatment applications.

28-1: Report on an Early Warning System. The paper discusses the events that began with the Mar. 27, 1980 eruption of Mt. St. Helens, the development of a volcano emergency action plan by the city of Portland, Ore., and some of the difficulties associated with emergency planning for volcanic eruptions as related to a surface water supply.

28-3: Mt. St. Helens' Fallout Problems. Spokane, located some 250 mi (400 km) northeast of Mt. St. Helens, was covered with approximately ½ in. (13 mm) of ash as a result of the May 18, 1980 eruption of the mountain. This paper will speak of the actions of the city in coping with this problem.

28-4: Public Health Considerations of Mt. St. Helens' Eruption. This paper reviews the public health concerns, investigations, and findings after the eruption of Mt. St. Helens in Washington state. Issues, such as the potential effects of volcanic ash on water quality, treatability of ash-laden water, and ingestion of water containing volcanic ash, are discussed.

30-1: Effects of Government Regulation. The paper deals with the effects of government regulations on water treatment plant design. An overview of the relationship of the deign engineer, owner, and state health department are discussed and a deeper study of the responsibilities of the state health department with regard to plant design and finished water quality is made.

30-3: Filtration Processes. From about 4000 B.C., the earliest date of documented water filtration, until the present, the filtration process has gone through a number of modifications but has retained the basic principle of the passage of water through a porous medium for the removal of suspended solids. Developments in filtration have prompted more efficient solids removal through the use of coagulants and improvements in media selection, underdrain design, backwashing techniques, monitoring instruments, and operational approach.

30-5: Water System Construction: Past, Present, and Future. The paper compares materials, equipment, and methods in the construction of water systems past, present, and future, and the transition from wood pipe to PVC and ductile iron, from manual gate valves to electrically operated butterfly valves, from manual controls to computer control.

31-1: Comparison of the DPD-Colorimetric, DPD-Steadifac, and FACTS Test Procedures for Free Chlorine Residual Analyses. The recent modification of the DPD test procedure is compared to the original colorimetric and the FACTS procedures. Data is presented on the interference of the test procedures by monochloramine and trichloramine during the free chlorine measurement. Color stability and lower detection limits are discussed for the procedures.

31-3: A Predictive Model for Chloroform Formation From Humic Acid. To assist in meeting the maximum contaminant level, set by the US Environmental Protection Agency, of 100 $\mu g/L$ of total trihalomethanes, an empirically derived multiple parameter model for the prediction of chloroform formation has been developed. The parameters considered are total organic carbon, chlorine to TOC ratio, temperature, and pH. A good correlation (r = 0.98) has been obtained between the measured and predicted chloroform concentration for reaction times ranging up to 96 hr.

31-4: Diffusion of Organics From Solvent-Bonded Plastic Pipes Used for Potable Water Plumbing. Diffusion of organic solvents and other synthetic organic contaminants from solvent-bonded PVC and CPVC potable water pipe systems was examined. High levels of solvent components from primers and cements and also chloroform and carbon tetrachloride were found in water residing for two weeks in PVC and CPVC pipes. These levels decreased rapidly but were significant after periodic refills. Solvent diffusion decreased rapidly to low levels during the early flow period of the usage simulation study.

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Pre-conference Seminars Speak to Current Concerns

The 1981 AWWA Centennial Conference Exposition in St Louis will be set in motion again this year by the popular pre-conference seminars—scheduled to begin Sunday June 7 at 9 00 a m

Two of the three seminars are being sponsored by the Water Quality Division Topics to be addressed in this area are "Small Water System Problems" and "Coagulation and Filtration—Back to Basics." A third seminar "Organic Chemicals Contaminants in Groundwater—Transport and Removal," is being cosponsored by the Resources Division and the Research Technical and Professional Committee

Of the total number of water systems in the United States, 85 percent are small systems "Small Water System Problems" will delineate the results of a 1980 AWWA survey of these small utilities and then discuss strategies for implementing the changes suggested by the survey

Of interest to the small-system operator, the seminar also has been designed to provide insight for consultants researchers, and others who have a stake in the future of small water utilities

The moderator will be Robert G McCall former director of West Virginia's Environmental Health Service A trustee of AWWA's Water Quality Division he also chairs an ad hoc committee charged with investigating and defining problems of small system operations

A panel of speakers familiar with the problems of small water systems will focus discussion on a number of pertinent topics Included are the research needs of small water systems their various demonstration projects operator training and certification, and the regionalization of small utilities through combined treatment operations and management functions.

The "Coagulation and Filtration" seminar will re-examine the theory and application of these two essential processes for controlling contaminants in drinking water Designers of water treatment plants will find this seminar valuable, as particular attention will be paid to new developments and design concepts related to the coagulation and filtration processes

Moderator for the seminar is Carol H Tate, vice president of James M Montgomery Consulting Engineers Inc and chairwoman of the Water Quality Division's Coagulation & Filtration Committee Experts in the field will discuss such topics as coagulation theory and coagulant selection filtration theory and media selection types of filter design and filtration rate

"Organic Chemical Contaminants in Groundwater" explores and updates a water resource problem that is currently of major concern to the water industry Programs aimed at controlling these groundwater contaminants are evolving rapidly but often without a thorough understanding of the problem's magnitude Management and technical personnel can use the seminar to become acquainted with the fundamentals of groundwater flow transport of organic contaminants and treatment for removal.

Moderators for the seminar are Francis A DiGiano and David W Miller DiGiano is a professor of civil engineering at the University of Massachusetts and chairs the Organic Contaminants Committee of AWWA's Research T&P Committee Miller is a principal in the groundwater consulting firm of Geraghty & Miller Inc and is chairman of the Groundwater Committee of AWWA's Resources Division

Speakers on the groundwater panel will cover a number of specific topics, including adsorption and air stripping as treatment processes, case studies involving removal or organic chemical contaminants from groundwater, and management alternatives for dealing with this problem.

Preregistration for the Sunday seminars can be made on the technical program registration form On-site registration can be completed in the hour before the seminars begin, from 8 00 to 9 00 a m, at the Marriott's Pavilion Hotel

Pre-conference Seminar Program Page 78

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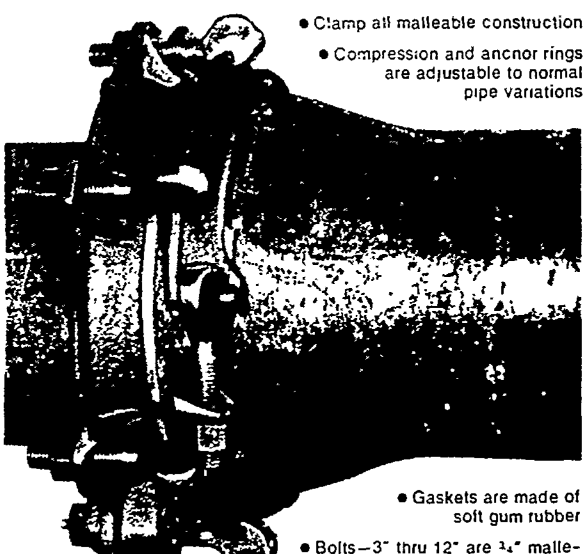

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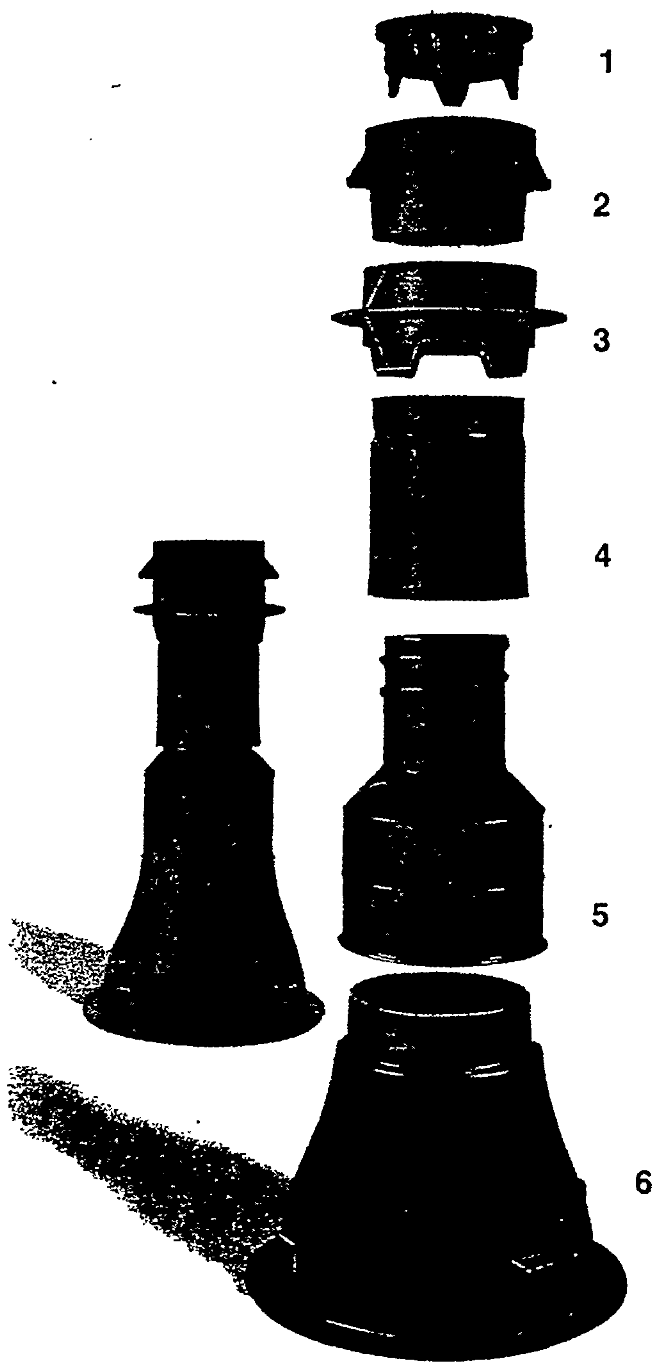

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1981 Annual Pre-conference Seminar Program

Sunday, June 7

S1 • COAGULATION AND FILTRATION: BACK TO THE BASICS

Water Quality Division

Moderator C H Tate

1. INTRODUCTION—*C.H TATE*
2. INITIAL MIXING—*A AMIRTHARAJAH*
3. COAGULATION—*J K EDZWALD*
4. FLOCCULATION—*R.D LETTERMAN*
5. FILTRATION—*J L. CLEASBY*
6. COAGULANT SELECTION USING JAR TESTS—*J.E. SINGLEY*
7. DETERMINING AND OPTIMIZING —*D A CORNWELL*
8. DESIGN CONSIDERATIONS IN FILTRATION—*B G STONE*
9. LOW DOSAGE TREATMENT FOR DIRECT FILTRATION—*H.E. HUDSON*

S2 • ORGANIC CHEMICAL CONTAMINANTS IN GROUNDWATER: TRANSPORT AND REMOVAL

Research T&P Committee and Resources Division

Moderators: F A DiGiano, D W. Miller, P R Cairo

1. DEVELOPMENT OF A NATIONAL GROUNDWATER STRATEGY
2. FUNDAMENTALS OF GROUNDWATER CONTAMINATION—*D.W. MILLER*
3. METHODS OF CONTAINING CONTAMINTED GROUNDWATER—*G.H. EMRICH*
4. NATURE OF ORGANIC CONTAMINANTS IN GROUNDWATER AND TREATMENT APPROACHES—*P.V. ROBERTS*
5. ADSORPTION AS A TREATMENT PROCESS—*V L SNOEYINK*
6. AIR STRIPPING AS A TREATMENT PROCESS—*M C. KAVANAUGH*
7. CASE STUDIES INVOLVING REMOVAL OF ORGANIC CONTAMINANTS FROM GROUNDWATER—*A.F HESS*

S3 • SMALL WATER SYSTEM PROBLEMS

Water Quality Division

Moderator R G McCall

1. OPERATOR TRAINING (Panel Discussion)—*HUGH HANSON, M.H. THOMPSON, R.W. LEIDHOLDT*
2. OVERVIEW OF SMALL SYSTEMS WATER TREATMENT STUDIES—*T.J. SORG*
3. INSTITUTIONAL ALTERNATIVES (Panel Discussion)—*R.K. JOHNSON, R.M. CLARK, J D. CLISE*
4. MARKET STUDY ON SMALL WATER TREATMENT PLANTS—*J.C. CLARK JR.*
5. FUNDING (Panel Discussion)—*GLEN BENNETT, J.M GASTON, R.L. WUBBENA*
6. REACTION AND STRATEGY (Panel Discussion)—*V J. KIMM, IRA MARKWOOD, R R LAMSON*

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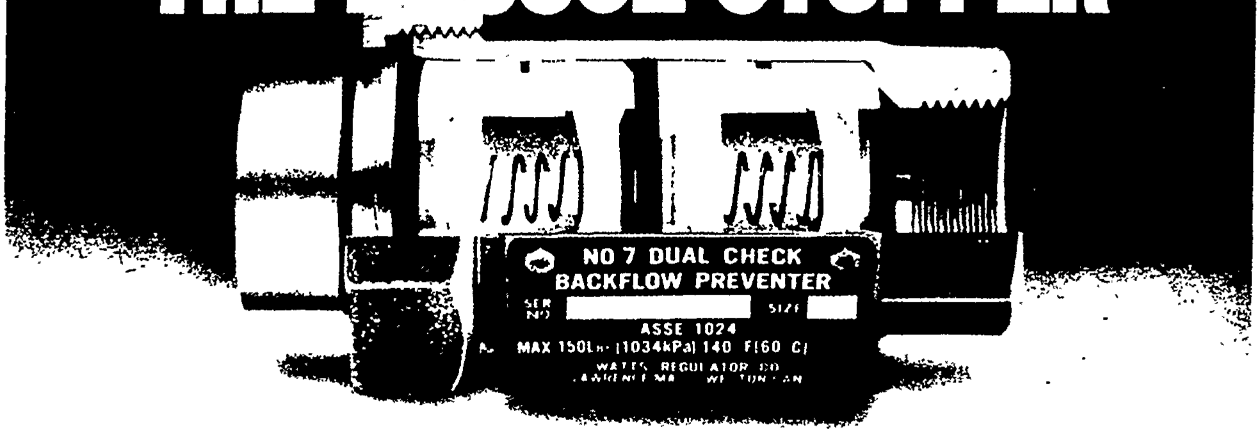

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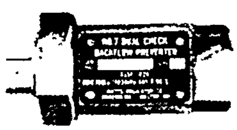
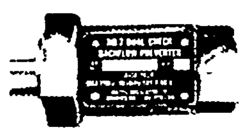
Backflow is the unwanted reverse flow of liquids in a piping system But it's easily avoided by the installation of a backflow preventer Here are a few of the excuses still being used for not installing backflow prevention devices And here are a few excuse stoppers from Watts Regulator

[illegible]



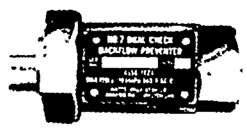
Homes traditionally have been low hazard areas But incidents of cross-connection and contamination of the public water supply do occur Hose aspirators mobile-home park developments photographic darkrooms, lawn sprinkler systems, exterminators bathtub whirlpool adapters and any illegal piping all present potential cross-connection problems The No 7 is compact and efficient, available in 3/4 and 1" and ideal for installation downstream from residential water meters or at other approved locations

[illegible]



Although hose bib vacuum breakers do protect against outside cross-connections through sillcocks, they don't provide protection of the public water supply from backflow. The No 7 does.

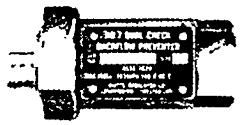
[illegible] Backflow preventers [illegible] to install for [illegible]



It used to be that backflow prevention wasn't feasible for homes because of the cost factor. But this Watts breakthrough provides *affordable*, efficient protection.

And no matter what the cost, you can never afford the damage your reputation would suffer if a backflow problem did occur

[illegible] They [illegible] make us [illegible]



Times are changing State, local and federal agencies are becoming more strict in their requirements for backflow prevention Codes and programs are being updated continually; you should be ahead of them

WATTS

THE NAME THAT PROTECTS YOUR NAME
Lawrence, MA 01842 617/688-1811

Excuse #5: "We've never had any backflow problems."

Maybe you've been lucky for years Statistics speak only of the past. the No 7 offers protection for the future. Water usage is increasing every day, and your risk is increasing right along with it. It takes only one incidence of backflow to ruin a long safety record.

Excuse #6: "A check valve is good enough."

Some protection is better than none But a single check isn't a backflow preventer When it fails you have no protection. The No.7 is a true backflow preventer, not just a check valve, because it complies with the requirements for back pressure and seat tightness of all backflow preventer standards. It has been tested,certified and listed under ASSE Standard 1024 for Dual Check Valve Backflow Preventers. GPM flow exceeds the ANSI Standard A112.26.2 (ASSE 1003) requirements.

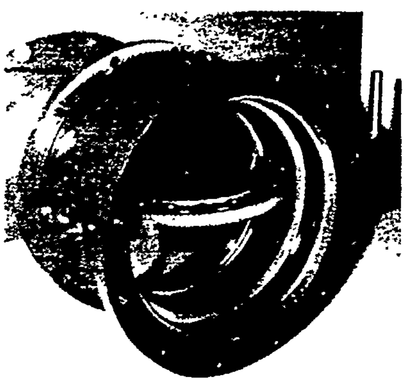
The Watts No.7 Dual Check Valve Backflow Preventer. It eliminates a lot of excuses.

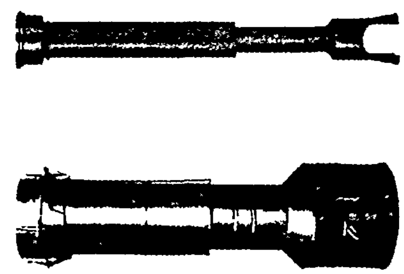
For complete information on the Watts No 7 Series Dual Check Valve Backflow Preventer write Watts Regulator Company 10 Embankment Street Lawrence, MA 01842 Phone (617) 688-1811

CAPCO JEN 0020698

CAPCO JEN 0020699

1981 Annual Conference Exhibitor Highlights





Allis-Chalmers Valve Div.

Featuring quality rubber-seated butterfly valves to meet the challenge of the 80s Code 22 STREAMSEAL butterfly valves new standard AWWA C504 butterfly valve from Allis-Chalmers sizes 3 in through 24 in for above ground and underground water distribution service Domed disc STREAMSEAL butterfly valves larger butterfly valves to meet AWWA C504 in sizes from 30 in through 72 in larger sizes meet AWWA design parameters

Visit Booth No. 515

American Cast Iron Pipe Co.

See our ad refer to page 24

Featuring the American Cast Iron Pipe Co pipe, fittings valves, and hydrants for the waterworks industry An audio-visual presentation describes the manufacture and testing of American ductile iron pipe For American valves and hydrants, photographs depict manufacture of American butterfly valves check valves and gate valves as well as the manufacture of American's fire hydrants for water service

Visit Booth No 325

Ametek Inc., Plymouth Products Div.

See our ad refer to page 77

Featuring POLYIRON® valve and curb boxes. Valve box magnetically locatable, two-piece screw style, thermoplastic valve boxes with cast-iron rings and covers 2-7-ft bury Curb service boxes magnetically locatable two-piece screw style, thermoplastic curb service boxes 2-7-ft bury

Visit Booth No. 619

(Continued on page 84)

CAPCO JEN 0020700

AWWA's complete training package

CHLORINATION PRACTICES

AWWA's newly developed CHLORINATION training package with instructional materials provides up-to-date information on chlorination principles and practices. It's prepared for utility supervisors and training organizations who can conduct in-service training programs. The package includes an instructor guide and slides that depict concepts and principles; a 16mm film; slide/tape presentation; reference texts; and student materials.

This instructional training program is:

Comprehensive:

It contains complete coverage of chlorination principles and practices including safety aspects and other important factors influencing the achievement of high performance standards in water treatment operations.

Essential:

The high risk associated with handling chlorine means that water treatment personnel must have a thorough understanding of properties and knowledge of the chlorination process to ensure more safe and efficient operations.

Adaptable:

Options are recommended in the instructor guide for conducting intensive one or two day courses. Developed with adaptability in mind, course materials can be modified to focus on local problems and special training needs.

Practical:

Aside from achieving a better understanding of chlorination, students are provided with hands-on experiences that apply to their everyday work.

Affordable:

Outside training is costly. With a relatively small investment in instructional materials, chlorination training sessions can be more economically conducted, realizing a substantial cost reduction in training.

Reusable:

By owning this package, the training program can be conducted over and over again as your needs require. It doesn't take long for the package to pay for itself.

Send in your order now for this special offer!

ORDER FORM TO:

AWWA Publications Dept.
6666 West Quincy Avenue
Denver, Colorado 80235

is available on:

The Complete Package for only $645.00

To purchase components separately:

Component I

Instructor Guide:

Provides instruction in an easy-to-use, concise format. The guide is 118 pages and conveniently packaged in an attractive, three-ring binder. Two student handbooks also are included. They are:

- Chlorine Manual, published by The Chlorine Institute
- AWWA Manual M-20, Water Chlorination *Principles and Practices*

If you want to distribute student handbooks, they may be purchased in quantity from AWWA.

80 Graphic 35mm Slides w/Carousel

Developed to supplement the lesson plans for each of the 10 modules of instruction. These visual aids clarify concepts and principles as they relate to specific areas of instruction.

TOTAL COST: $275.00

COMPONENT II

16mm Film:

Entitled *"Safe Handling of Chlorine,"* produced by PPG Industries.

Slide/Tape:

Presentation entitled *"Chlorine Residual,"* produced by AWWA.

TOTAL COST: $275.00

COMPONENT III

References:

Handbook of Chlorination authored by George Clifford White and published by Van Nostrand Reinhold.

Water Treatment Plant Design, a cooperative publication of ASCE, AWWA, & CCSE.

Standard Methods for the Examination of Water and Wastewater 15th Edition, a cooperative publication of APHA, AWWA, WPCF.

Water Quality and Treatment, Third Edition, prepared by AWWA and published by McGraw Hill.

TOTAL COST: $95.00

ORDER FORM

Please send me the following Packages:

COMPONENT I	• Instructor Guide • Chlorine Manual • M-20 AWWA manual • Slides with Carousel	Order No 1826 MB Packages Requested___ Cost: $275 00
COMPONENT II	• 16MM Film Safe Handling of Chlorine • Slide-Tape Presentation Chlorine Residual	Order No 1827 MC Packages Requested___ Cost $275 00
COMPONENT III	• Handbook of Chlorination • Water Treatment Plant Design • Standard Methods for the Examination of Water and Wastewater • Water Quality and Treatment	Order No 1828 MD Packages Requested___ Cost $95 00

COMPLETE PACKAGE COMPONENTS I, II & III — Order No 1829ME, Packages Requested___, Cost: $645.00

☐ *Bill Me* AWWA Members Only

☐ Payment Enclosed U.S. Or Canadian Funds
Make Checks Payable To AWWA

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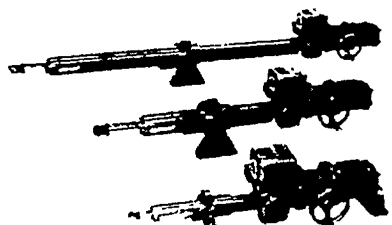
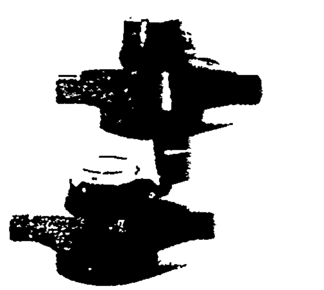
*Handling Charge Every order totaling less than $10 00 and not accompanied by remittance is subject to handling charge of $3 00 which will automatically be added to the bill This charge is necessary because of the extra clerical processing involved on such orders

(Continued from page 8)

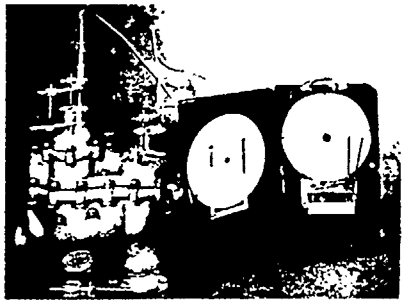


Andco Actuator Products, Inc.
Featuring electro-mechanical linear and rotary actuators Series 7000 Pos-Torq Actuator Electric actuators incorporating position and thrust limit switches for precise intermediate positioning as well as opening-closing applications
Visit Booth No 906

ARAD Water Meter
Featuring full line of domestic and main lines water meters automatic irrigation controls and accessories industrial flow controls Batching unit preset quantity of water displayed by three bright large size LED first settings automatically locked-in once process starts and new setting can be fed immediately for next batch standby switch and battery backup of memory in case of power failure are included Magnetic Multi-Jet 3-1/2 in and larger size Woltman meters 2-12 in optional features include most protection (US patent) and electrical output for remote quantity and rate-of-flow monitoring and control
Visit Booth No 512

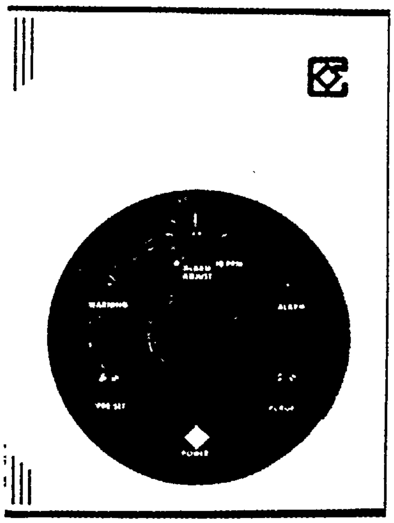


Badger Meter, Inc.
See our ad refer to page 8
Featuring high-speed order entry and distribution network to expedite meter deliveries to water utilities Recordall disc meters a full line of disc water meters with either plastic or bronze housings for residential and commercial applications capacities to 160 gpm Badger compound meters designed to provide high accuracy under rapidly changing flow conditions meter register includes a built-in generator for operating Read-O-Matic remote readout
Visit Booth No. 345

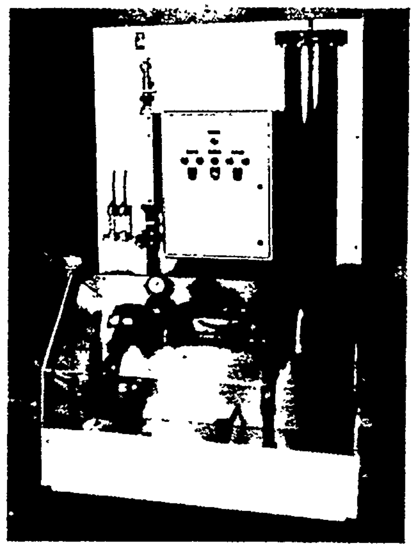


F.S. Brainard & Co., Inc.
Featuring chart recorders that attach to water meters and record flow versus time with pressure and temperature recording options METER-MASTER* for magnetic drive meters provides strip-chart recording of flow passing through any sealed register magnetic water meter METER-MASTER* for mechanical drive meters provides strip or circular chart record of meter flow.
Visit Booth No 631

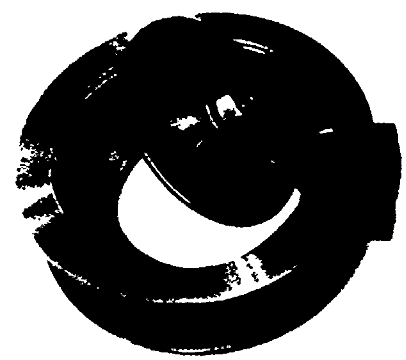
Butler Mfg. Co., Bolted Tank Group
See our ad refer to page 120
Featuring bolted tanks for the storage of water originally designed to American Petroleum Institute specifications to provide a versatile, completely leak-proof storage vessel They have proven themselves in more than 50 years of widespread use Now Butler offers those same advantages for potable water storage with bolted tanks built to the new AWWA D103 specifications
Visit Booth No. 811



Capital Controls
Featuring water treatment gas and liquid chlorine-feed equipment and instruments Chlorine gas detector Advance series 1030 is a compact, electronic totally solid state sensor designed to provide continuous sensing of chlorine in air Fluoride saturator the Advance II sodium fluoride saturator has been designed to meet the demand for fluoridated drinking water both floor and wall-mounted units are almost maintenance free and are designed to be simple to install and operate
Visit Booth No. 821



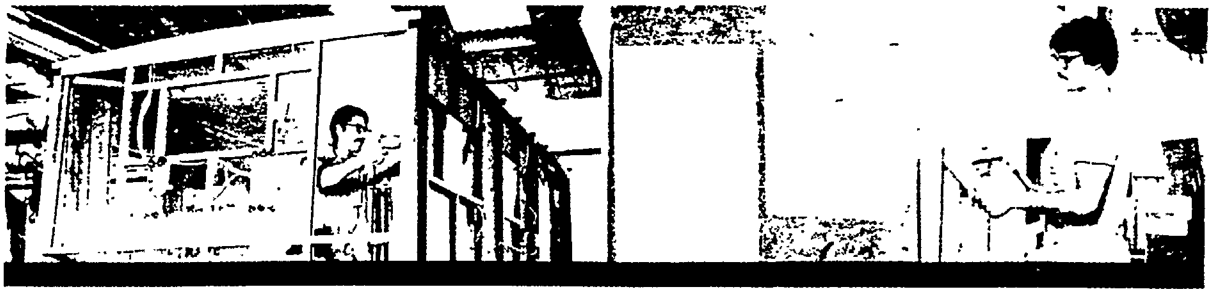
CIFEC
Featuring chlorine dioxide generator uses a new method with an enrichment loop that produces pure chlorine dioxide without residual acid or explosion risk
Visit Booth No. 717



Cla-Val Co.
See our ad, refer to page 121
Featuring the finest in automatic control valves for pressure reducing, pressure relief, pressure sustaining, flow control, liquid level control electrical on-off control Model 501 Wafer Swing Check Valve: this lightweight, space-saving design features low-head-loss characteristics. Spring-assisted closure prevents water hammer. Available in sizes 2-36 in. in cast iron, stainless steel, cast steel Model 100-01 Hytrol Valve, the basic valve for most Cla-Val Co control valves features guided stem, top and bottom renewable seat, one moving part, ease of maintenance. Available in sizes 1/4-16 in in a variety of materials.
Visit Booth No. 234

(Continued on page 86)

CAPCO JEN 0020703



A close-up of the lineup:

Baroid custom-made trailers for water wells.

Recently we received a call from a company that was drilling water wells for an irrigation project in the Sahara Desert. They needed trailers to house their men and laboratory equipment under the extreme temperature conditions of Algeria. Baroid met the demand: we custom-designed a line of 14 trailer units from the inside out.

Built to fit specifications.

Each trailer was built to be used as a drilling mud laboratory. Changes were made to adapt each to overseas specifications for electricity and to provide comfortable working conditions. And we switched from wood to aluminum trailers because Baroid wanted *durability* — trailers to withstand the severe temperature fluctuations of the desert.

Equipment for well-site testing.

You can order a Baroid trailer equipped with a complete line of Baroid testing equipment: Mud Balance, Marsh Funnel and Cup, Full Scale Filter Press and Graduate, Sand Content Set and Water Test Kit. Just about all the chemicals and lab equipment you need to make your trailer a mobile testing laboratory — one that checks drilling fluids and *even* detects oil or gas in water wells.

Solid construction for optimum working conditions.

We build trailers with durability in mind: all metal frames, galvanized steel sub-floors, vinyl-covered wood floors, interior paneling and acoustical ceiling tile.

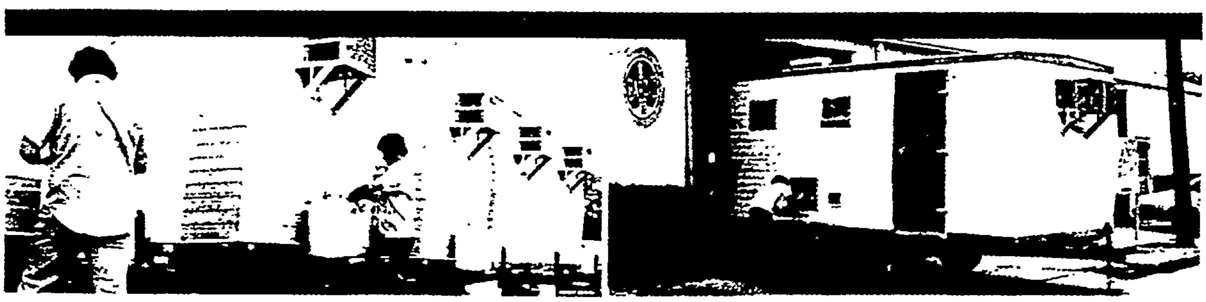
Polyurethane foam insulation maintains stable temperatures inside. Aluminum over plywood strengthens exterior walls and roofing. Waterproof sides, thermal windows, insulated doors, air conditioning and heating all help to protect your laboratory equipment.

Extras for comfort and convenience.

We design the interior to make things convenient. For example, we put a small kitchen with a stove and refrigerator, dinette and sleeping room adequate for three persons in each trailer. And, each has a skid-mounted 220 volt diesel driven generator. You also may choose your own trailer color — possibly your company's color if you wish.

So, when you need a trailer for your water well testing equipment and crew, call Baroid and we'll custom-design one to fit your special needs. We've proved our capability for 50 years ... now let us prove it to you. Write or call Baroid for more information about our customized trailers

NL INDUSTRIES, INC.
NL Baroid
P.O. Box 1675
Houston, TX 77001
(713) 527-1100

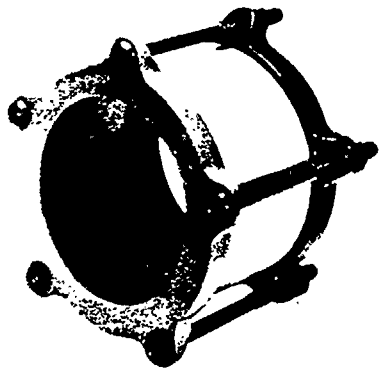


CAPCO JEN 0020704

Continued from page 841

Clow Corp.
See our ad refer to pages 49 57
Featuring pipe fittings valves hydrants and pipeline accessories for the waterworks industry. COMPIPE a new and innovative composite ... pipe in larger diameter pipe
Visit Booth No 839

EBAA Iron Inc.
Featuring products for underground joint restraint on mechanical joint ductile pipe valves and fittings flanges for steel process piping plastic saddles and fittings for plastic pipe. MJ retainer glands manufactured in sizes 2-36 in three styles are UL and FM listed saves end-user time and money over standard forms of joint restraint. E-Z Tap self-tapping valve allows the contractor to tap plastic main under pressure
Visit Booth No 419



The Ford Meter Box Co. Inc.
See our ad refer to page 16
Featuring a complete line of waterworks brass valves and fittings meter-setting devices and meter-testing equipment. The Ford pipe products line includes stainless steel repair clamps the unique 501 coupling system as well as a full line of ductile-iron tapping saddles. The Ford 501 coupling system uses color-coded end rings and gaskets which are interchangeable to cover the broadest range of ODs in the industry. All castings are ductile iron and the bolts are corrosion-resistant Mayari-R 50. The Ford Model ... drilling machine can be used on all types of main line material and will make taps up through and including 2 in. One machine does the work that previously required two or more machines
Visit Booth No. 136

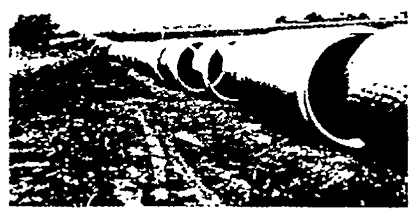
Foxboro Municipal Sales, Inc., The Foxboro Co.
Featuring "Meeting the Water Control and Management Challenge of the '80s" VideoSpec a CRT-based operator work station concept that incorporates all the functions necessary to monitor and control the plant. Fox 3 Computer System a microprocessor computer for plant monitoring and control features easy programming and standard software packages
Visit Booth No. 315

GA Industries, Inc.
See our ad refer to page 132
Featuring GA Valvecraft to solve valve problems Golden-Anderson waterworks valves surge control water level control check pump control pressure control and air release valves GA waterworks valves pump control check water level control, surge control air release and pressure control valves
Visit Booth No. 803

GEOMET Technologies, Inc.
Featuring services to identify measure, analyze and assess risk of health threats in the environment especially those posed by contamination of water sources by toxic chemicals
Visit Booth No. 428

Fisher Research Lab., FRL, Inc.
Featuring underground detection instruments to locate and trace service lines pinpoint leaks and find paved-over valve boxes. XLT professional leak detector amplifies the underground pipeline sounds and electronically filters out distracting sounds. TW-5 pipe and cable locator locates and traces underground metallic pipes
Visit Booth No. 225

L.B. Foster
See our ad refer to page 42
Featuring large-diameter steel pipe for water lines Fosterweld pipe four strategically located Fosterweld pipe mills provide a wide variety of wall thicknesses, diameters, and lengths. Steel pipe systems L B Foster provides the whole pipe package—pipe special fabrications, pipe coating to meet any specifications
Visit Booth No. 303

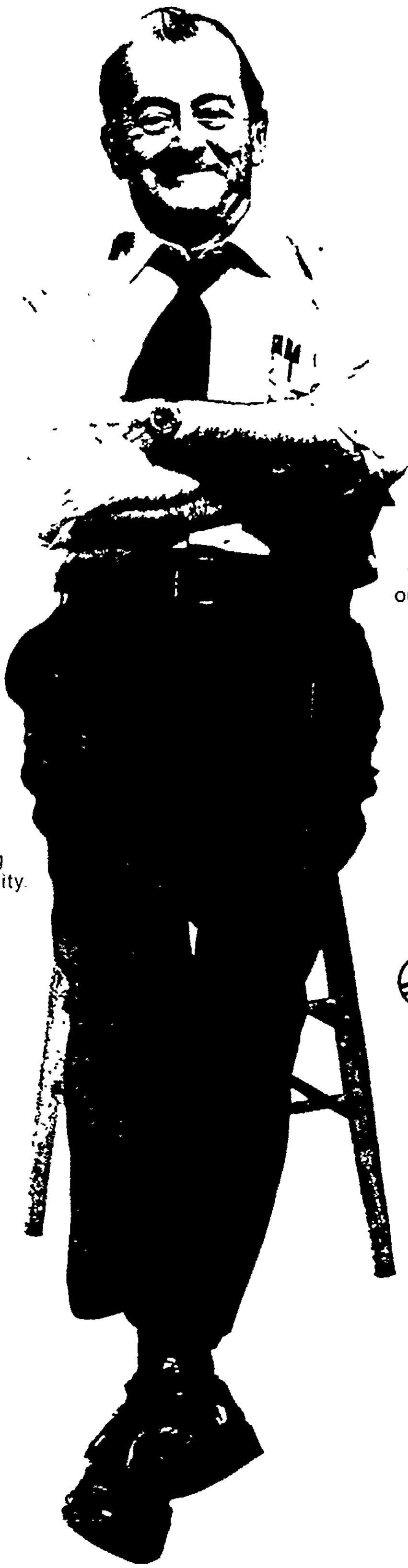


Gifford-Hill-American, Inc.
Featuring G-H-A's 35th anniversary of manufacturing concrete pressure pipe— "A Pipe for Every Water Works Need." Prestressed concrete-lined cylinder pipe L-301 and prestressed concrete-embedded cylinder pipe E-301 conform to AWWA Standard C301, in diameters 16 in through 144 in, for water transmission and distribution lines plant piping, etc. Pretensioned concrete cylinder pipe P-303 conforms to AWWA Standard C303 in diameters 10 in through 36 in, for water supply and distribution lines sewage force mains, etc.
Visit Booth No. 408

(Continued on page 88)

CAPCO JEN 0020705

RELAX.



TAP
TOTAL ACTION PROGRAM

WATER SERVICE IS ON THE JOB.

You can continuously, effectively eliminate taste, odor, color, and toxic organics from your water supply with HYDRODARCO® granular activated carbons, with little or no capital expense.

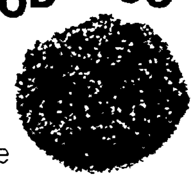
With the ICI Americas Total Action Potable Water Program the benefits are yours, the work is ours. TAP is a complete, custom designed carbon water treatment service that provides:

- A comprehensive plant review to determine the proper grade and amount of HYDRODARCO and the optimum operating conditions to meet your desired water quality.
- Equipment for the installation of HYDRODARCO in existing rapid gravity filters
- On-site water treatment expertise, laboratory analyses and technical and engineering assistance

Plus you choose from numerous options available that custom design the service to best meet your specific requirements. Financial arrangements can be custom designed, too.

Find out all the details in our new bulletin and put your water treatment worries to rest. Call our Purification Sales Manager at (302) 575-3549, or write ICI Americas Inc., Wilmington, DE 19897.

HYDRODARCO



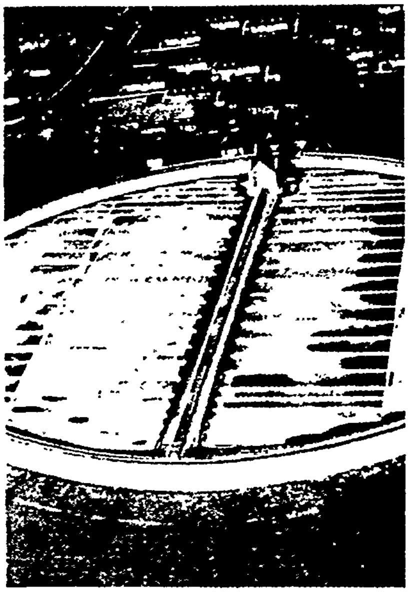
Acts Like A Sponge

ICI Americas Inc.

CAPCO JEN 0020706

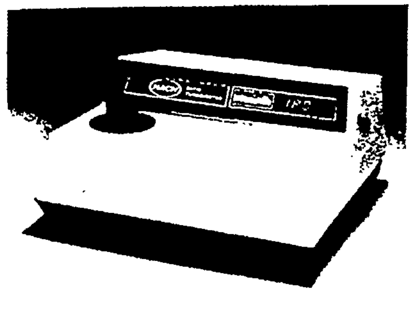
Continued from page 86

Girard Polly-Pig, Inc.
Featuring a full line of [illegible] water-main cleaners referred to in the trade as "aqua pigs." Our booth will be manned by distributors from all over the United States. Girard's Aqua Wire Brush Pig is designed to be used for removing hard buildups inside [illegible] water mains. The unit is a bullet-shaped, flexible foam cylinder that is hydraulically forced through pipes with restricted flow to restore full pipe capacity.
Visit Booth No 739

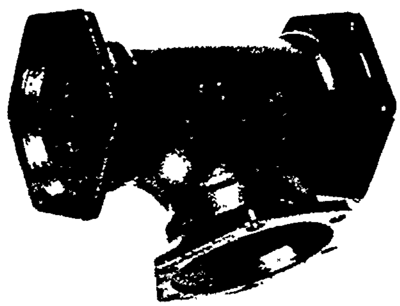


Globe Linings, Inc.
[illegible] covers [illegible] reservoir [illegible] chlorine [illegible] evaporation [illegible] seismic proof, long-term guarantee.
Visit Booth No 324

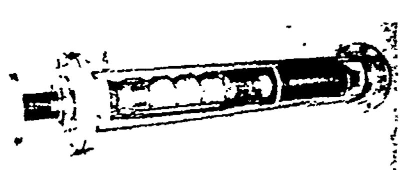
Griffin Pipe Products Co.
See our ad. refer to [illegible]
Featuring high quality ductile-iron pressure pipe and fittings designed and manufactured to meet or exceed ANSI/AWWA specifications. Available in 3-24-in. diameters with the push-on Super Bell-Tite joint or the easy-to-assemble mechanical joint. Griffin quality and service assure cost-effective, trouble-free installation.
Visit Booth No 519



Hach Co.
See our ad. refer to page 118
Featuring products for water and wastewater analysis. Pump-Colorimeter™ free chlorine analyzer from Hach Co. provides accurate continuous measurement of free chlorine residuals. Available in four ranges, these low-maintenance, on-line instruments feature reliable piston metering pumps, self-cleaning sample cell, alarm and controller capabilities, and split-beam, dual-wavelength optics for accuracy and stability. A Pump-Colorimeter total chlorine analyzer is also available. The Ratio™ turbidimeter, an exceptionally stable and accurate laboratory nephelometer with digital display, can determine turbidity down to 0.01 ntu in both highly colored and colorless solutions. It is available with recorder output and air purge. New slow-through cell accessory permits continuous monitoring of process streams.
Visit Booth No 824



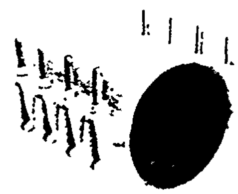
The Harrington Corp.
Featuring water and sewer main pipe fittings: Class 350 ductile-iron MJ fittings; new high-strength, lightweight ductile-iron fittings; PVC gasketed water and sewer main fittings; all molded PVC fittings incorporated square-shouldered gaskets that completely eliminate gasket roll-out problems.
Visit Booth No 232



Hayward Tyler Inc.
Featuring in-line submersible booster pumps. In-line Booster Barrel incorporates a submersible pump in-line to eliminate costly pump housing and noise pollution. Sumo submersible pumps and motors, all bronze and stainless steel for maximum corrosion resistance.
Visit Booth No. 818

Heath Consultants Inc.
Featuring worldwide services, products, and instruments for water system leak detection and underground pipe location. Heath Aqua-Scope, a rugged lightweight electro-sonic fluid leak detector for above-the-ground leak detection and pinpointing with ease and accuracy. Portable and stationary combustible and toxic gas monitors, safety monitors and detectors for protection in manholes, vaults, pits, and other confined work areas.
Visit Booth No. 548

Hydra-Shield Mfg., Inc.
Featuring tamper-proof fire hydrant cap that can only be removed with special wrench. The benefits include fewer caps to replace because of theft and large savings of water that would have been lost because of vandalism to the hydrant. The wrench, in addition to its cap-removing sections, has a pentagon socket to turn the top valve on the hydrant. This eliminates the need for fire companies to carry an extra piece of equipment for this purpose.
Visit Booth No 833



JCM Industries, Inc.
See our ad. refer to page 40
Featuring "Bullish On Service" to a service industry. JCM tapping sleeves, fabricated tapping sleeves for all types of pipe in sizes 6 in. and larger, can be shipped to meet your installation requirements. JCM universal clamp couplings to repair and connect all types and sizes of pipe, clamps can be shipped to meet your requirement, be it emergency or routine.
Visit Booth No. 817

(Continued on page 90)

CAPCO JEN 0020707

PATTERSON PUMPS

When pump performance counts...

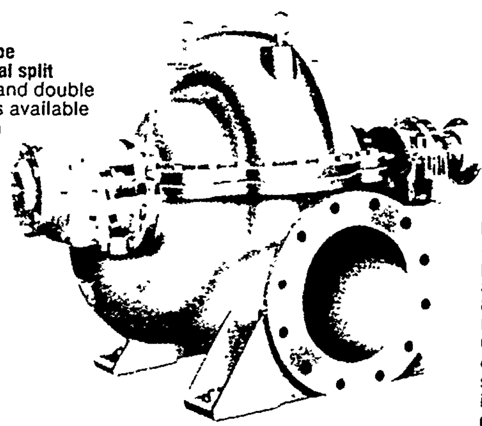
You can count on Patterson Pumps for dependability, efficiency, low operating costs and easy maintenance.

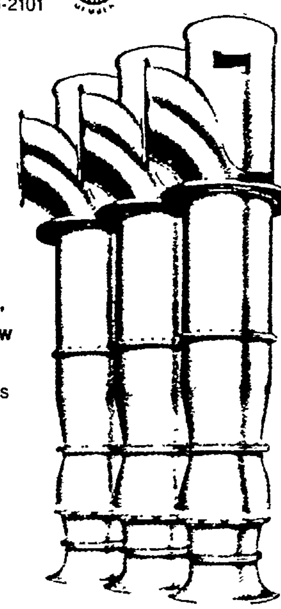
More than 75 years experience goes into every pump designed, built and tested to meet your requirements. A highly skilled work force uses modern manufacturing and testing facilities to produce pumps of unexcelled reliability. Every pump leaving the Patterson plant is individually tested and guaranteed to meet or exceed its specifications. In a growing number of applications worldwide, Patterson Pumps stand for "Progress Through Performance".

Call or write to find out how Patterson can fill your pumping needs.

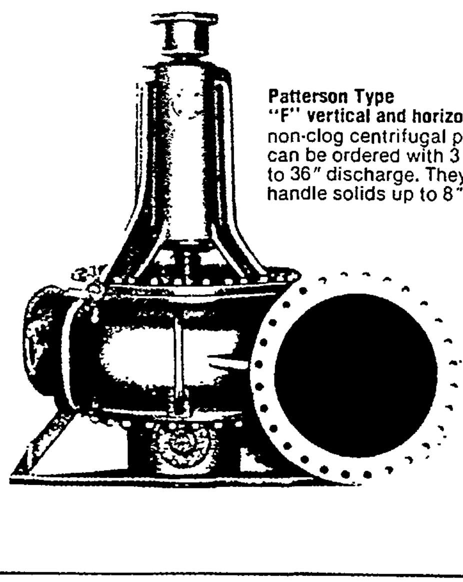
PATTERSON PUMP COMPANY
A SUBSIDIARY OF BANNER INDUSTRIES, INC.
TOCCOA, GEORGIA 30577 • TELEPHONE 404•886-2101

Patterson Type "A" horizontal split case single and double stage pumps available in sizes from 1½" to 54" discharge. Capacities to 100,000 GPM.



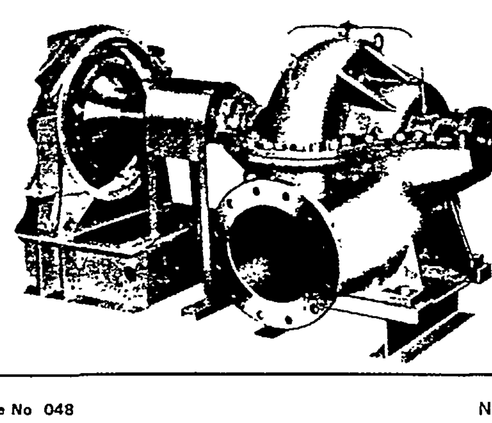


Patterson Type "G" axial and mixed flow pumps are available in sizes to 84" with capacities to 200,000 + GPM. Optional rotating element pull-out simplifies inspection and maintenance.



Patterson Type "F" vertical and horizontal non-clog centrifugal pumps can be ordered with 3" to 36" discharge. They handle solids up to 8".

Patterson Type "L" horizontal centrifugal fire pumps are built from 3" x 2" to 12" x 10" with capacities to 2,500 GPM. All are UL listed and FM approved.



CAPCO JEN 0020708

(Continued from page 88)

Johns-Manville Corp.

See our ad refer to page 34

Featuring Permastran® pipe meeting the requirements of AWWA Standard C950 for the water distribution and transmission markets Permastran® pipe is made by bonding continuous rovings of fiberglass and epoxy resin over a PVC core Available in 4 6 8 10 and 12-in diameters it is designed for operating pressures of 350 psi and must withstand a minimum quick-burst pressure of 1500 psi

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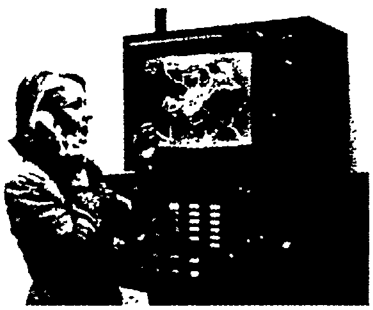

Kavouras Inc.

Featuring Radac Color Weather Radar provides [illegible] understood real-time weather information [illegible] images directly from the mammoth [illegible] Weather [illegible] the 500 000-watt S-band [illegible] country The precise [illegible] represents storm location [illegible] and intensity in order to [illegible] measure rainfall rates and [illegible]

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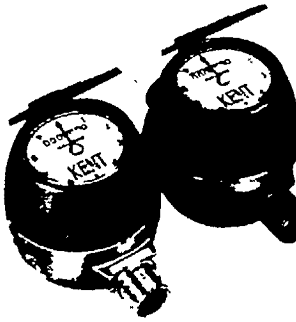


Kent Meter Sales, Inc.

See our ad refer to inside back cover

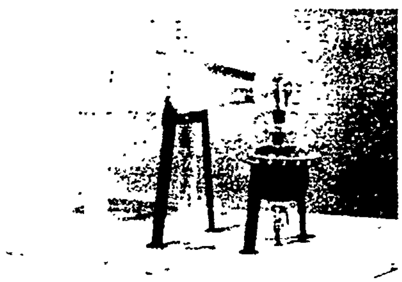
Featuring Kent bronze case and polymer case water meters bronze case and cast-iron case turbine meters remote reading meters and internal backflow check valves Kent Model C700 5/8-in through 2 in complete compliance with AWWA Standard C700-77 polymer cases available in [illegible] and [illegible] sizes backflow check valve optional remote reading optional Kent Series 2000 Turbine 1 [illegible] in through 20 in bronze case models from 1 [illegible] in through 6 in broad flow range low pressure drop high accuracy iron case models from 1 [illegible] in to 20 in

Visit Booth No. 139

George Koch Sons, Inc., Ashdee Div.

Featuring removal of trihalomethanes and synthetic organics naturally economically Hydro-fer air-stripping system for removal of trihalomethanes and synthetics from drinking water

Visit Booth No 125



Krebs Engineers

Featuring Krebs plastic display models of the KCSS and KD Water Desanders Models KCSS, KD KS Krebs Desanders designed specifically for the continuous removal of sand scale, and other particles from water

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Leopold Co., Div. of Sybron

See our ad refer to page 37

Featuring the new Leopold Simplex line of electronic instrumentation which includes a full-case receiver with digital indicator In keeping with the centennial conference theme Leopold will also display an early Simplex meter vintage 1920 [illegible] filtration equipment also will be displayed and information on other Leopold equipment will be available

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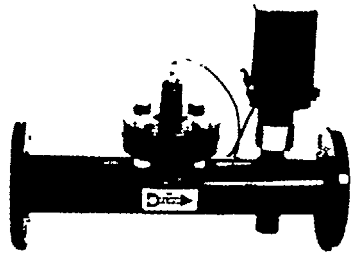

McCrometer, Div. of Ametek, Inc.

Featuring a wide range of flow meters to meet the demands of agriculture, municipalities, and industry Pressure variances and high temperature capabilities Electronic systems available for all models Standard parts, standard calibrations, and field serviceability Electronic turbo prop meter wide flow range and low pressure loss stainless steel bearing housing for measuring contaminated liquids, systems may be adapted to use model "M" or "ME" conversion modules to provide desired pulse and cable drive or local mechanical totalization or indication Flow controller flow proportioning accuracy of ±2 percent at up to 4500 gpm can be achieved, ideal where fixed rate of fluid is required, system includes electronic turbo prop meter, control valve with actuator, and flow control module

Visit Booth No. 924

A.Y. McDonald Mfg. Co.

See our ad. refer to page 119

Featuring underground service line valves and fittings, also a wide variety of meter setters, valves, and couplings Ball corporation stops available from ¾ in through 2 in for use with tapping machines or service saddles Angle ball meter valves the ¾-in and 1-in sizes have meter swivel nuts, the 1 ½-in and 2-in sizes have meter flanges

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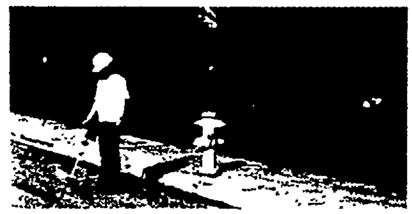


Metrotech Corp.

Featuring a full line of utility locator products including pipe and cable locators line tracers, ferromagnetic locators, valve box locators, and fluid leak detectors, plus accessory items. Model 810 automatic line tracer new computer-aided instrument has electronic guidance system to accurately pinpoint buried metallic pipes direct depth measurements are shown on its digital display Model 480 pipe locator this famous instrument is offered in a system approach with optional inductive probes and clamps to aid in locating hidden utilities with greater ease

Visit Booth No. 235

Motorola Inc.

Featuring Motorola's MX 300 series Handie-Talkie FM Portable Radio and Syntor, the first conventional synthesized FM two-way land mobile unit with industry-leading specifications The Syntor FM two-way radio utilizes a synthesizer to provide the most advanced method of generating frequencies The MX 300 series harnesses the performance capabilities of mobile radios in a truly portable package

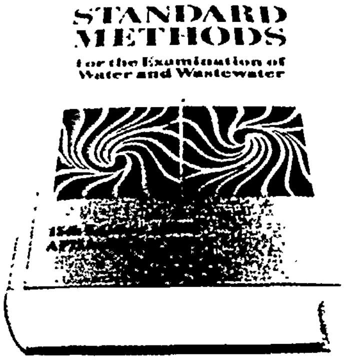
Visit Booth No. 816

(Continued on page 92)

CAPCO JEN 0020709

The Single Source

STANDARD METHODS for the Examination of Water and Wastewater
15th Edition



Thoroughly revised, refined and updated

At a time when environmental laws and regulations are constantly increasing in number and complexity - and compliance is more and more critical - scientists and technicians concerned with water problems can depend on *Standard Methods* for the most complete, detailed and up-to-date information on accepted methods of analysis of water and wastewater. First published in 1905 and now in its 15th edition, this manual provides sensitive and precise testing methods and procedures that will give consistent, reproducible and accurate results to meet today's needs.

Major changes in the 15th Edition

- The International System of Units (SI) is used in place of English units, except in a few instances.
- In view of new or proposed OSHA regulations and recent legal actions, greater attention is given to the subjects of laboratory safety and quality assurance.

Some important revisions and additions

- Emphasis on atomic absorption spectrophotometry as the preferred method of analysis of most metals.
- Revised sections on BOD, especially nitrification.
- New section on halogenated methane and ethane derivatives.
- Radiochemistry procedures expanded.
- New sections on Ra 228 and radioactive Cs and I
- New sections on special procedures for recovering stressed organisms, and on rapid microbiological technics.
- To supplement *Standard Methods*, a separately bound Appendix presents Government methods for water and wastewater analysis referenced in the *Federal Register*. No other single source provides this information along with generally accepted methods.

Contents (condensed) General Introduction/ Physical Examination/Determination of Metals Determination of Inorganic Non-Metallic Constituents/Determination of Organic Constituents Automated Laboratory Analysis Examination of Water and Wastewater for Radioactivity Bioassay Methods/Microbiological Examination of Water/Biological Examination of Water Index.

Published jointly by the American Public Health Association, American Water Works Association, and Water Pollution Control Federation. Joint Editorial Board: Arnold E. Greenberg, APHA, Chairman, Joseph J. Connors, AWWA, and David Jenkins, WPCF.

As stated in the Preface, the methods presented here "represent the recommendations of specialists, ratified by a large number of analysts...and as such are truly consensus standards, offering a valid and recognized basis for control and evaluation." *Approximately 1200 pages.*

AMERICAN WATER WORKS ASSOCIATION
6666 W. Quincy Ave., Denver, CO 80235

Order Form

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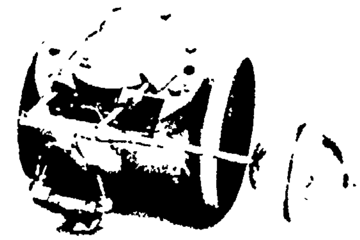

OCV Control Valves

See our ad refer to page 33

Featuring hydraulically operated diaphragm-actuated control valves for water and wastewater service up to 740 psi, temperatures to 180°F, pipe sizes from 1 ¼ in. to 16 in. Series 8000 float controlled valve controls liquid levels in tanks, ponds, and similar reservoirs; remote pilot may be used; automatic operation is fully hydraulic with no mechanical or electrical linkage. Series 3330 altitude control valves, one-way or two-way models for ground level control of water in elevated tanks 10 to 200 ft, operates fully open or tightly closed, maintains level within 4 in. of set point.

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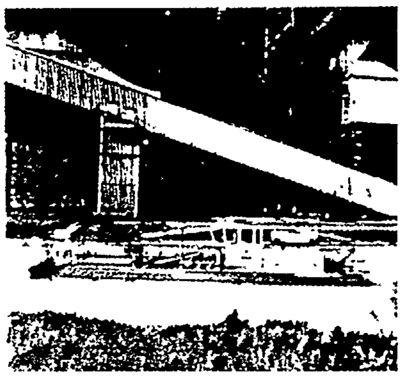
(Continued from page 90)



Mud Cat Div., National Car Rental

Featuring [illegible] systems. Mud Cat [illegible] used to remove silt [illegible] ponds, and a [illegible] Aquatic Weed [illegible] and economical way to [illegible] restore them to [illegible]

Visit Booth No 528

Mueller Co.

See our ad refer to page 14

Featuring the Mueller System—valves and hydrants from main to meter—one source. Mueller LINESEAL III butterfly valves are available in sizes from 12–48 in. and in mechanical joint, AC, or flanged ends. Mueller RSGV resilient seated gate valves are available in sizes 4–12 in. and in mechanical joint, AC, or flanged ends.

Visit Booth No 539

Natgun Corp.

See our ad refer to page 61

Featuring large-diameter prestressed concrete reservoirs. Shown is a recent achievement in Haverhill, Mass., of a 10-mil-gal precast prestressed concrete water storage reservoir, 206-ft diameter by 40-ft water depth.

Visit Booth No 410

Nipak, Inc.

Featuring high density, high molecular weight polyethylene pipe and fittings. Demonstrations will be showing the heat-fusion method of joining the pipe. Nipak sales staff will explain the sewer renewal method of sliplining. Nipak high density, high molecular weight polyethylene pipe is flexible, abrasion resistant, and non-corrosive. Since Nipak polyethylene pipe will not crack or corrode, it eliminates the problems of infiltration or exfiltration when in use. The flexibility of the pipe makes sliplining for sewer restoration easy and economical. Nipak polyethylene fittings, a wide variety of fabricated and machined fittings to complement the Nipak polyethylene pipe line.

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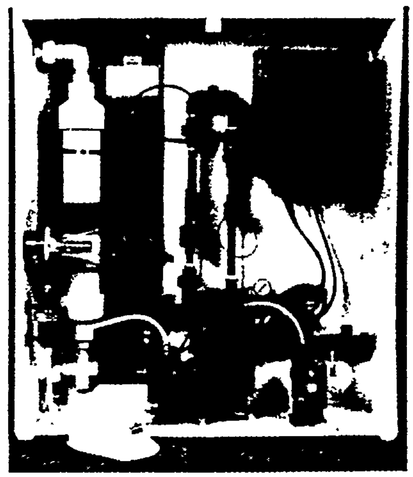


Olin Water Services

See our ad refer to page 67

Featuring Olin Water Services chlorine dioxide generators and ClO_2 application technology. ClO_2 is used for disinfection, THM control, taste, color, and odor control, iron and manganese removal in drinking waters. DIOXOLIN SYSTEMS® on-site chlorine dioxide generators designed for municipal water treatment applications. Olin 4010 liquid chlorine dioxide precursor chemical for use with the DIOXOLIN® process.

Visit Booth No. 122

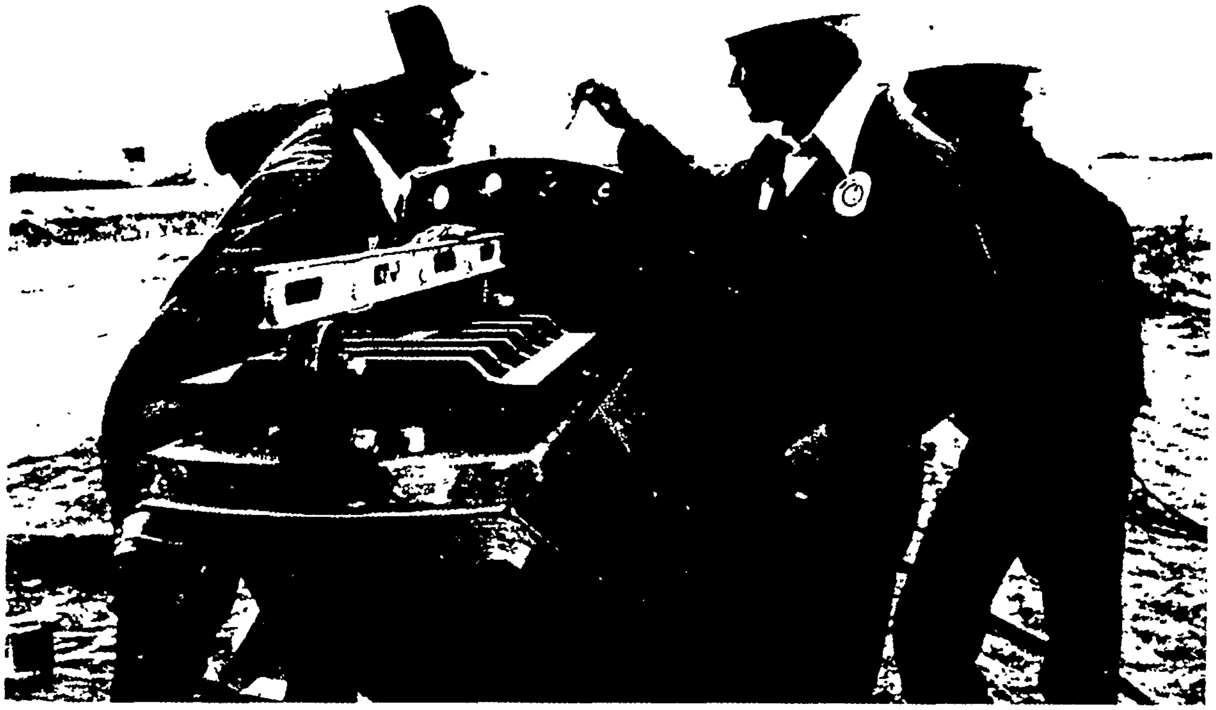
Pacific States Cast Iron Pipe Co.

Featuring ductile-iron pipe

Visit Booth No 122

(Continued on page 94)

CAPCO JEN 0020711



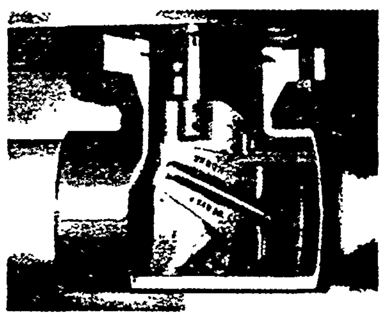
Water utility line relocated without interrupting flow to paper mill.

In Savannah, Georgia, a water utility needed to relocate a 42-inch line and still maintain water flow to a large paper mill.

Using two TDW Stopple® Plugging Machines and a 42-inch permanent bypass, TDW Services, Inc. routed flow around the site of new construction.

TDW Services, Inc. provides the technicians, the equipment and the capabilities to relocate, extend, repair or replace lines without interrupting service. Using the Stopple Plugging method, they can keep flow going through either temporary or permanent bypasses while temporarily plugging off the section of line being changed.

TDW Services, Inc. is the service division of T. D. Williamson, Inc., the pioneer and leading manufacturer of



Typical plugging head in sealing position inside the line

tapping and plugging equipment. Since the early 1950's, TDW has used hot tapping and plugging operations to make pipeline changes without shutdown.

Our pressure tapping and plugging capabilities range up to 60 inches.

Contact one of the following service centers to discuss your next job.

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Williamson International Corp. Chaussee de Charleroi 27
B 1060 Brussels Belgium

SOUTH AFRICA AND THE ASIA PACIFIC AREA
TDW P.O. Box 485 Tulsa OK [illegible] USA

Visit our booth at the AWWA Annual Conference in St. Louis.

TDW SERVICES, INC.
a subsidiary of T. D. WILLIAMSON, INC.
We put our experience on the line.

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Reader Inquiry Service No. 055

CAPCO JEN 0020712

(Continued from page 92)

Parco Engineering Corp.
Featuring water-hammer prevention. Parco Model DE surge control used with low head-loss power saving Parco valves to prevent water hammer because of starting and stopping pumps. Parco Hydraulic Oil Accumulator provides hydraulic oil under pressure for operation of all hydraulic valves in a pumping station.
Visit Booth No 712

Parkersburg Tank, Div. of Maloney-Crawford
Featuring AWWA D103-80 bolted steel tanks for potable water storage. Parkersburg tanks are used in storage of potable water and also in aeration and clarification processes and are used in water or liquid treatment facilities. Proven designs are available from 4000 to 858 000 gal plus accessories for specific application.
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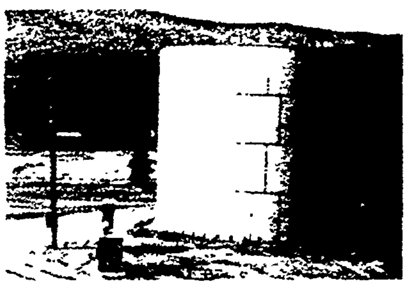

Peabody TecTank, Inc.
[illegible]
Featuring [illegible] storage tanks for containment of [illegible] water, wastewater, [illegible] water [illegible]. Factory-coated bolted steel [illegible] tanks economically [illegible] standard sizes available for [illegible] by experienced [illegible] maintenance [illegible] factory-applied thermoset epoxy coating; foundation designs available when necessary.
Visit Booth No 634

Pittsburgh-Des Moines Corp., (formerly Pittsburgh-Des Moines Steel Co.)
Featuring modern water storage in elevated steel tanks, standpipes and reservoirs. Elevated steel tanks, waterspheroid, double ellipsoids, torospherical, hydropillar, toropillar, pedestal spheres and spheroids. E-Cono-Ped. Ground storage tanks, standpipes and reservoirs of standard design or with embellishment such as pilasters and rings or aesthetic painting designs.
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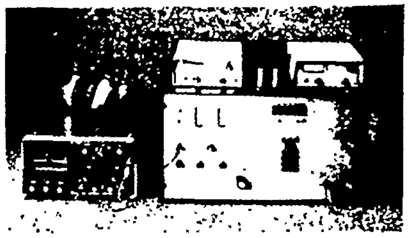

Plaunt & Anderson Sales Co., Inc.
Featuring leak detection and pinpointing equipment. DETECT-A-LEAK, a highly sensitive electronic listening device that specifies the presence or absence of a leak in a general area. LOCATE-A-LEAK once the presence of a leak is specified by the DETECT-A-LEAK unit, the LOCATE-A-LEAK machine pinpoints the location of the leak for accurate excavation and repair.
Visit Booth No 413

Joseph G. Pollard Co., Inc.
See our ad refer to page 55
Featuring water leak detection and pipe locating equipment, electronic metal detectors, safety, maintenance, meter and hydrant equipment. Pressure testing outfit consists of a hydrant flow gauge, a faucet pressure inspection gauge, a hydrant pressure gauge and a case. Gate valve and service box keys, a complete selection of combination tubular and adjustable wrenches are available in special lengths and infinite variations.
Visit Booth No 227

Polly Pig by Knapp, Inc.
Featuring a complete line of Polly Pig flexible pipeline cleaners of superior quality at reasonable prices available from the originators of Polly Pig products. Available in sizes 1 in through 108 in. Consult factory for custom styles to accommodate your specifications. Strip-C with internal port for flow-through of water, excellent for new construction cleanup before putting lines into service; removes debris and sand; provides cleaner, more efficient service to end user. Hydro Pig available with various outer coatings for light cleaning and scraping in lines with severe restrictions; removes minor films and debris from pipe wall; improves flow characteristics of pipe and saves in pumping costs.
Visit Booth No 318

Precision Meters, Inc.
See our ad refer to page 3
Featuring complete line of water meters in sizes 5/8 in through 20 in. Water meters-multi-jet multi-jet design featuring in-line repairability through precalibrated cartridges. Water meters--turbine multi-range turbine meters in sizes 3 in through 20 in featuring in-line repairability.
Visit Booth No. 815

Price Brothers
See our ad refer to page 133
Featuring prestressed concrete pipe in sizes 16 in to 144 in and larger. Applications include water transmission and distribution lines, gravity sewer lines, sewer force mains, power plant piping, industrial cooling lines, and subaqueous outfalls. A completely engineered joint system simplifies design and speeds installation. Concrete offers unsurpassed corrosion resistance. Meets AWWA standards.
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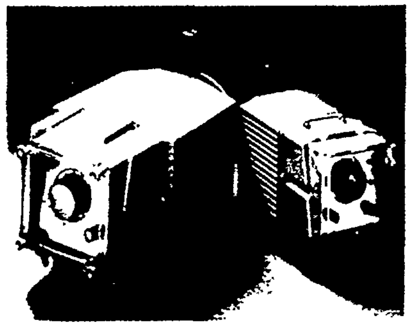

Prominent Fluid Controls, Inc.
Featuring metering pumps. Electronically activated, diaphragm pumps controlled by flow, pH, ORP, analog signal. Bello Zon Chlorine dioxide system designed for on-site generation of chlorine dioxide; compact, prewired, preplumbed and simple to operate.
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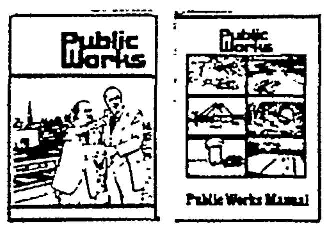
Protective Coatings, Inc.
Featuring protective coatings. Manufacturer of industrial specialty rubber products will feature rubber expansion joints for pressure piping and ducting systems and rubber lining capabilities for pipe and pipe fittings. PROCO 240 molded expansion joint an economical way to eliminate piping problems of movement, vibration, sound transmittal and electrolysis. TRUE Rubber Lining to protect pipe and pipe fittings from abrasion and chemical attack.
Visit Booth No. 207



Public Works Publications
Featuring publications, operational handbooks, and marketing data on water utilities. Of special value and interest to waterworks utilities, consultants, contractors and marketers. PUBLIC WORKS magazine, featuring several articles

(Continued on page 96)

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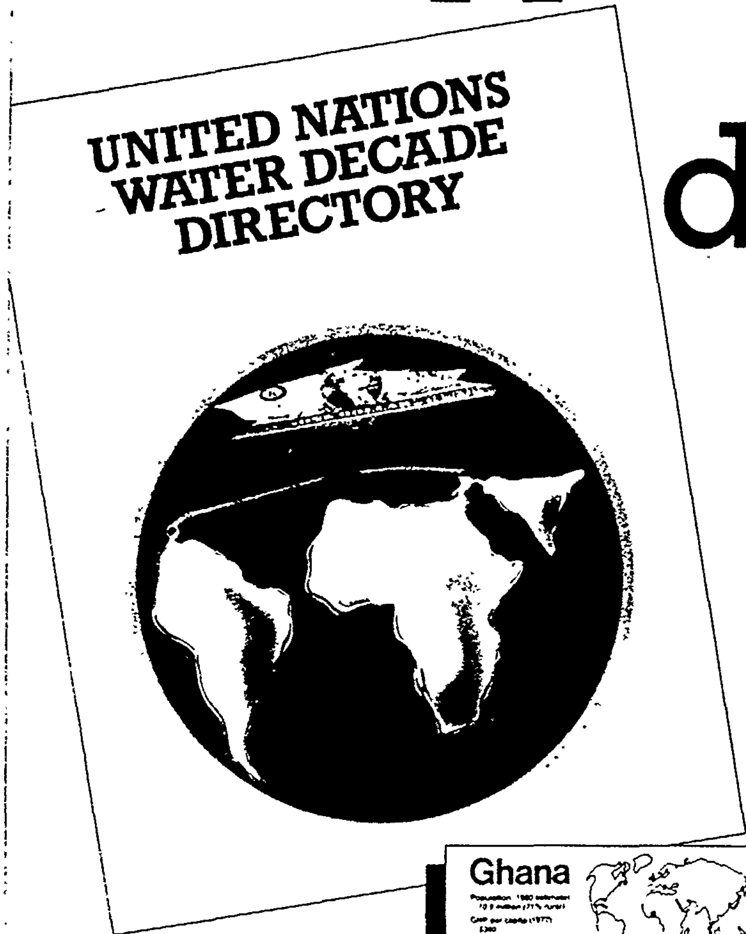
The opportunity of a decade



1981 1990

Don't miss this unique opportunity to obtain a copy of the nation by nation guide to Water Decade spending plans.

To be published in April, 1981, $100.00. Reserve a copy now by sending an order to the address below.

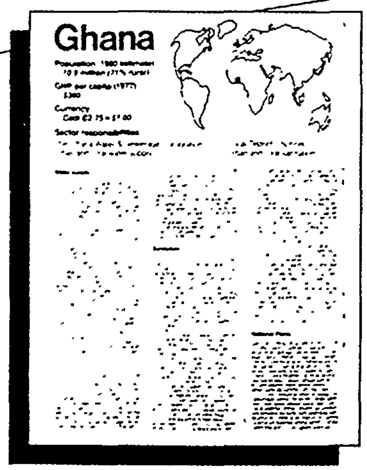
Also, the Directory will carry a limited number of advertisements For details of these pages please contact Ian North at the address below.

The United Nations International Water Decade launched in November [illegible] is influencing water supply and sanitation sector programmes worldwide

The Directory published by World Water in collaboration with the World Health Organisation contains around 300 pages of digests indicating spending plans and priorities in each country The Directory is to be used by UN representatives and national governments to monitor progress towards the Decade targets

Each entry will include demographic, economic and social statistics, details of responsible government departments; current status (coverage) of water and sanitation, actions and projects required, potential for external cooperation; and UN experts' assessment of country's capacity to handle accelerated sector investment.

The directory provides a valuable aid to defining the markets for all water and sanitation based products and services



WORLD WATER

Telford House, PO Box 101
26/34 Old Street
London EC1P 1JH England
Telephone: 01-253 9999
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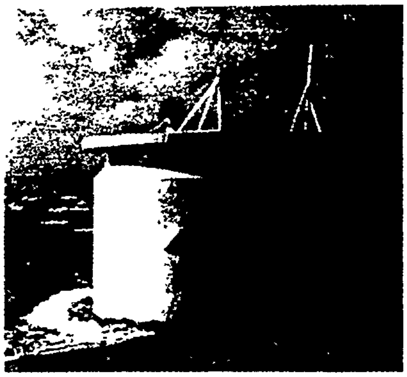
(Continued from page 94)

dealing with waterworks operations will be on display. Public Works Manual section C describes techniques, equipment, supplies and services used in the design, construction, operation and maintenance of waterworks programs and projects.
Visit Booth No. 834

Publishers for Conventions, Inc.
Featuring National Convention News distributing free copies of the National Conventioneer, a reference book of product literature relevant to the field of water.
Visit Booth No. 812



The Ranney Co., Ranney Method Western Corp.
Featuring large-scale water development for municipalities and industries the most economical groundwater and surface water systems. Ranney Collector Well designed to extract groundwater or filter seawater from sand and gravel aquifers capacities range from 0.5 mgd to 20 mgd from a single unit. Ranney Surface Water Intake Ranney's Johnson-screen intake screen system is environmentally sound, designed with no moving parts to be virtually maintenance free.
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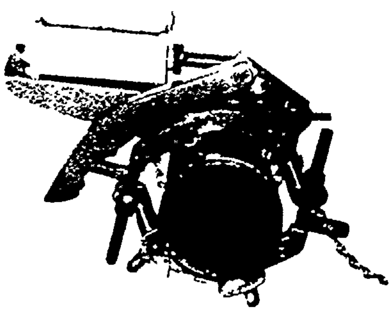

Reed Mfg. Co.
Featuring pipe tools Powered ductile pipe cutter air or hydraulically operated Reed rotary cutter cuts ductile iron pipe 5 in.-34 in. faster cheaper safer. Ratchet Shear for cutting up to 1 in. CTS PEPB tubing and schedule 40 PVC, PE and ABS pipe.
Visit Booth No. 807


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AIR · WATER · WASTE · NOISE · OCEAN
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Featuring trade publications *POLLUTION EQUIPMENT NEWS* a bimonthly publication, provides product information for specification, purchase, installation, and maintenance of air, water, waste, and noise pollution control equipment. *INDUSTRIAL HYGIENE NEWS*, including the Science of Toxicology a bimonthly publication presenting products for measuring and controlling employee health in the work environment, products are included for toxicological evaluations related to industrial hygiene.
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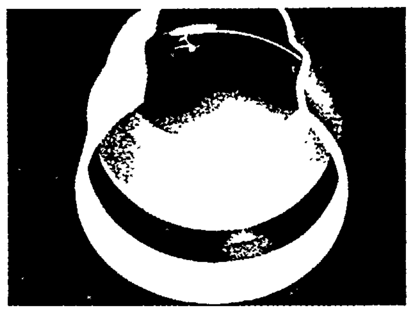

Robintech Inc.
Featuring plastic pipe and fittings for potable water distribution. Robintech's White Knight® pipe with the King's Joint™ joining system PVC pipe in diameters of 4, 6, 8, 10 and 12 in. meeting AWWA Standard C900. Three pressure classes are available 100, 150 and 200, each length is hydrostatically tested at four times its rating.
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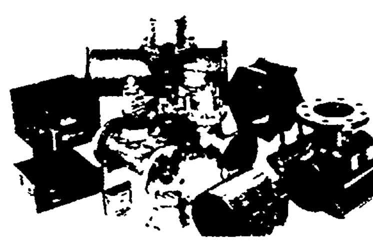
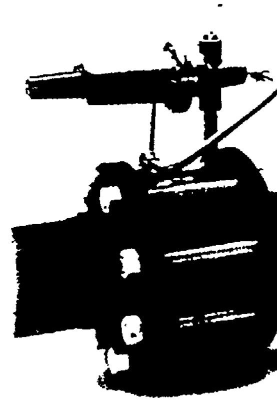


Rockwell International, Municipal & Utility Div.
See our ad, refer to page 31

Featuring how water utilities can reduce operating costs and increase revenues by purchasing the proper meter. Rockwell water meters and electronic instrumentation: sealed register water meters, compound and turbo meters, for water wastewater and irrigation applications, remote reading systems and ACT-PAK electronic instrumentation for monitoring, recording and controlling flow. Rockwell clamp and coupling products full circle clamp couplings cast and steel couplings, compression couplings tapping sleeves and saddles, pipe repair clamps, expansion joints, flanged coupling adapters.
Visit Booth No. 507



Roll Seal Valve Co.
Featuring Roll Seal automatic liquid control valves. Roll Seal valve automatic control valve with only two parts—a stainless steel body and an elastomeric liner or control element. Roll Seal Model 80 pilot control for pressure reducing, pressure sustaining, relief applications.
Visit Booth No. 307

Ross Valve Mfg. Co., Inc.
See our ad, refer to page 102
Featuring application of automatic control valves in municipal water systems. Sectional view of 6-in. pressure reducing valve.
Visit Booth No. 708

Schonstedt Instrument Co.
Featuring Model GA-52 magnetic locator, which has proven to be particularly useful for locating objects, such as shut-off valves, manhole covers, hydrants, and other iron objects covered by deep layers of snow and soil. The instrument functions by detecting the magnetic field of the object. Ice, snow, water, etc. do not affect its performance. Because the instrument detects the magnetic field of iron objects, it can detect these items at substantially greater range than can conventional metal detectors.
Visit Booth No. 932

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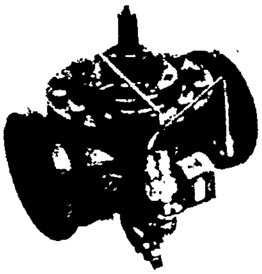

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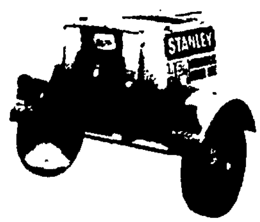

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(Continued on page 98)

The New England Water Works Association Announces the Re-publication of Clemens Herschel's Translation of

THE WATER SUPPLY OF ROME

by Sextus Julius Frontinus
Water Commissioner, City of Rome AD 97

This classic on early water supply engineering and administration which has been nearly lost is re-published by the New England Water Works Association as a service to the profession.

Included are the several chapters of explanation by Herschel and an introduction by R.H. Babcock, PE and James J. Matera, PE. This work, an immortal classic of engineering reporting, should be in the library of every water supply engineer and administrator as well as students of Latin and ancient history. Provides an excellent gift to schools, libraries, and friends. This is a limited edition. Do not delay—order promptly.

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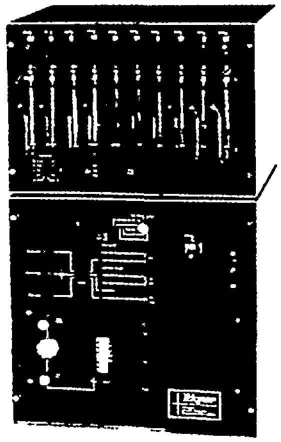
CAPCO JEN 0020716

Continued from page 97)



Tekmar Co.

See our ad, refer to page 112

Featuring automated purge-and-trap concentrators for analysis of volatile organic pollutants in water as well as a complete line of ion specific electrodes and dissolved oxygen meters. LSC-2 ALS automated purge-and-trap concentrator Model ALS interfaced to the LSC-2 permits the automated analysis of as many as 10 water samples for volatile organic pollutants, utilizing either frit or needle spargers. LSC-3 Semi-automatic Liquid Sample Concentrator is the newest of the Tekmar concentrators; the low-cost unit features heated sample lines and valves and an automatic drain, meets all USEPA requirements for THM and priority pollutant analysis.

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Trico Industries, Inc., Columbian Div.

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Tyler Pipe, Utilities Div.

See our ad, refer to page 47

Featuring pressure pipe fittings and municipal castings for the waterworks and process piping industries. Tyler Pipe will exhibit its complete line, including water main fittings for cast-iron, asbestos-cement, plastic, and fiberglass pressure pipe, flanged fittings and fabricated flanged pipe; valve, service, and roadway boxes; meter boxes; swivel hydrant fittings and adapters.

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See our ad, refer to back cover

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Water and Sewer Distributors of America

Featuring a rapidly growing organization with 55 member companies throughout the United States. The WASDA exhibit highlights the purposes and locations of WASDA members throughout the country. The most effective way to market water and sewer materials is through a netword of qualified water and sewer distributors; local distributors best fulfill the servicing needs of municipalities, contractors, and others.

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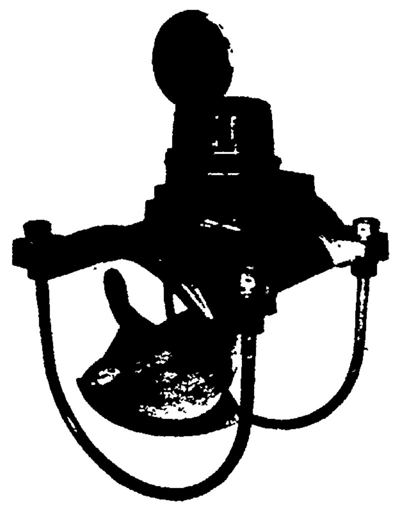

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CAPCO JEN 0020717

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See our ad, refer to page 71
Featuring an extensive line of fire hydrants and valves including three new products a resilient-wedge valve a butterfly valve and a new double-disc valve The resilient-wedge valve is a unique valve with a design that will set the standard for the rest of the industry to follow The butterfly valve is designed to make maintenance easier and less costly
Visit Booth No. 607

Waukesha Engine Div., Dresser Industries, Inc.
Featuring our line of gas and diesel engines from 30 to 2845 maximum hp and engine generators up to 1800 kW per unit for pumping compressing, and other water treatment applications
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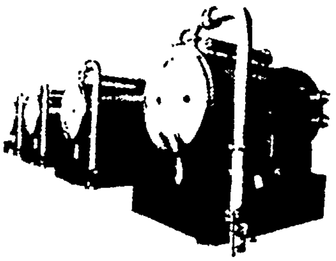

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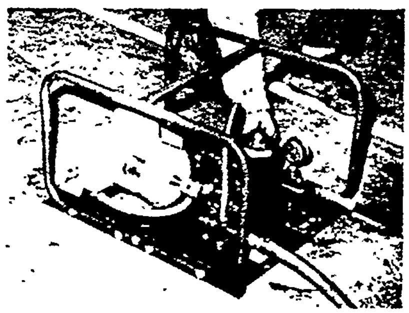

Wheeler Mfg. Corp.
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See our ad refer to page 93
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Visit Booth No. 713

SPECIFICATION FOR COLD-WATER METERS FOR CUSTOMER SERVICE

Sec. 1—GENERAL

Sec. 1.1—This specification covers Cold-Water Meters in sizes ⅝" through 2" for materials and workmanship.

Sec. 2—MATERIALS

Sec. 2.1—Main Casings, Register Box Rings and Lids shall be made of a copper alloy containing not less than 81% copper.

Sec. 2.2—Rotor Spindles shall be made of #316 stainless steel.

Sec. 2.3—Couplings and Companion Flanges shall be made of a copper alloy containing not less than 81% copper.

Sec. 3—GENERAL DESIGN

Sec. 3.1—Size and Performance Characteristics—shall equal or exceed all the applicable requirements of (American Water Works Assoc.) Standard No. C-708-76.

Sec. 3.2—Registers shall be of the magnetically driven type.

Sec. 3.3—Strainers shall be easily removable without disassembling the meter.

Sec. 3.4—Optical Magnifiers shall be included to enhance the readability of the number wheels.

Sec. 4—UNCONDITIONAL GUARANTEE

If within 5 years any meter is found to be defective under normal potable water use it shall be repaired or replaced by the manufacturer.

Courtesy of:

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NATIONWIDE 800-327-4325

Reader Inquiry Service No. 018

CAPCO JEN 0020718

AWWA Returns to St. Louis in a Dedication to Past and Future

The international conference of AWWA will return to its birthplace in 1981 when the worldwide organization will meet in St. Louis, June 7–11, to celebrate its centennial.

Headquarters of the week-long meeting will be the new $30 million Cervantes St. Louis Convention Center covering four square blocks in downtown St. Louis The center sits in the midst of a new 16-block convention plaza development containing hotels, shops, restaurants, entertainment areas, and a number of parking garages. It is within walking distance of the Mississippi Riverfront, the famous Gateway Arch, and Busch Memorial Stadium.

As early as 1879, some thoughts and correspondence about a meeting of "western water works administrators" were circulated, but it was finally formalized two years later.

On Mar. 29, 1881, when there were fewer than 1000 public water supplies and but a few rudimentary water treatment plants in the United States, 22 men gathered in Engineers' Hall at Washington University, which at the time was on the riverfront in St. Louis, to organize an "American Water Works Association."

The purpose of the organization, as stated in the preamble to its first constitution adopted on Mar. 30, 1881, was "for the exchange of information pertaining to the management of waterworks, for the mutual advancement of consumers and water companies, and for the purpose of securing economy and uniformity in the operation of waterworks."

The 20 individual and four manufacturer members who were enrolled by the end of that first convention thus formed the vanguard of what was to become the largest group of organized professional water supply people in the world.

It was not until 1910 that AWWA membership reached the 1000 mark, and it took another 14 years before that number had doubled. Today, the association's membership is more than 32 000, and about 10 000 are utility executives.

In the early years, AWWA members assembled only once each year to exchange information and discuss the progress of the industry. Records of the technical papers presented, and manufacturers' products exhibited, and business conducted at these annual meetings were published in a single volume of proceedings

By the time AWWA membership had grown to more than 1000, however, a need was recognized for breaking up these meetings into separate discussion groups on specialized topics Thus, in 1913, it was proposed that the association establish topical divisions to consider matters of special interest. The first such division was the Chemical and Bacteriological Division (now the Water Quality Division), formed in 1913. At present, AWWA has four functional divisions—Water Quality, Resources, Distribution, and Management.

An important step forward in the expansion of association activity was the formation in 1914 of its first regional section, the New York–New Jersey Section.

The Missouri Section was organized and first met in October of 1946 in Columbia, Mo. During the 1968 section meeting in St. Louis, a plaque was dedicated at Washington University memorializing the founding of AWWA on the campus and naming the 22 men who started it all.

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Reader Inquiry Service No. 033

CAPCO JEN 0020719

Centennial Celebrations Catch the 'Spirit of St. Louis'

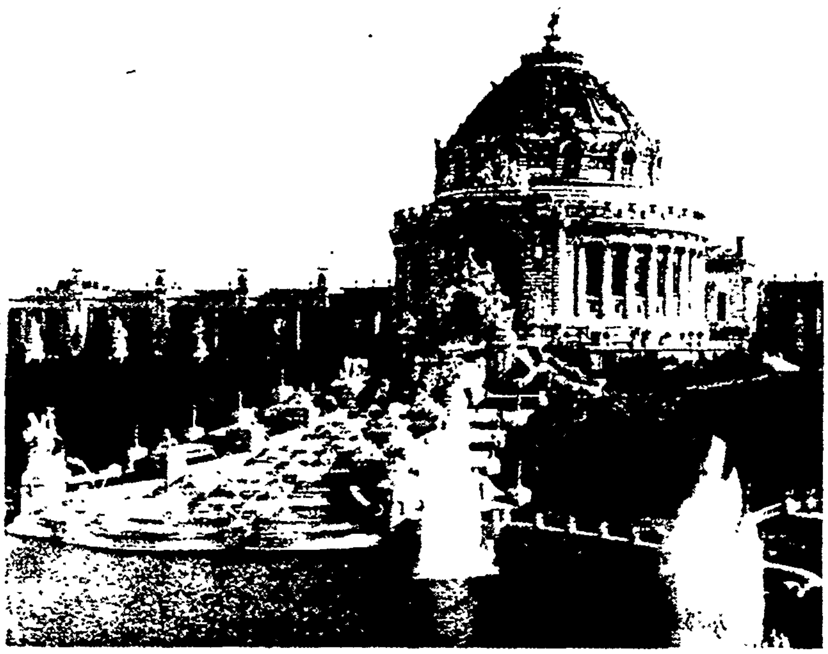


Photo courtesy of the Missouri Historical Society, St. Louis Mo

The World's Fair in 1904 commemorated the centennial of the Louisiana Purchase. Before water from the Big Muddy could be used for the baroque fountain display in front of Festival Hall, the water had to be treated. J.F. Wixford developed a clarification process to turn the turbid water from the Mississippi River into clear cascades.

Jazz, foamy tankards, the rolling Big Muddy, old-fashioned harmony, the drama of pennant competition—this is a part of the essence of St. Louis that will become the spirit of ACE 1981.

Returning to the place of its birth for this historic celebration, AWWA is planning special activities, decor and exhibits, in addition to an excellent technical program.

A stately, but colorful and fast-paced program is planned for the opening general session. Bunting and bugles will herald AWWA awardees and a not-to-be-missed keynote speaker.

Happy birthday, AWWA! A cake-cutting will start off the exposition opening and "meet & greet." Attendees will enjoy a *Biergarten* setting, complete with German folk dancers, ragtime bands and of course beer before visiting the exhibits.

Annual banqueters will don "boaters" and join in a barbershop sing-along. Song lyrics printed in a souvenir menu will prompt post-gramophone-era harmonizers. Ragtime pianists, the Amhurst Sax Quartet and the Ragtime Ensemble will recall the atmosphere of the riverfront and the ethnic culture of the city.

Old and new will come together in the Theme Center located in the exhibit hall. A turn-of-the-centruy "centennial village" is the backdrop for an exhibit of vintage waterworks equipment. The antiques, loaned by AWWA members across the country, show how far the industry has come over the years.

The "village theater" has an exclusive on a new AWWA sound-slide show. The show tells the story of AWWA's past accomplishments and future goals, and another display of still photography gives a concise visual account of AWWA functions and services.

Free afternoons and evenings will be what you make them. choose from showboat cruises, champagne dinners, nightlife, museums, brewery tours, sports . . . St. Louis has it all. Representatives from the St. Louis Scene will be in the registration area to help with plans and reservations.

A full schedule of activities is planned to acquaint spouses with the many facets of St Louis. After the bustle of downtown, spouses will enjoy a relaxing afternoon at the Missouri Botanical Gardens, followed by a historic homes tour. Also scheduled is a St. Louis highlights tour, ending with a Saint Louis Symphony "pops" concert. Many optional tours and activities can be arranged for those who wish to explore further AWWA's centennial city.

As an enduring commemoration of the event, a bronze casting of the centennial emblem will be added to the stone marker already in place at Washington University. It was at the University that AWWA founding fathers met on Mar. 29, 1881. A small ceremony including AWWA officers, board members, and university officials will mark the addition to the monument.

Every conference attendee will have the opportunity to take home a permanent memento of the centennial. A special commemorative magazine will be distributed free to all technical registrants. It will be on sale to others at the conference or by mail order. The magazine contains more than 100 pages of articles, photographs, and illustrations recounting the past and commenting on the future of the water industry, and AWWA.

Other souvenir items can be purchased at the conference or from headquarters.

One thing every conference attendee can take with him is the spirit of the centennial. This "spirit" has a lot in common with the spirit of St Louis. A lesser known story from the annals of water treatment history illustrates this:

At the turn of the century, St. Louis was a twitter making plans for the World's Fair. The centerpiece of the fairgrounds was to be a baroque display of fountains and cascades. This grand scheme had a serious drawback; the only water source was the muddy Mississippi.

The water department hired John F. Wixford, a genius of sorts with eccentric habits, to investigate the problem. Wixford went to work and soon came up with a new clarification process. It worked like a miracle on the turbid water. Clear, sparkling water rippled from the cascades and quenched the thirst of throngs of visitors. Wixford did his city proud and made an important contribution to purification technique.

A St. Louis native, Wixford had the pioneering spirit of the gateway city. This spirit of innovation and dedication will inspire AWWA members for another 100 years.

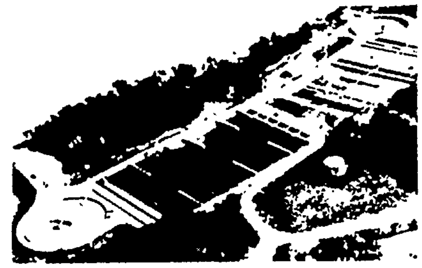
CAPCO JEN 0020720

Facility Tours Evoke Images of Mark Twain

Those far-away places with strange-sounding names are really water treatment plants for the St Louis city and county water utilities

This year the annual conference facility tours will visit Hog Hollow, Howard Bend, and Chain of Rocks water treatment plants, Tuesday and Wednesday, June 9 and 10.

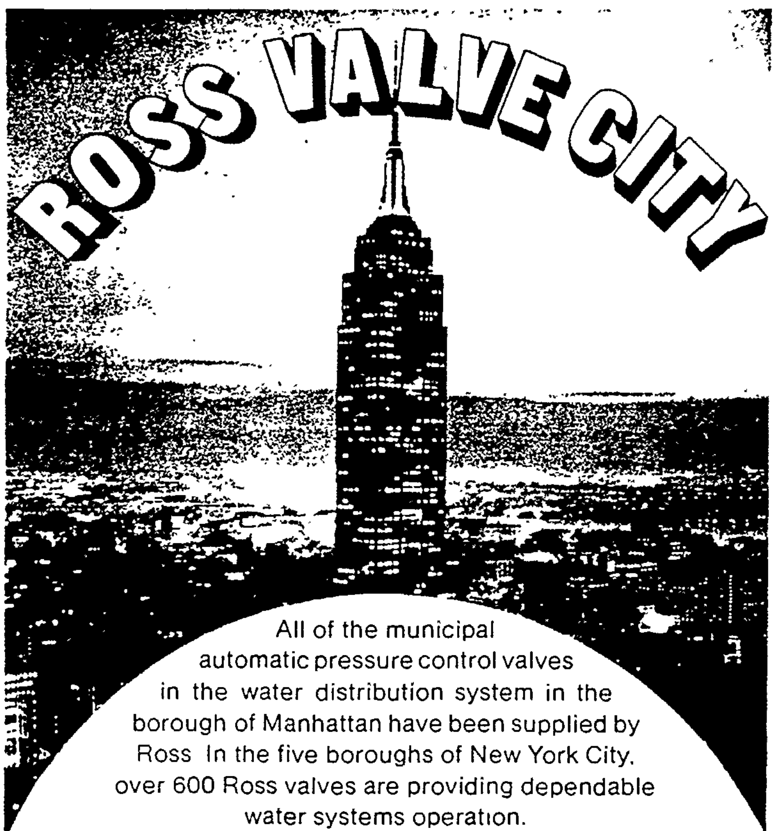
On both mornings, tour A will leave the Cervantes Convention Center at 8:30 a.m. to visit the Hog Hollow and Howard Bend plants, returning about 1 00 p m. Leaving the center about 1:00 p m. on Tuesday and Wednesday, tour B will take in the Chain of Rocks Water Treatment Plant, getting back about 5.00 p m. in time for evening plans. Each tour costs $15 and includes transportation, tours, and a light repast Registration for the tours can be made on the technical registration form or at the registration area of the convention center Sunday through Tuesday, June 7-9.



The Hog Hollow Water Treatment Plant is a 180-mgd facility of the St. Louis County Water Company. The plant treats Missouri River water with clarification, filtration, softening, and chlorination processes. Built in stages between 1930 and 1970. Hog Hollow has the most modern plant configuration in the water company's system. The 1970 addition is a single outdoor sand filter basin with chemical feed from an adjacent building; water is pumped directly from the basin into the distribution system The highlight of the Hog Hollow tour is its trace substances laboratory developed in response to the Safe Drinking Water Act and the attendant regulations of the US Environmental Protection Agency The laboratory uses a Finnigan gas chromatograph-mass spectrometer to analyze water samples for volatile organic pollutants. In addition, the laboratory also monitors for pesticides and heavy metals.

The Howard Bend Water Treatment Plant, owned and operated by the water division of the city of St. Louis, is located outside the city limits. The plant treats Missouri River water and is rated at 160-mgd but with the ability to pump 210-mgd from the underground filter basins and the 5-mil gal clearwell storage. Water is pumped to a 100-mil gal storage facility on the city distribution system. In addition to sand filtration, the plant utilizes liquid chemicals, like ferrous sulfate solution and liquid polymers The tour will feature the storage area for bulk liquid chemicals.

Tour B will visit the Chain of Rocks Water Treatment Plant, a facility of the city of St. Louis water division located on the Mississippi. The plant has the capacity to treat 388-mgd of surface water drawn from the Missouri River or the Mississippi or both. The plant's intake on the Missouri side of the Mississippi River draws only Missouri River water; the intake on the Illinois side of the Mississippi draws water from "Ol' Man River." The chemical treatment basins are located outside and the sand filters inside. It takes from one to three days for water to travel through the plant. The laboratory at Chain of Rocks tests for pesticides, herbicides, and trace metals.



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 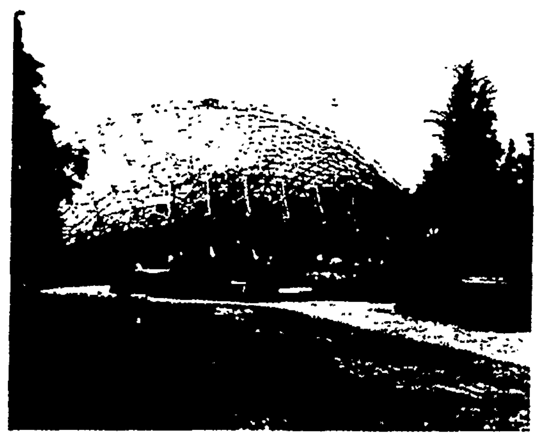

Gateway City Opens Door of Hospitality to Spouses

A stroll through the famous geodesic Climatron at the Missouri Botanical Gardens, the strains of the Saint Louis Symphony, and old and new friends at the Ladies' Hospitality Center are only a few of the offerings of this year's dynamic ladies' program at the AWWA annual conference, June 7–11, in St. Louis.

To start off the week, everyone is invited to the opening of the exposition at noon on Sunday, June 7 In the exhibit hall of the Cervantes Convention Center, the traditional "meet and greet" will feature entertainment from German and ragtime bands in a beer garden atmosphere, replete with refreshments, from 12 to 5 p m Also at the Cervantes Center, the Convention and Visitors Bureau of Greater St Louis will show two films on St Louis At 2 p m the movie will take viewers on a fast-paced armchair tour of St Louis and its many attractions The 3 p m show will detail the building of a modern marvel—St Louis Gateway Arch

Monday morning, spouses are invited to the opening general session to enjoy centennial entertainment, hear the well known keynote speaker, and applaud AWWA's winners at the awards ceremonies That afternoon participants will depart for a tour of St Louis through the historic South Side and the Lafayette Square and Soulard restoration areas, past the large complex of Romanesque and modern buildings of the Anheuser-Busch Brewery. At the Missouri Botanical Garden visitors will see the Climatron with its jungle of tropical plants, the Desert and Mediterranean houses, and the new 10-acre (4-ha) magnificent Japanese Garden. To complete the introduction to St Louis, a glass of wine complements a visit to one of St Louis' fascinating and historic homes.

Another tour of St Louis on Tuesday highlights new sights—the Riverfront area with the Old Courthouse, the Old Cathedral, the Gateway Arch, and the riverboats; Busch Memorial Stadium; Union Station; and St Louis University A visit to the New Cathedral will showcase the largest collection of mosaics in the western world, which cover nearly the entire interior AWWA sightseers will wind their way through Forest Park, site of the 1904 World's Fair and home of the Art Museum, the Muny Opera, the zoo, McDonnell Planetarium, and Jefferson Memorial, and stop to enjoy a glass of refreshing ice tea. After lunch at one of St. Louis' stylish restaurants, the buses will whisk the group to Powell Hall for a special pops concert by the renowned Saint Louis Symphony The tour will return to the Sheraton St Louis in mid afternoon—in time to relax before embarking for evening engagements

On Wednesday, the Ladies Program will offer participants two exciting speakers Clarissa Start, St Louis columnist and author of several books, will lecture on the best buys in antiques today In her talk, "We Buy Junque, We Sell Antiques," she will share what she has learned as an amateur going into the antique business and what you should not throw away as "junk" but keep as "junque"

The second speaker will discuss "Winning the Aging Game." Gary Couture, nutrition consultant, is associated with the Julian Medical Center in Hollywood, Calif., and the Duvendack Medical Center in Huntington Beach, Calif. He is a frequent lecturer on nutrition and health for professional and civic organizations and author of the popular book *How to Win the Aging Game.*

The ladies' program will repeat a successful innovation from last year's conference—a special technical session on Thursday morning. This year the session will feature three speakers Muriel Glasgow of the United Nations Children's Fund (UNICEF) will present "Water Means Life," a combination of film and lecture about the role of women in the public health aspects of community water supply, especially in underdeveloped countries. Jo Ann Dreas of the sex crime section of the St. Louis Metropolitan Police Department will discuss safety on the streets. The third speaker will be Abel Wolman, one of the most respected experts in the water supply industry.

Also on Wednesday and Thursday, several optional tours will be available at an additional charge, for those who wish to ride to the top of the Gateway Arch, cruise on the Mississippi, visit the estate of August Busch, Grant's Farm; journey to St. Charles, Missouri's first capital, tour three of St. Louis' most famous historic homes; or shop at Plaza Frontenac

Throughout the week, the Ladies' Hospitality Center will provide a special place for new and old friends to gather for morning coffee, a game of bridge, or relaxed conversation. A special memento of St. Louis will be given out at the hospitality room, located in the St. Louis Sheraton

Spouses are especially welcome at the closing luncheon, a new feature at the centennial conference. The luncheon will be held Thursday at noon and costs $10. The annual banquet will be held on Wednesday night this year with the traditional passing of the gavel and entertainment.

Registration for the ladies' program can be made on the conference registration form or at the registration area in the Cervantes Convention Center at the conference.

CAPCO JEN 0020722

Centennial Competition on Course and Court

To 100 AWWA golfers St. Louis will open the gates of the oldest country club west of the Mississippi for a day of competition and camaraderie.

The AWWA Centennial Conference Golf Tournament is scheduled for Monday, June 8, at the beautiful Glen Echo Country Club. Buses will leave the Cervantes Convention Center, headquarters of the annual conference, at 9 a.m. in time for a shot-gun start on the course at 9:45 a.m.

The Calloway system, which is a scoring method devised for golfers who do not know their handicap, will be used. Prizes will be awarded before participants return to the convention center in midafternoon.

Included in the $35 entry fee are transportation, greens fees, electric cart, and an informal lunch of hot dogs and hamburgers, beer and soft drinks at the Shack on the 10th hole.

Participants will be grouped in foursomes on a first come, first served basis. Preregistration is preferred, but late signups will be accepted at the convention center on Sunday, June 7, as long as there is still space available.

Those handy with a racquet may try their skills on the court at the Centennial Conference Tennis Tournament on Tuesday, June 9.

From 9 a.m. to 4:30 p.m. the South Hampshire Racquet Club will host AWWA conferees in a round robin tennis tournament. Buses will travel between the club and the Cervantes Convention Center, AWWA's conference headquarters, several times during the day. The cost of $10 per person includes transportation, court fees, balls, and prizes. Contestants are welcome to use the club's bar and restaurant for refreshment.

The tournament will include sections for men's singles, men's doubles, and women's doubles. Ranking for tournament play is based on the Lawn Tennis Association (LTA) ranking systems: A, excellent; B, good; and C, fair.

South Hampshire boasts 11 tennis courts, 7 raquet ball courts, and locker room facilities complete with saunas in addition to the bar and restaurant. Individual arrangements can be made to play racquet ball during conference week.

Preregistration is preferred, but late registration will be set up in the convention center on Sunday and Monday, June 7 and 8, as long as there is available space.

AWWA Centennial Conference Golf Tournament

Mail to: D.J. Costello
AWWA Golf Chairman
American Foundry & Mfg.
920 Palm St.
St. Louis, MO 63147

Please make checks ($35 per entrant) payable to AWWA Golf.

	Handicap	Calloway	System
		Yes	No
Name ______			
Organization ______			
Address ______			
______			
Telephone ______			
Name and address of others in foursome:			
1 ______	______	______	______
______			
2. ______	______	______	______
______			
3 ______	______	______	______
______			

AWWA Centennial Conference Tennis Tournament

Mail to. R.C. Matthews
AWWA Tennis Chairman
US Pipe & Foundry
5750 W. 95th St., Suite 206
Overland Park, KS 66207

Please make checks ($10 per entrant) payable to AWWA Tennis.

Name ______

Address ______

______

Telephone ______

Organization ______

Circle the appropriate designations:

M/S M/D W/D

A—excellent B—good C—fair

Name of doubles partner ______

CAPCO JEN 0020723

Getting There, Getting Around

Transportation in St. Louis will be no problem for AWWA conferees June 7-11.

The handy shuttle buses between hotels and Cervantes Convention Center will be provided by AWWA again this year at no cost. Conference attendees can also take advantage of the free transportation provided to all AWWA social events, facility tours, ladies' activities, and the golf and tennis tournaments.

Getting from Lambert-St. Louis International Airport to downtown can be managed in an airport limousine for $5.50 ($10 roundtrip). A one-way cab ride over the same route runs from $18 to $20, plus tip.

Public transportation around the metropolitan area is the Bi-State Transit system, which charges a basic fare of 50¢ and 10¢ for each transfer. Bi-State's bus service is exceptionally usable, as the more heavily traveled lines operate 24 hours a day, seven days a week. Convenient and economical connections can be made between hotels, downtown, shopping areas, sports facilities, city parks, meeting halls, or cousin Fred's house on the north side.

American Airlines, a top-rated domestic airline among frequent travelers, has been chosen as the official carrier for AWWA's 1981 centennial conference in St. Louis. American has one of the country's largest route systems, reaching most major airports, and offers conference attendees the services of its highly sophisticated reservations system.

American's information system can give you anything from flight times to the time and place of the banquet. It all centers on a toll free number—800-433-1790 (in Texas, call 800-792-1160).

This number connects you with a specially trained convention specialist with immediate access to conference-related information, as well as other travel services. And not only will these agents take care of ticketing and scheduling on American, but they will find the least expensive fare available on any airline and confirm a reservation for you.

American can remind attendees of hotel accommodations, make arrangements for shipping meeting-related freight, and answer a host of questions about AWWA's conference events.

Given American's reputation for thoroughness, AWWA conferees should have nothing but smooth sailing—or flying—to St. Louis in June.

MEET THOMPSON-HAYWARD'S HUGH CLIFT.

AWARDED THE 1976 FULLER AWARD FOR MISSISSIPPI/ALABAMA BY THE AMERICAN WATER WORKS ASSOCIATION.

It's not often that a supplier is awarded the coveted "Man of the Year" award by the American Water Works Association.

To Hugh Clift, and to Thompson-Hayward, the fact that he was chosen by the people he serves makes this award doubly meaningful. As a company, we're proud and grateful.

Hugh has been active in AWWA since 1954. He was instrumental in establishing the Water Works Short Course in 1955. A week-long certification course for water works operators, it is held each year at Mississippi State University. Enrollment has grown from 35 to 200 a year.

In 1961, Hugh was also responsible for organizing the first district water works meeting in Mississippi. He later established four more such meetings. So today, Mississippi water works personnel meet at five different locations monthly to discuss areas of concern.

A former Thompson-Hayward branch manager in Jackson, Miss., and now a consultant, Hugh works closely with water works personnel in Alabama, Louisiana and Mississippi.

Says Hugh:

"They tell me they look upon me as a friend, instead of a supplier. And that's the way I want it to continue."

As a company, so do we. When you need chlorine or other water treatment chemicals, we hope you'll turn to Thompson-Hayward. It's the company where you'll find people who do a little more.

People like Hugh Clift.

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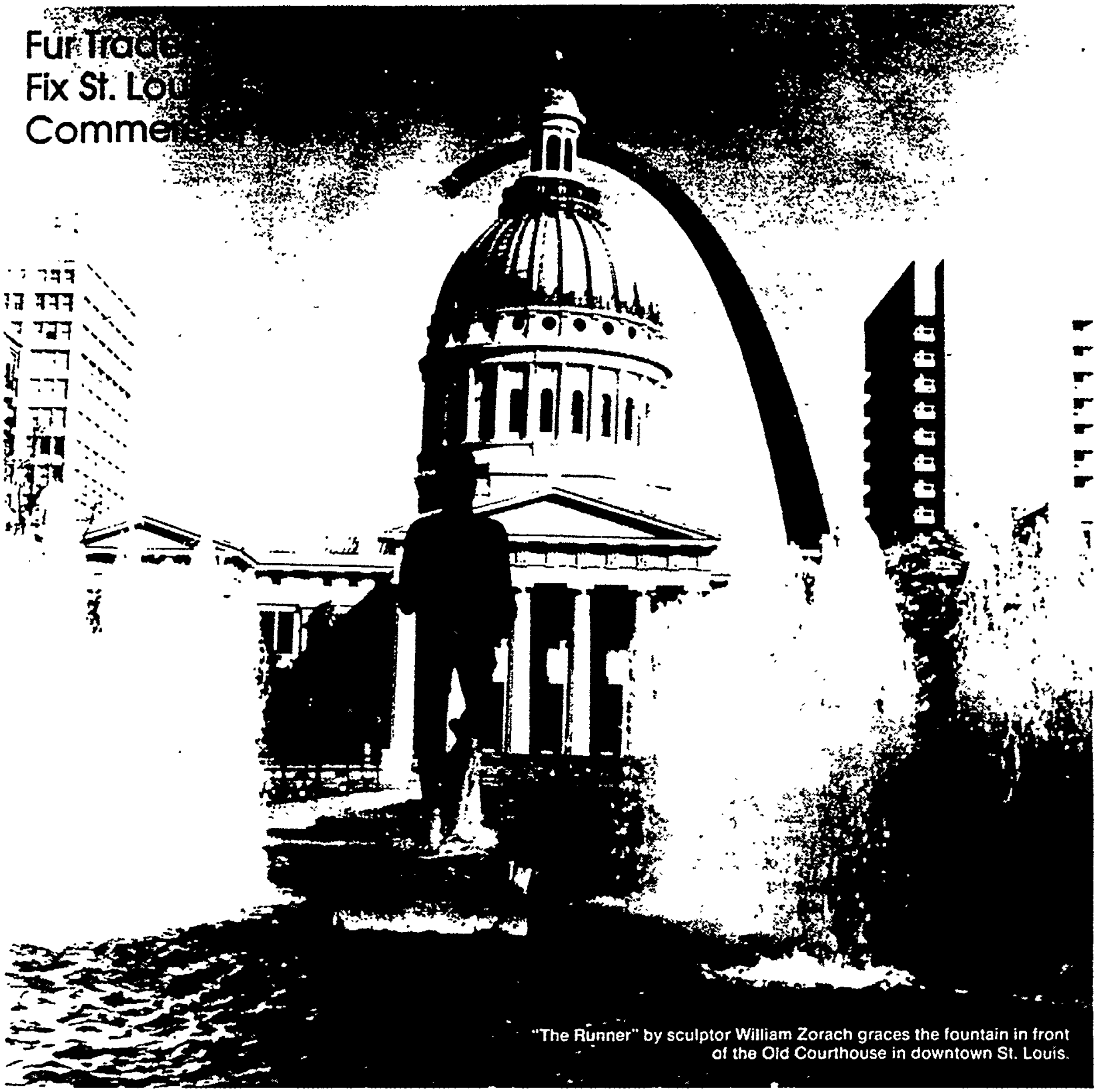


"The Runner" by sculptor William Zorach graces the fountain in front of the Old Courthouse in downtown St. Louis.

Located on the banks of the Mississippi River, St. Louis is a city steeped in historic tradition. Its beginnings go back to a wintry day in 1763 when French fur trader Pierre Laclede Liguest and his 14-year-old deputy Auguste Chouteau notched a grove of trees on the riverbank. Developed as a trading post, the site so impressed Laclede that he remarked it "might hereafter become one of the finest cities in America."

The small village was officially born the following February when the young Chouteau directed a party of workmen in laying the foundations of the settlement for the French monarch, Louis XV.

And it was Laclede himself who laid out the town in neatly squared off grids, carefully setting aside several open areas for public use. One of these was a site for the first log church, built along the riverfront in 1770. On approximately the same site, the Cathedral of St. Louis now stands. Built in 1834, the church has been designated as a National Museum and has been decreed a basilica by the Vatican.

In 1775, the "shot heard 'round the world" was barely heard in the provinical village of St. Louis, and the Revolutionary War was viewed complacently as an almost foreign clash. Because the village was technically under Spanish rule during the last years of the Revolution and because Great Britain and Spain were drawn into open warfare, "Spanish St. Louis" became an attractive target for attack from British Canada. Recognizing the danger, the townspeople began to build a fortification around the western edge of St. Louis. On Jun. 26, 1780, an advance party of the British contingent attacked the village. About 40 or 50 persons caught outside the fortification were killed, but the British were turned back. St. Louis was never again under fire.

When Thomas Jefferson negotiated the Louisiana Purchase in 1804, it set off

CAPCO JEN 0020725

The Old Cathedral (right) was decreed a basilica by the Roman Catholic Church in 1961. The National Museum of Transport (below) features more than 200 historic trains, cars, buses, streetcars, trucks, and other forms of transport.

speculation that opened up the West. St. Louis became a funnel, pouring explorers and pioneers into the uncharted expanse.

It was from this bustling young city that the Lewis and Clark expedition set out to explore the Missouri River water route to the Pacific Ocean. From St. Louis, many pioneers pointed their covered wagons westward—toward the Rockies and beyond. Some settlers, however, abandoned their ambitions and decided to stay on the banks of the Mississippi.

In 1804 the Mississippi River was narrow and swift, and the channel was about 75 ft (23 m) deep. A high limestone bluff marked the shoreline at the present location of the Eads Bridge and sloped gently southward. The riverfront rose in several terraces. Gradually a sand bar began to form on the Illinois side, causing the river current to cut away at the Missouri side. Dykes eventually were built to protect the endangered settlement, and it was Major Robert E. Lee who later supervised the channel work.

By 1816 the population of St. Louis was 3000, and residents were steadily pushing out the town's western boundaries. The steamboat era began in earnest when in 1817 the first steamboat, the *Zebulon M. Pike*, puffed its way up the Mississippi from Louisville. As the river traffic increased, so did the size of St. Louis. The city quickly became an important hub of commerce. In 1822, it was incorporated as a city with a mayor and nine aldermen.

St Louis' location at the geographic center of the country has always been of utmost importance. At the heart of a naturally bountiful land and strategically located near the confulence of the Mississippi and Missouri rivers, St. Louis has grown steadily in the past because it was simply the logical center for activity. A thick natural deposit of limestone provided a quarry for building material, and nearby clay fields were used as raw material for bricks and terra cotta.

The 1830s were marked by growth and prosperity. The decade also saw a large influx of German and Irish immigrants escaping political upheavals in their homelands.

The year 1849 proved to be a disastrous one for St. Louis. A great fire destroyed 15 city blocks along the riverfront, and that same year a serious cholera epidemic took a toll of thousands. This led to the eventual draining of the large Chouteau's Pond, as its pollution was thought to be a source of the disease. Its valley became the site of the railroad lines and yards.

Civil War years brought hardship and suffering to St. Louis. Although the city was never directly in the conflict, the war divided many families and stopped river traffic from the south—which severely depressed local business.

The city's flagging economy eventually got a shot in the arm with the coming of the railroad era. The construction of Eads Bridge in 1874 extended a rail link between the east and west that helped to initiate the golden era of railroading in the late 1800s. Although the railroads gave new impetus to the movement westward, they also hastened the demise of the steamboat days.

The final extension of the boundaries of St Louis occurred in 1876 when the city separated from St. Louis County. During the 1890s, the north-south axis of the downtown area was Broadway, and along this street the first of the skyscrapers changed the look of downtown St. Louis. The introduction of the elevator resulted in the design of more and more high-rise buildings, although they would hardly be recognized as such today. One of the more renowned of these early skyscrapers, the Wainwright Building, was designed by Louis Sullivan and still stands at 7th and Chestnut streets.

It was during this era of growth that many US industrial giants recognized the value of the city's location. St. Louis was viewed as a trade link to the expanding West and as a source of raw materials and foodstuffs to be exported to hungry consumers in the industrialized East.

Many corporations planted their roots alongside the Mississippi permanently. The city became the world's largest producer of beer, shoes, stoves, wagons, and many other products.

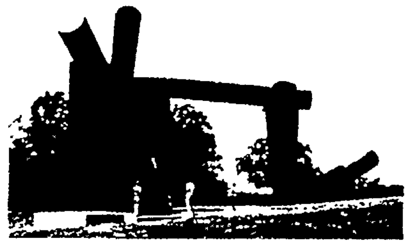
The Louisiana Purchase Exposition of 1904 (the St. Louis World's Fair) firmly established St. Louis as a world city. It was the greatest single event in the city's history, attracting about 2 million visitors.

Prompted by the centennial of the 1804 Louisiana Purchase, the fair was concentrated in the 1400-acre (570-ha) area of Forest Park. The tangle of wilderness slowly blossomed forth as a garden of palaces and lagoons. It opened Apr. 30, 1904, to a crowd of 200 000.

The intervening years have been filled with the triumph of expansion and progress, undercut with the disaster of two wars and the tragedy of the depression. Today the 63-story Gateway Arch stands as a proud reminder of St. Louis' key role in the nation's history, as well as a tribute to the brave venture westward.

CAPCO JEN 0020726

Gateway Arch Frames a City of Historic and Modern Attractions



St Louis, the historic starting point of the Lewis and Clark Expedition, has evolved into a bustling, friendly metropolis located in the heartland of the nation

With almost 90 million people within an easy day's drive over superhighways, the city hosts ever-increasing numbers of visitors annually

Although St. Louis saw the beginnings of westward expansion, it wasn't just a "gateway." For many, it was the new country. Many ethnic groups settled here, forming a delightful blend of customs, skills, and culture that were to give the city its unique flavor and personality

From the beginning the mighty Mississippi has played a key role in the city's development. Today St. Louis is the nation's busiest inland port with waterway connections to industrial centers in 20 states

Overlooking the Mississippi is the magnificent 630-ft (194-m) stainless steel Gateway Arch. As the nation's tallest man-made monument, it is a stunning tribute to the early pioneers and westward expansion. An intriguing set of elevators moves horizontally and then vertically in transporting sightseers to the top of the arch, where an observation deck provides a breathtaking view of the the surrounding rivers and cityscape.

An underground chamber beneath the arch houses a museum of westward expansion. Exhibits focus on the period from the early 1800s to the 1890s and tell the frontier story in the words of the history makers themselves—Lewis and Clark, Thomas Jefferson, and the unnamed settlers, miners, and soldiers who battled the wilderness

Looking down on the levee from the arch, one is struck by the number of vessels moored on the river. The gleaming, silver *Admiral* is the world's largest river excursion boat, with five decks for dancing, music, and sightseeing. The *Sergeant Floyd*, the US Army Corps of Engineers' bicentennial river towing boat, has been converted into a floating museum depicting the work of the corps. The *Huck Finn* and *Samuel Clemens*, replicas of 19th century steamboats, take nostalgic visitors on narrated harbor cruises

The *Goldenrod Showboat*, the last of the great Mississippi River showboats, is a registered National Historic Landmark offering comic melodrama and vaudeville performances. The *Robert E Lee* and *Belle Angeline* feature gourmet dining, but if you are in the mood for fast food, you can board the world's first floating McDonald's—an authentic replica of an 1880 sidewheeler boat

In the shadow of Eads Bridge is the historic riverfront area called Laclede's Landing. It contains the oldest buildings in St. Louis, some of which date back to the mid-1800s. In this nine-block area, asphalt has been carefully peeled away from cobblestone streets and gaslights reinstalled on the sidewalks. Seasoned warehouses have been converted into an engaging mix of bistros, shops, restaurants, and nightclubs

Gazing west from the arch's pinnacle one sees a city with modern skyscrapers, new hotels, and other buildings under construction. However, a closer look reveals a number of historic structures in their original state—testimonials to a city with pride in its heritage.

One of the first buildings noticed will be the Basilica of St. Louis, King of France, more commonly known as the Old Cathedral. The oldest cathedral west of the Mississippi, it stands on the original church site chosen by the city's founder. Masses are held daily, and a museum is located in the church basement.

Nearby is the Old Courthouse, scene of the pre-war slavery trial of Dred Scott. The lawyer defending the slave and his wife was R M Field, father of the famous children's poet, Eugene Field. The poet's fully restored home is located a few blocks south of the courthouse and, like the courthouse, is open to the public

A few blocks from the cathedral and courthouse is 50 000-seat Busch Memorial Stadium, home of the baseball and football Cardinals. The stadium also houses the St. Louis Sports Hall of Fame, which depicts the city's sports history through murals, films, trophies, and memorabilia.

To the west on Market Street is Union Station. This mammoth structure once served 300 trains daily; it is being renovated as Union Center and will contain a hotel, restaurants, and an entertainment center. Just across from the station is Aloe Plaza with its famed Milles sculpture group, "The Meeting of the Waters." The fountain, which signifies the confluence of the Mississippi and Missouri rivers, is one of the most photographed attractions in the city.

CAPCO JEN 0020727

World-renowned Forest Park is located in midtown and is easily accessible from downtown and outlying areas. Here are located a number of nationally known attractions—the St. Louis Zoo, the Art Museum, McDonnell Planetarium, the outdoor Muny Opera the Jefferson Memorial, the Jewel Box floral conservatory, and the Steinberg Skating Rink.

The zoo has won national acclaim for Big Cat Country, a 1.5 acre (0 6 hectare) natural outdoor home for lions, tigers, and other big cats. Forest Park also boasts large picnic areas, boat rentals, bicycle rentals, an archery range, a rugby field, three golf courses, handball and tennis courts, and even a fly casting dock. Visitors should allow plenty of time to savor the pleasures of this outdoor smorgasbord.

Farther out from St. Louis is Lone Elk Park, where visitors can drive leisurely through the 405 acres (164 ha) and enjoy the herds of bison, elk, deer, and Barbados sheep that roam freely throughout the park.

The Missouri Botanical Garden, one of the most remarkable botanical gardens in the United States, is also a National Landmark. It contains the famed Climatron and the country home of founder Henry Shaw, in addition to its vast collection of horticultural exhibits. The newest attraction is the Japanese Garden, the largest in North America. It contains 13.5 acres (5.5 ha) of lakes, several waterfalls, an authentic Japanese teahouse, a dry garden, stone lanterns, and traditional Japanese bridges.

The Museum of Science and Natural History in suburban Clayton features many fascinating exhibits, including a unique earthquake simulator machine that allows visitors to experience an earthquake in an intensity of their own choosing at the mere push of a button The National Museum of Transport in western St. Louis County traces the history of transportation in St. Louis and features locomotives, railway cars automobiles, streetcars, buses, and more.

Beer-lovers will not want to miss taking a tour of the Anheuser-Busch brewery with its famous team of Clydesdale horses and century-old buildings. Tours are free and include a sampling stop in the brewery's hospitality room.

The Saint Louis Symphony Orchestra has a year-round season and is recognized as one of the outstanding orchestras in the United States The orchestra performs 230 concerts yearly, including a series of free outdoor concerts.

Six Flags Over Mid-America, the Midwest's largest amusement park, is only a short drive from St. Louis At Six Flags you can ride the world-famous Screamin' Eagle roller coaster or the newest thrill, Sky Chuter—the world's tallest parachute jump. Six Flags has sidewalk artists, skill games, comical costumed characters, spectacular shows, picturebook landscaping, celebrity concerts, and thrilling rides.

St. Louis is a shopper's paradise. At Plaza Frontenac, Neiman-Marcus and Saks Fifth Avenue are under one roof, along with 60 other exciting places to explore. A visitor to West Port Plaza can browse through the many studio shops, try his hand at the ancient art of brass rubbing, watch a glass blower, and then shop seriously for Scandanavian glassware, gourmet foods, jewelry, or fashions from around the world.

St. Louis is also justly famous for its large number of moderately priced ethnic restaurants, each with its own specialty of the house. Italian, German, Polish, and other cultures of an earlier era have retained their distinctive flavor here. This gives the city a refreshing cosmopolitan atmosphere that still includes midwestern hospitality and friendliness—otherwise known as the spirit of St. Louis.

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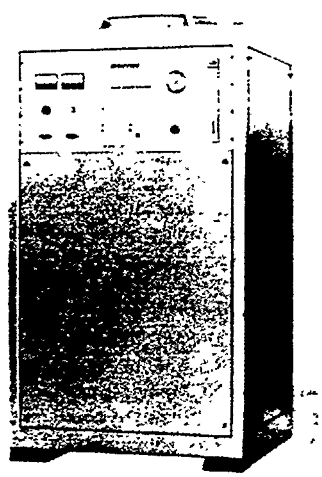

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Griffin Technics air-cooled, high frequency ozone generators provide continuous trouble free operation.

The *air-cooled* design allows for up to 65% energy recovery in the form of heat. This warm air could be used to heat a room, an entire building or a particular process depending on the size of the generator. Eliminating the need for cooling water and its associated piping: Both sides of the electrode are cooled for efficient heat removal.

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CAPCO JEN 0020728

Nightlife on the Mississippi

The first three nights of the annual conference, June 7-9, have been left open and—in an effort to allow more flexibility for conferees—AWWA is offering an attractive variety of social events on those nights. These optional tours provide attendees with an opportunity to mix and discuss business or pleasure on a casual basis.

If you would like to do some socializing while sampling what St. Louis has to offer, use the coupon on page 111 to make reservations for these tours and mail directly to the St Louis Scene Inc., 149 N Meramec St St Louis Mo 63105 The tour company will also have a reservation desk in the registration area of the Cervantes Convention Center Sunday through Tuesday of the conference.

Goldenrod Showboat—Sunday, June 7, and Tuesday, June 9, 6:15-11:00 p.m.; $23.25 (cash bar). Enjoy a merry evening of old-style entertainment on board the *Goldenrod*—last authentic showboat on the Mississippi. Sample spirits and tap to ragtime in the memorabilia-filled bar, then move to the captain's dining room upstairs for a sumptuous buffet. Downstairs in the theater, you can escape into laughter watching old-time melodrama and fresh young vaudeville acts, join in an old-fashioned sing-along, or savor the nostalgia of watching favorite movie stars in classic movies of the silent era.

Royal Dumpe Dinner Theater—Sunday June 7, and Monday, June 8, 7:15-11:00 p.m., $23.50 (cash bar). Spend a hilarious evening at the Royal Dumpe Theater, a 16th century dinner theater complete with strolling minstrels, serving wenches, and a cast providing raucous, riotous entertainment in a zany atmosphere. Dinner is served during a show that thrives on audience participation.

Champagne Twilight Tour—Sunday, June 7, 6:00-8:00 p.m., $17.00. What could be more pleasant than sipping champagne while seeing the sights of St. Louis? Each bus will be attended by a tour guide, as well as a bartender serving hors d'oeuvres and filling glasses. The tour will wind its way through the historic Riverfront section—past showboats and sternwheelers. You will see the Old Courthouse, the Old Cathedral, and the mammoth complex of Romanesque and modern buildings of the Anheuser Busch brewery. Then you cruise through Forest Park—past its Art Museum, Muny Opera, and Zoo—and end up viewing the fascinating architecture of Union Station and St. Louis University.

Baseball Game—Sunday, June 7, and Tuesday June 9; 6:15-11:00 p.m.; $13.50. Take part in America's favorite pastime at Busch Memorial Stadium with some exciting major league baseball. The St. Louis Cardinals' opponents will be the Los Angeles Dodgers on Sunday and the San Diego Padres on Tuesday.

Moonlight Dinner Cruise—Monday, June 8, and Tuesday June 9, 7:00-11:00 p.m.; $23.75 (cash bar). Aboard the *Tom Sawyer*, a replica of a 19th century sternwheeler, you can sit back and enjoy cocktails and a buffet dinner as you watch the banks of the Mississippi glide by. Later, strains of ragtime might rouse you from your thoughts and have you singing and dancing to this timeless American music.

Wild Times Corral—Monday, June 8, 7:00-11:00 p.m.; $26.00 (cash bar). Don your western garb and get ready to really eat—barbeque ribs, chicken, pork steaks, homemade pie, and more—at the Wild Times Corral overlooking Forest Park. After you have had enough of eating, you can loosen up and have a good time with some down-home country western music, performed by Jay Thomas and the Country Express.

See reservation form, page 111

CAPCO JEN 0020729

Optional Tour Reservations

Transportation, guides and admissions are included in all tours and activities. Meals are included in 1, 2, 5, 6, 7, 8 and 9. Buses to evening activities depart from Cervantes Convention Center, front entrance. Arrangements will be made to bring you to the convention center and return you to your hotel after the event. Pick up reserved tickets at the tour desk in the registration area at the convention center Tickets will be sold during registration hours on a space available basis at the tour desk. If fewer than 40 persons respond to any event, that event will be cancelled and money refunded in full.

Tour	Date	No. Persons	Cost	Total Amount
1—Goldenrod Showboat	June 7	______	$23.25	______
2—Royal Dumpe Dinner Theater	June 7	______	23.50	______
3—Champagne Twilight Tour	June 7	______	17.00	______
4—Baseball Game	June 7	______	13.50	______
5—Moonlight Dinner Cruise	June 8	______	23.75	______
6—Royal Dumpe Dinner Theater	June 8	______	23.50	______
7—Wild Times Corral	June 8	______	26.00	______
8—Goldenrod Showboat	June 9	______	23.25	______
9—Moonlight Dinner Cruise	June 9	______	23.75	______
10—Baseball Game	June 9	______	13 50	______

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Please enclose check or money order to: The St. Louis Scene, Inc.
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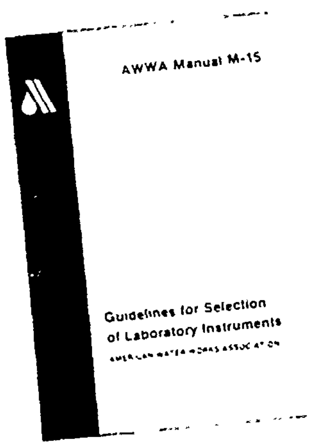
AT LAST! **A valuable new guide for the water lab! "Guidelines for Selection of Laboratory Instruments" (AWWA Manual M-15—Catalog No. 30015JL)**



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Developed to clear the air on the confusing subject of instrument selection, this concise, straightforward manual provides much of the necessary information to plan and implement testing required by the Safe Drinking Water Act.

Contents include: Incubators, Specific Ion Meters, Turbidimeters, Amperometric Titrator for Residual Chlorine Analysis, Spectrophotometers, Gas Chromatographs, and much more

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CAPCO JEN 0020730

Dining: From Haute Cuisine to Catfish

In 1904 at the World's Fair, St Louis introduced America to the ice cream cone and hot dog. But long before 1904 good food had become an important part of life in St Louis.

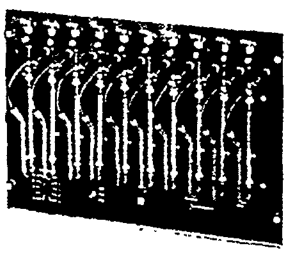
Then as now, some of the more interesting and enjoyable dining spots are those where authentic foreign dishes are served in the zestful atmosphere of the many ethnic groups that settled in St Louis.

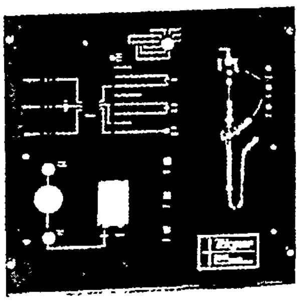
St Louis also has excellent steak houses and places specializing in fresh seafood. You can find hush puppies and fried catfish—served just as they were on riverboats, or home-made pastas as good as anyone's Italian mother makes.

Visitors will find that St Louis' restaurants have enough variety and style to suit just about everybody's taste and budget. The following list is just a sampler.

The Tekmar LSC-2 Concentrator meets or exceeds all EPA requirements for THM & priority pollutants.

Model ALS Automatic Sampler for Purge and Trap





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And now... add our new model ALS Automatic Sampler and run up to 10 purge and trap samples automatically.

The Tekmar LSC-2 is an automatic purge and trap concentrator which will allow your GC or GC MS to detect and quantitate purgeable organics in industrial and drinking waters.

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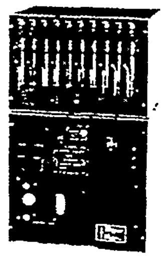
Interfacing capability, built into every LSC-2, allows operation as master or slave to your GC or GC MS system, or operation under computer control.

The Tekmar ALS Increases Sample Capacity. The Model ALS interfaced to the LSC-2 permits automated analysis of as many as ten water samples for volatile organic pollutants, accommodating either frit or needle sparge samplers.



Since its introduction, the LSC-2 has gained wide acceptance in the field. From early indications the same is true of the Model ALS Automatic Laboratory Sampler. **Call our Toll Free 800 number for information,** or check the reader service listed below.

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Reader Inquiry Service No 057

Angelo's "On the Hill." In the heart of the Italian Hill section—which fairly bristles with Italian-named restaurants. Angelo's specializes in veal and restaurant-aged steaks and also features steaks, seafood, and an outdoor patio. Located at 5226 Shaw Ave., open Monday through Saturday for lunch and dinner; closed Sunday.

Dominic's. Continental cuisine featuring white veal, home-made pasta, and home-made desserts. Served in an atmosphere of crystal chandeliers, oil paintings, and candlelight. Located at 5101 Wilson Ave.; open evenings Tuesday through Saturday.

Anthony's. French cuisine and seafood with continental service. Reservations, coat and tie required. Located at 10 Broadway; open Monday through Saturday for lunch and dinner.

Catfish and Crystal. Specializes in steak and seafood served in a pre-Victorian atmosphere entertainment provided. Located downtown at 11th and Locust; open for lunch and dinner Monday through Saturday.

Hannegan's Restaurant and Pub. Features Irish stew for lunch, and porterhouse steak for dinner, served in a political memorabilia decor. Located in Laclede's Landing at 719 N. 2nd St., open for lunch and dinner daily.

Eisele's Black Forest. German and American cuisine, with music and dancing. Located at 3126 Cherokee St., open for lunch and dinner daily.

Saleem's Restaurant. Lebanese cuisine, featuring shish-kebab of beef, lamb, marinated chicken or beef dishes. Entertainment provided. Located at 3170 S. Grand Blvd., open for dinner Monday through Saturday.

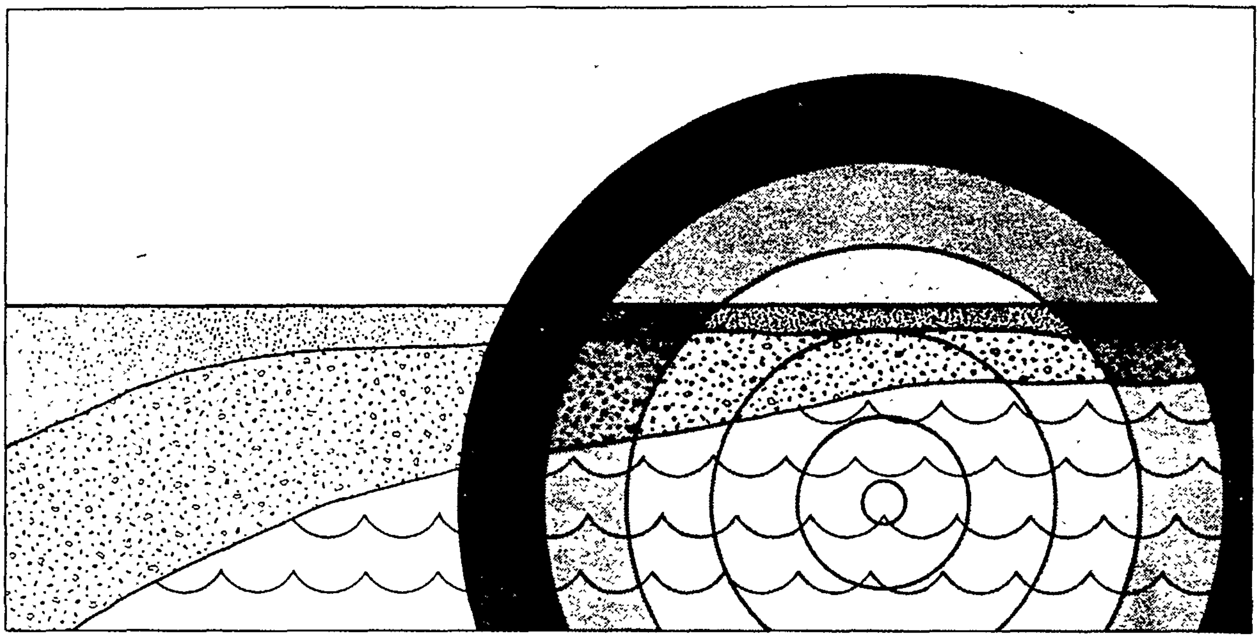
Southern Summer

St. Louis enjoys one of those all-American climates with four distinct seasons. Summers are generally warm but sustained periods of extremely hot weather are rare.

Although the average temperature for June is a very pleasant 74°F (23°C), summers there are humid—so light clothing is a must for daytime sightseeing.

However, because downtown St Louis is right on the Mississippi River, evening hours can sometimes be cool. It is wise to carry along a light jacket on those late nights out, in case the temperature does take a slight dip.

Evening dress in St Louis tends to be more casual in the summer, but those partaking of the night life should be aware that some restaurants and clubs may require a jacket and tie.



Groundwater: an endangered resource

The increasing scarcity of potable water—the most precious of all natural resources and this planet's *vis vitae*—is a much greater problem for mankind than the gradual depletion of oil and gas, coal, and other minerals. Since the earth's water supply is constant—the same microscopic molecules of hydrogen and oxygen continuously change form as they proceed in the hydrologic cycle—"new" or "more" water cannot be expected, only "recycled" water. Because the largest available source of freshwater is underground, groundwater contamination is becoming one of the greatest threats to civilization.

Everything that touches water affects its quality in one way or another. Most groundwater pollution is caused by the disposal of liquid and solid wastes, on or into the ground. The most common source is leachate from improperly designed septic tanks or cesspools, but possible groundwater pollutants are limitless.

Advances in various agricultural and industrial technologies have brought with them many liabilities. Agricultural causes of groundwater contamination include fertilizers and pesticides. Municipal and industrial sources include leaking sewers, oil and gas tanks and pipelines, and wastewater injection wells. The last two decades in particular have shown that deep-well injection of liquid wastes has become common practice among the chemical, petrochemical, and pharmaceutical industries.

Groundwater can also be polluted by such natural causes as excess mineral content or intrusion of saline water. Natural mineralization, which results from the slow erosion of rock in the aquifer, usually increases with depth, and in highly mineralized aquifers, water is no longer potable below a certain depth.

Salt water can easily invade freshwater aquifers and deteriorate the groundwater. Although salt water intrusion does occur in inland aquifers, usually caused by underlying saline water, it is most common in coastal aquifers. If freshwater is removed from the aquifer faster than it is replaced, saline water generally infiltrates the aquifer; if less water is withdrawn, the salt water will eventually be flushed out by freshwater. It is a slow process, though, and artificial or induced recharge is sometimes utilized to attack the immediate problem. The use of reclaimed water to recharge the groundwater aquifers artificially so that barriers will form between the fresh and salt waters is becoming an important tool in nonpotable water reuse; it cannot, however, be considered a dependable method of obtaining potable water, as too many problems, such as the fate of synthetic organic contaminants, have not yet been solved.

Although it is almost impossible to eliminate groundwater pollution altogether, the growing awareness of the importance of underground water resources is resulting in an effort to reduce groundwater pollution and to prevent further contamination. —JEL

CAPCO JEN 0020732

Energy conservation opportunities in municipal water and wastewater systems

Donald W. Lystra, Ashok K. Singhal, and
Philip N. Loud

Municipal water and wastewater systems have been shown to be the largest energy consumers in local governments. By studying unit processes at four utilities in the state of Michigan, the authors were able to pinpoint several areas in which sizable energy savings could be realized.

Municipal water and wastewater systems are heavy users of energy, not only directly through the use of electricity, natural gas, and other fuels but indirectly through the use of large quantities of chemicals produced by energy-intensive manufacturing processes. A recent study by the US Office of Water Research and Technology showed water and wastewater systems to be the largest single component of energy consumption by local units of government, averaging about 25 percent of the total municipal energy use.[1] Moreover, recent utility rate studies have shown that the direct energy costs of water and wastewater systems account for fully 20 percent of their total operating budgets.[2]

In 1979 the energy administration of the Michigan Department of Commerce sponsored a study to identify ways in which energy could be conserved in existing water and wastewater facilities. The objective of the study was to identify cost-effective energy conservation measures that could be implemented statewide at Michigan's 1100 municipal plants. These systems account for 2 percent of all electricity and 0.5 percent of all natural gas consumed in the state. The consulting firm of Ayres, Lewis, Norris & May, Inc., of Ann Arbor, Mich., was retained to perform this study.

The study methodology consisted of three phases: energy audits to identify energy conservation opportunities (ECOs) at four study sites; analysis of the ECOs for cost-effectiveness; and extrapolation of the results to identify the potential for statewide energy savings in water and wastewater facilities.

Phase 1: The energy audit

An energy audit has been defined as a critical examination of an energy-consuming facility for the purpose of identifying energy conservation opportunities. Because water and wastewater facilities had not previously been the subject of comprehensive energy audits, the firm conducting the study found it necessary to devise an audit methodology appropriate to facility characteristics.

Because of the overall complexity of water and wastewater facilities and the various technical specialties represented by their processes and equipment, the audits were broken down into smaller components. This made it possible to create specialized audit packages that could be addressed by team members from appropriate technical fields. The following subsystems were identified.

- Treatment system—all processes and equipment used to purify raw water or wastewater and render it suitable for drinking or for discharge into the receiving waterway
- Capacity control system—equipment used for pumping water or wastewater at various points in a treatment process to maintain sufficient pressures and flows to meet the system's the quantitative demands
- Heating, ventilating, and air conditioning system (HVAC)—equipment that provides the control for the internal environment of buildings, including the building envelope itself
- Electrical systems—equipment that distributes electricity to plant loads and provides artificial illumination for the interior and exterior of the facility

An auditing team composed of five to seven technical specialists in civil, sanitary, mechanical, and electrical engineering, as well as architecture, was created to perform the energy audits at each of the four study sites. The auditing procedures involved a review of existing documents and records, site visits, operator interviews, identification of ECOs, analysis of ECOs, and reporting.

Audit team members were instructed to look for ECOs in the following general areas: changes to operational and maintenance strategies; equipment changes (i.e., same function, different device); design changes (i.e., different function, different device); and relaxation or modification of design standards.

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CAPCO JEN 0020733

Regardless of the age of the equipment, pump operation is the largest consumer of electricity in a water system. Performing an energy audit to determine pumping performance and efficiency levels could point the way to significant savings for the utility.

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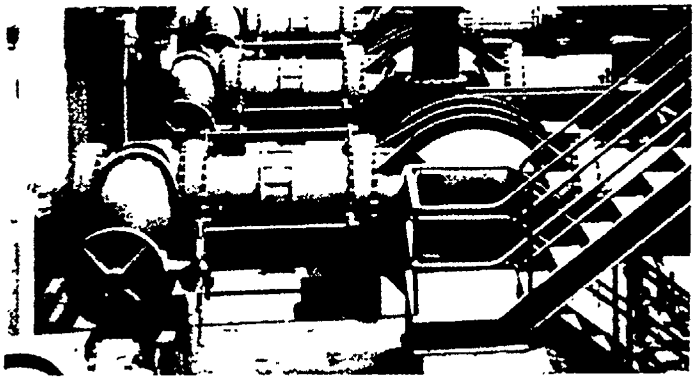

General auditing guidelines. The overall objective of the energy audit was to identify cost-effective ECOs. Although it was impossible to identify the exact procedure for discovering ECOs, it was necessary to set certain general guidelines for the team members.

1. Audit team members were instructed to identify ECOs that could be applied to existing study sites rather than setting design standards for new facilities. This guideline eliminated from consideration certain sweeping changes such as modification of treatment modes, site layouts, or building design. The ECOs had to be cost-effective as retrofit measures to existing facilities, as opposed to alternative "new design" approaches.

2. It was stressed that audit team members should not look for cost-saving methods not directly related to energy consumption. The study excluded, for example, strategies that would reduce labor costs, unless there was also a linkage to the consumption of electricity or fuel.

3. There was to be no "prescreening" of ECOs. Team members were not to make premature judgments about the cost effectiveness or engineering feasibility of potential ECOs. Rather, members were to propose ECOs having a reasonable chance of being cost effective. Detailed economic analysis would be undertaken later as a separate step.

4. Many ECOs had compound effects that were impossible to identify. Improving the efficiency of a pump motor, for example, would be interactive with an ECO that resulted in less use of the pump. Rather than trying to separate the potentially compound effect of two such ECOs, it was decided to present each ECO as a separate item. In some cases, however, the joint effect would be less than the sum of the separate effects.

5. In some instances it was found that plant operators had recently implemented ECOs on their own initiative. It was decided to include these ECOs, rather than to ignore them and lose their potential benefit, noting that they had been effected prior to the study. The total impact of these previously identified ECOs amounted to approximately 3 percent of the overall energy conservation identified in the study.

Description of study sites. Four Michigan sites were selected for site-specific investigation: two municipal water systems and two municipal wastewater systems (Table 1). It was felt that these sites were sufficiently varied in terms of age, size, and type of treatment to allow the ready extrapolation of findings to other municipal facilities in Michigan. In addition, all four systems employed relatively complex treatment processes so that a variety of equipment was available for study.

Energy consumption characteristics of study sites. All four facilities relied primarily on electricity and natural gas for their energy requirements. One, the Ann Arbor water system, consumed a relatively small amount of fuel oil for miscellaneous process and building heating requirements.

Electricity was typically used as the energy source for motor drives and illumination, whereas natural gas was used as the energy source for building heat, water heating, digester heating, sludge incineration, and chemical pretreatment. The Ann Arbor water treatment system was again an exception, employing a large amount of natural gas for engine drives on remote booster pumps and a recalcination system.

There was no apparent seasonal pattern in the consumption of energy in the two wastewater treatment plants studied. The water treatment plants exhibited approximately a 30 percent increase in natural gas consumption during the winter heating season and approximately a 12 percent increase in electricity consumption during the high water usage period of March through August, as compared to the period September through February.

The breakdown by energy source of total energy consumption at each study site is given in Table 2. The breakdown of energy consumption for each site within the four functional subsystems is shown in Table 3. In general, about half of the total energy requirements for the water facilities was for pumping, whereas more than half of the energy used by the wastewater facilities was for treatment equipment and relatively little was for pumping. The energy consumption and energy cost per cubic metre of water treated at each of the four facilities between Fall 1978 and Fall 1979 is given in Table 4.

Phase 2: Analyses of ECOs for cost effectiveness

The total number of ECOs identified at the four study sites was 93, ranging from 21 to 26 per site. Tables 5–8 list the ECOs for each site, and Table 9 summarizes the energy conservation potential of all four sites. As the

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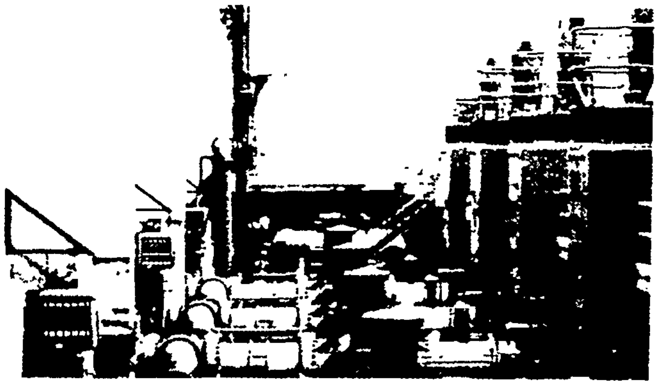

tables indicate, the individual ECOs varied widely in terms of conservation potential, implementation costs, and payback periods. In general, ECOs offering the greatest conservation potential in the wastewater facilities related to sludge handling and disposal and aeration system modifications. ECOs offering the greatest conservation potential in the water facilities involved the improvement of pumping efficiency.

The ECO having the greatest estimated conservation potential involved the reduction of fuel requirements for sludge incineration at the East Lansing wastewater treatment plant through the addition of a sludge dewatering system. This ECO was projected to reduce the natural gas requirements for the incinerator by almost 8.5×10^6 m^3 (3×10^8 cu ft) annually, currently worth about $90 000. This ECO was also the one having the greatest estimated implementation cost, $1.2 million.

Many ECOs cost little or nothing to implement and, therefore, had virtually instantaneous payback periods. These included operational changes, such as the preferential operation of the most efficient pumps or reduced aeration blower use, and low-cost maintenance items, such as the installation of weatherstripping or the modification of gravity turbine units.

The ECO having the most dramatic cost effectiveness involved lowering of the water level in the equalization basin at the East Lansing wastewater facility, thereby reducing the backpressure on aeration blowers with an attendant lowering of drive horsepower. This ECO, costing nothing to implement, was projected to save 641 600 kWh (2.31×10^9 kJ) of electricity annually, currently worth about $20 500.

At each site several ECOs were identified for the HVAC and illumination systems. Many of these ECOs proved to have significant energy impacts and cost little to implement. One reason for the relatively large number of HVAC and illumination system ECOs may be the unusual occupancy patterns of both water and wastewater facilities. Many interior areas in these facilities, while receiving only occasional inspection visits from operators, have HVAC and illumination systems apparently designed for continuous occupancy.

Several ECOs involved the recovery and use of waste heat; sources of waste heat that were examined included aeration blowers, incinerator exhaust heat, transformers, calciner systems, and wastewater influent.

Two ECOs involved what could be classified as resource recovery or alternative fuels. At the Big Rapids wastewater treatment plant the use of digester gas as a fuel for building heat was examined, and the use of dewatered sludge as a fuel for electric generation was examined for the East Lansing wastewater facility.

A number of ECOs at each site involved architectural changes to the buildings, such as improving insulation or replacing roofs or windows. In general, ECOs in this group tended to be costly and to have long payback periods.

One ECO is worthy of specific mention because of the significant indirect energy savings attributable to it. The reduction of lime feeding at the Ann Arbor water plant, while offering substantial direct energy savings due to reduced calciner operation, was also projected to have important indirect energy savings based on the substantial energy requirements for the manufacture and transport of lime. Recent figures from a report by the US Environmental Protection Agency (USEPA)[1] identified the amount of energy required for the manufacture and transport of various chemicals used in water and wastewater treatment facilities. In the case of lime (calcium oxide), the energy requirements for production alone were estimated to be 6396 kJ/kg (5.5×10^6 Btu/ton) for fuel and 600 kWh/ton (2381 kJ/kg) for electricity.

Categorization of ECOs by implementation cost. The aggregate ECOs were broken down into three categories: those costing less than $500 to implement, those costing from $500 to $2000 to implement, and those costing more than $2000 to implement. The statewide energy impact and the cost for implementation of each category were calculated.

Many of the ECOs in the first category could be implemented for no cost, whereas the cost of others was low enough to be within the regular operating budgets of most plants. The 24 ECOs in this category would create energy savings totaling over 1.05×10^{10} kJ/yr (10×10^9 Btu/yr) worth $118 000, while requiring a total implementation cost of only $2360. The aggregate simple payback period for the ECOs in the category is virtually instantaneous, 0.02 years. Total energy savings represent 5.6 percent of current consumption and 16 percent of the total identified conservation potential.

The second category of ECOs, those having an imple-

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TABLE 1

Sites selected for energy conservation study

Study Site	Design Capacity ML/d	Design Capacity mgd	Service Area Population
East Lansing	68	(18.0)	105 000
Big Rapids	9	(2.4)	16 500
Ann Arbor	189	(50.0)	110 000
Marysville	57	(15.0)	9300

TABLE 2

Energy consumption by fuel type at each study site—percent

Study Site	Electricity	Natural Gas	Fuel Oil
East Lansing	47	53	0
Big Rapids	46	54	0
Ann Arbor	42	55	3
Marysville	69	31	0

TABLE 3

Breakdown of energy consumption by functional sub-systems—percent

Study Site	Capacity Control System	Treatment System	HVAC System	Electrical System	Miscellaneous
East Lansing	6	72	14	4	4
Big Rapids	3	58	31	6	2
Ann Arbor	43	46	9	2	1
Marysville	49	3	32	6	10

TABLE 4

Energy consumption and energy cost of water treated at each facility between Fall 1978 and Fall 1979

Study Site	Energy Consumption per m³: kJ/m³	Energy Consumption per m³: Btu/mil gal	Energy Cost: per m³	Energy Cost: per mil gal
East Lansing	6.1×10^{4}	21.9×10^{6}	$.035	$133
Big Rapids	3.9×10^{3}	14.0×10^{6}	$.026	$98
Ann Arbor	4.0×10^{3}	14.2×10^{6}	$.019	$73
Marysville	1.6×10^{3}	5.74×10^{6}	$.013	$49

TABLE 5

Energy conservation opportunities at the Ann Arbor water treatment plant

Energy Conservation Opportunities	Projected Annual Energy and Cost Savings: Electricity Amount kWh	Electricity Cost $	Natural Gas Amount m³	Natural Gas Amount cu ft	Natural Gas Cost $	Total Amount J × 10⁹	Total Amount Btu × 10⁶	Total Cost $	Implementation Cost $	Simple Payback Period years
Preferential operation of the most efficient raw water well pumps			7193	254 000	690	268	254	690	0	0
Installation of more efficient variable-speed drives	154 400	5400				556	527	5400	82 000	15.2
Improved maintenance of pumps	348 400	12 300	7998	282 400	760	1553	1471.5	13 060	26 250	2.0
Elimination of soda ash feed*	1633	59 517				6	5.6	59 517	0	0
Reduction of lime feeding†	65 900	2310	95 580	3 375 000	9110	4692	4447.2	18 040	0	0
Cleaning of boiler			37 184	1 313 000	3550	1385	1313	3550	1400	0.4
Recovery of waste heat from calciner			25 204	890 000	2400	939	890	2400	0	0
Reduction of outside air			6457	228 000	615	241	228	615	1750	2.8
Conversion of fuel oil burner‡						0	0	3408	6000	1.7
Improvement of roof insulation at Barton pump station			4531	160 000	430	169	160	430	7800	18.1
Replacement of sealant on exterior doors			835	29 500	80	31	29.5	80	500	6.3
Installation of weatherstripping on exterior doors			2673	94 400	255	100	94.4	255	1200	4.7
Recovery of waste heat from transformers	48 750	1706				175	166	1706	17 000	10.0
Increase in conductor size§										
Installation of high efficiency motors	252 000	8820				907	860	8820	100 000	14
Correction of plant power factor**								3000	2000	0.7
Correction of motor circuit power factor§										
Installation of electric metering††										
Use of standby generator as on-peak cogeneration unit‡‡								3200	0	0
Possibility of small-scale hydroelectric development at existing municipal dam§§										
Replacement of incandescent fixtures with low-wattage fluorescent fixtures	85 100	2980				306	290	2980	10 400	3.5
Replacement of incandescent lamps with self-ballasted metal halide fixtures	79 800	2800				287	272	2800	2280	0.8
Replacement of recalcination building lights	13 500	473				49	46	473	2500	5.3
Replacement of pipe gallery lights	5120	179				19	17.5	179	1600	8.9
Replacement of manual switches with time-out switches	41 800	1460				151	142.7	1460	2720	1.9
Installation of night lighting system	12 140	425				44	41.4	425	850	2.0
Total	1 108 543	98 370	187 657	6 626 300	17 890	11 875	11 255.8	131 278	466 250	

*Much of the large monetary savings from this ECO is not due to direct energy savings but rather to the reduction of soda ash purchases. The secondary energy savings possible by reduced soda ash production and delivery were not quantifiable in the scope of this study.

†Additional energy savings from this ECO are 25 057 L (6620 gal) of number 4 fuel oil, worth $6620. Secondary energy savings are also realized through reduced lime production costs.

‡Only the implementation costs and energy cost savings are listed for this ECO because it involves switching from one fuel type to a less expensive type; no actual energy is being saved.

§Because the energy that could be saved through this ECO and the cost to implement the ECO are both dependent on the extent of implementation, these estimates were not included.

**The energy savings from this ECO are unquantifiable. However, the reduced penalty charge and implementation costs can be reasonably estimated.

††An implementation cost is given for this ECO, but no estimates of energy savings or cost savings are given because they could not be estimated with any accuracy. The fact that this ECO could save both energy and money, however, is not questionable.

‡‡Only the implementation costs and energy cost savings are listed for this ECO because it involves switching from one fuel type to a less expensive type. Actual energy savings are minimal and difficult to quantify.

§§Because the implementation costs of this ECO are so variable, all values for this ECO have been excluded from this table in order to avoid distorting the total values.

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TABLE 6

Energy conservation opportunities at the East Lansing wastewater treatment plant

Energy Conservation Opportunities	Projected Annual Energy and Cost Savings: Electricity Amount kWh	Electricity Cost $	Natural Gas Amount m^3	Natural Gas Amount cu ft	Natural Gas Cost $	Total Amount $J \times 10^9$	Total Amount Btu $\times 10^6$	Total Cost $	Implementation Cost $	Simple Payback Period years
Installation of more efficient variable-speed drives	55 500	1780				200	189 4	1780	27 000	15.2
Preferential operation of most efficient raw sewage pumps	6000	200				22	20 5	200	0	0
Monitoring of pump efficiency*										
Reduction of fuel requirements for sludge incineration			827 000	29 200 000	87 600	30 807	29 200	87 600	1 200 000	13.7
Recovery of incinerator exhaust heat†										
Bypassing of tertiary filters‡										
Modification of aeration system	396 000	12 700				1426	1351 5	12 700	70 800	5 6
Lowering of water level in equalization basin	641 600	20 500				2310	2189 8	20 500	0	0
Cleaning of boiler			41 064	1 450 000	4350	1530	1450	4350	800	0.18
Reduction of HV-2 use	25 200	810	13 395	473 000	1420	590	559	2230	0	0
Reduction of outside air			128 205	4 527 000	13 580	4776	4527	13 580	7700	0 57
Recovery of waste heat from aeration blowers			4191	148 000	440	156	148	440	0	0
Installation of water source heat pumps§						3135	2971.6	300	75 000	250
Installation of insulated glass			2583	91 200	273	96 2	91.2	273	11 195	41
Recovery of waste heat from transformers	116 000	3713				418	395 9	3713	37 000	10
Increase in conductor size**										
Correction of motor circuit power factor**										
Replacement of standard fluorescent fixtures with low-wattage fluorescent fixtures	40 200	1290				145	137 2	1290	3240	2 5
Replacement of incandescent lamps with self-ballasted metal halide fixtures	97 900	3130				352.4	334.1	3130	3370	1.1
Replacement of mercury vapor fixtures with high-pressure sodium fixtures	48 500	1550				175	165.5	1550	2520	1 6
Replacement of manual switches with time-out switches	108 500	3470				391	370 3	3470	1760	0 5
Total	1 535 400	49 143	1 016 382	35 889 200	107 663	46 529	44 101	157 106	1 440 385	

*This ECO is unquantifiable within the scope of this study so no values are given for costs or savings.
†The energy savings associated with this ECO are estimated. It was beyond the scope of this study to estimate the implementation costs; therefore, all values for this ECO were omitted, rather than inflate the total energy savings for all ECOs relative to implementation costs.
‡Annual totals cannot be estimated for this ECO because it applies to only certain periods of the year.
§Because this ECO involves changing from one heating source to another, only the total savings in (J) Btu was given.
**Because the energy that could be saved through this ECO and the cost to implement the ECO are both dependent on the extent of implementation, these estimates were not included.

TABLE 7

Energy conservation opportunities at the Big Rapids wastewater treatment plant

Energy Conservation Opportunities	Projected Annual Energy and Cost Savings: Electricity Amount kWh	Electricity Cost $	Natural Gas Amount m^3	Natural Gas Amount cu ft	Natural Gas Cost $	Total Amount $J \times 10^9$	Total Amount Btu $\times 10^6$	Total Cost $	Implementation Cost $	Simple Payback Period years
Reduction of lift pump speed	4000	160				14	13 6	160	100	0 625
Reduction of blower operation	30 700	1228				111	104 8	1228	0	0
Use of fine bubble aeration diffusers	111 300	4500				400	379 8	4500	10 000	2 22
Increased use of digester gas			16 992	600 000	1800	633	600	1800	0	0
Solar heating of digesters			52 250	1 845 000	5535	1947	1845	5535	150 000	27 1
Reduction of sludge trucking*						138	130 5	1175	0	0
Modification of final effluent supply pumping	154 000	6160				555	525 6	6160	2670	0 43
Cleaning of boiler			1190	42 000	126	44	42	126	600	4 8
Installation of nighttime setback controls			10 478	370 000	1110	390	370	1110	5000	4 5
Reduction of temperature in storage room			3852	136 000	410	143	136	410	200	0 49
Modification of gravity turbines			2648	93 500	280	99	93 5	280	320	1.14
Reduction of outside air			19 937	704 000	2120	743	704	2120	4600	2 2
Use of waste digester gas			7646	270 000	810	285	270	810	9000	11 1
Weatherstripping of double-door astragals			524	18 500	55	20	18 5	55	70	1 3
Enclosure of existing main entrance			187	6600	20	7	6 6	20	1020	51
Recovery of waste heat from transformers	12 300	492				44	41.9	492	4920	10
Increase in conductor size†										
Replacement of incandescent fixtures with low-wattage fluorescent fixtures	40 200	1610				145	137.2	1610	2940	1 8
Replacement of incandescent lamps with self-ballasted metal halide fixtures	48 127	1930				173	164 3	1930	490	0 25
Replacement of mercury vapor fixtures with high-pressure sodium fixtures	6131	245				22	20 9	245	770	3.1
Replacement of manual switches with time-out switches	20 150	800				73	68.8	800	280	0 35
Total	426 908	17 075	115 704	4 085 600	12 266	5985	5673	26 066	192 980	

*The energy saving associated with this ECO is 3868 L (1022 gal) gasoline, worth $1,175, based on a cost of $1.15/gal.
†Because the energy that could be saved through this ECO and the cost to implement the ECO are both dependent on the extent of implementation, these estimates were not included.

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TABLE 8

Energy conservation opportunities at the Marysville water treatment plant

Energy Conservation Opportunities	Electricity Amount kWh	Electricity Cost $	Natural Gas Amount m³	Natural Gas Amount cu ft	Natural Gas Cost $	Total Amount J × 10⁹	Total Amount Btu × 10⁶	Total Cost $	Implementation Cost $	Simple Payback Period years
Optimum use of storage	53 500	2020				193	182.6	2020	0	0
Preferential operation of the most efficient pumps	7650	290				40	26.1	290	0	0
Improved maintenance of pumps	115 500	4350				416	394.2	4350	6750	1.6
Operation of pumps during off-peak hours*		187					0	187	0	0
Reduction of chlorine feed†		281					0	281	0	0
Increased use of treatment instrumentation‡										
Cleaning of boiler			6599	233 000	650	246	233	650	600	0.9
Installation of nighttime setback controls			9062	320 000	900	338	320	900	4000	4.4
Conversion of dehumidifier from oil- to gas-fired§							0	2530	5200	2.1
Replacement of older building roofs			11 894	420 000	1170	443	420	1170	34 200	29.2
Replacement of other roofs			11 413	403 000	1120	425	403	1120	34 200	30.5
Removal of skylights			96	3400	9.5	4	3.4	9.5	700	73.7
Correction of vertical gaps			1977	69 800	195	74	69.8	195	400	2.1
Insulation of walls			1467	51 800	145	55	51.8	145	12 000	82.8
Replacement of windows			312	11 000	31	12	11	31	900	29.0
Installation of weatherstripping			1396	49 300	138	52	49.3	138	800	5.8
Recovery of waste heat from transformers	17 100	650				62	58.4	650	6500	10.0
Increase in conductor size**										
Installation of high-efficiency motors	34 800	1310				125	118.8	1300	50 000	38.2
Installation of electric metering††										
Replacement of incandescent fixtures with low-wattage fluorescent fixtures	75 700	2850				272	258.4	2850	10 500	3.7
Replacement of incandescent lamps with self-ballasted metal halide fixtures	4420	167	-			16	15.1	167	1090	6.5
Replacement of mercury vapor fixtures with high-pressure sodium fixtures	3180	120				12	10.9	120	1240	10.3
Replacement of manual switches with time-out switches	14 678	555				53	50.1	555	800	1.4
Installation of night lighting system	22 600	852				81	77.1	852	600	0.7
Total	349 128	13 632	44 216	1 561 300	4359	2905	2753	20 520.5	170 480	

*There is no direct energy savings realized from this ECO, but there is a direct energy cost savings.

†There is no direct energy savings possible from this ECO, but there is a direct energy cost savings attributable to reduced lime purchases.

‡No values for costs or savings are given for this ECO because they are unquantifiable within the scope of this study.

§There is no energy savings associated with this ECO, only a cost savings as a result of changing from one type of fuel to a less expensive one. Energy consumption is unchanged.

**Because the energy that would be saved through this ECO and the cost to implement the ECO are both dependent on the extent of implementation, these estimates were not included

††No estimates of energy savings or cost savings are given for this ECO because they could not be estimated with any accuracy. The fact that this ECO could save both energy and money, however, is not questionable.

TABLE 9

Summary of energy conservation potential at four study sites

Study Site	Electricity Amount kJ	Electricity Amount kWh	Electricity Cost $	Natural Gas Amount m³	Natural Gas Amount cu ft	Natural Gas Cost $	Total Amount kJ	Total Amount Btu × 10⁶	Total Cost $	Implementation Cost $	Average Simple Payback Period year
East Lansing	5.49 × 10⁹	1 525 400	49 143	1 016 382	35 889 200	107 663	46 527	44 101	157 106	1 440 385	9.2
Big Rapids	1.54 × 10⁹	426 908	17 075	115 704	4 085 600	12 266	5985	5673	26 066	192 980	7.4
Ann Arbor	3.99 × 10⁹	1 108 543	98 370	187 657	6 626 300	17 890	11 874	11 255	131 278	466 250	3.6
Marysville	1.25 × 10⁹	349 128	13 632	44 216	1 561 300	4359	2904	2753	20 520	170 480	8.3
Total	1.23 × 10¹⁰	3 419 979	178 220	1 363 959	48 162 400	142 178	67 290	63 782	334 970	2 270 095	6.8

TABLE 10

Estimated annual energy conservation and cost-savings potential in Michigan water and wastewater systems

Type of Treatment Plant	Electricity Amount kWh × 10⁶	Electricity Cost $ × 10⁶	Natural Gas Amount m³	Natural Gas Amount cu ft × 10⁶	Natural Gas Cost $ × 10⁶	Total Amount J × 10¹²	Total Amount Btu × 10⁹	Total Cost $ × 10⁶
Wastewater	96	3.4	56	1979	6.1	2434	2307	9.5
Water	94	3.5	18	642	1.8	1016	963	5.3
Total	190	6.9	74	2621	7.9	3450	3270	14.8

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mentation cost ranging from $500 to $2000, would create energy savings totaling more than 4.22 × 10[illegible] kJ/yr (4 × 10[illegible] Btu/yr) worth $18 757, while requiring a total implementation cost of $20 480. The aggregate simple payback period for the 19 ECOs in this category is only 1.1 years. Total energy savings represent 2.2 percent of current consumption and 6 percent of the total identified conservation potential.

The third category of ECOs has implementation costs exceeding $2000. Generally, an expenditure of this magnitude would require some form of capital planning on the part of municipal administrators. In addition, the technical complexity of some of these measures would probably require the involvement of professional engineers as consultants. The total energy savings possible from the implementation of 37 ECOs in this group is about $2 250 000, creating an aggregate simple payback period of 11.0 years. Total energy savings in this category represent 28 percent of current consumption and 78 percent of the total identified conservation potential.

A portion of the total energy savings for the study sites is attributable to reduced electricity consumption. Approximately 3.4 × 10[illegible] kWh/yr (1.22 × 10[illegible] kJ/yr) of electricity could be saved by implementing all ECOs at all four plants. This represents 14.3 percent of the total electrical consumption of the sites and would reduce electricity costs at the sites by about $180 000. The rest of the energy savings would come from reduced natural gas consumption. The aggregate natural gas savings from all ECOs at all four sites is estimated to be about 1.36 × 10[illegible] m[illegible] (48 × 10[illegible] cu ft/yr), which is 58 percent of the total present natural gas consumption of the sites.

The total implementation cost of all identified ECOs is estimated to be $2 270 000. The estimated total energy cost savings of $335 000 annually leads to an aggregate simple payback period of 6.8 years. On a per-site basis the aggregate simple payback periods ranged from 3.6 years for the Ann Arbor water system to 9.2 years for the East Lansing wastewater system.

In summary, the ECOs identified at the two wastewater system study sites would result in an estimated average electricity saving of 16.0 percent of current usage and an estimated average natural gas saving of 85.7 percent of current usage. The ECOs identified at the two water system study sites would result in an estimated electricity savings of 12.4 percent and a natural gas savings of 32.8 percent. The figures shown in Table 10 indicate the potential statewide energy savings, if it is assumed that the study sites are representative of municipal water and wastewater systems throughout Michigan.

Conclusions

Based on the information acquired from the study, the following conclusions have been identified.

1. Municipal water and wastewater systems in Michigan rely almost entirely on electricity and natural gas for their energy requirements. The reliance on each of these two energy sources is roughly equal.

2. The major component of energy consumption in water systems is electricity for pumping. The major components of energy consumption in wastewater systems are electricity for aeration blower drives and natural gas for sludge heating and incineration. Therefore, these areas offer the greatest opportunity for conservation.

3. No obvious relationship exists between the size of a water or wastewater facility and the efficiency with which it consumes energy.

4. Each year the 1100 municipal water and wastewater facilities in Michigan consume about 1.4 × 10[illegible] (6.12 kJ) of electricity at a cost of $50 million and about 1.2 × 10 m[illegible] (4.3 × 10[illegible] cu ft) of natural gas at a cost of $12.5 million. This accounts for about 2 percent of all electricity and about 0.5 percent of all natural gas consumed in the state.

5. It is projected that municipal water and wastewater systems in Michigan could reduce their electricity consumption by about 14 percent and their natural gas consumption by about 60 percent through the implementation of cost-effective conservation measures. The annual savings in municipal energy costs would be approximately $15 million.

6. Approximately 16 percent of the total identified energy-saving potential in water and wastewater systems can be achieved through operational and maintenance changes costing less than $500 and having an average simple payback period of less than one month.

7. Significant energy conservation opportunities relating to HVAC and illumination systems exist in municipal water and wastewater facilities because of the unusual occupancy pattern in many areas of the facility.

8. Municipal water and wastewater facilities have significant indirect energy impacts as a result of their consumption of large quantities of chemicals produced by energy-intensive manufacturing processes.

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Slow sand filter design and construction in developing countries

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Sand filtration is an important unit operation in the purification of surface water supplies. It is usually achieved by either slow sand or rapid gravity filters. Because slow sand filters require a larger area than rapid filters, a general misconception prevails among decision makers that they are expensive. This is not, however, always true, and for many small water supplies, slow sand filters are appropriate and cost effective.

Millions of people are living in thousands of villages without safe drinking water. These villages are in countries with financial resources that are strained by competing demands for transportation, electrification, education, and health services. Water supply is a capital-intensive utility, and the meager resources available for it must not be wasted on overdesigned facilities or on choice of technology. The guiding factor should be to supply water to the greatest number of people, with optimal use of funds. The design should be realistic and adequate for the intended service. As far as possible, materials and equipment should be manufactured or be available locally, and they should be matched to the skill level of operating and maintenance personnel.

Slow sand filtration

The appropriate technology for purification of surface water supplies for villages and small towns is often slow sand filtration, which has many advantages.

- It provides a single-step treatment for raw water with turbidity not exceeding 50 ntu.
- It improves simultaneously the physical, chemical, and biological quality of raw water.
- It is simpler to implement than alternative technologies, as operating costs are low and based on labor rather than energy or chemical inputs.
- It is reliable. There is no machinery to fail; treated water quality does not decrease even when raw water quality changes rapidly; construction is so simple that prefabrication may be possible; and the technology has been "tried and proven" for many decades.

Basic design considerations

Design period. An important decision in planning a new water supply system concerns the design period.

The stick marks the proposed location of a public water tap in a village near Nagpur, India. The man standing behind it owns the nearest house. He and the designers are debating the relative importance of public access, drainage, and other considerations that will determine the final site of the tap. The villagers participate in the decision.

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The single major constraint in the provision of water supplies in developing countries has been inadequate finances.[1] When money is scarce and interest rates are high, long-range investments are less preferred to investments that bring immediate benefits. This paper illustrates that since there is very little economy of scale in slow sand filter construction, the design period should be short: for example, 10 years. This will help to optimize the long-term investment in water supply and will allow the available money to finance more new projects immediately.

Design population and per capita supply. The population to be served during the design period has to be estimated by considering all the factors governing the future growth and development of the community: transportation, agriculture, electrification, education, and health services. While several methods are available for population forecasting, no single method will be uniformly applicable to all situations.

It has been recommended[2] that there be a minimum requirement of 40 Lpcd for rural communities where the supply is only through handpumps or central standposts and 70 Lpcd when house service connections are contemplated. The recommended per capita rate also varies with the size of population: ≤10 000 (70–100 Lpcd), 10 000–50 000 (100–125 Lpcd), >50 000 (125–200 Lpcd).

The per capita demand multiplied by an estimate of the future population gives the total design volume. When considering the design of slow sand filters, it would be more convenient to convert the daily required volume to a design flow Q, the quantity of water to be treated per hour rather than per day, because the daily requirement of water may be treated over a period of 24 hours or just a few hours, which is common in small plants. Thus, for a given daily output, the size of the plant depends on the duration of filter operation.

Rate of filtration. The traditional rate of filtration adopted for normal operation is 0.1 m/h (2 gph/sq ft). Pilot plant studies have shown that it is possible to produce safe water at a rate of 0.2 m/h or even 0.3 m/h. Of course, at these higher rates, the interval between filter cleanings is shortened, but the treated water quality does not deteriorate. The 0.2-m/h rate is considered a maximum desirable rate during those periods when some filters are out of service for cleaning or repairs. If only two filter units are built and the normal rate is 0.1 m/h, the overload rate with one unit out for cleaning will be 0.2 m/h, which is acceptable, but the minimum number of units should be two.

The recommendation deviates from the general practice in many states in India of providing one extra unit so that the overload filtration rate is kept to 0.1 m/h. A design that does not allow even occasional overload seems to increase the size and cost of the facility unnecessarily.

Continuous versus intermittent operation. Given the daily demand, the size of a plant is governed by the effective duration of filter operation. Pilot studies[4] have shown that intermittent filter operation is not desirable. A short time after startup, the bacteriological quality of filtered water deteriorates and becomes unacceptable. Because the purification process is as much biological as physical, the biological organisms do best when conditions are nearly steady. Further, continuous operation over 24 hours obviously requires an area only one third of that needed for intermittent eight-hour operation. The savings in filter construction can pay for storage reservoirs and additional operators.

TABLE 1

Overload and average filtration rates

Number of Filters	Number of Operating Filters	Filtration Rate m/h
2	2	0 100
2	1	0 200
2	0	0 000
3	3	0 100
3	2	0 150
3	1	0 300
4	4	0 100
4	3	0.133
4	2	0 200
5	5	0.100
5	4	0.125
5	3	0.166
7	7	0 100
7	6	0.118
7	5	0.140
10	10	0.100
10	9	0 111
10	8	0 125

Number of filter beds. To ensure uninterrupted production, a minimum of two filter units should be built irrespective of the plant capacity. Three or more units may be required because the size of each unit cannot exceed certain maximum practical dimensions, or three or more units may be desired simply to gain flexibility and to reduce overload on the filters that are operated when one unit is out of service for cleaning or repairs. Table 1 shows the average and overload filtration rates, depending on the number of filters.

For a given area, the cost of filter media and underdrain is practically the same for any number of filter beds. However, when the number of beds is increased, the cost of construction will increase because of increased wall length. The extra cost to be paid for higher flexibility and reliability is only a fraction of the cost of the least flexible acceptable design, which has only two filters and may often be judged a good investment. It can also be shown that the total cost of values, piping, and control weir chambers does not necessarily increase with an increase in the number of filter units.

Filter shape and plant layout. Filters may be circular or rectangular. Circular filters are not economical except for very small installations. For a 100-m^2 plant with two filters, the diameter of each filter would be about 8 m. Two rectangular beds would have dimensions of about 5.77 m × 4.33 m. The common wall of the two rectangular units may offset the inherent structural advantages of the circular shape. Rectangular filter dimensions have been determined so that the wall perimeter for a given area is minimal (Table 2).

Arranging the filters in a row maximizes the number of common walls and facilitates construction, operation, and maintenance. Filters arranged symmetrically in blocks on each side of the inlet pipe can also be attractive. Local topography and the placement of pump houses, storage, and other facilities will probably be important in determining the layout. The total area

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TABLE 2
Optimal size of filter unit for a given area

Area m	Two Units Length m	Two Units Breadth m	Two Units Perimeter m	Three Units Length m	Three Units Breadth m	Three Units Perimeter m	Four Units Length m	Four Units Breadth m	Four Units Perimeter m	Five Units Length m	Five Units Breadth m	Five Units Perimeter m
50	5.77	4.33	34.62	5.00	3.30	40.00	4.47	2.60	44.70	4.18	2.45	48.96
100	8.16	6.12	48.96	7.07	4.67	56.56	6.32	3.95	63.20	5.77	3.47	69.24
150	10.00	7.50	60.00	8.66	5.71	69.28	7.74	4.64	77.40	7.07	4.24	84.84
200	11.54	8.66	69.24	10.00	6.60	80.00	8.94	5.58	89.40	8.16	4.90	97.92
300	14.13	10.60	84.60	12.24	8.10	97.92	10.90	6.84	109.00	10.00	6.00	120.00
400	16.32	12.24	97.92	14.14	9.34	113.12	12.64	7.90	126.40	11.54	6.92	138.48
500	18.25	13.70	109.50	15.88	10.43	126.40	14.13	8.83	141.30	12.90	7.74	154.80
600	20.00	15.00	120.00	17.31	11.43	138.48	15.48	9.67	154.80	14.14	8.48	169.70
700	21.60	16.20	129.60	18.70	12.34	149.60	16.72	10.45	167.20	15.25	9.16	183.12
800	23.10	17.33	138.60	20.00	13.20	160.00	17.87	11.17	178.70	16.32	9.80	195.84
900	24.50	18.37	147.00	21.21	14.00	169.68	18.96	11.85	189.60	17.31	10.38	207.72
1000	25.80	19.35	154.80	22.36	14.75	178.88	19.98	12.50	199.80	18.24	10.95	218.88
1200	28.30	20.22	169.80	24.50	16.16	196.00	21.90	13.68	219.00	20.00	12.00	240.00
1500	31.60	23.70	189.60	27.38	18.10	219.04	24.47	15.30	244.70	22.35	13.41	268.20
2000	36.50	27.40	219.00	31.62	20.87	232.96	28.26	17.66	282.60	25.80	15.48	309.60

TABLE 3
Cost in Indian rupees for a given area and number of units*

Area m	Indian Rupees: Two Units	Three Units	Four Units	Five Units
50	37 234	40 300	42 980	45 407
100	62 908	67 240	71 204	74 467
150	86 700	91 980	96 618	100 859
200	109 468	115 600	120 958	125 814
300	151 336	160 816	167 298	173 400
400	195 814	204 360	212 048	218 934
500	237 414	247 048	255 540	263 236
600	278 400	288 934	298 236	306 729
700	318 672	329 872	340 304	349 378
800	359 002	371 200	381 960	391 629
900	398 780	411 716	423 072	433 400
1000	438 236	451 960	463 886	474 762
1200	516 786	531 720	544 830	556 800
1500	633 072	649 852	664 478	677 874
2000	824 830	844 188	861 082	876 472

*U.S. $1 = approximately Rs 8

TABLE 4
Percentage increase in cost of two units when a given number of filter units is provided for a given area

Area m	Rate of Cost Increase: Three Units percent	Four Units percent	Five Units percent
50	8.23	15.45	21.95
100	6.68	12.90	18.37
150	6.10	11.44	16.33
200	5.60	10.49	14.93
300	5.81	9.04	13.08
400	4.42	8.29	11.80
500	4.05	7.63	10.87
600	3.78	7.12	10.17
700	3.44	6.72	9.56
800	3.39	6.36	9.08
900	3.24	6.09	8.68
1000	3.13	5.85	8.33
1200	2.68	5.42	7.74
1500	2.65	4.96	7.07
2000	2.34	4.39	6.26

of land covered by filters is not a factor, as it is virtually the same regardless of layout.

Depth of filter box. The elements that determine the depth of the filter box and their suggested depths are free board (20 cm), supernatant water reservoir (100 cm), filter sand (100 cm), supporting gravel (30 cm), and underdrainage system (20 cm), with a total depth of 270 cm. The use of proper depths for these elements can reduce the cost of the filter box considerably. It is general practice to adopt a total depth of 3–4 m for the filter box, but use of a 2.7-m box depth will reduce the cost without adversely affecting efficiency.

Choice of filter sand and gravel. Undue care in the selection and grading of sand for slow sand filters is neither desirable nor necessary. Use of builder grade or locally available sand can keep the cost low. Similarly, rounded gravel, which is often quite expensive and difficult to obtain, can be replaced by hard, broken stones to reduce cost.

Economic considerations

Minimum filter cost. The cost of a filter excluding pipes and valves is made up of two components: the total cost for floor, underdrains, sand, and gravel; and the cost of walls of the filter box.

This cost in general is

$$C = K_A A + K_p P \tag{1}$$

where A is the total filter bed area in m², P the total wall length in m, K_A the cost per unit area of filter bed, and K_p the unit length of wall.

For rectangular filters with common walls, the problem is to minimize C subject to

$$A = nlb \text{ and } P = 2\,nb + l\,(n + 1) \tag{2}$$

where n is the number of filters, b is the breadth, and l is the filter length.

The term $K_A A$ is constant for any value of n and any filter shape. Hence, the minimum cost solution is the solution that minimizes P, which is

$$l = \frac{2A}{n + 1} \tag{3}$$

and

$$b = \frac{(n + 1)l}{2n} \tag{4}$$

The equation for b, when rearranged, shows that $2nb = (n + 1)l$, or the condition for minimum filter cost is to have the sum of the lengths equal to the sum of the breadths. It can be shown that this is true whether filter

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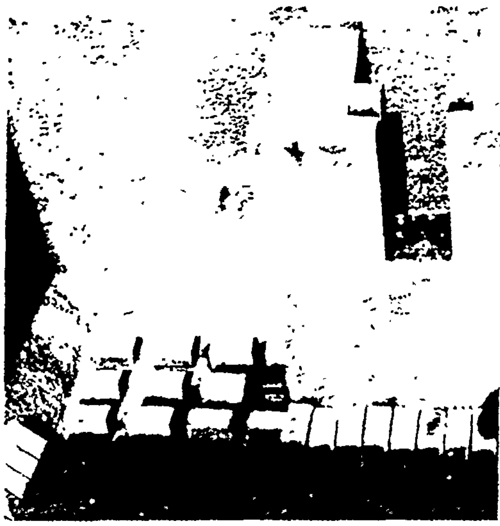

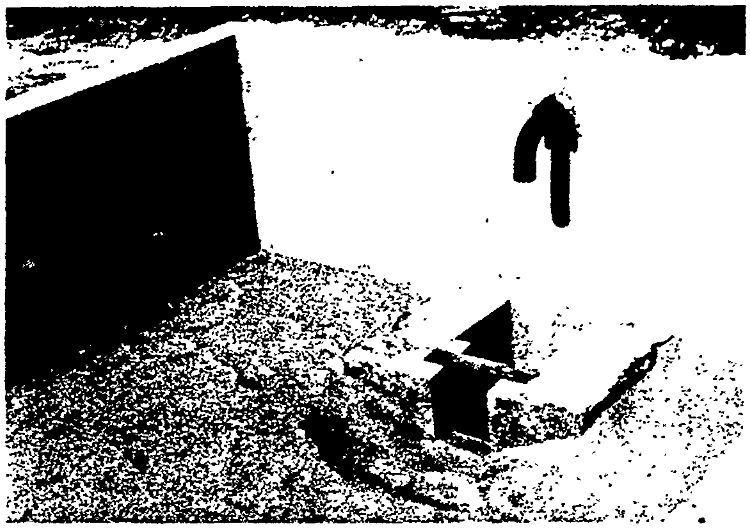

Two slow sand filter units were recently constructed in the village near Nagpur. The underdrain collection structure is at the base of the unfinished filter box at left; the unit at right is more complete, with sand, inlet, and stilling well.

units are arranged in a single row or as blocks on each side of a central gallery.

The general expression for the minimum cost is found by substituting Eq 3 and 4 for Eq 1.

$$C = K_A A + 2K_p\left(\sqrt{2A\,(n + 1)}\right) \tag{5}$$

A detailed cost estimate based on 1979 prices (in Nagpur, India, and excluding contractor's profit) for various materials and items of work has shown that the filter bed cost per square metre is Indian Rs.350 and the wall cost per metre length is Rs.570.

Therefore, $K_A = 350$ and $K_p = 570$, the specific cost function (Nagpur, 1979) written in terms of area A is

$$C = 350\,A + 1140\left(\sqrt{2A\,(n + 1)}\right) \tag{6}$$

Table 3 gives the costs for filters ranging in total area from 50-2000 m². At 0.1-m/h filtration rate and 24-hour operation, this size range corresponds to a range in production of 120 m³/d to 4800 m³/d. With a per capita supply at 70 Lpcd, this would serve a population range from 1700 to 68 000 people. A large percentage of villages and towns in India and other developing countries fall within this population range.

The cost of operating flexibility. The percentage increase in cost with reference to the minimum of two filter units is shown in Table 4. The table of costs shows that the number of filters can be raised from two to three by spending roughly 2 to 8 percent more money. Building five units instead of two costs roughly from 6 to 22 percent more.

The smaller the total area, the greater the additional cost for building more than the minimum of two units. However, it would not be wise to build more units for small areas, as the unit size would become too small for practical construction. Too many filters would also demand greater attention from the operator.

If it is assumed that for a given filter area, the increase in cost to provide a given number of units (against a minimum of two) will not exceed 5 percent (based on the cost equation $C = 350\ A + 570\ P$), the lower limit of area A can be worked out for different values of n. Based on this information and the cost figures given in Table 3, the number of units for a given area, and the cost thereof, have been worked out and presented in Table 5, which can serve as a ready reference for a design engineer. It can be concluded that there is no significant cost penalty for making the number of filters greater than two in order to gain reliability and operating flexibility.

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TABLE 5

Cost of filters for optimum number of units

Area m²	Number of Units	Cost of Filters Rs
50	2	37 234
100	2	62 908
150	2	86 700
200	2	109 468
300	3	160 816
400	3	204 480
500	3	247 048
600	3	288 934
700	3	329 872
800	3	371 200
900	3	411 716
1000	3	451 960
1200	3	571 720
1500	4	664 478
2000	4	861 082

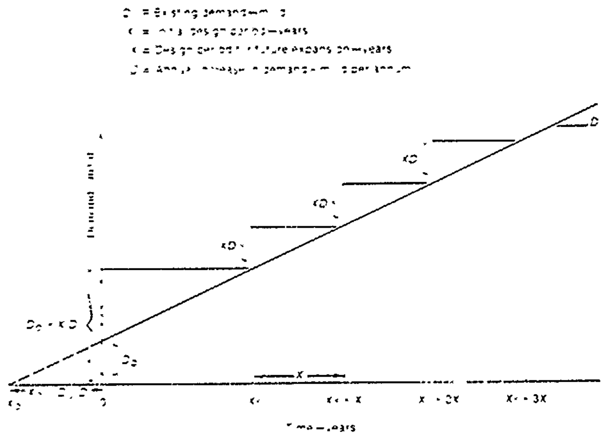

Figure 1. Model definition for initial construction and expansion in the case of linear growth in demand, with an unsatisfied demand at time zero

Traditionally villagers transported water from the river. Now, water flows into the collection well (the structure on the left) from an infiltration pipe buried in the riverbed; from there, it is pumped to the slow sand filtration plant.

Economy of scale. A general cost model for the filter beds can be written

$$C = K(A)^a \tag{7}$$

where A is the total area of the filter beds, $K(A)$ is the cost per unit area of filter bed construction including walls, and a is the exponent that represents the economy of scale factor.

The cost data given in Table 5 have been used to determine the parameters K and a of the function by the method of least squares. Slight changes in the unit cost of filter bed and box wall, from the values of 350 and 570 used to derive Table 5, do not significantly change the value of the exponent a.

The resulting equation is given by

$$C = 1218\,A^{0.857} \tag{8}$$

where A is square metres. Hence, the cost per unit area of slow sand filter is seen to be Indian Rs. 1218, and the economy of scale exponent is 0.857.

If the exponent were 1, the cost would vary in direct proportion to the area of the filter. If the exponent a is small, there will be little additional cost for building a larger unit. If $a = 0$, the cost is independent of size. Large economies of scale are associated with small values of the exponent. Until the exponent decreases to about 0.6 or 0.7, there is no economic incentive to overdesign. Thus, very little saving is accomplished by increasing the size of the project in order to provide service over a long time into the future.

Construction staging and expansion

In developing countries, the major problem in providing public water supplies has been insufficient funds. The planning problem is to find the optimal design period that minimizes present and long-range

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costs. It is important on national and international levels to bring safe drinking water to as many people as possible in the shortest time. The available money must be invested wisely. It would not, for example, be wise to invest money in overdesigned treatment plants by building treatment capacity that would not be used for ten to twenty years, unless the extra capacity could be provided inexpensively.

In this section, an argument is made for building the initial plant smaller and planning for rather frequent but smaller expansions, which is contrary to traditional practice. This recommendation is based on an economic analysis of current construction costs for slow sand filters and on the balance between a lower cost yield per unit of capacity in large plants, against the cost of interest on money tied up in unused capacity. The problem simply is to find the design period that minimizes the total long-range cost of the treatment facilities. The solution to this problem has been published by several engineers, including Lauria.[5]

The problem is solved by finding the design period that minimizes the present value of construction costs required to keep the system at a capacity that meets the demand over a period of time from the present into the future. The present value P of an amount of money F to be spent in n years, given a time value of money of r percent per year (interest or discount rate), is

$$P = F/(1 + r)^n \tag{9}$$

This is equivalent to the amount of money that could be invested today at a return of r percent per year, in order to have the amount F when it is needed after n years.

It is important to account for the time value of money in this way, not only because some agency may actually have to pay interest on it but also because money

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invested in one project is unavailable for investment in an alternative project that may have a real value to the economy of r percent per year. Because of government subsidies, the actual interest rate paid on a loan may not be the correct discount rate to use in determination of a sound investment policy. In today's economy, a discount rate of 6 percent per year is very low, and a discount rate of 12 to 15 percent per year may not be too high.

Lauria[·] has fitted an approximate model to the exact solution to the problem of building a new plant and then expanding it as needed in the future for the case where the demand grows linearly, that is, at a constant increment (not constant percentage) each year, and where the demand will always be satisfied. The new plant must satisfy an existing, unmet demand of the people already in the village and must also serve the village for some time into the future. In Figure 1, the initial, unmet demand is labeled D_o, and the length of time the first stage will serve is X_1. At time X_1, an expansion goes into service. The expansion is of capacity XD and is adequate for X years. A second expansion of the same capacity is needed at time $X_1 + X$ years, and so on into the future.

The size of the initial stage is $D_o + DX_1$, where D is the annual increase in demand (for example, m³/d per year).

The exact solution to this problem[·] can be found by using Lauria's approximate solution

$$X_1 = \frac{2.6\,(1-a)^{1.12}}{r} + \frac{0.3\,(1-a)\,(D_o/D)^{0.5}}{\sqrt{r}} \qquad (10)$$

where a is the economy of scale exponent of Eq 8 and r is the discount rate of Eq 9. X_1, D_o, and D are defined above. Note $D_o/D = X_o$.

The exact solution is more explicitly dependent on the growth rate D than this approximating function, which is accurate enough to be useful.

Solving this equation for a variety of values of D_o, D, and r shows that the initial design period X_1 should be less than the 20 to 30 years commonly estimated by water supply agencies in the past. For example, if $D = 2.5$, $D_o = 50$, $r = 0.08$ (8 percent per year), and $a = 0.857$, X_1 will be about 6 years. Figures 2 and 3 show other results.

Eq 10 shows how little incentive there is to overdesign. Note that X_1 approaches zero when the exponent a approaches unity. For slow sand filters, a is so close to unity that the value of X_1 will always be small, regardless of the values used for other variables. Higher interest rates also make X_1 smaller, and a faster rate of growth in demand (larger D) will reduce the time before expansion.

The inescapable conclusion is that planning should be for frequent and fairly small expansions. The commonly used design periods of 20 to 30 years tie up scarce resources unproductively. The cheapest way to bring safe water to a large number of villages is to construct several plants that are expected to serve up to 10 years before they are expanded.

The values calculated from Eq 10 are useful approximations of the exact solution, which Lauria has called

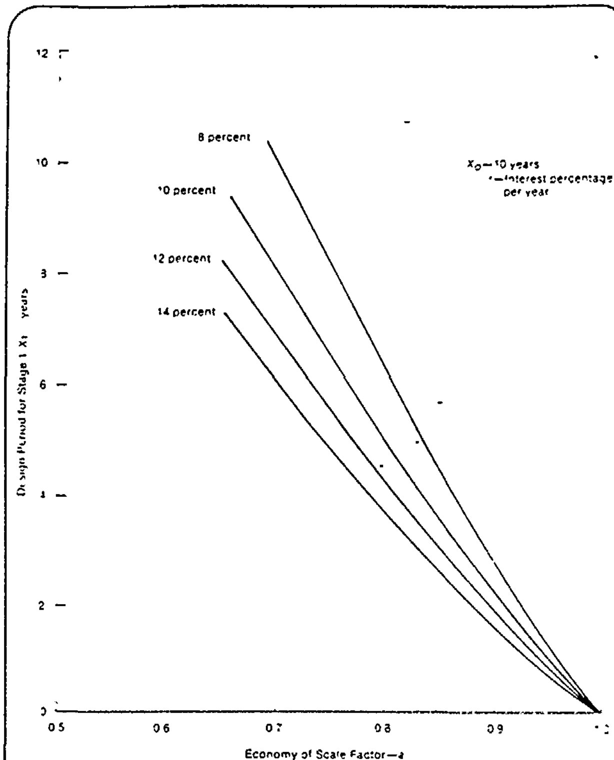

Figure 2. Design period of stage 1 when there is an unsatisfied initial demand and X_o = 10 years
Lauria's approximation used in calculation.

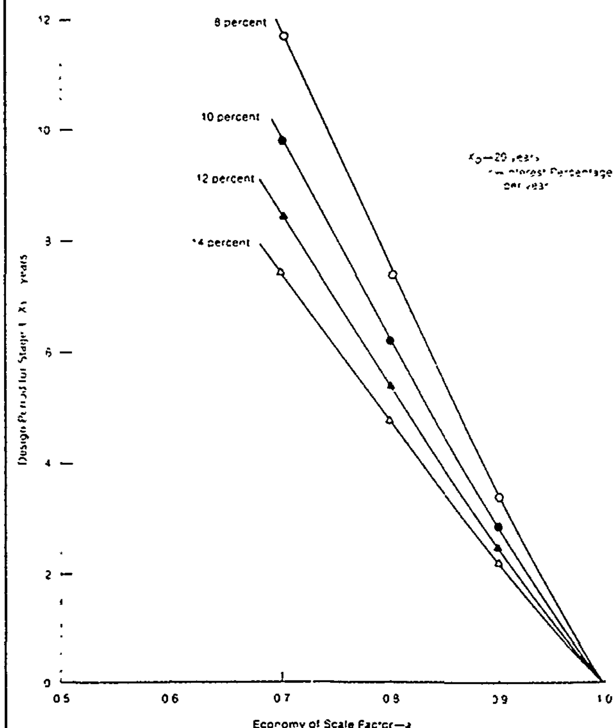

Figure 3. Design period of stage 1 when there is an unsatisfied initial demand and X_o = 20 years
Lauria's approximation used in calculation.

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the optimal solution. This solution is optimal in the real sense only in so far as the model from which it is calculated reflects all the important features of the decision-making problem. In this problem, there are practical, logistic reasons for not accepting the calculated values as optimal in the real sense; for example, those shown in Figures 2 and 3. As a practical matter, no organization would want to organize an expansion every two or three years, and no treatment plant operator would want to have his operation interrupted by construction every few years. The model does not incorporate these realities, nor does it include the cost of periodic design and other administrative costs.

In spite of these imperfections, the model gives good advice: No matter how small the economy of scale factor a, or how low the interest rate r, or how long the backlog of unmet demand X_0, the design period of the first stage should not be longer than 10 years. Design periods shorter than 10 years are economical if just construction costs are considered. Although the numerical values calculated from these models are only guidelines, they should be taken seriously as good advice in favor of short design periods.

Future expansion. Expansion of existing plants can also be calculated by using Lauria's approximation Eq 10 and setting $X_0 = 0$. This assumes, of course, that the expansion is timed so that there will not be a new unmet demand before the expansion goes into service. The model for the design life of an expansion is

$$X = \frac{2.6\,(1-a)^{\cdots}}{r} \tag{11}$$

It is clear that even for low discount rates the period between expansions should be short (about five years). As a practical matter, some engineers and administrators will think that five years is too short, considering the usual time lags in arranging financing and other logistics of construction. Nevertheless, it is clear that frequent expansion is the best economic policy. There should be no great difficulty at the regional or national level to program one or two expansions when the initial stage has already been built.

Uncertainty. In a given village, there will be uncertainty about the rate of population growth and the actual maximum average and peak filtration rates. These two factors determine the actual time between filter expansions and the size of the first installation and subsequent additional stages.

This uncertainty is not damaging since the decision about what capacity to install will be made thousands of times, and overestimates at some plants will be cancelled by underestimates at others. There is no penalty for the underestimate because there is no substantial economy of scale savings.

The case for standardization

Because there are virtually no savings available through economy of scale, savings should be sought elsewhere. The first method, which has been employed for some time, involves careful hydraulic and structural designing to minimize materials. The second method standardizes the design (comparable to the standardization of water heaters and automobiles). A small number of models (capacities and layout) would be available, and one would be selected to fit a particular situation best. A detailed design would not be made for each village; rather, a selection would be made from a catalogue of already optimized designs.

Prefabrication of components would be possible since there would be a limited number of sizes available. Wall slabs might be precast, just as building slabs are precast. Pipes could be precut and partially fitted at the factory. Economies from this kind of mass production are as high as 30 percent on some components. The savings arise from reduced wastage of cement and other materials, fabrication by crews that have gained efficiency by repeated practice, and more precise design of all components.

Standardization and prefabrication are subjects for future research. The number of villages having a given range of population at the present time and 10 years in the future needs to be tallied; then the best sizes for installation can be determined, and detailed optimal plans can be made. Precise construction details, as well as careful study of prefabrication methods, are needed at this stage.

Summary

The slow sand filter is effective and appropriate technology for rural water supplies in developing countries. In the light of recently completed research, the traditional design and economies of filter construction have been reviewed. It has been shown that by use of optimal filter dimensions, the number of filters can be increased at almost no extra cost so as to gain flexibility and reliability in operation. A model for filter cost has been suggested and, since there is no economy of scale, it has been shown that at the national level it would be more advantageous to adopt a strategy that provides for system expansion at frequent intervals (10 years) than to plan for large initial plants. Further research on standardization and prefabrication is suggested as a means for further reducing costs.

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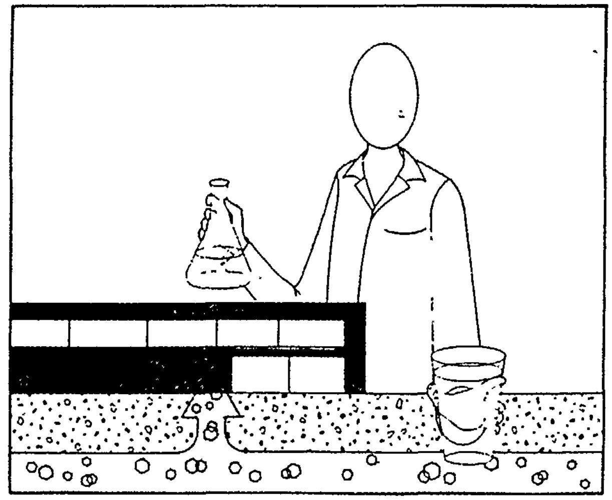
Rights and liabilities of water suppliers arising from groundwater pollution



Edward I. Selig

Suppliers of water are subject to exceptionally high standards of care towards the consuming public. Even where contamination is not the result of negligence on the supplier's part, he may be held strictly liable for all resulting injuries to users. Moreover, very small concentrations of organic chemicals in drinking water supplies, detected by sophisticated modern measuring techniques, may be grounds for health authorities closing wells and consumers claiming damages against the supplier for sickness and disease. Suppliers should, therefore, test for priority toxic pollutants (PTPs) and learn both the waste disposal practices and groundwater flow systems of their watersheds, in order to formulate and pursue preventive strategies before trouble occurs. Such strategies may include reduction of pumping rates, demands for land-use controls in critical recharge zones, and lawsuits for damages and injunctions against upstream sources of contamination.

By and large, water suppliers are subject to the same rules of product liability as are other purveyors of goods and services to the consuming public. Every water company must offer a reasonably pure and wholesome supply. If a company negligently allows its supply to become contaminated, or if it fails to protect its purity through appropriate safeguards, the company may be held liable to pay damages for ensuing injuries. The courts have traditionally defined negligence as a departure from standards of reasonable care that the defendant, because of his position or activity, owes to the plaintiff. Accordingly, a court will ask whether the defendant company used reasonable care to discover and correct or prevent any contamination of its supply that might render it unfit for human consumption.[1]

Strict liability

In fact, because of their status as public utilities and monopolies on which the public must rely for a prime necessity of life, water suppliers are now held to an exceptionally high standard of care. A relatively recent case in point is *Moody v. City of Galveston.*[2] The plaintiff, a user of water supplied by the city of Galveston, was injured by ignition of gas that had been introduced into plaintiff's water line from defendant's wells. The court held that the city had supplied a product that was in a defective condition and that was unreasonably dangerous to the user, in violation of an implied warranty of fitness for human consumption. The presence of gas in the water line created an unreasonable risk of harm to the plaintiff, for which the defendant could be held strictly liable. There is no reason to believe the case would have been decided differently if the contaminant had been some chemical transported to defendant's well from an industrial wastewater plume.

The *Galveston* case underscores two important trends in the current law of products liability, with particular reference to water suppliers.

- Even where contamination is not the result of negligence on the part of the supplier, he may be subject to the rule of strict liability for all resulting injuries to users. The *Galveston* case goes beyond any mere finding that the defendant was at fault for failing to discover and eliminate the gas from its supply.
- A municipal or other public supplier cannot plead sovereign immunity as a bar to suit, for the government acts here in a proprietary rather than a regulatory or adjudicatory capacity.

Determination of injury

Both public and private suppliers, then, may be held liable, without proof of fault, for any injury to users that is occasioned by the furnishing of contaminated water. But when may an injury be said to result from such a cause? Suppose that analysis of a county's water supply, using the most sensitive measuring techniques currently available, reveals 1 $\mu g/L$ (ppb) of benzene and that the incidence of cancer among users of this supply is significantly higher than among consumers in an adjacent county served by a different supply. A plaintiff in the former county who has contracted cancer sues the water company for all his damages, including medical expenses, lost income, and pain and suffering. The usual contradictions in expert medical testimony are presented to a jury, which awards damages of $1

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million against the water company and in favor of the plaintiff. Is this a mere fantasy? By no means. Cases of this type are now being filed in the courts in increasing numbers. It remains to be seen how many of them will succeed.

On the one hand, juries will be sympathetic to claims of serious injury, especially where a plaintiff can buttress his case for strict liability by introducing some evidence of possible negligence on the defendant's part, such as failure to employ advanced water testing and treatment technologies. Moreover, as a matter of law, compliance by a water supplier with federal and state drinking water standards will not shield him from tort liability, if the plaintiff can establish a causal connection between pollutants in the water supply and the injury for which damages are claimed. On the other hand, courts remain generally unsympathetic to offers of proof based only on the statistics of epidemiology or other disciplines, and it will usually be both difficult and costly for a plaintiff to prove specific physical causation. The plaintiff may also be barred by a statute of limitations that requires suit to be filed within four or five years of first exposure to the carcinogen, regardless of the later time at which the disease is likely to have become manifest.

Nonetheless, the possibility remains of large damage awards against water companies in such cases. What, then, can suppliers do to minimize this risk? There are no easy answers. Modern measurement techniques disclose an ever-expanding number of industrial, commercial, and household chemicals in underground water supplies, but the technology of measurement has raced far ahead of anyone's ability to assess and respond to the data intelligently. The US Environmental Protection Agency (USEPA) has published a list of 129 priority toxic pollutants (PTPs); yet it is not known whether a few μg/L (ppb) of this or that chemical is cause for alarm. Testing for the full list of 129 is said to cost about $1000 per sample.

How many samples at what frequencies are water suppliers supposed to afford, and how much treatment at what further cost must they undertake to protect users from possible injuries giving rise to charges of negligence and strict liability? Compliance with regulations under the Safe Drinking Water Act (SDWA) requires testing for 7 of the 129 PTPs; presumably, USEPA has persuasive data on adverse health effects from these seven pollutants, and it is feasible to remove them by treatment of the water supply. But the list of suspect chemicals is far more than 7 or 129. Thus, water companies now face a dilemma that current regulations do not resolve.

Preventive strategies

At the least, a water supplier should test periodically for any priority toxic pollutants that are known to exist or are likely to exist in the watershed of his wells. If such a pollutant is discovered in a supply, the costs of treatment to remove it before trouble occurs may be less onerous than the risk of future liability.

But a prudent approach to the problem requires more. The supplier should learn both the history and the current pattern of waste disposal practices that could affect the aquifers feeding his wells, and he should become acquainted with the groundwater flow systems of those aquifers. What plumes of contaminated groundwater are now advancing towards those wells, and when can they be expected to arrive? With this information in hand, the supplier can decide not only what tests to conduct but what strategies to adopt now for protecting well fields from predictable contamination next year or five years from now. The supplier might reduce pumping rates in order to avoid attracting plumes. He can demand that waste disposal be prohibited or restricted—by watershed districting or other land-use controls—in the recharge zones on which he relies. He can sue to enjoin, or get the cognizant government authority to enjoin, the siting or continuation of insufficiently controlled discharge sources in those zones.

In short, a variety of technical, political, and legal strategies are available to water companies that are prepared to seize the initiative in protecting their interests—which are also very much the interests of the public—instead of adopting merely defensive postures in the face of growing threats to groundwater supplies. As the saying goes, an ounce of prevention is worth a pound of cure.

Suppliers can bring a variety of legal actions to protect their own groundwater rights, whether these have been obtained under riparian, appropriative, or other systems of law. Pollution of groundwater is both an unreasonable use under riparian law and a nonbeneficial use under appropriative law. Moreover, if a supplier can trace pollution of his well to a specific waste discharger, the supplier can sue the discharger for damages and perhaps even for an injunction against the threat of pollution before it occurs, on common law grounds of nuisance, negligence, trespass, or strict liability. The doctrine of strict liability may certainly be invoked against disposers of hazardous waste or other handlers of hazardous materials, when the consequence of their activities is pollution of water supplies.

Causality is often difficult to prove in such cases, but it should become easier with growing knowledge of groundwater flow systems, and the burden of proof can be met with evidence falling short of conclusive scientific demonstration. In cases where pollution may be attributed to two or more dischargers, a plaintiff can sue them collectively as joint tortfeasors and invoke the doctrine of joint and several liability, under which any defendant may be held liable for the entire damages, with the burden of proof then resting upon him to establish how they should be equitably apportioned among the several codefendants.

Few cases have been reported so far involving suits by water suppliers against groundwater polluters. However, such litigation can surely be expected to increase over the next several years.

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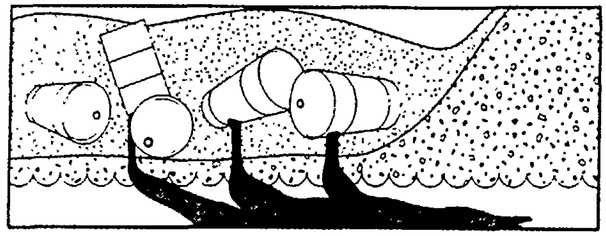
Groundwater contamination in Connecticut



Richard S. Woodhull

Trace quantities of volatile organic chemicals that are potentially carcinogenic are widespread in Connecticut's groundwaters. Techniques are being found for identifying and dealing with this contamination. The cost to towns and individuals runs high, warranting the development of a governmental aid program directed specifically to this problem.

Traditional health department programs have established and maintained good control over groundwater contamination from bacteria or viruses carried by sewage effluent. This achievement is a result of the establishment and enforcement of codes that regulate the location and construction of both wells and subsurface sewage disposal systems in relation to each other. Because Connecticut's thin soil cover is spread atop bed rock, it is extremely important to purify sewage before it enters the rock crevices.

The current serious groundwater contamination problems stem from the previously unregulated discharge of various kinds of chemicals or chemical solutions onto or into the ground. These contaminants include road salt used for melting away ice and snow, fertilizers used on crops and lawns, volatile organic solvents or degreasers, gasoline and oil from storage tanks, oil from distribution system leaks, and leachates from domestic and industrial wastes disposed of at municipal and industrial dumps or landfills. A separate but equally serious source of chemical contamination is the production of trihalomethanes (THMs) by chlorination of waters containing natural precursors such as humic acids, lignins, and tannins.

Detection of contamination

In 1977 the Connecticut legislature directed the Department of Health Services (DHS) to monitor annually the organic chemical content of all public water supplies to determine which potential carcinogens might be present, to rank the chemicals in order of potential danger, and to estimate the cost of removal. These findings are to be reported to the legislature each year.

This testing program has resulted in the detection of some quantity of volatile organic contaminants in 87 percent of the waters that have been tested thus far and that supply utilities serving populations of 1000 or more persons. This percentage is based on testing the supplies used by 78 of the 95 water utilities in this category.

Use of SNARL. Twenty-three wells serving 17 of these systems were found to contain chemical levels in excess of the US Environmental Protection Agency's (USEPA) suggested no-adverse-response level (SNARL). Connecticut first began application of the SNARL concept in June of 1979, after meeting jointly with representatives of the USEPA and the other New England states to work out a strategy for dealing with the problem. SNARLs have been effectively used by requiring notification of the consumers whenever a water did not comply with these guidelines. A statement that was satisfactory to both the utility and the health department was drafted to encompass such situations. The plan outlined below is to be followed by each utility in dealing with chemical contamination that is deemed to constitute a threat to human health.

1. Measures will be promptly instituted to locate the source of the contaminant and, if possible, to remove it, neutralize it, or contain it.
2. The consumers of the water supply will be notified of the nature and degree of the contamination and will be advised of the health hazard. They will be informed of the actions being taken by the utility to correct the problem and instructed about where or how to obtain safe drinking water in the interim.
3. If the problem with the source water cannot be corrected quickly, the utility shall, if feasible, connect to another source of water supply and remove the affected source from use.
4. If a satisfactory water source cannot be obtained promptly, adequate water treatment to remove the contaminant shall be promptly instituted. If a substantial time period is required to design and construct permanent facilities, mobile emergency treatment shall be used in the interim.
5. In an extreme emergency, the utility shall arrange for tank trucks of water or the home delivery of bottled water from an approved source where piped connection from a suitable water source cannot be obtained.

Of the 23 contaminated public wells with measurements above SNARL, 11 wells contained 1,1,1-trichloroethane concentrations ranging from 40 to 1300 µg/L. Nine wells contained trichloroethylene in the range from 26 to 3100 µg/L, seven wells tetrachloroethylene from 16 to 200 µg/L, and one well contained 1.6 µg/L of a chemical in the "benzene area."

The source of contamination was identified in 13 cases as an industrial discharge, whereas three others were a combination of industrial discharge and municipal landfill. Scavenger dumping was responsible for contamination of one community well in addition to seven other nearby private wells. An illicit septage lagoon that polluted a mobile home park well has a plume of contamination that threatens a large city's well supply. In five cases the source of contamination has not been pinpointed but is believed to involve illegal dumping or burial of chemical wastes.

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Solutions. Granular activated carbon treatment is being used successfully to treat a well supply contaminated by up to 100 $\mu g/L$ 1,1,1-trichloroethane and 25 $\mu g/L$ trichloroethylene. In two cases interceptor wells are being pumped to waste in order to protect production wells. Two contaminated wells are being blended with better quality water so as to maintain contaminant concentrations below SNARL in the blended effluent. A total of 14 wells have been removed from use for drinking water; eight of these have been replaced either by piping in water from another existing water utility or by developing new wells.

The Connecticut DHS has developed a course of action to be implemented whenever a test of a public water supply shows measurements that exceed 70 percent of a SNARL. The water utility, the town officials, and the state Department of Environmental Protection (DEP) are promptly notified. The DEP is requested to initiate an investigation of the source of contamination, and the DHS initiates a sampling program consisting of a minimum of weekly samples for four weeks. If the average results of these tests exceed the SNARL, the utility is then requested to notify consumers of the problem and to initiate corrective action in accordance with the five-point plan previously outlined. If the average of the test results is between 70 and 100 percent of SNARL, quarterly tests are required to keep track of the degree of contamination. An average that falls below 70 percent of the SNARL requires no further action on the part of the utility, but the supply may be noted by DHS for annual testing for volatile organics.

Other groundwater contaminants

The salt used for melting the ice and snow from highways is also adversely affecting the quality of Connecticut's groundwater. Some 107 community wells have been identified as having excessive sodium or chloride levels. Whereas a few of these wells are being affected by seawater encroachment and some others by discharge from home water softeners, the majority are victims of the practice of applying sodium chloride, either straight or mixed with sand, to road surfaces during the winter. Open storage of salt and mixed sand and salt is also part of the problem. It is necessary to develop guidelines that will regulate the application and storage of highway salt so as to reduce waste and hold groundwater damage to a minimum.

Fertilizers used for farming and for home lawn care in areas with sandy soil have caused excessive nitrate levels in five community well supplies. The DHS is urging control of fertilizers to promote more efficient use and to reduce nitrate levels. Techniques are being developed for applying liquid fertilizer directly on individual plants rather than broadcasting the dry chemical. This reduces loss of the chemical to the underlying groundwater.

Treatment to remove nitrates is difficult and expensive and has not been used in Connecticut. One utility has had to furnish bottled water to those families needing it. Blending with low-nitrate water has been used successfully. Low-nitrate surface water has also been used for aquifer recharge and groundwater replenishment.

Leakage from gasoline and oil storage tanks has affected one community well supply and a number of private wells. The DHS sees a need to impose more stringent standards for gasoline and oil storage, both above and below ground, in aquifer recharge areas. In such critical areas the DHS advocates the provision of impervious concrete pads and curbing under and around above-ground tanks and the use of concrete vaults to house metal or fiberglass underground tanks. In the case of existing underground tanks, DHS recommends the installation of a monitor pipe adjacent to the tank for quick detection of leakage.

Municipal dumps and landfills have been identified as sources of contamination of both public and private wells. The DHS and DEP are embarking on a program to delimit the leachate plume from each dump so that necessary control measures can be taken. A priority system is being set up for the approximately 55 landfills where such information needs to be developed.

Groundwater classification scheme

The Connecticut DEP is in the process of developing a scheme for classification of the state's groundwaters. Under this plan, drinking water aquifers will receive top priority for protection from discharge of chemical contaminants. The plan is presently in the public hearing stage and is expected to generate considerable interest once the specific proposals for classification and the attendant restrictions on discharges become known.

The state legislature recently passed a bill to establish a board whose members will be responsible for approving the siting and construction of facilities for the secure disposal of hazardous wastes. Presently, no such site exists in Connecticut, which means that wastes are either stockpiled on the premises of the producer, shipped to out-of-state disposal facilities, or illegally dumped. The DHS believes the establishment of proper disposal facilities is urgent.

Conclusions

Because of the groundwater contamination problems being uncovered, the author believes there is need for a federal and state aid program to furnish funding for the cost of piping in alternate water from a distance or developing new water sources. Where water supplies have been found contaminated by improper disposal of chemicals, many private well owners face very high treatment costs in addition to a loss of property value. Funds have been established to help with cleanup of the wastes, but none is specifically designated to aid distressed well owners. In Connecticut alone, approximately 60 private wells have been identified as contaminated with volatile organic chemicals, and it is estimated that $1 650 000 is needed to provide safe drinking water to these consumers. This comes to an average of nearly $26 000 per home, a prohibitive cost for most persons. An aid program is warranted because in most cases it is impossible to prove where the contaminant originated and to collect adequate damages from the responsible party.

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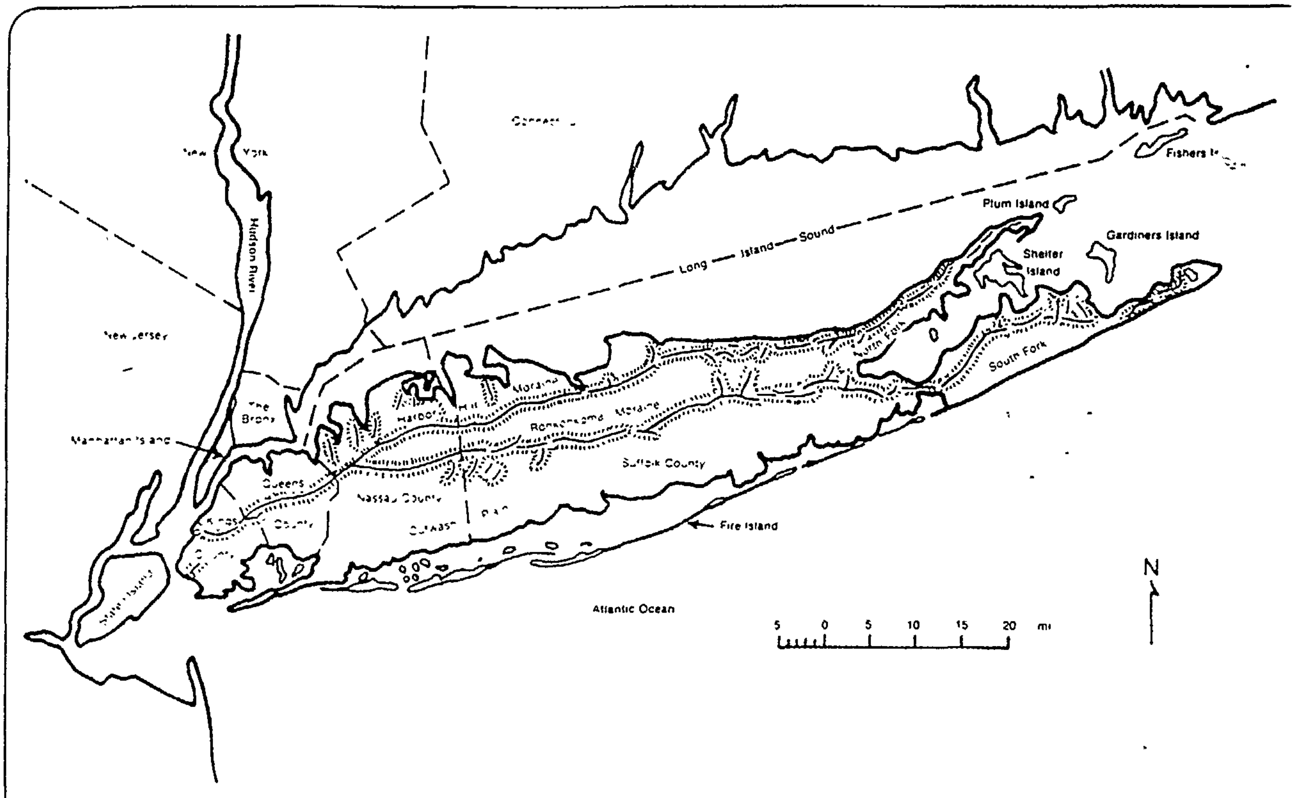

Figure 1. Physiographic features of Long Island N.Y.

Chemical contamination of aquifers on Long Island, New York

August A. Guerrera

On Jun. 21, 1978, the US Environmental Protection Agency determined that the aquifer system underlying Nassau and Suffolk counties on Long Island, N.Y., is the principal source of drinking water for these counties and that if the aquifer system were contaminated, it would create a significant hazard to public health. This "sole source" designation made pursuant to Section 1424 (e) of the Safe Drinking Water Act (Public Law 93-523) requires that a federal agency may not commit funds (through a grant, loan guarantee, contract, or otherwise) to any project that may contaminate the aquifer system through a recharge zone. Although this designation has only rarely been utilized to influence the commitment of any federal funds on Long Island, it does emphasize the unique hydrologic situation there, where almost three million people are served exclusively with groundwater developed on an island surrounded by salty water.

The Long Island, N.Y., area has experienced a dramatic increase in population since the end of World War II, but it is only in the past two decades that extensive sewerage projects have been advanced to protect groundwater quality. Although more than 568 ML (150 mil gal) of untreated domestic wastes are still discharged to the ground daily through on-site disposal systems, only recent experiences with contamination of these aquifers by chemicals introduced by other activities of man will be discussed in this paper. These chemicals include volatile halogenated hydrocarbon solvents and a carbamate pesticide extensively used by potato farmers. The detection of these chemicals at $\mu g/L$ (ppb) levels and the response of local regulatory agencies to the uncertain health risks associated with them have had a dramatic and costly effect on the ability of local water suppliers to meet the needs of their consumers.

There is considerable information about the water resources of Long Island as a result of the 50 years' activities of a renowned subdistrict office of the US Geological Survey (USGS) performing technical studies at the request of local governments and with their matching-funds support. The following synopsis of

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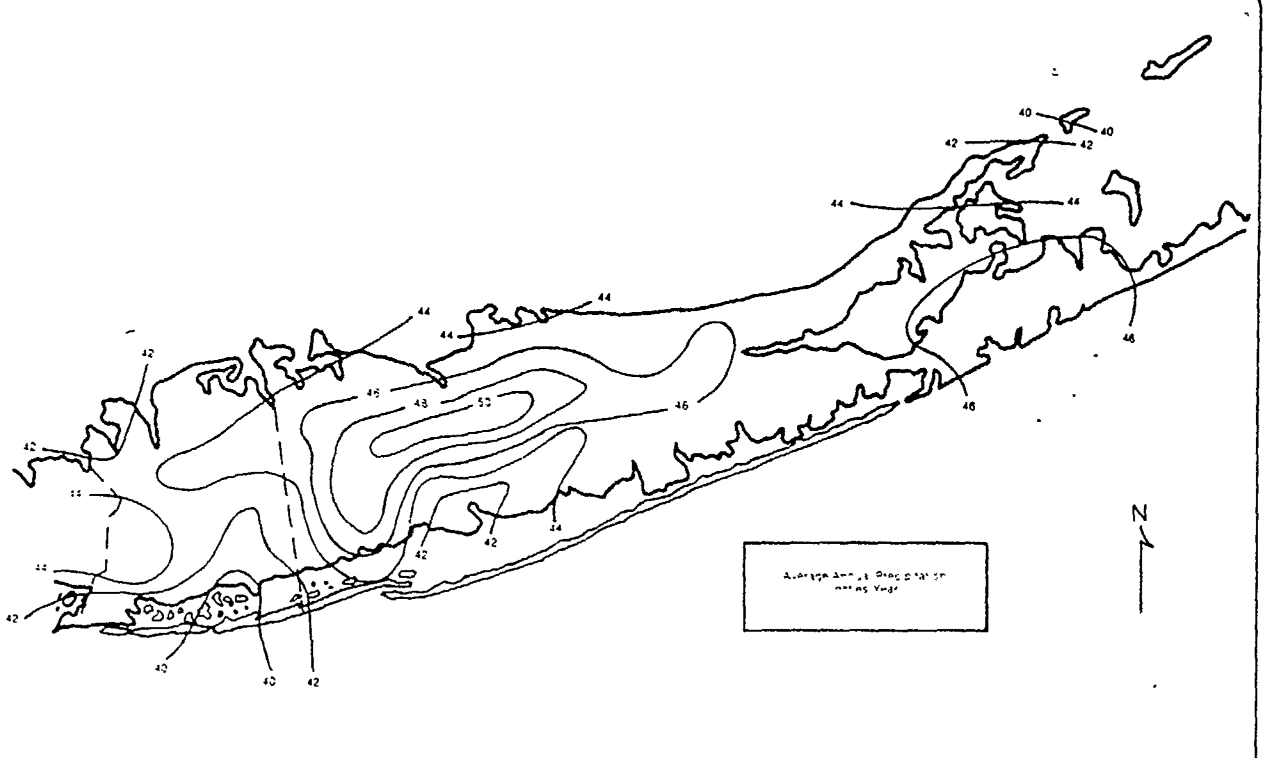

Figure 2. Annual precipitation on Long Island N.Y

portions of these studies is presented to demonstrate the uniqueness of this resource and its vulnerability to contamination.

Location and extent of area

Long Island extends eastward from the mainland part of New York state, about 193 km (120 mi) into the Atlantic Ocean. Kings and Queens counties are part of New York City and derive most of their water supply from surface waters from central New York state. However, the three million people occupying the 3108 sq km (1200 sq mi) of Nassau and Suffolk counties derive their entire water supply from wells tapping the underlying groundwater reservoir. Fire Island is the longest of several barrier beaches that parallel the south shore of Long Island, where the major water supply sources are free-flowing artesian wells intercepting underflow from the main part of the island and discharging to the Atlantic Ocean. The two eastern peninsulas, known locally as the North and South Forks, are considered hydrologically separate from the main part of the island, as they are supplied from freshwater lenses which are several hundred feet thick and are underlain by salty water with chlorinity equal to that of the Atlantic Ocean.

Topographic and physiographic features

During the Pleistocene or Ice Age, great continental ice sheets developed and spread over Europe and North America. At least two glaciers of the Wisconsinan Age reached Long Island and began retreating 12 000 to 15 000 years ago. The southerly limits of the ice advances are marked by terminal moraines with lines of hills reaching a maximum altitude of 122 m (400 ft). The Ronkonkoma Moraine is the oldest of the southernmost line of hills and extends eastward to form the South Fork. The Harbor Hill Moraine, in the northern line of hills, extends eastward to form the North Fork (Figure 1). The moraines are composed of poorly sorted rock debris consisting of boulders, gravel, sand, and silt. This debris was pushed ahead of and incorporated within the continental ice sheets when they rode over New England and advanced onto the island, and it was deposited during the melting of the ice.

The moderate flat surface south of the Ronkonkoma Moraine (Figure 1) is a glacial outwash plain composed of sands and gravel deposited by streams that were fed by glacial-melt water draining into the ocean, whose level was then more than 61 m (200 ft) lower than at present. Along the north shore are eroded headlands composed of glacial deposits and harbors eroded by northward flowing streams. Wave erosion on Long Island Sound has steepened the northern slopes into nearly vertical bluffs some 30 m (100 ft) high in places.

Climatic conditions

Long Island is located between 40° and 42° north latitude in a temperate climate belt. The mean annual temperature of 11°C (51°F) is several degrees higher

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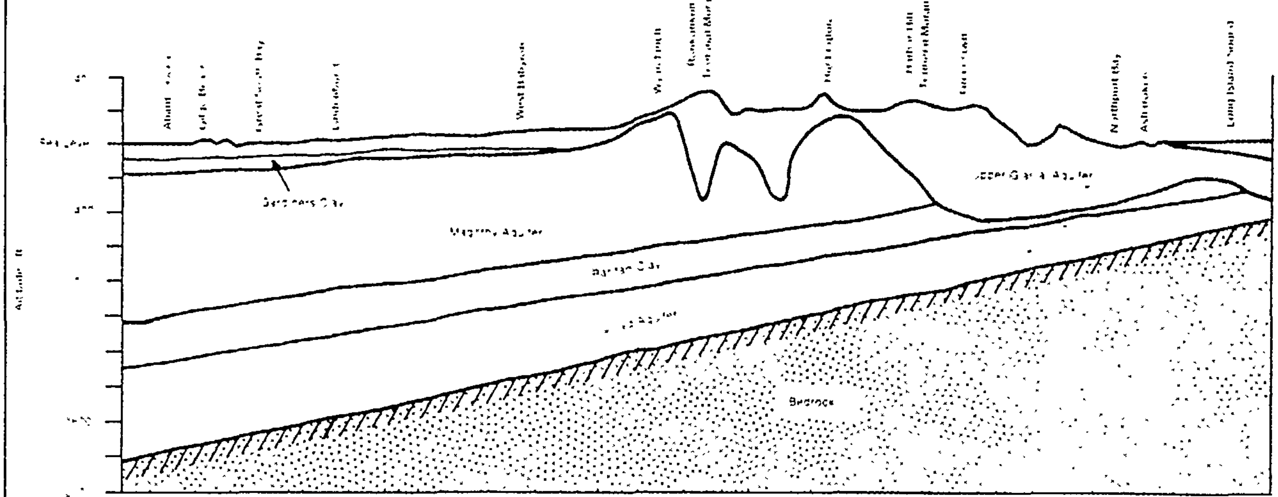

Figure 3. Geological cross section of Long Island N.Y.

than that of nearby New York state because of the influence of the Atlantic Ocean and Long Island Sound. The eastern end of the island is a popular vacation resort because temperatures are moderated by the ocean, with cooling on-shore breezes during the summer months when the prevailing winds are from the south and southwest. Precipitation averages about 112 cm (44 in.) per year and is fairly evenly distributed throughout the year (Figure 2). At depths of 30–122 m (100–400 ft) below the land surface, the groundwater temperature is also 10°C (50°F).

There are, therefore, in all four counties many wells withdrawing water for air-cooling purposes. In Nassau and Suffolk counties, state law requires recharge of that water to the same aquifer from which it was withdrawn.

Major hydrogeologic units

Long Island is geologically part of the Atlantic coastal plain and is more directly related to the coastal regions of New Jersey than New England. Long Island is composed of unconsolidated deposits of sand, gravel, and clay in more or less parallel beds on a hard bedrock surface. The crystalline bedrock, of schist or gneiss, appears at the surface in Manhattan and Queens counties and slopes to the southeast at 11–13 m/km (60–70 ft/mi). The unconsolidated rock materials that overlie the bedrock and that constitute the groundwater reservoir form a wedge-shaped mass ranging in thickness from about 200 m (650 ft) to more than 600 m (2000 ft). They consist primarily of a series of Pleistocene glacial deposits and fluvial deltaic deposits of the Cretaceous Age. The glacial deposits lie on an irregular surface and in some places fill valleys cut by preglacial streams.

Groundwater in the uppermost part of the zone of saturation is under water-table conditions, but artesian conditions predominate in most other parts. The hydraulic head in the confined or partially confined aquifers ranges from about 3 m (10 ft) below the water table, near the groundwater divide in the center of the island, to as high as 6 m (20 ft) above it along the north and south shores and on the barrier beaches (Figure 3).

The outwash deposits are moderately to highly permeable, with specific capacity of wells ranging from 3 to 13 L/s (40 to 200 gpm/ft) of drawdown. The Magothy Formation in Cretaceous material is poorly to moderately permeable with specific capacity of wells from 0.06 to 1.9 L/s (1 to 30 gpm/ft). Recharge to the water table occurs virtually all over the island, and the water table surface, therefore, represents a variable potential that is equal to the altitude of the water table at any point.

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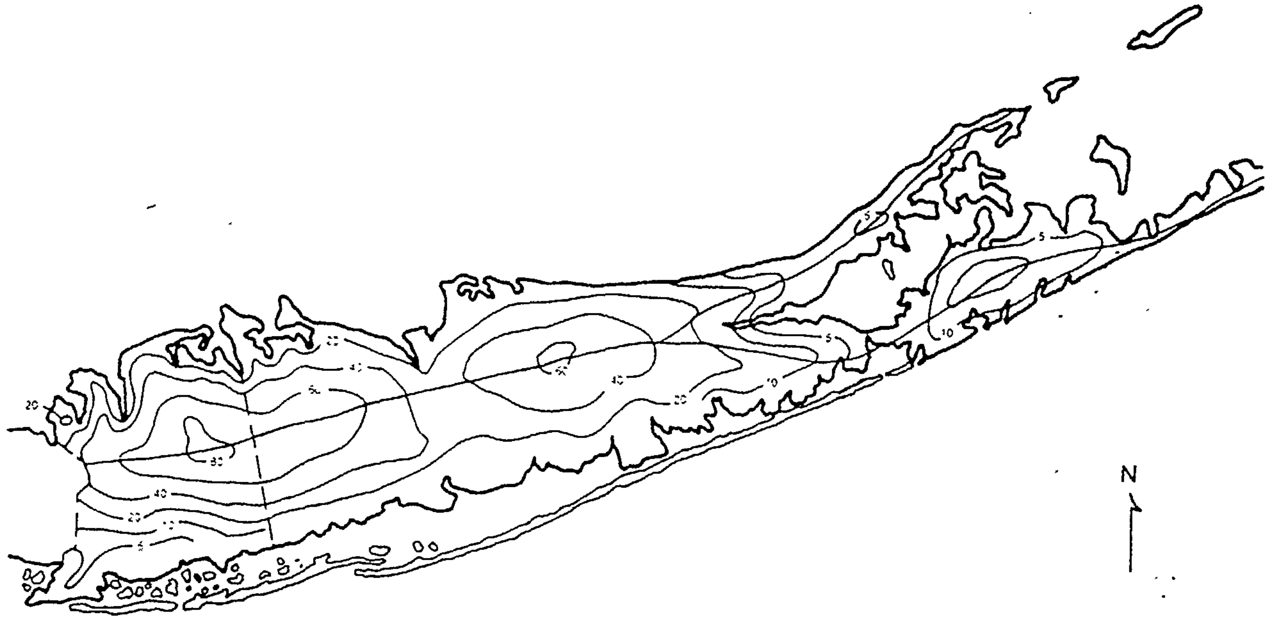

Figure 4. Groundwater contours on Long Island N.Y.

About half of the precipitation is lost because of surface water runoff and evapotranspiration: the remaining precipitation infiltrates the ground and recharges the aquifer. A map of the contours of the water table on Long Island indicates two prominent highs—one about 24 m (80 ft) above sea level in Nassau and one about 18 m (60 ft) above sea level in Suffolk (Figure 4). The horizontal component of the direction of groundwater movement is at right angles to the contours with velocities ranging from 9 to 61 cm/d (0.3 to 2 ft/d). Since the differences between vertical and horizontal permeability are substantial, vertical movements in the saturated zone may be as slow as 3 m/year (10 ft/year), even near the maximum elevation of the water table. The residence time of water in this system may, therefore, be extremely long, estimated by the USGS at many hundreds of years (Figure 5).

Water quality

Under predevelopment conditions, the natural freshwater of Long Island had a remarkably low dissolved solids content, primarily because of the relatively inert deposits within the groundwater reservoir and its replenishment exclusively by precipitation. Total dissolved solids are less than 50 mg/L and in some cases as low as 20 mg/L, with total hardness and alkalinity less than 10 mg/L. The pH of Long Island groundwater is generally low, commonly less than 6 and in the deeper aquifers less than 5. Some of the groundwater, especially the older, deeper waters near the south shoreline, has a high iron content considerably above the 0.3 limit with H_2S present.

Man's activities have affected the quality of the water on Long Island through a variety of mechanisms including

- Rainwater with sulfates and low pH;
- Discharge of cesspool effluents with increases in nitrogen, sulfate, and sodium;
- Discharge of industrial wastes through recharge basins or leaching pools, with increases in heavy metals, detergents, and solvents;
- Leachate from sanitary landfills with increases in metals, sodium, calcium, and chloride;
- Leaching of fertilizers and agricultural chemicals from farming and cultivation of turf; and
- Increases in chlorides, sodium, and calcium from the storage and application of roadway deicing salts.

Development of the groundwater supply

The amount of water stored within the groundwater reservoir is so vast (more than 227 trillion litres [60 trillion gallons]) that there is sufficient available

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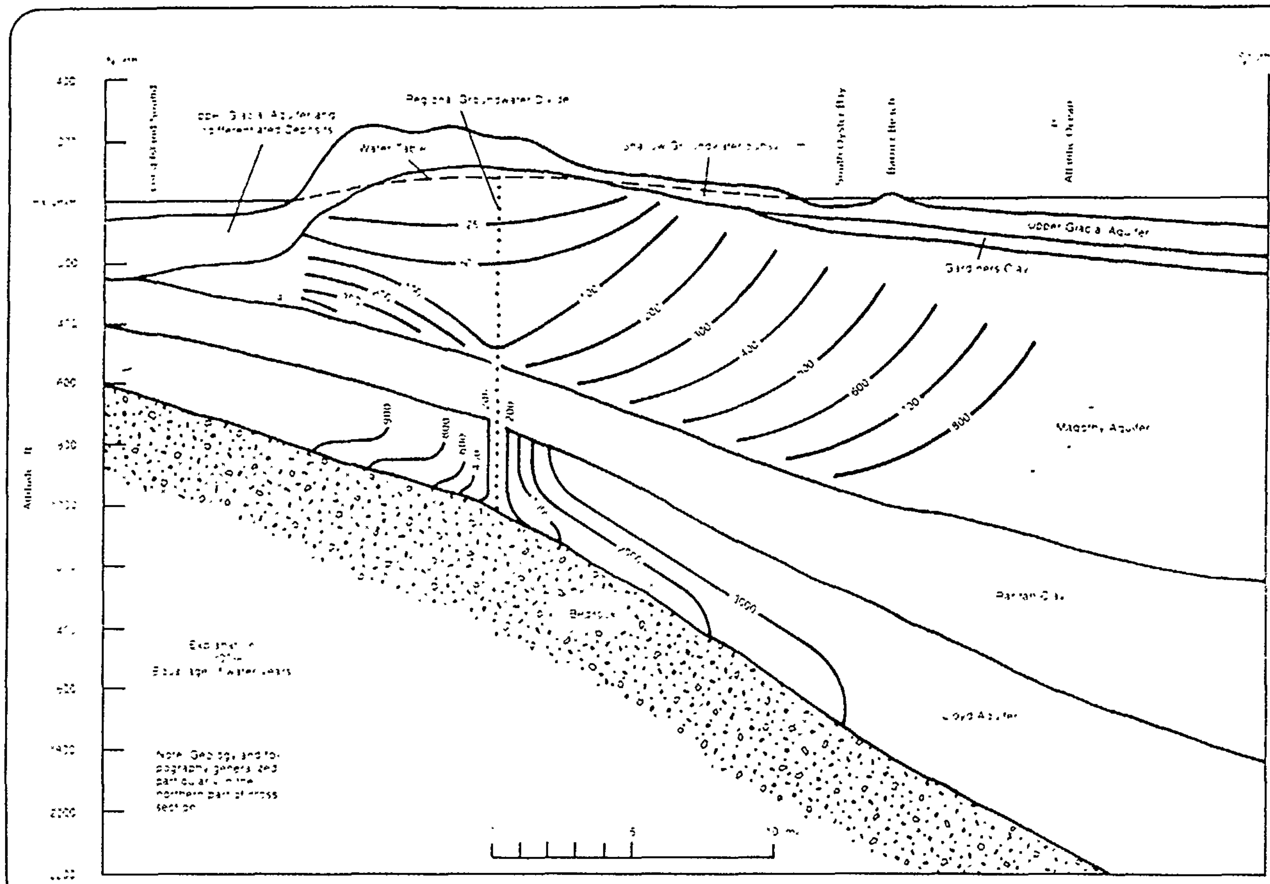

Figure 5. Time required for water movement within the regional groundwater system

groundwater to supply Long Island's future saturation population, provided that provisions are made for solving water quality problems in local areas and for adopting proper management techniques to alleviate production imbalances.

Major concentrations of pumpage have developed near areas of dense population, leaving other portions of the subsurface reservoir underutilized. This is partly due to the ability to install high-capacity wells nearly everywhere on the island, the cost effectiveness of well supplies compared to larger transmission and distribution systems, and to the multitude of agencies in the water supply field. In Nassau and Suffolk counties there are, at present, 128 community water supplies ranging from apartment complexes and trailer parks with less than 100 services to the Suffolk County Water Authority (SCWA) with 243 000 active services representing a population of 900 000. Some of these utilities are stockholder-owned, tax-paying corporations. Most are municipal or tax-collecting water districts, and the SCWA is a public benefit, tax-exempt utility financed by revenue bonds. Service areas are assigned by the state of New York and range from less than one to more than 1295 sq km (500 sq mi).

These utilities operate 935 wells with capacities from about 15 L/s (235 gpm) to 150 L/s (2380 gpm). The SCWA operates 350 wells located at 150 separate well fields and pumping stations (Figure 6). An attempt is made to maintain equilibrium groundwater levels by not withdrawing more water per square mile of recharge area than the estimated infiltration rate. Consumptive use in the bicounty area mainly consists of 416 ML/d (110 mgd) of sanitary wastes discharged through ocean outfalls and 57 ML/d (15 mgd) by farm irrigation, compared to average daily production of nearly 1514 ML/d (400 mgd).

Experiences with contamination

Volatile halogenated hydrocarbon solvents. In March 1975, the employees of a major aerospace facility in Nassau County reported objectionable tastes and odors in their drinking water. This facility then employed more than 10 000 people and produced its own potable and industrial water supply with nine wells having a capacity of 38 ML/d (10 mgd). Chemical analyses indicated satisfactory compliance with all the drinking water standards in effect at the time. More than a year had elaspsed before the offending chemicals were identified as trichloroethylene, tetrachloroethylene, and, in one well, vinyl chloride. The metal-treating activities at this site included dipping product into a degreasing bath and then finishing in spray booths

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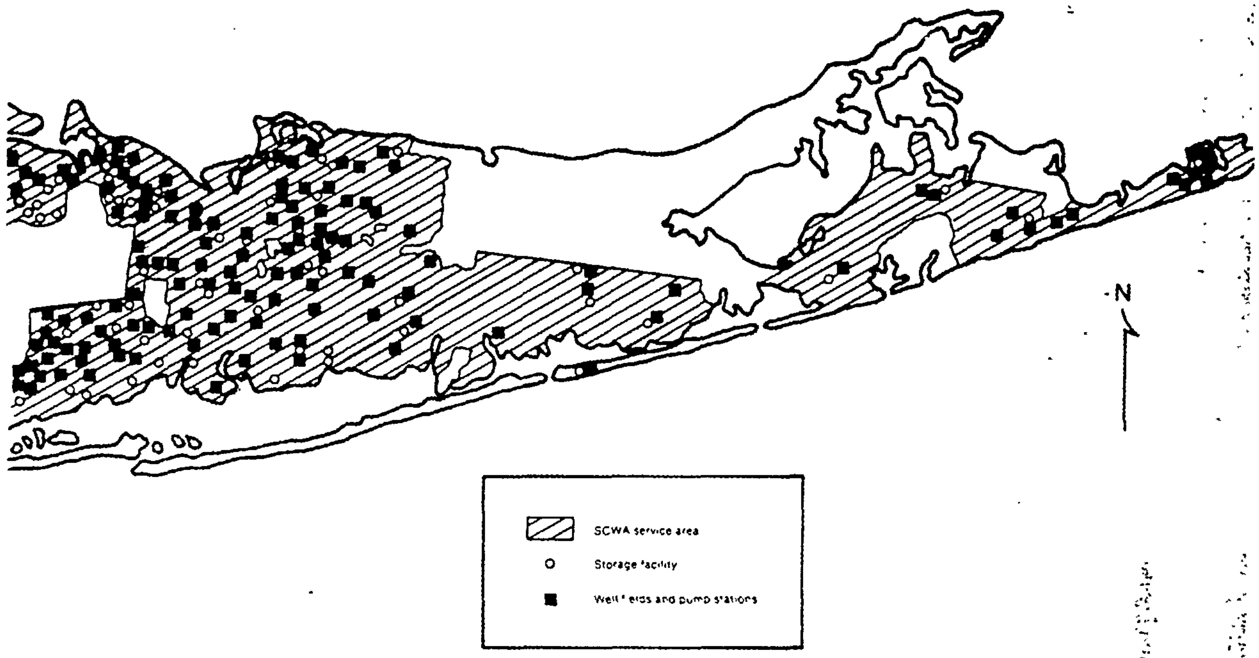

Figure 6. Map showing Suffolk County Water Authority service area

before curtains of water. In retrospect, there was no analytical capability to detect and quantify these compounds at µg/L levels. Bellar and Lichtenberg had only just published in late 1974. The National Organics Reconnaisance Survey was just beginning but dealt with only six compounds in surface water supplies. The subsequent National Organics Monitoring Survey in 1976–1977 looked for 27 specific compounds, again concentrating on raw and finished surface waters. Only the trihalomethanes in finished waters exceeded 2 µg/L in the four New York state supplies included in the survey. These studies emphasized the importance of the quality of the raw water, especially the presence or absence of precursor compounds. In the SCWA's gas chromatography laboratory, studies on total trihalomethane potential indicated low generation of these compounds even with chlorinating to very high residuals and at elevated pH (Figure 7). These results were obtained even with well waters already contaminated with degreasers such as trichloroethylene or with constituents of cesspool-leaching origin.

Intensive surveys were conducted and are continuing in both counties for the presence of volatile organic compounds. The extent of these surveys and the degree of contamination of the groundwater resource are demonstrated by the number of wells sampled and by the range of concentrations of the various compounds detected. The departments of health of the two counties requested assistance from the state and the USEPA in establishing threshold limits of maximum contaminant levels. There were not then, and there are not now, established limits for any organic compounds other than the six pesticides and herbicides in the SDWA primary drinking water regulations. The New York State Commissioner of Health in early 1977 recommended "actionable guidelines" of 10 µg/L for vinyl chloride, 50 µg/L for any other volatile halogenated organic compound, and 100 µg/L for the sum of all organic compounds, based mainly on an extrapolation of the 95 percent confidence limit of the no-adverse-response dose in test animals, and for human risk levels of one excess cancer death per lifetime in 100 000 population, assuming an intake of 2 L of water per day, a 70-kg body weight, and a 68-year life span. This rationale was referenced to the 1977 National Academy of Sciences (NAS) report entitled *Drinking Water and Health*. These guidelines are enforced through the cooperative compliance of the water utilities, which is encouraged by the weekly press releases issued by the regulatory agencies involved.

The initial surveys concentrated on wells within or near industrial activities, and many samples were

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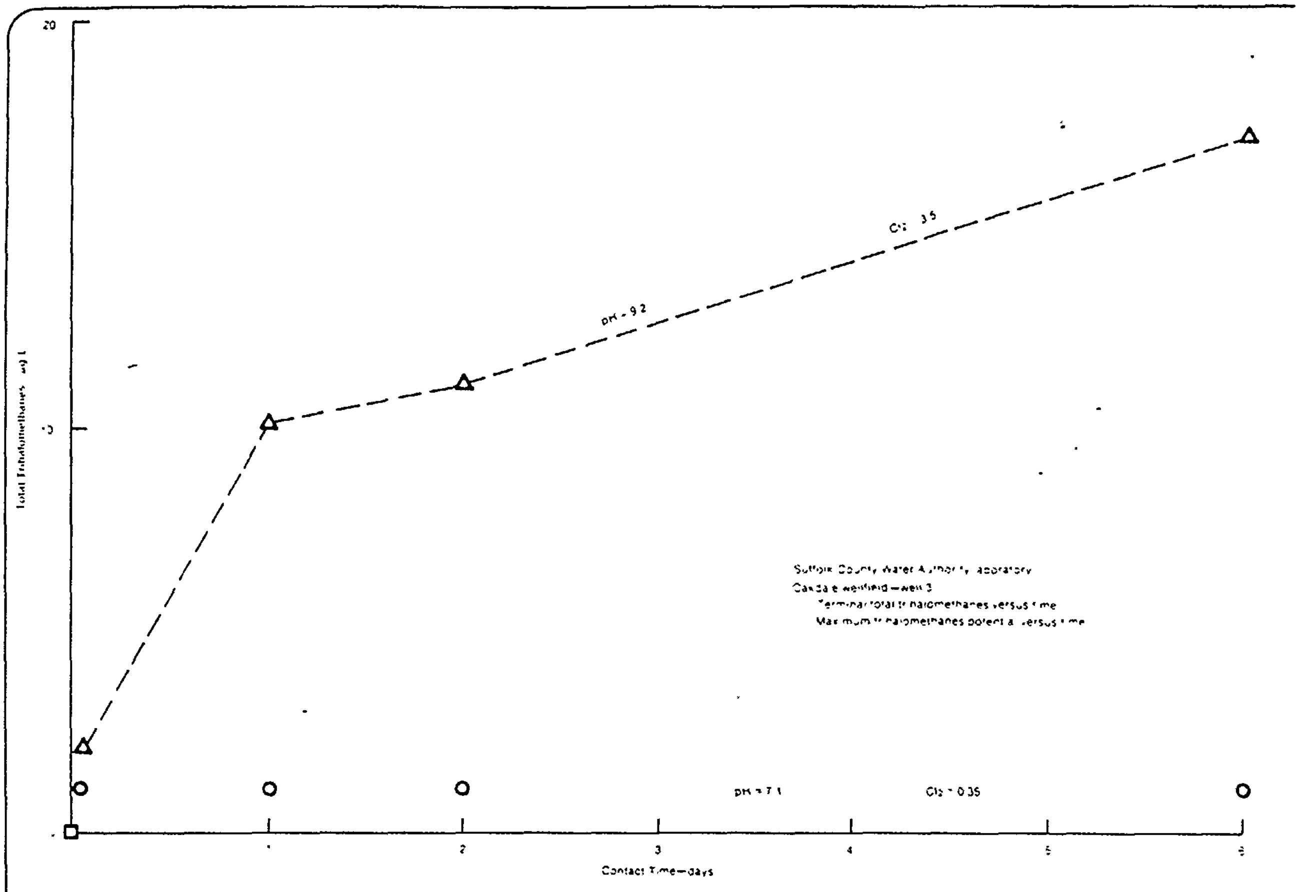

Figure 7. Suffolk County Water Authority's studies on total trihalomethane potential

reported to contain trichloroethylene and tetrachloroethylene. However, an even greater percentage contained 1,1,1-trichloroethane. This compound is a constituent of many household cleaning products, but it is also a major constituent of a popular and widely used product sold to open clogged cesspools and drains.

In Nassau County, where 389 public supply wells are utilized by 48 water suppliers to serve 1.5 million persons, 13 wells are at present restricted because of the presence of one or more of these three compounds in excess of 50 μg/L. However, of another 50 nonpotable water wells that also exceed the guidelines, 17 are screened in the Magothy Formation, the aquifer from which virtually all of the drinking water is produced. Many of these nonpotable wells are high-capacity air-conditioning wells that have companion diffusion wells to recharge this water to the same aquifer.

In Suffolk County, where 527 public water supply wells are utilized by 80 water utilities to serve 1.4 million persons, 16 wells are still restricted owing to the presence of these same three chemicals in amounts exceeding 50 μg/L. Ten of these are part of the 352 wells operated by the SCWA. One of the others also contains 1,2-dichloroethylene, benzene, toluene, and several of the xylenes. The difficulty in interpreting these results is apparent in Figure 8, which shows the location of only the restricted public water supply wells. Each of these wells may have its own point source, or the sources may be so diffuse (such as the 400 000 cesspools in the two counties) as to be considered nonpoint.

The uncertainties in the early analyses made evaluation of results and response to public reaction very difficult. Two examples are indicative. Early in 1976, a major governmental laboratory, which was requested to serve as a "referee" laboratory, reported at a press conference that analyses of eight wells at various locations and at varying depths showed that all contained the same 300 μg/L chloroform. The retraction two days later, explaining atmospheric contamination of the laboratory, received considerably less press space. In another case, results of more than 100 μg/L trichloroethane were reported in a well screened to 193 m (632 ft), where the USGS estimated the age of the water at hundreds of years. This well was closed despite the fact that another well 61 m (200 ft) away and screened at the same depth was shown to be free of contamination. It was subsequently determined that Suffolk County Water Authority mechanics and electricians routinely cleaned electrical connections and column pipe threads when installing pumps, by using wire brushes dipped in a commercial solvent. Pumping to waste cleared this particular problem, and the well

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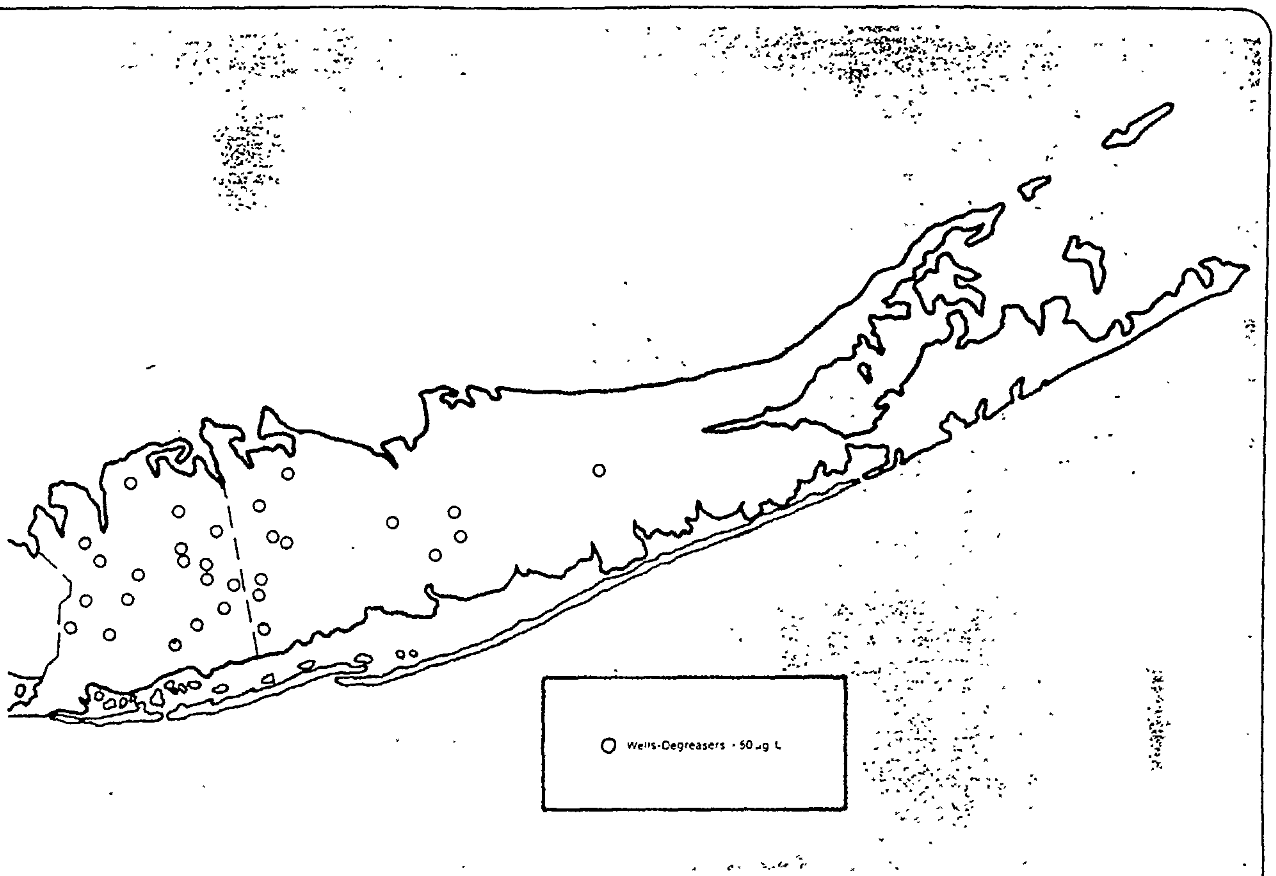

Figure 8. Location of restricted public water wells in Suffolk County

has since been returned to service.

The SCWA has already expended more than 1.5 million dollars to replace the lost capacity of the restricted wells. If a positive sample indicates a contaminated aquifer, production screens can no longer be deepened, as has been customary; rather, many new wells must be drilled at new locations. With wells of 152-m (500-ft) depth now being bid at nearly $150 000 and with attendant costs (for land, building, fencing, landscaping, and chemical treatment), the cost of a new 7.6-ML/d (2-mgd) facility has escalated to $0.05 million.

Pesticides including aldicarb. In December 1974, the Nassau-Suffolk regional planning board received a $5.2 million grant from the USEPA to conduct a regional wastewater management study under Section 208 of PL 92-500. One of the consultants retained by the technical advisory committee to investigate the role of agricultural chemicals on groundwater quality was the Cooperative Extension Association of Cornell University. Early in the study, the consultants reported their concern over the almost exclusive use by potato farmers of a broad spectrum pesticide that exhibits several chemical properties indicating potential hazard. Aldicarb* (Figure 9) is a highly toxic, oxime carbamate pesticide and is labeled for use on potatoes, cotton, peanuts, sugar beets, and some ornamental plants. Aldicarb and its metabolites are highly soluble in water. Its solubility of 0.6 percent is equivalent to 6×10^{6} μg/L (ppb). It is persistent in soils under certain conditions, and it is so resistant to heat that it can survive long periods of boiling. Aldicarb is applied at the time of planting with the seed. It is taken up in the stem and leaves and becomes a systemic poison when the plant is eaten by pests. It acts by inhibiting cholinesterase, an enzyme required for nerve function. This pesticide has been found to be very effective against two pests that have long plagued Long Island potato farmers, the golden nematode and the Colorado potato bettle. Since 1975, it has been the principal chemical weapon used by the 200 Long Island farmers who grew 22 000 acres of potatoes in 1979 (Figure 10).

Because of studies reported at the time of USEPA registration, the pesticide was expected to break down in the soil and was not supposed to leach to the groundwater. In fact, some studies reported apparent volatilization of the product along with evaporation of capillary water from the soil.

When aldicarb was first registered for use on potatoes in 1974, the USEPA accepted a rate of three pounds

Temik aldicarb pesticide. Union Carbide Corp., New York.

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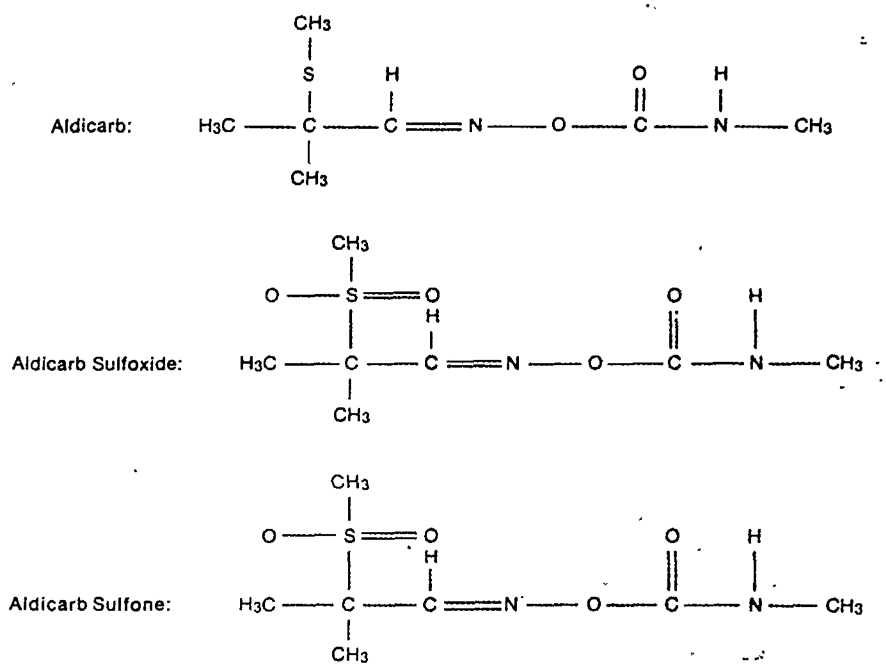

Figure 9. Aldicarb—chemical equations

of active aldicarb per acre for control of the potato beetle. In 1975, New York state approved the use of five pounds per acre for control of the golden nematode. In 1977, USEPA amended the aldicarb federal label to allow the use of five pounds per acre in Long Island, N.Y., only. In June 1978, New York state approved the use of postemergence side-dress application of two pounds of active aldicarb per acre in addition to the five pounds applied at planting. The USEPA countermanded New York state's recommendation until it was conclusively shown that aldicarb residues in potatoes were less than the established Food and Drug Administration tolerance of 1 mg/L (ppm). These data were procured in 1978, and New York state reinstituted the postemergence side-dress application in May 1979.

Research studies are routinely conducted by the staff of Cornell University's Long Island Horticultural Research Laboratory at Riverhead, Long Island. Samples were collected from shallow wells located within potato fields and were accepted by the manufacturer's laboratory for analysis. In August 1979, the Union Carbide Corp. notified the USEPA that aldicarb was detected in Long Island groundwater in a few areas. Over the next few months 145 samples were collected from wells on or near farms and analyzed by Union Carbide, USEPA, and New York state health department laboratories. In spite of the biased sampling procedure, where wells on or within 457 m (1500 ft) of active farms and as shallow as 9 m (30 ft) were tested, considerable publicity was given to the discovery that 26 wells exceeded the "actionable level" of 7 μg/L (ppb). Two of these wells were public water supply wells. One is owned by the SCWA and was reported to contain 6 μg/L aldicarb and, later, 3 μg/L of carbofuran, another carbamate. This well was removed from service. A subsequent split sample from this well was reported to contain 2, 4, and 6 μg/L by these three laboratories. Subsequent samples yielded results of 1 μg/L and "none detected," and the well has since been returned to service.

The toxicity of aldicarb in rats has been reported to be an LD_{50} of 1 mg/kg. Instances of human exposure are rare, with symptoms being short term and reversible and with no systemic accumulation. Aldicarb and its metabolites are not carcinogenic, they are not mutagenic, and they are not teratogenic. Based on available data on rats and dogs, the highest no-adverse-effect level was determined to be 0.1 mg/kg per day. Dividing by an uncertainty factor of 100, an acceptable daily intake (ADI) of 0.001 mg/kg per day was recommended in the NAS study. The actionable level of 7 μg/L was calculated by using the assumptions of the ADI of 0.001 mg/kg per day, an average adult weight of 70 kg, an average consumption of 2 L of water per day, and that 20 percent of the total ingestion of that compound would be from the drinking water.

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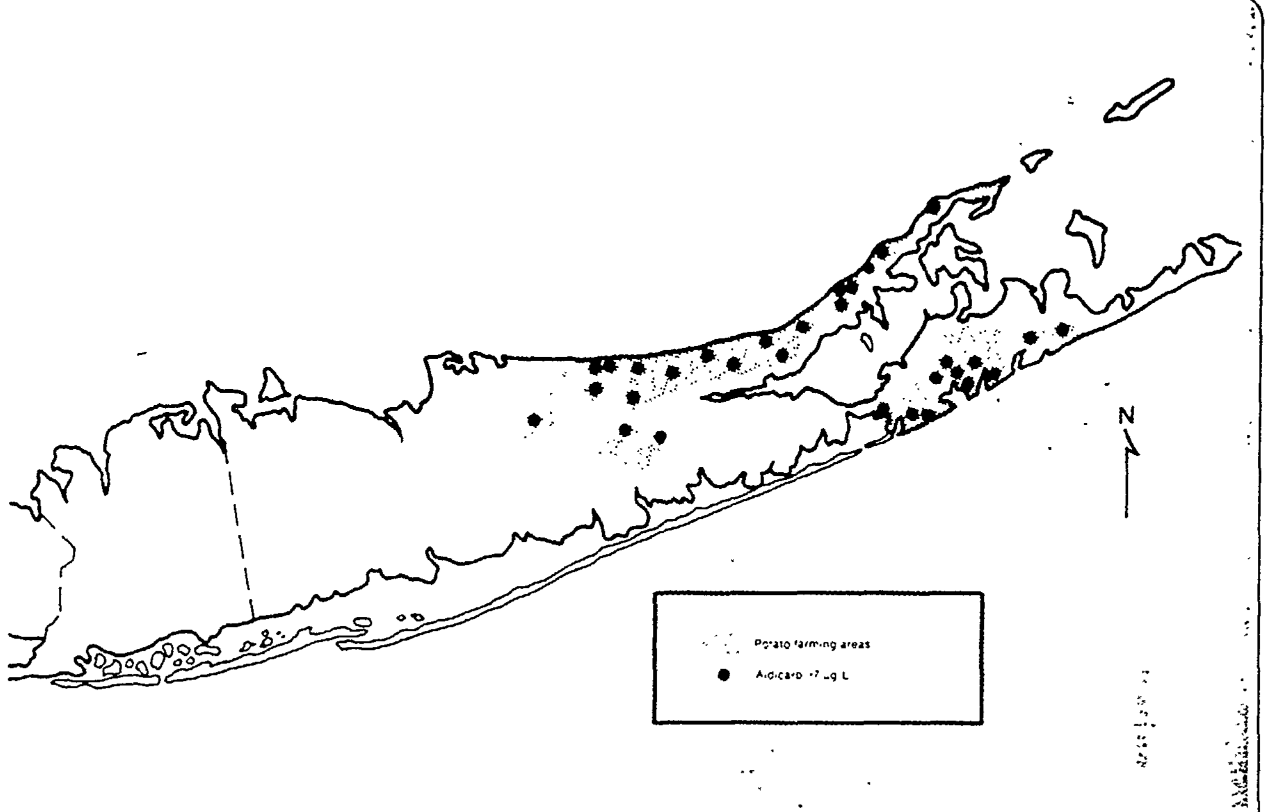

Figure 10. Map of Long Island, showing areas of potato farming and aldicarb concentrations exceeding 7 $\mu g/L$

Recognizing the effectiveness of aldicarb and its value to the farmers and local economy, the county commissioner of health requested in December 1979 that the state reduce the allowable application rate, especially at planting. However, in February 1980 the manufacturer* asked the USEPA to revoke its approval of aldicarb on Long Island. The removal is expected to be a severe blow to the farmers. In March 1980, the manufacturer agreed to undertake the analysis of 6000 samples from wells within 760 m (2500 ft) of all treated farms, as well as investigations of the effectiveness of carbon filters for treatment of some affected wells.

Conclusion

The water supply industry on Long Island has borne a disproportionate share of expense and loss of consumer confidence through the premature and incomplete release of findings of instances of contaminated samplings. The cost of replacing lost well capacity because of the rigidity of interpretation of laboratory data of uncertain precision has been substantial. The damage to public relations and the human costs in responding to near-hysterical consumers, who cannot accept the rationale involved in estimating risk factors based on lifetime exposures with uncertainty factors applied to no-adverse-effect levels, cannot be calculated. A local health officer even stated his preference for public water supplies over individual household supplies because the public water supplies were "manipulable." The water supply community must plead that future controls of environmental risks be evaluated in terms of total exposures.

*Union Carbide Corp., New York.

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RESEARCH AND TECHNOLOGY

Trichloroethylene and methyl chloroform in groundwater: A problem assessment

John C. Petura

The national effort of past decades to reduce pollution has made great strides on some fronts, while practically ignoring potential disasters on others. Billions of dollars have been expended to equip and operate air pollution control systems, such as electrostatic precipitators, SO_2 scrubbers, and catalytic converters. Similarly, water pollution control has seen tremendous investment in both the industrial and municipal sectors, including advanced waste treatment practices for phosphorus removal, nitrification and denitrification facilities, and tertiary organic removal via carbon adsorption. Groundwater pollution remains a problem of immense importance, and only recently have methods been developed to help decontaminate polluted wells.

With the advent of environmental awareness, giant leaps have been made in analytical techniques for the detection of compounds in air and water at very low levels—into the nanogram per litre range. A geometric increase in information has also occurred regarding the effects of numerous compounds on fish, mammals, birds, plants and other forms of living organisms. Many compounds, such as chloroform, have been definitively linked to cancer and subsequently limited in application.

The impetus for this activity was a massive legislative assault by federal and state governments in response to intense public pressure to reverse the trend of environmental devastation being imposed on air and water—the very resources on which all life depends for survival. Within the last decade, response at the federal level resulted in no less than thirteen major laws pertaining to environmental concerns ranging from occupational safety and health to regulation of pesticides.

The Safe Drinking Water Act of 1974 was enacted amidst a storm of controversy relating to the numerous toxic materials that had been detected in the New Orleans potable water supply. Two years later the Toxic Substances Control Act (1976) established a regulatory framework for the release of toxic substances to the environment.

Perspective on groundwater contamination

Unfortunately, such legislative efforts have proved to be extremely controversial with regard to interpretation, implementation, and enforcement and have done little to correct the problems of the past. In the last few years extensive evidence from laboratories across the country indicates that misuse, mishandling, or improper disposal of a group of chlorinated organics has caused widespread groundwater contamination.

This paper focuses on two particular chlorinated organic compounds that have been recurringly detected nationwide in numerous contaminated groundwater samples, namely, trichloroethylene (TCE) and methyl chloroform (MC). The molecular structures, synonyms, and initial dates of manufacture of these compounds are shown in Table 1. Particular care must be taken to distinguish these compounds from substances with similar-sounding names or with similar chemical structures. The difference between a single versus a double bond between two carbon atoms or the position of a chlorine atom in a molecule can make the difference between a relatively innocuous material and a potent toxicant.

These compounds do not naturally occur in groundwater resources, and their presence has created a serious problem for numerous locations in the United States, among them Pennsylvania, Delaware, Michigan, New Hampshire, and California. One area in which extensive amounts of these materials have been discovered is southeastern Pennsylvania, particularly Montgomery and Bucks counties. While these counties are not unique in their exposure to these substances, it is distressing that literally hundreds of wells, many in totally unrelated aquifers, were found to contain one or both of these compounds.

In many cases the probable cause of contamination was determined to be a current or past user of the compounds. In other cases, no probable source was tracked down, although speculation revolved around possible contamination by unsuspecting homeowner's use of septic tank cleaners or illicit dumping of industrial wastes in nearby locations.

To understand the difficulty in establishing a cause-and-effect relationship for contamination of any particular well, the problem must be viewed from two perspectives. First, these materials have been used in a myriad of ways over the years, by industrial and commercial establishments as well as residential consumers. Secondly, these compounds

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TABLE 1

Groundwater contaminants trichloroethylene and methyl chloroform

Compound Name	Formula	Symbol	Synonym	Start of Commercial Manufacture
Trichloroethylene	$CHCl.CCl_2$	TCE	(1,1,2-trichloroethylene)	1925
Methyl chloroform	CH_3CCl_3	MC	(1,1,1-trichloroethane)	1950s

TABLE 2

Uses of trichloroethylene and methyl chloroform

Use	Trichloro-ethylene	Methyl Chloroform
Metal degreasing	major	major
Dry cleaning	major	
Cleaning and drying of electronic parts	major	minor
Paint, varnish, and finish remover	minor	
Extraction of fats and oils (septic tank cleaner)	minor	minor
Solvent dyeing	minor	
Refrigerant and heat exchanger	minor	
Fumigant	minor	
Pesticides		minor
Rubber adhesives agent		minor
Shrinkage retardant for potatoes		minor
Textile processing	minor	
Others	minor	minor

TABLE 3

Physical and chemical characteristics of trichloroethylene and methyl chloroform

Characteristic	Trichloro-ethylene	Methyl Chloroform
Formula weight	131	133
Percent chlorine by weight	81	80
Specific gravity—compound °C/water °C	$1.46^{20/4}$	$1.32^{20/4}$
Boiling point—°C	87	74
Melting point—°C	−87	−33
Vapor pressure at 20°C—mm Hg	58	100
Solubility		
Water—mg/L (at temperature °C)	1100^{25}	4400^{20}
Alcohol		
Ether		
Odor	chloroform-like	slightly sweet
Color	colorless	colorless
State at 20°C	liquid	liquid
Flammability	nonflammable	nonflammable
Flash point—°C	none	none

TABLE 4

Toxicological properties of trichloroethylene and methyl chloroform

Means of contamination	Trichloro-ethylene	Methyl Chloroform
Toxic by ingestion	•	•
Toxic by inhalation	•	•
Toxic by skin absorption	•	•

have been manufactured in the United States for many decades. TCE became a common degreasing agent in the 1920s and was incorporated in the drycleaning business in the 1930s.[2] The use of methyl chloroform as a cold cleaning solvent began in the 1950s. Table 2 lists the common uses of these compounds.

Most of these uses remain prevalent, since legislation has not yet been enacted to limit their use in either general or specific applications. However, the environmental consequences of continuing unrestricted manufacture, distribution, and application may ultimately approach the significance of unrestricted pesticide use during the 1960s. In time, strict regulations were imposed on both the pesticide manufacturer and user, including bans on some materials and limitations on the application of certain herbicides.

Properties of TCE and MC

Before studying the results of inadvertent handling and disposal of these materials, it will be helpful to review certain physical and chemical properties of the compounds and to understand how these chemicals have become groundwater contaminants. Table 3 shows selected physical and chemical characteristics of TCE and MC and illustrates their similarity.

The two most important properties relating to groundwater contamination are specific gravity and water solubility. Both compounds are heavier than water and only sparingly soluble in water. Thus, if spilled onto the ground and allowed to contact water, TCE and MC, having only limited solubility, would sink to the bottom of the water phase. The mere presence of these compounds in groundwater would not be significant if they were nontoxic and would readily biodegrade in a subsurface environment. Unfortunately, this does not occur to any significant degree. Table 4 summarizes the toxicological information available on these compounds.

Trichloroethylene is without question the more toxic of the two and has been shown to cause cancer in laboratory test animals.[2] Thus, TCE has been classified as a suspected human carcinogen, although no definitive data have confirmed such a linkage.

Apart from the matter of carcinogenicity, trichloroethylene is intrinsically toxic and its action can be acute or chronic.[1] When the vapor is inhaled, it is diffused through the bloodstream from the lungs. Both the liver and kidneys can be severely damaged by chronic exposure. Continued inhalation of high concentrations can produce drowsiness and eventually unconsciousness. TCE has also been shown to have effects on the nervous system, resulting in impaired vision and changes in skin sensitivity. Ingestion of high concentrations of liquid TCE have resulted in death through edema of the lungs and severe damage to the liver and kidneys. The current suggested no adverse response level (SNARL) in drinking water recommended by the US Environmental Protection Agency is 4.5 $\mu g/L$.[2]

Methyl chloroform has a depressant action on the central nervous system and mildly affects the kidneys and liver at very high dosages.[2] Results of studies to date have exhibited negative indications with regard to the carcinogenic effects of methyl chloroform. However, the National Institute of Occupational Safety and Health (NIOSH) has recommended that the maximum acceptable level in drinking water be set at 33 $\mu g/L$. This level is meant to serve as a guide for short-term exposure only. The prolonged use of water containing MC is not recommended because there are insufficient data available regarding both long-term exposure effects and synergistic effects of methyl chloroform with other contaminants.

Response to the discovery of contamination

When a well is discovered to be contaminated, the primary concern should focus on public health. Persons who have been using contaminated water must immediately be afforded relief from further exposure. The usual response is to cease using the well for drinking and cooking purposes and to obtain bottled water. Medical assistance may be required if the contamination exposure has been severe.

After an alternative source of clean water has been obtained for short-term use, it is essential that a testing program be initiated to determine if, and to what extent, other wells in the immediate area have been affected. This effort will also assist investigators in establishing the zone of contamination and possible sources of contamination. As additional test data become available, hydrogeologists can evaluate the necessity of conducting further tests to establish definitively the boundaries of the contamination by confirming that wells outside a specific zone are free of contamination.

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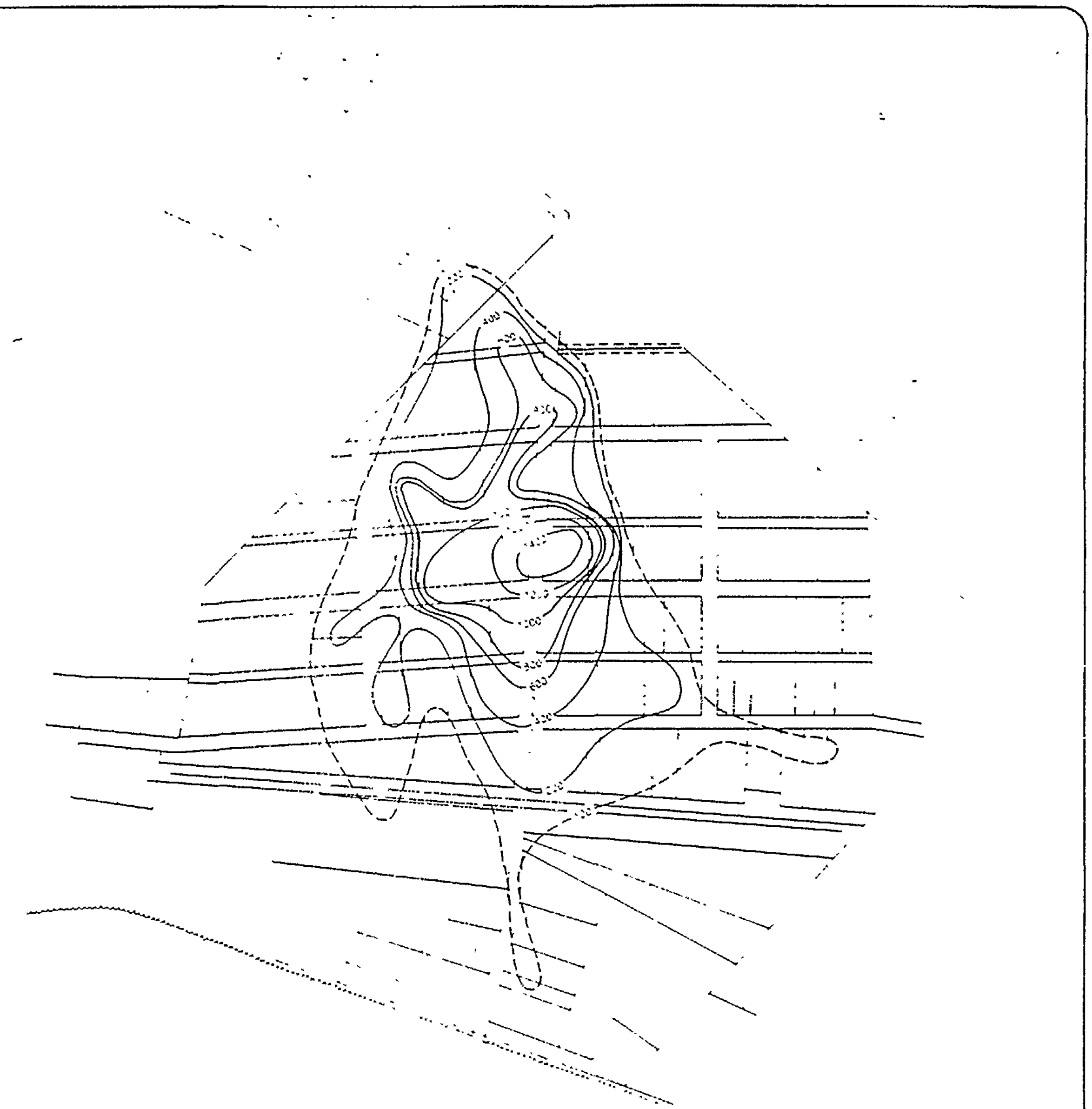

Figure 1. Definition of a TCE contamination zone
Units indicate ng/L

If the initial information indicates that this zone could be widespread and could affect numerous private wells, it may be appropriate to recommend that all residents in the immediate area cease using their wells as sources of potable water. In some instances the contamination level may be high enough (generally greater than 500 μg/L) to call a halt even to skin contact uses. An illustration of a well-defined contamination zone is presented in Figure 1.

Any investigation to determine the source of contamination will confront several hurdles and, therefore, will require a systematic and professional approach. Canvassing the area for potential users of these compounds will be a sensitive matter, since admission of use may bring hasty accusations from affected parties who do not have substantiating evidence. Industrial and commercial businesses should be canvassed first; then active and inactive disposal sites should be considered. The possibility that local septic systems may have at one time received spent cleaners containing TCE or MC should not be overlooked.

Long-range problems

The long-term problems associated with TCE or MC groundwater contamination are:

- Locating a new permanent water supply for the affected residences or businesses.
- Developing and carrying out a recovery program to prevent the further spread of contamination, followed by the eventual restoration of the affected aquifer to acceptable quality.

Depending on the degree of contamination in a well, several courses of action are available to obtain a permanent supply of clean water. Connection to an existing private or municipal water supply is one option, assuming that this

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water source is uncontaminated. Digging a new well is a second option, but its location must be considered carefully to avoid contact with or influence from the contamination zone. This obviously is a risky proposition until the zone of contamination has been defined. Finally, there is the alternative of treating the existing well to remove the contaminants. Particularly in rural areas, the choice may be between treatment and the potentially expensive alternative of digging a new well.

If it is not possible or economical to obtain potable water service from a community system, it will be necessary either to develop a new water supply or to treat the existing well water. The decision is basically a question of economics, encumbered by the risk of developing a new well that might also be contaminated. The costs involved in developing a new well vary widely, based on the particulars of a given location. Certain elements must be assessed.

- Daily water supply requirement (gallons)
- Selection of a suitable site with regard to both yield and noncontamination (fire flow)
- The depth of well required
- The type of soil to be penetrated
- Development and installation of the well
- Pump tests and analytical determinations
- Requirements for treatment, such as disinfection, filtration, softening
- Requirements of storage, pumping, and housing equipment
- Distribution system requirements, including mains and house connections
- Permit requirements from regulatory bodies
- Operational requirements—chemicals, labor, utilities
- Access of drilling equipment to the selected site

Although many of these elements are not applicable to private residential wells, the possibility of inadequate yield confronts any new well-drilling venture and should not be taken lightly.

Isotherm Conditions

Temperature—Ambient
Pretreatment—n/a
Contact time—4 hours
Sample volume—500 mL
Component measured—trichloroethylene

Carbon Dosage	Component Remaining		Component Adsorbed	Capacity
grams	mg L	mg	mg	mg gm
Control	1 600	0 800		
0 0005	1 490	0 745	0 055	110
0 0010	1 520	0 760	0 040	40
0 0025	1 290	0 645	0 155	62
0 0050	1 060	0 530	0 270	54
0 010	0 860	0 430	0 370	37
0 025	0 285	0 143	0 657	26
0 050	0 165	0 083	0 717	14
0 100	0 035	0 018	0 782	8
0 250	<0 010	<0 005	0 800	
0 500	<0 010	<0 005	0 800	

Data courtesy of Calgon Corporation, Pittsburgh, Pa

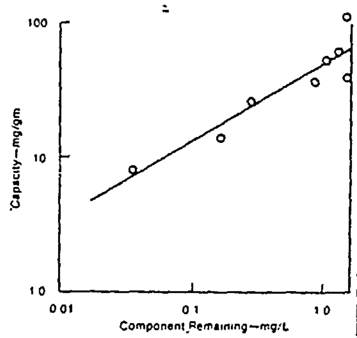

Figure 2. Carbon isotherm evaluation

TABLE 5

Comparison of treatment methods for the removal of trichloroethylene from groundwater

Item	Aeration	Adsorption: Granular Activated Carbon	Adsorption: Synthetic Resin*
TCE removal effectiveness	apparent limiting concentration of about 10 $\mu g/L$	effluent of $< 1\ \mu g/L$ for extended time	effluent of $< 1\ \mu g/L$ for extended time
Flexibility to concentration fluctuations	fair	good	good
Major equipment components	packed tower, basin with diffused aeration, or tray tower prior to chlorination	adsorption column (pressure vessel) prior to chlorination	adsorption column (pressure vessel) prior to chlorination, distillation unit, steam generation unit
Technology status	developed	developed	under development
Intermedia transfer	air phase	exhausted carbon disposition-replacement	regenerant disposition
Implementation time	two to six months	two to six months	four to six months
Winter operating consideration	potential freezing	requires housing	requires housing
Operator training required	minimal	moderate	substantial
Relative capital cost	\$X	\$2X to 3X	\$2.5X to 4X
Relative operating cost	\$Y	\$3Y to 5Y	\$3.5Y to 6Y

*Carbonaceous adsorbent XE-340, Rohm and Haas Co., Philadelphia, Pa.

Treatment of contaminated well water

Alternatively, the existing well may be treated for removal of any contaminants. Although this appears to be easier than developing a new well, there are many concerns that must not be overlooked, including protection of public health. The economy of scale when opting for a treatment system to cleanse either individual residential wells or small municipal system wells is prohibitive.

Air stripping is impractical since it would require repumping water after passage through a tower or aeration basin and would necessitate proper venting of the liberated vapors. Furthermore, to achieve the recommended drinking water criteria, large volumes of air compared to the water flow rate, as high as 3000:1,[3] may be required in conjunction with tall packed towers or sizable aeration basins.

The only other proven treatment technology for consistently reducing these compounds to recommended drinking water levels is adsorption by means of synthetic resins or granular activated carbon (GAC). Performance data for this type of application indicate that a carbonaceous adsorbent has a bed volume capacity, or bed life, up to 100 percent greater than GAC.[4,5] However, the initial cost for the carbonaceous adsorbent is about 15 to 20 times greater than GAC and, therefore, GAC has an overall cost advantage for this scale of application.

In either case the adsorbent eventually reaches exhaustion and has to be replaced or regenerated. Since it is not economical to consider on-site regeneration for such small exhaustion rates, replacement is the only practical approach. Replacement services are generally available for GAC systems in the United States. On the other hand, steam regeneration, which appears to be the most feasible method of removing contaminants from a carbonaceous adsorbent, is still in the developmental phase and is not currently available on a commercial scale for residential or small community users.

Thus, small-scale applications are basically limited to GAC adsorption. However, it is important to recognize that although this treatment method will achieve the objective of removing TCE and MC from a contaminated well, there may be other contaminants in the well that are not amenable to adsorption. Documented cases show that many wells with TCE or MC also contain excessive nitrate, fluoride, or chloride levels, indicating that organic contamination is not the only problem. This type of situation may require other treatment processes such as ion exchange, a fact that substantially changes the economic impact of cleanup.

Another important aspect of using GAC filters is the need to determine the

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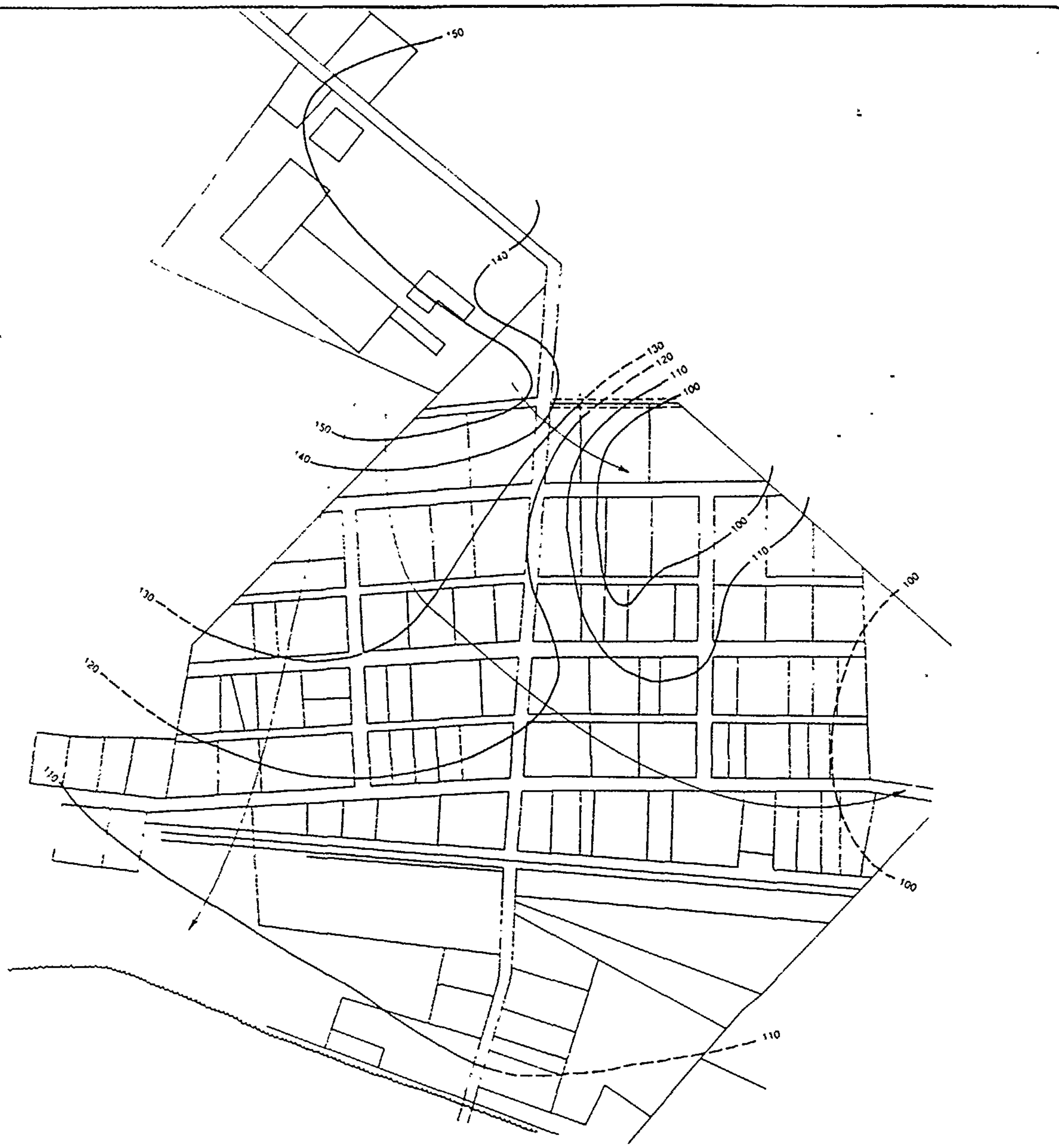

Figure 3. Groundwater elevation and flow direction

life of the carbon bed for each application. Adsorption is a concentration-sensitive unit operation in which there is a logarithmic relationship between the capacity of the adsorbent for a given substance and the concentration of the substance in the liquid passed through the adsorbent, as shown in Figure 2. In simpler terms, the higher the concentration of a contaminant in the well water, the greater the capacity of the carbon to adsorb the contaminant. However, a given quantity of carbon will have a greater service life for lower concentrations than for higher concentrations. Thus, the useful life of a bed of carbon in one situation may be only a fraction of its useful life in a different situation involving the same contaminant.

Consequently, it is necessary to provide a means of determining when the carbon reaches breakthrough. This can be done by monitoring well water on a frequent basis, particularly during the first cycle. A single test for TCE-MC, however, can cost in the range of $20 to $50, depending on sample collection, transport, and the premium assigned by a qualified laboratory to conduct such a sophisticated analysis. The cost of frequent analysis to ensure that the carbon is functioning properly is usually considered prohibitive. A carbon filter that typically provides at least 3.5-min contact time at peak flow may last from six to nine months in a residential application where there are four family members and a TCE well water concentration of 600 µg/L.

Alternatively, a two-stage system can be applied in which two identical beds are operated in series. In effect this provides a spare bed of carbon, which will significantly reduce the monitoring requirements. When the lead bed becomes exhausted, which may be long after breakthrough has been reached, the second, or polish, bed is moved into the lead

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position. The exhausted carbon is replaced (an operation that takes about 15 min), and the fresh bed is restored to service in the polishing position. After the first exhaustion cycle, the monitoring requirements are further diminished. The only major concern at that stage is the level of contamination in the well over long periods of time. If the level increases significantly, the lead bed may break through above the desired concentration sooner than expected.

A two-stage residential system designed to treat up to 0.3 L/s (5 gpm) will cost in the range of $850 to $1000, including installation. Each carbon bed replacement can be expected to cost approximately $130 to $150 and may last from several months to more than a year, depending on the contaminant concentration and the water usage rate.

A two-stage 3-L/s (50-gpm) GAC treatment system will cost in the range of $65 000 to $80 000, exclusive of costs associated with well development, storage, housing, and distribution system. Direct annual operating costs, on the order of $10 000 to $20 000, could vary significantly, depending on the carbon exhaustion and replacement rate.

Although GAC adsorption has been proven to be technically effective for removing these materials from numerous private residential wells, the problem of monitoring for breakthrough has concerned some regulatory agencies sufficiently enough that they have been reluctant to endorse the application of carbon filters for TCE and MC removal for potable water. The most significant concern appears to be allowing individual residents to decide when to change the carbon. This is of particular concern since neither of these compounds imparts a taste, odor, or color to water when present in the nanogram per litre range. Another concern, still under investigation, is the effect of increased bacterial levels in the water when GAC is applied without postdisinfection.

The same technical concerns that apply to individual residential applications are pertinent to contaminated community wells. The matter of economics appears to invite investigation of air-stripping methods as a complement to GAC. In one process under design, a 95-L/s (1500-gpm) system will include air stripping as the initial unit operation followed by GAC as the polishing step. If this approach is followed, the cost of carbon replacement will be markedly reduced, and the economies of scale using air stripping will be achieved.

Contamination containment and recovery

The final chapter of any groundwater contamination saga is the containment-recovery phase. Hydrogeological expertise is requisite to making this a successful endeavor. Through a method of piezometric mapping of water table elevations, as shown in Figure 3, the directions of flow in an aquifer can be approximated. Coupled with the concentration gradient of contaminants in the affected area, a plan of dynamic pumping can be developed to contain the zone of contamination to prevent its spreading farther and to remove contaminated water from the aquifer, preferably from the area with the highest level of contamination. It may be necessary to pump test either existing wells or new retrieval wells in order to determine a satisfactory rate of withdrawal. Although high-yield retrieval wells would appear to be advantageous, they may not be possible because of the geological structure of the subsurface or because of adverse effects on nearby wells, such as excessive lowering of the water table.

Another problem confronted during the recovery program is the disposal of recovered contaminated water. Depending on the contaminant concentration and the mass loading relationship to a potential receiving stream, it may be acceptable to discharge into a local sewer system. The significant volatility of TCE and MC under such conditions would reduce the impact of these substances on the wastewater treatment facility. Nonetheless, careful investigation should be conducted before advocating this action. Some questions have been raised as to the effect residual TCE would have on the acceptability of using digested sludge for agricultural land application.

If the contaminant concentration is too high to allow discharge into a sewer system or direct discharge into surface waters, it may be necessary to treat the recovered contaminated water prior to discharge. Again, there are two fundamental methods of removing these compounds from water—air stripping and adsorption. Experience with both methods indicates that at high TCE or MC concentrations, air stripping should be given primary consideration, based on its economic advantage over carbon or resin adsorption.

Several successful applications of air stripping have been demonstrated, including packed tower aeration using countercurrent flow, stripping in a conventional aeration basin, and the use of spray aeration. Generally, spray aeration is limited to situations where the flow rate is relatively low and there is adequate land nearby, the use of which will not adversely affect neighbors. Diffused aeration basins have the distinct advantage over spray systems of being less susceptible to freezing during severe winter weather. However, packed towers appear to be the most efficient vehicle of contacting large volumes of water with sufficient air to achieve high percentage reduction of TCE and MC without exorbitant power requirements.

Treatment costs for 3.8-ML/d (1-mgd) to 760-ML/d (200-mgd) systems have been determined for the removal of trihalomethanes (THMs) from surface water supplies, but little information is available on the removal of TCE and similar compounds from groundwater in small systems applications.[6] Table 5 presents a qualitative comparison of the various treatment techniques, including relative cost estimates based on a flow rate of 3 L/s (50 gpm).

Regardless of the method chosen to conduct the recovery program, it must be recognized that in almost all cases encountered to date, recovery programs are still ongoing, several years after inception. Aquifer water moves very slowly and is not subject to the purging effects characteristic of surface streams. Therefore, it should be anticipated that three or more years may be required before the contamination is flushed from a contaminated aquifer.

Summary

The contamination of groundwater resources by substances such as TCE and MC has created a dilemma that requires the attention of public health officials and professional specialists in chemistry, hydrogeology, and environmental engineering. Each situation is unique and should be studied carefully before any conclusions are reached and action is taken. However, because these materials cannot be detected via the senses until the concentrations reach toxic levels, expeditious action must be taken to protect public health.

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Detection of trace organics in well water near a solid waste landfill

Foppe B. DeWalle and Edward S.K. Chian

The majority of municipal and industrial solid wastes is disposed of in landfills. Although sanitary landfill guidelines have reduced the immediate public health hazards from vector exposure, environmental degradation can occur through leaching of organics and inorganics from the solid waste by infiltrating rainwater. This study evaluates the migration of leachate containing trace contaminants away from a solid-waste landfill located upstream from an artesian well field operated by a local water company.

Explosive methane and carbon dioxide gas generated during anaerobic solid waste decomposition can migrate away from a solid waste landfill, and leachate can contaminate downstream groundwater with its toxic substances. Analysis of leachate for organics has shown the presence of nine free volatile fatty acids and high molecular weight humic substances[1] and five alcohols.[2] A study using vacuum distillation has noted the presence of 40 organics in leachate collected from a municipal landfill.[3] Dunlap et al[4] have detected 50 organics in well water collected near a municipal landfill. An industrial fill, such as the one in Love Canal, can release as many as 82 different organic compounds.[5]

Site characteristics

The 19 ha (47 acre) Llangollen landfill, renamed Army Creek landfill, is located 96 km (60 mi) southwest of Wilmington, Del., and is 1220 m (4000 ft) long and up to 275 m (900 ft) wide. The fill is at the site of an abandoned sand and gravel pit utilized by New Castle County as the primary disposal location for municipal and industrial solid wastes between 1960 and 1968. The landfill was constructed by use of a modified area fill method, and at its completion it encompassed a volume of 1.4×10^{6} m^3 (1.9×10^{6} yd^3) and had a thickness of 6 m (20 ft) to 9 m (30 ft) (Figure 1A). About 30 percent of its volume is located beneath the seasonal high water table.[6] Refuse burial proceeded from east to west and municipal garbage and liquid industrial wastes were initially dumped in the standing water, resulting in contamination and poor compaction. The landfill was covered with 0.6 m of sand in 1970 and purchased by the county for a future park.

The upper geologic layer used in the gravel operation, the Columbia Formation, consists of coarse textured sand deposited with glacial melt waters.[7] The top of the formation varies from 0 to 20 m (60 ft) above mean sea level, and the base is located between 8 m (25 ft) below and 1.7 m (5 ft) above mean sea level (Figure 1 B). The top of the screens of the wells tapping this formation have a depth of 10 m (31 ft) and −2.6 m (−8 ft).

The Columbia Formation is underlain by a clay layer varying in thickness from less than 0.3 m (1 ft) to 33 m (110 ft), with a median thickness of 20 m (61 ft), as deducted from the depth of the top of the well screens tapping the Upper Potomac Aquifer. There are several indications, including old aerial photographs, that the clay layer has been removed during excavation at five locations to expose the underlying Upper Potomac Aquifer to landfill leachate.

The confined Upper Potomac Aquifer has a thickness ranging from 0.6 m (2 ft) to 24 m (80 ft), with a median value of 3 m (10 ft), as derived from the recorded length of well screens or perforations. These sands thicken and dip toward the southeast near the landfill. The transmissivity, defined as the product of hydraulic conductivity and aquifer thickness, is about 500 m^2/d (40 000 gpd/ft).

The Lower Potomac Aquifer, with its highest point 151 m (496 ft) below sea level, has a thickness of 1.5 m (5 ft) and transmissivity values less than 12 m^2/d (1000 gpd/ft) and is separated from the Upper Potomac Aquifer by a 116-m (380-ft) deep confining layer.

As the Upper Potomac is one of the most productive groundwater reservoirs of New Castle County, major well fields were located about 1000 m (3000 ft) south and southwest of the landfill by the Artesian Water Company and the Amoco Chemicals Corporation, respectively, between 1952 and 1969. The pumpage from each well field was about 5700–7600 m^3/d (3 mgd), thus increasing the total pumpage in the area to 24 700 m^3/d (6.5 mgd). This pumpage lowered the water level near the pumping wells to about 7 m (20 ft) below sea level, and the cone of depression allowed migration of leachate contaminants from the landfill toward the well field.

Contamination history

A residential well located 170 m (550 ft) southwest of the landfill developed a disagreeable odor and a permanent staining of porcelain fixtures in late 1971. Further testing* indicated the presence of leachate migrating southward in the direction of the artesian well field. The monitoring network consisted of twelve 15-cm (6-in.) diameter steel casing wells and forty-six 10-cm (4-in.) and nineteen 2.5-cm (1-in.) diameter polyvinyl chloride (PVC) pipes with depths ranging from 3 m (10 ft) to 53 m (173 ft), all located south and southwest of the landfill. In addition, fifteen 10-cm (4-in.) diameter PVC wells were installed down to the bottom of the solid waste in the central part of the fill to measure the leachate strength while thirty-three 3-cm (1.25-in.) diameter wells were installed at the perimeter.

Chemical analysis of the well water in mid-1973 showed elevated chloride concentration as far as 800 m (2500 ft) down gradient from the fill. The cross-sectional data evaluation showed a downward moving plume (Figure 2) with a thickness of about 25 m (80 ft), indicating that it had moved through the punctured clay layer. With a permeability of 20 m/d[6] and a hydraulic gradient of 0.017 m/m, it would have taken about 6.5 years to travel such a distance, which indicates that the migration might have started about one year before the landfill closure.

Analysis of the leachate collected from the center wells of the landfill showed respective maximum values for chemical oxygen demand, Cl, and Fe of 179.800 mg/L, 1625 mg/L, and 2500 mg/L, with median values of 3200 mg/L, 295 mg/L, and 90 mg/L, respectively. The leachate was moderately biodegradable, with an average biological oxygen demand to chemical oxygen demand (BOD:COD) ratio of 0.49.

Counter pumping program

After the extent of pollution was established, a contaminant control program was designed to halt the plume migration. In mid-1973, seven 25-cm (10-in.) diameter steel-cased recovery wells were installed between the landfill and the two well fields in order to create two additional cones of depression by pumping 13.25 ML/d (3.5 mgd) from the aquifer. Thus, the recovery wells acted as a drainage divide, capturing contami-

*Conducted by the Delaware Geological Survey, the New Castle County Public Works Dept., and Roy Weston, Inc.

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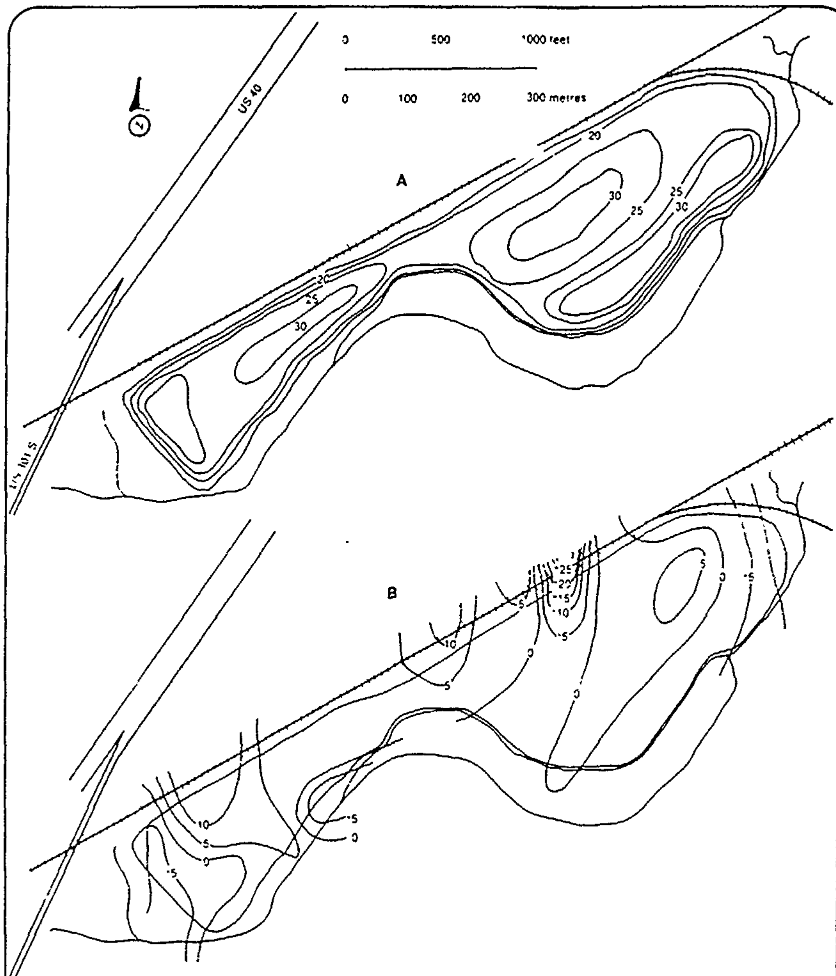

Figure 1A. Contours (ft) of refuse thickness in the Army Creek landfill
Figure 1B. Contours (ft) of the top of the clay layer beneath the landfill

nated groundwater and discharging it to Army Creek and, subsequently, to the Delaware River. In addition, the pumping in each of the artesian well fields was reduced to about 5.67 ML/d (1.5 mgd).

Examination of the piezometric surface around the landfill (Figure 3) showed that the two small cones of depression directly south and southeast of the landfill prevented migration to the large artesian well cone farther south of the fill, as measured in mid-1976. Some migration, however, could occur to three low-capacity wells west of the larger well field.

The problem of contaminated drinking water at the houses directly southwest of the landfill was eliminated by connecting them to the Artesian Water Company system in early 1973; houses farther south were connected by mid-1974.

Analysis of trace organics

Conventional analysis did not show a further deterioration of the water quality in the two artesian well fields after the start of the counter pumping program; however, this could be the result of a lack of sensitivity, as most tests fail to detect pollutant concentrations below 0.1 mg/L. In addition, tests such as COD and BOD are nonspecific for individual organics. The USEPA, therefore, contracted with the authors to conduct in mid-1977 a trace organic survey of the leachate, the recovery system, and the raw and finished drinking water. Nine samples were analyzed for volatile organics, and three were tested for extractable organics.

The methodology for collection and analysis utilized in the survey has been described extensively.[4] Aliquots for volatile organic analysis are collected and stored in a refrigerated 125-mL zero-headspace glass container, and the aliquot for the extractables is placed in a 3.8-L (1.0-gal) glass container. The volatile organics are stripped from a 100-mL aliquot at 60°C in a 1000-mL stirred stripping flask in which 200 mL/min of nitrogen gas is purged over the liquid surface to replace the headspace continually. The volatile organics are removed from the gas stream during subsequent passage through 0.5 g of a porous polymer column packing material based on 2,6-diphenyl-p-phenylene oxide.* This method is preferred to the bubbling method, as the latter results in foaming of the sample. The vapor trap,† in turn, is heated at 250°C for 6 min, after which the released organics are flushed through a separate loop into the GC column and chromatographed on a 3.6-m (12-ft) 60/80 mesh graphitized carbon black‡ coated with 0.2 percent polyethyleneglycol§ that is temperature-programmed** from ambient to 200°C at 8°C/min.

The base-neutral extractable organics are removed from the aqueous phase at pH 12 with 100/50/50 mL portions of spectra grade chloroform,†† after which the solvent is evaporated to 0.4 mL.‡‡ The aqueous sample is subsequently acidified to pH 2 and again extracted with 100/50/50 mL portions of chloroform. After replacement of chloroform by methylene chloride, the organics in the concentrated acid extract are derivitized with diazomethane and further reduced to 0.4 mL.‡‡ All solvent extracts are analyzed on a 3.6-m (12-ft) long, 2-mm ID glass column packed with 3 percent OV-17 on 80/100 mesh silinized diatomaceous-earth support.§§ which was temperature-programmed from 50°C to 300°C at 10°C/min.

The GC-MS-DS analysis was conducted with a mass spectrometer*** and a data system††† and stored on a magnetic tape for subsequent compound identification.‡‡‡

Groundwater collection and analysis

A total of six drinking water wells were sampled by using existing deep well centrifugal pumps with surface drive; i.e., three from the Artesian Water Company, two from the Amoco Chemicals Corporation, and one from the upstream Midvale Artesian Water Company, which served as a control (Table 1). In addition, a sample was taken from the leachate in the landfill and the major recovery well that was removing the contaminated groundwater (Figure 3). After aeration, lime treatment, chlorination, and fluoridation were completed,

*Tenax GC, AKZO Research Laboratories, Enka N.V., The Netherlands.
†Tenax trap, AKZO Research Laboratories, Enka N.V., The Netherlands.
‡Carbopack C, Supelco, Inc., Bellefonte, Pa.
§Carbowax® 1500, Union Carbide Corp., Chicago, Ill.
**5700 Model GC, Hewlett-Packard, Palo Alto, Calif.
††Burdick and Jackson, Muskegon, Mich.
‡‡Micro-Kuderna-Danish evaporator, Kontes, Vineland, NJ.
§§Supelcoport, Supelco, Inc., Bellefonte, Pa.
***Varian-MAT 311A, Varian Associates, Palo Alto, Calif.
†††Varian-MAT SS100, Varian Associates, Palo Alto, Calif.
‡‡‡Cyphernetics Mass Spectral Search System (MSSS), Varian Associates, Palo Alto, Calif.

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TABLE 1

Volatile organics identified in different well water samples—μg/L

Compound Number and Identification	Relative Retention Time	Sample Number and Identification: (1) Midvale Artesian Well 1	(2) Artesian Well G3	(3) Artesian Well 7	(4) Artesian Well 2	(5) Finished Water	(6) Amoco PW1	(7) Amoco PW3	(8) Recovery Well RW3	(9) Llangollen Fill S1
(1) Unknown	0.12									
(2) Unknown	0.20	0 2	0 1	0 2		0 2				5080
(3) Acetone	0 49	0.3	0.2	0 3	0.7	0.3		0.4		43 700
(4) Butanol	0 62							0.4		46 570
(5) Tetrahydrofuran	0 83			0 2					1.2	
(6) Diethylether	0 96							2.5	2.5	
(7) Chloroform	1 00		0 3	0 5	1 8				6.5	21 800
(8) Dichloroethane	1 08	0 4	0 2	0 3	0 3	0 3		1.1	392	44 720
(9) Unknown	1.19	0 3	0.1	0.1	0.2					4640
(10) Pentanol	1.23									11 660
(11) 1,4-dioxane	1.24				0.5			0.1	2.4	
(12) Unknown	1.31	0.4	0 2	0.3	0.3	0.4	0.4	0.3	0.5	1700
(13) Unknown	1 36							0.2		270
(14) Unknown	1.50									1980
(15) Trichloroethylene	1 52	0 6			0 3			4.1	4.6	2140
(16) Unknown	1 54	0 6		0 3	0 3					
(17) Unknown	1.56			0.1						
(18) Benzene	1 55	1 5	1 1	1 6	1.4	3 0	0 5	6.5	4.3	9550
(19) Unknown	1 63							0.1		100
(20) Hexane	1 69	3.9	1 3	1 4	4 0	1.0	4 7	0.6	1.4	5530
(21) Unknown	1 73							0 2	0 3	230
(22) Unknown	1.75									130
(23) Unknown	1.77					1 0		0.1		630
(24) Unknown	1.83					0 3		0 3	1.2	2050
(25) Unknown	1.90								0.4	
(26) Unknown	1.93							0.1	0.1	1080
(27) Unknown	1 99								0.4	3080
(28) Tetrachloroethylene	2 00	5 4	0 1	0 2	0 4	0.2			0.5	2380
(29) Toluene	2 09	0 7	0 4	0 8	1.9	0.3		13 5	0.9	660 000
(30) Unknown	2.19	5 2								
(31) Unknown	2 25							0.3	1.5	4220
(32) Unknown	2 28	1.4								940
(33) Unknown	2 31		0 6		0.1	0.2				1090
(34) Bis(2-chloroethyl) ether	2.35	0 3	0 1	0.2	0.2	0 2		1.4	3.1	12 400
(35) Unknown	2.37			0 2						
(36) Xylene	2.40	0 8		0 2	0.1	0.1			0.4	4490
(37) Unknown	2.42									10 030
(38) Unknown	2.48					0.1			0.2	
(39) Xylene	2.68	0 8	0.2	0.5	0 6	0.2		1.5	1.2	5030
(40) Xylene	2 76	0.7	0 3	0 6	0 5	0 3		2.1	2 9	39 260
(41) Propylbenzene	2 92							0 5		
Total number of compounds		24	5	8	13	8	6	36	429	982 480
Greater than 0 1 μg/L		17	14	17	17	17	3	21	22	30
Greater than 1 μg/L		5	2	2	4	3	1	8	13	30
Unidentified		6	4	6	4	6	1	8	8	16

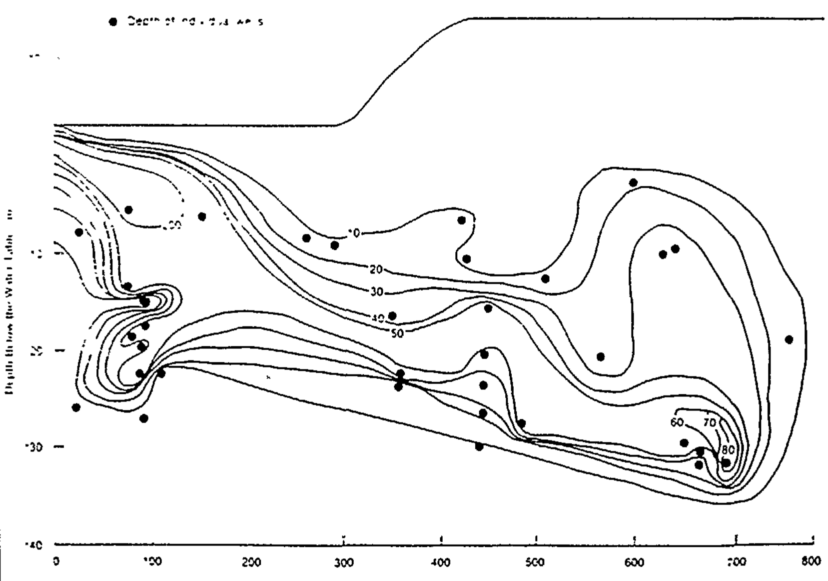

Figure 2. Isopleths of different chloride concentrations at different depths downstream from the landfill

TABLE 2

Frequency of detection and attenuation factors of volatile organics detected in groundwater sample

Compound	Detected Frequency percent	Attenuation Factor§
Benzene*,‡	100	2220
Hexane*,‡	100	3950
Dichloroethane	88	115
Toluene*,‡	88	
P-xylene*,†	88	13 540
Bis(2-chloroethyl)ether	88	4000
O-xylene*,†	88	4190
Acetone*,‡	88	48 560
Tetrachloroethylene	75	4760
M-xylene*	63	11 230
Trichloroethylene	50	465
Chloroform*,‡	50	3300
1,4-dioxane	37	
Diethyl ether	25	
Tetrahydrofuran	25	
Propyl benzene	13	
Butanol*	13	
Pentanol	13	

*Also found by Khare and Dondero (1977)
†Also found by Dunlap et al (1976)
‡Also found by Webb (1974)
§Attenuation factor after passage through 500 m of soil between landfill and recovery well

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TABLE 3
Extractable organics found in different groundwater samples—μg/L

Compound Number and Identification	Groundwater Samples: Relative Retention Time	Artesian Well 2	PW3	Recovery Well 3
Acid fraction				
(1) Unknown	0.70			14
(2) Unknown	0.76		5	
(3) Methylpalmitate	0.91	0.5	1	
(4) Dibutylphthalate*	1.00	0.5	0.5	1
(5) Di(2-ethylhexyl)phthalate	1.22	2	0.5	5
(6) Terpineol C.,	1.28	0.5	0.5	
Base/neutral fraction				
(7) Diethoxyethane	0.14	4	15	7
(8) Dichlorobutane	0.33	19	27	4
(9) Unknown	0.42		40	
(10) Unknown	0.48		16	
(11) Unknown	0.74		7	
(12) Unknown	0.76		2	
(4b) Dibutylphthalate*	1.00	0.5	1	1
(13) Butylphthalylbutylglycolate	1.16			2
(5b) Di(2-ethylhexyl)phthalate)*	1.22	0.5	2	100
Total		18	118	134

*Also found by Dunlap et al (1976)

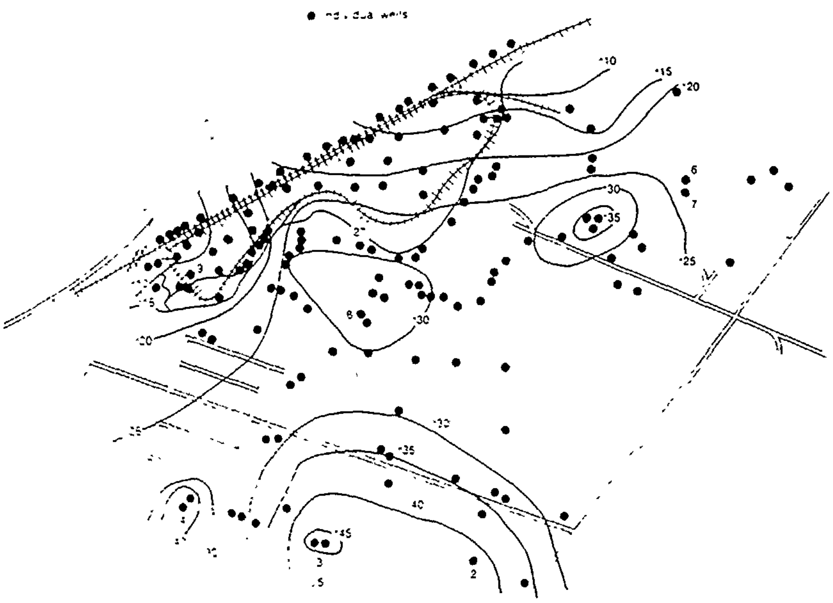

Figure 3. Location of different monitoring and drinking water wells and piezometric contours (ft) of the groundwater table around the landfill

the finished tap water from the Artesian Water Company was tested.

The GC-MS-DS analysis of the nine samples identified and quantified a total of 25 volatile and extractable compounds (Tables 1, 2, 3), 18 of which are volatile. An additional 23 volatile and 6 extractable compounds not clearly identifiable were present in the water samples. The greatest number (30) of individual volatile compounds was noted in the leachate sample (Well S1), with toluene, dichloroethane, butanol, and acetone present in the highest concentrations. The total concentration of volatile organics present in the leachate was 982 mg/L. The second most polluted well was the recovery well RW3 containing 22 volatile organics and making a total of 429 μg/L.

The most polluted drinking water well was PW3. Its total volatile organic level was about six times greater than the least polluted well, with toluene, benzene, and trichloroethylene present in significant amounts. The least polluted wells were G3, the farthest from the landfill, and PW2, which had the greatest well depth (192 m) and the smallest number of individual volatile compounds of all wells sampled.

The most frequently detected compounds (Table 2) such as benzene, dichloroethane, and toluene result from industrial wastes, whereas organics such as acetone, butanol, and pentanol result from biological fermentation reactions. The limited analysis for extractable organics showed the widespread presence of dibutylphthalate and di(2-ethylhexyl) phthalate used as common plasticizers. As these compounds are not totally extracted with the base/neutral fraction, the remainder shows up in the acid fraction during the second extraction. Most of the frequently found compounds, with the exception of dichloroethane, bis(2-chloroethyl)ether, and tetrachloroethylene, were also found in an earlier study that tested four samples around the same landfill. That study also measured significant amounts of free volatile fatty acids ranging from C. to C., thereby confirming earlier analyses by the authors.

Attenuation of organics in soil

The attenuation of individual volatile compounds through 500 m of soil was calculated by dividing the leachate concentration by the concentration in the recovery well. Of the individual compounds, dichloroethane and trichloroethylene had the lowest attenuation factor, while butanol and pentanol showed the largest decrease, likely a result of biodegradation when the leachate permeated the soil. The ratio of volatile to extractable organics decreased from 3.2 (429 μg:134 μg) to 0.3 (36 μg:118 μg) and 0.5 (13 μg: 28 μg) between the recovery well and the most polluted groundwater well and the main artesian well, respectively. The decrease in this ratio is primarily due to the stability of dichlorobutane and diethoxyethane, which together with dichloroethane and trichloroethylene are among the very stable and mobile organics in the soil.

An earlier analysis of the extractable organics around the landfill that identified and quantified 30 organics and tentatively identified 13 others, noted only a 100-fold concentration reduction between the leachate and the recovery well as compared to a 2300-fold reduction noted for the volatile organics in the present study. The stability of o-cresol, p-cresol, isovaleric acid, and acetic acid accounted for the lower attenuation. As most complex organics are hydrolized to acetic acid, its presence indicates that these bacterial processes are still active after 500 m permeation.

The attenuation tends to decrease with decreasing molecular weight, possibly because of the decreasing adsorptive capacity that lower molecular weight compounds have with respect to the soil adsorptive complex. The attenuation factor decreases from 4760 for tetrachloroethylene (MW 166), to 465 for trichloroethylene (MW 156), and to 115 for dichloroethane (MW 99). The alcohols and ketones present in the leachate, such as butanol and pentanol, were not detected

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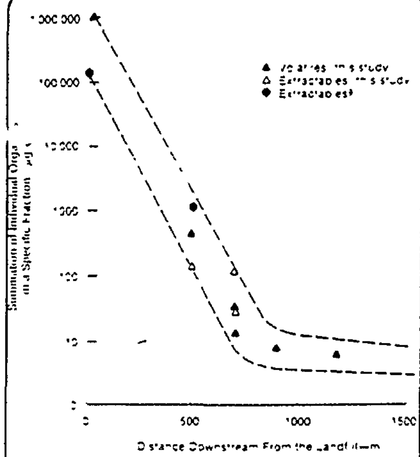

Figure 4. Logarithmic decrease of trace organics after soil permeation

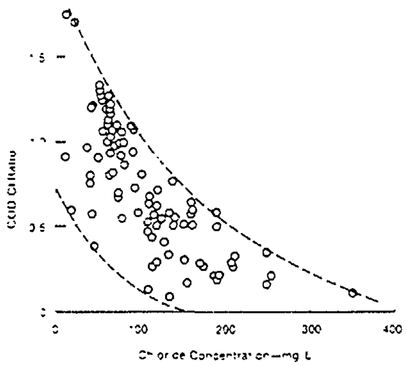

Figure 5. Ratio of chemical oxygen demand (COD) to chloride (Cl) concentration (mg L) in the sample

in any of the artesian wells: none of the linear alcohols present in the leachate was present in the recovery well.'

The total amount of trace organics downstream from the fill showed a logarithmic decrease for the first 1000 m, i.e., a 90 percent reduction for every 200 m permeated (Figure 4), which takes about 19 months. Earlier studies by the authors showed a logarithmic decrease of a mixture of complex organics even though individual organics showed a linear decrease during biological degradation or physical adsorption.[11] Attenuation will also result from direct dilution of the leachate plume with the unpolluted groundwater.

The limited available data would indicate that most of the biological degradation of the leachate occurs during the first few hundred metres of permeation. While the average COD:Cl ratio of the leachate in the landfill is 10.8, it decreases to 0.1 in the most contaminated water samples collected from well 27 (Figure 5), which is located 150 m southwest of the landfill, about halfway to the recovery well RW3. In the absence of any dilution, this represents a biological degradation greater than 99 percent. At a 50-fold dilution, when the Cl concentration is reduced to 20 mg/L by the 14 mg/L Cl in the unpolluted water, the COD:Cl ratio actually increases again to 1.7, possibly indicating the presence of refractory organics.

The polluted downstream wells also showed a seasonal effect in which the highest COD and Cl values were observed during the summer months when the largest rainfall occurs. This seasonal effect was especially pronounced in well PW3, which was not effectively protected by the recovery wells.

Effectiveness of groundwater protection system

The present trace organics analysis shows that substantial amounts of trace organics are still present in the landfill leachate seven years after closure of the site. The next most polluted well is the recovery well RW3, indicating that it is effective in collecting the trace organics in leachate migrating away from the landfill. Analyses for COD and Fe in its well water showed that these parameters stabilized after about one year. The presence of trace organics in the slightly polluted drinking water of well PW3 located to the west of the landfill indicates that the second recovery well to the west of the landfill is less effective than the larger well south of the landfill. The remaining drinking water wells all had trace organics concentrations below that of the Midvale control well, indicating the effectiveness of the system.

Installing the current monitoring network and the groundwater recovery wells has cost the county $1.35 million to date. The alternative of developing a new artesian well field at a sufficient distance away from the landfill was estimated to cost approximately $3 million. Removing the landfill to a more environmentally acceptable location was estimated at $15 million. In 1977, a panel of consultants recommended reduction of the infiltrating rainwater by installing an impermeable cover material on top of the solid waste. Groundwater inflow was to be reduced by installing a cutoff trench along the northwestern boundary of the landfill. In addition, leachate was to be recovered by installing recovery wells in the solid waste to remove the estimated 170 m^3/d (45 000 gpd) leachate, which could then be discharged to an existing nearby municipal sewer. This alternative was estimated by the county consultant at $4.4 million, with a yearly operating cost of $0.99 million. A substantially lower estimate by the authors of this study includes installing an impermeable cover on top of the 190 000 m^2 fill at $5.75/$m^2$ ($1.1 million) and using 10 already existing wells in the landfill to recover the leachate at a total cost of $10 000 for well preparation, installing 2000 m of transmission mains at a cost of $45/m ($90 000) and pumps ($50 000) for a total of $1.25 million. The annual operating and maintenance costs of wells and mains are estimated at $3000, pumping costs at $6000, and sewer charges at $6000 for a total of about $15 000 per year, indicating that this alternative is cheaper than installing a new artesian well field.[1,4] The initial cost represents about $1.80 per ton of waste delivered to the landfill.

Conclusions

The present study evaluated the effectiveness of a counter pumping program to halt the migration of trace contaminants away from a solid waste landfill. The trace organics analysis, which noted 41 volatile and 13 extractable compounds, showed that the recovery wells were effective in preventing leachate from migrating to the artesian wells. It was tentatively concluded that low molecular weight chlorinated compounds have a much lower attenuation than biodegradable organics such as alcohols and ketones. It was also calculated with the limited data that the trace organics showed a 90 percent concentration reduction for every 200 m permeated through the aquifer.

Acknowledgments

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Selecting polymers for direct filtration

Hsuan-Hsien Yeh and Mriganka M. Ghosh

Cationic polymers with low to medium molecular weights and high charge densities are ideally suited for direct filtration. Rapid mixing at a velocity gradient of 300–650 sec ' for 3–6 min is necessary before filtration. In most cases slow flocculation may be avoided. Modified jar tests with high intensity mixing followed immediately by particle size distribution analysis should be the method of choice for selecting polymers for direct filtration. For optimum filtration, an optimum floc size distribution exists that depends on filter and particulate characteristics.

New drinking water standards, the discovery of new particulates in some waters, and expanded sludge disposal problems created by new water pollution control requirements have impelled engineers to look into innovative treatment methods involving the use of synthetic polyelectrolytes.

The conventional method for removing colloidal and other particulates from water consists of flocculation, sedimentation, and deep bed filtration through granular media. The direct filtration process differs from conventional methods of treatment in that all solids, those occurring naturally and those added in the course of treatment, must be removed in the filter. This process usually consists of the addition of destabilizing chemicals, followed by some flocculation with no settling, and, finally, filtration. However, in some cases, depending on the raw water quality, an organic polyelectrolyte may be added by rapid mixing and the water filtered directly with no flocculation. The absence of flocculation and sedimentation tanks represents a significant savings in terms of plant size and capital investment. Further, the use of polyelectrolytes instead of metal coagulants, such as alum, may substantially reduce the amount of sludge to be handled. However, a recent survey by the Filtration Committee of the American Water Works Association indicated that most direct filtration plants use polymer as a coagulant aid rather than as the sole coagulant.[1]

Very little attention has been given to developing a rational procedure for the selection of the "right" polymer for a specific job in water treatment. Most often polymer selection is made on a hit-or-miss basis. The clarity of the treated water from the direct filtration process depends in large measure on successful polymer-preconditioning of the water. Polymers, pH, and ionic strength of natural waters are the three most important variables that can be used to improve the efficiency of direct filtration by modifying the surface characteristics of either the suspension, filter, or both. In practice, however, pH and ionic strength are not the variables routinely controlled during the course of water treatment. The improvements in direct filtration that are obtained from a proper selection of polymer and polymer dosages are: (1) increased rate of deposition, (2) increased bed penetration and better utilization of the entire bed depth, and (3) minimized headloss and prevention of premature clogging.

The present rate of progress with synthetic polymers would be vastly improved by a more enlightened attitude on the part of some manufacturers. Information supplied by the manufacturers should include the type of polymer or copolymer, the concentration of active ingredient, the concentration of free monomer, the proportion of ionizable groups, and the molecular weight or intrinsic viscosity under specified conditions. This type of information, in conjunction with information on the extent of mixing required to disperse polymers effectively in the water, is needed in selecting polymers for direct filtration.

The work reported herein was concerned with methods of selecting polymers for direct filtration and with developing data on the filtration of dilute clay suspensions using preselected polymers and polymer dosages. In particular, the influence of such important polymer characteristics as molecular weight and charge density and the effect of mixing energy on the polymer-particle interaction were investigated using electrokinetic measurements, colloid titration, residual turbidity, and detailed analysis of particle size distributions. Evidence of in-filter flocculation and breakthrough of particulates caused by in-filter floc breakup under high shear, such as encountered in clogged beds, were investigated extensively using particle counting techniques.

Polymer use in water treatment

Experience has shown that the use of polymers may be the key to solving many of the problems facing the water industry. Hunter and Alexander[2] demonstrated that using a cationic polymer to reverse the charge on silica sand from negative to positive greatly improved the filtration of kaolin. As reported by Adin and Rehbun,[3] the sorptive and bridging properties of polymers are primarily responsible for the improvement of filtration of low turbidity waters.

Polymer adsorption and destabilization. According to the commonly accepted Simha-Frisch-Eirich model, the polymer molecule is attached to any adsorbent surface by a fraction of the total number of segments of the polymer chain.[4] This model reduces to Langmuir's sorption isotherm when the number of adsorbed segments is reduced to one. The destabilization of colloidal dispersions of negatively charged clay, achieved by using a cationic polymer, could be accomplished by "charge neutralization coagulation" or by "bridging flocculation."[5] Depending on the concentrations of clay and

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polymer and on the pH, the aggregation by low to medium weight polymers (MW = 10 000 to 100 000) occurs by either or both of the mechanisms cited. According to O'Melia and Stumm,[5] if the total concentration of polymer required to produce a certain fractional coverage Θ of the colloid surface is expressed by $C_{t\Theta}$, then

$$C_{t\Theta} = \frac{\Theta}{K(l-\Theta)}[l + KS\Gamma_m(l-\Theta)] \qquad (1)$$

given that $C_{t\Theta} = C_e + C_a$ and $C_a/S = \Theta\Gamma$

where C_a is the concentration of polymer adsorbed—mol/L, C_e the concentration of residual polymer in solution—mol/L, S the concentration of colloid surface—m²/L, K the equilibrium constant for adsorption-desorption reaction, and Γ_m the ultimate adsorption capacity of colloid surface—mol/m.²

When $C_a > C_e$, Eq 1 reduces to

$$C_{t\Theta} = \Gamma_m S\Theta \qquad (2)$$

Lindquist and Stratton,[7] reporting on the adsorption of cationic polymethylenimine (PEI) on colloidal silica, found that below the critical coagulant concentration (ccc) virtually complete adsorption of polymer occurred regardless of pH, ionic strength, and molecular weight, in accordance with Eq 2. However, if $C_{t\Theta} >$ ccc, Γ_m increased with molecular weight. Above pH 9, bridging was the dominant mechanism for destabilization since charge density of PEI at high pHs was small. At pHs less than 9, charge interaction between negative colloid and cationic PEI was the dominant mechanism for all molecular weights studied (MW = 1760 to 18 400). Moreover, logarithm of ccc dosage exhibited an inverse linear relationship with logarithm of cationic charge per molecule, regardless of pH, molecular weight, and ionic strength.

Floc strength under hydrodynamic shear. The essential function of polymeric flocculation is to produce aggregates that will be large enough to be captured and strong enough to withstand shear in the filter voids. However, shear may not be the mechanism of floc breakup, if any, in filters. The shear stress at 25°C and at a mean velocity gradient G of 1000 sec^{-1} is equivalent to an energy of only 9 dyne-cm/cc or 4.8×10^{-6} kcal/mole of water, much less than the weak van der Waals forces or hydrogen bonds (about 5 kcal/mole). Conceivably, the flocs are held together by interfacial tension.

Tomi and Bagster[8] showed that the maximum stable size of floc is universally related to the one-half power of G. Smith and Kitchener[9] reported that the maximum diameter is proportional to the −0.2 power of G. Similar relationships between relative floc binding strength and maximum size for the microscale of isotropic turbulence in the inertial and viscous subranges have been proposed recently by Tambo and Hozumi.[10] Letterman et al[11] attempted to develop a method for predicting an optimum combination of G and t for rapid mixing for a predefined minimum residual turbidity. The existence of an optimum t for all values of G tested, as measured by residual turbidity, suggested that the early conditions of floc formation are important and the function of rapid mixing is more than simply dispersing the flocculant.

Polymers in depth-filtration

Despite dramatic progress in understanding the filtration process, exemplified by the rich and varied literature that it has produced, a comprehensive method capable of predicting the dynamic behavior of a filter over its entire operational span has remained out of reach. Deep filters are increasingly being used for the removal of suspended solids from wastewaters, in addition to being used in various modified forms for water treatment. It is well documented in the literature that many undesirable trace pollutants, such as trace metals, toxic organic material, and viruses, are usually associated with colloidal or coarse colloidal (size > 0.4 µm) particulates.[12-14] Direct filtration can easily remove these fine particulates and associated pollutants if they are appropriately conditioned with suitable polymers before filtration. Proper mixing of polymer is a prerequisite to the success of direct filtration. Provision of some flocculation may or may not be necessary since flocculation may occur during contact of particulates with the filter medium.[1] Cationic polyelectrolytes of low to medium molecular weight seem to be most effective in the direct filtration process, especially in dual or multimedia filters treating natural suspensions.[1,15] Glaser and Edzwald[16] observed better filter performance with increasing molecular weight only when a reasonable flocculation period was provided, and Treweek[17] observed that a minimum flocculation time of 7 min was required to obtain aggregation of singlets. Further, with a prefiltration Gt of 42 000 or higher, direct filtration removed all particles larger than 7.5 µm.

Mechanistic models. In the last decade major emphasis has been given to developing a fundamental theory of filtration based on the hypothesis of removal mechanisms and analysis of particle motion.[18-20] All attempts at modeling the packed-bed filtration process have been limited to clean filters. Recently, O'Melia and Ali[21] attempted to develop a fundamental model to describe the improvement of water quality during the initial "ripening" period, based on the premise that particles removed during the early stage of filtration can serve as collectors themselves. Traditionally, models for clogging filters have evolved from a semi-empirical macroscopic standpoint.[22] The filter constants are usually evaluated with experimental data. Among these, the study by Herzig et al[23] is particularly noteworthy in that it reduces the macroscopic mass balance and rate equations to two ordinary differential equations that can be solved rather easily.

Notably different from these semi-empirical models are the two recent models, the first of which was reported by Wnek et al.[24] As part of the phenomenological description, a charge balance was made to account for the altered surface interaction resulting from the deposition of colloidal matter. The assumption that particle deposits form a smooth coating around filter grains is open to conjecture. In the second study, reported by Tien et al.,[25] the dynamic behavior of a filter during the entire filtration cycle was modeled through the use of a two-stage discontinuous deposit morphology. This model considers nonretentivity or reentrainment of deposited matter.

Experimental methods

Polymers and colloids. The polymers that were used in this study are listed in Table 1. The number-average molecular weights and active ingredients are also listed. The concentration of free polymers in solution was found by using the colloid titration technique[26,27] for all polymers except polyethylenimines, which were titrated according to a method developed by the Dow Chemical Company.[28] In colloid titration, a positive colloid reacts stoichiometrically with a negative colloid forming a precipitate at the isoelectric point. The residual concentration of positive colloid is directly titrated with PVSK (potassium polyvinylsulfate) solution with toluidine blue (TB) indicator. In determining the charge density of negative colloids, a known excess of a positive colloid, glycol chitosan (GC), is added first, and the GC remaining after neutralization is back-titrated with PVSK. The electrophoretic mobility of colloids was measured by using electorphoresis apparatus.*

Coagulation studies. A jar test apparatus† was used for determining optimum dosage. Rapid mixing at 85 rpm for 1 min, slow mixing at 25 rpm for 20 min, and then quiescent settling for 30 min were used before the turbidity of the supernatant was measured.‡

A separate, 3.7-L volume mixing chamber equipped with a variable speed

*Zetameter, Zeta Meter, Inc., New York, N.Y.
†Phipps and Bird, Inc., Richmond, Va.
‡Hach 2100A turbidimeter, Hach Chemical Co., Ames, Iowa.

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TABLE 1
Characteristics of Polymers

Polymer*	Type	Molecular Weight	Structure
A	cationic	1200	polyethyleneimine
B	cationic	2×10^4	polyethyleneimine
C	cationic	4×10^4	polyethyleneimine
D	cationic	5×10^4	polyamide
E	cationic	1 × 10[illegible]	polydiallyldimethyl-ammonimum
F	cationic	3 × 10[illegible]	organic copolymer of acrylamide
G	cationic	5×10^4	acrylamide-based polymers
H	cationic	high	acrylamide-based polymers
I	cationic	≃2 × 10[illegible]	polyamide
J	anionic	5×10^4	copolymer of acrylic acid and sodium acrylate

*Polymer A, Corcat P-12; Polymer B, Corcat P-200; Polymer C, Corcat P-145, Cordoba Chemical Co., Sacramento, Calif. Polymer D, Betz 1190. Polymer F, Betz 1160; Polymer I, Betz 1180, Polymer J, Betz 1100, Betz Laboratories, Inc., Trevose, Pa. Polymer E, Cat-Floc, Calgon Corp., Pittsburgh, Pa. Polymer G, Percol 751; Polymer H, Percol 759; Allied Colloids, Inc., Fairfield, N.J.

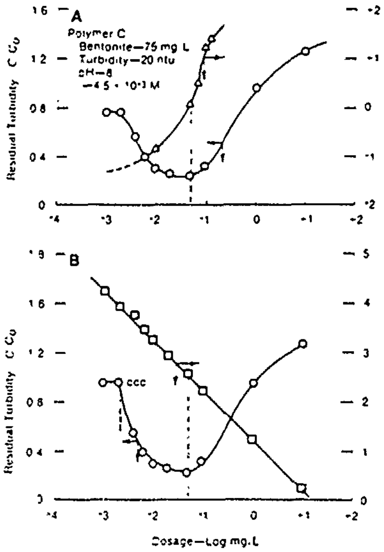

Figure 1. Relationship between electrophoretic mobility and polymer dosage

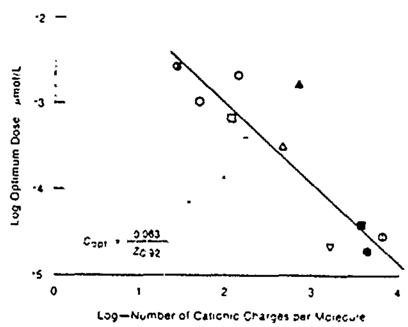

Figure 2. Relationship between optimum dose and charge density of polymer

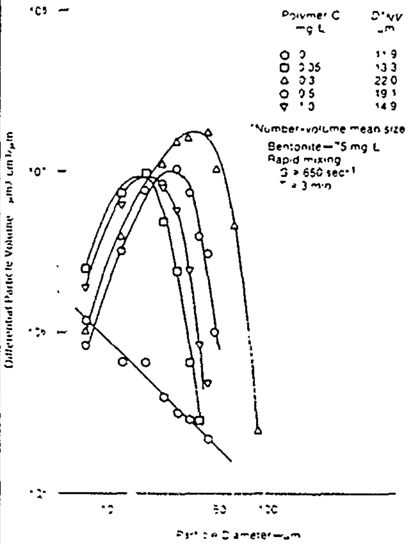

Figure 3. Particle size distribution with various dosages of polymer C after rapid mixing

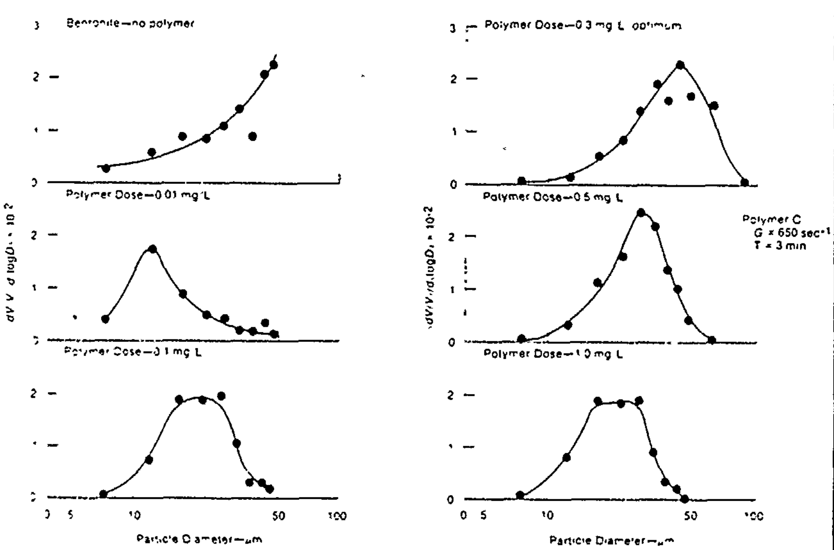

Figure 4. Log-normal distribution of particles after mixing with polymers

impeller was used to study the effect of velocity gradient on flocculation and filtration. The torque of the rotating impeller was measured by mounting a torquemeter* between the motor and mixing paddle. The torque readings were taken using a stroboscope.

Particle size distribution. Particle size distributions were measured using a 12-channel HIAC particle counter.† A 5-300 μm sensor was employed for all particle analyses. Sizes less than 5 μm could not be measured; consequently, all coagulated samples yielded higher counts in all measured size classes than those present in the original clay suspension. This was caused mainly by the coagulation of particles of less than 5 μm into larger particles.

Laboratory filter unit. A constant rate pilot filtration plant was used for all filter runs. The filter column was 2.54-cm (1-in.) ID acrylic plastic and contained 15.2 cm of silica sand with an effective size of 1.0 mm and a uniformity coefficient of 1.2. All filter runs were made by using a 75 mg/L suspension of bentonite clay, with an influent turbidity of 20 ntu. University of Missouri tap water (pH = 8.0; ionic strength = 4.5×10^{-3}M) was used in making all feed suspensions. The rate of filtration was varied from 1.4 to 2.4 mm/s (2 to 3.5 gpm/sq ft).

Results and analysis

Optimum dosage from coagulation studies. For determining the optimum dosage for turbidity removal by coagulation-flocculation and by direct filtration, jar testing is the most commonly used laboratory procedure. The correspondence between the dosages for optimum coagulation and direct filtration has been well demonstrated.[19,29] In all experiments for the selection of dosages by jar tests, a 75 mg/L suspension of bentonite (20 ntu)

*Model 783-C-10, Power Instruments, Skokie, Ill.
†Model PC-320, Pacific Scientific Co., Montclair, Calif.

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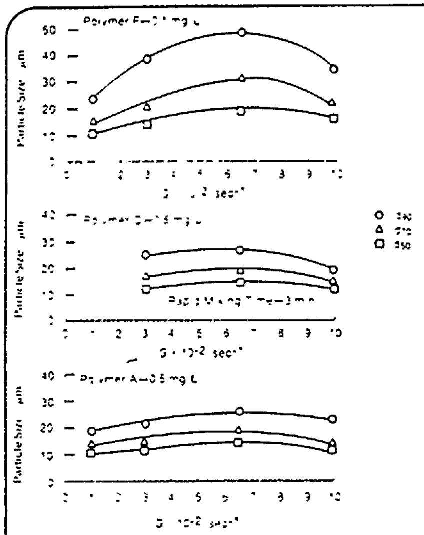

Figure 5. Effect of mixing intensity on particle size distribution at optimum polymer dose

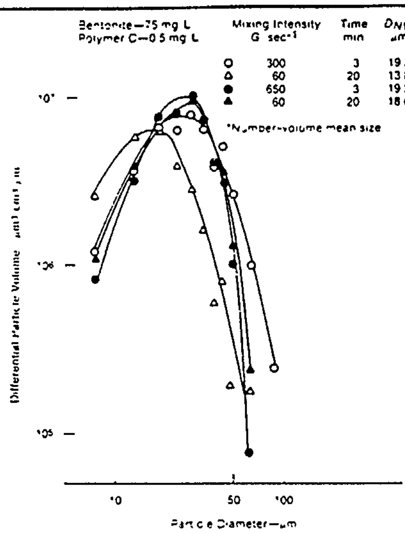

Figure 6. Effect of slow mixing on particle size distribution with polymer C

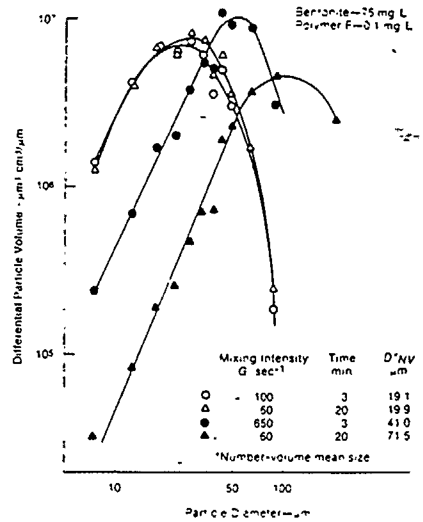

Figure 7. Effect of slow mixing on particle size distribution with polymer F

was used. The polymers were mixed for 1 min in a standard jar test apparatus at 85 rpm ($G \simeq 170$ sec⁻¹), followed by slow agitation at 25 rpm ($G \simeq 50$ sec⁻¹) for 25 min. A 30-min quiescent settling was provided before determining the residual turbidity of the supernatant.

Figure 1 shows the results for polymer C, a polyethylenimine with a number-average molecular weight, $<M>_n$, of 40 000. The correspondence between residual turbidity from jar tests and electrophoretic mobility was excellent. Minimum residual turbidity corresponded to a zero electrophoretic mobility at an optimum dosage of 0.05 mg/L.

In part B of the figure, the ratio of charges of bentonite to the polymer at various dosages has been plotted on logarithmic scales. The charges on bentonite clay and polymer C were determined by colloidal titration. There was no one-to-one charge neutralization observed at the optimum dosage. Therefore, although charge neutralization appears to be a major mechanism of coagulation with low molecular weight cationic polymers as seen in part A of Figure 1, there is no linear stoichiometry between polymer and colloid charges, indicating bridging to be partly responsible for the observed results. The results from jar tests, electrokinetic measurements, and corresponding charge ratios at optimum dosages have been summarized in Table 2 for several cationic polymers with $<M>_n$ ranging from 1200 to 3×10^6.

The number of cationic charges per molecule of a polymer can be computed from the known charge density of polymer (C/gm), its weight-average molecular weight, $<M>_w$, calculated from light scattering data using the method of Zimm[11] and Avogadro's number. Figure 2 shows the relationship between optimum polymer dosage and the cationic charge per molecule z for various cationic polymers used in this study. Only data for cationic polymers with $<M>_n$ not exceeding 100 000 have been included. The relationship is empirical for adsorbable polymeric ions and is a distant parallel to the Schulze-Hardy rule. It does point out, however, that differences in flocculating ability between polymer molecules of different $<M>_w$ or under differing conditions of pH or ionic strength may not be due to size and chain length but rather to the number of cationic charges carried per molecule, under the operating conditions. In particular, for most low molecular weight polymers, coulombic interactions between colloid and polymer may play a dominant role, and bridging, as modeled by La Mer,[3] only a minor one. As proposed by Gregory,[11] the adsorption of a charged polymer segment on an oppositely charged surface is much faster than the collision kinetics. Therefore, adsorption and charge neutralization, at the "patches" where polymer is adsorbed, are essentially complete before particle aggregation begins. Although not presented here, results obtained in this study showed that polymer concentration needed to initiate flocculation (ccc) does not depend on $<M>_n$ or the maximum amount of polymer adsorbed, which, in turn, may depend on the electrostatic interactions among molecules of the polymer and on the space requirement of the polymer molecule.

Optimum polymer dosage and particle size distribution. The sorting of natural particulates into size groups classifiable either by diameter or volume is a well-established technique that has been used extensively in geochemical research.[12] However, interest in size distribution of particulates in freshwaters has arisen only recently. The size-frequency distribution of most natural particulates, such as clay, is described by the power law or Pareto distribution (Eq 3 and 4).

$$\frac{dN}{dD} = A_1 D^{-b} \qquad (3)$$

$$\frac{dV}{dD} = A_2 D^{3-b} \qquad (4)$$

where N is the particle number concentration, D the particle diameter, V the particle volume, and A_1, A_2, and b the empirical constants characterizing the distribution. However, following polymer treatment, the modified size distribution of flocculating clay was found to fit a log-normal distribution (Eq 5) rather than the Pareto distribution.

$$f(x)dx = \frac{1}{x\sigma\sqrt{2\pi}} \exp\left(-\frac{(\ln x - \mu)^2}{2\sigma^2}\right) dx \qquad (5)$$

where the probability density function $f(x)dx$ can be either for particle number density N or particle volume density V. The constants μ and σ are the characteristic constants of the distribution. The variable x in the probability density function $f(x)dx$ could be either N or V. In this research, all data for polymer-treated clay was subjected to a volume-based log-normal distribution. The change in size distribution and the number–volume mean diameter, d_{NV}, for each distribution following treatment with different dosages of polymer C are shown in Figure 3. It should be noted that

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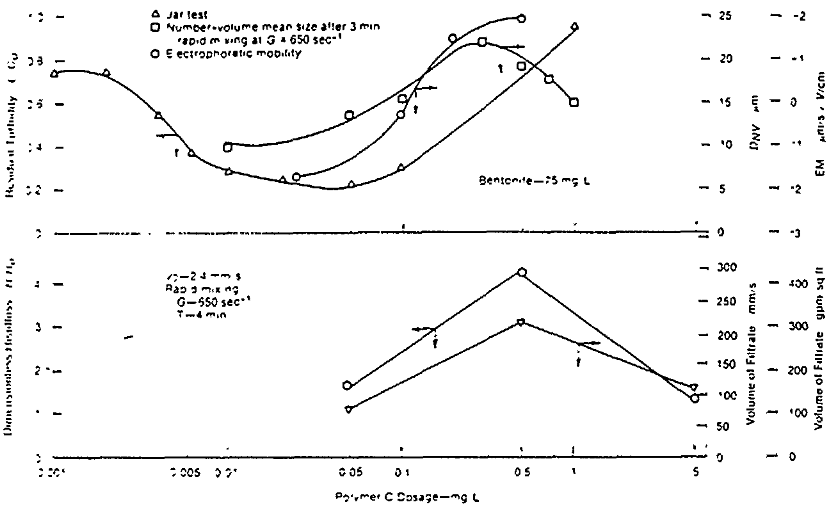

Figure 8. Optimum filtration with preselected doses of polymer C

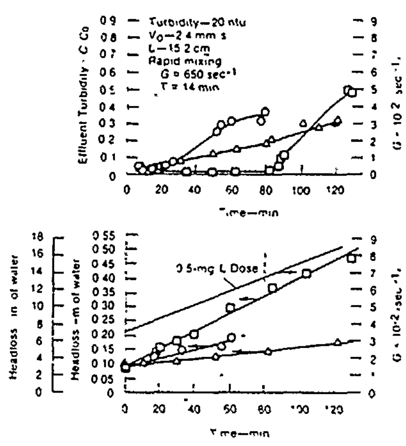

Figure 9. Effluent turbidity and headloss for polymer C

because of limitations in analytic detection, only particles above the 5-µm size were counted. The values of d_{VV} for the distributions were calculated from

$$d_{VV} = \left(\frac{\Sigma dV}{\Sigma dN}\right)^{1/3} = \left(\frac{\Sigma D^3\, dN}{\Sigma dN}\right)^{1/3} \qquad (6)$$

The optimum dosage was found to be in the range of 0.3 to 0.5 mg/L for polymer C, and this was the dosage selected for later filter runs. The same data from Figure 3 were replotted in a different form in Figure 4 to yield the log-normal distribution of relative percentage frequency. In this case density function $f(x)dx$ is equal to $(dv/v)/d(\ln D)$. The original dispersion of clay, as expected, did not fit this type of distribution. The shift in the distribution to higher sizes and also to narrower shapes clearly illustrates the effect of flocculation as the optimum dosage was approached.

Effect of mixing intensity and duration. The effect of mixing intensity and duration on polymer flocculation has been studied by several investigators.[11-13] Generally, this study determined that for most polymers a rapid mixing time of 3 to 8 min was sufficient at a G of 650 sec⁻¹. Mixing beyond 8 min appeared to cause some floc breakup, especially for large molecular weight polymers. For low molecular weight polymers, the optimum dosage was independent of rapid mixing intensity G for values in excess of 300 sec⁻¹, if a minimum mixing duration of 3 min was provided. The effect of rapid mixing intensity on particle size distribution at optimum dosage of three polymers is shown in Figure 5. The size distributions were measured immediately after 3 min of rapid mixing. It should be noted that for most polymers, the optimum dosage based on particle size distribution was somewhat higher than that estimated from either jar tests or electrophoretic mobilities. Since the method of polymer addition before direct filtration did not include any flocculation beyond rapid mixing, dosage from size-frequency analyses was based on samples collected immediately after rapid mixing. Slow flocculation and settling in a typical jar test reflect the effect of phase separation, which cannot be obtained in direct filtration without preceding flocculation. The particle sizes are plotted as finer than 90 percent (d_{90}), 70 percent, and so forth. For low molecular weight polymers, the effect of G on particle size was insignificant. However, for polymer F ($\langle M\rangle_n \simeq 3 \times 10^6$), the optimum mixing intensity was clearly 650 sec⁻¹.

In the next set of experiments, polymers were rapidly mixed at different Gs for 3 min, followed by slow agitation at $G = 60$ sec⁻¹ for 20 min. Samples of polymer-reacted suspensions were analyzed immediately after rapid mixing and again after 20 min of slow agitation. The results for polymers C and F are shown in Figures 6 and 7. These experiments were carried out at the optimum dosage of the respective polymers; the pH and ionic strength remained constant at 8 and 4.5×10^{-3} M, respectively. For the low molecular weight polymer C, the effect of mixing at low intensities beyond rapid mixing was insignificant. In fact, when initially mixed at $G = 300$ sec⁻¹, subsequent slow mixing appeared to cause some unexplained breakup in the flocs. For polymer F, a high molecular weight polymer, the insufficiency of $G = 100$ sec⁻¹, regardless of subsequent slow mixing, in producing any significant flocculation is obvious. When rapidly mixed at low Gs, the polymer was not dispersed sufficiently, and, therefore, subsequent slow mixing had no effect on flocculation. With proper dispersion at high mixing intensities, subsequent slow mixing was conducive to flocculation. It should be pointed out, however, that for natural waters with extremely low turbidities, slow flocculation may be of some advantage.

Filtration with preselected polymer dosages. The purpose of the studies on direct filtration was to investigate how well the dosages, mixing intensities, and durations could be selected from jar tests, particle size analysis, and electrokinetic measurements. In all filter runs reported here, no slow mixing was provided beyond rapid mixing for 14 min or less. The optimum dosages of polymer C for the direct filtration of 75 mg/L bentonite suspension were preselected using various methods, as shown in Figure 8, along with results for the volume of water filtered and headloss until 10 percent breakthrough of solids ($C/Co = 0.1$) occurred. The stoichiometry between optimum dosage and filter performance is abundantly clear, as is the superiority of the particle size distribution analysis method for determining optimum dosage for direct filtration without any slow flocculation. Optimal filtration was obtained at a dosage that also yielded the largest number-volume average diameter of 20 µm. In fact, in experiments with different polymers it was discovered that, for the operating parameters used in these filtration experiments, 20 µm was the optimum floc size that yielded the best filtration, regardless of the type of polymer used.

The effluent turbidity and headloss for

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TABLE 2
Summary of coagulation tests for 75-mg/L bentonite suspension—20 ntu at pH 8*

Polymer†	Charge Density C/g	Optimum Dose mg/L	Colloid to Polymer Charge Ratio at Optimum Dose
A—$<M>_n$ = 1200	900	0.1	48
B—$<M>_n$ = 20 000	390	0 02	625
C—$<M>_n$ = 40 000	300	0 05	317
G—$<M>_n$ ~ 5 × $10^{[illegible]}$	32.5	0.32	457
K—$<M>_n$ ~ 5 × $10^{[illegible]}$	51	0.1	931
F—$<M>_n$ ~ 3 × $10^{[illegible]}$	120	0.2	148

*Charge density of bentonite = 63 6 C/g
†Polymer K, Percol 744, Allied Colloids, Inc., Fairfield, N.J.

TABLE 3
*Effluent volume and headloss at breakthrough**

Polymer	Number-Average Molecular Weight $<M>_n$	Charge Density C/g	Optimum Dose mg/L	Volume Filtered at c/co = 0.1 m^3/m^2	Dimensionless Headloss H/Ho at c/co = 0.1
A	1 2 × 10^{3}	900	5	5 42	1.56
B	2 × 10^{4}	390	5	2.93	1 55
C	4 × 10^{4}	300	0 5	12.92	4.15
D	5 × $10^{[illegible]}$	240	0 5	5 86	2.99
E	1 × $10^{[illegible]}$	192	1 0	6 55	3.46
F	3 × $10^{[illegible]}$	120	0.1	12.13	6 14
G	5 × $10^{[illegible]}$	30	1.0	7 0	4.40

*(V_o = 8 6 m/h; L = 15 2 cm; G = 650 sec^{-1}; t = 3 min.' pH = 8)

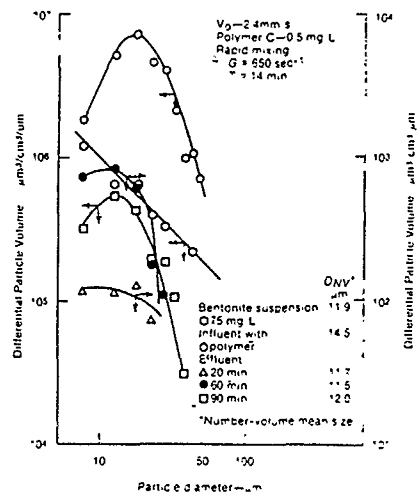

Figure 10. Effluent particle size distribution during filtration

the filtration of a 20 ntu (75 mg/L) bentonite suspension, with a predetermined optimum dosage of 0.5 mg/L of polymer C, are shown in Figure 9, along with filtration data at two other polymer dosages. A stoichiometry between polymer dosage and effluent quality was exhibited clearly, as was the correspondence between optimum dosage for filtration and optimum dosage for coagulation based on particle size distribution. During the first 5 min, the filtrate quality improved. Beyond this time period, no effect of "ripening" was observed. The typical S-shape of the effluent turbidity curve conforms very well to a classic adsorption-desorption type wave front migration pattern, as documented by Adin and Rehbun.[..] The G values, shown along with headloss, were calculated from headloss with the equation

$$G = \left(\frac{v \gamma h}{f L \mu} \right)^{½} \tag{7}$$

where v is the approach velocity (cm/s), γ the specific weight of flocs ($\simeq$1.01 gm/cc at 27°C), h the headloss (cm), f the porosity, L the media depth (cm), and μ the viscosity ($\simeq$0.0086 poise at 27°C). If most of the headloss occurs in the top 3.8 cm, a filtration rate of 8.6 m/h, a temperature of 27°C, and a porosity of 0.42, Eq 7 reduces to

$$G = 717\ h^{½} \tag{8}$$

At an optimum polymer dosage, breakthrough occurred at 80 min, when estimated G within the bed was about 679 sec^{-1}. This is an insignificant energy input that corresponds to a shear energy of only 6 dyne-cm/cc. It is highly unlikely that floc breakup would be caused by such small shear energies.

The particle size distribution and the number-volume average diameter for the influent and effluents collected at different times during the filter run are shown in Figure 10. The influent bentonite suspension before polymer addition is also included in the figure. After the polymer had been added, a significant increase in particle volume for all size intervals was noted. This increase occurred because the original bentonite suspension had many particles of less than 5 μm (limit of detection) in diameter that flocculated into larger aggregates in the detectable size ranges. Interestingly, the number-volume average diameter did not change significantly during the entire filter run, although the magnitude of dV/dD changed because of filtration of large particles. The absence of a shift in distribution indicates that even at breakthrough there was, perhaps, no breakup of flocs caused by high-velocity gradients within the filter.

The effluent turbidity and headloss for the filtration of bentonite with polymer F ($<M>_n$ = 3 × $10^{[illegible]}$) are shown in Figure 11. The results of filter runs at different dosages and at two different durations of mixing at G = 650 sec^{-1} are included. From flocculation studies and particle counts, the optimum dosage was predicted to be 0.1 mg/L when mixed for 3 min at a G = 650 sec^{-1}. Under these conditions, however, good effluent quality could be maintained for a long time, with the result of high headlosses. When the rapid mixing time was increased to 14 min, the filtrate quality deteriorated much faster, even at the optimum polymer dosage. When an overdose of polymer ($\geq$ 1.0 mg/L) was used, a large floc blanket formed at the top of the media and caused extremely high headlosses that mimicked septum filtration.

Macroscopic characteristics of filtration. The relationship between the filter coefficient and the specific deposit for different polymers is shown in Figure 12. This relationship is also expressed by the following well-known equations:

$$-\frac{\partial c}{\partial x} = \lambda c \tag{9}$$

$$V \frac{\partial c}{\partial t} + \frac{\partial \sigma}{\partial t} = 0 \tag{10}$$

where c is the local concentration of particulate matter, x the filter depth, t the time of filtration, and V the approach velocity. Figure 12 clearly demonstrates that the maximum value of λ is independent of either the molecular weight or the charge density of the polymer. However, the amount of material removed and, therefore, the length of filter run were greatest for polymers C and F, with $<M>_n$ of 4 × 10^{4} and 3 × $10^{[illegible]}$ and charge density of 300 and 120 C/gm, respectively. The headloss data corresponding to the filter runs in Figure 12 are summarized in a similar manner in Figure 13. The dimensionless headloss

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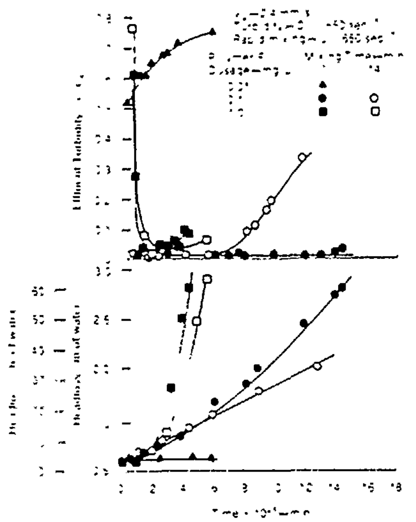

Figure 11. Effluent turbidity and headloss for polymer F

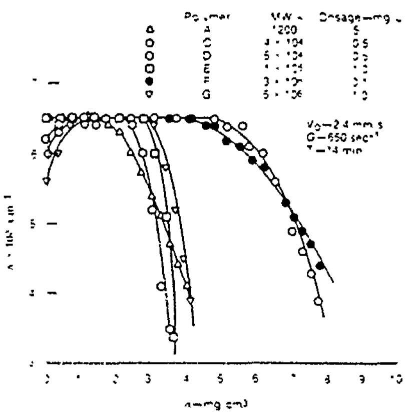

Figure 12. Relationship between filter coefficient and specific deposit for different polymers

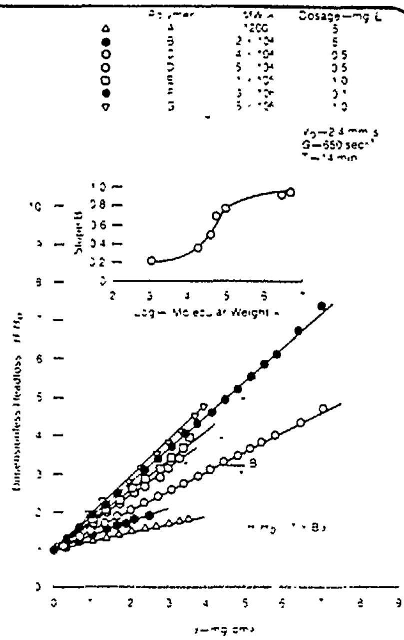

Figure 13. Relationship between headloss and specific deposit for different polymers

H/H_o (H_o being the headloss for clean bed) is shown as a function of σ. The inset indicates that headloss in direct filtration is directly related to molecular weight of the polymer. Therefore, although polymer F yielded very good results for filtrate quality, headloss was extremely high. Table 3 summarizes the volume of water that had been filtered with optimum dosages of various polymers and the resulting dimensionless headloss, until a 10 percent breakthrough of particulates occurred. Polymers C and F yielded better quality effluent than the rest of the polymers studied. However, the headloss with polymer F was extremely high.

Summary and conclusions

Polymers found to be good flocculants and filter aids are usually linear homopolymers. Proper characterization of polymers, including degree of hydrolysis, charge density, weight-average molecular weight, rate of solution, and intrinsic viscosity is essential if the mode of action of these polymers is to be understood. The size and shape of polymer molecules in solution are important from the standpoint of their use in flocculation or direct filtration. In freshwaters with low ionic strengths, the polymer assumes an extended coil configuration that affords the formation of bridges spanning double layers.

The method to be used for determining optimum dosage depends on the molecular weight and charge characteristics of polymers. Polyelectrolytes, i.e., polymers with ionizable groups, always interact strongly with surfaces of opposite charge and are quantitatively adsorbed, at least up to the point of charge neutralization. Measurement of electrophoretic mobility and of particle size distribution seem to be the ideal methods for determining optimum dosages for filtration. Restabilization caused by overdosing may simply be a result of charge reversal rather than colloidal surface saturation by adsorbed polymer segments. Because of strong electrostatic interactions, polyelectrolyte chains may assume a flat configuration on colloidal surfaces, reducing the chance of bridging.

The effect of mixing on polymer dosage and filter performance is significant. For direct filtration, low to medium weight polymers (10 000 to 100 000) seem to perform best. For such polymers rapid mixing at velocity gradients in the range of 300 to 650 sec^{-1} for a period of 3 to 8 min appears to be necessary. Since the adsorption process has to overcome a diffusion barrier, rapid mixing must precede filtration. Standard jar test apparatus is incapable of providing the necessary G values for mixing most polymers of interest in direct filtration. Rapid mixing should not be continued for prolonged periods, as it may cause shearing of polymer segments and thus impair the flocculating capacity of the polymer. For most direct filtration operations, slow flocculation following rapid mixing may not be needed, especially if the suspended solids concentration is 30 mg/L or higher.

High molecular weight polymers may give excellent filtrate quality, however, with excessive attendant headlosses. These polymers are not well suited for direct filtration. In the selection of cationic polymers for direct filtration, both charge density and molecular weight should be given equal consideration. Although it is conceivable that in-filter flocculation could occur, no evidence of such a phenomenon could be detected in this research. Further, estimated G values in a clogging bed did not seem to be high enough to cause quality failure through floc breakup. The effluent concentration profiles obtained in this study were reminiscent of typical adsorption front migration profiles.

A methodology based on the particle-size analysis seemed to offer a precise description of the actual separation process, either through flocculation or filtration. The optimum polymer dosages, based on particle-size analysis, should be favored over those determined by turbidity measurements in traditional jar tests.

Acknowledgments

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Conduct and uses of jar tests

Herbert E. Hudson Jr. and E.G. Wagner

If procedures that simulate treatment plant conditions are followed, jar testing can produce important information quickly and economically, and the data are directly applicable to plant design, modification, and operation. The procedure offers greater flexibility and economy than the traditional pilot plant test for pretreatment. It has shown excellent scale-up correlations with plant operating records.

Experience has shown that the jar test procedure has many uses other than coagulant dosage control. Beyond the use of the jar test technique for control of coagulant dosage, other uses include but are not limited to: (1) determining the strength of floc, (2) predicting filtered water quality, (3) determining the optimum coagulant pH, (4) determining the optimum mixing intensity, (5) evaluating the optimum mixing intensity taper, (6) evaluating rapid mix duration and intensity, (7) evaluating the effect of lag time between rapid mixing and flocculation, (8) evaluating optimum coagulant aid dosages, (9) evaluating the sequence of coagulant and coagulant aid dosages, (10) establishing which coagulant is most suitable, (11) evaluating the effects of sludge recycling and concentrations of sludge for recycling, (12) predicting the effects of short circuiting, (13) predicting sludge deposit configuration, (14) predicting design criteria for in-plant settling, (15) establishing design criteria for tube and tray settlers, and (16) evaluating direct filtration possibilities and coagulant dosages.

These techniques have been used over the past twelve years in correlating jar test and plant operating records in more than 60 treatment plants,[1] and similar assignments have recently been completed in six additional plants. Because of this wide experience in the application of the technique, great confidence has been gained in its applicability. The data in this paper illustrate many of these techniques.

Concept of settling velocity

Seventy-five years ago, Hazen published a paper in which it was pointed out that the important criterion in sedimentation is surface loading of the basin, rather than residence time.[2]

Surface loading has traditionally been expressed in units of volume per unit of basin surface area per unit of time. Units

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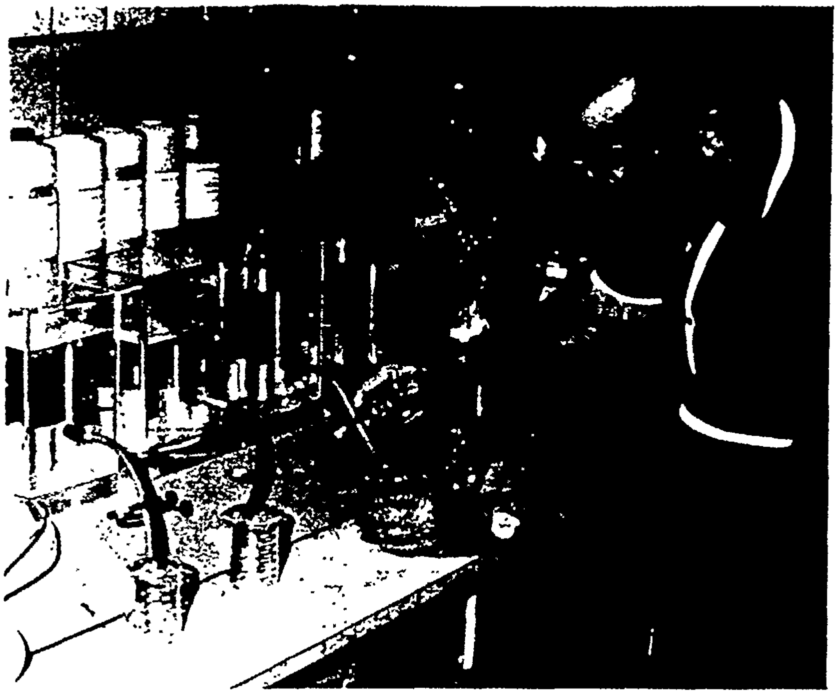
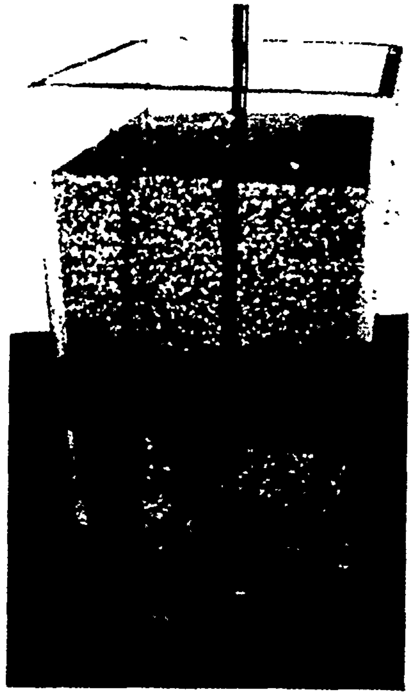


Jar testing set-up in which a magnetic stirrer was used with the square jars.



Floc formed with the use of ferric chloride and a high molecular weight nonionic polymer in water at the Potomac, Md., filtration plant.

commonly used heretofore were gallons per day per square foot or gallons per minute per square foot. Some authorities have used, in English units, inches per minute. Outside the United States it has been common to use volumes per unit of time per unit area. Some European and South American authorities use cubic metres per square metre per day. The British have long used Imperial gallons per square foot per hour. For a considerable period of time the use of centimetres per minute has been the standard. These latter units are very easily derived by simple arithmetic manipulation. The equivalency of the units most widely used in the United States is:

1 gallon per minute per square foot
1440 gallons per day per square foot
1.6 inches per minute
4 centimetres per minute

The surface loading rate for settling basins is equivalent to a vertical velocity, which is the descent velocity of particles that are settling in the basins. This value is found by dividing the volume of flow through a basin by the basin's surface area, with appropriate arithmetic adjustment. If good inlet and outlet design of the basin is provided, particles that have settling velocities greater than the basin loading (expressed as a settling velocity) will be removed in the sedimentation process. A few of the particles having settling velocities less than the basin settling velocity will be removed.

Procedure and equipment. A revised standard procedure now uses square jars that are fabricated by cementing together sheets of acrylic plastic, with dimensions as shown in Figure 1. After 2 L of water have been added and the water level graved on the container, a sampling tap is inserted through the wall of the container at a distance 10 cm below the surface of the water. Samples are withdrawn through this sampling tap at intervals of 1, 2, 5, and 10 min following termination of the period of flocculation. These correspond respectively to settling velocities of 10, 5, 2, and 1 cm/min. This range covers that encountered in most plants, which is most commonly from 2 to 8 cm/min (0.5 to 2 gpm/sq ft).

Many researchers working with jar testing on a bench-scale basis have used much longer times of sedimentation and have not controlled the depth from which the sample was taken. Accordingly, the settled water quality data have little relation to reality. The authors' experience has been that settling for very long periods of time in the laboratory produces results that fail to discriminate among the merits of various pretreatments nearly as well as do those in the range described above. Another weakness in bench-scale testing has been in the use of stirring speeds that do not produce mixing energy G equivalent to that occurring in full-scale plants. In full-scale plants, G values range from 10 to 150 sec^{-1}.

The results of the bench-scale tests, following rapid mixing and flocculation, are then plotted graphically to produce a line that defines the "settling velocity distribution curve." Since there are four points on the curve for each jar, the number of points makes it possible to determine whether erratic results are being obtained (Figure 2). The graph paper used may be either logarithmic-normal probability paper, semilogarithmic, or logarithmic paper. In log-normal graphs, settling velocity is plotted against the percent of turbidity remaining. For the other types of graphs, turbidities remaining may be plotted directly against settling velocity. As indicated in Figure 3, plant loading data may also be shown for comparison with what may be expected if the jar test treatment is applied in the plant. Actual plant results can also be plotted on the same graph for comparison.

The authors calibrated the square jars with a torque meter system* similar to that described in an earlier publication.[4] Calibration curves appear in Figure 4.

The square plastic jars have a number of advantages over the normal glass beakers or glass containers used in jar test work in that (1) the plastic jars are less fragile; (2) rotational velocity stops quickly upon the termination of stirring; (3) no siphon or pipette is needed for

*Phipps and Bird stirring machine, Phipps and Bird, Inc., Richmond, Va.

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sampling, and the sample is withdrawn without disturbing the settling water; and (4) the acrylic plastic walls are less heat-conductive than the glass walls of other jars. The plastic has lower thermo-conductivity than glass, and the wall thickness in the plastic units is about fourfold that of glass beakers. Plastic units can therefore be used in the laboratory without a water bath. No material change in temperature of the water occurs during testing.

Occasionally, the question is raised as to whether the results in jar testing compare with those in the plant, because of the continued rotation of the water in the jars on termination of stirring. Field experience does not confirm this to be a factor, particularly with baffled jars or square beakers. Apparently, the brief 20 to 30 s period required to slow the water down in these beakers is analogous to the turbulent inlet zone of the settling basins.

The photo on page 219 shows the jar testing setup used in recent work, in which a magnetic stirrer was used with the square jars. Settled water samples were taken at closely regulated time intervals. A small portion of each sample was bled to waste to flush out the sampling tube, and a sample large enough for a turbidity determination was collected. For this purpose, it is convenient to use 30-mL plastic cups that commonly serve for dispensing medicine in hospitals. Turbidity is then determined in a 90-deg light-scattering nephelometer.

The second photo on page 219 shows floc formed with the use of ferric chloride and a high molecular weight nonionic polymer in water at the Potomac, Md., filtration plant. This illustrates a well-flocculated water. In a number of plants, the authors have found the use of ferric coagulants to be advantageous over alum. This is not universally the case, however. Fallin has previously reported plant-scale experience with the use of a ferric coagulant.[4]

In the conduct of bench-scale testing, it is important to simulate as closely as possible the rapid mixing and flocculating conditions of the plant both as to nominal duration and mixing intensity. The bench-scale procedure may also be used in the same period of testing to simulate the modified conditions to be anticipated in the plant with improvements. Jar test procedures, repeated under the extremes of water quality such as occur in winter versus summer and checked against actual plant performance, provide an excellent alternative to pilot plant operation.

A factor that makes the use of extrapolation of jar test results to plant behavior conservative is that there is always far greater residence time in the plant settling basins than there is in the jars, for which the maximum sedimentation time

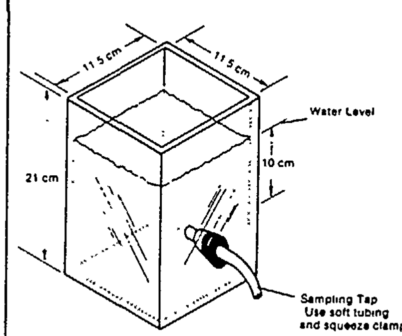

Figure 1. Two-litre jar for bench-scale testing, fabricated from acrylic plastic

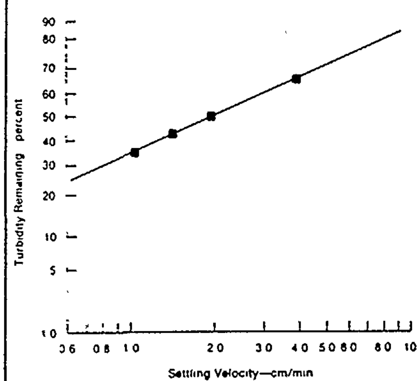

Figure 2. Settling velocity distribution curve produced from jar testing in a single jar

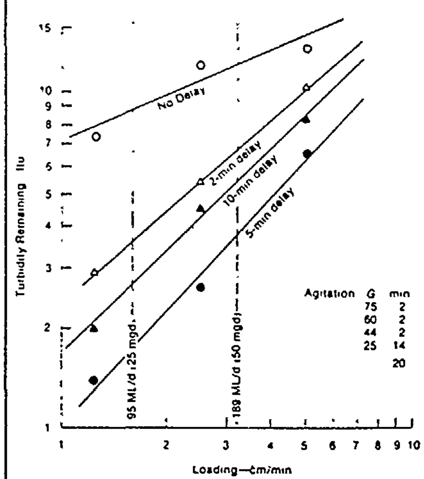

Figure 3. Evaluation of polymer application point

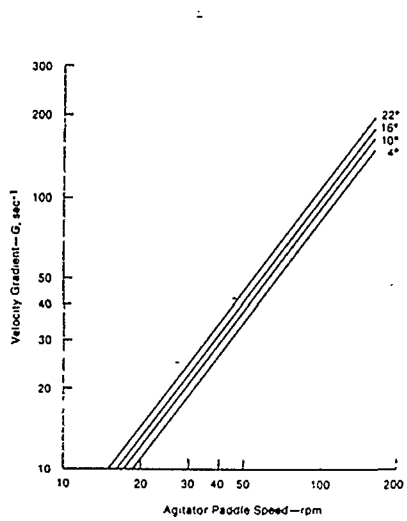

Figure 4. Velocity gradient versus rpm for a 2-L square beaker

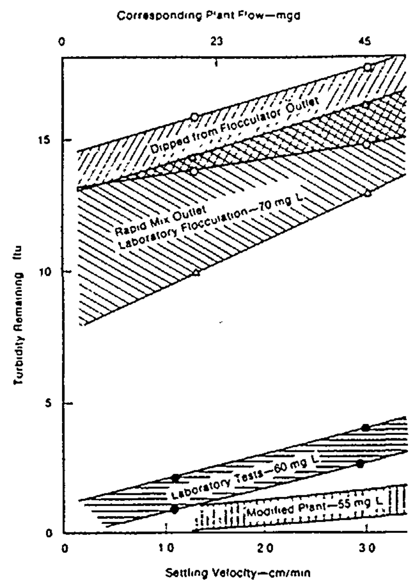

Figure 5. Comparison of performance of plant, plant dose and process, laboratory dose and process, and performance of plant under modified conditions with stated alum doses

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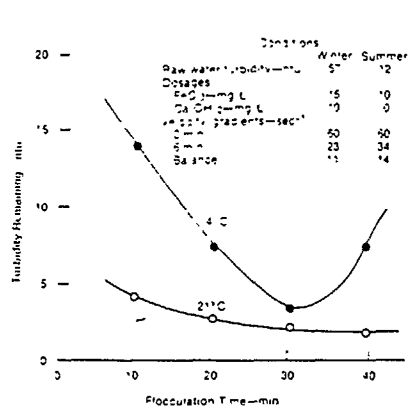

Figure 6. Effect of temperature on floc formation and settling at Potomac, Md.
Values shown are for settling velocity of 5 cm/min

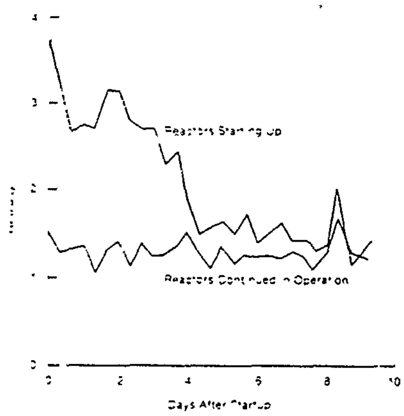

Figure 7. Comparison of effluent quality from reactors starting up with reactors in long-term operation at the Rinconada plant.
Average of seven cases—1977 to 1979

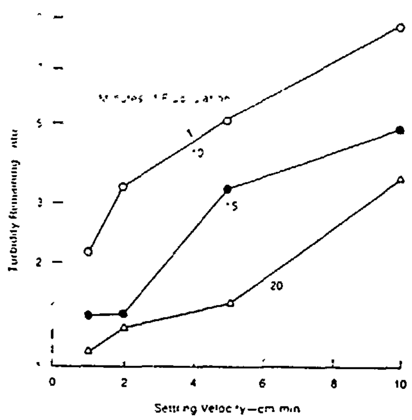

Figure 8. Effect of period of flocculation on sedimentation
Coagulants used were alum and polymer

is 10 min. Even when there is short circuiting in a plant, there is usually an hour or more of time in the settling basins. As a result, there appears to be continuing flocculation going on in settling basins after the water has passed from the flocculating chambers into the basins, with the result that data from well-designed plants are usually better than those predicted from jar testing.

In traditionally designed plants, testing by bench-scale procedures frequently yields considerably better settled water quality than is obtained in the plant. This is due to short-circuiting factors throughout the pretreatment phase of the plant, including rapid mix, flocculation, and sedimentation. When these problems are overcome by modifications, plant results actually exceed those secured under comparable jar testing conditions (Figure 5). The settled water quality is usually so much improved that much higher filter and basin loadings are possible, thus opening the door to increasing capacity rating and at the same time maintaining high quality.

The procedure just described lends itself well to the establishment of the optimum coagulant dose and pH. It is sometimes found that the traditional procedure of simply observing the appearance of the floc and its settling behavior gives misleading results. Determining the settling velocity distribution curve for each beaker, with a different coagulant dose for each, better quantifies the optimization of the dosage.

Floc strength. Until recently, it was thought that floc strength could be determined only by observing whether a terminal breakthrough occurred in the filtering process. Recent experiences in the conduct of jar testing under winter and summer conditions at Potomac, Md., gave the results illustrated in Figure 6. Under summer conditions at 21°C, no terminal breakthrough occurred in the plant. Continued prolonged stirring at a velocity gradient of 14 sec^{-1} caused no impairment of floc sedimentation. However, when jar testing work was carried on at 4°C, continued prolonged flocculation revealed a deterioration of the floc settling capability. It seems evident that the continued agitation, even though it was at a velocity gradient of 11 sec^{-1}, caused breakup of floc. Terminal breakthroughs were also observed in the filtered water, the quality of which tended to deteriorate under cold water conditions. Breakup has been recorded previously[5] but not as related to temperature conditions.

Another useful technique is to dip samples from points in the process train in the plant, such as the rapid mix outlet and the flocculator outlet. Samples dipped from the rapid mix outlet can then be flocculated in jars and settling velocity tests made. Settling velocity determinations can be made directly in the jars on samples dipped from the flocculator outlet, although great care must be taken in dipping the samples in order to avoid breaking up the floc.

Figure 5 shows a range of turbidity values found for samples of settled water dipped from the flocculator outlet, as compared with rapid mix samples stirred in the laboratory. Two resultant ranges for samples treated in this fashion are shown in the upper part of Figure 5. With modified chemical treatment sequences and dosages and tapered flocculation in the laboratory, much better results were obtained on the bench scale than from samples dipped from the nominal 91-ML/d (24-mgd) plant in Maratee County, Fla. Treatment was then applied to the plant. Use of the improved sequence of chemical additions further improved the plant performance. After six months of testing in a modified section of the plant, there was clear evidence of good performance at much higher loadings. Approval has been obtained to double the nominal capacity of the flocculation and settling basins.

Sequence of application. Figure 3 illustrates a set of bench-scale trials to determine the best sequence of addition of the polymer. The data in the figure show that addition of the polymer at the same time as the alum gave results dramatically inferior to those obtained when the polymer was added 5 min after the flocculating period had commenced. A delay in adding the polymer until 10 min after flocculation had occurred worsened the results by reducing too much the time available for the polymer to bring the floc particles together.

The sequence of application of the reagents used in treatment, such as the coagulant, alkali, and flocculation aid, is important. It can never be assumed that the same sequence will work well on different waters. In some cases it may be necessary to reverse the sequence for best results. This was observed at the R.A. Skinner plant for the Metropolitan Water District of Southern California. Alum and a cationic polymer were applied virtually simultaneously in the rapid mixing chamber in a location that did not provide the greatest mixing intensity. A diffuser was installed at the point of highest turbulence for the addition of the alum, with the cationic polymer following later. This caused a deterioration of results. The sequence of application was then reversed, and the results were better than with either of the other two procedures.

Sometimes unexpected results were obtained. For example, at Kingston, Jamaica, where water of moderate alkalinity is treated, the treatment supervisor stated that better results were obtained by adding lime with the alum, bringing the water to a pH well above 7. This

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seemingly dubious reaction was rechecked on the bench scale and found to be valid.

Evaluating other variables. *Sludge recirculation.* The effect of sludge recirculation in solids contact reactors in plant-scale operation is shown in Figure 7. The effluent quality from reactors starting up without sludge was considerably worse than that of reactors continuing in operation with a substantial solids buildup. After about four days, sufficient sludge was accumulated in the starting reactors to increase improvement substantially and to approximate closely that of the units continuing in operation. This same phenomenon has been evaluated on a bench-scale basis by accumulating sludge from prior jar tests. Frequently, improved results were obtained through the reuse of accumulated solids from prior jar tests. Sludge return can have extremely beneficial results on the operation of some plants.

Duration of flocculation. The effect of duration of flocculation on the settling velocity distribution curves is shown in Figure 8. Under testing conditions using Sacramento Delta water, considerably improved results were obtained when flocculating time was increased from 10 min to 15 min and then to 20 min, both for alum and for ferric chloride.

Rapid mixing intensity. The effect of rapid mixing intensity can also be dramatic. Figure 9 shows three different rapid mix regimes. The poorest results were obtained by using a paddle* with a mixer that operated at 1000 rpm for 2 min. When a blender† was used for a 10-s initial mix (≃10 000 rpm), somewhat better results were obtained. When the first machine* was used for rapid mix at 160 rpm for 4 min, even better results were obtained. Camp had previously reported that excessive initial mixing would prevent subsequent flocculation.

Polymer. The beneficial effects of a high molecular weight nonionic polymer with alum as the coagulant are shown in Figure 10.

Alum and ferric coagulants with high-energy tapered flocculation are compared in Figure 11. The alum dose was 20 mg/L and the ferric dose was 12.5 mg/L. Nonetheless, the ferric coagulant yielded a superior result. At these relative dosage levels, the ferric coagulant was more economical than alum.

Lag time. In the jar testing procedure it is feasible to determine whether there is any lag time effect between the rapid mix and the beginning of flocculation. In some plants, the flocculating chamber is located so that there is a considerable period of quiescent flow between the application of the coagulant in the rapid mix and the beginning of the flocculating period. Published curves have shown a jar test in which a delay was deliberately employed between the rapid mixing time and the period of flocculation. It became evident that the lag time was impairing the results obtained. As a result, the rapid mix in the plant under study was relocated to reduce the lag time greatly.

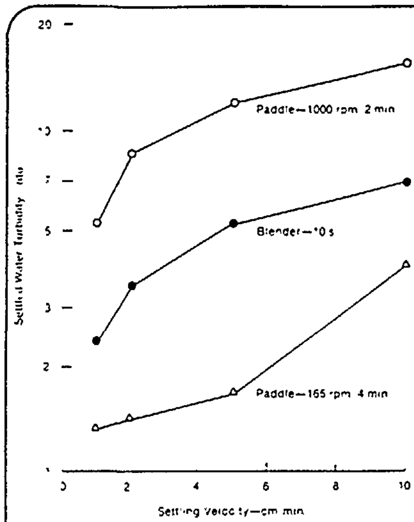

Figure 9. Effect of rapid mix intensity on sedimentation after 20 min flocculation

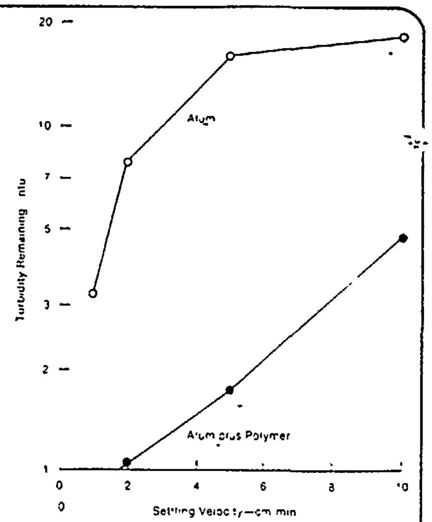

Figure 10. Effect of nonionic polymer on sedimentation
20 mg/L alum; 0.05 mg/L nonionic polymer

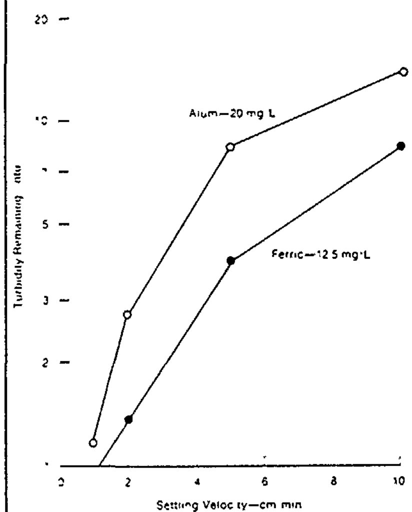

Figure 11. Comparison of alum and ferric coagulants
No polymer

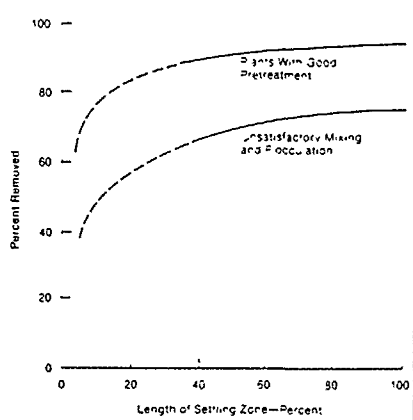

Figure 12. Distribution of removal by sedimentation along length of settling zone
Basin designed for settling velocity of 2 cm/min

Short circuiting. The bench-scale procedure has been used to predict the effects of short circuiting. The effects of flocculating too long or too little were calculated, with a result that it was possible to calculate from the jar test data what to expect with a single compartment flocculator or with a multiple compartment flocculator. The results of the multiple compartment unit were clearly superior. The short circuiting in a single compartment flocculator closely approximated results obtained on dipped samples taken from the plant flocculator outlet.

Distribution of sludge solids. Once the settling velocity distribution curve has been established for a given water, it is then possible to use the results to determine the distribution of sludge solids along the length of the basin. Figure 12 shows curves based on such calculations. Such data make it easy to determine the cost effectiveness of sludge removal mechanisms of various configurations. Obviously, in well-flocculated water much of the sedimentation takes place near the inlet to the basins, and sludge removal equipment may be needed only in that portion of the basin. The balance of the basin is cleaned peri-

*Phipps and Bird paddle, Phipps and Bird, Inc., Richmond, Va.
†Waring blender, The Waring Corp., New Hartford, Conn.

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odically by manual means, which saves on installation costs.

Bench testing and filtered water quality

The bench-scale testing procedure may be used to predict the filtered water quality by the use of filtration through filter papers.* Fresh filter papers should be used for each jar. The first portion of the filtrate should be discarded and the balance used for measuring filtered water turbidity. The authors have found this method to give good replication of water quality results in the plant. It does nothing, however, to determine the relative lengths of filter runs. This can be determined only by full-scale operation or by pilot plant testing of filters.

Conclusion

In the last two years, extensive jar testing work using filter papers at widely varied locations—including the Southern California Metropolitan Water District Skinner plant, the Santa Clara Valley Penitencia plant, the Navy's Fena plant on Guam, and the Kano, Nigeria, plant—has established that the dosage of coagulant needed to achieve high quality filtered water is often far below that required to produce a floc that settles well. Bench-scale results at the Skinner plant yielded filtered water turbidity values of 0.2 ntu. These were identical with plant operating results based on corresponding ages of alum and polymer. At the Skinner plant, no settleable floc formed, and no measurable change in quality occurred in the flocculators or sedimentation basins. The flocculators were shut off without any effect on the filtered water turbidity or particle counts. In effect, this conventional treatment plant was being operated in a direct filtration mode most of the time.

Following a similar line of attack, the south filtration plant at Chicago now operates with dosages of 0.12 mg/L of nonionic polymer followed by 1.2 mg/L of alum during low turbidity periods. In this plant, however, visible floc particles and some settling do occur.[9]

The implications of the finding that, for some waters, a high quality filtrate can be obtained with a greatly reduced coagulant dosage are significant.

- In these days of rapidly rising costs for coagulants, substantial cost savings are definitely feasible.
- Reduced coagulant requirements are sure to result in reduced sludge quantities.
- In many instances, increased filter run lengths result.
- Flocculation systems can be taken out of service during direct filtration to save operation and maintenance costs.

*Whatman No 40, Whatman, Ltd, England.

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The relationship between asbestos and turbidity in raw water

Richard K. Severson, James Harvey, and Lincoln Polissar

Determining historical exposure to asbestos in drinking water has been a limiting factor in many studies dealing with waterborne asbestos and disease. Thirty-five raw water samples from a watershed area were analyzed for turbidity and asbestos levels. A significant correlation between turbidity and asbestos was found. It is concluded that asbestos levels are significantly related to turbidity levels in raw water; thus, it may be possible to use historic turbidity data to assess past imbibed asbestos exposure. However, more research is needed to document this relationship fully.

A few years ago, asbestos was discovered in several municipal water systems.[1,2] Since then, additional studies[3-7] have attempted to assess the potential relationship between waterborne asbestos and cancer. These studies have assumed that historical asbestos exposure levels are the same as current exposure levels, but little evidence has been provided to support this assumption.

The US Environmental Protection Agency[8] has determined that the water of the Sultan Basin watershed contains unusually high levels of asbestos. The authors have studied this watershed, which provides about 329 ML/d (87 mgd) to a population of about 200 000 (including the city of Everett, Wash.). The watershed consists primarily of the north and south forks of the Sultan River, Williamson Creek, Elk Creek, Spada Lake, and a 10-km (6-mi) portion of the Sultan River itself. Historical turbidity data, collected by the city of Everett, are available for the Sultan Basin, but the relationship between turbidity readings and asbestos levels has not been well established.

Methods

The results of analyses for turbidity and asbestos levels (chrysotile and amphibole combined) on 35 raw water samples were obtained from R.W. Beck and Associates.[9] These samples were drawn from the Sultan River watershed from July 1978 to March 1979. One of these samples was a surface sample taken near a boat launch area on Spada Lake. This sample was potentially inconsistent with the rest of the data because nearby recreational activity may have had some unusual effect on surface turbidity and asbestos levels. Thus, analyses were performed once on all 35 sample results and once on 34 sample results, dropping the potentially confounding sample.

Scatterplots were examined and Pear-

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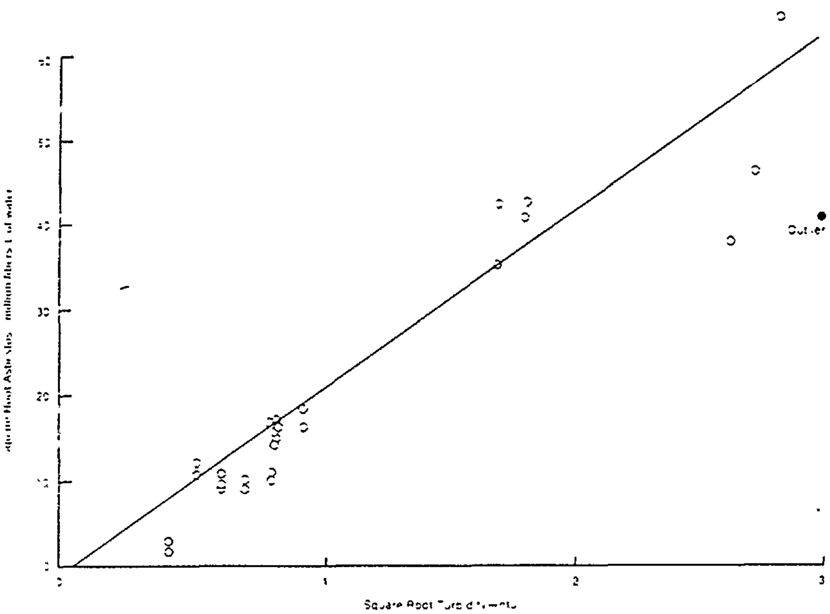

Figure 1. Thirty-five samples drawn from the Sultan River, plotted for correlation between asbestos and turbidity levels

son's product-moment correlation coefficient calculated for the paired turbidity and asbestos measurements. As a further test, Spearman's rho, a nonparametric correlation coefficient based on ranks, was calculated.[10]

Results

In the first correlation analysis, examination of the residuals suggested that the assumption of homogeneity of variance for the error components may have been incorrect. Through a square root transformation, this assumption appeared to have been satisfied. With all 35 samples in the analysis (Figure 1), a correlation of 0.933 ($p < 0.001$) was obtained. With the potentially inconsistent sample dropped, a correlation of 0.952 ($p < 0.001$) was obtained. Spearman's rho was 0.9113 ($p < 0.001$) for all 35 samples and 0.9134 ($p < 0.001$) for the 34 samples. Thus, a high correlation between turbidity and asbestos levels was found in these data.

There are two groups of sample points in Figure 1: group one consisting of 25 points in the lower left and group two consisting of 9 points in the upper right. This grouping can be explained by considering both sample location and date. All nine samples in the second group were taken in February and March of 1979, during the wet season of the year at the time of or immediately after a heavy rainfall. Storms raise turbidity levels and probably increase asbestos levels as well. Heavy precipitation is a normal condition in the Sultan Basin during February and March. Twenty-four of the 25 samples from group one were taken in July and October of 1978, during the dry season of the year. The remaining sample was taken in February 1979 from the south fork of the Sultan River, which is historically lower in turbidity than the other basin tributaries.

A regression line was fitted to each of these two groups separately and compared with the overall fitted regression line. For the lower left group, the correlation was 0.86 ($p < 0.001$) and Spearman's rho was 0.7985 ($p < 0.001$). For the upper right group, the correlation was 0.58 ($p = 0.050$) and Spearman's rho was 0.6135 ($p = 0.039$). All three regression lines had a positive slope. It is hoped that intermediate values gathered in future studies will show that treating the data as one group is the correct procedure.

Discussion

The results of this study suggest it may be possible to use turbidity as a surrogate measure of asbestos levels in raw water. These findings were based on water sampled from a mountain watershed. Although the results may not be directly comparable to other water systems, an unpublished study[11] of another mountain watershed obtained similar results.

Even though a significant correlation was found between asbestos and turbidity in water, the study has limitations. Current electron microscopy methods for asbestos analysis allow samples to vary by a factor of two to three and still be considered not significantly different from each other. More precise counting techniques do not exist.

This study was based on 35 water samples taken over a nine-month period. Ideally, both the number of samples and the time frame of the study should be increased. Unfortunately, asbestos analysis for water samples is expensive. With costs of up to $500 per sample, waterborne asbestos data are usually difficult or impossible to obtain.

It might be expected that these limitations would decrease the strength of the association between asbestos and turbidity, yet, in spite of this, a significant correlation was found between them. It is hoped that this study will spawn other studies that will further clarify the relationship between turbidity and asbestos levels in drinking water.

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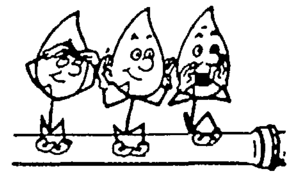
CAPCO JEN 0020787



Percolation & Runoff

Eric F. Johnson

As the Northeast drought bout continued into 1981, Mayor Koch of New York City joined the fray, declaring a drought emergency and appointing more than a million deputy mayors—the children of the city—to help "Keep New York Wet." Then, as the supply in the Delaware River Basin area dropped below the critical level, the governors of Delaware, New York, and Pennsylvania joined Governor Byrne of New Jersey in placing 22 million residents using that water under a series of emergency orders, designed, it was said, to help replenish depleted reservoirs by June. Meanwhile, in the West, where lack of precipitation threatened not only the ski season and the winter wheat crop but the navigability of the Mississippi River, Governor Lamm of Colorado, where 15 in. of moisture per year is full measure, announced: "The drought is here. We cannot avoid saying that any longer."

Not only was it "here" and "there" but almost everywhere in the country, according to weathermen who have labeled 1980 the year when weather went wild. Atmospheric scientists agree that 1980 weather presented one of the most unusual patterns ever recorded, and some think it presages a highly erratic era.

Presager Douglas Paine of Cornell University, relying on his study of sunspot activity, hit the headlines with word that, at least in the Northeast, the drought will remain until 1985. Paine warned New York City of the drought's peril and recommended that farmers in the Midwest hold back exporting some of this year's crop against a shortage expected to result from next year's drought. Professor Robert Harnack of Rutgers University hastened to arraign Paine, perhaps unfortunately for the fate of Governor Byrne's $385-million bond issue, if 1981 rains turn out to be anywhere near normal. According to Harnack, "There is no known method for making a five-year forecast that would show any skill. Daily predictions out to five days and seasonal forecasts (for three months) have shown some reliability. But we may never be able to make a safe prediction for even one year."

Nevertheless, the media do dote on doom and professors do publish, so Paine may well persist until Election Day, especially if an earthquake hits Peru in June.

June, by the way, has been called crucial for New York City, too. That is when the city's three reservoir systems must, it is said, be nearly full to avoid a summer crisis. So, to "Keep New York Wet," the drought-emergency proclamation included a first-phase ban on the use of city water to wash cars and trucks, to water golf courses, or to operate ornamental fountains, and mandated installation of water meters on all air-conditioning units of more than two-ton capacity. No doubt doubtful that these measures would achieve much saving in the middle of a frigid winter, the mayor turned to voluntary individual conservation as "the single most important facet of our antidrought program," the goal of which is to reduce water use from 190 to 160 gpcd. Major tools in the voluntary campaign have been advertising and publicity, and of these there has been no shortage, with space and display almost wholly provided as a public service. Thus, radio and television commercials, newspaper stories, billboards, and placards in subways, buses, and city facilities have inundated the city. About the only gimmick not yet brought to bear on the problem is the overall symbol that a New York Times editorial suggested would do for New York what Smokey the Bear did for forests: Mayor Koch on a camel!

For longer-term "wetness," meanwhile, all the untried and true remedies have once more been dusted off for reappraisal. On January 28, Mayor Koch directed the buildings commissioner and the environmental protection commissioner to look into the possibility of requiring water meters in individual apartments in buildings under construction, yet to be built, or undergoing large-scale rehabilitation. The City Council was considering a bill to require metering for all apartment buildings. On January 7, the Department of Environmental Protection began to advertise contracts to shut off the water in 6000 vacant buildings; vandals had stolen plumbing fixtures in many of the buildings, leaving water running in one school building at a rate of 1 mgd. At the same time, the department began to work with two new electronic leak detectors, which one engineer said would bring the city "out of the Stone Age" in seeking the sources of the estimated 100 mgd in leakage. And finally, of course, there is reconsideration of tapping the Hudson River, which for almost a century has been recommended and re-recommended as the permanent solution to the city's problem. Reduction of leakage, which represented 7.5 percent of the water brought into the city, is under way, but the opposition being what it is, meters and the Hudson will probably be washed away in the next wet spell, even be it Painestaken. So, in the words of the New York Times editors, not usually inclined to sensationalize:

> Without a combination of abnormal precipitation and unusual conservation, there is simply no way to head off a summer of dry horrors.
>
> What horrors?
>
> Minimal air conditioning in offices and factories that cannot recirculate cooling water. Discouragement of tourism. Thus, a loss of jobs. Laundries and car washes cut back, then shut down. Little water in the upper apartments of the typical six-story buildings in older sections of Manhattan, Brooklyn, and the Bronx—those that depend on natural pressure. And probably no water at all, anywhere, during emergency shutdowns of several hours each day, and longer at the end of the water line, in places like Staten Island.

(Continued on page 114)

CAPCO JEN 0020788

(Continued from page 113)

For survival, of course, just add water!

Survival, by the way, seems to be on the minds of a growing number of people who have been doomstruck by fear of such cataclysms as nuclear war or pollution, total economic collapse, uncontrolled immigration and criminal activity, or even natural disasters. Estimated at "millions" by *U.S. News & World Report*, survivalists are apparently holing up in rural isolation with hoards of food and precious gems or metals, many with an arsenal of weapons to protect their hoards against less foresighted friends. Others less antisocial and with a taste for something better than a cave or hut are buying into survival condominiums such as the 240-unit underground refuge at La Verkin, Utah, where the $39 000 one-bedroom furnished apartments are equipped with "enough dried food stuffed in the ceilings, walls, and furniture to last a person four years." Then there is the 45-family retreat on an island off Florida, complete with its own sewer system and underground telephone and power service, serving precataclysmically as a place for weekend fun.

Providing the acreage, food, shelter, and weaponry for the disaster cult has apparently become "one of the nation's liveliest growth industries," but, as usual, water supply seems to have been taken for granted. True, Gary McDaniel, building his sanctuary on a farm near Miamisburg, Ohio, was reported to have augmented his year's supply of freeze-dried food with 400 gal of water, and survivalists have noted that a waterbed will store 220 gal for an emergency, but I suspect that munching powdered peanut butter and dry grain in a cave for a year could build up quite a thirst. Even the freeze-dried turkey Tetrazzini, shrimp creole, and chicken stew now available, not to mention freeze-dried coffee, might well run water requirements up to more than even a king-size waterbedful per year.

The only survival is hydrated survival. In other words, just add water!

To make even hydrated survival more survivable, the Japanese have just announced the successful development of powdered booze, produced, it seems, by enveloping the alcohol of your favorite firewater in dextrin and glucose. Actually, the technology is said to have been discovered back in 1966, but the stuff hasn't been marketed because of the lack of a liquor tax law to make it expensive enough. This spring, however, the Sato Food Industry Co. is expected to begin marketing foil packets of powdered whiskey, brandy, sake, and a variety of cocktails, to which a thirsty tippler need just add water—hot or cold, liquid or solid.

Apparently unimpressed by such a lightweight competitor, Jeffrey Wormstone, spokesman for the Scotch Whiskey Association, indicated that traditional distillers were not about to be weaned from their bottles. But it sounds as if the ultimate in a dry martini has at last arrived. And to think it will soon be available in Clancy's powder room.

The powder room as a source of supply not for whiskey but for water is something else—something given a boost by the *New York Times* last February 5 in an article on the "Lifetime's Supply of Recycled Water" at the home of John and Rosalind Cusack of Evergreen, Colo. There, an initial 1000-gallon supply is recycled through a computer-operated system developed by Pure Cycle Corp. of Boulder, Colo., and approved by the health departments of Colorado, Wyoming, New Mexico, and Arizona. The system incorporates a five-step process from aerobic and anaerobic digestion, through microscreening, activated-carbon and ion-exchange filtration, to ultraviolet disinfection. The process is monitored by the computer, which is programmed to warn the service department of any malfunction and to shut down the system in case of failure. The $15 000 installation cost, plus $35 per month for service, is said to be comparable to the cost of a septic tank system in poor soil areas—not to mention the paltry cost of the unrecycled water then required.

According to Pure Cycle vice president Robert Mankes: "The system has a 99.3 percent recovery rate, so the average family that consumes 300 gallons of water a day loses two gallons daily. This loss is more than made up by the beer, soda pop, and liquid from canned goods that the family pours down the drain."

This zero consumption, said the *Times*, compares with the 73 000 gallons of water consumed annually by a family of four in a conventional house.

Keeping the powder room dry, on the other hand, was one concerned citizen's suggestion on how to "Keep New York Wet." Having learned that between 40 and 50 percent of domestic supply is used to flush the toilet, he proposed that, at least in all new construction, composting toilets, such as the famous Swedish Clivus Multrum, be required. Perhaps he, too, had read of the 109-year-old two-story double-three-seater outhouse in Belle Plaine, Minn., described by the local historical society as "one of the world's greatest engineering marvels." Remembering New York City, it's a bit difficult imagining not only multiple compost ramps of 50 or more stories but also their eventual subterranean discharge points. However, the announcement of "Mullbank" describes it as "A toilet that uses no water and has no effluent. Here is Sweden's most popular composting toilet, designed for full-time use by a family and ideal for vacation homes also. No freeze-up problems, no water problems, no drainage problems. Mullbank is completely odorless, quiet, uses no water and has no effluent."

I can smell it now, that invisible compost heap on Times Square!

As to virtually dry powder rooms, one of them became almost Carsonigenic last year when Earl Braxton of Utica, Mich., named the portable toilet he rented to construction firms "Here's Johnny." He even applied for a patent on the name. "Here's Johnny" Carson took no time at all in suing Earl for $1.1 million, later reduced to $10 000 (who needs the money?) for infringement on his trademark (but he had none), invasion of privacy, and embarrassment. US District Judge Julian Cook, in what will probably be called a landfillmark decision, ruled that there was no real Tonightsoil caused by the potty of the second part!

CAPCO JEN 0020789

Names in the News

Jerome B. Gilbert (Active Member) will become the sixth general manager of the **East Bay Municipal Utility District** (Utility Member) in May, when current general manager **John S. Harnett** (Active Member) ends his 13-year tenure in the position. Gilbert, current president of AWWA, has almost 30 years' experience in water and wastewater engineering and related fields, with special interest in water and energy conservation, water supply quality and threats of new contamination, and reduction of treatment costs. Gilbert founded his own firm of consulting engineers in 1972, later merging with Brown and Caldwell. He is currently president of the J.B. Gilbert and Associates Division of Brown and Caldwell, and vice president of the parent firm.

Earl H. Graham (Affiliate Member), president and chief operating officer of the **Philadelphia Suburban Water Company** (Utility Member), announced that **Timothy D. Lloyd** has been named assistant to the vice president of public relations. In his previous post as loss control representative in the administration department, Lloyd was responsible for resolving damage claims and conducted many studies relating to company operations. Lloyd joined the utility in 1970 as a technical service representative and assumed his most recent position in 1979.

Robert A. Baker (Active Member) has been elected a fellow of the American Association for the Advancement of Science. AAAS defines a fellow of the organization as "a member whose efforts on behalf of the advancement of science or its applications are scientifically or socially distinguished." Baker was cited "for multidisciplinary advances in environmental technology and management, particularly for research in isolation, identification, fate, and sensory effects of microorganic constituents in water."

M&E Pacific, Inc. announced the appointment of **Wallace S. Miyahira** (Active Member) to vice president of the firm. Miyahira has more than 23 years of extensive design and management experience in a broad range of engineering projects.

Calvin R. Melrose has joined the **Permutit Company** (Associate Member) as manager of Canadian operations.

Kaiser Engineers, Inc. (Consultant Member) reported that **David A. Johnson** has been named vice president of the firm.

Leon E. Langford (Active Member) has been appointed director of business development of the **Chester Engineers, Inc.** (Consultant Member). Langford, who has been with Chester since 1951, is a member of the board of directors and formerly served as chief engineer. The firm also announced the appointment of **Anthony F. Lisanti** to vice president of engineering.

Charles J. Leary (Life Member) has been promoted to chairman of the board of the **Leary Construction Company, Inc.** (Contractor Member). **Charles D. Leary** (Active Member) has assumed duties as president of the firm.

Francis C. Smith (Active Member), partner, **Burgess & Niple, Ltd., Engineers** (Consultant Member), has been appointed managing director of district operations. Smith will maintain his current position as district director of the firm's branch office in Mentor, Ohio.

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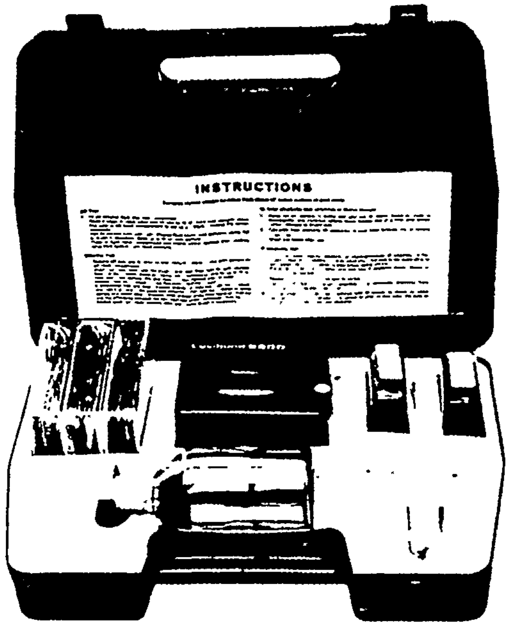

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CAPCO JEN 0020790

Law and Water

Rate increase via "rate base" upheld

A public utility commission did not err in establishing the rate for a water company by utilizing the "rate base" method, according to the Court of Appeals of North Carolina.

The Springdale Water Co. applied for proposed new rates for water service to customers in the Springdale Estates service area. At the rate hearing, the company's financial status reflected a debt owed to Springdale for the installation of the system. This debt was used to calculate the return on investment necessary in order for the company to realize a reasonable profit. The commission used a "rate base" formula in determining the propriety of a rate increase, finally approving an 11.85 percent rate of return as a basis for fixing the rate.

On appeal, the Springdale customers claimed that the purchase price of lots included certain amounts, estimated at $750 per lot, that went to the repayment of the cost of the water system. Thus, they claimed the figure adopted by the commission was overstated and the rate base artificially inflated. The court, however, concluded that the evidence did not sustain the claim that any of the purchasers of lots in Springdale contributed to the cost of the water system. The court said the evidence indicated no breakdown between the cost of the land and the alleged amount to be applied to the water system.

State Ex Rel Utilities v. Springdale Estates, Court of Appeals of North Carolina, May 6, 1980 **(AWW/01/A.-$5)**

Contractor found to act in good faith

A contractor was within his rights by continuing to carry out his part of a contract in good faith as long as such work could go forward, according to the Supreme Court of Utah.

A sewer and water district contracted with a construction company to relocate its sewer line to accommodate a highway project under construction by the state. The construction company proceeded according to the contract and reached a point of conflict between the work as outlined and the simultaneous highway construction being carried on by the state. The possibility of a change order had been discussed in light of this anticipated conflict, but none had been forthcoming from the sewer district. The contract prepared by the district placed the onus on the construction company to obtain change orders or to proceed further at its own risk. After notice, the contractor ceased operations when no change order was forthcoming. The company sued for damages and won a $25 000 verdict in the trial court.

The appellate court said that under state law the requirement for written change orders was binding on the parties and had to be complied with or the contractor might waive recovery for such work outside the contract specifications. In the absence of a change order, the court concluded, the contractor had the election either to proceed outside the terms and specifications or to shut down and declare the contract breached.

Darrell J. Diderickson & Sons v. Magna Water, Supreme Court of Utah, Jun. 10, 1980. **(AWW/02/A.-$5)**

Water district bound by merger agreement

An agreement providing for a city to manage and operate both its own water system and a district's system was not an unconstitutional delegation of the legislative power of the district, according to a California appellate court.

The Rincon water district was a public agency that originally included lands outside the boundaries of the City of Escondido. Because of annexations to the city, certain lands now lie within Rincon and the city. For many years the city owned and operated its own municipal water system. The agreement challenged here was entered into with the long-range objective of merging the two respective systems by interconnections into a single system, with the city being its exclusive operator. Some Rincon taxpayers challenged the merger, contending that rates would be based on expenses incurred or assumed by the city and that the merger would not benefit Rincon or result in improved water service at the lowest cost. The trial court found the merger agreement void.

The appellate court said the agreement was valid because the district's board of directors was afforded effective means to control the city's performance as operator of the systems and to achieve the ultimate objective of providing the most efficient and economical water service at uniform rates for all inhabitants of the valley, including Rincon. The court was satisfied that the agreement included sufficient safeguards or standards to assure this policy decision would be implemented.

Hewitt v. Rincon Del Diablo Municipal Water, California Court of Appeal, Jun. 18, 1980 **(AWW/03/A.-$5)**

Copies of the entire decisions described in this column may be obtained for one year after publication from Cases Unlimited, Inc., 2650 Hurd Avenue, Evanston, IL 60201, which prepared these summaries. Please enclose a check for $5 per case and specify the code number indicated at abstract's end (e.g., AWW/01/A.-$5).

CAPCO JEN 0020791

News of the Field

An alternative to centrifugation and vacuum filtration

Shortly after the city of Danville, Va., began operating its 91-ML/d (24-mgd) capacity secondary wastewater treatment plant in 1976, it was discovered that some 80 percent of its average 68 ML/d (18 mgd) contained fibrous industrial textile waste that was difficult to dispose of when it mixed with the scum removed from the flotation units.

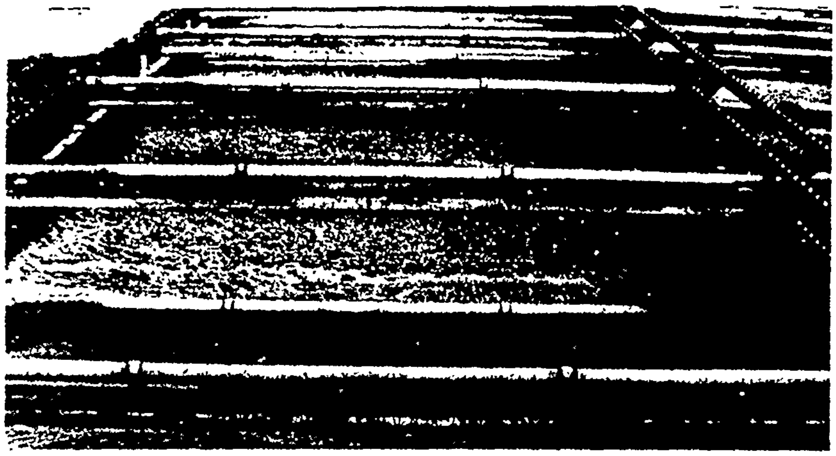
Treatment for this influent consisted of three bar screens with 1.27-cm (0.5-in.) free openings to remove strings and rags, six raw sewage pumps with a total pumping capacity of 204 ML/d (54 mgd), two parallel combination grit separation and scum flotation tanks (the scum flotation tank functioned chiefly to remove short textile fibers), two parallel pure oxygen enclosed aeration tanks, four peripheral feed clarifiers, and two chlorine contact tanks.

The flotation material was too low in solids content to be acceptable for direct disposal to a sanitary landfill. As an emergency procedure for disposing of the material, deep trenches were excavated on city property adjacent to the plant. This procedure was unsuccessful because it was expensive, the pits filled rapidly, water did not leach rapidly into the soil, and flies swarmed around the area during the summer months.

As an interim procedure while new dewatering equipment was being evaluated, the flotation material was trucked to an existing vacuum filter at the city's Southside wastewater treatment plant. For obvious reasons, a 16-km (10-mi) haul through residential and commercial areas was a highly inefficient way to deal with the malodorous flotation scum. Additional disadvantages were that production of cake was very low and that the filter required constant monitoring.

In evaluating dewatering equipment, the utility quickly focused its attention on a dewatering press. During a six-month trial of the press, Danville found that the weekly 318 000 L (84 000 gal) of scum could be reduced to six cubic yards of dry cake that easily met sanitary landfill requirements.

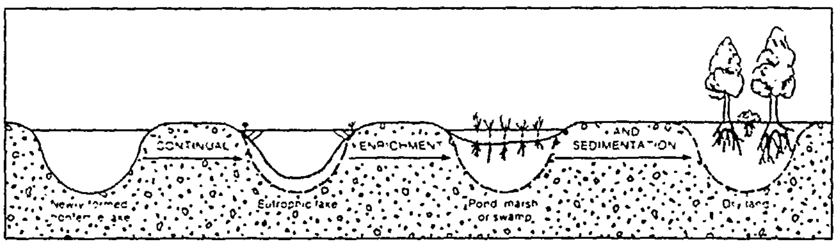
According to Bobby E. Bentley, Danville's sludge processing and disposal supervisor, after a year and a half of operation, the dewatering system has worked well. "There are a lot of things to like about the [press]. The unit has been virtually maintenance-free and requires minimal operator time: the operator just starts the pump and leaves it. About four hours a day is all the time it takes to convert the scum to an acceptable landfill material. We also like the fact that the press's 5-hp motor represents low power consumption."



Flotation skimmers help to remove short textile fibers from the water at Danville's wastewater treatment plant.

The stainless-steel dewatering machine performs the various dewatering functions with variable-speed options. It operates by accepting material to be dewatered into the bottom of a screw chamber, where solids are evenly distributed over a fine screen surrounding a rotation screw. As solids build up on the screen surface, they are collected and moved toward the top of the unit into a plug section. Plug solids are compacted against previously deposited materials, resulting in a solid mass that is carried upward and plowed out of the unit with adjustable-height plug cutters. Blinding of the inner surface of the screens is eliminated by use of continuous brushes attached to the underside of the screw flights.

Danville uses the press in conjunction with a dissolved-air flotation system whereby all floating material is skimmed off the flotation units into a small pit. Two variable-speed pumps carry the sludge to the press for dewatering. The dry cake is deposited into a 5-m (6-yd³) bucket, while the "clean" pressate is sent back to the raw influent. No chemicals are required since the short textile fibers are a built-in filter aid.



Artificial, human-related contributions of nutrients can hasten natural eutrophication.

New method may slow lake pollution

The impact of past and future land development on the quality of urban and rural lakes can be better assessed by a new method that helps compare the natural and human-related amounts of phosphorous pollution being added to the lakes, according to a US Geological Survey (USGS) study.

Although the USGS report focuses on the impact of phosphorous as a spur to algae growth and the deterioration of lakes in the Puget Sound region of the Pacific Northwest, the results are expected to be useful in evaluating the aging and death of similar urban lakes throughout the United States.

According to Robert Gilliom, USGS hydrologist, "Lakes naturally [undergo] eutrophication . . . [but] the aging process of urban and farm lakes tends to be

(Continued on page 118)

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(Continued from page 117)

greatly accelerated as a result of increases in the phosphorous loads associated with these land uses. The results can be high rates of aquatic plant growth, murky water, floating scum, depletion of oxygen, dead fish, and, in general, lakes that become more nuisance than asset."

The new method for estimating predevelopment phosphorous levels uses relatively low-cost information, such as regional runoff data and lake and drainage basin dimensions, which can be used effectively by local governments and consultants. By comparison, most other methods for assessing development impacts on water quality are prohibitively expensive and not necessarily more reliable, Gilliom says.

Tree rings tell tale of lengthy droughts

California droughts have lasted as long as 60 years, according to a study funded by the California Department of Water Resources. The investigation, based on the study of tree rings, was conducted to learn about California's climate in years before weather records began.

The study reconstructs California's annual precipitation since 1600. According to its findings, one drought extended from 1760 through 1820. Other long, dry periods occurred from 1600 to 1625, 1665 to 1670, 1720 to 1730, and 1865 to 1885. The latter drought destroyed most of the then-thriving cattle businesses in southern California and altered the pattern of the state's development.

One of the most significant conclusions of the study, according to department director Ronald B. Robie, is that "in the perspective of 360 years, the period since 1890 has been one of precipitation surplus." Robie went on to say that "while the study is only one of many tools available for water planning, it may be [an] indication that droughts and dry years are both more frequent and of longer duration than any we have planned for in the past. Until the 1976-77 drought, the record drought for planning purposes was the seven-year span from 1928 through 1934."

The Department of Water Resources funded the study because of indications that the California climate in recent years has not been representative of long-term trends. Research based on tree ring study can extend reliable climatic records back for hundreds of years.

Samples from living trees are taken with coring devices. Comparison of a large number of samples produces a pattern that reliably dates periods of wet and dry weather. The dating system is based on the fact that in dry years, tree growth is slowed, resulting in narrower rings or no rings for those years.

Hydraulic jacking raises elevated tank

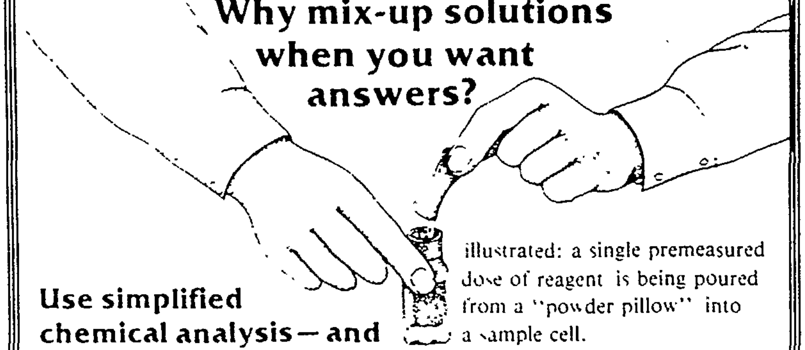
Jacking equipment attached to the support structure's legs allowed Bradenton's new water storage tank to be raised an additional 3.7 m (12 ft).

When the city of Bradenton, Fla., bought a new water storage tank whose operating elevation was higher than that of the existing one, it didn't tear down the old tank's support structure and erect a new one; instead, the city raised the old structure an additional 3.7 m (12 ft).

Through a precise hydraulic jacking procedure, the 1893 kL (500 000-gal) tank and its support structure were lifted in 20-cm (8-in.) increments. Jacking equipment was secured to each of the support structure's eight legs, and extensions were erected at the base of the legs and riser pipe.

The operation was performed by Hydrostorage, Inc., of Franklin, Tenn. Hydrostorage Vice President James R. Foster says the jacks were equipped with "dogs" that would have allowed the tank to drop only one inch if the hydraulic pressure had failed. It didn't.

Why mix-up solutions when you want answers?



illustrated: a single premeasured dose of reagent is being poured from a "powder pillow" into a sample cell.

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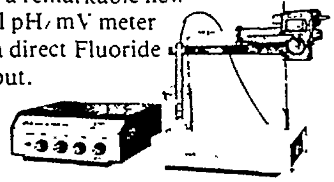

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Business news

The US Environmental Protection Agency (USEPA) has selected Culp/Wesner/Culp, a California firm of consulting engineers, to analyze how water treatment processes can be modified to remove trihalomethanes. The 18-month study will include an analysis of how changes made to remove these compounds may affect the quality of drinking water.

CAPCO JEN 0020793

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Ecodyne/Smith & Loveless, 14040 W. Sante Fe Trail. Lenexa. Kan. 66215. Smith & Loveless 6D3A 3-in. pumps reduce intake screening, concrete, and station size requirements, thereby providing significant cost savings for any system. These solids handling pumps are immediately available.

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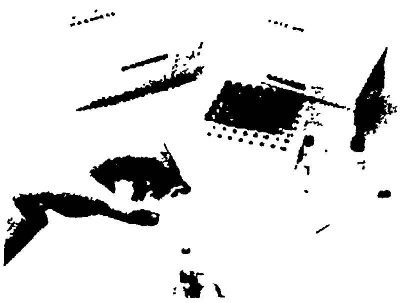

Water Dynamics, Inc., 375 Central Ave., Bohemia, N.Y. 11716. The first low-cost digital colorimeter, Wet Meter, has been introduced. The easy-to-read digital meter provides the user with direct readings in absolute concentration of the unknown sample. Having eight filters in the visible range, this 4½-lb unit offers two ranges of concentration, 0.0 to 199.9 and 0 to 1999 mg/L. The modern solid-state design circuitry eliminates the need for conversions from absorbance or percent transmittance into concentration. To make operation even simpler, instructions for use are printed on a face plate on the front of the unit.

Reader Inquiry Service No. 124

Perkin-Elmer Corp., Main Ave., Norwalk, Conn. 06856. The Model 2280 is being introduced as Perkin-Elmer's newest low-cost microcomputer-controlled single beam atomic absorption spectrophotometer. Designed to replace the Model 280, the new instrument incorporates the same electronics as the Model 2380, thereby providing a computing capability allowing the user to perform complex calculations and implement sophisticated logic programs quickly and

(Continued on page 120)

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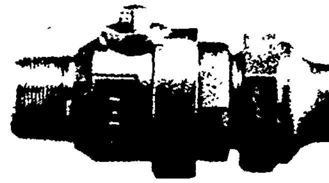

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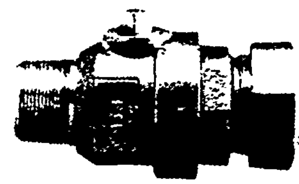

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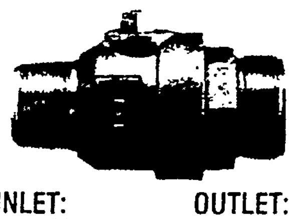

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Reader Inquiry Service No 038

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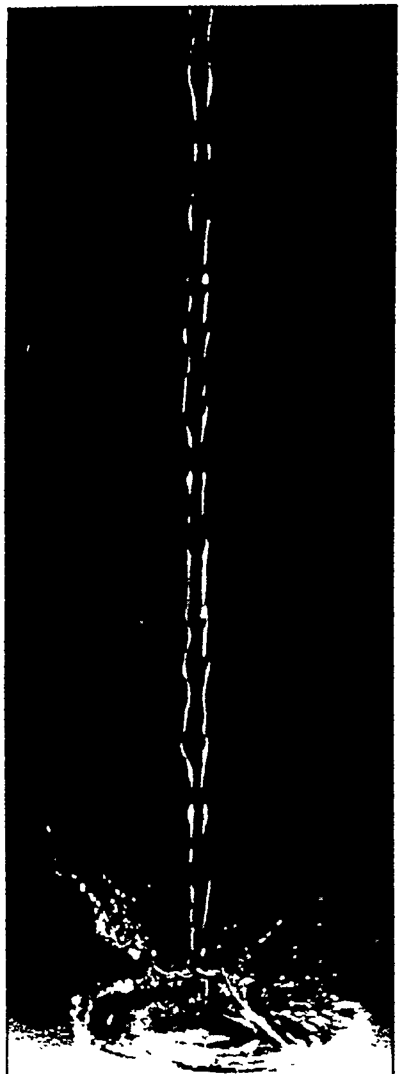

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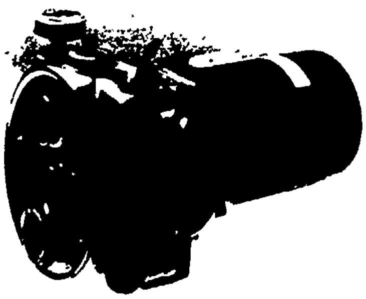
VISIT OUR EXHIBIT, BOOTH NO. 811
Reader Inquiry Service No. 008

(Continued from page 119)

accurately. The 2280 features quartz-coated reflecting optics for high durability in harsh environments and employs a high dispersion grating monochromator.

Reader Inquiry Service No. 125



Red Jacket Pumps, P.O. Box 3888, Davenport, Iowa 52808. The "Quick-Set Jet," a new convertible jet pump which reduces operating and inventory costs and cuts installation time, has been introduced. The new pump replaces the traditional jet pumps with the bolt-on and cast-on injectors, with lightweight plastic components. Plastic shallow injectors or deep well plug kits convert the jet to deep or shallow well applications in minutes. Different pressure-volume settings are made by selecting the appropriate component and screwing it into the case.

Reader Inquiry Service No. 126

LaMotte Chemical Products Co., Box 329, Chestertown, Md. 21620. A fully portable, digital pH meter with LCD readout capabilities is now being marketed. Designed to meet the accuracy requirements of technical laboratories, the meter measures pH over the range of 0-14 with an accuracy of ±0.01 pH unit. The meter features a large 0.5-in. LCD which can be read easily, even in bright sunlight. The meter can be operated without removing it from its foam-cushioned, compact carrying case which when opened becomes an on-site testing station. An electrode stand supports the gel-filled silver-silver chloride combination electrode during testing. This electrode requires no refilling with electrolyte and is furnished with a 30-in. lead and BNC connector. The outfit includes three buffer solutions (pH 4.01, 7.0, and 9.18) for instrument calibration.

Reader Inquiry Service No. 127

Fisher Scientific Co., 711 Forbes Ave., Pittsburgh, Pa. 15219. The new Fisher Titralyzer II LS/FEP titration system is designed to add speed, simplicity, and

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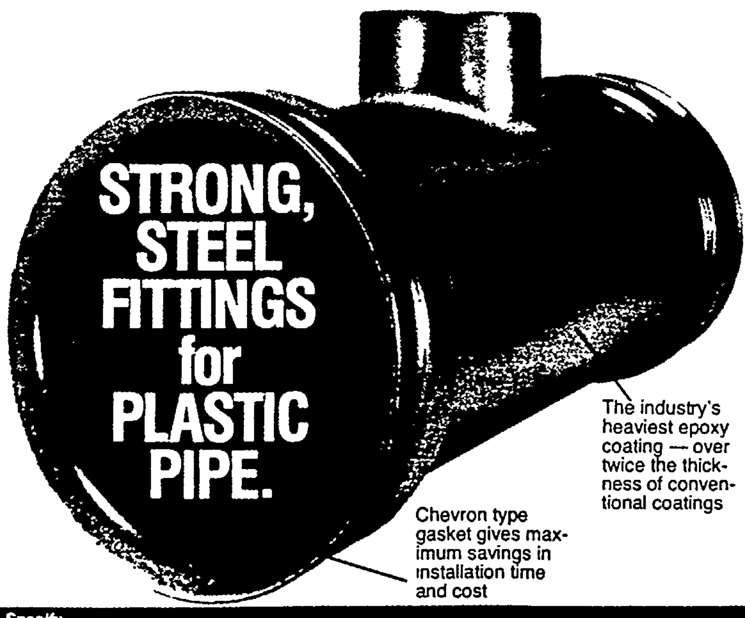

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flexibility to high-volume wet chemical analyses. This systems performs single or dual fixed-endpoint pH or mV titrations and features automatic sample handling or up to 32 samples in 200-mL beakers. It automatically dispenses titrant with accuracy of ±0.1 percent of syringe volume and ±0.02 precision, continuously displays dispensed titrant volume to the nearest 0.01 mL on a digital LED display, and prints out titrant volume (to the nearest 0.01 mL), pH, or mV of one or two endpoints and sample ID number. Endpoint approaches are fully proportional with titrant delivery rate continually decreasing as the endpoint is approached, thus preventing the common problem of overshooting the set endpoint. The nuisance of false endpoint readings has been eliminated with solid-state adjustable timers.

Reader Inquiry Service No. 128

Victaulic Co. of America, 3100 Hamilton Blvd., South Plainfield, N.J. 07080. A complete line of tools for cut grooving pipe from ¾ in. through 24 in. is now being marketed. The tools are designed to provide fast, easy cut grooving for most types of metallic pipe, either on-site or in the shop. The VG-28 is fully adjustable for cut grooving 2-in. through 8-in. ips pipe. Driven around the outside circumference, the VG-28 is equipped with pipe stops and depth stop for precise groove dimensions. The VG-28 can be driven by any external power source at approximately 22 rpm. The tool is also designed for use on 3-in., 4-in., and 6-in. cast or ductile iron pipe by using special radius groove tool bits. The larger VG-824 is designed to cut groove 8-in. through 24-in. ips pipe and the same size range cast or ductile iron pipe with only a tool bit and drive roll change. This tool is also driven around the outside circumference of the pipe by an external power source.

Reader Inquiry Service No. 129

MAPCO Inc., 1800 S. Baltimore Ave., Tulsa, Okla. 74119. A portable model of the recently introduced NUSONICS Doppler Flowmeter is now available. Designated the Model 1080, this flowmeter is packaged in a briefcase weighing 10½ lb and is powered by a rechargeable 24-V DC battery. It comes equipped with clamp-on transducer assembly and 15 ft of transducer-to-electronics cable. It uses the same basic electrodes as the NUSONICS Model 1180 which is designated for permanent installations requiring a wider range of outputs and other options.

(Continued on page 122)

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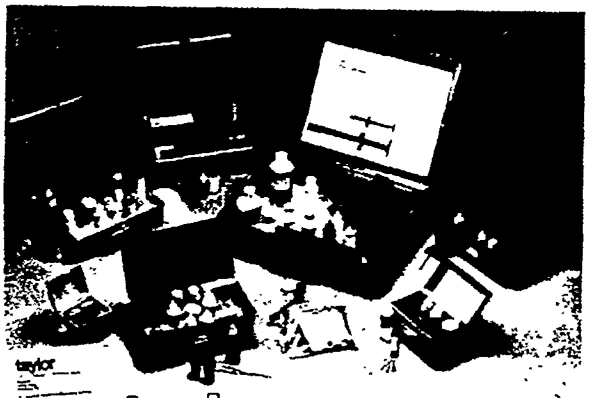

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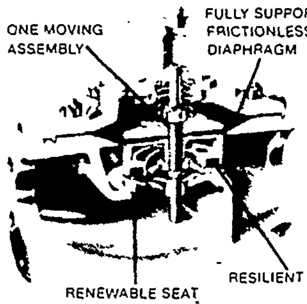

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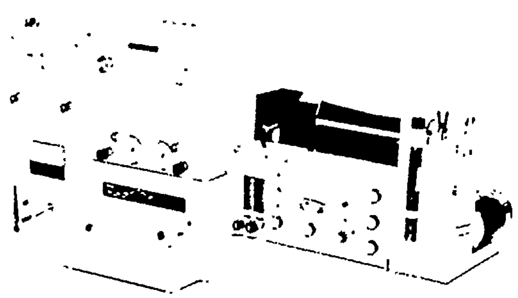

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Reader Inquiry Service No. 044

(Continued from page 121)

This flowmeter can be used for experimental purposes to qualify new applications for subsequent installation of the Model 1180 and for surveying flows for relatively short periods of time in a number of different locations.

Reader Inquiry Service No. 130

Limitorque Corp., 5114 Woodall Rd., Lynchburg, Va. 24502. A new 90-degree turn, heavy duty actuator featuring a unique colinear design concept that eliminates center of gravity problems occurring with side-mounted units has been introduced. The NDT series actuator places the entire actuator colinear with the valve shaft to combine reduced weight and space requirements while providing dependable control whenever seismic exposure or high vibration is present in the piping system. Geared to permit operating times varying from 10 to 66 s, the NDT series is capable of producing a torque range from 200 ft lb up to 1300 ft lb. The valves meet all requirements of the applicable standards for CSA, FM, IEEE, NEMA, CEMA, and AWWA.

Reader Inquiry Service No 131

Envirex, a Rexnord Co., 1901 S. Prairie Ave., Box 1067, Waukesha, WI 53186. A new belt filter press designed specifically to dewater both municipal and industrial sludges is now available. The belt press reduces energy consumption by 75 to 85 percent compared to other dewatering devices, while achieving optimum dewatering concentrations for the various sludge applications. The unit is designed for continuous operation and features a single hydraulic power pack that provides uniform operation for both pressure belts, automatic tensioning and tracking mechanisms, and any optional equipment. A hydraulic microtorque sensing device continuously checks upper and lower belt position and belt tension, then automatically adjusts the belts for simplified operation and longer belt life. The sensing device minimizes operator attention and helps reduce operation and maintenance expenses.

Reader Inquiry Service No. 132

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OFFICIAL NOTICE

This shall constitute official notice of the availability of the following new or revised AWWA standard:

AWWA C550-81 AWWA Standard for Protective Interior Coatings for Valves and Hydrants

The effective date of this standard shall be the first day of the month following publication of this notice of availability in JOURNAL American Water Works Association. To obtain copies of this or any AWWA standard contact the Publication Sales Department:

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Classified ads will be accepted only for "Positions Available" or "Positions Wanted." Rate: 75¢ per word (minimum $7 00), payable before publication. Deadline for ad copy 25th of second month prior to month of publication desired. To place ad obtain "Classified Ad Authorization Form" from: Classified Ad Dept., Journal American Water Works Assn., 6666 West Quincy Ave., Denver, Colo. 80235.

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WATER PLANT SUPERINTENDENT, Oberlin, Ohio (Population 8 600+) Seeking applicants for position of Water Plant Superintendent Position reports to Public Works Director and is responsible for direction and operation including water production, treatment and storage Plant operates average of 13 5 hours and treats average of one million gallons per day Must have State of Ohio Class III license or obtain within one year. Salary negotiable $17 000-$20 000 Send resume to, City Clerk, 85 South Main Street Oberlin, Ohio 44074 Equal Opportunity Employer Closing Date May 1, 1981.

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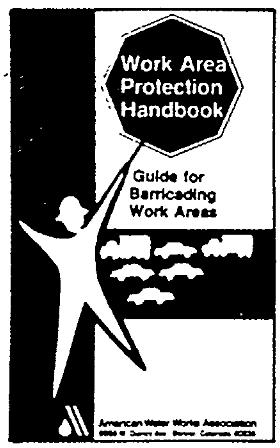

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California-Nevada—Apr. 9–10 at the El Rancho/Tropicana in Santa Rosa, Calif. Secy. W.J. Bardin Jr., James M. Montgomery Consulting Engineers, 555 E. Walnut St., Pasadena, CA 91101.

Hawaii—Apr. 8–10 at the Kona Surf Hotel in Kona, Hawaii. Secy. M. Morita, Deen Morita Plumbing, Inc., 1658 Auiki St., Honolulu, Hawaii 96819

New England—Apr. 30 at the Hyatt Regency in Cambridge, Mass. Secy. P. Janjigian, City Hall, Newport, RI 02840.

New York—Apr. 28–May 1 at the Nevele Country Club in Ellenville, N.Y. Secy. J.J. Moran, Kennedy Valve, Box 931, Elmira, NY 04902.

Pennsylvania—Apr. 21–24 at the Host Corral Resort in Lancaster, Pa. Secy. J. B. Smith, Gannett Fleming Corddry & Carpenter, Inc., Box 1963, Harrisburg, PA 17105.

Southeastern—Apr. 5–8 at the Hyatt on Hilton Head in Hilton Head, S.C. Secy. R.T. Tindal, 307 N. Trenholm Rd., Columbia, SC 29206.

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- Yakima, Wash — Apr 13
- Indianapolis, Ind — Apr 13
- Bloomington, Minn — May 6
- Waltham, Mass — May 11

Cross Connection Control
- Bowling Green, Ky — Apr 27

Safety
- Kansas City, Mo — Apr 15
- Greenville, S C — May 5
- Ann Arbor, Mich — May 20

Water Loss Reduction
- Portland, Ore. — Apr 7
- Philadelphia, Pa. — May 4
- Pittsburgh, Pa — May 6
- Boston, Mass — May 7
- Connecticut — May 8
- San Antonio, Tex — May 18
- Denver Colo — May 20
- Phoenix, Ariz — May 22

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Alabama-Mississippi	Oct. 25-28 Biloxi, Miss.	Sep. 23-26 Mobile, Ala.
Arizona	May 6-8 Tucson, Ariz.	May 5–7 Flagstaff, Ariz.
Atlantic Canada	Sep. 13-17 Moncton, N.B.	
British Columbia	**Apr. 26-28 Penticton, B.C.**	Oct. 6-8 Vancouver, B.C.
California-Nevada	**Apr. 9-10 Santa Rosa, Calif.** Oct. 28-30 Palm Springs, Calif.	Apr. 15-16 Long Beach, Calif.
Chesapeake	Sep. 9-11 Ocean City, Md.	Sep. 8–10 Ocean City, Md.
Connecticut	May 20-22. North Falmouth, Me.	
Florida	Nov. 10-14 Miami Beach, Fla.	
Hawaii	**Apr. 8-10 Kona, Hawaii**	
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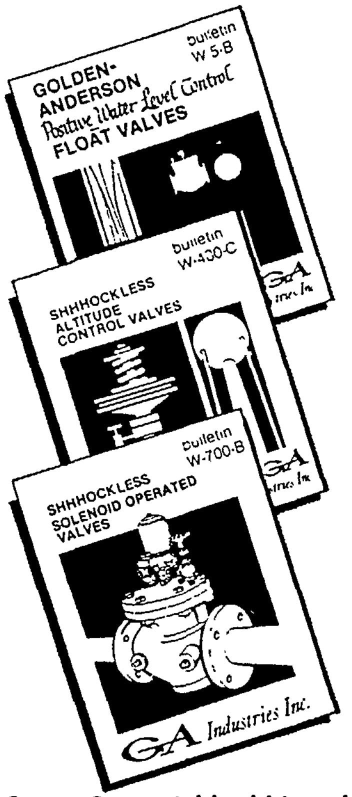
Iowa	Oct. 21-23 Ames, Iowa	
Kansas		Mar. 24-26 Salina, Kan.
Kentucky-Tennessee	Nov. 15-18 Ft. Mitchell, Ky.	Nov. 14-17 Nashville, Tenn.
Mexico		
Michigan	Sep. 28-Oct. 1 Detroit, Mich.	Sep. 20-23 Grand Rapids, Mich.
Missouri	Jun. 7-12 St. Louis, Mo.	Apr. 14-16 Lake Ozark, Mo.
Montana		Mar. 25-26 Helena, Mont.
Nebraska	Nov. 5-6 Columbus, Neb.	
New England	**Apr. 30 Cambridge, Mass.**	Apr. 29 Danvers, Mass.
New Jersey	Sep. 15-18 Atlantic City, N.J.	
New York	**Apr. 28-May 1 Ellenville, N.Y.** Sep. 22-25 Niagara Falls, N.Y.	Apr. 2-7 Rochester, N.Y.
North Carolina	Nov. 8-11 Asheville, N.C.	
North Central	Sep. 23-25 Duluth, Minn.	Sep. 29-Oct. 1 Fargo, N.D.
Ohio	Nov. 11-13 Cincinnati, Ohio	Nov. 3-5 Cleveland, Ohio
Ontario	May 10-13 London, Ont.	Apr. 18-21 Ottawa, Ont.
Pacific Northwest	May 6-8 Spokane, Wa.	Apr. 14-16 Medford-Ashland, Ore.
Pennsylvania	**Apr. 21-24 Lancaster, Pa.**	Jun. 20-24 Hershey, Pa.
Puerto Rico	May 30-31 Dorado, P.R.	
Quebec		
Rocky Mountain	Oct. 25-28 Sante Fe, N.M.	Sep. 19-22 Snowmass, Colo.
South Dakota	Sep. 16-18 Yankton, S.D.	
Southeastern	**Apr. 5-8 Hilton Head, S.C.**	Apr. 18-21 Savannah, Ga.
Southwest-Texas	Nov. 8-12 Corpus Christi, Tex.	Oct. 17-21 Oklahoma City, Okla.
Virginia	Oct. 13-16 Arlington, Va.	Oct. 26-29 Roanoke, Va.
West Virginia	May 17-19 Charleston, W. Va.	
Western Canada	Sep. 30-Oct. 2 Saskatoon, S.K.	Sep. 22-24 Winnipeg, Man.
Wisconsin	Sep. 30-Oct. 2 Delavan, Wis.	

GOLDEN-ANDERSON solves valve problems



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(Continued from page 131)

Water Quality Technology Conference: Seattle, Wash., Dec. 6-9, 1981; Nashville, Tenn., Dec. 5-8, 1982.

Annual Conference: St. Louis, Mo., Jun. 7-11, 1981; Miami, Fla., May 16-21, 1982; Las Vegas, Nev., Jun. 5-10, 1983.

Distribution System Symposium: Milwaukee, Wis., Mar. 7-10, 1982.

Other Organizations

Apr. 1-3
The Effects of Acid Precipitation on Ecological Systems in the Great Lakes Region of the United States. Michigan State University Institute of Water Research, US Department of the Interior's Office of Water Research and Technology, US Park Service, US Fish and Wildlife Service, US Environmental Protection Agency's Acid Precipitation Program. East Lansing, Mich

In a multidisciplinary forum 25 scientists will exchange information on the ecological impact of acid rain. Sessions will focus on sources, monitoring, and the resultant effects on aquatic and terrestrial ecosystems, particularly in the Great Lakes region. The participants will also identify future research needs and suggest priorities for them.

Contact: Howard Bernson, Conference Coordinator, University Conference and Institutes, 49 Kellogg Center, Michigan State University, East Lansing, MI 48824.

Apr. 5-6
Water Systems Council Meeting. Bloomingdale, Ill.

Contact: Pam Williams, Associate Director, Water Systems Council, 221 N. LaSalle St., Suite 2026, Chicago, IL 60601.

Apr. 6-10
Corrosion/81. National Association of Corrosion Engineers Toronto, Canada.

More than 250 papers are expected to be presented in approximately 40 technical symposia during this conference. Session topics will be corrosion kinetics, corrosion monitoring, localized corrosion, stress corrosion cracking, hydrogen embrittlement corrosion fatigue, inhibitors and coatings, and general corrosion problems.

Contact: Conference Coordinator, National Association of Corrosion Engineers, P.O. Box 218340, Houston, TX 77218.

Apr. 12-14
American National Metric Council: 7th Annual Conference. American National Metric Council. Washington, D.C.

This conference will examine the practical aspects of developing metric capability in American industry by focusing on the areas of management, marketing, productivity, and procurement.

Contact. American National Metric Council, 1625 Massachusetts Ave., N.W., Washington, DC 20036.

Apr. 15
1st Annual Water-Wastewater Instrumentation Conference and Workshop. California Water Pollution Control Association, American Water Works Association, and the Instrument Society of America. Santa Clara, Calif.

The joint instrumentation conference and workshop will provide current information and ideas related to system analysis and control of water and wastewater, as well as the latest methods and techniques for improved application, operation, and maintenance of various types of instrumentation and analyzers.

Contact: William Kopet, Publicity Coordinator, Joint Instrumentation Committee, 132 Helen Way, Escondido, CA 92025.

Apr. 23-24
Understanding and Managing a High Quality Water System. Bureau of Business Research and Services at California State University. Long Beach, Calif.

Six distinguished experts in the water industry will discuss all phases of managing high quality, deionized, and demineralized water systems. Topics include purification techniques and processing steps, costs, equipment, water testing, sterilization, and preventive maintenance. The seminar is designed for managers, process engineers, utility engineers, and water managers involved with high quality water.

Contact: Seminar Coordinator, Bureau of Business Research and Services, California State University, 1250 Bellflower Blvd., Long Beach, CA 90840.

Call for Papers

37th Annual Conference of the SPI Reinforced Plastics/Composites Institute
Abstract deadline: May 1, 1981

Papers are sought on new and developing uses for reinforced plastics in all markets: on new resins, reinforcements, fillers, and additives; on advances in processing involving both reinforced thermoset and thermoplastic resins; on new and improved processing machinery and tooling; on research and development activities; on energy-saving and alternate energy applications; on management and marketing; and on other topics such as health and safety.

Abstracts of proposed papers, consisting of approximately 500 words, should be sent to RP/C Conference Administration, The Society of the Plastics Industry, Inc., 355 Lexington Ave., New York, NY 10017.

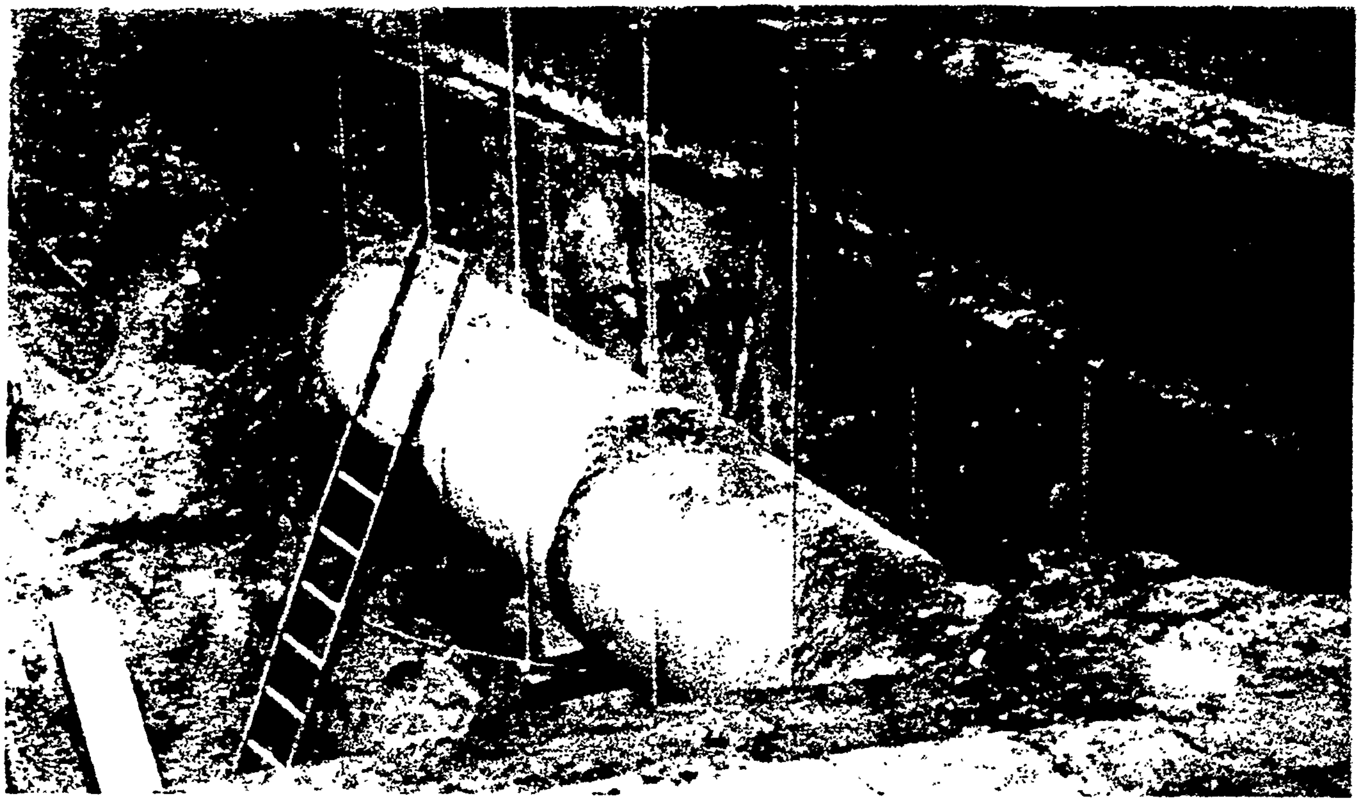
Call for Reviewer-Discussers

A conference on Pump Station Design for the Practicing Engineer will be held Aug. 31 to Sep. 2, 1981, at Bozeman, Mont. Authors for the 54 papers have been selected and reviewer-discussers are sought. The range of subjects includes system design transients, pumps, driver, piping, instruments and control, electrical design, heating and ventilating, location and layout, wet wells, pump room arrangement, booster stations, wastewater pumping, water pumping, sludge pumping, costs for facility planning, and so forth.

Manuscripts will be sent to reviewers on June 15. By July 15 reviewers must submit a camera-ready discussion for inclusion in the preprinted proceedings. Discussions are expected to be incorporated into a three-volume text to be published approximately two years after the conference is held.

For further details please contact Editor, Pump Station Design, Dept. CE/EM, Montana State University, Bozeman, MT 59717.

CAPCO JEN 0020807



This 36-inch concrete force main was exposed during excavation to upgrade a storm sewer running below it. After 31 years of service, the main still looks as good as the day it went in the ground.

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NEW FRP-II AERGAP™ BACKFLOW PREVENTER

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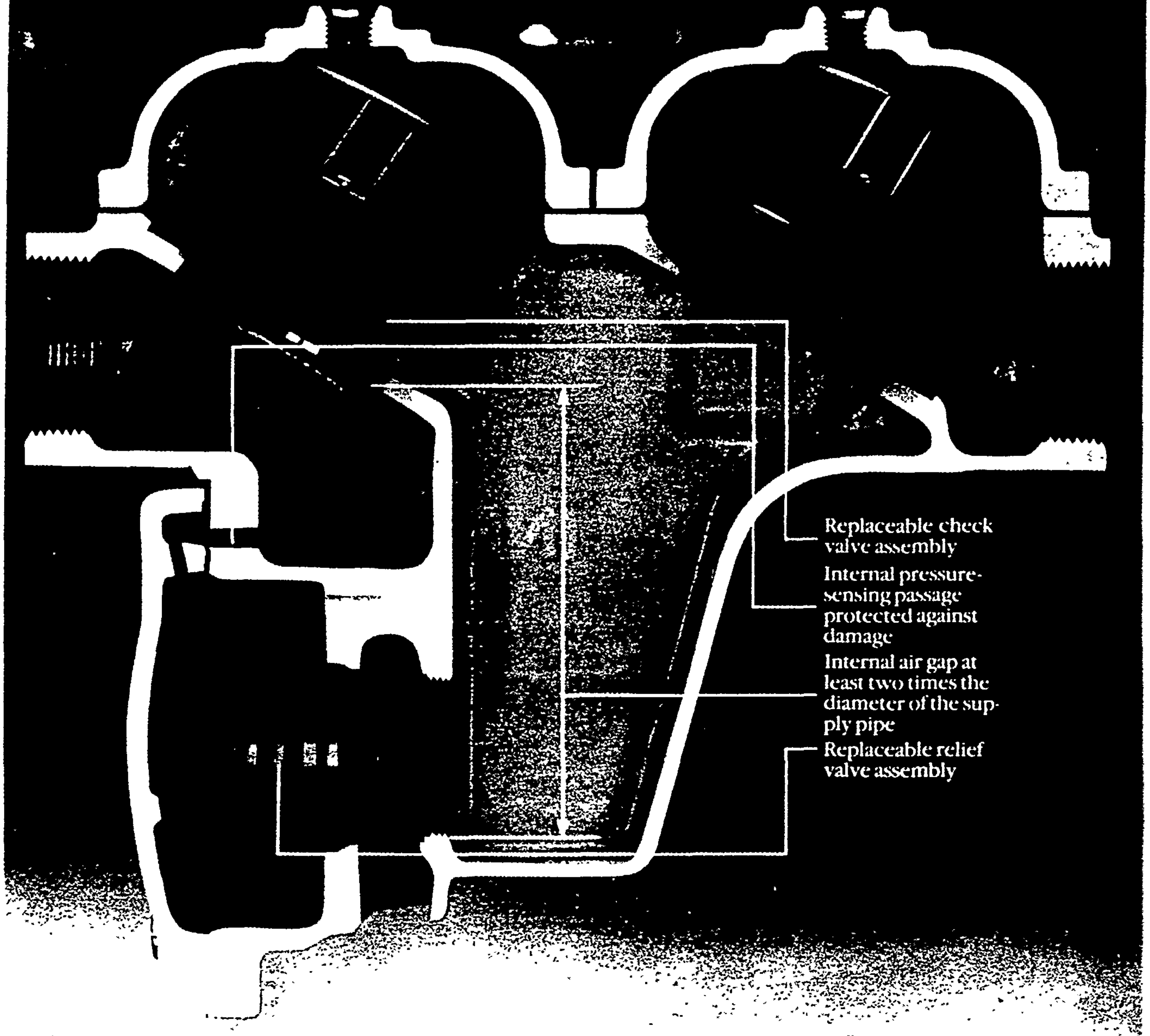
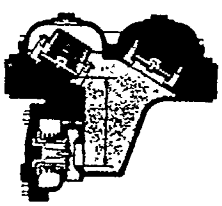
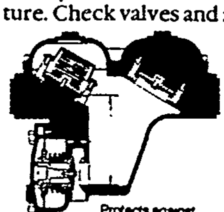


The new Hersey Model FRP-II reduced pressure backflow preventer protects against both backflow *and* backsiphonage. Should supply pressure drop, the relief valve opens to maintain a 3 psi positive pressure differential between the supply and the RP zone. Under Normal Conditions if supply pressure drops to atmosphere or below, the relief valve stays open and the water in the reduced pressure zone drains out creating an internal air gap at least twice the diameter of the supply pipe.



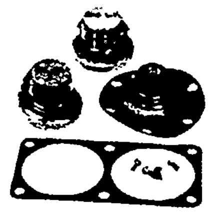
Protects against backflow

Easy In-Line Maintenance is another feature. Check valves and relief valves are independent modular assemblies. They can be removed intact—valve, spring and seat—and replaced using low-cost replacement kits. All parts are of corrosion-resistant materials, and the pressure-sensing passage and diaphragm are contained within the housing, fully protected from vandalism or accidental damage.



Protects against backsiphonage

FRP-II backflow preventers are approved by the U.S.C. Cross-Connection Control Lab, U.S. Army Corps of Engineers, U.S.Navy, IAPMO, AWWA, and ASSE.



Low-cost replacement kit includes valve, spring and seat.

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