

Making the River Safe to Drink



(Jaymie Oehler)

By Pamela Eyden

Two dozen fat mucket mussels, living in a dark cylindrical tub and bathed with flowing river water, are the first line of defense against unknown hazards of raw river water in Minneapolis.

The city's Water Works plant in Fridley, Minn., looks pretty well defended from the outside. Tall chain link fences surround the compound. Behind the thick glass window of the guardhouse, an unsmiling uniformed guard asks for identification, and keeps it, before he raises two sets of swing arms allowing a visitor to enter. Cameras monitor the buildings, inside and out.

Guarding the water supply begins with the fat muckets, special ordered

from the U.S. Environmental Protection Agency. They are the first to taste and test the river water destined to be consumed by hundreds of thousands of people. Each mussel is wired to sensors. If it tastes anything disagreeable, it clamps shut immediately, triggering an investigation from the lab.

That's never happened at the Minneapolis plant, although mussels have died natural deaths, which also causes their shells to close.

From the Twin Cities to the Quad Cities, only six water treatment plants draw water from the Mississippi River: Minneapolis and St. Paul; Davenport and Bettendorf, Iowa; and Rock Island and Moline, Ill. These big metro plants also provide water to surrounding

communities. Other towns draw water from underground aquifers.

With such a huge source of water nearby, why do some cities take advantage of it, while others dig wells? Cost has a lot to do with it. The cost of treating river water can be 10 times the cost of treating groundwater, if treatment chemicals, energy, manpower, testing and capital costs are included. Groundwater may only need to be filtered, chlorinated and fluoridated, unless toxins, such as arsenic or perfluorocarbons, are found.

The river, on the other hand, is complicated, and its chemistry changes from hour to hour.

"Most people have a static view of the river," said utilities general manager Greg Swanson of Moline, Ill., "but the river's characteristics are always changing. The turbidity changes, the pH changes and so does the temperature. After a rain, the river may have more ammonia and nitrates in it, from farm runoff. No two surface-water treatment plants are constructed or operate the same. They all must adapt to the river, which is a very complex ecosystem."

Source Mississippi

Water plants that draw water from the northerly stretches of the river — St. Paul and Minneapolis — deal with cleaner water than do the plants in the south, but the southerly river is bigger so there's more water to dilute the pollutants.

No matter where the water comes from, it's held to the same standards. Under the Safe Drinking Water Act, the U.S. Environmental Protection Agency (EPA) regulates more than 90 microorganisms, disinfectants, disinfection byproducts, inorganic chemicals, organic chemicals and radionuclides in drinking water. (See sidebar "List of EPA-Regulated Drinking Water Contaminants") All public water systems — both groundwater



Andy Weyer, chemist-bacteriologist with the Minneapolis Water Works, stands next to the mussel tank. (Pam Eyden)

and surface water — are held to these standards. All have to provide “Consumer Confidence Reports” (available online) about the quality of the water they deliver.

Up in Fridley, the Mississippi River water is fairly clean.

“It’s basically just what Mother Nature gives us,” said Andy Weyer, chemist and bacteriologist with the Minneapolis Water Works. “We don’t have a lot of pesticides or salt, although salt levels have been increasing because of what we put on our roads and highways. In winter our river water is much harder with more minerals in it. In the spring and summer it tends to get softer, with rain diluting the minerals.”

The Minneapolis Water Works softening plant is noisy with the sound of rushing water. Water rushes through open channels and pipes, into pools and out again. It changes color along the way. One of the first steps is to add a slurry of thick, light gray slaked lime, which turns the water

an opaque gray-brown and raises the pH levels to over 10.2. (The acidity and alkalinity of water are measured by pH. Values below 7 are acid, and above 7 are alkaline.) This kills most bacteria. The water then flows into 12 large round pools, where the lime works on the water to precipitate out mag-

When there's a heavy rain, turbidity, ammonia and nitrate levels can jump in 12 hours.

nesium and calcium. Water here looks lagoon-blue. In the center of each pool sits a giant cone-shaped precipitator. These “Spaulding precipitators” were invented here in the 1930s and were built first, then the building was built to enclose them.

Municipal Water Plants that Draw from the Mississippi

Facility	State	River Mile
St. Cloud Water Treatment Plant (WTP)	Minn.	928.4
St. Paul Regional Water Services	Minn.	863.0
Minneapolis Water Works	Minn.	859.0
E. Moline WTP	Ill.	489.2
Moline WTP	Ill.	485.9
Rock Island Arsenal	Ill.	484.2
Iowa American-Davenport	Iowa	483.8
Rock Island WTP	Ill.	482.9
Burlington WTP	Iowa	404.5
Nauvoo WTP	Ill.	375.8
Keokuk Water Works	Iowa	364.5
Hamilton Water WTP	Ill.	363.9
Warsaw WTP	Ill.	359.8
Quincy WTP	Ill.	327.0
Hannibal WTP	Mo.	308.9
Louisiana WTP	Mo.	282.8
Ameren UE - Sioux Plant	Mo.	209.6
Illinois American-Alton	Ill.	204.2
Olin Corp. East Alton Plant	Ill.	199.7
Illinois American-Granite City	Ill.	192.2
City of St. Louis	Mo.	190.3
Illinois American-East St. Louis	Ill.	180.6
Jefferson County Water Authority	Mo.	150.1
Ameren UE - Rush Island	Mo.	140.4
Chester Water Department	Ill.	109.5

Testing, Testing

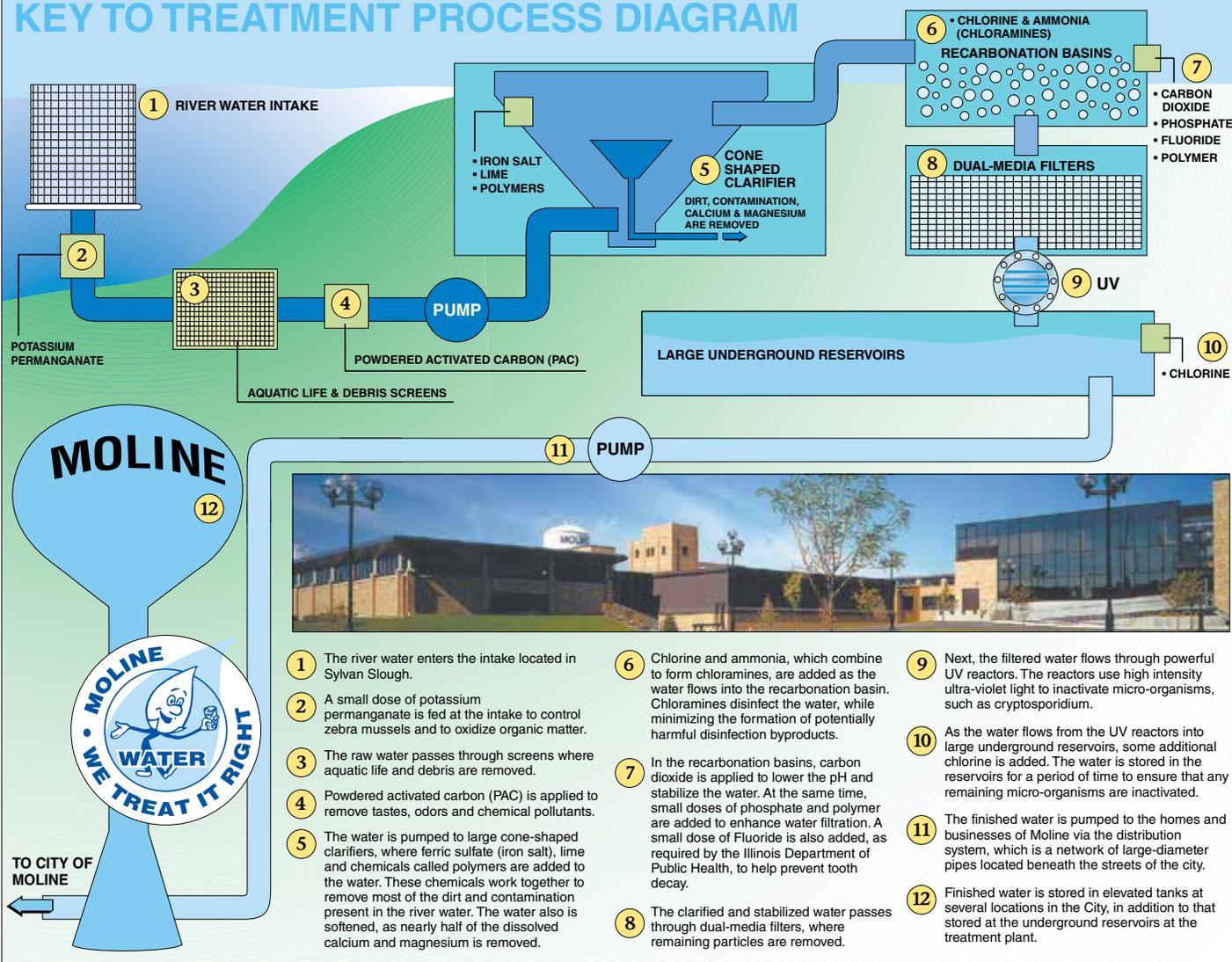
Moline and Davenport are nearly 400 miles downriver. By the time the river gets here, it has collected water from dozens of farmland tributaries — the Minnesota, Root, Chippewa, Upper Iowa, Wisconsin, Maquoketa, Apple and Wapsipicon, among others. Water treatment plants here have a lot to watch and compensate for — ammonia and nitrates, for example.

“Ammonia compounds require more disinfectant to remove. It’s present all the time, but is higher in some seasons. We monitor ammonia weekly, with increased testing during high-water seasons, typically spring into early summer,” said Lisa Reisen, external affairs manager at Iowa American Water in Davenport.

The Davenport plant also monitors atrazine, an herbicide commonly used on cornfields. Reisen said monitoring

MOLINE WATER TREATMENT PLANT

KEY TO TREATMENT PROCESS DIAGRAM



- 1** The river water enters the intake located in Sylvan Slough.
- 2** A small dose of potassium permanganate is fed at the intake to control zebra mussels and to oxidize organic matter.
- 3** The raw water passes through screens where aquatic life and debris are removed.
- 4** Powdered activated carbon (PAC) is applied to remove tastes, odors and chemical pollutants.
- 5** The water is pumped to large cone-shaped clarifiers, where ferric sulfate (iron salt), lime and chemicals called polymers are added to the water. These chemicals work together to remove most of the dirt and contamination present in the river water. The water also is softened, as nearly half of the dissolved calcium and magnesium is removed.
- 6** Chlorine and ammonia, which combine to form chloramines, are added as the water flows into the recombination basin. Chloramines disinfect the water, while minimizing the formation of potentially harmful disinfection byproducts.
- 7** In the recombination basins, carbon dioxide is applied to lower the pH and stabilize the water. At the same time, small doses of phosphate and polymer are added to enhance water filtration. A small dose of Fluoride is also added, as required by the Illinois Department of Public Health, to help prevent tooth decay.
- 8** The clarified and stabilized water passes through dual-media filters, where remaining particles are removed.
- 9** Next, the filtered water flows through powerful UV reactors. The reactors use high intensity ultra-violet light to inactivate micro-organisms, such as cryptosporidium.
- 10** As the water flows from the UV reactors into large underground reservoirs, some additional chlorine is added. The water is stored in the reservoirs for a period of time to ensure that any remaining micro-organisms are inactivated.
- 11** The finished water is pumped to the homes and businesses of Moline via the distribution system, which is a network of large-diameter pipes located beneath the streets of the city.
- 12** Finished water is stored in elevated tanks at several locations in the City, in addition to that stored at the underground reservoirs at the treatment plant.

Moline's water treatment plants put river water through 12 distinct processes to create clean, tasty drinking water. (courtesy of Moline Public Utilities)

is done annually in July, to capture the highest levels in runoff from spring rains and snowmelt, but levels are not high enough to be an issue.

Freshwater intake pipes at the Moline water plant are at the head of Sylvan Slough, just downstream of where the Wapsipinicon River enters the Mississippi. The Wapsi drains a lot of croplands. When there's a heavy rain, turbidity, ammonia and nitrate levels can jump in just 12 hours.

"Raised ammonia levels can compromise chloraminization," said Moline's Greg Swanson.

Chloraminization is a disinfection process, in which ammonia is added to water that has been chlorinated, creating chloramines. They disinfect the

water, but don't react as strongly to the organics in river water as chlorine does. Hence, there are fewer byproducts, which can be toxic and are themselves regulated by the EPA. If the water source is already high in ammonia, this needs to be taken into account.

Nitrates are another problem. Levels change a lot faster in river water than in ground water, but all plants have to keep watch. Des Moines, Iowa, draws its water from the Raccoon and Des Moines rivers. This water often contains high levels of nitrates. While low levels of nitrates are natural, industrial agriculture adds a lot more by letting runoff from fields flow through field tiles into drainage ditches and streams that feed the river. The EPA limits the

amount of nitrates in drinking water to less than 10 milligrams per liter. Anything greater than that is unsafe. Removing nitrates adds to the cost of using the river for drinking water —\$4,000 to \$7,000 per day, according to Des Moines Water Works. The city's new water plant has only been operating since December 2014, and the utility is concerned that it will need to invest another \$80 million to \$100 million in new denitrification facilities.

In March 2015 the Des Moines Water Works sued the 10 drainage districts in three counties where tests showed nitrate levels four times the limit.

The case was scheduled for August 2016, but has been delayed until June

26, 2017, due to court conflicts and a request for the Iowa Supreme Court to determine whether drainage districts can be sued for damages.

Filtering

After the water is treated, it is pumped into large chambers to filter out protozoa, cryptosporidium, Giardia, parasites and chemicals, and make it clearer and better tasting. The Des Moines Water Works filters water through two feet of sand on top of two feet of gravel. St. Paul uses 26 inches of gran-

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ulated carbon on top of four inches of sand. Minneapolis filters water through membranes that hold back all impurities greater than 0.03 micrometers, which includes most bacteria.

Moline adds another step to its treatment process, exposing water to ultraviolet light provided by six 1,500-watt lamps in each of eight UV reactors. The UV light inactivates even the small cryptosporidium, against which chlorine has no effect.

Pipes and Teeth

Finally, many cities add fluoride as a public health measure to prevent tooth decay. Some cities also add a chemical that forms a thin coating inside lead pipes to act as a barrier between the metal and the water, and prevent corrosion. The corrosion-inhibiting chemicals, orthophosphate or polyphosphate, must be carefully balanced. In Minneapolis, they add “a pop can in every million gallons,” said Weyer. This last step is critical for cities with aging lead water lines and pipes, which includes nearly every city.

When Flint, Mich., switched its source of municipal water from Detroit, which draws water from the

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Spalding precipitators at the Minneapolis Water Works. (Pam Eyden)

The EPA regulates drinking water for more than 90 contaminants.

Microorganisms

- Cryptosporidium
- Giardia lamblia
- heterotrophic plate count
- Legionella
- total Coliforms
- turbidity
- tiruses (enteric)

Disinfection Byproducts

- bromate
- chlorite
- haloacetic acids
- total trihalomethanes

Disinfectants

- chloramines
- chlorine
- chlorine dioxide

Inorganic Chemicals

- antimony
- arsenic
- asbestos (fiber > 10 micrometers)
- barium
- beryllium
- cadmium
- chromium (total)
- copper
- cyanide
- fluoride
- lead
- mercury
- nitrate
- nitrite

- selenium
- thallium

Organic Chemicals

- acrylamide
- alachlor
- atrazine
- benzene
- benzo(a)pyrene
- carbofuran
- carbon tetrachloride
- chlordan
- chlorobenzene
- 2,4-D
- dalapon
- 1,2-Dibromo-3-chloropropane (DBCP)
- o-Dichlorobenzene
- p-Dichlorobenzene
- 1,2-Dichloroethane
- 1,1-Dichloroethylene
- cis-1,2-Dichloroethylene
- trans-1,2-Dichloroethylene
- dichloromethane
- 1,2-Dichloropropane
- Di(2-ethylhexyl) adipate
- Di(2-ethylhexyl) phthalate
- dinoseb
- dioxin (2,3,7,8-TCDD)
- diquat
- endothall
- endrin
- epichlorohydrin
- ethylbenzene

- ethylene dibromide
 - glyphosate
 - heptachlor
 - heptachlor epoxide
 - hexachlorobenzene
 - hexachlorocyclopentadiene
 - lindane
 - methoxychlor
 - oxamyl (vydate)
 - polychlorinated biphenyls (PCBs)
 - pentachlorophenol
 - picloram
 - simazine
 - styrene
 - tetrachloroethylene
 - toluene
 - toxaphene
 - 2,4,5-TP (Silvex)
 - 1,2,4-Trichlorobenzene
 - 1,1,1-Trichloroethane
 - 1,1,2-Trichloroethane
 - trichloroethylene
 - vinyl chloride
 - xylene (total)
- Radionuclides**
- alpha particles
 - aeta particles and photon emitters
 - radium 226 and radium 228 (combined)
 - uranium

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Great Lakes, to the Flint River, the water treatment chemistry should have been adjusted, but it wasn't. As a result, thousands of adults and children drank water contaminated with high levels of

“Water isn't like wine,” he said. “We want it to be fresh and crisp and clean. We keep it moving. It doesn't age well.”

lead, which causes nerve damage and slows brain development.

Arguments about how this happened in Flint and who's to blame will probably go on for years, but water treatment professionals speculate that the plant may have added too much carbon dioxide after the softening process, which brought the pH down

too far. Also, they may not have added enough orthophosphates and/or polyphosphates to coat lead pipes.

A Matter of Taste

Water drinkers are at the other end of the pipe. We want our water to be both safe and delicious, however that's defined. We're a particular bunch. We don't want our water to taste musty, bitter or like algae or have a chemical aftertaste that causes us to call the local water department. The water department doesn't want that either. Andy Weyer said a lot of the work at the Minneapolis Water Works is to analyze and prevent the factors that cause taste and odor problems.

“Water isn't like wine,” he said. “We want it to be fresh and crisp and clean. We keep it moving. It doesn't age well.”

This March, the Moline water plant won an award for “Best Tasting Water in Illinois” from the American Water Works Association, based on taste, smell and smoothness. Utilities

director Greg Swanson said the key is in balancing the minerals in the water. Moline's water will go on to national competition for the People's Choice and Best of the Best awards this summer.

This spring the Water Bar opened on Central Avenue in northeast Minneapolis. Here customers belly up to the bar and pick from a list of waters drawn from the Twin Cities and suburban water taps. They can sip and judge to their hearts' content. Drinks are on the house, and the bartenders are volunteers.

The Water Bar is the project of a group of activist artists called Works Progress Studio, which aims not to make a profit but to start conversations about our communal water supplies and get people to notice something we usually take for granted. The Water Bar is open intermittently, so check its website before you drop by. 🏠 🍷

Pamela Eyden is the news and photo editor.