

## CONTROL OF ZEBRA MUSSELS IN RESIDENTIAL WATER SYSTEMS

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### Introduction

The zebra mussel, *Dreissena polymorpha* and *Dreissena bugensis*, is a small bivalve mollusk (a clam-like shellfish with two matching shell halves; Fig. 1) that has invaded North America's fresh surface waterbodies from Duluth to Massena, New York; from Chicago to Vicksburg, Mississippi; and from Nashville to Little Rock. Since their initial discovery in Lake St. Clair in 1988, the mussels have spread rapidly throughout all of the Great Lakes, the Hudson River, the St. Lawrence River, much of the Mississippi River Basin, including major tributaries such as the Tennessee, Ohio, and Arkansas Rivers, and parts of the Canadian Provinces of Ontario and Quebec (Fig. 2. See insert). Biologists believe that transport of the mussels from infested waters to other, uninfested inland fresh surface waters will continue to take place as a result of natural and human activities. In all likelihood, the mussels will ultimately infest most areas south of central Canada and north of the Florida Panhandle, from the Pacific coast to the Atlantic coast, perhaps in as few as 20 to 25 years.

The most highly visible impact of the zebra mussel has been its fouling of large-scale raw water intakes, such as those at industrial and electric generation facilities and municipal drinking water treatment plants. These facilities are vulnerable because the mussels are capable of attaching to most submerged hard surfaces (substrates) by means of tough elastic fibers (called

*byssal threads*) tipped with a natural adhesive akin to that produced by barnacles. Once attached, zebra mussels reproduce in prolific numbers and colonize extensive portions of large-scale water handling facilities, greatly reducing pumping efficiency — even totally clogging smaller pipes.

Zebra mussels are also capable of clogging the small water intake pipes found in private homes and cottages along North America's many inland lakes, streams, and rivers (they have already begun to clog some residential

systems in parts of the Great Lakes and Finger Lakes regions). Conservative estimates place the number of private dwellings with threatened water systems in the eastern half of North America at more than 100,000.

This publication is directed at the owners of residences with private water systems. It discusses the several components of such systems and presents a number of alternative control and mitigation measures that can be undertaken to cope with zebra mussels. Not all alternatives will work equally well for all systems; most will need to be finetuned to match up with the particular system being retrofitted.

It is recommended that homeowners engage the services of a qualified plumbing contractor to develop and install the best alternative for a given situation. Local, state, or provincial permit authorities should be consulted to determine what, if any, permits might be required for construction or installation of control projects.



**Figure 1.** The zebra mussel is a small clam-like shellfish capable of attaching to most submerged hard surfaces. Once attached, they reproduce in prolific numbers forming extensive colonies, often totally clogging water intake pipes.

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## The Threat to Small Water Systems

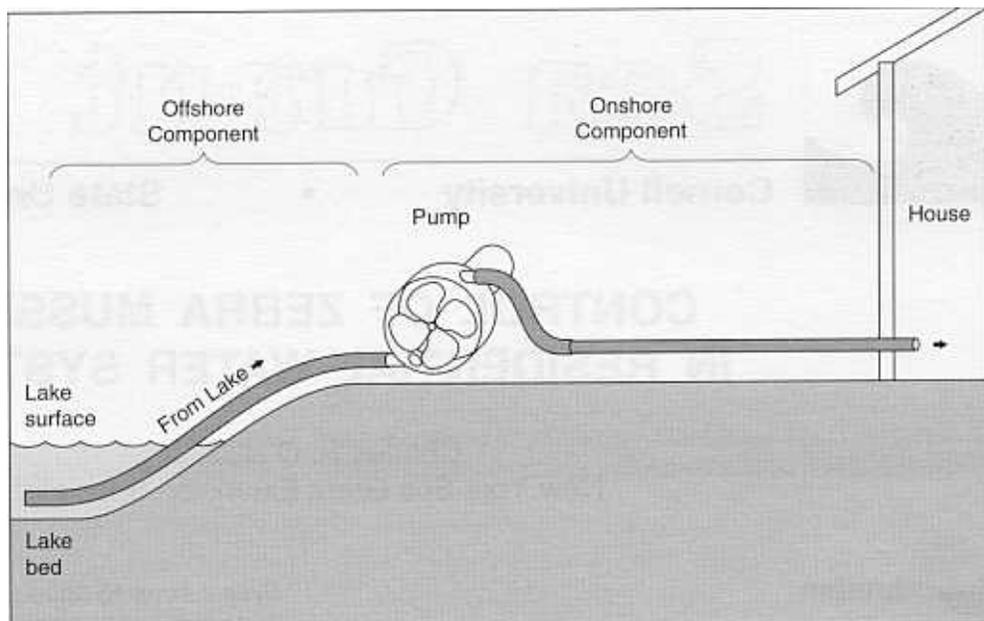
Why are zebra mussels a threat to large-scale and residential water systems? Water intake structures (pipes and their supporting cribwork) serve as an excellent habitat for zebra mussel colonization. The continuous flow of water into the pipes carries with it a continuous source of food and oxygen for the mussels and carries away their wastes, while the structures themselves protect the mussels from predation and environmental conditions such as storm wave activity and scouring by ice.

The zebra mussel can attach to intake pipes at water flow velocities of approximately 6.5 feet (2 meters) per second and below. In some large public facilities, layers of mussels up to 2 feet (.61 meters) thick have been observed. The typical 1- to 2-inch (2.54- to 5.1-centimeter) diameter residential pipe simply doesn't stand a chance against an organism capable of such fouling.

Zebra mussels enter water intakes via several mechanisms: in the form of veligers (microscopic larvae) they are carried by the water flow; as juveniles, they can crawl in using their clamlike foot; and as adults they can break loose from colonies and travel to the mouths of intakes by lake or river currents.

Mussel spawning can take place during the time of the year that surface waters are approximately 50°F (10°C). Zebra mussel veligers hatch from eggs at a size of approximately 70 microns (.00275 inch). Both shallow and deep intakes are affected since zebra mussels generally colonize from 2 feet (.61 meter) of the water surface down to depths of 200 feet (61 meters) or more.

Why hasn't more been heard about the clogging of residential water systems? Actually, there have been private residential systems fouled on the Great Lakes, as well as in the Finger Lakes in New York State. The number of systems fouled to date may be small because of several reasons. First, there may be many such systems in which failure is imminent but in which water flow has not yet gotten bad enough to be reported to local health departments or other authorities (or even noticed by the owners). Second, such small systems are drawing in relatively small amounts of water per day (250 to 400 gallons per day [gpd]; 946.4 to 1514.2 liters per day [lpd], for a 3-bedroom year-round residence, perhaps only an intermittent 25 to 100 gpd [94.6 to 378.5 lpd] for a weekend cottage) compared to larger municipal, in-

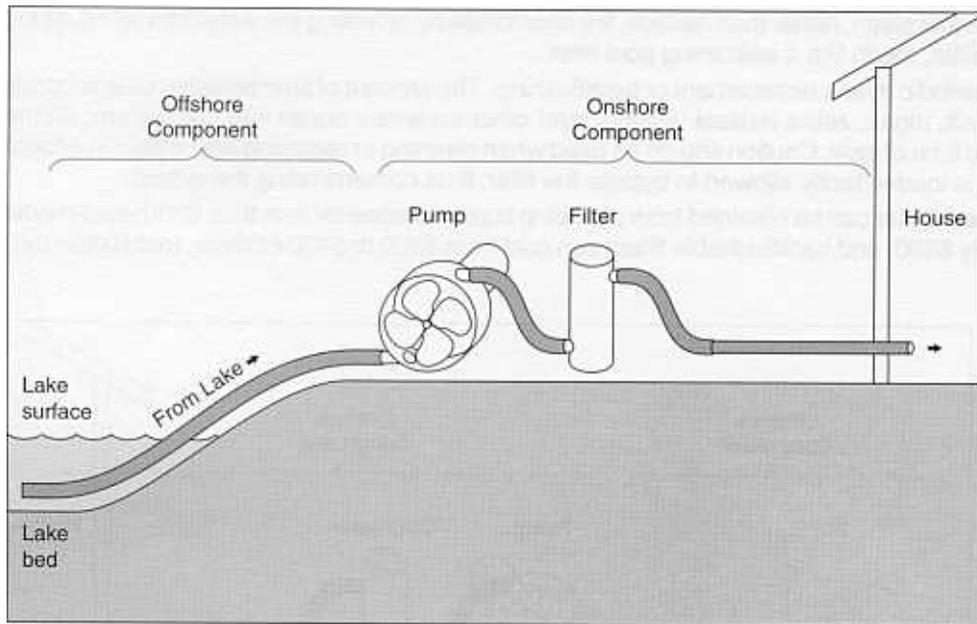


**Figure 3.** Residential water systems have two parts: an offshore component from the lake/river end of the pipe to the pump on the shore; and, an onshore component from (and including) the pump to the distribution pipes and faucets inside the residence.

dustrial, and power facility systems (hundreds of thousands or even millions of gpd). Residential systems are, therefore, taking in far fewer zebra mussel veligers compared to larger systems and are suffering the consequences slower and later than the larger systems. Finally, zebra mussel colonization tends to be spotty along the shoreline of any given waterway, particularly in the early stages of infestation. Given such spottiness and the high degree of variability of mussel veliger densities in the water column, larger systems have a much higher probability of early (and heavier) impact than smaller, residential systems.

Once in a water intake line, zebra mussels can colonize any part of the system from the mouth of the intake in the lake or river to the distribution pipes within the residence. Impacts of this colonization include loss of pumping efficiency, obstruction of foot valves, putrefactive decay of mussel flesh, production of obnoxious-tasting and foul-smelling methane gas, and increased corrosion of steel, iron, and copper pipes.

The first indication that zebra mussels are in a water intake is usually the discharge of shells or shell parts at the shore end of the pipe, a noticeable decrease in pumping head (water volume and pressure), or obnoxious tastes and odors in the water. The rate of overgrowth and clogging of water intakes by zebra mussels depends upon a number of factors, including the chemical and physical characteristics of the waterbody, the velocity and volume of flow within the system, the positioning of the intake end of the pipe in the waterbody, the material the pipe is made of, and the type and amount of natural substrate (such as rock) around the intake. Mussel densities in industrial intake canals and pipes have been recorded as high as 627,000 per square yard (roughly 750,000 per square meter).



**Figure 4.** A 25–50 micron (absolute) in-line filter capable of filtering the total water consumption needs of a household (250–400 gpd for a year-round home of a family of four) installed in the onshore component to keep zebra mussel veligers and shells out of a house's interior plumbing.

## Control Alternatives

Experience with public and industrial water intakes has demonstrated that it is best to eliminate zebra mussels in water intake pipes at the veliger stage or before juvenile mussels are able to pass unhindered into critical areas of the water system. In other words, the mussels should be killed or removed from the system before they get into areas that are difficult to clean, and before the mussels can attach, grow, and become problematical. Control can be **continuous** (no mussels tolerated, *ever*), or **periodic** (some mussel growth allowed until no longer tolerable, followed by removal, the removal schedule being based upon the rate of colonization in that particular system). Given the foul tastes and odors associated with zebra mussels in water intakes, most homeowners will probably choose to tolerate few or no mussels in their systems.

When considering the potential clogging of a private residence water intake system, homeowners should view the system in two parts. Part 1 is the **onshore component**, that part of the system from (and including) the pump to the distribution pipes and faucets inside the residence, including the piping between the pump, the house, and any storage tank. Part 2 is the **offshore component**, that is, the pipe from its intake end in the lake or river to the pump on the shore (Fig. 3).

The onshore component will, in most cases, be the simplest and least expensive section to protect but the most difficult and costly to clean out if infested (because of the difficulty of physically removing plugged pipes from within the walls of a house). On the other hand, in most situations, the offshore component will be the most difficult and expensive section to protect against clogging by zebra mussels but the least difficult section to remediate (clean out) once it does become infested (pg 9). As control of the mussels is more easily accomplished in the onshore

rather than offshore component, this area will be addressed first.

## Control of Zebra Mussels in the Onshore Component

Homeowners using a zebra-mussel-infested waterbody as a water source are advised to take early action to keep the mussels out of the onshore component of their systems **before the systems become infested**. Alternatives for accomplishing this goal include installation of a replaceable or cleanable in-line filter, chlorination, or a combination of filtration and chlorination.

While screening or straining the water in the offshore component, at the intake (lake or river) end of the

pipe, is an obvious method of protecting a residential water system from zebra mussel infestation, this alternative is a very difficult undertaking of questionable effect, and will be discussed below.

## In-line Filtration

**In-line filtration** is a far more easily accomplished control alternative for the onshore component. This involves the installation of a “whole house” in-line filter on the water line (either ahead of or behind the pump, depending upon the specific type of pump in use) prior to the pipe's entrance to the in-the-house distribution (plumbing) system (Fig. 4). All water used by the residence passes through the filter before distribution. Such a filter must be capable of filtering the maximum total amount of water reasonably expected to be used by a private residence in a day (250 to 400 gpd [946.4 to 1514.2 lpd] for a full-time residence of a family of four, perhaps as little as 25 gpd [94.6 lpd] for a seasonal weekend cottage), **and** be capable of removing all particulate matter larger than approximately 50 microns (about .00196 inch), effectively keeping out particles 20 microns (.00079) smaller than the size of a zebra mussel veliger. Flow rates of 6-20 gpm (22.7-75.7 lpm) will be needed to serve the needs of a year-round residence.

In-line whole house filters come in a variety of configurations, including:

- single-media filters containing fiber or filamentous “angel hair”-like media, able to remove particles down to 25 to 50 microns (.00098 to .00196 inch);
- dual-media filters with fiber media surrounding a center section of activated charcoal capable of filtering down to 20 microns (.00079 inch) or smaller and removing many flavors and odors; and,

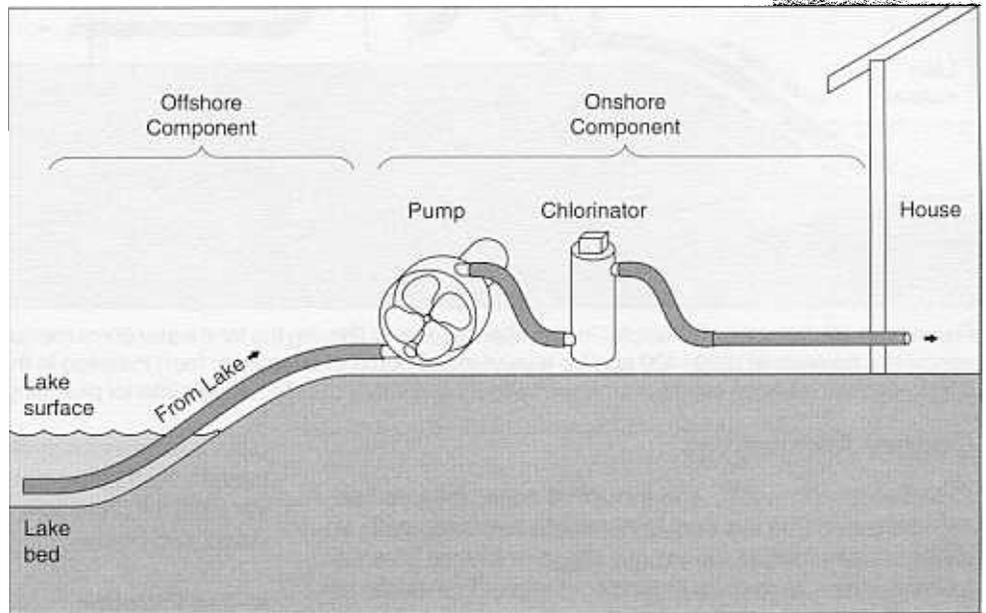
- backflushable filters or strainers that clean, rather than replace, the filter media by reversing the water flow and flushing the trapped particles from the filter, much like a swimming pool filter.

All in-line filters require either periodic media replacement or backflushing. The amount of time between cleanings will depend upon: (1) the amount of silt, algae, zebra mussel veligers, and other materials drawn into the system; (2) the location the waterbody; and (3) the time of year. Caution should be used when cleaning or replacing filter media to ensure that none of the trapped material is inadvertently allowed to bypass the filter, thus contaminating the system.

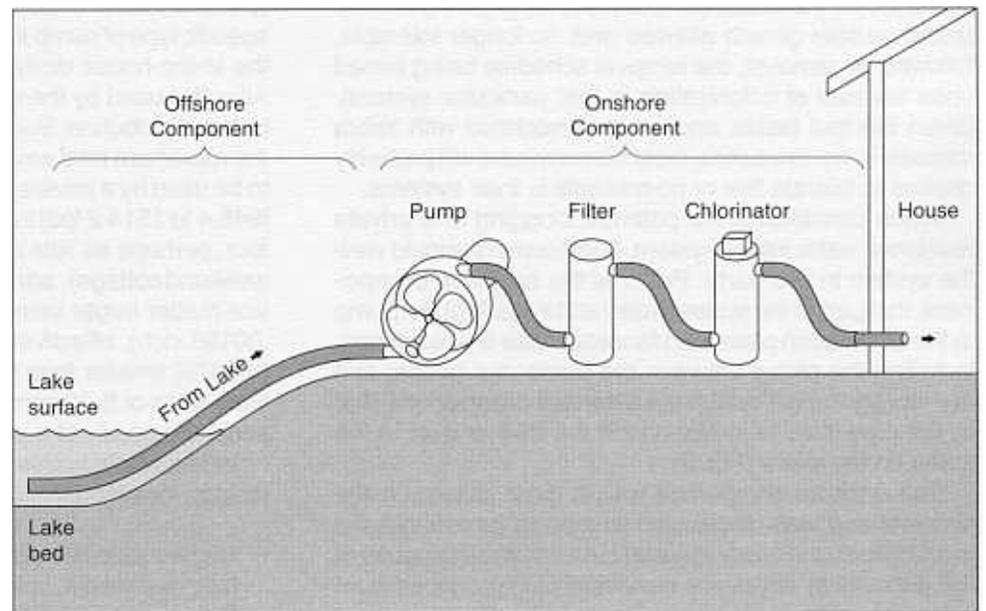
At this writing, a good single-media filter can be obtained from plumbing supply houses for less than \$200; dual-media filters can cost up to approximately \$300; and backflushable filters can cost from \$200 to \$400 or more. Installation by a plumber adds to the initial cost of in-line filtration systems. The replacement of clogged filter refills is an ongoing cost and time commitment for the homeowner.

### Chlorine Injection

Another method of preventing colonization in the onshore portion of a residential water system is the installation of an in-line chlorine injector after the pump, before the water enters the in-house distribution system (Fig. 5). Such systems add a small amount of potable chlorine to the incoming water every time the pump runs. The amount of chlorine injected is comparable to that added to municipal water for disinfection purposes prior to being pumped to consumers, about 0.25 ppm TRC (parts per million total residual chlorine). This amount, added each time water is drawn from the lake or river, is sufficient to kill zebra mussel veligers, juveniles, and adults being drawn into the system with the water, and will keep the in-house plumbing clean of zebra mussels. (This may have the added benefit of improving the water potability by destroying other pathogens, such as bacteria—homeowners should check with their county health department or Cooperative Extension Service for guidelines on human consumption of lake or river water.) A chlorinator will not, however, keep shells and shell fragments drawn in from the lake or river from clogging faucets; a filter should be used in conjunction with a chlorinator for best effect (Figure 5a).



**Figure 5.** An in-line chlorine injection system, dosing at 0.25 ppm TRC every time the pump operates is designed to prevent the settling and growth of zebra mussels; it does not keep out shells.



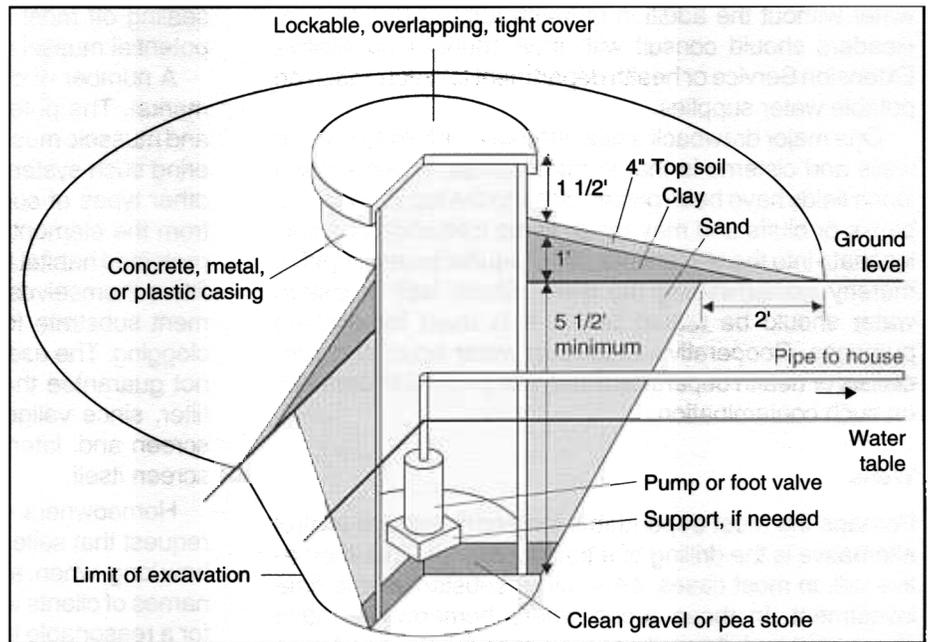
**Figure 5a.** The combination of a 25–50 micron (absolute) in-line filter capable of filtering (250–400 gpd for a year-round home of a family of four) installed in combination with an in-line chlorine injection system, dosing at 0.25 ppm TRC whenever the pump runs, should ensure that the onshore component will remain mussel-free and will improve the quality of the water in the process.

## Shore Wells and Cisterns

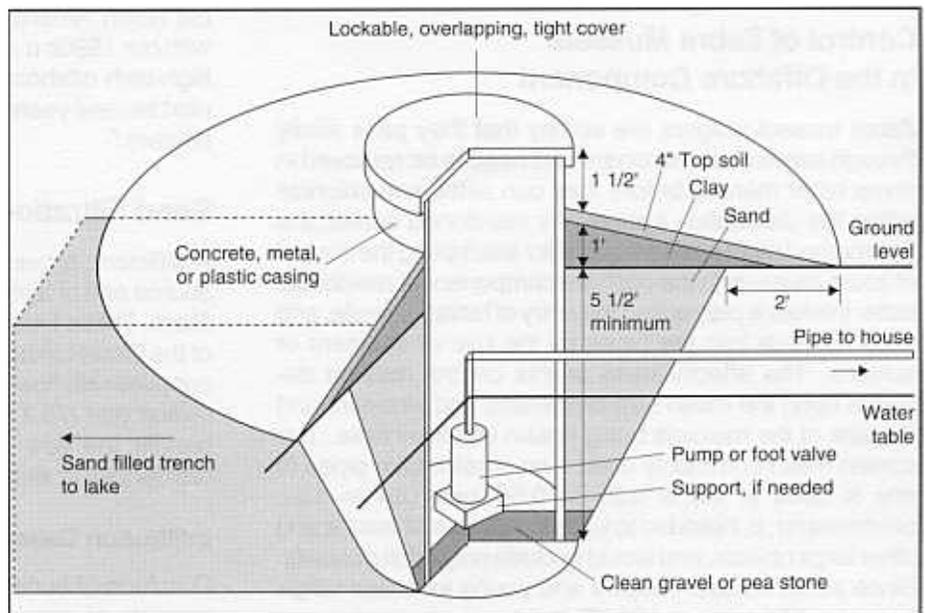
In some locales, specifically those with a sand and gravel shoreline, an old shoreline residence water source may be ready for a comeback — the use of **shore wells** and **shoreline cisterns**. Shore wells and cisterns utilize sand and gravel to filter out particulate materials, including zebra mussel veligers. In its simplest form, a shore well consists of a pipe tipped with a “well point” driven into a sandy shore until the point penetrates into the **low water** water table associated with the river or lake. The pipe must penetrate the low water table to ensure a constant flow of water even during drought conditions. This alternative requires a very sandy shoreline with little or no rock to allow the well point to be driven down to the water table. The well point is driven down to the water table to ensure a constant flow of water even during drought conditions. This alternative requires a very sandy shoreline with little or no rock to allow the well point to be driven down to the water table.

Another approach is to dig a **cistern** approximately 24 to 36 inches (60.96 to 91.44 centimeters) in diameter deep enough to penetrate at least several feet into the **low water** water table. The sides of the cistern should be sleeved with either a plastic, concrete, or metal liner to prevent its caving in and to serve as a holding area for water infiltrating from the water table. Water will infiltrate into the cistern from the open bottom of the casing; the liner can also be perforated at the bottom where it penetrates the water table to facilitate water infiltration (Fig. 6). The cistern should be located far enough landward from the water’s edge to place the top of the well above the high water wave run-up line to prevent overtopping during storms. The cistern should have a watertight cover installed to prevent contamination. The pump can either be installed in the cistern or outside the cistern in a wellhouse with a pipe running into the cistern.

Neither shore wells nor cisterns are practical in areas with rocky shorelines or with shallow bedrock. In some cases, this problem can be overcome by digging a pit much larger than the diameter of the cistern itself (6 to 10 feet [1.83 to 3.05 meters], for example), positioning the cistern casing in the center of the pit, and filling the pit with coarse sand and gravel around the casing (Fig. 7). A channel is dug, connecting the cistern to the lake or river.



**Figure 6.** In the shoreline cistern, a 24- to 36-inch diameter cistern is dug down into the **low water** water table. A plastic, concrete, or metal liner prevents caving in and serves as a holding area for water infiltrating from the water table.



**Figure 7.** Where hardpan or bedrock near the surface precludes water infiltration into a shoreline cistern, a sand-and-gravel-filled channel can be installed between the cistern and the water source.

The channel, like the cistern pit, is filled with coarse sand and gravel. Water from the lake or river percolate through the channel into the pit. Water percolates into the cistern, where it is then pumped to the residence. The cistern physically excludes mussel veligers and other particles as the water passes through the sand and gravel. The entire structure, channel and pit, is capped with a layer of impermeable clay to prevent contamination of the cistern by overland flow.

While a shoreline cistern can remove zebra mussel veligers and other particles, it may not provide potable

water without the addition of some form of disinfection. Readers should consult with their county Cooperative Extension Service or health department for information on potable water supplies.

One major drawback associated with all forms of shore wells and cisterns is that in many areas, septic system leach fields have been placed close to the top of shoreline banks or bluffs and may result in the infiltration of septic leachate into the shallow shoreline aquifer (water supply), thereby contaminating the wells. Shore well or cistern water should be tested before it is used for drinking purposes. Cooperative Extension water education specialists or health department staff can provide information on such contamination.

## Wells

Perhaps the most dependable longterm onshore control alternative is the drilling of a traditional well. This alternative will, in most cases, be a rather substantial one-time investment. In those areas where homeowners have chosen not to drill a well because of bad water conditions (no viable aquifer available, sulfur or salt in the water, pollution of groundwater, etc.) this choice may not be a viable alternative.

## Control of Zebra Mussels in the Offshore Component

Zebra mussel veligers are so tiny that they pass easily through screens and strainers and need to be removed in some other manner before they can settle and colonize within the distribution system. As mentioned earlier, the first method most people think of for attempting the control of zebra mussels in the offshore component of residential water intakes is preventing the entry of larval, juvenile, and adult mussels into the pipes by the use of strainers or screens. The effectiveness of this control method depends upon the mesh size of screens and strainers and the size of the mussels being drawn into the intake. The screen mesh commonly used over small intake pipes (if any is used at all) is 0.25 to 0.50 inch (.64 to 1.27 centimeters), is intended to keep out pieces of leaves and other large objects, and would exclude only adult mussels. Since zebra mussel veligers and young juveniles range from about 70 microns (.00275 inch) and up, simply using strainers or screens at the intake is ineffective as a control strategy and should not be relied upon by owners of residential systems.

Although the effectiveness of screens or strainers could be increased by reducing the mesh size, it is impractical to place a strainer with very small mesh over the end of a pipe in a waterbody since it will quickly clog with silt, algae, and debris. Since zebra mussels attach to virtually any hard surface, offshore strainers or screens are also subject to direct fouling by the mussels they are intended to keep out. While this can be temporarily minimized by using copper for screens or strainers (copper ionizes in water; copper ions apparently prevent zebra mussel attachment), once the copper has formed a greenish oxide surface layer,

sealing off most of the copper ions, it, too, becomes a potential mussel attachment surface.

A number of offshore filters are now coming onto the market. The potential for clogging by silt, algae, debris, and mussels must be considered by homeowners considering such systems. Enclosing filters in metal, plastic, or other types of containments in an effort to protect them from the elements may actually provide a very suitable, protected habitat for mussel growth around the filters. The filters themselves, being hard, will also serve as attachment substrate for the mussels, leading to fouling and clogging. The use of a copper screen around a filter does not guarantee that zebra mussels will not attach to the filter, since veligers can pass through openings in the screen and, later, as the screen oxidizes, attach to the screen itself.

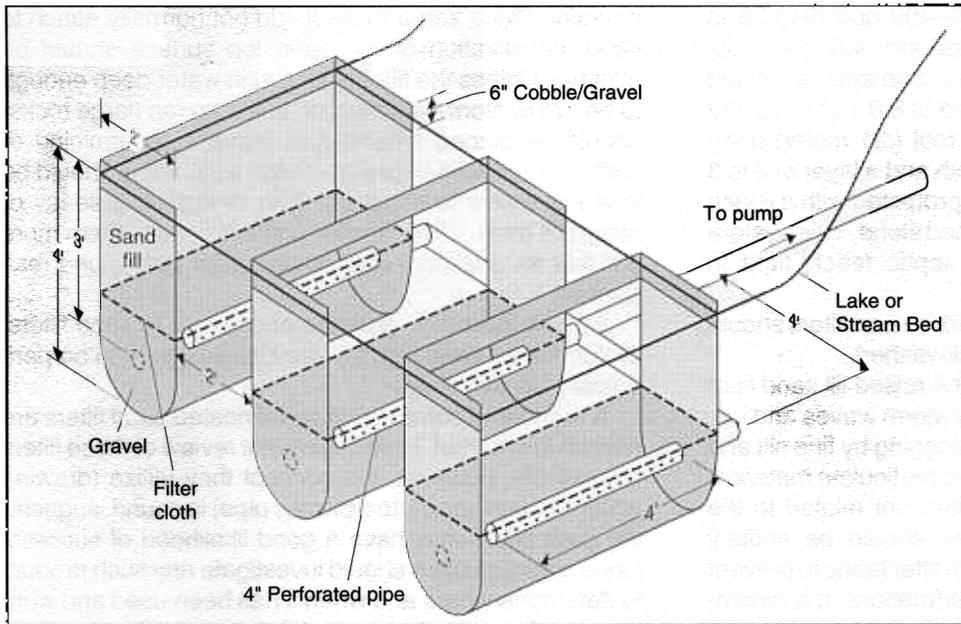
Homeowners considering such new systems should request that sellers provide detailed information on how, how long, when, and where the systems were field-tested; names of clients who have had such systems in the water for a reasonable length of time; and what the seller will do in the event that the system clogs. Purchasers should be aware that product testing should be performed during the spring through the fall when veligers are in the water — not in winter, when they pose little or no threat to intakes. Good old North American know-how will most likely combine with our 1990s market economy to produce some form of high-tech offshore mechanical filtration devices over the next several years. But until then, the best advice is “buyer beware.”

## Sand Filtration for Offshore Controls

A different, proven approach for filtration of water at the source end of a pipe is the use of buried intakes and sand filters. These types of filters are used in Europe and parts of the Great Lakes for small municipal and industrial water supplies with flow requirements of up to approximately 20 million gpd (75.71 million lpd), but can be downsized to handle the flow requirements of groupings of private residences or even single residences.

## Infiltration Galleries

One form of buried intake is the **infiltration gallery**. This consists of porous intake pipes or well screens laid in trenches excavated in the bed of a lake or river. The trenches are backfilled with sand and gravel and covered over with larger crushed stone or cobble. A pump draws water downward through the sand and gravel which obstructs the passage of zebra mussel veligers and other organic and inorganic particulate material such as detritus and silt (Fig. 8). The anoxic (oxygen-starved) conditions that exist within such filter beds create a very hostile environment, killing veligers trapped therein. Such filters generally have flow rates of 0.5 to 1.0 gpm (1.89 to 3.79 lpm) per square foot (.09 square meter) of filter surface. General dimensions for an infiltration gallery suitable to reliably serve a residence requiring 250 to 400 gpd (946.35 to 1514.16 lpd) are a 4-inch (10.16 centimeter) diameter



The time period between backwashes will depend upon the amount of water drawn through the filter on a daily basis and the amount of particulate matter in the water. If the homeowner's pump is not sufficiently powerful to accomplish this, it may be necessary for a plumbing contractor to perform the operation utilizing a more powerful portable pump. If a gallery cannot be backwashed, it may be necessary for the filter sand to be manually "fluffed up" or replenished by a diver.

### Raised Fill Sand Filters

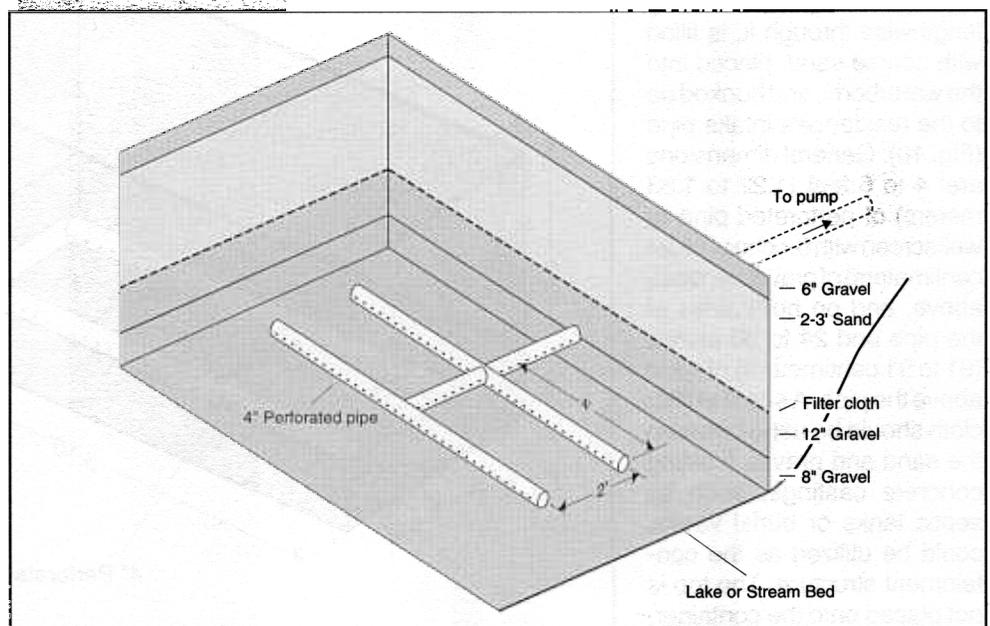
A form of sand filtration, the **raised fill sand filter**, eliminates the trenches and replaces them with a shallow layer of gravel placed directly on a lake or river bed, upon which perforated pipes or well screen are laid. The pipes are covered with a raised fill of gravel and sand that is then covered with gravel

**Figure 8.** In an infiltration gallery, a pump draws river/lake water downward into porous intake pipes or well screens laid in sand- and gravel-filled trenches excavated in the bed of the river/lake. Zebra mussels and other particles are removed from the water as it passes through the sand and gravel. The trenches are covered with crushed stone or cobble to protect against wave and ice scouring. Such filters generally have flow rates of 0.5 to 1.0 gallons per minute (gpm) per square foot of filter surface.

perforated pipe or well screen placed into a trench 4.0 feet long, 4.0 feet deep, and 2.0 feet wide (1.22 meter by 1.22 meter by .61 meter), filled with a one foot layer of washed gravel, covered by a sheet of filter cloth, and backfilled with at least three feet of coarse sand which contains no fine particles (e.g., silt), and protected by a cover layer of cobbles. Readers may notice that this alternative resembles a septic system leach field operating in reverse, drawing water in rather than discharging it.

As water is drawn through the sand portion of infiltration galleries, mussel larvae and juveniles, as well as silt and other particulate matter will fill in the spaces between the grains of sand. In addition, sand will tend to pack and cake as water is drawn through it, leading to the formation of cracks through which larger particles may pass into the water intake system. For these reasons, infiltration galleries must be designed in such a manner as to allow for backwashing of the filter sand. This is usually accomplished by periodic reversal of the water flow, pumping filtered water from the shore back through the filter gallery.

and crushed stone or cobble (Fig. 9). This raised fill sand filter functions in the same way that an infiltration gallery functions, with water drawn down through the sand and gravel into the pipes, excluding mussel veligers and other particulate materials. General dimensions for this type of



**Figure 9.** In a raised fill sand filter, perforated pipes or well screen are laid upon a layer of gravel placed on the river/lake bed. The pipes are covered with a raised fill of gravel and sand which is then covered with gravel and crushed stone or cobble.

sand filter, suitable to provide 250–400 gpd (946.35 to 1514.16 lpd) to a private residence are: 4.0 feet (1.22 meters) of 4-inch (10.16 centimeters) diameter perforated pipe or well screen, placed on a bed of 8.0 inches (20.32 centimeters) of gravel, buried 1.0 foot (.31 meter) deep under gravel, covered with filter cloth and a layer of 2 to 3 feet (.61 to .91 meter) of sand, and protected with a 6 inch (15.24 cm) layer of gravel and crushed stone. This system greatly resembles a raised fill septic leach field in reverse.

As with infiltration galleries, raised fill sand filters should be designed to be periodically backwashed.

Both the infiltration gallery and the raised fill sand filter are subject to scouring (erosion) by storm waves and ice. They are also subject to eventual clogging by fine silt and clay from adjacent soils, and organic particulate materials in the water drawn through the filter, not related to the zebra mussel problem. The pipes should be entirely embedded in gravel or wrapped with filter fabric to prevent sand from migrating into the pipe perforations. It is recommended that at least three or four such pipes be placed to ensure an adequate water supply for extreme events, or that the filters be designed to allow for periodic backflushing to remove the buildup of silt and clay particles.

### Enclosed or Prefabricated Sand Filters

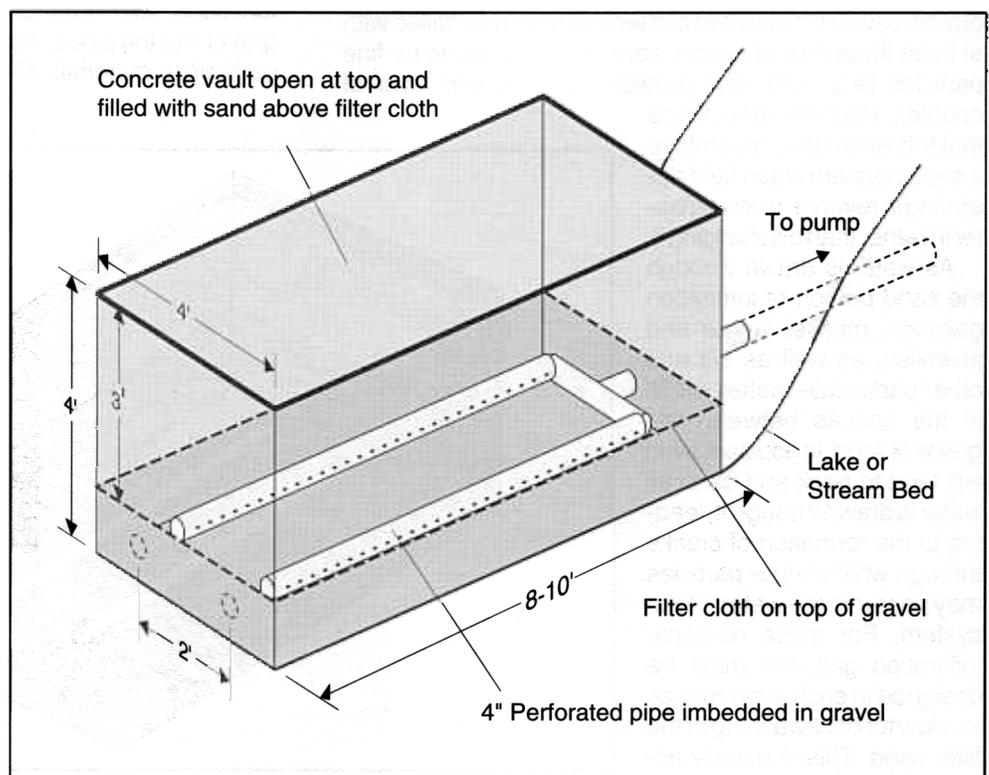
While the expense of one of these sand filters may be justified for a year-round residence, this might not be true for a seasonal cottage with a lower water demand. A possible alternative type of sand filter for such situations is the **enclosed or prefabricated sand filter**. In this approach, a concrete, steel, or plastic box, with a perforated pipe running lengthwise through it, is filled with coarse sand, placed into the waterbody, and hooked up to the residence's intake pipe (Fig. 10). General dimensions are: 4 to 6 feet (1.22 to 1.83 meters) of perforated pipe or well screen with 6 inches (15.24 centimeters) of gravel beneath, above, and on both sides of the pipe and 24 to 36 inches (61 to 91 centimeters) of sand above the pipe. A sheet of filter cloth should be used between the sand and gravel. Existing concrete castings, such as septic tanks or burial vaults, could be utilized as the containment structure. The top is not placed onto the container, allowing water to be drawn downward through the sand into the pipe excluding mussel veligers and other particulate

material. Since zebra mussels do not normally attach to sand, colonization of the open top surface should be minimal. Unless the filter is placed in water deep enough to be below storm wave scour, some rip rap (large rocks) should be placed around it to prevent undermining or shifting. Enclosed or prefabricated sand filters should be less expensive to construct than infiltration galleries or raised fill beds. Their smaller capacity makes them more suitable for seasonal cottages than for year-round residences.

As with infiltration galleries and raised fill sand filters, prefabricated sand filters should be designed to be periodically backwashed.

A number of commercial prefabricated sand filters are now on the market. No independent review of these filters is available, however, the concept they utilize (drawing water through sand into a porous pipe) is sound, suggesting such filters may have a good likelihood of success. Once again, readers should investigate any such product to determine where and when it has been used and what the rate of success has been. It is important that the filters have been tested or installed (and in operation for a season) in waters infested by zebra mussels and not merely tested against silt and algae.

In-the-lake sand filtration should prove successful for removal of zebra mussels and other larger planktonic animals and plants, but by itself is not intended to provide potable water. Additional treatment at the house end of the pipe, by chlorination, may still be needed to



**Figure 10.** An enclosed or prefabricated sand filter constructed of a perforated pipe running lengthwise through a concrete, steel, or plastic box filled with coarse sand and placed into a waterbody is a lower cost alternative suitable for seasonal or weekend cottages.

disinfect for bacterial contamination. Readers should consult their county Cooperative Extension Service or health department for more information on potable water supplies.

Possible environmental impacts of these in-the-lake sand filter alternatives include: the temporary degradation of localized water quality due to an increase in turbidity during excavation and backfilling; the disturbance of natural lake or river bottom habitats during construction; and, a change in bottom habitat type from natural to human-influenced substrate. Turbidity impacts can be mitigated through the use of trenching equipment (such as that used by utility pipeline contractors) rather than backhoes to dig the trenches and through the use of silt screens around the excavation site. With the infiltration gallery and the raised sand filter, habitat impacts may be in part offset by the provision of new bottom habitat in the form of the stone cover material. The enclosed or prefabricated sand filter may help to minimize habitat impacts by having a smaller “footprint” or area of disturbance than the other filter beds. All of these in-the-lake sand filter alternatives will almost certainly require permits from state natural resource management agencies (DECs, DNRs, etc.). A nonenvironmental drawback of these alternatives is the rather high initial cost of construction.

### **Ceramic and Cartridge Filters**

Several ceramic and cartridge filters intended for use on the intake (lake) end of the pipe are now on the market. Readers interested in these products should ascertain how long they have been in service in mussel-infested waters, what the porosity is (it should be a small enough opening that no life stages will be passed live into the intake pipe), how often they need to be backwashed (some need to be manually backwashed, some are automatic), and how often they need to be replaced with new material.

### **Removing Zebra Mussels from the Offshore Component**

Another approach to controlling zebra mussels in the offshore component is to allow a certain amount of clogging in the intake pipe followed by periodic mechanical cleaning of the system (remember, the onshore component is always protected by its own filtration/chlorination system). Such cleaning may be mechanical or thermal. To facilitate mechanical cleaning of an intake pipe, it would be advisable to install a cleanout “Y” at the shore end of the pipe to provide access to the intake. It should be noted that many people have replaced older metal pipes with new, more easily worked with PVC pipe. In terms of zebra mussel control, this may pose a major problem: researchers have found that zebra mussel larvae tend to have a preference for settling on PVC materials. PVC is even used for settlement plates in many experiments and monitoring systems. For the long term, readers might consider the use of copper or galvanized pipes.

### **Snaking**

For pipes that are short enough and that have easy access from the shore end, cleaning can be as simple and low-tech as running a modified plumber’s snake through the pipe on a periodic basis. This may not be possible for very long pipes. Once the pipe is snaked, the debris must be removed by pumping the pipe at a high rate, and the debris-laden water must **not** be allowed to enter the household distribution system. The effectiveness of this method depends upon the design of the pipeline and the intensity of the infestation. Snaking is not effective in pipes with sharp, short radius bends or anywhere the infestation is so great that the amount of dislodged mussels might prevent their effective removal from the pipe or obstruct the progress of the snake through the pipe.

### **Suffocation and Desiccation**

Since zebra mussels “breathe” oxygen as they draw water over their gills, oxygen deprivation (suffocation), accomplished by sealing off pipes long enough for the water to lose all of its dissolved oxygen, can be used as a control method. Mussels’ demand for oxygen is greatest in warm water; therefore, oxygen deprivation tends to work best in summer. Two or three days exposure to water with no dissolved oxygen at 73.5°F to 75°F (23.06°C to 23.89°C) should result in 100 percent zebra mussel mortality. Unfortunately, this means that any pipe treated in this manner must be able to be shut down and sealed for a number of days. To use this control strategy in year-round residential water systems, a second intake pipe should be added, allowing one pipe to be closed down for cleaning while water is pumped through the second.

A similar use of dual piping, most useful for seasonal cottages not using their intakes during the wintertime, is the installation of short dual pipes laid above the bed of the lake or river. When one pipe becomes clogged, it can be pulled from the waterbody, allowed to dry out completely, killing the mussels in it, and cleaned while pumping continues through the second pipe. To utilize this method in a year-round home, the main pipe, buried for protection against freezing, would be used only after the water temperature has dropped below the temperature needed for mussel spawning (approximately 50°F [10°C]). Two short pipes, which could be alternately pumped and cleaned, would be added to the system for use during the summer spawning season.

Some people have advocated the movement of intakes to deeper water in the hopes that this would prove too cold for zebra mussel colonization and lack sufficient supplies of mussel food to sustain large numbers of mussels. There is little data, however, to support this idea. Zebra mussels easily survive near-freezing water temperatures through Great Lakes winters with little damage to established colonies below the ice zone. Zebra mussels have been found colonizing down to about 200 feet (60.96 meters) and veligers have been

found as deep as 220 feet (67.06 meters) in Lake Ontario. For residential systems, deeper intakes would seem, therefore, to hold little potential for success.

For a weekend cottage using only small amounts of water for nonpotable uses, the use of a very short plastic pipe that could be disconnected and laid on the shore at the end of a weekend and reattached when the cottage is next inhabited might be a very practical control strategy. A "last resort" mechanical control for any extreme situation is the removal and replacement of clogged piping.

### Thermal Treatment

Another effective and environmentally sound method of controlling zebra mussels in intake pipes is systematic, periodic flushing of intakes with heated water. Local resource management agencies should, however, be consulted to determine whether the amount of hot water that might get into the environment would require any type of discharge permit.

Water temperatures must exceed 98.6°F (37°C) for about one hour to ensure 100 percent mortality for mussels acclimated to 50°F (10°C) water. Water temperatures greater than 131°F (55°C) will result in almost immediate death of most mussels of most sizes. After the thermal flush, mussels will remain attached to the inside of the pipe for several days; they must then be removed by pumping the pipe at a high rate of flow.

Heat treatments may be performed by flushing a pipe with hot water. The intake pipe cannot have a foot valve that would restrict the flow of water from the shore or would need a mechanically openable foot valve to be treatable in this manner. A large hot water heater would be needed to provide sufficient hot water for a heat treatment because heat loss through pipe walls into cold lake or river water is considerable. The discharge of large amounts of heated water into a waterbody could have negative local environmental impacts and may require a discharge permit from state resource management agencies.

A more suitable alternative would involve the use of a long steam hose connected to a portable steam generator set up at the shore end of the pipe. This steam hose would be tipped with a multidirectional nozzle and would be fed into the pipe through the cleanout recommended on page 9, treating the inside of the intake pipe with live steam. The more often the pipe is heat treated, the more the number and size of mussels to be removed from the pipe will be reduced. A number of plumbing contractors are utilizing this technique to clean intake pipes up to 200 feet long in the Finger Lakes. One caution: steam lines cannot be sent through pipes that

have tight bends.

### Chemical Treatment of the Offshore Component

***At this time, there are no reliable chemical treatment systems suitable for use in the offshore component of residential water intakes.*** There is great concern about potential negative effects of chlorine or other chemicals on fish or other aquatic organisms in lakes and rivers should any of those chemicals be released into the environment. Homeowners ***should not*** pour or backflush any chemicals down their water intake pipes. Such chemicals could be illegal if discharged into surface waters, might be environmentally harmful, might be harmful to human health, and might not even be effective in controlling zebra mussels. Before using any chemical treatment method, readers are strongly advised to check with local environmental regulatory agencies.

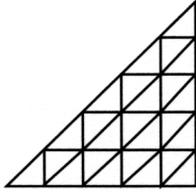
### Long-Term Socioeconomic Control Alternatives

Most, if not all, of the alternatives described in this fact sheet could be scaled up to meet the needs of more than one residence. Multiresidence zebra mussel control systems would have the benefit of reducing an individual's installation costs and might also have the environmental benefit of eliminating a proliferation of smaller, less efficient (possibly poorly installed) systems. Taken to a large enough number, multiresidence systems might facilitate the establishment of special taxation districts to pay for the installation and operation of a community-wide water treatment and zebra mussel control system.

A long-term social solution to the problem of zebra mussel fouling of residential water systems might be the extension of public water to those areas not already serviced by public water. This alternative would not be inexpensive and would take some time to implement.

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