February 2009

CASE STUDY:
The Option of Pools without 'Main Drains'

Background

The Virginia Graeme Baker Pool and Spa Safety Act ("VGB Act") and the *ANSI/APSP-7 Standard for Suction Entrapment Avoidance in Swimming Pools, Wading Pools, Spas, Hot Tubs, and Catch Basins*i are dedicated to the common goal of saving lives by eliminating entrapment deaths and injuries in pools and spas.

The focus of this study is public and commercial pools. Most public pools are regulated by state health departments. These departments formulate and enforce, among other things, the requirements for circulation and sanitation of these pools. Review of all epidemiological reports collected by the U.S. Consumer Product Safety Commission (CPSC) has revealed five distinct entrapment hazards related to drains:

- **Body entrapment**
- **Limb entrapment**
- **Hair entrapment**
- **Evisceration (disembowelment)**
- **Mechanical entrapment**

The CPSC and the industry have acknowledged these 5 forms of entrapment as affirmed in national standards approved by the American National Standards Institute (ANSI), CPSC guidelines, and many building codes. Further research has revealed three underlying causes of entrapment hazards and some serious misconceptions on the part of many regulatory agencies. Sadly, these misconceptions have contributed to entrapment deaths and injuries.

A goal of this study is to dispel those misconceptions and reveal the simplicity, functionality, and efficacy of the most overlooked solution to all of the five known suction entrapment hazards. Hopefully, this will induce health departments across the United States to take immediate action to employ this simple solution and completely eliminate even the possibility of such entrapments in the future.

To accomplish this goal it is first necessary to understand the three underlying causes of the five

entrapment hazards.

1. **Flow** (speed or velocity) of moving water through the submerged outlet
   Responsible for hair entrapment
2. **Suction** (atmospheric pressure) or the force pushing water through the submerged outlet
   Responsible for body entrapment and evisceration
3. **Mechanical causes** (shape and/or size of openings and edges of components)
   Responsible for limb entrapment and mechanical entrapment (finger, jewelry, belts, etc.)

The VGB Act and the ANSI/APSP-7 standard both require that, when submerged suction outlets are used, each outlet be protected by a cover that meets the ASME/ANSI A112.19.8 2007 suction fitting standard. When in place, with water flowing at or below the listed flow rate, these covers will prevent all five hazards.

However, as the ANSI/APSP-7 standard correctly states, there is no such thing as a backup for a broken or missing cover. Hence, should a cover become missing or broken, the only safe course is to immediately close the pool or spa to bathers until repairs can be made. It must also be noted, however, that in each of the reported entrapment tragedies in recent years, including the death of Abigail Taylor in Minnesota, the cover was not in place, and the facility was not closed as required by the ANSI/APSP-7 standard or applicable laws. This was the same issue involved in the June 24, 1993, evisceration of Valerie Lakeyii and also what killed Kiah Milsom on July 20, 2008. We can't be certain why screws become "missing," but we know that it continues to happen. Human error cannot be legislated away. There is no way to assure that such mistakes will not occur in the future. Every hazard protection method relies, to some extent, on human behavior and common sense. Elimination of the hazard though, when accomplished through design, is foolproof. It is for this reason that the U.S. Consumer Product Safety Commission wrote the following words in the latest "CPSC Staff's Guide to Complying with the Law":

> *CPSC staff recommends that to ELIMINATE and not just MITIGATE the drain entrapment hazard in pools and spas, pool owners should disable old drains or build new pools without any drains and use gutters, overflows and/or skimmers to provide water to the pump.iii*

The following historical and scientific review provides irrefutable evidence that submerged suction outlets are not required for proper sanitation or circulation of public pools and common sense dictates that elimination of the hazard is superior to mitigation every time. NO DRAINS = NO HAZARD.

Myth

A main drain is essential in a pool to maintain healthy water.

Science does not support this conclusion. In fact, science concludes just the opposite. In a 2006 issue of Fluent News, the leading manufacturer of computational fluid dynamics software, an article ran that compared pools with and without drains. The conclusion: there were no significant differences between the circulations of the two pools. In fact, the skimmer-only pool was slightly better.iv What is even more disturbing is that on page 50 of this same 2006 issue, the software was used to model a revolutionary new swim skin technology that was sure to dominate the upcoming 2008 Olympic Games. Pictured in that review: Michael Phelps, Olympic swimming gold medalist. The swim-speed technology was embraced, but the swim-safety technology was essentially overlooked by the mainstream media.

Circulating and sanitizing water in recreational bathing facilities (hereinafter referred to as pools), both residential and commercial, is neither complex nor difficult to achieve. There are only three reasons, historically, associated with requiring drain(s). First, cleaning the water. Second, sanitizing it. Both are achieved through the use of circulation and filtration systems. The third reason, historically cited, is the practical need to empty a pool.

One need only look at the wording in current state codes, for example the state code*v* in Kentucky where Kiah Milsom died on an uncovered drain in 2008, to validate that all state codes once reflected the science behind circulation:

> *Section 9. Facility Water Treatment Systems.*
>
> *(7)(c) Inlets shall be located and permanently directed to produce uniform circulation of water to facilitate the maintenance of a uniform disinfectant residual throughout the entire facility without the existence of dead spots. Inlets in facilities with skimmers shall be twelve (12) inches below the midpoint on the skimmer throat. Inlets in facilities with a prefabricated perimeter overflow system shall be eight (8) inches or more below the lip of the gutter.*
>
> *(7)(f) At least one (1) inlet shall be located in each recessed stairwell or other space where water circulation might be impaired.*

Water is cleaned mechanically by filtering out particulate matter, which is collected by vacuuming the pool, either manually or with an automatic cleaner. Water is sanitized through the use of chemicals, which can be distributed throughout the pool manually or through automatic chemical feeders. We could expand this discussion further by going into detail regarding the various methods and devices for distributing sanitizer, but for purposes of this discussion, this ancillary information will only complicate the obvious: submerged suction outlets are not necessary to accomplish either of these tasks.

The issue at hand is: where possible, “design out” the main drain. Its potential to create a hazard far outweighs its insignificant contribution to cleanliness or sanitation. This doesn’t mean drains should be outlawed, but if main drains are used, they must be safeguarded. The

purpose of this discussion is to examine whether submerged suction outlets (drains) are required to achieve adequate circulation and sanitation. All of the ANSI/APSP pool and spa construction and design standards, the VGB Act, and the latest *ANSI/APSP-7 Standard for Suction Entrapment Avoidance in Swimming Pools, Wading Pools, Spas, Hot Tubs, and Catch Basins* allow for pools to be built without submerged suction outlets (main drains).

The focus of this report is on the potential risk associated with uncovered suction outlets (main drains). Even properly installed suction outlets with approved safety covers have a potential to become a hazard if a cover becomes missing or broken. Incident reports (see data chart below) collected by the Consumer Product Safety Commission conclude that the main reason for body and limb entrapment is a missing or broken main drain cover. The data also revealed that limb entrapments have occurred in coverless open pipes when there was no water flowing through the system at all; the pumps weren't even running.*vi*

First, let's look at the history. Why do we have drains in the first place? To answer that question, one need look no further than the Biltmore Estate in North Carolina. Completed in 1895, it included a 70,000-gallon swimming pool. The Vanderbilt family would fill the pool, invite guests from all over the world to stay for a weekend, feed them southern fried chicken and collard greens, and encourage everyone to go for a swim. When the guests left for home on Monday, they would pull the plug from the bottom drain and empty the pool.

When technology advanced to the point where circulation systems were developed for recreational water facilities to clean the water, they simply hooked a pipe to the existing bottom drain and used it to feed water to the pump for filtration. That is where drains originated. They were the convenient way to transfer water from the pool to the pump. This building practice was carried over to the soon-to-be-born pool and spa industry after World War II. Research reveals no scientific basis linking the need for a main drain to properly maintained healthy pool water.

Interestingly, this advancement, from "drain and fill' to "circulate and sanitize," leads to another misconception which stubbornly persists to this day: the belief that drains are necessary to empty the pool. The reality is that pool circulation pumps drawing their water through the piping systems from the bottom drains are terribly inefficient at emptying pools. Pools today are typically emptied using high-volume centrifugal pumps designed for the task. The pump is placed on the deck near the deep end of the pool, a flexible suction hose, usually 3" or 4" in diameter is placed into the water at the deepest point, and the pump is started. A typical deckmounted centrifugal pump will empty a 15,000-gallon pool in about 1½ hours. The typical pool circulation pump could take all day to do the same job. While one might think that because a public pool requires a 6-hour turnover, that means the pool can be completely drained in 6 hours, this is not the case. As the pool water level falls, the circulation pump typically begins to lose prime and the flow rate drops dramatically.

Again, the Kentucky state code example from above confirms this misconception in its section for pool outlets:

Section 9. Facility Water Treatment Systems.
(8) Outlets.
(a) All facilities shall be provided with a main outlet at the deepest point to permit the facility to be completely and easily drained.

In fact, even the most often-used term – *main drain*, not outlet – is a clear sign of what these devices were used for before we had inexpensive and improved means to drain a pool. With the risk of suction entrapment reaching the point of requiring federal legislation, it is time to let go of tradition, and let science and engineering dictate how swimming pools are built in order to completely eliminate the possibility of entrapment.

Now, let's take a look at the empirical data and experience that challenges the "need" for drains. To begin, tens of thousands of residential in-ground concrete, fiberglass, and vinyl liner pools are constructed without bottom drains. Further, there are more than 4 million above-ground pools in use across the United States today. Typically, these pools have minimal circulation systems, many with one skimmer and one circulation return fitting. Yet, even without drains, these pools are able to circulate and sanitize pool water very effectively. There have been no health or disease epidemics reported in these pools. Consider these numbers and the evidence becomes compelling – main drains aren't necessary.

There is a tendency to attribute a different set of parameters to public pools because they are typically larger and hold more bathers. That may be true, but they also have larger and typically more sophisticated filtration and sanitation systems. Systems designed for a specific bather load are designed and equipped to maintain sanitary conditions for said load.

The pool shown below is located at a very well known South American resort and it has no submerged suction outlets (main drains). All of the water for the circulation system is delivered from skimmers placed around the perimeter of the pool spaced approximately every 15 feet. This is typical of new, leading edge, public pool construction technology. In fact, the pool in Omaha, Nebraska, where the Olympic Swimming Trials were held for the 2008 Olympics, was constructed without drains; this training pool was 25 meters wide, 50 meters long, and had a minimum depth of 2 meters.

What this shows is that a healthy bathing environment can be achieved and maintained without main drains despite huge bather loads – and is being achieved in public pools with hundreds of thousands of gallons of water.

As to the science behind cleaning and circulating sanitized water, there is one simple scientific fact at the core of this discussion: ***water, like air, cannot support a tensile force; water cannot be "pulled."*** This means that if water is to be moved, it must be "pushed" as it is through the return side of pool circulation systems. Water and air share this common characteristic. To illustrate, try sucking out a birthday candle a foot from your mouth – it is impossible. You can,

however, blow it out from a couple of feet away by pushing or forcing a blast of air at the flame. The same scientific principle applies to water.

Accepting this scientific fact leaves only one significant question relating to the suction side of any circulation system: how can the water be most effectively moved or “pushed” from the pool back to the pump? Historically, installing suction outlets (main drains) was one of the methods used to simply deliver or “push,” through force of atmospheric pressure, water towards the pump. The function of the pump was to then deliver or “push” the water through the filter and back into the pool by way of the circulation returns. Utilizing drains is one way to deliver the water; all they do is deliver the water. Utilizing only surface skimmers or overflow gutters are other accepted delivery systems that provide the additional benefit of not only delivering the water, but also cleaning the water by skimming floating debris from the surface.

The force exerted on a bottom drain, even in a gravity flow design, where the bottom drain delivers water to a collector tank with no direct connection to the pump, can be extraordinary. Atmospheric pressure is 14.7 pounds per square inch and increases as the water depth increases. This is the force that pushes the water through the piping to the pump. At a depth of 6 feet, the atmospheric pressure and the hydrostatic pressure (weight of the water) pushing on an 8-inch round drain sump could produce a force exceeding 700 lbs.

Public pools designed and constructed utilizing these same engineering concepts would actually be easier and less expensive to build – and clearly safer than pools utilizing submerged suction outlets (drains). There have been other articles on building pools without drains in *Pool & Spa News*[vii] dating back to 2003 – and others as recently as the November 2008 Issue of *WaterShapes* magazine.[viii]

The single most commonly held, yet mistaken, belief regarding drains is that they "vacuum or suck in dirt" and somehow "clean the floor." They do not. Remember the candle experiment? Pool drains are no different. If a leaf is placed two inches from the opening of a flowing two-inch pipe, it will never enter the pipe unless it is pushed in – either by a brush or by a stream of water specifically directing it to the pipe opening. In fact, a pool left un-vacuumed for several weeks is complete proof that the drain alone cannot clean the settled debris. Some debris does enter the drain, by chance, but the pool will still require routine vacuuming in order to remove settled debris. Since vacuuming, manually or via automatic cleaner, is a routine part of pool maintenance, why rely on a drain that might remove "some" of the settled debris, but also leaves bathers exposed to a proven lethal hazard?

When one vacuums a dirty pool, it clearly leaves a "clean spot" where the submerged vacuum head has moved across the bottom of the dirty pool floor. If one pushes too fast, the settled debris will be agitated and stirred up into the water – and not enter the vacuum. This happens with direct suction on the vacuum cleaner head. Vacuuming the pool requires slow, careful movement of the head so as not to disturb the settled dirt.

At home, one need look no further than the living room for proof of this same phenomenon.

When vacuuming carpet next to the couch, does it suck dirt out from under the couch or must the couch be moved to clean under it? In fact, if we were to spread some dirt out on the living room carpet and vacuum it with direct suction, it would indeed leave a clean track, just like vacuuming a pool. Now imagine if we were to switch from a vacuum cleaner to a leaf blower and try to blow that dirt out the front door? You can easily see the picture. In moments, the entire house would be consumed with clouds of dust that would settle out on every bookshelf, windowsill, china cabinet, and counter top.

Not unlike the leaf blower, it is the strategically placed return inlets that are responsible for distributing sanitizer throughout the pool. Additionally, as pools scale in dimension and size, more return inlets are required, as are skimmers. Interestingly, no matter how large a pool is, not a single state residential or public pool code requires that more than one set of drains be installed. If drains are critical to circulation, how could all states have made such a universal mistake? Submerged suction outlets, unless part of a strategically designed in-floor cleaning system, do little to clean the pool floor. Professional engineers and designers understand this phenomenon and design public pools accordingly.

Licensed professional engineers who design the construction documents and specify the circulation system requirements for commercial and public pools call for the addition of circulation return inlets as pools grow in size and shape to effectively distribute sanitized water throughout the pool. For example, they call for return inlets to be placed in alcoves and step areas outside the pool perimeter. They may call for additional skimmers or conversion from skimmers to a perimeter overflow gutter to better clean the pool surface in large pools.

They never call for additional submerged suction outlets (drains). This is not an oversight or an error. The professional design engineers clearly understand that circulation and distribution of sanitizer is achieved by the “pushing water” phenomenon through the return side of the system – and not through suction outlets (drains). And they specify separate vacuum pump systems for debris removal, knowing that drains do not remove dirt or contaminants. Number, location, size, and direction of return inlets and fittings determine how well water is circulated, agitated, and distributed to all areas of the pool.

In summary, with regard to sanitation and distribution of sanitizer, main drains contribute virtually nothing to the distribution of sanitizer in a pool. They simply deliver “used” water back to the pump after the sanitizer has done its job. The main drain delivers the "used" water back to the pump where it is pushed through the filters and picks up fresh new sanitizer to be delivered back to the pool on its return trip.

Another myth regarding drains is that they are required to produce adequate water flow. Consider the circulation requirements. The *ANSI/APSP-5 2003 Standard for Residential Inground Swimming Pools* requires that all the water in the pool must be filtered and circulated at least once in 12 hours. In a 15,000-gallon pool, that would equate to a flow rate of 21 gallons per minute (gpm). Most skimmer manufacturers recommend a minimum flow rate of 30 gpm for effective skimming. Many of these skimmers are NSF-rated to 55 gpm and some skimmers

are rated up to 80 gpm by the National Sanitation Foundation. By arranging the return fittings in a pattern to direct the water into all areas of the pool, a single skimmer is all that is needed. And all the water in a 15,000-gallon pool could be filtered in 7 hours and 15 minutes, saving energy at the same time. If the equipment were run for a full 12-hour cycle, it could filter and sanitize 25,200 gallons effectively.

Commercial codes vary as to circulation requirements, but short of some theme parks, wave pools, and special effect pools, virtually all of them could operate without submerged suction outlets and most of their circulation systems are already capable of providing 100% of the flow from the skimmers or gutter system.

Finally, consider existing public pools. Old, single drain pools should be the highest priority when considering drain safety, since they represent the greatest potential hazard. Why? Because they are prone to having older covers and sumps on single-source piping connected directly to a pump. These covers and sumps have probably degraded and weakened over time, posing a greater risk of failure. The solution, in almost every case, is a relatively simple re-piping at the equipment to reverse the flow and transform the main drain suction outlet into a return inlet. Disconnect the drain(s) from the suction side of the pump and re-connect them to the return side of the system after the heater and sanitizer. By converting the drain(s) to a return, circulation and sanitation can be greatly improved and you have successfully “designed out” the primary cause of suction entrapment in a pool. If there is a concern for enough water to supply the pump in a residential application, a skimmer could be added or the flow rate could be reduced. As shown above, most residential pools currently flow at a rate exceeding the needs of the system.

Most commercial pools are already sized to have the capacity to deliver all of the required system flow from the skimmers or overflow gutter. If the piping is not accessible or for some reason cannot be reversed, permanent drain disablement is the next best option. Permanently “glue in” a plug or fill the drain outlet with concrete.

Even in the case of flow reversal or drain disablement, it is still critically important to keep listed safety covers in place to prevent a limb entrapment or mechanical entrapment.

The Consumer Product Safety Commission has reported 155 entrapment incidents over a 17-year period from February1985 through August 2002. Of the 155 data files, there were 141 that provided enough information to categorize. Of the reported incidents, 52% occurred in residential pools and 48% in public pools.

CPSC DATA

Entrapment Type	# Entrapped	# Deaths	% Deaths
Hair	50	14	28%
Limb	39	10	26%
Body	47	8	17%
Evisceration	5	0	0%

These incidents were investigated, analyzed, discussed, and categorized – all in the effort to find solutions and prevent such tragedies in the future.

The *ANSI/APSP-7 Standard for Suction Entrapment Avoidance in Swimming Pools, Wading Pools, Spas, Hot Tubs, and Catch Basins* offers this technology and other options that are completely consistent with the federal Virginia Graeme Baker Pool and Spa Safety Act which, too, allows for pools to be built without a main drain.

For further study and test data, go to this scientific Fluent Studyix and review this Dye Test Videox of water entering a drain flowing at 800 gpm under only 11 inches of water. Note that the dye casually disperses and is not immediately "sucked" into the drain.

The conclusion of all these investigations is that none of the reported entrapment incidents would have or could have occurred if there were no submerged suction outlets. The message is clear. Where possible, "design out" the main drain – but if drains are used, they need to be safeguarded with existing technology.

---

i ANSI/APSP7
Standard for Suction Entrapment Avoidance in Swimming Pools, Wading Pools, Spas, Hot Tubs, and Catch Basins, The Association of Pool & Spa Professionals (the ANSI/APSP-7 standard was approved in 2006 by the American National Standards Institute).

ii During the 2004 U.S. Vice-Presidential Debate (October 5, 2004, in Cleveland, Ohio), Senator John Edwards stated: "It turns out the company knew of 12 other children who had either been killed or severely injured by the same problem. They hid it. They didn't tell anybody. They could have fixed it with a 2-cent screw. That's wrong."

iii U.S. Consumer Product Safety Commission, Virginia Graeme Baker Pool and Spa Safety

Act, CPSC Staff's Guide to Complying With the Law (2008).

iv "Eliminating the Risk of Swimming Pool Drains," *Fluent News: Applied Computational Dynamics*, Volume XV, Issue 2 (2006).

v Kentucky State Code: 902 KAR 10:120. Kentucky public swimming and bathing facilities.

vi "Limb entrapment in a swimming pool suction outlet: A multidisciplinary approach to inhospital extraction," Injury Extra, Toosy, N.A. *et al.*, Volume 37, pp. 225-337 (2006).

vii "A Draining Experience – a pool builder's fight to change Florida's dual main drain code and 50-year-old industry assumptions," *Pool and Spa News*, April 2003.

viii "Considering an Option," *WaterShapes* magazine, Volume 10, Number 11 (2008).

ix "Computer Simulation Shows Pools Can Be Made Safer by Eliminating Drains," 2006 (http://www.fluent.com/solutions/sports/CS103-trilogy-pools.pdf).

x "Drain Testing Using Dye for Effect on Pool Circulation," 2008 (http://www.youtube.com/watch?v=0IOUGhuKkSM).

Disclaimer

This article contains information believed to be accurate and correct as of the date of publication by the members of The Association of Pool & Spa Professionals (APSP) who have reviewed it, including members of the APSP Technical Committee, under whose auspices this article was prepared. The information contained in this article does not constitute legal advice. The Association of Pool & Spa Professionals makes no claim, promise or guarantee about the accuracy, completeness or adequacy of the information contained in this article, and accordingly assumes no liability for the use of the information contained herein. The Association of Pool & Spa Professionals will not be liable for direct, indirect (including, but not limited to, any loss of business or anticipatory profits), incidental or consequential damages resulting from reliance on the information contained in this article.

Copyright Notice