The lighting of water in motion is equal parts engineering and art. To be successful at it, observes Paul L'Heureux of Crystal Fountains, you need to combine an understanding of the available technology with an eye for what's involved in accenting movement with light. Here, in the second part of his discussion of fountain lighting, he gets specific about techniques that bring moving water to life when the sun goes down.

Light Sensations

By Paul L'Heureux

Just as a painting comes alive with a tiny lamp perched over its frame or a simple landscape becomes a nighttime spectacle with strategically placed spot and flood lights, illuminated water creates an intense experience for the eyes. Lighting adds depth and dimension while revealing subtle details and producing emotional responses among those who view and enjoy these scenes.

The simple truth is, if we didn't light water in fountains and other watershapes, much of its visual beauty would be lost. As we discussed in "Guiding the Lights" (*WaterShapes*, March 2001, page 48), understanding and applying the various approaches and techniques of lighting water enables professional watershapers to operate on whole new levels.

In the following pages, we'll continue that discussion with a look at what it takes to maximize the aesthetic effects of water in motion and discuss some practical issues having to do with lighting installation and safety.

Solutions in Motion

Last time, we identified the various categories of water effects, design considerations for each and the most effective of the available lighting solutions. This time we'll dig deeper, exploring ways of achieving those solutions and showing off certain water effects to the greatest possible extent.

To review the basics, water in motion typically does one of four things. It either falls downward from a water source, flows over a surface, shoots up in the air or arches from one point to another. The "look" of each of these motions can be dramatically maximized using specific lighting strategies.

▼ **Falling Water:** Natural light is still one of the most effective lighting sources for water as it falls, but relying strictly on that source means that the nighttime drama of falling water will not be exploited. Taking advantage of that drama means that you must set up the appropriate type of lighting fixtures in adequate numbers in the correct locations and at the proper angles.

Because the majority of waterfalls are less than six feet high, up-lighting is usually the most effective method for evening viewing. We recommend using wide floodlights (250-watt halogen lamps minimum) spaced four to five feet apart for even lighting across the entire waterfall (Figure 1). You'll want to use angle-adjustable fixtures and position them either in front of or behind the falling water.

Remember to keep light fixtures away from the heavily aerated water that circulates around the "landing zone," because this bubbly water disperses too much of the illumination.

▼ **Sloped spillways:** These water effects are among the greatest challenges in watershape lighting. Just what do you illuminate?

The key to capturing the water's motion is to create "pick-up" points for the lighting – that is, places where the water vertically drops (however slightly) or where water and air mix together. By designing these details into the project, you provide ample opportunities for creative lighting.

In the case of sloped water, we often design the surface with plated elevation changes. Where two plates of stone are overlapped, it causes turbulence in the water's flow that allows air to mix with the water (Figure 2). These spots are excel-

Figure 1: Many waterfalls are designed with water drops of six feet or less. In these cases, you can position light fixtures in front or behind the water to good effect – so long as you keep them away from the foamy water.

Figure 2: When it comes to illumination, sloped water spillways are among the most challenging of all water effects. Fiberoptic lighting has definitely simplified the process because of its compact nature and the fact that it doesn't heat up the way conventional lighting fixtures do.

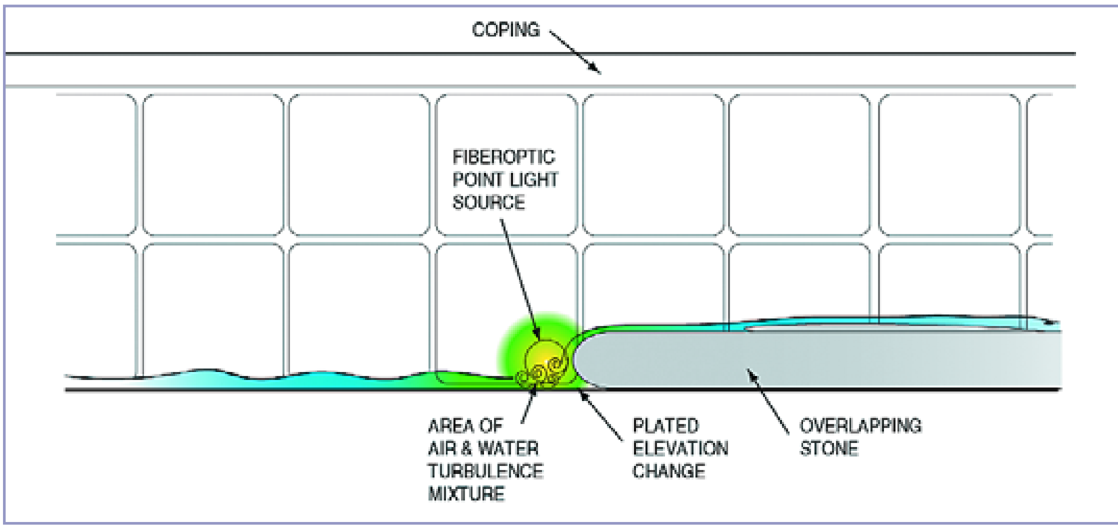

Figure 3: For best results with sloped water-features, locate fiberoptic point lights in a wall close to the elevation change.

lent locations for evening illumination.

The next question has to do with *how* these small places are to be illuminated. The answer, naturally, is that small details require small lighting solutions. In general, we've found that fiberoptic lighting is ideal in these situations (Figure 3). Point lights made with 100 fibers (and 150-watt metal halide illuminators) or with 50 fibers (and 250-watt metal halide illuminators) can be used in the walls beside the plated elevation changes, washing light over the surface and the drop to great effect.

▼ **Vertical fountain effects:** A vertical fountain effect is one of the more common and traditional forms of watershaping. Illumination is generally straightforward and typically means placing a submersible fixture next to the nozzle.

Most practitioners will design with spotlights for narrow and high water effects and floods of medium beam width for wider effects such as a ring of closely grouped small vertical nozzles (see Table

I for some selection guidelines).

Grouping or arranging the submersible fixtures is just as important as selecting the correct lumens level and beam characteristics. We usually design water-effect illumination with at least two submersible fixtures because most are viewed from all sides and angles (Figure 4). Exceptions to this rule occur when vertical water nozzles are grouped together (as in a circle, for which you can achieve consistent illumination from all viewing angles by locating the fixtures *inside* the ring of nozzles).

Place the fixtures close to the surface of the water, just one or two inches below the surface, because lighting efficiency drops considerably when you get much deeper. Lighting efficiency also

Table I: This chart helps when it comes to picking lights for different water effects.

Primary Applications/Types of Effects	Beam Height	Lamp Life (hours)	Watts	Volts	Lamp Type	Beam
Reflecting surfaces	N/A	7500	80	120	A-21	Flood
and pool perimeters	N/A	8000	100	120	A-21	Flood
Medium single jets	10 ft	6000	100	120	PAR-38Q	Spot
Low waterfalls, rings, bell jets	6 ft	6000	100	120	PAR-38Q	Flood
Medium single jets	15 ft	6000	250	120	PAR-38Q	Spot
Medium waterfalls, rings, bell jets	8 ft	6000	250	120	PAR-38Q	Flood
Low waterfalls, rings, bell jets	5 ft	2000	150	120	MCQ	Flood
Medium waterfalls, rings, bell jets	8 ft	2000	250	120	MCQ	Flood
Medium waterfalls, foam & cascade jets	2 ft	2000	500	120	MCQ	Flood
Medium single jets & pools	25 ft	2000	300	120	PAR-56Q	Spot
Medium rings, spheres & foam jets	15 ft	2000	300	120	PAR-58	Flood
Medium single jets & pools	25 ft	2000	300	12	PAR-56Q	Flood
Large single jets	35 ft	4000	500	120	PAR-56Q	Spot
Large rings, foam & cascade jets	20 ft	4000	500	120	PAR-56Q	Flood
Very large single jets	50 ft	4000	1000	120	PAR-64Q	Flood
Very large rings, jets, pools	30 ft	4000	1000	120	PAR-64Q	Flood

drops significantly when the fixture can't be aimed accurately at a water effect, so seek out submersible fixtures with tilt-and-swivel adjustments. They're a little more expensive, but well worth the flexibility and the larger grins on your clients' faces when they see their waterfeature beautifully illuminated at night.

▼ **Aerated vertical fountain effects:** Aerated water is the white, foamy stuff created by combining air and water. This effect requires double the light intensity per vertical foot when compared to clear-stream nozzle effects.

When positioning fixtures to illuminate these effects, the key is to keep as much foamy water away from the light sources as possible in order to maximize light intensity (Figure 5). Again, be sure the light fixture lenses come close to the water surface, within an inch if possible. If you're designing with large aerated nozzles, such as cascade jets or aerator jets over 1-1/2 inches in diameter, always position the light fixtures at least two feet away from the nozzle (Figure 6).

▼ **Sculptural and structural waterfeatures:** Sculptures and structures will take on different attitudes when you illuminate selective features, so your lighting design can take advantage of all available corners, angles and hollows. By using narrow-beam spots, for example, you can create striking contrasts between the illuminated features and their offsetting shadows (Figure 7 on page 44).

The key to lighting sculptural waterfeatures is to start with moveable floor fixtures so you can optimize lighting locations *after* construction. Non-moveable fixtures will limit your options, and we've found that it's better to give yourself as many alternatives as possible. For exam-

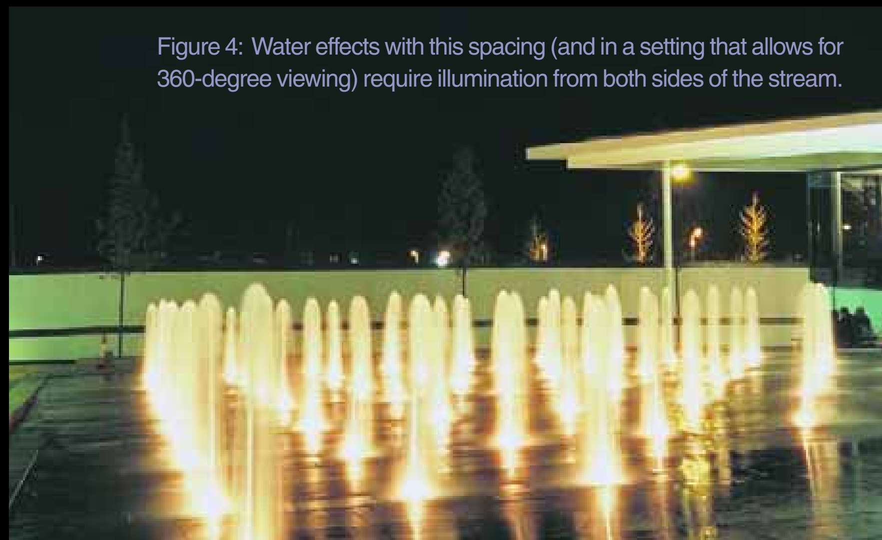

Figure 4: Water effects with this spacing (and in a setting that allows for 360-degree viewing) require illumination from both sides of the stream.

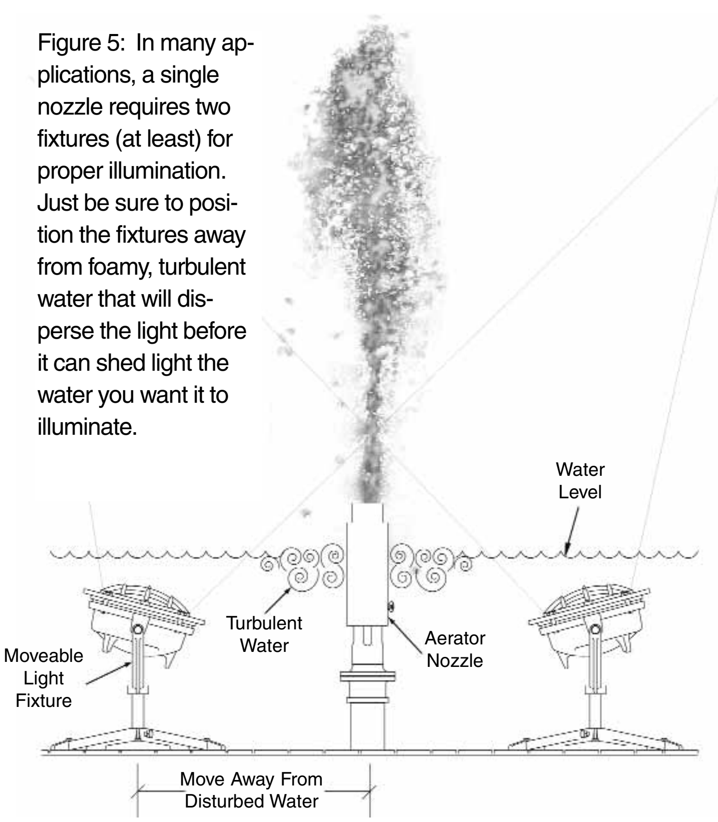

Figure 5: In many applications, a single nozzle requires two fixtures (at least) for proper illumination. Just be sure to position the fixtures away from foamy, turbulent water that will disperse the light before it can shed light the water you want it to illuminate.

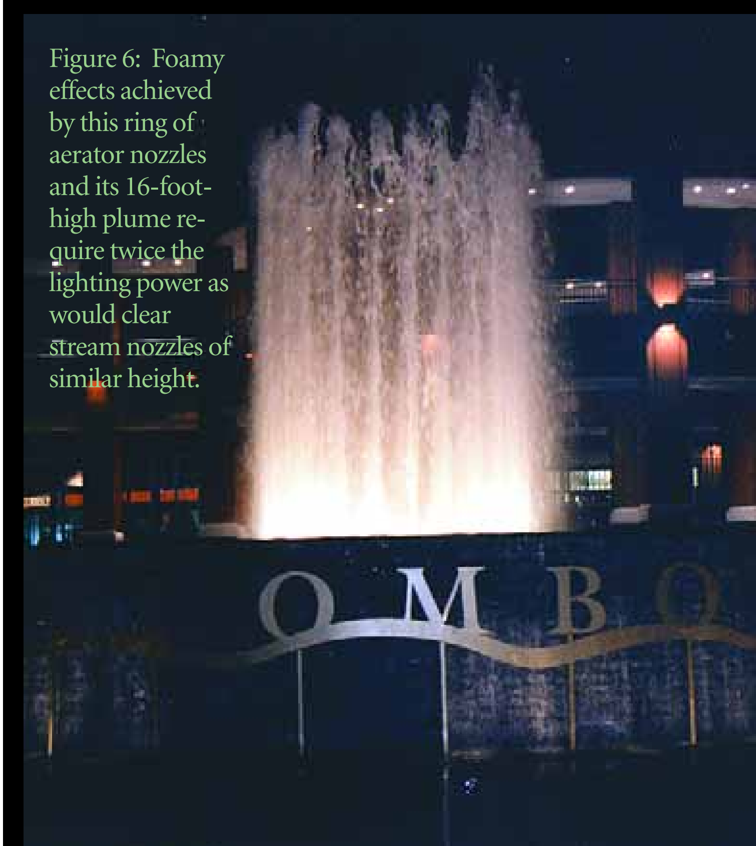

Figure 6: Foamy effects achieved by this ring of aerator nozzles and its 16-foot-high plume require twice the lighting power as would clear stream nozzles of similar height.

Clean and Clear

Dirty lenses on submersible fixtures affect lighting performance in the same way muddy headlights reduce visibility for a driver.

If you require a rock guard on your submersible fixtures to meet local electrical codes, purchase one that can easily be moved away from the lens surface for routine cleaning. In our experience, we've found that hinged rock guards are ideal for this purpose.

– P. L.

ple, simply being able to adjust the angle of a light allows you to capitalize on an opportunity previously unseen. In fact, the places you thought might be best for fixture location might turn out to be less than optimal in actuality.

Spotlighting of this sort generally calls for halogen lamps between 75 and 150 watts when projecting through clear, non-aerated water. Floodlighting will require lamps between 150 and 300 watts, depending upon illumination heights.

Physical Factors

As you ponder the potential of lighting to make your water effects into 24-hour wonders, there are a number of basic, practical issues you need to consider.

▼ **Rock guards:** To protect outdoor lighting fixtures from vandals and wayward stones, you may wish to add rock guards. These devices protect the glass lenses of submersible fixtures from breakage. Depending on the manufacturer, their construction can be bronze, stainless steel or lexan (polycarbonate plastic). If you need to use these fittings, expect to lose between 10% and 15% of the light intensity.

Figure 7: Illuminating selective features of a structure (A) or sculpture (B) sets up an entirely different impression for evening viewing.

▼ **Water Level Protection:** Submersible lights generate a good deal of heat and need water to keep them within allowable operating-temperature ranges. To ensure that the light fixtures are submerged when operating, NEC requires a device to protect these fixtures from overheating – meaning you have no choice in the matter.

Traditionally, the most effective solution is incorporating a water-level-sensing device in the control circuit of the light fixtures (Figure 8). These low-voltage devices, which are available in many types, sense the level in the body of water in which the fixtures are submerged. We often use simple magnetic-read switches – a technology that has been around for decades and offers great reliability in a compact package.

▼ **Thermal Protection:** This offers you an alternative to water-level sensing as a way to deal with potential overheating of submersible light fixtures. Thermal protection devices were introduced about 14 years ago and feature bi-metallic strips that bend when heated. This causes a metal contact to open, shutting off power to the lamp.

This is the same device that the average household toaster uses to prevent burnt toast. They are less effective than water-level sensors but let you comply with NEC rules where the physical configuration won't let you use a water-level device.

▼ **Ground Fault Protection:** The most important consideration in setting up lighting systems in water is public safety. NEC calls for class 'A' ground-fault protection for electrical devices of more than 12 volts that are within 15 feet of a publicly accessible body of water.

For swimming pools and fountains, this means that any light fixtures the public can touch, either in or around the pool, must be ground-fault protected if they exceed 12 volts. (This is, by the way, the

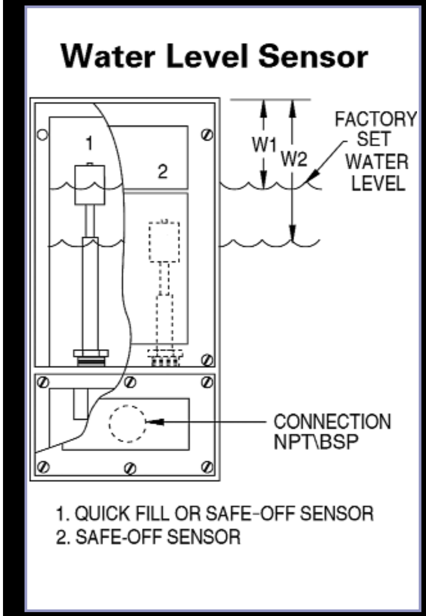

Figure 8: A float-style sensor will reliably detect safe levels of water and ensure that an underwater light is submerged before operation.

Fiberoptic Advice

At Crystal Fountains, we've had extensive experience with fiberoptic illumination in both commercial and residential waterfeatures. Through the years, we've found that the commercial-grade metal halide illuminators are far superior to (less-expensive) residential-grade metal halide illuminators in lumen output (light intensity).

The lamp technology is identical in both cases. The most significant difference is that the optic packages – that is, the lenses and mirrored surfaces that sit between the lamp and the fiberoptic port – are far superior in the commercial units. In this situation, you truly get what you pay for!

– P. L.

same level of protection required for receptacles in bathrooms.)

▼ **Light-Fixture Cooling in Special Applications:** We've been involved in more than 800 watershaping projects around the world, and our experience has often led us to lighting applications that require creative, hybrid or weird solutions.

In one case, we had designed an interior waterfall that created so much aerated water over the submersible light fixtures that it virtually choked off the light and wouldn't let it illuminate the falling water. Our solution was to raise the submersible fixtures out of the water and hook up the lighting circuit through a time delay relay with a contact on the pump overload. This allowed foam to build up at the base of the waterfall and surround the fixtures before the lights turned on.

Another project required lighting in a fountain that had no body of water. The solution was to divert water from the pump and have it circulate through a water jacket surrounding each light fixture – the same principle as the cooling system in the engine of an automobile.

A Different World

Lighting design and application is very much its own science and art. No set of magazine articles can replace personal exploration of the technologies and techniques used to illuminate moving water, and what we've covered here is no more than an introduction to a fascinating field.

There is no shortcut: True expertise in lighting is gained only through experience and applied knowledge built upon a foundation that starts with the principles and technologies discussed here. Ultimately, when you approach the design or installation of a watershape with lighting as an integral part of the project, you'll see that creative illumination is the key to a whole set of wonderful aesthetic possibilities.

Emerging Technologies

The accompanying text began by stressing the importance of understanding how lighting works – as well as being aware of the technologies available to you in developing good lighting solutions.

Not surprisingly, as moving water has become ever more prevalent in residential and public settings, new technologies have made their way into the market. Two of them in particular have gained popularity in recent years:

❑ **Metal Halide Lighting:** Metal halide lighting is a form of high-intensity-discharge (HID) technology that has been used for many years in industrial and commercial lighting. It is often used in highway illumination, for example, and for other applications requiring *very* high light outputs.

Recent changes to the National Electrical Code (NEC) and Underwriters Laboratories (UL) requirements for submersible fixtures have made it possible to use ballasted light sources for the first time, opening the watershaping trades to this powerful light source.

Previously, the maximum voltage allowed in the water prevented such applications. Now, provided that the supply does not exceed line voltage, a ballast may be used within a sealed light fixture. This has led more lamp manufacturers to develop HID lamps, which includes the PAR-style bulbs that have proved very attractive in fountains.

Metal halide's advantages include long bulb life and substantially higher lumen output per watt. This efficiency also comes with a higher color temperature than halogen and a whiter (less yellow) light. While it can be used in submersible applications, it has seen limited underwater use thus far: Most U.S. jurisdictions would allow its use, but electricity is still cheap enough that other approaches are still preferred, while in Europe, where only low-voltage lighting can be used in submersible applications, metal halide use is prohibited.

Nonetheless, this technology has sparked interest in the Americas because it has potential to light a fountain or pool with strong white light at lower wattages. Expense is a limiting factor because of the need for a ballast-and-transformer arrangement and the higher cost of the bulbs. In the near future, however, we foresee the use of 500-watt metal halide light sources with very large fountains (that is, those with 40- to 60-foot high plumes) in place of the 1,000-watt halogens currently being used.

One area where the flexibility of metal halide lighting may allow it to advance more quickly is with wet/dry applications and deck-level fountains: As the lamp manufacturers develop more HID bulb varieties in lower wattages, this field in particular will open up. So in general terms, it'll pay to watch this category of lighting for future developments: Lighting suppliers are moving in this direction at a rapid clip in all areas.

❑ **Light Emitting Diode (LED) Lighting:** It's not ready for the fountain market just yet, but super-bright LED lighting – an industrial-strength version of the familiar LED lights on clocks, dashboards and computers – has great things going for it.

It's a new way to create color effects. In the past, filters were placed in front of fixtures to isolate selected parts of the color spectrum. A company called Color Kinetics has developed an interesting technology that generates intense colors directly, without filters, in a way that gives the user real control of the color output.

The system has plenty of advantages:

• First, the average incandescent or halogen bulbs last 2,000 to 5,000 hours, which means re-lamping every six months to a year. By contrast, LED products have 100,000 hours of life, meaning it'll be 10 or 12 years before they need replacing.

• Second, because they produce less heat per lumen, this will allow manufacture of housings and lenses from plastic instead of metal and glass, resulting in cheaper fixtures that don't radiate as much heat as other lights.

• Third, LED products can be *tiny* – as small as 1/4-inch in diameter and just 3/8-inch in height. This means that, without the constraints of big bulbs or fiber bundles, we'll be able to create smaller light sources and enjoy far greater design flexibility.

Those are big potential advantages to which must be added a fourth: LED products are both energy efficient and submersible. LEDs will be great in wet/dry applications, for example, because they radiate less heat. They'll offer a nice glow beneath the coping at the edges of fountains or swimming pools. We could even create submersible cove lighting.

A limiting factor at this point is the relatively low amount of light LED systems produce compared to halogen lights. But where the application makes sense (that is, with a five-foot column of water rather than a 20-foot column of water), LED shows great promise.

This is another area where lighting suppliers are investing a great portion of their research and development budgets. These lights are already being used in architectural applications as a replacement for fluorescents and in exit signs and flashlights. The cost is still high at the moment, but once these LED systems gain greater acceptance in the design community, it's likely that prices will drop.

– P.L.