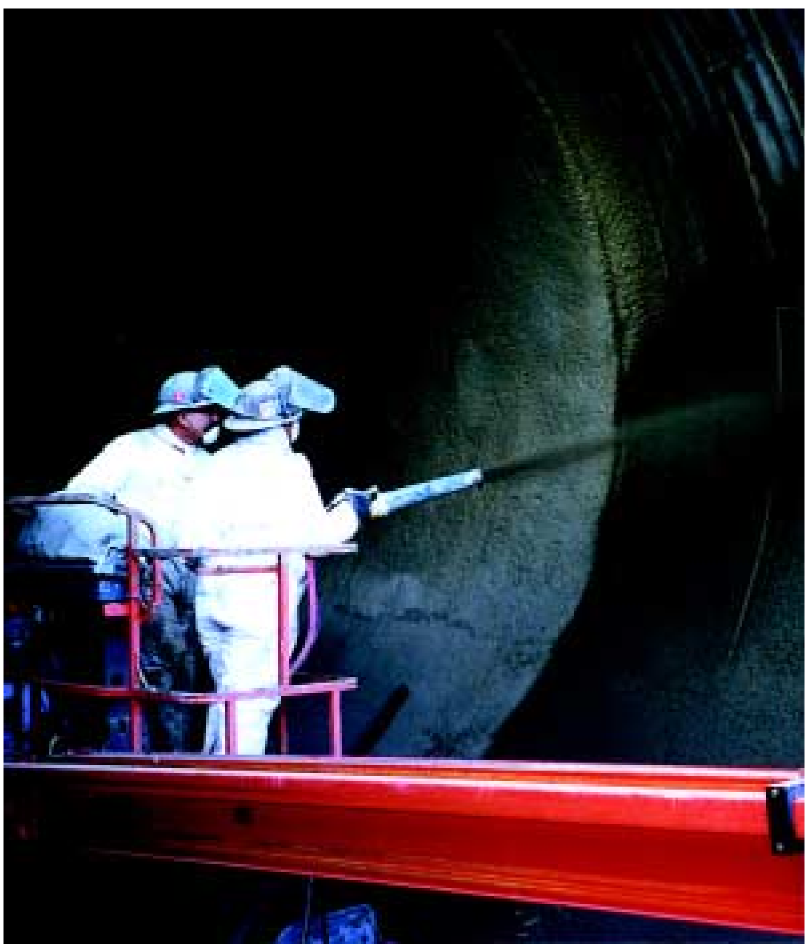
Welcome to Underground Atlanta

by Charles M. Brown

We are standing in the very bowels of the City of Atlanta. This isn't the trendy "Underground Atlanta" of rock-till-you-drop nightclub fame. The millions of busy Atlanta citizens above us today don't have any idea that we are down here. All they care about is that when they flip the little silver lever on the water tank, everything that is disagreeable goes somewhere else.

Where it goes, how it gets there, and what happens to it is our job. This 12-ft-diameter, man-made cavern known as the Highland Creek Trunk Sewer Interceptor stretches seemingly forever before and behind us. The professional shotcrete applicators of the Coastal Gunite Construction Company are here placing a new, biologically active gunite in this sewer interceptor. The Department of Public Works is here to inspect the rehabilitation work as Coastal Gunite recoats the interior of the Highland Creek Interceptor with this new bacteria-fighting gunite material.



Coastal Gunite employees shoot the final coating on the walls of the Highland Creek project.

The Highland Creek Trunk Sewer Interceptor was built during the same period that Elliot Ness was chasing Al Capone around in another big city well north of here. While Big Al was ducking the feds, Atlanta's city fathers, engineers, and contractors were busy building a sewer system that would serve Atlanta for decades to come. Little was known then about the corrosive effects of long-term exposure to acids caused by hydrogen sulfide gas-fed microbial growth. At that time, Atlanta's builders thought their bricks and mortar would last for centuries to come. It wasn't until 1945 that Australian C. D. Parker identified *Thiobacillus* bacteria as the source of microbial-induced corrosion (MIC) in sewers.

In early 1996, a material was perfected and tested that demonstrated an extraordinary array of performance characteristics. The material results in a 100% reduction of *Thiobacillus* bacteria on and in concrete upon placement and has been shown to maintain a 100% reduction of microbial growth for a 5-year period. The material is water-soluble and can be used like a common admixture for gunite or concrete. Coastal Gunite simply adds the manufacturer's recommended dosage rate to the mixture water for the gunite. This material is 100% safe for animals and humans. It attacks only single-cell microbes. There is no leeching out of this material; it becomes bonded to the molecules of concrete and makes the concrete material a hostile environment—but just to microbes. Microbes are no longer free to colonize in or on the concrete. Best of all, ConShield™ is EPA-registered (Registration Number 70871-12) for use as an antimicrobial admixture for concrete.

Fortunately, since January 1997, the City of Atlanta, aided with this new biologically potent concrete additive, has taken a proactive approach to fighting MIC in our sewers and manholes.

Curt White, President of Coastal Gunite Construction Company, is very happy with the results of our microbe-fighting additive in his shotcrete mixture. Curt reports, "We don't even notice it. It's just part of the mixture water. ConShield™ doesn't disrupt any of our normal gunite procedures."

To fight MIC in the sewer environment with gunite, we must understand why the sewer pipes are eaten away and fail. Hydrogen sulfide gas (H_2S) is a natural gas-off of sewer effluent. Extended flow times in the sewer line allow increased production of H_2S. The more turbulent the effluent, the more H_2S is released. This commonly occurs at lift stations and manholes. This gas collects in the top of the wet sewer pipe above the flow line, where it combines with carbon dioxide (CO_2). Both of these "acid" gases produce a mild, weak acid solution when they dissolve into the moist environment on the top of the sewer pipe. The CO_2 produces carbonic acid, and the H_2S produces thiosulfuric and polyphonic acid. Both of these acids combine with the calcium hydroxide ($Ca(OH)_2$) in the concrete to reduce the pH of the surface. But these mild acids are not to blame for sewer line corrosion. Once the pH of the concrete falls from its initial levels of pH 11 or pH 12 to approximately pH 9, biological colonization by *Thiobacillus* bacteria will occur. At this point, the contest between the durability of the concrete or mortar and the deterioration from acids produced by the *Thiobacillus* bacteria begins. The timeline toward serious corrosion and even line collapse has started. And now, it's just a matter of time—the concrete will eventually lose.

The various species of *Thiobacillus* bacteria have the unique ability to convert H_2S gas to sulfuric acid (H_2SO_4) in the presence of oxygen. As the *Thiobacillus* bacteria colonize, they absorb H_2S and excrete H_2SO_4 in greater and greater amounts. Different species of *Thiobacillus* colonize, reduce the pH, and die out, leaving the acid production to the next, more aggressive species of *Thiobacillus*. The pH of the concrete changes from alkaline to very acidic. Once the pH of the concrete surface reaches pH 4, the most aggressive species of *Thiobacillus* colonizes and takes over. This species is known by its common name *Thiobacillus concretivorous* (Latin for "eats concrete"). The presence of *Thiobacillus concretivorous* can thrive at a pH level of 0.5.

The H_2SO_4 volumes at this very acidic level attack the matrix of the concrete or the mortar and brick of the sewer system. Concrete is composed of calcium silicate hydrate gel (CSH), calcium carbonate ($CaCO_3$) from aggregates (when present), and $Ca(OH)_2$. The primary by-product of concrete decomposition by H_2SO_4 is calcium sulfate ($CaSO_4 \cdot 2H_2O$)..."gypsum."

That's right, the acidic conditions caused by the colonization of the *Thiobacillus* bacteria turn the concrete matrix into another material. We know "gypsum" as the base material of gypsum drywall board. Of course, this gypsum in the sewer line is very wet and has no structural value. Imagine your concrete or brick and mortar sewer lines constantly turning into wet gypsum wallboard from the inside out. Gypsum appears as a pasty, white mass on the deteriorating inside surface of the top of sewer pipes. As the deterio-

Finished sewer line.

ConShield™ protected concrete applies just like plain gunite or shotcrete. No adjustments need to be made in the application.

ration continues, the blobs of gypsum paste grow larger, and the structural concrete of the pipe deteriorates into yet more gypsum. Depending on the conditions in an individual sewer system, the reduction in pH or, conversely, the rise in acid levels may take years or just a few months.

Once the Department of Public Works understood the mechanisms of MIC, we considered the various ways to combat this acid invasion into the Atlanta sewer systems. Several methods have been used in attempts to combat sewer system decomposition from MIC. Most of them are mildly successful at best, and almost all are very expensive. Some of these methods include: 1) oxygen injection in force mains, inverted siphons, U-tubes, hydraulic falls, and side streams; 2) chlorination; 3) hydrogen peroxide; 4) iron and zinc salts; 5) shock dosing with sodium hydroxide; 6) potassium permanganate; 7) sodium nitrate; 8) ozone; and 9) bacterial cultures and enzymes. All of these expensive processes are only temporary fixes, and are costly and never-ending. Even the use of calcium aluminate cement, which is touted as being corrosion-resistant, is not an EPA-registered material and is very costly. Liners for sewer pipes will often delaminate from the walls of the structure and form an area that itself requires costly repair.

Since January 1997, the City of Atlanta has been using ConShield™ in new sewer construction, and now we are including ConShield™ in the gunite refurbishing of old corroded sewer lines and interceptors like Proctor Creek Trunk and Highland Creek Trunk. As we stand here inspecting this biologically active gunite protection to this 100-year-old interceptor line, it feels good to know that once our work is completed here, the Highland Creek Trunk Sewer Interceptor will be better than new, as well as corrosion-resistant for many years to come.

Charles M. Brown is Installation Chief and Principal Field Engineer in the Engineering Operations Division of the Department of Public Works, City of Atlanta, Georgia. He is a 16-year veteran with the Department of Public Works. For more information, please contact Charles Brown at (404) 817-6828. Information about ASA member company Coastal Gunite can be found at www.coastalgunite.com.