Something extraordinary is happening below the land that surrounds South Boston’s North Dorchester Bay. Beneath the streets and the sands on the shore, a remarkable system is being put in place that will address a problem that has long plagued the area’s popular beach. For decades, rainfall in the area has often resulted in contaminated water flowing directly into the bay, frequently followed by the raising of red flags on the beach warning swimmers to stay out. In a typical summer, the beaches of South Boston and North Dorchester Bay close on average once every five days due to water quality problems. When the system under construction is complete, the swimming will hardly ever need to cease.

Despite the project’s significance, few people even know it is going on. Sunbathing, strolling, swerving through the traffic on William J. Day Boulevard—it all went on uninterrupted this summer while underground a marvel of engineering bore its way through soft ground, slowly snaking its way along a 2.1-mile-long subterranean route and leaving behind the carefully sculpted tunnel that is the project’s centerpiece. Keeping disruptions to a minimum has been a goal of the project’s developer—the Massachusetts Water Resources Authority or MWRA—but the agency is not trying to keep it a secret. Nor should it be. The undertaking has been uniformly praised, even by those who have never shied away from criticizing the MWRA in the past.

“This is a project that will give us one of the cleanest urban beaches in America,” said Bruce Berman, director of strategy and communication at the Boston-based non-profit Save the Harbor/Save the Bay.

The beaches will be clean because the polluted water that streams into the bay during a rain event will instead flow into the tunnel for storage until it can be treated. It is a clean, logical solution. But executing it is an elaborate, expensive endeavor. Completion of the project is still years away. For now, the tunnel is empty and dry. And on occasion, it is open to visitors.

JOURNEY DOWN BELOW
A small group of NEIWPCC Commissioners and staff gathered at the project’s headquarters, a temporary cluster of offices in South Boston’s Conley Terminal, best known as the place where colossal cargo ships are loaded and unloaded around the clock. We were there at the invitation of Charles Button, a NEIWPCC Commissioner and the MWRA’s deputy chief operating officer, who...
has been intimately involved with the project since its infancy. Button ushered the NEIWPCC group and the dozen other people on the tour into a small conference room, its walls lined with minutely detailed drawings of the tunnel and the machines involved. He spoke briefly about the project and the exquisitely crafted Japanese-made tunnel-boring machine or TBM that was doing the digging. He then introduced Ian Ward-McNally of Hatch Mott MacDonald/Shaw, a joint venture overseeing the construction for MWRA.

Ward-McNally, who is British, has been an engineer on tunneling projects around the world for 36 years, and is different about the MWRA project, he said, that is it is one of the few low-cover tunnels he has worked on. There are only about 20 feet between the tunnel and the surface above.

“The challenge,” he told the group, “has been to stay above the bedrock.” And below the obstacles above. “We have to mine under high-pressure gas mains, cast iron water mains, as well as the normal electrical lines.”

They also must dig beneath the sewer pipes that discharge polluted water into North Dorchester Bay during storms. Like many parts of Boston, the neighborhoods around the bay are still serviced by an aging combined sewer system, meaning the pipes carry both domestic sewage and stormwater—that is, the runoff from rain or snowmelt that becomes tainted with pollutants as it moves across streets and other impervious surfaces. A combined system works fine except when rain creates an inflow of stormwater that pushes the system beyond its capacity. When the system cannot handle the flow coming in, the excess wastewater, containing stormwater and raw sewage, is piped straight into a waterbody—all treatment bypassed. It is called a combined sewer overflow or CSO, and they are not rare. The U.S. Environmental Protection Agency estimates that every year the combined sewers in this country spill about 850 billion gallons of untreated waste and stormwater into America’s waterways.

The sewer pipes through which the spilling occurs are called CSO outfalls, and around North Dorchester Bay, there are seven of them, known unaffectionately as BOS081 through BOS087. Their days of sullying the Bay, were built in the middle to late 19th century. The systems provided a key public health function: they kept out of the streets and away from people. But in time, as BOS081 through BOS087. Their days of sullying the Bay, we moved.

In case we needed reminding, a demonstration by a guide made clear this was no art museum tour. He showed us the masks we would be given if a fire broke out. The masks convert deadly carbon monoxide into carbon dioxide, and while the odds of needing the masks were exceedingly remote, you do not take chances underground. Tunneling remains dangerous work.

In New York City, 23 workers have died since 1970 in accidents related to the construction of a third water tunnel for the city. During the building of the Channel Tunnel between the United Kingdom and France, ten workers died. Thankfully, the MWRA project has been largely accident-free. And any risks to our tour group were minimized by the TBM taking a time-out. It had been moving so steadily through the ground—averaging 80 feet a day—that the project was ahead of schedule.

The digging was on hold for several weeks while New Hampshire-based CSI Concrete Systems made more of the concrete slabs that line the tunnel walls.

With the introductory talks complete, we left the office and walked across the Copley Terminal grounds, in the shadow of towering cargo cranes, to the rim of the vertical mining shaft through which people and equipment enter the horizontal tunnel. We clambered down stairs into the shaft, and peered into the dark. As guides steered us into worn, cramped open-air cars on the small train that runs on rails laid down as the TBM advanced. A warning came: don’t stick your head out when the train is rolling unless you want to lose it. Guides latched safety chains, like those on an old amusement park ride, next to each row of seats. Into the earth, we moved.

LONG TIME COMING

As the train crept through the 17-foot wide tunnel, it was hard not to think about the progress it represents—and how long it took to get to this place. To get to the roots of the project, you must go back a very long way. The combined sewer systems found in many older U.S. cities, including Boston, were built in the middle to late 19th century. The systems provided a key public health function: they finally got human waste, and its inherent health hazards, out of the streets and away from people. But in time, environmentalists and health advocates seized on their one major drawback—combined sewer overflows, which convey into watersways bacteria and other microbial pathogens that can kill fish and cause skin rashes, diarrhea, fever, and stomach cramps in humans.

One way to avoid CSOs and their health hazards is to get rid of combined sewers altogether. Most younger American cities are serviced by separate sewer systems, which transport only sewage from homes and businesses, with the water flowing down storm drains conveyed by a different set of pipes. While there is no threat of a CSO with a separate sewer system, they are not foolproof. They can be afflicted by sanitary sewer overflows or SSOs, dangerous releases of raw sewage that occur when their capacity is exceeded, usually during heavy rains when water infiltrates cracked pipes or surges in through illegally connected sump pumps and drains.

Replacing a combined sewer system with a separate system also involves serious costs, financially and logistically—which has not prevented it from being done in some neighborhoods in the Boston area, just not everywhere in the city. Legally, something had to be done. In 1983, the Conservation Law Foundation sued government agencies, demanding that the discharge of raw sewage into Boston Harbor be halted and the harbor cleaned up. The lawsuit initiated years of legal wrangling in what became known as the Boston Harbor Case, and ultimately resulted in a Federal District Court Order requiring among other things action on CSOs. In 1990, the MWRA and its engineering consultants proposed a $1.3 billion CSO plan that involved building an extensive system of pipes for diverting CSO flows into tunnels dug deep into bedrock. Four years later, the MWRA came back with a different, less expensive plan that took into account sewer system improvements that had already reduced CSO volumes. Rather than proposing a grand scheme of deep tunnels, the 1994 plan called for some 25 different CSO projects throughout Boston, Cambridge, Somerville, and Chelsea. The court and regulators approved, and the plan remains in effect today, though the number of projects now stands at 35, with a total price tag of $840 million. As of the end of 2007, 21 of those projects had been completed, contributing significantly to the 81 percent drop in CSO discharges in the Boston area since 1988. The projects range from sewer separations costing less than $3 million to the grandaddy of them all, the North Dorchester Bay storage tunnel and its related facilities, which are projected to cost $264 million.

Where is the money coming from? Not long ago, Washington would have been the likeliest answer, but no longer. The stream of federal grants for wastewater infrastructure, which was crucial in helping communities across America build much-needed wastewater treatment plants and related systems in the middle part of the last century, dried up in the 1990s as the grants program shifted to a low-interest loan program known as the Clean Water State Revolving Fund. While the CWSRF has undeniably been helpful—providing $63 billion in loans since its inception—a loan with a low interest rate is still a loan: it has to be paid back. And that has put an added burden on state and local governments, which have not exactly been flush with cash in recent years.

To get the CSO projects done, the MWRA is relying on its own resources—that is, the money it gets from ratepayers. Such an approach is only viable because the MWRA keeps the money it collects for providing water and sewer services to 61 Boston area communities, rather than sending it to a general city or state fund where it could be tapped for projects far more popular with
politicians and the public, such as school improvements or more police on the street. For fiscal 2007, the MWRA reported customer service revenues of $306 million, with operating expenses less than half that at $227 million. Even if you consider the agency’s hefty liabilities—it has incurred more than $5 billion in long-term debt—the MWRA is still in good shape: its total assets in fiscal 2007 exceeded total liabilities by well over $2 billion. With a balance sheet like that, the MWRA appears to be on a firm financial footing with the capacity to spend on major projects. It also has the capacity to listen and to adapt to what it hears, according to Bruce Berman of Save the Harbor/Save the Bay. Berman said that early plans for the North Dorchester Bay tunnel called for the construction of a system that would eliminate CSO discharges in even the most rare, freakish storms. It was an admirable, ambitious plan. But clean water advocates saw a flaw: it might not lead to fewer beach closings. Damaging as they are, CSOs are not solely to blame for the fouling of the bay’s waters during rainstorms; there is also the dirty stormwater runoff that enters the bay not through the combined sewer system, but via separate drainage systems run by the Boston Water and Sewer Commission and the Massachusetts Department of Conservation and Recreation. Even when there is not enough rain to trigger a CSO, the stormwater flowing through these separate systems alone can taint the waters to the extent that swimming must be shut down. So, the advocates pushed for a different system, one that would forego the containment of CSO discharges during extremely severe, seldom-seen storms in exchange for controlling CSO and separate stormwater discharges during lesser but far more frequent rain events.

“The MWRA was a little skeptical at first,” Berman said. “But as we worked together, and focused on what we should be looking for, they began to realize what the benefits were. They’ve been a fantastic partner, and Charlie Button was really instrumental in helping us to craft the plan.”

That plan—the one we were seeing being executed on our tour—calls for the tunnel to not only be linked to the CSO outfalls but also to the separate stormwater drainage systems, so the runoff they have traditionally conveyed into the bay will instead be redirected to the tunnel. That will mean a whole lot fewer beach closings than there would have been in a CSO-only plan, since the system will capture all the CSO discharges and stormwater generated by rain events up to the size of a one-year storm—that is, storms that are so big, they happen on average only once a year. When the area gets hit by a one-year or larger storm, the system will catch less than everything, with the amount going out to sea depending on the amount of rainfall. The system will likely be overwhelmed in a 25-year storm, which is a storm seen on average just once every 25 years, or to put it another way, with a 4 percent chance of occurring in any single year. With a storm that size, the MWRA’s Button said, “All bets are off.”

Beach advocates accepted the tradeoff. “We thought it was a good idea to design a program to address low-rain events that are frequent,” Berman said, “and to basically back off on the largest events, when you were going to lose the beach anyway.”

The MWRA’s embrace and execution of the plan, and its heavy spending on it, is all the more impressive when you consider it is under no legal obligation, no statutory or regulatory requirements, to manage separate stormwater. The tunnel we were traveling through could easily have dealt with only CSOs, but the MWRA was open to other ideas.

“I never thought five years ago that I’d be saying this,” said Berman, “but it’s a pleasure to be working with them. It is a pleasure now.”

**FRONT OF THE LINE**

The train stopped when it reached the temporarily silenced tunnel boring machine, and we stepped out into the brightly lit work area. We milled about in the dank air, admiring the machinery, while around us, workers took advantage of the downtime provided by the shutdown to perform maintenance tasks. One worker told us we were not missing much by being there when the TBM was idled.

“It’s so slow that the movement is barely perceptible,” he said.

But its progress could easily be perceived. After receiving the TBM unassembled from Japan on September 6, 2007, the MWRA’s contractors on the tunneling job—M.L. Shank of Denver, Colo.; the British engineering firm Balfour Beatty; and Barletta Engineering of Canton, Mass.—pieced it together at the top of the mining shaft and then lowered it in to begin drilling in mid-October. Twenty hydraulic cylinders pushed the massive 350-ton drill forward as the cutterhead at the front spun slowly (a few times per minute) and relentlessly. The tunnel began to take shape.

In November, when the TBM was about 300 feet in, in went all the trailing gear, including the rail cars used to carry out the roughly 900 cubic yards of dirt and rocks (or muck in tunneler’s parlance) carved out of the earth each day. By March 2008, the TBM had mined 3,200 feet, and on the date of our tour, May 7, the tunnel was well over a mile long. In mining, slow but steady gets the job done.

Ward-McNally pointed out the smooth, curved, 4-foot wide, 10-inch thick concrete slabs being installed as the tunnel’s walls in the wake of the TBM’s progress, then led a small group of us up to what he called the “nerve center” of the operation, the TBM operators’ cabin. When the machine is drilling, two workers sit in a space barely large enough to accommodate them, keeping an eye on screens and instruments that monitor

continued on page 4

*Underground Expert* Adjacent to the temporarily idled tunnel boring machine, Ian Ward-McNally of Hatch Mott MacDonald/Share, the joint venture managing the construction of the CSO tunnel, speaks with Becky Weidman, NEIWPCC’s director of water resource protection.

*Seat of Control* In the TBM operators’ cabin, every movement of the machine is carefully directed and monitored. Note the circle of 20 lights, each of which corresponds to one of the TBM’s push cylinders. When the TBM is operating, the lights shine bright red for all cylinders engaged in the drilling.
every aspect of the TBM’s operation and progress. Amid the impressive technological array, a circular group of colored lights stood out. Ward-McNally explained that each light corresponded to one of the machine’s 20 push cylinders, or rams as they are sometimes called.

“Depending on how you’re steering the machine,” he said, “you may be only say engaging the bottom ten cylinders, and their lights would all be bright red. That would be if you were trying to push the machine up to keep it on grade. Likewise, you might be using more rams on the left-hand side to push you around a right-hand turn.”

Because of the shutdown, the seats in the cabin were empty, but that was an anomaly. Considering that work was going on in the tunnel in two nine-hour shifts, five days a week, the TBM was usually plowing ahead, with operators watching every move. Careful monitoring was also being done above ground, as survey crews watched closely for any signs of settlement in the ground over the tunnel. With any tunnel, some settlement is inevitable, but too much of it can lead to damage to buildings and streets. At most points along the North Dorchester Bay tunnel route, no more than an inch of settlement is allowed. Ward-McNally said that limit had been exceeded a few times, but without any major impact.

A climb up a short ladder led us to a walkway above the train we’d rode in on. With the work on hold, it was quiet and calm there—but that too was unusual. On a normal day, with the powerful TBM noisily grinding away, workers on the walkway would be keeping a close eye on the muck carried on conveyor belts and dropped into the rail cars below. The crew knew exactly how much muck should be generated based on the type of soil the TBM is moving through. Too much muck is a sign of overmining—that is, too much ground being removed too quickly. When that occurs, the TBM is quickly throttled back to avoid potentially dangerous settlement above.

From the walkway, it was hard to miss the large ventilation tube that runs along the top of the tunnel and brings fresh air to the front. It was one more reminder of the unnaturalness of a human presence in this place. Some workers seemed to revel in that, and in the obvious chasm between their everyday experience and that of the office workers they were escorting.

“Software when we lose power,” said a worker standing on the walkway, “it’s so black you can’t see the hand in front of your face. That’s why we’re all wearing headlamps.” He smiled. Most of us did too, though uneasily. We were all aware of looking slightly ridiculous in the plastic helmets we had donned at the tour’s outlet—and in the lack of a lamp on our heads. You had to hope nobody pulled the plug.

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