

## ENGINEERING

# Boston down under

Stabilizing water table is key to 'mooring' imperiled townhouses

By Brad Pokorny  
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If there were a device that could peer below ground as easily as a telescope scans the sky, the landscape beneath Boston's Back Bay would appear as an inverted forest, awash with the detritus of several generations, a dank and surreal place traversed by sewers, water, subway, and abandoned railroad lines.

Stripped of their branches and driven into the ground upside-down, thousands of spruce trees stand under the stately 19-century townhouses for which Back Bay is famous. Because the Back Bay was once a huge tidal flat, the trees were needed as support pilings to moor buildings into the heavy marine clay that lies below the organic silt and porous gravel fill on top.

Although wood usually begins to rot when it is buried, if the ground is saturated with water, the cellulose within its cells is protected from the fungi and bacteria that cause decay.

That's why, a hundred years ago, townhouse builders were confident about the strength of the piles. They knew that with the sea all around, the underground water level would seek the mean tidal level, especially given the porous nature of the sand and gravel fill. And so they cut the piles off

below sea level, assuming they would be protected by the heavily saturated silt.

What they did not count on, however, was the complexity of Boston's future - underground, from the turn of the century on, subway tunnels and buried railroad embankments, which act like and buried railroad embankments, which act like underground dams, and expanding sewer lines, which can serve to drain groundwater away, have caused the Back Bay's underground water level to fluctuate in some areas - a factor that directly affects the pilings' durability.

That understandable miscalculation now has dozens of Beacon Hill homeowners facing potentially huge foundation repair bills to shore up rotting wooden pilings, decaying because of a localized drop in the water table that has exposed the wood to oxygen, inviting the growth of decay-causing fungi and bacteria.

In the last two years, for example, at least five townhouses along Brimmer street on lower Beacon Hill have undergone extensive foundation repairs. And, engineers who have studied the problem say, other townhouses in Back Bay and the Fenway could be threatened in the future if groundwater levels are not carefully monitored.

"The problems on Brimmer street, they are PILINGS, Page 38

ELEVATION IN FEET

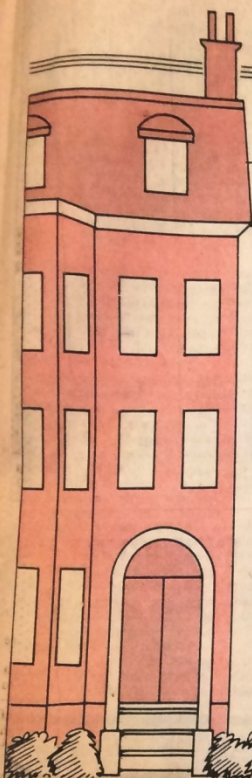
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TYPICAL GROUNDWATER LEVEL

Zone where damage is occurring

RECENT GROUNDWATER LEVEL

Fill

Rotted pilings are cut off below lowered ground-water level, replaced with steel beams and encased in concrete

Organic silt

Marine clay



Groundwater seeps into sewer system through cracks in pipe and is drained away, thereby lowering water table



Source: Haley & Aldrich, Inc.



# Stabilizing water table a key

## ■ PILINGS

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flashy and the owners are distressed, but they are an indication of problems that can occur elsewhere," said James R. Lambrechts, a senior engineer with Haley and Aldrich, Inc., a Cambridge-based geotechnical firm.

Repairing the townhouses on Brimmer street have cost their owners between \$150,000 to \$200,000. In many instances the upper two feet of the piles have been turned into a soft, clay-like substance that crumbles at the slightest touch. Repairs require cutting off the rotted piles below the lowered water level, where the wood is still good, and shoring up the foundation with new concrete and steel pilings.

City building inspectors say dozens more among the 188 homes in a nine-block area around Brimmer street could ultimately require similar repairs. Otherwise, they say, the building run the danger of collapse.

Engineers suspect the water table on lower Beacon Hill has dropped because the sewer system there is draining away groundwater. Because sewer pipes are usually empty and often lie below the underground water surface, they can act to drain away ground water if they are cracked or leaky.

The search for leaks has entailed a months-long examination of the sewerage pipes — an examination that at one point required special water-proofed television cameras dragged through in the sewers on a cable.

Once the pipes that are draining away the groundwater are found, they will likely be replaced, relined, or permanently plugged, according to Charles Button, the chief engineer for the Boston Water and Sewer Commission. Button said his engineer are in the final stages of their search, and should be able to decide on a course of action soon.

## Solution may be costly

That may not be a simple or inexpensive task. Several of the pipes run near or under Storrow drive, Button said, and traffic might have to be diverted there if those particular pipes need to be dug up and replaced. On the other hand, he said, there are techniques available for re-lining sewer pipes without digging them up — but only if the cracks are small.

Button acknowledged, as well, the possibility that similar problems could arise suddenly almost anywhere in the Back Bay. He believes the situation is far from critical, however. "There are no signs right now to indicate that buildings are settling anywhere except in the Brimmer Street area," Button said.

One private contractor who specializes in restoring wood piling foundations, however, said last week that at least one building in the Fenway has been found to have rotted pilings. William Langrill, an engineer at F.E.S. Inc. who is doing the work to repair those piles, declined to identify the building. However, he said it seems to be an isolated case. "Not all the pilings under the building are rotted," Langrill said. "So that doesn't really indicate a prolonged lack of submersion."

A look at the geological and topographical history of Boston explains why wood pilings were used in the first place.

When the first English settlers arrived in 1625, most of modern Boston was submerged or part of a



Clifford Kay, geologist, on lower Beacon Hill. GLOBE PHOTO BY WENDY MAEDA

vast tidal flat. But as the city grew and prospered, more land was needed.

## Trains carried in fill

In 1857, the Legislature authorized a vast project to fill in the Back Bay. The project took nearly 30 years. For a time, three special 35-car trains were used around the clock to haul sand and gravel in from the hills of Needham. The fill was dumped directly on the soft peat and decayed organic matter of the tidal flats. To support the heavy brick townhouses of the period, long pilings were sunk through that fill and into the firm marine clay underneath.

"Basically, they banged in a whole forest of pilings beneath each building," said Clifford Kaye, who has been studying the geology under Boston for the US Geological Survey since 1955. (Most modern buildings are set on steel and/or concrete piles where necessary, and are not affected by drops in the water table.)

The first major problems came in 1929 when cracks appeared in the walls of the Boston Public Library. An investigation showed its wooden support piles had rotted because of groundwater leaks into a nearby sewer — much like on Brimmer street.

That led to a groundwater monitoring program in the late 1930s. Under supervision of the US Works Progress Administration, 70 monitoring wells were sunk throughout Back Bay and the water table was carefully mapped for the first time. Many of those wells have since been paved over and lost.

"The thing people should key in on is the lack of data about ground water in the area," Lambrechts said. "What happened on Brimmer street could have been prevented had groundwater levels been monitored." He believes the city should begin again to carefully monitor its underground water levels.

## TV cameras used in search

In some respects, the Brimmer street problems have been complicated by an underground system that has become so complex engineers are not always sure how a change in one section might affect the water levels elsewhere.

Specifically, engineers believe the water tables along Brimmer street are somehow tied into the flow levels of the Boston Marginal Conduit, a 8-foot-diameter sewerage thoroughfare that runs under Storrow drive along the Charles River along most of the perimeter of Back Bay.

This spring, TV cameras were dragged through the conduit and connecting pipes to search for the cracks and breaks that might be taking in groundwater. "In the old days, they would put a man thought the smaller pipes, but this is a much safer thing to do," Button said.

Some cracks were found, Button said, and engineers continue to work to define which cracks are critical in draining away the groundwater. This is done by plugging and unplugging the pipes, in an attempt to find out which have the greatest effect on underground water levels.

Engineers have discovered that by raising the flow in the Boston Marginal Conduit, groundwater levels in the Brimmer street neighborhood can also be made to rise, indicating that the conduit is partly responsible for groundwater drainage.

## Could be other factors

Flow levels within the conduit appear to have dropped in recent years because of a pollution control pumping station installed in 1981 near the Museum of Science, according to John Vetere, a sanitary engineer with the newly formed Massachusetts Water Resources Authority, which manages the flow in the Boston sewerage system and elsewhere.

Engineers such as Vetere and Button are quick to add that cracks in Brimmer street could be caused solely by the Marginal Conduit. In addition, to the connecting sewer pipes, Button and Vetere said, other contributing factors could include leaky connections to the homeowners' own sewers and/or a powerful sump pump that keeps the Storrow drive underpass at Berkeley Street dry. That pump, for example, removes 20,000 gallons of water a day even in dry weather, indicating a possibly large drain on local groundwater supplies.

Whatever the cause of the Brimmer street depression, Lambrechts believes residential and commercial building owners throughout the Back Bay should be alert for signs of water table depression in their own neighborhoods. According to the US Census Bureau, there are more than 15,000 housing units in structures built before 1940 in the Back Bay and Beacon Hill.

Said Lambrechts: "If you have problems like quickly increasing cracks in your walls, tilting window sills, or floors that are not level anymore, than you should call in somebody for a professional opinion."