

WOOD PILINGS, GROUNDWATER, AND THE BOSTON GROUNDWATER TRUST:

A Model of Cooperative Problem Solving

By Elliott Laffer

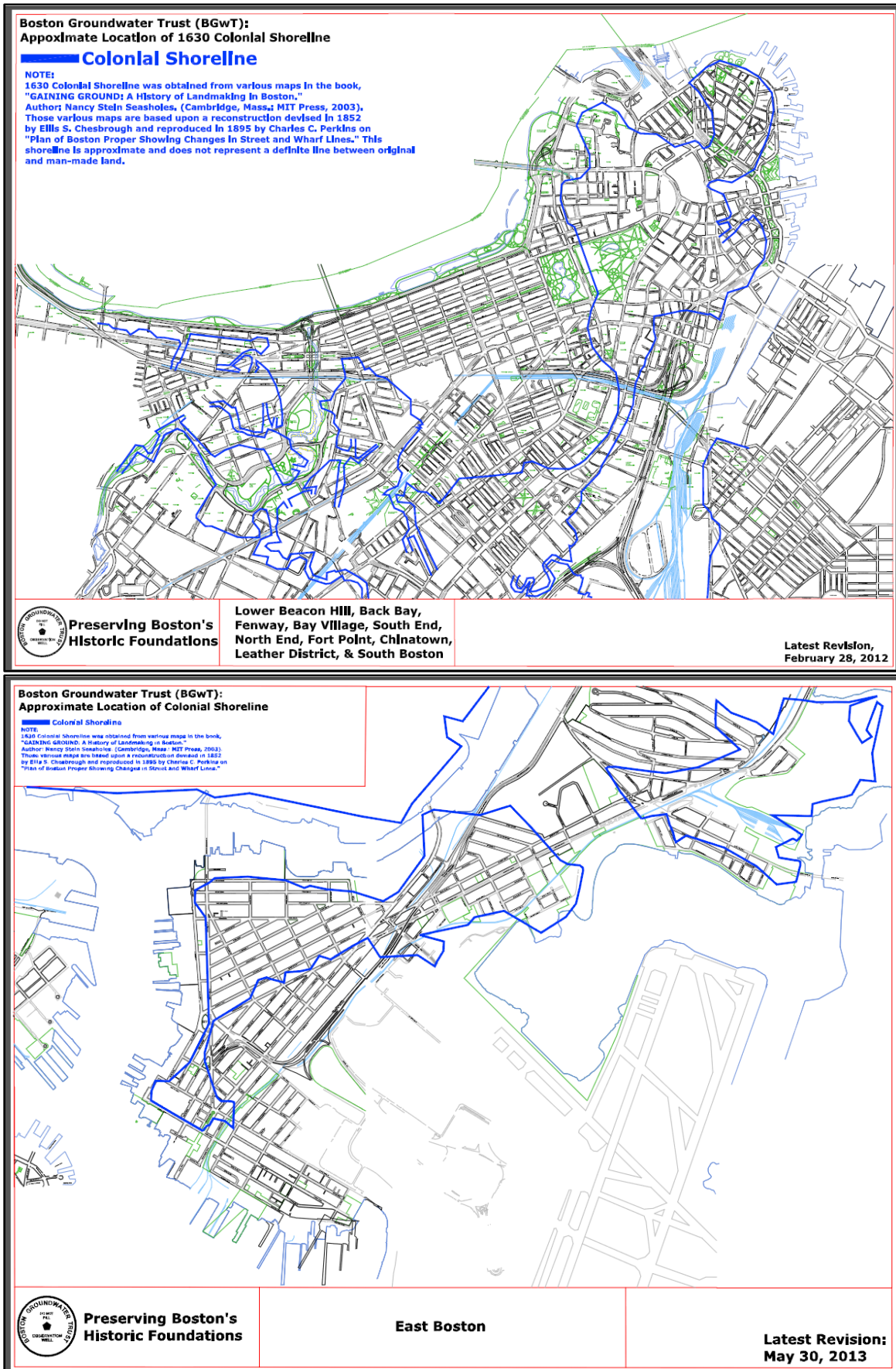
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INTRODUCTION

As Boston grew, it would create the conditions for an eventual groundwater crisis. The need to keep submerged in groundwater wood pilings that support buildings in areas where the ground is unable to do so was well understood from centuries of use of the technology in Europe by the time structures were built in Boston using that foundation system. Designers and builders did consider the elevation of the groundwater table when deciding at what level to cut off the tops of the pilings. Yet, with all of that forethought, groundwater levels still dropped below the piling tops as the addition of sewers, tunnels, multiple level basements, and other below grade infrastructure blocked the water flow and provided paths for the removal of groundwater from a trapped system. At the same time, paving of streets and parking areas, along with the installation of roof drains to the sewer system, cut off natural recharge of groundwater from precipitation. From the early part of the twentieth century on, there were sporadic attempts to implement policies to protect these foundations. Yet, problems persisted as lessons went unlearned or forgotten, other concerns were considered more important, and the different levels of government and the private sector failed to work together to solve the problem.

This history is an effort to understand why it took so long for the issue to get adequate attention, how a group of Boston citizens and neighborhood groups raised the alarm, and how the multiple entities involved have joined together to work successfully toward solutions. It is based on interviews with many of the people who have been involved in the process, my experiences as executive director of the Boston Groundwater Trust from 2004-2014 and in other earlier roles with the Neighborhood Association of the Back Bay, and a review of many documents. I want to thank all of those, listed below in chronological order of the interviews, who gave their time to share their recollections with me. I also want to thank my daughter, Dr. Stephanie Laffer, a professional historian who guided me through the thought process on how to approach the project and how to conduct oral history interviews and who acted as my editor. I particularly want to note the critical contribution to solving the groundwater problem of Mayor Thomas Menino who passed away as I was conducting interviews; I believe it is fair to say that, without his decision that the City would devote serious efforts to solving the problem, very few of these successes would have occurred.

ORIGINAL SHORELINE MAPS



INTERVIEWEES

Galen Gilbert, former trustee and secretary, Boston Groundwater Trust

Paul Demakis, former state representative

Robert Beal, Beacon Hill homeowner

Peter Pogorski, South End homeowner and member Citywide Groundwater Emergency Taskforce

Jim Lambrechts, professor at Wentworth Institute of Technology

Jim Hunt, former Chief of Energy and Environment, City of Boston

John Sullivan, Chief Engineer, Boston Water and Sewer Commission

Antonia Pollak, former head of Environment Department, City of Boston

David Jacobs, Publisher, *Boston Courant*

State Representative Aaron Michlewicz, trustee, Boston Groundwater Trust

U.S. Representative Michael Capuano

Jon Lenicheck, aide to Rep. Capuano

Tom Keane, former Boston City Councilor

Henry Luthin, City of Boston Law Department

David Scondras, former Boston City Councilor

Peter Sherin, former trustee and treasurer, Boston Groundwater Trust

Don Wiest, former zoning attorney, Boston Redevelopment Authority

Tony Pangaro, Beacon Hill homeowner

Marty Walz, former state representative

Tim Mitchell, trustee and cochair, Boston Groundwater Trust

Gary Saunders, trustee and cochair, Boston Groundwater Trust

GROUNDWATER TIME LINE

- 1907** – Maximum wood piling height cutoff elevation of 5' BCB is included in Boston Building Code
- 1911** – Rotted pilings reported in a building on Beacon Street in Back Bay
- 1920's** – Piling repairs required for some buildings in the flat of Beacon Hill
- 1929** – Boston Public Library requires underpinning of some of its supporting pilings at cost of \$250,000
- 1936** – Works Progress Administration (WPA) funds installation of an observation well network of about 1000 wells. Network is monitored through 1940, then abandoned after expiration of the contract
- 1970's and early 1980's** – Buildings in Fenway and Chinatown are demolished because of rotting pilings
- Mid 1980's** – Piling problems surface in the Brimmer Street area of Beacon Hill. Lawsuits filed against City and MDC/DCR
- 1986** – Boston Groundwater Trust (BGWT) established by Boston City Council. Geography generally restricted to area of City Council District 8
- Early 1990's** - Trustee terms expire; Trust goes dormant because of a lack of quorum
- 1997** – New trustees appointed; Trust resumes meetings, gets first City funding
- 1999** – BGWT begins reading water levels in about 150 preexisting observation wells from WPA and other projects after hiring coop students to locate them and confirm they were still operational.
- 2002** - \$1.6MM included in Environmental Bond Bill to install new well network. Swift administration agrees to release funds over three years, Romney administration follows through on promise, City contracts with Trust to install well network
- 2002** –Trust launches www.bostongroundwater.org to post elevations from observation well readings as well as other groundwater related information
- 2002** – Public forum sponsored by a coalition of South End and Back Bay neighborhood associations
- 2003** – Boston Water and Sewer Commission (BWSC) and Massachusetts Bay Transportation Authority (MBTA) install pilot continuous recharge system on Saint Charles Street in South End
- 2003** – Trust begins installation of well network using funds from Environmental Bond Bill as well as funds provided by US Environmental Protection Agency (EPA)
- 2004** – Trust hires first full-time staff, gets a separate tax id and becomes a City-related 501(c)3 organization
- 2005** – City hires Jim Hunt as first Chief of Energy and Environment. He is charged by the Mayor with addressing groundwater as one of his first priorities
- 2005** – Citywide Groundwater Emergency Taskforce organizes forum of citizens and officials at the Boston Public Library's Raab Auditorium. More than 500 people attend.

2005 – Sept 15 is groundwater day at City Hall as Mayor Menino signs ordinance extending Trust’s purview City-wide as needed, EPA announces additional grant to City for groundwater related work, Mayor announces that Boston Redevelopment Authority (BRA) will develop Groundwater Conservation Overlay District (GCOD) zoning, and, most importantly, a Memorandum of Understanding is signed by City, Commonwealth of Massachusetts, MBTA, Massachusetts Turnpike Authority (MTA), Massachusetts Water Resources Authority (MWRA), BWSC, and BGWT. MOU establishes City-State Groundwater Working Group, directs members to share information about groundwater issues and to repair infrastructure that “is reasonably demonstrated to contribute substantially to groundwater depletion...”

2006 – GCOD is established in Back Bay, Fenway, South End, St Botolph, Bay Village, flat of Beacon Hill, and Chinatown. Modified version added in Fort Point, North End waterfront, and Bulfinch Triangle in 2007 at neighborhood request. BRA adds geotechnical/groundwater issues to items to be addressed in Article 80 Large Project Review. Compliance with standards is nearly 100%, with variances only for justified site specific technical reasons.

2007 – Trust completes installation of well network which now exceeds 800 observation wells

2008 – MBTA commits to finding interim and long term solutions to groundwater problems in South End near Back Bay Station, commits funding in long term capital plan; State adds \$2MM to funds. MBTA pays to recharge with BWSC water and groundwater levels rise

2011 – DCR begins to divert water drained from Storrow Drive Tunnel to recharge system installed by BWSC in Back Street. Groundwater levels rise by 1-2 feet along Back Street

2011 – MWRA fills abandoned pipe along Porter Street in East Boston; groundwater levels rise 3-4 feet

2012 – MassDOT repairs drain line from Mass Turnpike. Groundwater levels in sections of Bay Village rise 1-2 feet

2013 – BWSC repairs leaking CSO in Dartmouth Street in Back Bay; groundwater levels rise by about 2 feet

2014 – Over 250 recharge systems have been installed under the GCOD

THE EARLY YEARS

The roots of the groundwater and wood piling problem go back to the geography that defines our city. The original town of Boston was located on the Shawmut Peninsula, a relatively small near-island connected to the Roxbury mainland by a narrow neck, located along present day Washington Street near where it crosses the Massachusetts Turnpike, that was barely a block wide and often flooded at high tide. The Charles Street edge of the Boston Common and Beacon Hill was waterfront property, as was the Congress Street area behind Boston City Hall. As the town grew into the thriving City of Boston, it became increasingly crowded and needed space to grow. Entire neighborhoods were created by making new land along tidal flats and in marshy areas: Back Bay, Fenway, much of the South End, the Flat of Beacon Hill, Bay Village, much of Chinatown and the Leather District, the Bulfinch Triangle, the North End and Downtown waterfronts, and vast areas of South Boston and East Boston. In all of these areas, the newly made land could not support heavy structures. Before about 1920, the only way to build substantial buildings in these areas was to support them on wood pilings, essentially inverted tree trunks with branches removed driven to a level where the underlying ground was strong enough to carry the weight. A typical row house might be supported on a hundred pilings. Trinity Church in the Back Bay is supported on almost 5000 of the inverted tree trunks.

Because the technology had been used for centuries in Europe, it was known that keeping the pilings submerged in groundwater protected them from rot, while dropping groundwater levels could lead to building settlement and ultimate collapse. (Unknown at the time, the problem is actually caused by microbes that, when conditions are ideal, feed on the wood.) Architects and builders were aware of the issue, and pilings were generally cut off at an elevation low enough to keep them submerged. However, as underground infrastructure like sewers, tunnels, and below ground garages was built, the inevitable imperfections led to leaks that could draw groundwater away and blockages that could impede the underground flow. At the same time, paving over much of the area for streets, alleys, and sidewalks reduced the flow of rainwater that could replenish the aquifer, and storm drains directed the water into the Charles River and the Boston Harbor. Over time, groundwater levels dropped in many areas.

In an effort to minimize potential problems, a maximum elevation for the cutoff of pilings under new structures was included in the Boston Building Code by 1907. While most earlier structures had cutoff elevations at or below the specified height, some did not. Unfortunately, this led to problems at some buildings. As early as 1911, the *Boston Globe* reported on piling problems at a building on Beacon Street in the Back Bay. Other problems were reported in several buildings on the Flat of Beacon Hill in the mid 1920's. Fortunately, the buildings could be repaired, albeit not easily or inexpensively, and most of them survive today. In 1929, major settlement problems, later traced to a sewer in Dartmouth Street, led to very extensive repairs to the McKim Building of the Boston Public Library, then barely thirty years old, that cost over \$250,000 (well into the millions in today's dollars). The repair, called underpinning, requires digging below the building to expose the rotted section of pile, cutting it away, replacing it with steel, and wrapping it in concrete. The difficult, labor intensive process is largely unchanged today.

To prevent additional problems, something more needed to be done. In an effort to understand the groundwater level and how it changed at different locations, the federal government's Works Progress Administration funded the installation of a network of about 1000 observation wells throughout the man-made land sections of the city. Levels were carefully measured and recorded in ledgers from 1936-1940. Unfortunately, only partial records remain, showing only the first, last, highest, and lowest groundwater level measured at each well. The records do let us see that groundwater levels varied significantly over time, and that in some areas the levels were consistently higher than the height where the tops of the pilings were cut off for most structures, while in some areas, low levels persisted and threatened the integrity of the building foundations.

With the approach of World War II, attention shifted away from long term building foundation issues. After the war, the population of Boston dropped rapidly, property values in most areas were very low (there are records of waterfront Beacon Street townhouses being purchased for \$5000 in the 1950's), and the loss of structures because of piling failure created opportunities for parking lots. In the 1960's and 1970's, buildings providing affordable housing in Chinatown and the Fenway were lost to piling rot, but no policy efforts were put in place to address the problem. Some buildings continued to be lost into the 1990's.

The first post- World War II effort to address the problem came in the early 1980's with the construction of a large office complex at 500 Boylston Street. The then rector of Trinity Church, Spencer Rice, chaired the Civic Advisory Committee (CAC) to the Boston Redevelopment Authority for the project. Trinity Church had sustained substantial foundation damage during the construction of the nearby John Hancock Tower (having little to do with groundwater lowering), and the congregation was concerned that any drop in groundwater levels could cause grave additional damage to the landmark structure. (Trinity Church, along with the Boston Public Library, the Lenox Hotel, and some other structures had long monitored groundwater levels on their property.) As part of the review process, in which the author participated as a member of the CAC, rules were put in place that specified a minimum acceptable groundwater level in the monitoring wells that the project installed. If levels dropped below that minimum, construction would have to halt. The foundation was redesigned so that it would not be the cause of a drop, and levels stayed above the threshold during construction.

However, despite this success, new problems were about to emerge nearby that would require broader solutions.

PROBLEMS ON THE FLAT OF BEACON HILL AND ESTABLISHMENT OF BOSTON GROUNDWATER TRUST

At about the same time that the discussions around groundwater monitoring were occurring on the 500 Boylston Street project, Robert Beal was discovering problems in the Beacon Hill home he had purchased several years earlier. Significant cracks were developing, and floors that had previously been level no longer were. Mr. Beal called on a geotechnical engineer, Harl Aldrich of Haley & Aldrich, who advised him that the problems were caused by differential settlement of the building because of failure of some of the wood pilings that supported the foundation. The failure had been caused by a drop in groundwater level of several feet that exposed the piling tops to oxygen. The condition was revealed in the digging of a test pit that allowed the engineers to physically examine the pilings. Mr. Beal spoke with many of his neighbors, including Tony Pangaro who had a test pit dug at his home about 100 feet away. The results were similar.

Alarmed, Mr. Beal and Mr. Pangaro rallied others to try to find a cause. Haley and Aldrich dispatched a young engineer, Jim Lambrechts, who had developed expertise on groundwater issues during design work for the new Southwest Corridor tunnel that was then under construction, to lead the inquiry. The conclusion was that lowering of the water level in the Boston Marginal Conduit (BMC) that runs beneath Storrow Drive for the construction of the new dam at the mouth of the Charles River was likely to have caused the lowering of surrounding groundwater levels that contributed to the problem. The homeowners approached William Geary, then Commissioner of the Metropolitan District Commission, the state agency that had responsibility for the dam and the metropolitan sewer system at the time. Mr. Geary took immediate action to try to find the cause, even though that might expose the agency to legal liability. The agency installed some groundwater observation wells to determine water levels and placed devices in some of its combined sewer overflow lines that would raise the water levels in the pipes. Installation of the devices led to an immediate recovery of about half of the observed drop in groundwater levels. The agency also discovered that the pumps in the dam were moving far more water from the Charles River during dry weather than had been anticipated. The effect of infiltration into the sewers and a lower water level in the BMC removed water that was normally trapped in the aquifer and led to reduced groundwater levels. Eventually, the homeowners filed a lawsuit against several City and State agencies, leading to a substantial financial settlement, although one that did not come close to completely reimbursing the property owners for the cost of their repairs.

The lack of information about changes in groundwater levels exposed a significant gap in the ability of government and property owners to protect the many historic properties that are supported on wood pilings. Mr. Beal approached many officials about the need for government to get involved. At the same time, articles began to appear in the press about the problem, including a major piece in the *Boston Globe* in August 1985. The City convened some educational sessions about the problem. David Scondras, then the District 8 city councilor representing Beacon Hill, Back Bay, and the Fenway among other neighborhoods, had lengthy discussions with Mr. Beal and others about the problem. In 1986, he introduced, with substantial support from Hyde Park district councilor Thomas Menino, a proposed ordinance to establish the Boston Groundwater Trust. The purpose of the new body, as described in the

original Declaration of Trust, was to reactivate existing observation wells (like those installed decades earlier by the WPA) and to install new wells in Back Bay, parts of Beacon Hill, Bay Village, and parts of the Fenway. The wells would be read by the City's Inspectional Services Department, while the Trust would hire professionals to analyze the findings and make recommendations for solving the problem.

The BGWT was established as a municipal trust so that it could accept funds from outside parties and be sure that the funds would not be used for other purposes. Trustees were to be appointed by the Mayor and included the collector-treasurer of the City, a member of the City Council appointed by the Council President, the Commissioner of the Inspectional Services Department, an engineer from the Department of Public Works, and trustees nominated by the Greater Boston Real Estate Board, Fenway Community Development Corporation (CDC), Neighborhood Association of the Back Bay, Coordinating Committee (the "Vault"), Beacon Hill Civic Association, and Back Bay Association.

The trustees began to meet and discuss causes of the groundwater problem. Later, funds were set aside for the Trust from the Raymond Cattle Company, developer of a project on Dartmouth Street, and from the community benefits fund allocated by the Prudential Project Advisory Committee in its work on redevelopment of the Prudential Center. However, with additional stories appearing in the press, including in the Boston Herald and the Boston Tab, there was rising concern that the City could find itself a defendant in additional lawsuits. At the same time, there was a concern that providing additional exposure to the issue would lead to reduced property values. The issue had never been a high priority for Mayor Raymond Flynn and his administration. As the terms of trustees expired, the Mayor declined to reappoint them or to name replacements. As the ability to raise a quorum became more difficult, the Trust became inactive by the early 1990's.

GROUNDWATER BECOMES A BIGGER ISSUE AND THE TRUST IS REVIVED

In 1993 Mayor Flynn resigned to become U.S. Ambassador to the Vatican, and City Council President Thomas Menino became Acting Mayor. That fall, as he was elected to the first of his five full terms as mayor, groundwater did not surface as a campaign issue. Even in the tightly contested race for the District 8 council seat, in which Tom Keane defeated David Scondras by less than 100 votes, the issue never came up. The Trust remained dormant.

Over the next few years, however, interest grew. The Neighborhood Association of the Back Bay (NABB) had appointed Tim Mitchell, one of its board members, to focus on groundwater issues. Concern was beginning to rise in other neighborhoods like the South End, while problems continued on the Flat of Beacon Hill. Mayor Menino, who had been supportive of the creation of the Trust when he was a Councilor, looked for ways to revive it while limiting potential legal liability. The legislature adopted a law that defined groundwater as not a concern of the Boston Water and Sewer Commission, creating a shield to protect it from litigation. With what the administration thought were adequate safeguards in place, and with a desire to act before the next election, the Mayor moved to reestablish the Trust.

In 1997, the Mayor appointed the designees of NABB and the Back Bay Association, Tim Mitchell and Gary Saunders, as trustees and they became the co-chairs of the revived entity, as they remain in 2014. They set about working with the other groups that were also designated to nominate trustees to find people who would be willing and able to serve. One of the nominees, Galen Gilbert from the Fenway CDC, had served on the original group of trustees and brought continuity and institutional memory. The Coordinating Committee had disbanded; its role passed to the Greater Boston Chamber of Commerce. Once the board was reconstituted, it began to meet in City Hall. However, it was more tolerated than effective, as some important members of the Administration remained concerned about liability issues.

Things began to change the next year, as Bo Holland, one of the Mayor's closest advisors, took an interest in the groundwater problem. The Mayor designated Toni Pollak, the head of the Boston Environment Department, as his point person and asked her to investigate the issue. There was no department in the City, not even the Environment Department, that had the jurisdiction to deal with the issue. As she investigated the groundwater issue, she found a lack of understanding about the breadth of the problem. The only entity taking any effective action was the BWSC, whose sewer repair program, while not aimed at raising groundwater levels explicitly, removed some of the causes of low groundwater at particular locations. Since much of the infrastructure was owned by the Commonwealth, she enlisted the support of Jim Hunt, then at the Executive Office of Environmental Affairs (EOEA).

In December 1998, the *Boston Courant* ran the first of what would be many articles on the groundwater problem, playing a critical role in raising the profile of the issue. The Trust, which had received a commitment for some modest funding from the City, was able to hire co-op students from Wentworth Institute of Technology (including Christian Simonelli, now the Trust's Executive Director) who, working under the volunteer supervision of specialized engineers, primarily Jim Lambrechts, located existing observation wells that could be incorporated into a network; readings from these wells began in 1999. The volunteer group of specialized engineers would grow into the Trust's Technical Advisory Committee, a volunteer group of engineers and geologists, that meets regularly to assist the Trust's staff in understanding the results from, and any necessary additions or modifications to, the observation well network.

Although helpful, the network of about 150 wells was relatively random, with locations that did not cover key areas. For example, there were only four usable observation wells in the entire residential portion of the Back Bay. The Trust knew that there needed to be a more extensive network, likely mirroring that established under the WPA in the 1930's, to effectively understand what was happening with groundwater levels. They began looking for ways to fund a new more comprehensive network.

At the same time, concern about the issue was growing in other areas. A new lawsuit had been filed by some Beacon Hill property owners in 1998. In 2000, NABB increased its focus on the issue, and it became a potential political problem in the 2001 mayoral campaign. A forum, cosponsored by NABB and the Ellis South End Neighborhood Association, was held at the YWCA building at the edge of the two neighborhoods in 2002. It was around this time that the seriousness of the low groundwater issues in the South End near Back Bay Station (first raised in 1984) became public. City Councilor James Kelly, who represented the South End, took an active interest in the problem, as did Sal DiMasi, the state House Majority Leader, who also represented the neighborhood. The MBTA, which had denied any potential responsibility for the problem, said that it would "take care of its problems".

Funding for the increased well network, which had so long seemed out of reach to the leaders of the Trust, now seemed possible. An Environmental Bond Bill was making its way through the legislature that would authorize funding for many environment related projects over the next half decade. When the bill reached the State Senate, Senator Warren Tolman sponsored an amendment that added \$1,600,000 to the bill to build a monitoring well network. With the support of State representatives Salvatore DiMasi, Paul Demakis, and Byron Rushing, the House agreed to the amendment when the bill went through the conference committee. After a meeting that included Representative Demakis, Councilor Kelly, Tim Mitchell, and Jim Hunt of EOE, as well as other discussions, the administration of Acting Governor Jane Swift, then in its final months in office, committed to release the funds over three years. The incoming administration of Mitt Romney kept the promise. In addition, U.S. Representative Michael Capuano was able to get \$200,000 earmarked for well installations into a funding bill for the Environmental Protection Agency. With the funding committed, installation of the long sought network could now go forward.

Momentum continued to build. The MBTA agreed to fund a continuous recharge system that would put potable water from BWSC into the ground on Saint Charles Street in the South End around the clock. The system, installed by BWSC in 2003 as a pilot program, dramatically raised groundwater levels there, preserving threatened building foundations. Favoring public education instead of litigation, the neighbors in that area came together to form the Groundwater Emergency Taskforce, later to grow into the Citywide Groundwater Emergency Taskforce and bring a bright spotlight onto the issue in other neighborhoods as well. BWSC, and especially Chief Engineer John Sullivan, felt more comfortable in sharing information they had that might help understand the issue. The Boston Redevelopment Authority began asking developers to discuss potential impacts their proposed projects could have on groundwater levels. The Trust established its website, www.bostongroundwater.org, to make the readings from the observation well network public along with other information about the issue.

At the Boston Groundwater Trust, the added interest, along with the efforts required to contract for and supervise the installation of the new well network, which would eventually grow to over 800 observation points, was straining the time and resources of the all-volunteer board. In addition, although the original Declaration of Trust had specified that the Inspectional Services Department would read the wells, the Mayor felt that readings done by a more independent body would have more credibility. Now, the Trust would not only have to install the wells and work with professionals to analyze the data, it would need to find a way to read over 800 wells 4 to 6 times a year, generate, and disseminate the information. If it was going to succeed, the Trust would need full-time professional management.

BIG CHANGES AND MUCH PROGRESS

During the early part of 2004, while wrestling with the increased workload caused by the start of the well network installation project and the need to comment on an increasing number of development projects in areas of critical concern to the preservation of wood piling supported buildings, the leaders of the Boston Groundwater Trust developed plans that would allow them to hire their first executive director. By August, the trustees had made their selection, bringing onboard Elliott Laffer, a well-known community activist in the in-town neighborhoods. The news received significant publicity, including front page coverage in the *Boston Courier*.

In addition to Mr. Laffer, the Trust added Christian Simonelli as its full-time technical coordinator. Under his supervision, the Trust was installing over 100 wells a year, and the expanded coverage allowed a much better understanding of where low groundwater levels were a persistent problem. At the same time, the Boston Water and Sewer Commission was doing repairs to its sewer network that reduced infiltration of groundwater, both reducing the load on the system and eliminating some of the paths for groundwater to leak away from the areas where it was needed. As part of its Article 80 Large Project Review process, the Boston Redevelopment Authority invited the Trust to participate with City agencies in the scoping sessions that helped to define issues that prospective developers had to address. Because of the addition of full-time staff, the Trust was now able to comment on all projects that were in areas of concern. Importantly, it was no longer an outsider trying to get agencies to pay attention to the issue.

The Trust was also dealing with many lingering internal issues, including updating its Declaration of Trust and By-laws, adopting operating policies, and looking to expand its board to include representatives from additional neighborhoods. The expansion of the operation into additional areas that had not been contemplated when the Trust was established in 1986 would require a new ordinance to be passed by the City Council.

At the end of the year, Mayor Menino brought in a new member of his administration who would have a profound positive impact on the issue. Jim Hunt was the City's first Chief of Energy and Environment. When the Mayor appointed him, Mr. Hunt later reported, he asked that the first focus be on two issues: the first was a stray voltage problem that had electrocuted several pets as they walked on electrical grid access covers; the second was groundwater. The problem was clearly one into which the administration was now putting a major effort.

Jim Hunt had been the Assistant Secretary of Environment for the Commonwealth when the Environmental Bond Bill that funded the well network was making its way through the Legislature, first exposing him to the issue. He worked closely with the Trust and others to help develop groundwater

policies that would effectively attack the problem while building institutional support for the effort. Outside pressure on groundwater was building as well. In addition to the *Boston Courier*, which continued its extensive coverage of the issue, stories appeared in the *Boston Globe*, other community newspapers, and even the *New York Times*.

Early in 2005, the Citywide Groundwater Emergency Taskforce began to develop plans for a major forum to be held on groundwater issues. The event in April filled the Raab Auditorium at the Boston Public Library beyond capacity, with over 100 people accommodated in overflow space. It brought together activists on the problem with representatives from all involved levels of government. The forum made the very effective case for groundwater as a potential regional economic problem as well as one of preserving homes and other buildings that, in many ways, defined the character of Boston to the outside world.

After the forum, increased coverage continued, including a major television piece on Channel 7 and more stories in local papers. It also started to become an issue in that year's at-large City Council election. As the City developed its budget plans for the fiscal year that would start on July 1, there was debate within the Administration about whether to increase the City's funding level to the Trust to cover the cost of permanent full-time staff. With the strong support of the City Council, led by District Councilor Mike Ross and At-Large Councilor Steve Murphy, the Mayor committed to adequately fund the Trust that year and in the future, assuring its ability to continue its important role.

During 2005 and 2006, a committee of South End architects, working with code consultants R.W. Sullivan and the Geotechnical Advisory Committee of the State's Board of Building Regulations and Standards, established a clear groundwater protection mandate in the Massachusetts State Building Code. During that time, the Neighborhood Association of the Back Bay submitted draft language for a zoning amendment that would require Zoning Board of Appeals approval of projects in areas of concern for wood pilings that might have the possibility to reduce groundwater levels. Although the staff of the Boston Redevelopment Authority had developed some language that could have implemented the change, the proposal had languished for an extended period. As with many of the issues around groundwater, that was about to change.

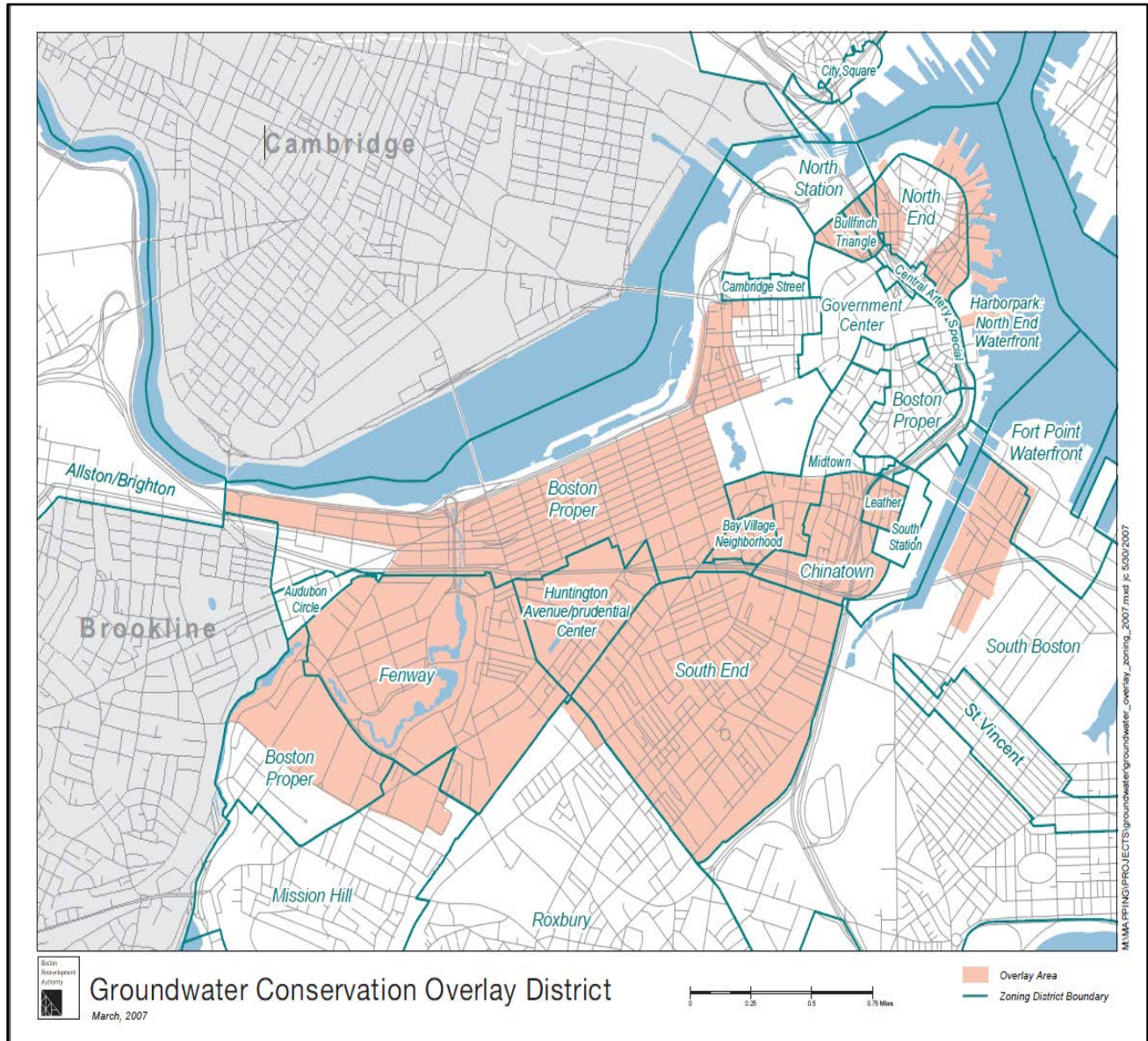
September 15, 2005 was Groundwater Day at Boston City Hall. The Mayor hosted a major press conference and signing ceremony. In the first and most important announcement, leaders of all of the public agencies with an interest in underground infrastructure in areas of concern for the preservation of wood pilings – the City; the Commonwealth; the Boston Water and Sewer Commission; the Massachusetts Water Resources Authority; the Massachusetts Bay Transportation Authority; the Massachusetts Turnpike Authority; and the Boston Groundwater Trust – signed an unprecedented Memorandum of Understanding that committed them to work together in a City-State Groundwater

Working Group to share information about the issue and to repair infrastructure that was substantially likely to cause a reduction in groundwater levels in areas of concern.

In addition, the Mayor announced that he was directing the staff of the Boston Redevelopment Authority to develop zoning that would establish a Groundwater Conservation Overlay District in Boston. He also signed an ordinance passed by the Council that amended the Boston groundwater Trust's Declaration of Trust to allow it to operate anywhere in the City where the groundwater problem arose. Finally, the U.S. EPA announce a further grant of \$200,000, which had been earmarked through the efforts of Representative Capuano, to address additional groundwater efforts.

From then on, it was clear that both the City and the Commonwealth were committed to the effort to overcome groundwater issues, an effort that has continued through changes in administration at both the state and city levels and through many changes in leadership of involved agencies. As time would show, agencies across both the City and the Commonwealth would become increasingly supportive of the effort.

GROUNDWATER CONSERVATION OVERLAY DISTRICT



IMPLEMENTATION AND COOPERATION

The City-State Groundwater Working Group held its first meeting in October 2005. While it was designed for cooperation, it was still unknown how well it would actually function. In a sign of that concern, several of the agencies brought lawyers along with operating staff to make sure that their interests were protected. Success of the Working Group would require an open interchange and sharing of information, as committed to in the Memorandum of Understanding. Fortunately, cooperation prevailed. The format, established at that first meeting and followed since, was for the Boston Groundwater Trust to report first, detailing groundwater levels across its network, how they were changing, and “hot spot” areas of concern. Agencies responded to this data and also spoke of their initiatives and findings. The MBTA, which in the past had sometimes been reluctant to share information, committed to providing complete pump flow records from its Southwest Corridor drains. In a sign of the success of the effort at cooperation, within a few meetings, the lawyers had largely withdrawn. For almost a decade, the Working Group meetings, which are open to the public, have been a prime example of cooperation across agency lines and between City and State entities.

At about the same time that the Working Group was first meeting, the Boston Redevelopment Authority was refining the language that would define the Groundwater Conservation Overlay District. While language was drawn from the earlier draft, Jim Hunt saw an opportunity to add the recharge of rainwater to the prevention of drops in groundwater elevations caused by construction work. Working with BWSC, the BRA developed language that would require the infiltration of a specified amount of water within a certain period after a storm. This technically valid approach would necessitate substantial engineering and testing to determine soil characteristics, adding significant costs to the smaller projects that would be required to comply. After discussions among a number of stakeholders, including BWSC and the Boston Groundwater Trust, the requirement was changed to a system that would capture a specified amount of water. This simplified language was included when Article 32 of the Boston Zoning Code, establishing the Groundwater Conservation Overlay District, was adopted by the Boston Zoning Commission in February 2006.

The GCOD encompassed most of the areas of man-made land where there were substantial numbers of wood piling supported buildings and a history of low groundwater levels, including the Flat of Beacon Hill, Back Bay, Fenway, South End, Bay Village, Chinatown, and the Leather District. It required that any projects in those areas that dig down below the elevation where there was concern, cover more than a nominal amount of land, or do substantial renovation to receive a conditional use permit (often called a GCOD permit) from the Zoning Board of Appeals. Again, cooperation was vital, as BWSC agreed to review the recharge systems for compliance, the Trust also reviewed all applications and appeared at the Board hearings to advise whether standards appeared to be met, and the Board insisted that any variances be thoroughly justified. Of over 400 cases that have appeared before the Board for GCOD thus far, only five have received variances because it would be impossible to comply without harming neighbors. The standards have been completely met in all other cases. The GCOD was considered an important enough protection that neighborhood groups in the Fort Point Channel section of South

Boston, the Bulfinch Triangle, and the North End and Downtown Waterfront asked to be added to the district. In 2007, the GCOD was expanded to those neighborhoods, although, because groundwater levels were relatively high in most parts of these areas, recharge was not required there.

At the same time, the members of the Working Group were taking other steps to address groundwater issues. BWSC used data from the Trust's observation well network to develop projections of groundwater elevations throughout the areas of concern. The data, which they shared with the Trust, was used to pinpoint areas where their sewer and drain lines could be causing low groundwater levels. BWSC has made substantial efforts to repair lines in those areas. They have also installed large recharge systems as part of reconstruction projects in the Fenway, South End, Back Bay, and Beacon Hill. According to Trust data, these systems have made a measurable difference in area groundwater levels.

When installing the recharge systems under Back Street, which parallels Storrow Drive in the Back Bay, BWSC made them large enough that they could handle additional flow that might come from the tunnel that carries a portion of Storrow Drive near the edge of Back Bay and Beacon Hill. That tunnel had, from its construction in the early 1950's, been designed to discharge any groundwater infiltration to the Charles River. As concern rose about low groundwater issues, the Department of Conservation and Recreation (DCR), which is responsible for Storrow Drive, determined that the flow even in dry weather was about 40,000 gallons a day. During discussions about a plan to repair the tunnel structure, DCR was requested to divert the flow from one of the two pumping stations to the recharge galleries that BWSC had constructed. In early 2008, the DCR commissioner committed to the plan. Since the diversion system was installed, groundwater levels along that section of Back Street have risen over two feet.

After receiving complaints about potential piling problems in East Boston, Trust staff and members of its Technical Advisory Committee (made up of representatives of most of the geotechnical engineering firms doing work in Boston, plus the all-important Professor Jim Lambrechts) considered the problem and agreed that the network should be extended into that section of the city. Most of the wells were installed in 2006 and showed very low readings in an area called the Paris Flats. The Massachusetts Water Resources Authority was rebuilding its sewer system in East Boston under a court order having nothing to do with groundwater issues. As part of that project, they would be removing from service a sewer pipe that ran under Porter Street near many of the lowest groundwater levels. Although a television inspection of the pipe did not reveal leaks, MWRA agreed to fill the pipe after it was no longer in use with material that would prevent any water flow. After the work was done, nearby groundwater levels rose by as much as four feet.

The MBTA, which had begun charging potable water into the ground on Saint Charles Street in the South End in 2003, committed to developing a long term solution to the problem. They added potable water recharge wells on Cazenove and Berkeley Streets in 2007, raising the depressed groundwater levels there. After extensive engineering studies and a significant public process, the MBTA determined that the best long term plan was to install additional potable water recharge wells; the expanded system went into service in 2013. In addition to funding from the MBTA, the Commonwealth, due to the strong

efforts of former Representatives DiMasi and Walz and current Representatives Rushing and Michlewitz, has provided \$2,000,000 to assist in the effort. The MBTA will continue to look for a more permanent, cost effective solution while injecting the water to protect building foundations.

The Massachusetts Turnpike Authority, since consolidated into the Department of Transportation, also contributed to solving groundwater issues. The drain line from the Turnpike's tunnel under the Prudential Center and Copley Place had not been cleaned out since the road was opened in the early 1960's. As part of a major repaving project, MassDOT agreed to clean out, inspect, and, if necessary, repair the line. Work began in 2011 and repairs led to increases in groundwater levels in sections of Bay Village along the Turnpike of over two feet.

As this work was proceeding, the Boston Groundwater Trust was improving its organization and enhancing representation as well as its reporting to the community. Its website was enhanced in late 2005 with an expanded map and the ability to post well readings as soon as they were reviewed. In early 2006, the Trust received approval from the IRS of its 501(c)3 nonprofit tax status. Trustees were added to the Board representing the Ellis South End Neighborhood Association, the Chinatown Neighborhood Council, and the North End Neighborhood Council. Later, the Boston Preservation Alliance, which seemed to be a better fit with the work of the Trust, replaced the Greater Boston Chamber of Commerce as one of the organizations represented on the Board.

Remarkably, almost all of this progress was being made cooperatively, with very little of the contention that had been necessary to raise the issue to public attention. Were the results verifiable? Would the gains be maintained? How would future discoveries of low groundwater levels be handled? These questions still remained.

MONITORING PROGRESS

The plan for raising groundwater levels in areas where they were inadequate or only marginally adequate to protect wood piling supported building foundations was based on a simple mathematical concept: more water put into the ground (recharge) + less water removed from the ground (infrastructure repair) = higher groundwater levels. The point of monitoring an extensive network of groundwater wells is to verify whether the efforts that have been undertaken to raise groundwater levels have paid off.

Since the GCOD was established in 2006, more than 250 recharge systems have been installed under its provisions. In addition, BWSC has installed multiple recharge systems, the MBTA is continuously recharging in the South End, DCR is diverting much of the groundwater pumped from the Storrow Drive tunnel to the recharge galleries under Back Street, and the City has participated in pilot projects to assess the value of recharge through the use of pervious pavement in alleys and sidewalks in raising groundwater levels. As described previously, major efforts have been made to repair infrastructure across the areas of concern.

How effective has the work been? The Boston Groundwater Trust sponsored a research project at Tufts University, the results of which are posted on its website, which used the extensive data from wells in the Back Bay to develop a mathematical model for the effect of recharge from any given source on raising groundwater levels. The model makes clear that any individual source has a small but statistically significant impact on groundwater levels that varies with the size of the recharge system and distance from it. Since the effect from each source is additive, increasing the number and size of recharge systems has an ever larger impact on groundwater levels. As a critically important side benefit, it also reduces the load on the storm drain system and prevents phosphorous from entering the Charles River and the Harbor. This was the third academic research project sponsored by the Trust. Earlier efforts at both MIT and Northeastern University had attempted to develop methods to determine where pilings were cut off, and possibly their condition, without the necessity to dig a test pit. While these efforts were not successful, the Trust remains committed to working with academic institutions where it makes sense to try to improve our tools for dealing with groundwater related issues.

The benefits of infrastructure repair are seen more quickly, as was noted in previous examples. When the ultimate source of the drawdown is identified (often a difficult task) and repaired, groundwater levels can recover within weeks. The majority of the low groundwater “hot spots” identified in our early monitoring have seen significant improvement: along Storrow Drive levels over time have risen over three feet after installation of the recharge from the tunnel; in the Ellis neighborhood of the South End, levels have risen as much as five feet in areas where the MBTA is injecting water; installation of a closed loop pumping system in lieu of discharge to sewers at the Benjamin Franklin Institute on Berkeley Street to keep its basement dry has raised levels by two feet at a nearby well; repairs to the Massachusetts

Turnpike drain line have raised levels in parts of Bay Village by two feet or more; in the Fenway, repairs to sewer lines and installation of a recharge system under a line in a nearby alley have raised levels along Hemenway Street by a foot or more; in the Bulfinch Triangle area near the TD Garden, BWSC repairs to their sewer system as part of a combined sewer separation project have led to groundwater elevation increases of about two feet; filling in the no longer active sewer under Porter Street in East Boston has raised nearby levels by as much as four feet.

In the overall system, there are other signs of the positive impact of the efforts of all those working on the groundwater problem. In seven of the eight years since 2006, when many of the plans to combat low groundwater levels began to take effect and the observation well network was largely completed, the number of wells reaching new highs has exceeded those reaching new lows, often by a large margin. The system seems to be increasingly responsive to precipitation, as one would expect with additional rainwater recharge. Average groundwater levels across the network have risen in most years. When reporting results, the Boston Groundwater Trust categorizes wells by the range of groundwater elevations into which they fall; by the end of 2013, the number of wells in the lowest category was consistently small enough that the Trust changed the definition of that group by raising the reporting threshold by a foot. While there are still too many wells that indicate inadequate groundwater levels, the number where that gap is largest has fallen substantially.

The progress made has been substantial, but what does the future hold? What lessons have been learned?

LESSONS LEARNED AND LOOKING TO THE FUTURE

The effort to increase and maintain groundwater levels so that they are adequate to protect wood piling supported building foundations in Boston has taught us several lessons. The most important of these is the need for constant vigilance. Because our infrastructure is man-made, it will inevitably deteriorate over time and require maintenance and repair. In order to discover leaks, one of the most important tools is the elevation information generated by the Boston Groundwater Trust's observation well network. An example of the importance of this resource occurred on Dartmouth Street in the Back Bay in 2008. After an earlier repair, groundwater levels in the area had risen by about two feet and had held for several years. Then a sudden drop was noted in the groundwater level at the Trust's nearby observation wells. When the level did not recover within a month, the Trust sounded the alarm, informing both the Boston Water and Sewer Commission (owner of the only low lying infrastructure in the immediate area) and the public of the problem. Ultimately, after significant time and effort, BWSC was able to locate the leak and make repairs, leading to a recovery in groundwater levels. Abandonment of the monitoring effort, as happened to the network installed by the WPA in the 1930's, would have left this problem to fester.

A related lesson is the importance of community involvement. The establishment of the Trust in 1986, its revival in 1997, the commitment of funding to install the observation well network and support the Trust, the commitment of the MBTA to deal with the results of the groundwater depression near Back Bay Station in the South End, and the establishment of the GCOD and City-State Groundwater Working Group were all responses to a problem highlighted by an informed community, often led by the Citywide Groundwater Emergency Taskforce, that pressed government for solutions. In the example of Dartmouth Street referred to above, the Neighborhood Association of the Back Bay pushed hard for a solution until the problem was solved.

A third lesson is the importance of having an entity that focuses on this problem, an issue that can easily be ignored when its symptoms appear to be under control. The Boston Groundwater Trust is very small, with never more than three people including part-time help on its payroll, but it has been able to shine a light on the issue and keep larger agencies engaged. The Trust has been well worth its modest government funded operating budget of less than \$250,000 per year.

A larger lesson has been the value of cooperation and looking for solutions rather than blame. The City-State Groundwater Working Group has become a model of how agencies can work together across jurisdictional lines to tackle a thorny problem. The open transfer of information has been too rare, especially in cases where entities focus on blame and potential legal liability. The success in Boston is in marked contrast to a similar groundwater problem in Milwaukee, where problems have built up as blame has been apportioned, including in a case that went to the Wisconsin Supreme Court. Authorities there showed no interest when approached by Representative Capuano's office about sharing what we

had learned in Boston about how to attack the problem. Piling problems because of low groundwater levels require repairs to the Milwaukee City Hall, for which cost estimates recently noted in the press exceed \$60,000,000.

Going forward, it is crucial that the commitment to monitoring, problem solving, and cooperation continue. While there may be ways to streamline the GCOD process (some of which have already been implemented), the commitment to maintaining the benefits of that ordinance is critical. It may also be worthwhile to enshrine the City-State Groundwater Working Group, created by a voluntary Memorandum of Understanding from which any signatory group can withdraw at any time, more permanently into law. No matter what, the Boston Groundwater Trust, now under the leadership of its superbly qualified executive director, Christian Simonelli, should remain an important part of the continuing effort to protect the buildings and neighborhoods that have been and remain such a crucial piece of Boston's identity and a national legacy.