NEW YORK CITY DEPARTMENT OF ENVIRONMENTAL PROTECTION
BROOKLYN-QUEENS AQUIFER FEASIBILITY STUDY

CITIZENS ADVISORY COMMITTEE MEETING: June 5, 2003

MINUTES

The 13th meeting of the Brooklyn-Queens Aquifer (BQA) Feasibility Study Citizens Advisory Committee (CAC) was held on Thursday, June 5, 2003 at the Hillside Manor Comprehensive Care Center. (See Attachment A for Attendance List.)

Helen Neuhaus, Helen Neuhaus & Associates (HNA), opened the meeting by welcoming the group and noting the excellent turnout from the Scientific Review Panel (SRP). Ms. Neuhaus then asked for comments on the Minutes of the May 1, 2003 CAC meeting. Michael Turner commented that the Minutes did not appear to reflect the CAC's discussion on delaying future public outreach activities until the technical work was more advanced. In response, Ms. Neuhaus clarified that the Minutes referred only to the Committee's decision to defer a public presentation on health issues until a later date. Instead, there will be greater emphasis on other public outreach activities, including widespread distribution of a project newsletter this summer. Following adoption of the Minutes of the May 1st CAC meeting without changes, Ms. Neuhaus facilitated a discussion of follow-up items from that meeting. These included the following:

- In response to a question from Debora Hunte concerning the proposed frequency of bromate testing, Bill Yulinsky, New York City Department of Environmental Protection (NYCDEP), explained that United States Environmental Protection Agency regulations require bromate testing on a monthly basis. He added that although specific testing protocols for Station 6 have not yet been developed, NYCDEP is likely to conduct more frequent bromate testing during the plant's first year of operation.

- Ms. Hunte and Tracey Bowes asked whether ozone oxidation has previously been used at any facility in New York. After Mr. Yulinsky noted that Station 6 would be the City's first plant to use ozone oxidation, Mark Lenz, Malcolm Pirnie, Inc., noted that plants in a number of states, including Connecticut, Massachusetts, and New Jersey, are using ozone oxidation. He also offered to check into its use elsewhere in New York State.

- Deputy Commissioner Doug Greeley, NYCDEP, reported that the capital improvement project to install storm sewers in the vicinity of 112th Avenue is still in the planning and development phase. The project must then go to the New York City Department of Design and Construction for inclusion in its capital budget.

- As a follow-up to the issue reported last month regarding elevated levels of methyl-tert-butyl ether (MTBE) that have been detected in Well 6D, Don Cohen, Malcolm Pirnie, Inc., reported on the results of a Freedom of Information Law (FOIL) request that was filed with the New York State Department of Environmental Conservation (NYSDEC) to obtain gas station compliance records.

- Soil contamination was found by a contractor removing two gas tanks at City Gas (105th Street and Merrick Boulevard). Mr. Cohen will follow up to determine whether removal of the contaminated soil was ever completed.
- A review of records concerning the Atlas Gas Station (108th Avenue and Merrick Boulevard) documented the failure of air pressure tests involving two of its tanks. However, there was no indication that a follow-up investigation has taken place. In a related comment, Jeff Diggs noted previous Atlas station problems, including an instance when the station's pumps were chained due to watered-down gasoline. Mr. Cohen indicated that he would check to see if Atlas had filed its compliance reports, as required since 1998.

- Referring to the meeting handout (see Attachment B), Ms. Neuhaus noted responses to three additional items:
  - The library on Guy R. Brewer Boulevard was built in 1999. Since the gas station previously located on that site operated until the late 1990's, it would have been subject to bunkering requirements.
  - The "Filtered Water Quality Chart" was revised, as per Dr. Paul Lioy's suggestion, to provide a more detailed analysis of iron concentrations. The revised chart specifically indicates that iron registered lower than the equipment detection limit following membrane filtration.
  - In response to Dr. Jack Caravonos' question regarding the size of membrane filters, a table was prepared to illustrate the filter diameter, by manufacturer.

In response to Ms. Hunte's inquiry on sewer issues, Ms. Neuhaus reiterated that the focus of the CAC is Station 6 and Station 24/West Side Corporation (WSC) clean-up. She added that Commissioner Greeley had discussed flooding and sewer repair matters at the previous evening's meeting of the Brinkerhoff Action Association.

Update on Station 24/WSC Remediation

Nicole Brown, Malcolm Pirnie, Inc., provided an update on work at Station 24, indicating that a Granular Activated Carbon (GAC) system was selected for treatment of groundwater at the site. (See Attachment C.) Displaying a 1983 photograph of the now-removed perchloroethylene (PCE) tanks, she explained how PCE was unloaded via train into five ten thousand-gallon tanks that were the source of spills and leakage. Emphasizing that the area that held the tanks is considered the worst contaminated area at the site, Ms. Brown further explained that the plume would be contained and remediated in two phases. Phase I, to begin prior to the operation of Station 6, will involve one well pumping water at 550 gallons per minute (gpm). This well, located in the vicinity of 170th Street, has already been installed. In Phase 2, after operations begin at Station 6, a second well will be brought on line, bringing the combined draw to 1,550 gpm. The total volume will ensure that the PCE plume is drawn away from Station 6.

Before describing the remediation alternatives, Ms. Brown reviewed the three treatment goals for Station 24: effective removal of PCE, minimal effects of iron and manganese deposits on equipment and minimal environmental impacts. The two (2) alternatives considered for treatment of the contaminated groundwater were: 1) air stripping with off-gas treatment and 2) GAC. She explained that air stripping removes PCE from the water, discharges the remediated water to the storm sewer, and treats the PCE-contaminated air (off-gas) prior to release to the

atmosphere. The GAC system uses carbon to directly remove PCE from the water before discharging it to the sewer. Contaminated water flows in series through two tanks filled with carbon. The majority of the contamination is adsorbed in the first tank, and the second tank provides a back-up. Over time, the carbon loses its ability to adsorb contaminants and is considered "spent". The spent carbon is taken off-site for treatment and reuse at other facilities. Although both technologies dramatically reduce PCE levels, air stripping was rejected for several reasons: first, the equipment quickly fouls with iron and manganese deposits and second, the off-gas introduces the risk of air pollution. While the GAC system can also be fouled with iron and manganese deposits, maintenance is easier and there are no air emissions.

Ms. Brown also reported that a test will be conducted at the site using two 55-gallon drums of carbon. A sequestering agent (a chemical that prevents iron from settling onto the carbon) will be added to one of the drums. The purpose of the test is to determine whether the sequestering agent will significantly reduce fouling in the carbon bed. Ms. Brown passed around a sample of granular activated carbon to members of the group.

Ms. Brown noted that while NYSDEC will begin to clean the soil at the WSC site using Electrical Resistance Heating (ERH) before Station 24 begins pumping, this is not absolutely necessary, as the GAC system is capable of removing the PCE on its own. She then enumerated the next steps in Station 24 design and construction: determining where to place the GAC vessels, which are large (approximately 23 feet high and 10 feet in diameter) and require access by one or two tanker trucks per week; structural concerns (i.e., how the ground will support the weight of the vessels); and weathering issues (i.e., preventing the water-filled vessels from freezing in the winter). Ms. Brown stressed that trucks accessing the site will use 180$^{th}$ Street, an industrial route, and will not travel through residential areas.

A summary of questions and comments related to the presentation is provided below:

- Dr. Gil Hanson asked if the treated water could be returned to the aquifer. Commissioner Greeley indicated that this will not occur, because NYCDEP has already promised the community that water from Station 24 will never be used for drinking. Furthermore, NYSDEC has issues with recharging a drinking water aquifer with water from hazardous waste sites, regardless of its treatment.
- In response to a question from Dr. Len Lion, Ms. Brown described how a fairly benign sequestering agent (Redux 300) must be added to prevent iron and manganese from forming deposits on the equipment and "globbing" it up. She stressed that this chemical is not caustic or toxic and that it can be handled without protective equipment.
- When asked why use of a reducing agent such as sodium thiosulfate (which is used for drinking water treatment) was not considered, Ms. Brown responded that it would most likely be expensive and reiterated that the goal at Station 24 is to remediate the groundwater, not to produce drinking water. As a follow-up, Kenneth Gill asked why he has seen GAC tanks at drinking water facilities, specifically at Francis Lewis Boulevard and Murdock Avenue, if they are not being considered to filter drinking water on the BQA project. Ms. Brown explained that the same technology is used for both groundwater remediation and drinking water treatment. Mr. Yulinsky added that another GAC system is located at 193$^{rd}$ Street and Jamaica Avenue.

- In response to questions related to scheduling, Ms. Brown indicated that the bulk of the WSC clean-up is expected to be completed by 2006. Mr. Cohen added that the contract will remain open-ended in case the site is not fully remediated by that time. Ms. Brown noted that although the wells at Station 24 could operate for twenty years or more, the bulk of the PCE will be removed after the first few years. In a related question, Ms. Hunte asked how pumping could begin at Station 6 (scheduled to start in 2006-2007) if Station 24 could be removing the plume for up to 20 years. Mr. Cohen explained that the remediation system at Station 24 will contain and remove the bulk of the PCE plume within the first 2-3 years after start-up. The facility will continue to operate for many years to assure continued containment of any residual contamination and prevent it from reaching Station 6.
- Responding to Dr. Jack Caravanos' question concerning whether the project team expects to encounter pockets of PCE, Mr. Cohen indicated that the intent is to hydraulically capture the entire contaminated plume, which contains dissolved PCE. He emphasized that the Station 24 wells will serve to both pump out the contaminated groundwater and neutralize the effects of pumping created by the fully operational Station 6. Mr. Cohen also reminded the group that monitoring wells have been installed (on the Station 24 property and in the adjacent residential areas) to track the progress of the clean-up.
- In response to a question from Dr. James E. "Chip" Kilduff regarding whether or not the process will capture new compounds formed by the breakdown of the PCE, Ms. Brown assured him that it would.

Presentation of Pilot Treatment Memorandum #5

Mr. Lenz began the presentation (see Attachment D) by reviewing the Station 6 process flow diagram and the previously presented results, including the determination that initial pH adjustment will not be needed prior to ozone oxidation and membrane filtration to remove iron and manganese. The remainder of his presentation focused on the results of membrane softening testing, which reduces the hardness of water by removing calcium and magnesium. Mr. Lenz described hardness as a measure of "the ability of water to produce lather or foam from soap." He added that hard water can make dishes and glasses look spotty and leave whitish scales on surfaces. After noting that the presence of calcium and magnesium are aesthetic, rather than health, concerns, he explained that some degree of hardness must be retained to prevent corrosion of plumbing and to ensure that water does not taste 'flat.'

Mr. Lenz reviewed the two tested membrane types: nanofiltration and reverse osmosis. He explained that while both are similar in construction and use, the pore size of membranes in the reverse osmosis system is much smaller. He continued by explaining that neither technique requires backwashing, as was discussed with the membrane filters used to remove iron and manganese. In the membrane softening process, filtration occurs as water passes through a series of membrane elements (cylindrical tubes filled with membranes that filter the water). Mr. Lenz passed around an example of a cylinder.

Before presenting the results of the membrane softening tests, Mr. Lenz explained that there is no regulated standard for water hardness. As a result, a target value of 100 mg/L of calcium carbonate was used for pilot plant testing. In order to provide some parameters for comparison, he noted that water from the Catskill/Delaware reservoir system has an average hardness of 26 mg/L; the Croton reservoir system ranges from 60-100 with an average of 92 mg/L; and the

groundwater system in southeast Queens has an average of 110 mg/L, although levels can rise to 352 mg/L from a specific well. Both Mr. Lenz and Commissioner Greeley stated that water with a hardness of only 26 mg/L is corrosive enough to require chemical treatment, which the City has done for several years.

Mr. Lenz reported that both nanofiltration and reverse osmosis effectively reduced hardness levels: nanofiltration removed about 82% of the calcium carbonate, while reverse osmosis filtered out over 99%. Since both systems lower hardness levels far below the target level of 100 mg/L it would not be necessary to filter the plant's entire flow. Approximately 2% of the water in a nanofiltration system and 25% of the flow in a reverse osmosis system could bypass the membrane entirely and then be blended with treated water to meet target hardness levels. Mr. Lenz stressed that all applicable drinking water standards would be met prior to membrane softening.

In his final comments, he emphasized that both systems delivered high scores on all significant parameters, including flux (gallons of water filtered per square foot of membrane per day), recovery (the percentage of water successfully cleaned), pressure (pounds per square inch required to push water through the membrane), and permeability (flux divided by pressure).

Questions and comments related to membrane softening are summarized below:

- In response to a question from Mr. Diggs, Mr. Lenz explained that any rejected water (water not used for drinking water) would be sent to the storm sewer after processing at the treatment plant.
- Mr. Lenz indicated that although Volatile Organic Compounds (VOCs) will be treated between the membrane filtration and membrane softening stages, both nanofiltration and reverse osmosis would filter out any remaining VOCs.
- Dr. Kilduff questioned why reverse osmosis systems are not substantially less expensive than nanofiltration systems, given the need to filter significantly less water. Mr. Lenz explained that while the systems are more efficient, the membranes are more expensive. However, he noted that actual costs vary according to vendor, adding that the overall costs of both systems have been similar at some facilities.
- Dr. Lioy suggested that information comparing nanofiltration and reverse osmosis be clearly presented, particularly with respect to their effectiveness in filtering out minerals and VOCs. He recommended that this data be included as an addendum to the Minutes (see Attachment E). Commenting on Dr. Lioy's suggestion, Commissioner Greeley noted that although the pilot plant was not intended to test the removal of VOCs, results showed that the membranes were effective in reducing levels. Mr. Yulinsky suggested that a cost breakdown also be provided to compare the costs of the two membrane softening systems.

Other Issues

- Councilman Leroy Comrie noted that fire hydrant flushing has been occurring without community notification. Commissioner Greeley agreed to obtain a hydrant flushing schedule for the Councilman and acknowledged that notices should be sent to the Community Boards.
- Asking whether NYCDEP has observed changes in groundwater saturation levels as a result of the recent heavy rains, Councilman Comrie expressed particular concern about the

possibility of a "flood" of contaminated water. Mr. Cohen reported that the depth to groundwater was measured at approximately 11 feet from the surface during the week of May 25th, as compared to the more typical 11 to 13 foot range. In response to a follow-up question concerning movement of the PCE plume in relation to groundwater levels, Mr. Cohen explained that although the plume has probably existed for 30 years, it has not spread very far during that time. He added that since groundwater levels rise regionally during rainfall, there would be no radical movement of the plume due to the current wet weather.

- Assemblyman William Scarborough raised the issue of sodium levels in drinking water, noting that although previous testing revealed levels of sodium below regulatory levels, they were not low enough to eliminate community concerns. Mr. Lenz explained that both membrane softening systems would significantly reduce sodium levels. Nanofiltration reduces sodium to 50-60 mg/L, while reverse osmosis lowers it to 30-40 mg/L. Mr. Lenz noted that the New York State health standard for people on a moderately restricted sodium diet is 270 mg/L. There are no federal health standards for sodium in drinking water.
- In response to a question about the hardness of water in northern Queens, Mr. Lenz stated that most of the area uses Catskill/Delaware water, which has a hardness level of about 26 mg/L. Commissioner Greeley added that about 80% of the water used in southeast Queens comes from the Catskill/Delaware system.
- In response to questions regarding the well reactivation program, Mr. Yulinsky explained that although a number of wells are being tested and repaired, they are not pumping water into the drinking water system. After confirming that Community Boards would be notified prior to any plans to activate the wells, he emphasized that although some wells are being readied for use in the event of future droughts, there are currently no plans to use them on a regular basis.
- Dr. Lioy asked if the broader community is still skeptical of its drinking water supply. Both Ms. Bowes and Mr. Diggs responded emphatically that this is so. Mr. Gill commented that although the CAC is convinced of the effectiveness of the Station 6 pilot program, the greater community remains suspicious, particularly considering the past history of the Jamaica Water Supply Company (JWS). Mr. Diggs noted that although JWS water may have met health standards, it did not meet the aesthetic standards of taste or odor, a fact that contributes to residents' continuing concerns. Dr. Lioy responded that the City has done a good job of providing quality drinking water and encouraged the CAC to focus on the effectiveness of the proposed treatment processes in filtering out constituents of concern and in communicating these benefits to the broader community. He noted that he has worked on other projects with HNA, for which the firm developed effective presentations and newsletters that used clear and simple language to communicate complicated technical issues. The CAC urged HNA to proceed with drafting a newsletter for community-wide distribution, and several CAC and SRP members volunteered to review and comment on the draft document. In addition, it was suggested that a question and answer format be used to highlight critical project issues and concerns.

Looking Ahead

Ms. Neuhaus led a brief discussion on the need for CAC activities during July and August. She indicated that an Executive Summary of the Technical Memoranda is being prepared and should be ready in approximately one month. Although the CAC should meet to discuss

recommendations for the Demonstration Plant that will be based on the memoranda, it is unlikely that the project team will be ready for this presentation during the summer, since NYCDEP must review membrane options and resolve cost and operational issues prior to making a decision on the plant. She therefore suggested that the CAC not schedule a summer meeting at this time. This suggestion was unanimously endorsed. However, it was agreed that a meeting would be held if conceptual design of the Station 6 Demonstration Plant progressed to a point where the architectural plans could be presented to the New York City Art Commission in September or if another significant issue arises. In the interim, the project team will focus on newsletter preparation and preliminary planning for a public forum in the fall.

The next CAC meeting is tentatively scheduled for **Thursday, September 5th at 7 p.m.** at the Hillside Manor Comprehensive Care Center, 188-11 Hillside Avenue, Jamaica Estates.

Follow-up Items:

1. Determine whether ozone oxidation has been used anywhere in New York State (Tracey Bowes). Responsibility: Mark Lenz, Malcolm Pirnie.
2. Provide information regarding the City's schedule for flushing out fire hydrants to Councilman Comrie; ensure that Community Boards receive notice. Responsibility: DEP.
3. Distribute clear copies of the "Station 6 Pilot Plant Testing Summary—Part III" presentation with the Meeting Minutes. Responsibility: Malcolm Pirnie, HNA.
4. Provide cost analysis information for nanofiltration and reverse osmosis to the CAC and SRP. Responsibility: Malcolm Pirnie, HNA.
5. Identify the chemicals used as sequestering agents at Station 24. Responsibility: Malcolm Pirnie.
6. Prepare an Executive Summary of the Station 6 Pilot Plant Technical Memoranda for distribution to the CAC. Responsibility: HNA, Malcolm Pirnie.
7. Prepare a project newsletter for community-wide dissemination this summer. Provide interested members of the SRP and the CAC with the opportunity to review the draft document. Responsibility: HNA.

**ATTACHMENT A**

Brooklyn-Queens Aquifer Feasibility Study
Citizens Advisory Committee
Thursday, June 5, 2003

Attendance List

CAC Members/Alternates

Tracey Bowes
Community Board #12

Linda Caleb Hazel
A Better Day Inc./St. Benedict The Moor/
St. Bonaventure

Leroy Comrie
New York City Council

Jeff Diggs
Councilman Leroy Comrie

Kenneth Gill
Addisleigh Park Civic Association

Richard Hellenbrecht
Community Board #13

Irving Hicks
Brinkerhoff Action Association

Debora Hunte
Brinkerhoff Action Association

William Scarborough
New York State Assembly

Michael Turner
Addisleigh Park Civic Association

Guests

Philda Barnes
Resident

Sarah Hicks
Resident

Maurice R. Muir
Community Board #12

Scientific Review Panel

Dr. Jack Caravanos
Hunter College

Dr. Gilbert Hanson
State University of New York at Stony Brook

Dr. James "Chip" Kilduff
Rensselaer Polytechnic Institute

Dr. Leonard Lion
Cornell University

Dr. Paul Lioy
Environmental and Occupational Health
Sciences Institute

Dr. Alan Rabideau
State University of New York at Buffalo

Project Team

Nicole Brown
Malcolm Pirnie, Inc.

Don Cohen
Malcolm Pirnie, Inc.

Stacy Cyrus
New York City Department of
Environmental Protection

Lillie Farrell
New York City Department of
Environmental Protection

Doug Greeley
New York City Department of
Environmental Protection

Mark Lenz
Malcolm Pirnie, Inc.

Karim Naraghi
Malcolm Pirnie, Inc.

Helen Neuhaus
Helen Neuhaus & Associates Inc.

Denise Woodin
Helen Neuhaus & Associates Inc.

Anita Wright
Helen Neuhaus & Associates Inc.

Bill Yulinsky
New York City Department of
Environmental Protection

Adam Zeller
Helen Neuhaus & Associates Inc.

**ATTACHMENT B**

**Brooklyn-Queens Aquifer Feasibility Study**
**Citizen Advisory Committee Meeting—May 1, 2003**

Follow-up Items—Additional Information

*3. Determine when the library on Guy R. Brewer Boulevard, which was built on the site of a former gas station, was constructed.*

According to the circulation desk, the library at 108-41 Guy R. Brewer Boulevard was built in 1999.

*5. Consider Dr. Paul Lioy's suggestion that the "Filtered Water Quality" chart shown in the PowerPoint presentation be revised. Dr. Lioy noted that currently, all samples are shown with an iron concentration of .10mg/L, the detection limit, even though the actual levels are predicted to be considerably lower.*

| | Units | Well 6B Inlet Average | Mixed Permeate | Standard |
|---|---|---|---|---|
| **Metals** | | | | |
| Total Iron | mg/L | 6.6 | <0.1[1] | 0.3 |
| Manganese | mg/L | 1.0 | 0.02 | 0.05 |

[1]The actual level of iron in the water was below the laboratory's detection limit. Field testing at the pilot plant indicated that iron was consistently at or below 0.01-0.02 mg/l, which was the detection limit of the field testing methodology.

*6. Determine the cross section diameter of the membrane filter (Dr. Jack Caravanos).*

The table below provides a summary of the inner and outer diameter of the three manufacturers' membrane fibers. Also included is a preliminary assessment of the number of fibers that would be used in each manufacturer's full-scale system at the Station 6 Demonstration Plant.

| | Pall | Ionics | Zenon |
|---|---|---|---|
| Fiber inner diameter (mm) | 0.6 | 0.8 | 0.4 |
| Fiber outer diameter (mm) | 1.1 | 1.1 | 0.7 |
| Fibers per Pressure Vessel (PV) | 6,250 | 40,000 | 29,000 |
| Number of PVs/Skids | 76 | 32 | 72 |
| Number of Skids | 6 | 6 | 18 |
| Total # Fibers | 2.85 million | 7.68 million | 37.6 million |

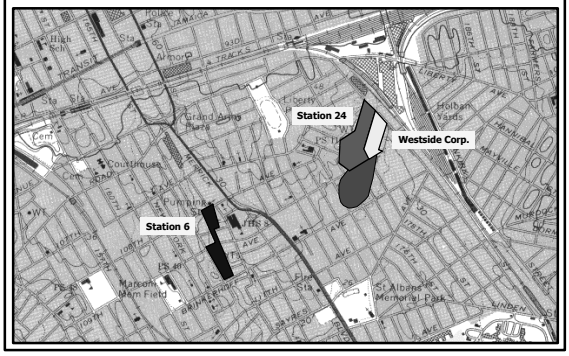
# Brooklyn-Queens Aquifer Feasibility Study

## Station 24 Project Update

## Station 24

- Project background
- Treatment process selection
- Drum test
- Schedule

## Westside Corporation Plume



## Site Location


## Plume Containment Two Phase Process

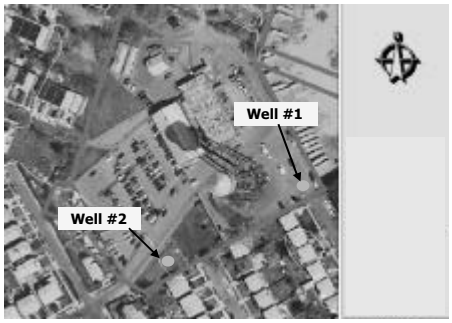
- **Phase 1**- Prior to Station 6
  Well #1 at 550 gallons per minute (gpm)

## Site Location Close Up

## Plume Containment Two Phase Process

- **Phase 1**- Prior to Station 6
  Well #1 at 550 gallons per minute (gpm)
- **Phase 2**- During Station 6
  Wells #1 and #2 at 1,550 gpm

## Site Location Close Up




## Raw Water Quality

- PCE - up to 18 ppm
- Other compounds
- Iron
- Manganese

## Treatment Concerns

- Effectiveness of PCE removal
- Iron & manganese deposition
- Environmental Impacts

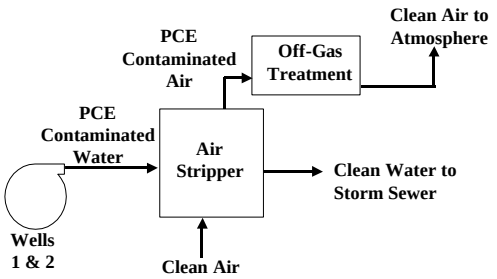
## Iron & Manganese

- Naturally occurring minerals
- Become solids under certain conditions
- Can cause operational & maintenance issues
- Chemical addition can lessen effects

## Treatment Alternatives

- Alternative 1
  Air Stripping with off-gas treatment
- Alternative 2
  Liquid Phase Granular Activated Carbon (GAC)

## Alternative 1 Air Stripping with Off-Gas Treatment




## Alternative 1 Treatment Concerns

- Effectiveness of PCE removal
  **Works GREAT!**
- Iron & manganese deposition
  **Fouls easily hard to remove solids**

## Pilot Plant Aerator

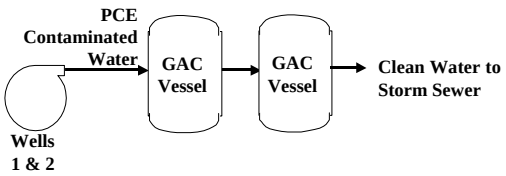
## Alternative 1
## Treatment Concerns

- Effectiveness of PCE removal
  **Works GREAT!**
- Iron & manganese deposition
  **Fouls easily  hard to remove solids**
- Environmental Impacts
  **Potential air emissions**

## Alternative 2  GAC

- What is GAC?
  Carbon media in vessel
- How does GAC work?
  PCE transfers from water to carbon
  Spent carbon is taken off-site
  Water flows in series for better removal

## Alternative 2  GAC



## Alternative 2
## Treatment Concerns

- Effectiveness of PCE removal
  **Works GREAT!**
- Iron & manganese deposition
  **Fouls easily  easier to remove solids**
- Environmental Impacts
  **No air emissions**
  **Truck traffic**

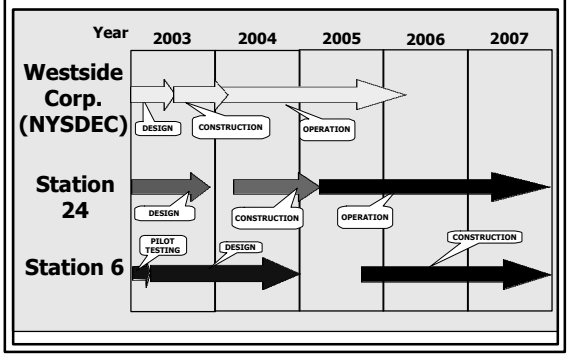
## Chosen Treatment Process
**Granular Activated Carbon**

## Drum Test

- Purpose
  Iron fouling
- Set-up
  7 gallons/minute
  Chemical addition vs. no chemical
- Duration
  Approximately 1-2 months

## Drum Test

## Schedule

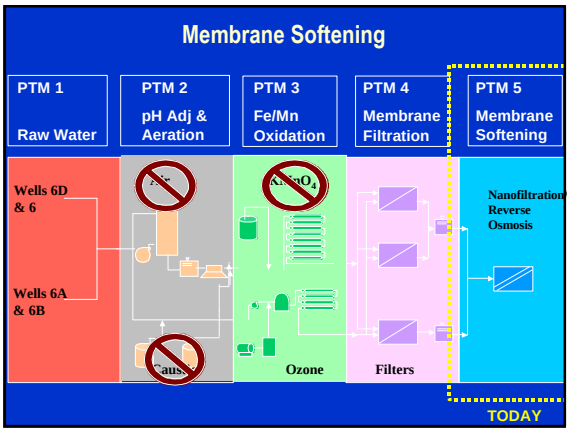



## Outline

- Brief Background/Recap – Station 6 Pilot Test Program
- Pilot Testing Results
  - Membrane Softening – for Hardness Removal --- -- IT WORKS!

## Goal

**Evaluate Treatment Processes to ensure that Station 6 Demonstration Plant provides drinking water of the highest quality.**




## Pilot Testing Results
## Membrane Softening

### What is Membrane Softening?

- Softening, also known as hardness removal, removes dissolved calcium and magnesium from the water.
- The term hardness comes from the ability of water to produce lather or foam soap – "hard" water is difficult to lather…


## Pilot Testing Results
## Membrane Softening

### What is Hardness?

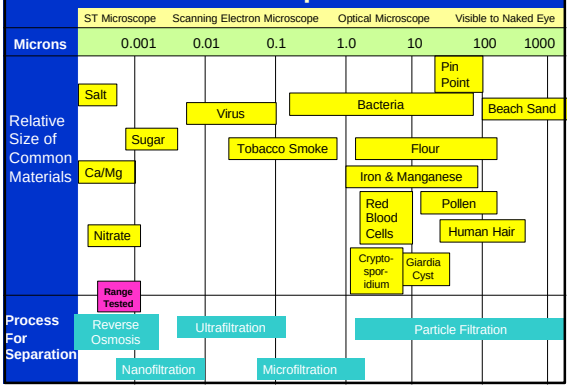
- As groundwater moves through soil and rock, it dissolves small amounts of minerals such as calcium ($Ca^{2+}$) and magnesium ($Mg^{2+}$) - these minerals contribute to what is known as hardness.
- These minerals can later be precipitated (converted back to solid form) when the water is aerated, the pH rises, and/or the temperature rises.
- Common indicators of hard waters include:
  - dishes and glasses look spotty
  - films develop on bathtubs
  - white/gray 'scaling' on pots/pans and inside hot water heaters

## Pilot Testing Results
## Membrane Softening

**What is Membrane Softening ?**

- A physical removal mechanism
- Measured in % removal
- Tested two types:
  - Nanofiltration (NF)
  - Reverse Osmosis (RO)

## The Filtration Spectrum




## Pilot Testing Results
## Membrane Softening

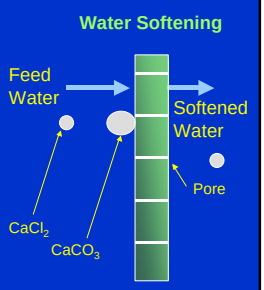
**Hardness - Calcium & Magnesium Compounds**

- **$Ca^{2+}$ & $Mg^{2+}$ form compounds with other anions ($CO_3^{2-}$, $Cl^-$, $SO_4^{2-}$) in solution**
  - Calcium Carbonate ($CaCO_3$)
  - Calcium Chloride ($CaCl_2$)
  - Calcium Sulfate ($CaSO_4$)
  - Magnesium Carbonate ($MgCO_3$)
  - Magnesium Sulfate ($MgSO_4$)

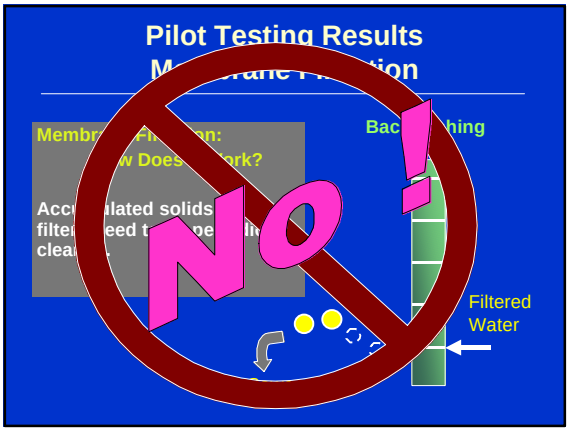
## Pilot Testing Results
## Membrane Softening

**Membrane Softening:**
**How Does it Work?**

1. Unsoftened 'Feed' Water is pushed against membrane.
2. Particles larger than pore size (i.e. calcium & magnesium compounds) are trapped on "unsoftened" side of filter.
3. Softened water flows out.

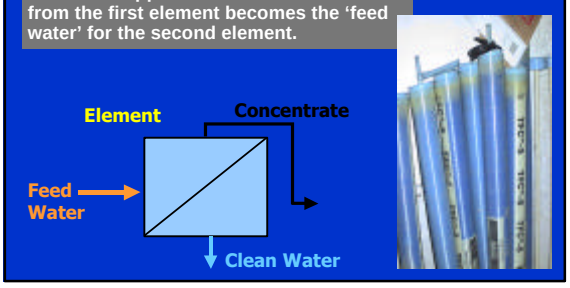



## Pilot Testing Results
## M...ion




## Pilot Testing Results
## Membrane Softening

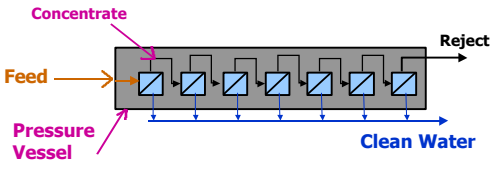
**Membrane Softening: How Does it Work?**
**Filtration happens in series. Concentrate from the first element becomes the 'feed water' for the second element.**



## Pilot Testing Results
## Membrane Softening

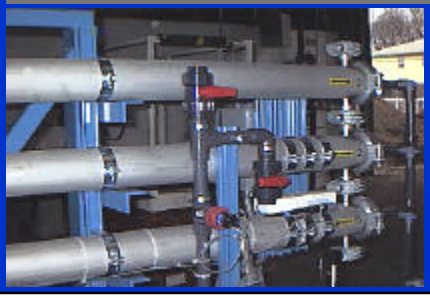
**Membrane Softening:**
**How Does it Work?**

Concentrate from the first element within a pressure vessel becomes the 'feed water' for the second element




## Pilot Testing Results
## Membrane Softening

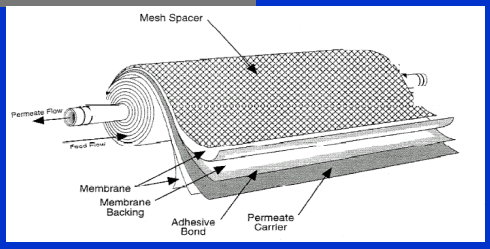
**Membrane Softening: How Does it Work?**



NF/RO Pilot Skid Pressure Vessels

## Pilot Testing Results
## Membrane Softening

**Membrane Softening:**
**How Does it Work?**




Spiral Wound Membrane Element

## Pilot Testing Results
## Membrane Softening

**Membrane Softening – How do we measure *how well* it is working?**

- **Primary Goal is to reduce Hardness.**
- **No drinking water standards for Hardness.**
- **Therefore, consider existing NYC supplies to determine desired range of values.**

## Pilot Testing Results
## Membrane Softening

**Membrane Softening – How do we measure *how well* it is working?**

| | Hardness (mg/L $CaCO_3$) | |
|---|---|---|
| | Range | Average |
| Catskill/Delaware System * | 19 - 47 | 26 |
| Croton System * | 57 - 106 | 92 |
| Groundwater System * | 34 - 352 | 110 |

* from 2002 NYCDEP Drinking Water Quality Report

## Pilot Testing Results
## Membrane Softening

| | Hardness (mg/L $CaCO_3$) | |
|---|---|---|
| | Range | Average |
| Well 6 | 359 - 391 | 377 |
| Well 6A | 160 - 187 | 173 |
| Well 6B | 148 - 240 | 164 |
| Well 6D | 409 - 600 | 473 |
| Well 33 | 243 - 250 | 247 |
| Station 6 Raw Water | 300 - 350 | 300 |
| STATION 6 HARDNESS TARGET | 80 - 100 | |

## Pilot Testing Results
## Membrane Softening

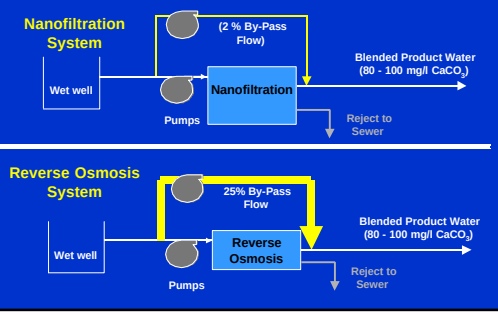
| | | NF | RO |
|---|---|---|---|
| Hardness | Raw | 167 | 162 |
| | Est. Feed | 548 | 558 |
| | Clean Water | 97 | 2 |
| | Rejection | 82 % | > 99% |

All concentrations in mg/L – hardness mg/L as $CaCO_3$

**It Works!**

## Membrane Softening
### Projections for Sta. 6 Demonstration Plant

**NF & RO systems are designed to treat only part of total plant flow.**




## Pilot Testing Results
### Membrane Softening

**It Works!**

Both systems meet hardness goal !

**What else do we need to know?**

- Flux → How much floor space?
- Recovery → How much water?
- Pressure → How much force?
- Permeability → How efficient?

## Pilot Testing Results
## Membrane Softening

**What else do we need to know?**

| | NF | RO |
|---|---|---|
| Flux, gallons per square foot per day (gfd) | 17.5 | 17.4 |
| Recovery, % | 89.3 | 90.3 |
| Pressure, pounds per square inch (psi) | 111 | 122 |
| Permeability, gfd/psi | 0.17 | 0.15 |

**Both systems operate at high flux, recovery, & permeability!**

## Pilot Testing Results
### Membrane Softening

**Overall Summary**

- Membrane softening met hardness target

**IT WORKS !!**

- Data collected during the pilot testing will be used to analyze and design Demonstration Plant.
- Decision on which technology to use (NF or RO) will be made by DEP based on capital and operating costs of the systems.

**ATTACHMENT E**

STATION 6 PILOT PLANT
IMPURITIES REMOVED BY SOFTENING MEMBRANES

| | 7/31/02 | 10/02/02 | 10/30/02 | 11/20/02 | 11/25/02 | 12/18/02 | 12/26/02 | 1/02/03 | 1/09/03 | 1/29/03 |
|---|---|---|---|---|---|---|---|---|---|---|
| *Sodium* | | | | | | | | | | |
| Nanofiltration | | | | 87% | 24% | | | | | |
| Reverse Osmosis | | | | | | 70% | 71% | 73% | 71% | |
| *Chloride* | | | | | | | | | | |
| Nanofiltration | | | | 16% | 17% | | | | | |
| Reverse Osmosis | | | | | | 86% | 84% | 86% | 87% | |
| *Nitrate* | | | | | | | | | | |
| Nanofiltration | | | | 12% | 2% | | | | | |
| Reverse Osmosis | | | | | | 46% | 46% | 51% | 54% | |
| *MTBE* | | | | | | | | | | |
| Nanofiltration | 96% | 100% | 100% | 100% | 100% | | | | | |
| Reverse Osmosis | | | | | | 96% | 100% | 100% | 100% | 99% |
| *PCE* | | | | | | | | | | |
| Nanofiltration | 80% | 60% | 67% | 59% | 51% | | | | | |
| Reverse Osmosis | | | | | | 48% | 45% | 43% | 54% | -389%[1] |

[1]Represents a release of PCE from the membrane into the treated permeate. This was caused by excessive build-up of adsorbed PCE into the saturated membrane lining.