SUMMER 2004

Ohio Section
NEWSLETTER
AMERICAN WATER WORKS ASSOCIATION

Nanofiltration Water Softening for the City of West Carrollton

by James Gagnon, BBS Corporation

The City of West Carrollton currently provides finished water to its customers that complies with all regulatory requirements. Further responding to its customers' aesthetic needs, the City has chosen to enhance the water quality by adding a water softening process. For this reason, the City is pursuing the construction of a new membrane water-softening facility to add to its existing 2.5 MGD Water Treatment Plant (WTP).

A significant step in executing this project was the successful piloting operation of the nanofiltration process. The pilot-scale plant was used to demonstrate that the nanofiltration process meets the City's goal of providing good quality, softened water to its customers. The pilot study confirmed the water quality parameters of both the membrane permeate and concentrate. The membrane fouling potential of the raw water was evaluated and found to require only infrequent cleaning of the membranes. The pilot-scale study also developed sufficient information to determine design criteria for the full-scale facility. Lastly, the City obtained Ohio EPA approval of the nanofiltration process using the pilot study results.

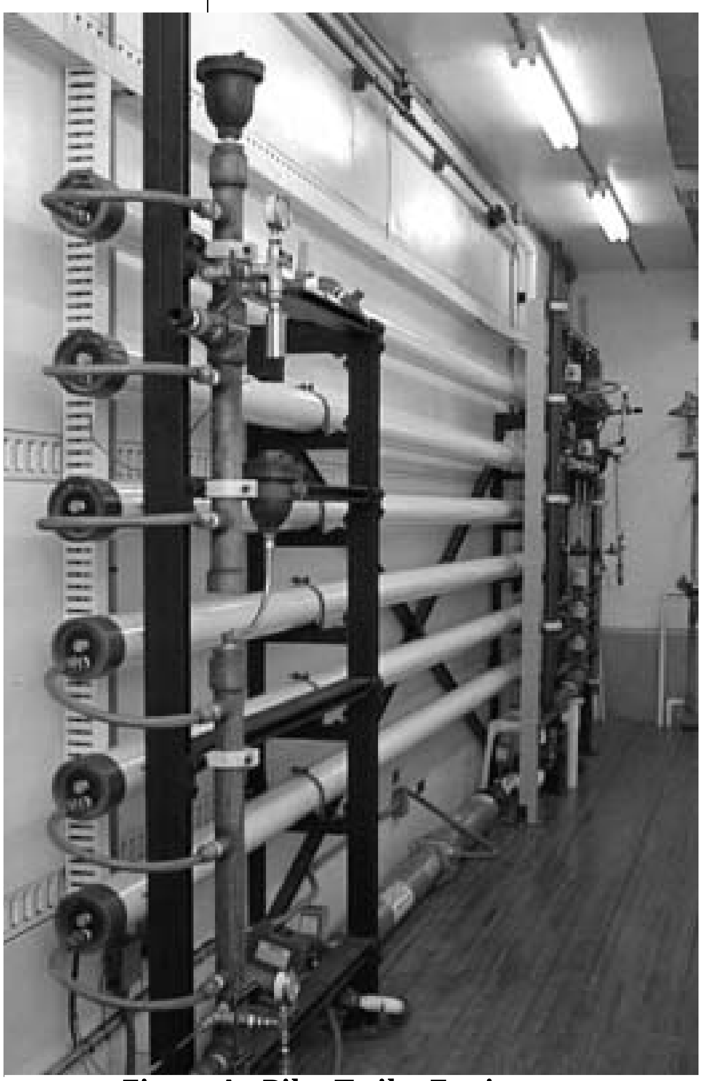

Figure A.: Pilot Trailer Equipment

Background:

The City of West Carrollton's existing WTP uses well water from the Great Miami River Valley Aquifer as the source water. The treatment plant consists of:

- Three wells, each pumped by a vertical-turbine pump,
- Four sand filters for iron and manganese removal,
- A 50,000-gallon serpentine clearwell immediately downstream of the filter control weir,
- And three high-service pumps to convey water from the clearwell into the distribution system.

Treatment provided at West Carrollton's WTP includes addition of:

- Potassium permanganate (KmNO4) to the raw-water lines for pre-oxidation,
- Hydrofluosilicic acid to the clearwell influent for fluoridation,
- And gaseous chlorine to the raw water line and to the clearwell influent for disinfection.

The source of water for the new WTP will be the City's existing wellfield, which includes Wells 1, 3, and 4. Well 1 obtains water from a lower, yet interrelated, level of the same aquifer that supplies Wells 3

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Straight From the Chair

Since this is my last opportunity to address you from this forum, I would like to begin with a couple of thank yous. The first thank you goes to the City of Springfield, especially Director Len Hartoog and all the employees at the Water Treatment Plant. They are the people who picked up my slack by completing all the daily duties that come with the working life at the Water Plant. Without their support and assistance, I would not have been able to give the time nor expend the effort that this position requires.

Jerry Swanton, ***Chair***

The last thank you goes to all the Ohio Section volunteers. Thanks for the support you have given me, the hard work you have done on behalf of the organization, and for further enhancing the reputation that the Ohio Section enjoys with the International Association.

So what is going on in the Ohio Section? Let's start with TOLEDO. The state conference will be in Toledo from September 14-17 this year. It will be chock full of your favorite events and even, or so I hear, a surprise or two. This is the premier event for our organization, so mark your calendars and plan to attend.

We have opened the lines of communication so far with the Ohio EPA that we now have face-to-face interaction on a regular basis. Through the efforts of leadership in both organizations, Mike Baker (Chief of the Division of Drinking and Ground Waters of the Ohio EPA) has been attending our Governing Board meetings. Mr. Baker's attendance enables both of our organizations to express the needs, concerns, and issues of interest on a regular basis in an open forum. This effort is beneficial for all and we are very appreciative to Mr. Baker for taking time out of his busy schedule to attend.

An area that the Governing Board is trying to expand the efforts Ohio Section is in governmental advocacy. All too often, there are things going on in the State Legislature that are of concern to our membership and we don't know anything about them until the very last minute. The Board is working with Kevin Strang of Ohio Rural Water Association to remedy this deficiency. This is just another way that we are working to strengthen our cooperative efforts with other organizations.

We have also joined with OTCO, OWEA, and ORWA to participate in a workgroup with OEPA in order to develop a program that would allow the approval of training providers instead of getting approval for each individual course. The goal of this workgroup is to provide a framework that would allow an organization,(and not just OAWWA or OTCO or OWEA or ORWA but the City of Columbus or the City of Cleveland or the City of Springfield and so on), to get blanket approval as training providers for their training courses. This workgroup is in its infancy stage so updates on the progress will be forthcoming.

On May 10th, we had a meeting to update our Strategic Plan. Twenty-five of our members met with Nancy Sullivan, from the International Association in Denver, to work with us on this plan. The goal of this meeting was not to provide the Section with some lofty document labeled "The Plan" and then set on some dusty bookshelf, but to provide a real-world working document that would allow us to measure our progress and provide a continuity of our efforts towards our goals. Debbie Metz and her committee are using the results of this meeting to update the Strategic Plan. So, all you District Chairs and Committee Chairs, be on the look out for the completed document and try to use it to guide your future efforts on behalf of the organization.

Inside this Issue

Director's Report

I would like to take this opportunity to discuss with you a little known or recognized part of our organization and that is the Washington D.C. Office. This office is critical to the long-term success

Robert Stevenson, *Director*

of the AWWA mission as it deals on a daily basis with the policy makers. All of the national laws and EPA policies come from Washington D. C. I think it is important that we all are familiar with their charge and how they accomplish it.

The Washington staff is under the able leadership of Tom Curtis. It is his responsibility to coordinate the Association activities with the United States Congress, the Environmental Protection Agency and any other federal agency that has influence over our industry. It is a huge task. Helping him is Alan Roberson, Albert Warbuton, Tommy Holmes and Steve Via. Together they form an experienced staff that represents this organization well.

Another integral part of the Washington D.C. effort is the Water Utility Council. This Council is made up of AWWA members that have an interest in legislative or regulatory affairs. Together the Washington office and the Water Utility Council supply scientific and technical information to legislators and regulatory officials in order to produce better rules. With this coordinated effort, the Association speaks with one voice on issues.

It is traditional for the Chair of the Water Utility Council to present much of the Association ideas in the form of testimony on Capitol Hill. Currently, Howard Neukrug is serving in this role. He recently has testified on the lead levels in Washington D. C. water and the chemical candidate list.

The Water Utility Council has a network of committees that serve on technical committees in support of their effort. The Water Industry Coordinating Committee (WICC) and the Technical Advisory Workgroups (TAWs) are the most visible of these groups. It is important to remember that the states Utility Councils also are a part of this effort. Ohio has had an active Water Utility Council for years that has participated in formulating laws and regulations.

But, even more important, the Washington office is part of the overall information network available to our members. They can provide you with up-to-the-minute information on where a particular piece of legislation is in the process, help explain current policies or assist you in finding a state or federal contact.

I would encourage you to go to the AWWA web site and browse the governmental affairs section. The action of this office directly affects every utility and it deserves our support.

Don't Forget!!!
September 14-17 2004
2004 Annual Conference
Toledo, Ohio

Marvin Gnagy Non International Direct

Ohio Section Bylaws require the Nominating Committee notify the Governing Board of its nomination and announce it to the membership prior to the Annual Section Conference. Members may make additional nominations until 30 days prior to the September 16 election held at the Business Luncheon.

The Nominating Committee with the concurrence of the Board, has nominated Marvin Gnagy as International Director.

Marvin Gnagy

Marvin is a Design Engineer for ARCADIS FPS in Toledo, Ohio. He started his water career in 1977 in LaGrange as an operator and later accepted an operator position with the City of Berea. In 1983, Marvin became Superintendent of the Berea plant and is thought to be the youngest recipient to receive a Class IV Water license, receiving his certificate in 1985. In 1986, he moved to Defiance as Superintendent of Water. In 1989, Marvin became an Operations Specialist with Jones & Henry Engineers in Toledo. He accepted a position with Finkbeiner, Pettis & Strout in 1996, who later merged with ARCADIS in 2003. Marvin went back to complete his college career after a successful career in water and graduated from the University of Toledo in May 2004 with a degree in Chemical Engineering, an accomplishment he is especially proud of.

Marvin has been an active member of AWWA for 20 years. He served as Ohio Section Chair in 2000-2001. He presently serves on the Technology Committee, Continuing Education Committee, the Ohio EPA Drinking Water

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Advisory Committee, the Ohio State Standards Committee (TOSS), chairs the Technical Program Committee, co-chairs the 2004 Conference Planning Committee, and is a member of the Ohio Section MAC. He was previously a member of the Safety Committee, Research Committee, Finance and Audit Committee, Strategic Planning Committee, and the Nominating Committee. Marvin also authored, directed, and produced the AWWA video "Guide to Water Sampling" in 1995 under a grant from AWWA and the Ohio Section Small Systems Committee. He served as NW District Chair in 1989-1990 and operated the NW District study sessions from 1990-1999. He has helped more than 1,200 operators prepare for the Ohio EPA exams over his 27-year career.

He is well known for his volunteer work with OTCO serving as a Basic Water Instructor, an Advanced Water Instructor, and has authored numerous one-day seminar courses. These courses include "Jar Testing- Back to Basics", "Filter Inspection Workshop", "Solids Contact Clarifiers – Optimizing Performance", Precipitative Softening and Recarbonation" and "Disinfection Practices for Water and Wastewater". Marvin also co-authored the Advanced Water Course for OTCO in 1999.

Marvin received a number of awards in the past years including the M.W. Tatlock Award, AWWA Education Award for the "Filter Inspection Workshop", the Richard F. Melick Award and the George W. Fuller Award. He continues to be an active member in AWWA and OTCO as an instructor, author, presenter, and educator. Marvin and his wife Paula have three children, Chad, Erin, and Kyle. He enjoys golf, fishing, woodworking, and his family and friends.

Don Freisthler Nominated As First Year Trustee

Ohio Section Bylaws require that the Nominating Committee notify the Governing Board of its nomination and announce it to the membership prior to the Annual Section Conference. Members may make additional nominations until 30 days prior to the September16 election held at the Business Luncheon.

Don Freisthler

This year, the Nominating Committee consisting of Rick Schantz, Cliff Shrive, and Robert Stevenson, with the concurrence of the Board, has nominated Don Freisthler as First Year Trustee.

Don has been employed with the City of Sidney since 1978 and has been in his current position of Water Plant Superintendent since March 1994. Prior to his employment with the City of Sidney, Don served as Village Service Officer with the Village of Anna from 1976-1978. In that position he was in responsible charge of both water and wastewater treatment.

Don received his Class I Wastewater license in April of 1977. After moving to Sidney, he received his Class I Water license in April of 1980, Class II Water in November of 1980, and his Class III Water in April of 1981. He attained his Class IV Water license in October of 2000. All of his training for his licensing was completed through the Operator Training Committee of Ohio.

For the past six years, Don has been an instructor of the Basic Water Class for OTCO. He has instructed nearly one hundred students. He has enjoyed watching his former students compete in Top Ops competitions, as well as seeing them advance in their careers.

Don became actively involved in AWWA in 1994 by hosting a NW District meeting. He has served on AWWA committees and served as NW District Chair in 1999. Don has taught several district study sessions as well as ORWA study sessions. He has been Shelby County's' Youth Education Committee representative for a number of years.

Don teamed up with his local agriculture extension agent to start the Upper Miami River Watershed Group. This group has helped with conservation and educational efforts in the Upper Miami River area. This group was able to attain a 319 Grant to assist with incentives for filter strips as well as "cost buy downs" on conservation tillage equipment. The Watershed Group sponsors an annual River Clean Up Day.

Don and his wife Carolyn have been married for 32 years. They have two children, Stephanie (29) an RN and Nick (25) a police officer and a MP for the U.S. Marines Reserves who is currently serving in Iraq.

Don likes to spend his leisure time traveling, golfing, and camping with his family.

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and 4. The raw water from this aquifer has high levels of calcium, magnesium, and alkalinity and moderate levels of iron and manganese. **Table 1** provides raw water quality data for the three wells.

Parameter	Avg Raw Water Well 1	Avg Raw Water Well 3	Avg Raw Water Well 4	Avg Current Finished Water	Finished Water Goals	Projected Avg Day (2 wells)	Projected Avg Day (3 wells)
Alkalinity, Total (mg/L as CaCO3)	296	281	278	280	75 - 150	120	120
Calcium (mg/L)	107	92	94	93	—	30	34
Chloride (mg/L)	93	74	81	78	<250	54	59
Hardness, Total (mg/L as CaCO3)	427	357	370	362	75-150	117	136
Iron (mg/L)	1.4	BDL	BDL	<MCL	<0.3	<MCL	<MCL
Magnesium (mg/L)	39	31	33	32	—	10	12
Manganese (mg/L)	0.18	0.11	0.06	<MCL	<0.05	<MCL	<MCL
pH	7.3	7.3	7.3	7.3	8.0 – 9.0	8.6	8.5
Sulfate (mg/L)	70	58	58	58	<250	23	27

Table 1
City of West Carrollton Wellfield Water Quality

Table 1: City of West Carrollton Wellfield Water Quality

The existing WTP provides a finished water that currently exceeds all regulated parameters. However, the total hardness is high, prompting many residential customers to use in-home softening units. **Table 1** provides finished water quality data for the existing plant.

The City has established finished water quality goals for the new WTP following the addition of the membrane softening facility. These goals are listed in **Table 1**. The finished water goals for parameters not listed in **Table 1** are intended to continue to meet the proper regulatory limit.

The City commissioned MWH to perform a feasibility study to continue the investigation into adding a new membrane filtration facility at the existing WTP site to provide centralized water softening. The feasibility study developed a conceptual WTP process train indicating how the membrane softening process would be integrated into the existing WTP. The conceptual process train was developed based on raw-water quality from the City's existing wellfield, finished water quality goals for the new WTP, and regulatory requirements. Based on the proposed process design, the projected finished water quality for the new WTP is shown in **Table 1**. The projected finished water quality is presented during average day flow (wells 3 and 4 only) and maximum day flows (all three wells in operation). Under either scenario, only minor differences in finished water quality are noted.

The City decided to continue towards providing centralized water softening and, based on the raw water quality and the projected water quality, to perform a pilot-scale study at the existing WTP site to obtain Ohio EPA approval of the nanofiltration process.

Pilot-Scale Facilities:

The pilot-scale equipment was operated at the site of the existing treatment facility and wellfield. An on-site trailer, equipped for piloting a two-stage nanofiltration membrane system (shown in **Figure A**), was used for the pilot study. Because of operational considerations of the existing WTP, a pilot well was drilled for use during the pilot study. A comparison of the pilot test well and the existing wells indicated that the pilot test well provided representative raw water for the pilot study. Based on the raw water sampling requirements of the Pilot Study Protocol, the average pilot test well water quality is provided in **Table 2**.

A schematic of the membrane softening pilot equipment is provided in **Figure B**. The membrane pilot consisted of pretreatment chemical feed systems, membrane cleaning system, cartridge filters, high-pressure membrane feed pump, membrane pressure vessels, and various meters and gages.

As shown in **Figure B**, raw water was supplied to the pilot plant from the pilot well. The raw water was pH-adjusted with sulfuric acid (66°Baume) to the target membrane feed pH of 5.3 to 6.0. Scale inhibitor was added based on a dose of 2.5 mg/L neat to prevent scaling of the membrane elements. The water then passed through a 5-micron cartridge filter, which

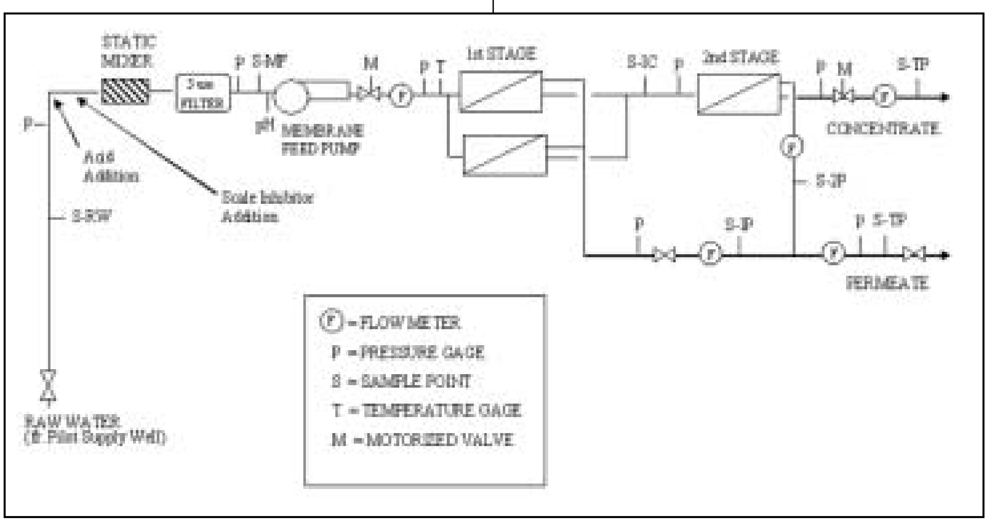

Figure B: Membrane Softening Pilot Plant Schematic

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served to remove any suspended impurities from the raw water. Desired membrane operational conditions (water recovery, permeate flux) were achieved using a motorized feed control valve placed on the feed pump discharge line and a second motorized valve on the final concentrate discharge line.

The membrane softening pilot study modeled a two-stage, 2 x 1 array of six-element pressure vessels. The first stage consisted of two, 6-element pressure vessels. The second stage consisted of a single, 6-element pressure vessel. Permeate from the first and second stages was combined. (Combined first and second stage permeate is termed ‘overall’ or ‘total permeate’.) The first stage concentrate became the feed for the second stage. The second stage concentrate, or final concentrate, was directly discharged from the pilot plant. The total permeate and final concentrate, along with the waste from the pilot facility’s lab sink and emergency shower drain, was discharged to the nearby sanitary sewer system.

Table 1
City of West Carrollton Wellfield Water Quality

Parameter	Avg Raw Water Well 1	Avg Raw Water Well 3	Avg Raw Water Well 4	Avg Current Finished Water	Finished Water Goals	Projected Avg Day (2 wells)	Projected Avg Day (3 wells)
Alkalinity, Total (mg/L as CaCO3)	296	281	278	280	75 - 150	120	120
Calcium (mg/L)	107	92	94	93	—	30	34
Chloride (mg/L)	93	74	81	78	<250	54	59
Hardness, Total (mg/L as CaCO3)	427	357	370	362	75-150	117	136
Iron (mg/L)	1.4	BDL	BDL	<MCL	<0.3	<MCL	<MCL
Magnesium (mg/L)	39	31	33	32	—	10	12
Manganese (mg/L)	0.18	0.11	0.06	<MCL	<0.05	<MCL	<MCL
pH	7.3	7.3	7.3	7.3	8.0 – 9.0	8.6	8.5
Sulfate (mg/L)	70	58	58	58	<250	23	27

Table 2: Average Water Quality

The membrane elements used in the pilot study were GE Osmonics Model HL nanofiltration membranes. This membrane is characterized as a proprietary nanofiltration thin-film membrane (TFM), with a molecular weight cutoff of 150 – 300 Daltons for uncharged organic molecules.

The membrane softening pilot plant contained seven sample points: raw water, membrane feed water, first stage permeate, second stage permeate, total permeate, first stage concentrate, and final concentrate.

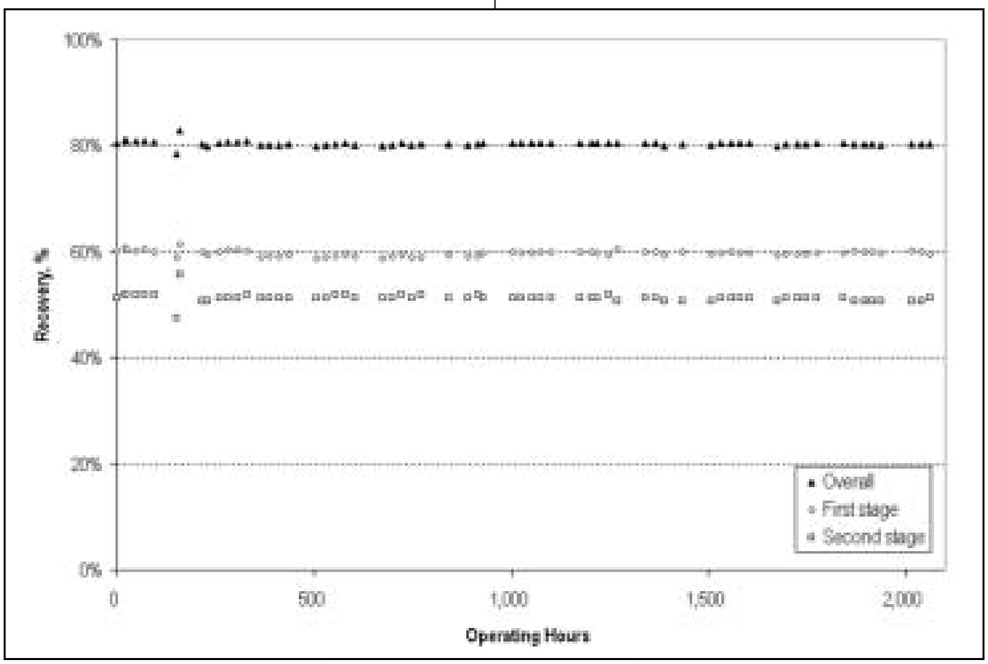

Figure C: Recovery vs. Time

Pilot Study Operations:

The pilot plant was operated for a total duration of approximately 2,200 hours. City staff and MWH personnel monitored the pilot system on a daily basis during normal working hours. The pilot plant operator recorded data during regular on-site monitoring. This data was analyzed to calculate membrane operational parameters. Samples collected during sampling events were delivered on the same day to the destination laboratories for analysis.

The nanofiltration membrane pilot plant operation consisted of two phases: the initial break-in period and the long-term operation period. The parameters for these operating conditions are listed in **Table 3**.

During the extended operation under the long-term operation condition, various data were collected to study the feasibility of applying membrane technology to the City’s water sources, and to investigate the membrane fouling potential of the raw water. The pilot unit was observed five times per week, and the various operational parameters, such as flow meter and pressure gage readings, were recorded by the pilot plant operator. Approximately three times per week, the pilot plant operator sampled the raw water, membrane feed water, total permeate, and final concentrate for different water quality parameters. These parameters were analyzed in the City of West Carrollton’s laboratory. In addition, an Ohio-certified water quality laboratory was retained by

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the City to perform further analyses of water quality parameters.

Post-treatment requirements of

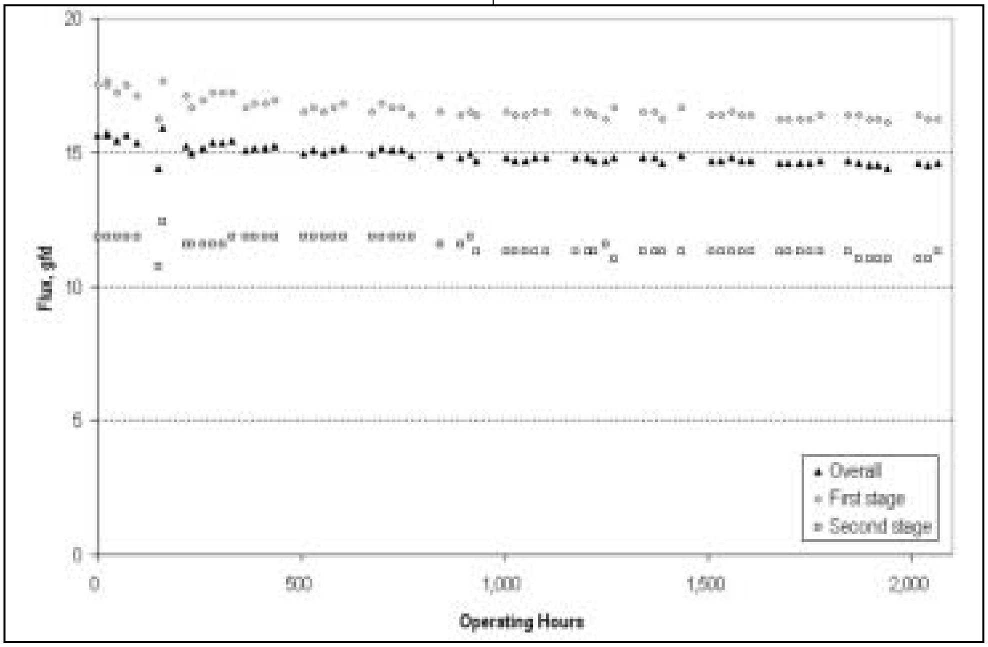

Figure D: Permeate Flux vs. Time

the permeate, such as air stripping for carbon dioxide removal, and blending studies with a split stream to verify the selected blending ratio for full-scale design were part of bench-scale studies performed during the long-term operating condition.

Concentrate bench-scale testing was conducted once at the conclusion of the pilot study to confirm aeration of the concentrate would not cause excessive production of solids.

Operational Data and Analysis:

The target water recovery was 80% during the long-term operation period. **Figure C** shows the temporal variation of stage 1, stage 2 and overall system recovery. The overall recovery value was held fairly constant and averaged 80.4%. The average recovery values for first stage and second stage were 59.7% and 51.3%, respectively.

The target total permeate flux was 15 gfd. The actual average permeate flux during the pilot study period was 14.9 gfd. A slight decrease in permeate flux was observed due to membrane fouling. The temporal variation of stage 1, stage 2, and total permeate flux is presented in **Figure D**. The ratio of first stage flux vs. second stage flux averaged 1.4.

Permeate mass transfer coefficient MTC_W is a measure of membrane productivity. **Figure E** shows the fluctuation of the first stage, second stage, and overall permeate MTC_W over time during the pilot long-term operation period. The overall permeate MTC_W experienced only a very slight drop during the entire long-term operation period. This result verifies that scale inhibitor plus acid pretreatment was effective in limiting the decline of the overall permeate MTC_W. Based on the linear interpolation of the overall permeate data MTC_W, a cleaning interval projection can be made for a full-scale system. Assuming the membrane system is operated continuously under the tested conditions, and membrane cleaning is triggered after a drop of 15 percent in overall permeate MTC_W, cleaning would be required after approximately 10,500 hours of operation, equaling 14 months of full-time operation.

As described previously, the pilot plant operator took samples approximately three times per week to measure different water quality parameters. The averages for key parameters for the total permeate are listed in **Table 2**. Addition of sulfuric acid to the raw water resulted in a shift of the carbonate equilibrium towards aqueous carbon dioxide. Easy passage of aqueous carbon dioxide through the NF membrane resulted in a carbon dioxide rich permeate. The presence of carbon dioxide and absence of alkalinity-contributing species in the permeate water, resulted in a low pH, low alkalinity permeate. Blending post-treated permeate water with plant finished water was evaluated to assure the WTP will be able to provide a stable finished water.

The permeate was air-stripped until the pH stabilized at 7.5. The air-stripped permeate and existing WTP finished water were measured and mixed according to permeate/split stream ratio of 75/25. The blended water was then dosed with caustic soda and chlorine to produce a final pH of 8.5±0.25 and a minimum chlorine residual of 0.2 mg/L. The averages for key parameters for the blended water are listed in **Table 2**.

The concentrate contains high levels of elements originally present in the well water, such as iron,

Table 3
Parameters for Pilot Plant Operating Periods

Operating Period	Duration (hours)	Recovery (%)	Permeate Flux (gfd)	Feed pH
Initial Break-In	~ 150	75	15	5.5 – 6.0
Long-Term	2,062	80.4	14.9	5.5

Table 3: Parameters for Pilot Plant Operating Periods

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calcium, and manganese. When aerated, these elements might be oxidized and precipitate in the aeration basin. At the conclusion of the pilot study, concentrate testing was conducted to confirm aeration would not cause such a problem. During the testing, concentrate was air-stripped until pH stabilized at 7.7. Total suspended solids (TSS) and turbidity levels were measured and compared before and after aeration. The concentrate testing results are shown in **Table 4**. Although the turbidity and TSS levels did increase after aeration, it was concluded that the minimal increases would not cause excessive settling in the concentrate aeration basin.

Table 4
Concentrate Water Quality Before and After Aeration

	pH	TSS, mg/L	Turbidity, NTU
Before Aeration	5.7	<3	<1
After Aeration	7.7	6	9

Table 4: Concentrate Water Quality Before and After Aeration

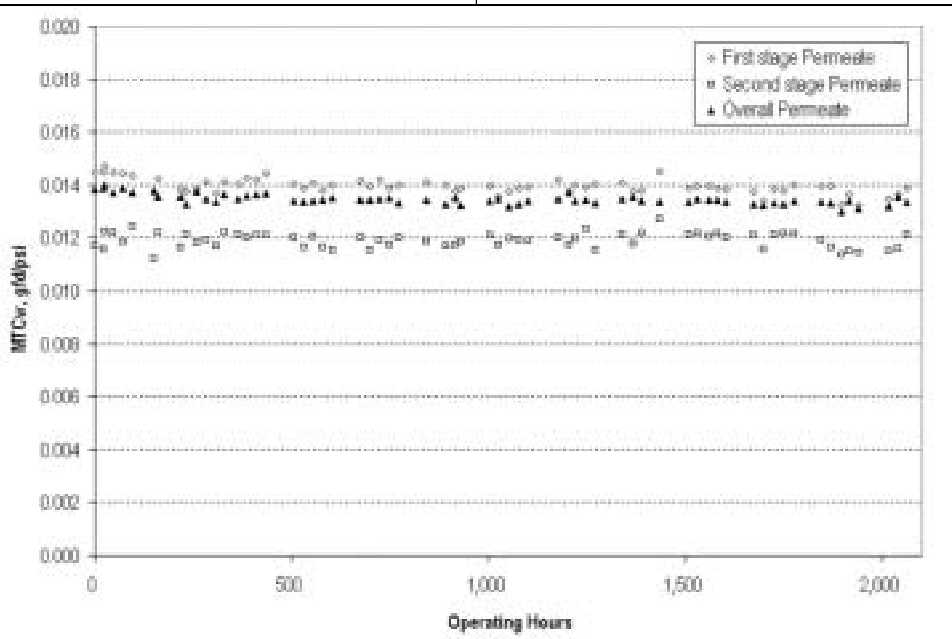

Figure E: Permeate Mass Transfer Cefficient (MTC_w) vs. Time

Conclusions:

The pilot-scale study successfully demonstrated the efficacy of the nanofiltration membrane process for treating the City of West Carrollton's existing well water. All desired water quality and regulatory goals were achieved. Pilot operational and water quality data contributed towards establishing full-scale design criteria.

Design operational parameters for the full-scale membrane softening facility were determined as follows:

Water recovery: 80%
Permeate flux: 15 gfd
Feed pH: 5.5
(desired pH was achieved by using sulfuric acid)
Scale inhibitor dosage: 2.5

Operating the pilot plant at the above operational parameters is expected to result in a steady, gradual decrease in permeate specific flux over time. The decline in overall permeate mass transfer coefficient was controlled by the use of scale-inhibitor in conjunction with sulfuric acid. According to the pilot plant operating data, cleaning would be required after approximately 14 months of continuous operation.

Laboratory sampling of the membrane permeate verified it conformed to all Ohio EPA Primary and Secondary standards. The corrosive nature of the permeate caused by low pH, low hardness and low alkalinity was successfully neutralized with air-stripping post-treatment, blending with split stream water in a ratio of 75:25 (permeate-to-existing WTP finished water), followed by pH adjustment and chlorination.

The results of the pilot study were submitted to Ohio EPA for review and acceptance. After a relatively brief period of review, Ohio EPA responded with their acceptance of the nanofiltration process for treating the City's well water. As part of Ohio EPA acceptance of the pilot results, the City also received the ability to bid and install the GE Osmonics HL membranes. In the future, installation of different membrane elements will require only a 30-day proof test.

Status of Project:

Following Ohio EPA acceptance of the pilot results, MWH completed the detailed design of the membrane softening facility, and Ohio EPA reviewed and approved the detailed plan and specifications. The construction contract was successfully bid in August 2003, and construction began in September 2003. The project has a one-year construction schedule, with final start-up and testing expected to be completed by the end of 2004.

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(1) At the time the events reported in this article took place, the author was employed by MWH.