ICR Treatment Study Summary Report

Evaluation of Membrane Technology Using Pilot-Scale Testing for Compliance with the Information Collection Rule

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Prepared by:
Camp Dresser & McKee Inc.
800 Brickell Avenue, Suite 710
Miami, Florida 33131

In April 1999

For:
Miami-Dade Water & Sewer Department,
PWSID# FL 4130871
4200 Salzedo Street
Coral Gables, Florida 33146
(305) 669-7611
(305) 669-3762

Hialeah Water Treatment Plant, Plant ICR #302

Attachment: 1 diskette containing the Data Collection Spreadsheets

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Section 1
Conclusions and Recommendations

This section summarizes the major conclusions and recommendations resulting from the nanofiltration (membrane softening) pilot plant studies conducted at the Hialeah Water Treatment Plant (Hialeah WTP) for the Miami-Dade Water and Sewer Department (MDWASD) in partial fulfillment of the requirements of the Information Collection Rule (ICR). In reviewing these conclusions and recommendations, it should be noted that while the ICR process studies were performed at the Hialeah WTP, the overall process evaluation included the consideration of impacts to the adjacent John E. Preston Water Treatment Plant (Preston WTP). The Hialeah and Preston WTPs share certain raw water supply lines, clearwell storage, and high service pumping facilities. These two facilities have a total near term capacity of 235 million gallons per day (mgd) with 70 mgd of capacity at Hialeah WTP and 165 mgd at the Preston WTP. There facilities serve the northern half of Dade County within the MDWASD service area. The impacts of a process change at one facility would need to be considered at the other facility.

1.1 Conclusions

The subsection summarizes the major conclusions evident from the operational and analytical activities during the ICR membrane pilot plant studies. The conclusions are grouped as follows; operational considerations, water quality considerations, and economic considerations including capital as well as operation and maintenance (O&M) costs.

1.1.1 Operational Conclusions

The most significant operational conclusion to be drawn from the ICR pilot studies centers around the critical nature of the quality of the source water to the successful operation of the membrane pilot plant. As discussed more extensively in the body of the report, several severe cartridge filter and membrane fouling events occurred during the course of the study, caused by iron hydroxide forming when air entered the feed water. The air was thought to have entered the system at the wellheads through well column surging and, potentially well column corrosion holes. The problem would have been difficult to remediate during the study due to the large number of wells and the difficulty of isolating the problem wells. To allow the study to continue in an orderly manner, a single onsite well was dedicated to providing source water for the Hialeah membrane pilot plant. Water quality in this well was sufficiently similar to overall wellfield quality so as to not compromise process evaluation. A submersible pump was installed in this well to minimize air entrainment in the raw water. After this modification, the pilot plant ran without major incident for the remaining seven months of the study.

Other major operational considerations included the disposal of concentrate water from the membrane process, potential co-operation of a membrane process with the current lime softening process, and the physical location of a new membrane facility. For the disposal of concentrate waters from a membrane softening process, two reasonable and feasible methods are workable to MDWASD, deep well injection and discharge to brackish/saline tidewater. Both methods have been successfully permitted in South Florida.

As further detailed in Section 1.1.2 and Section 4, the permeate water resulting from the nanofiltration process demonstrated low concentrations of the primary parameters of regulating interest, disinfection by-product formation potential (DBPFP), color, and total organic carbon (TOC). In addition, the permeate exhibited low levels of total hardness and alkalinity and potentially high levels of carbonic acid (dissolved carbon dioxide). As such the permeate water was amenable to blending with lime softened water from the present process to achieve the known Stage 1 Disinfectants/Disinfection By-products Rule (D/DBPR) regulation and the anticipated Stage 2 D/DBPR regulation. The estimated membrane permeate to lime softened blend water ratios are 25 million gallons per day (mgd)/210 mgd for Stage 1 and 140 mgd/95 mgd for Stage 2 based upon the near term production capacities for the Hialeah WTP and the directly associated comparison plant, the Preston WTP.

The current Hialeah and Preston WTP sites are highly constrained both in terms of on-site facilities that leave little room for expansion and the presence of adjacent residential neighborhoods. While highly compact in terms of available production per unit of area, the necessary membrane facilities could not be reasonable or feasibly located at either plant site. As such it was concluded that a membrane facility would be best located at the Northwest Wellfield, which primarily serves the Preston WTP and, periodically, the Hialeah WTP. This wellfield area provides sufficient area for the membrane facility. In addition, this location would allow the membrane process to treat the relatively higher color and TOC raw water at this wellfield while allowing the lower organic content raw water from the Miami Springs/Hialeah Wellfield, which currently serves the Hialeah WTP, to be partially diverted to the Preston WTP for lime Softening.

1.1.2 Water Quality Conclusions

The water quality results from the membrane ICR pilot studies indicate that the membrane product water easily meets the Disinfection By-Products Rule (DBPR) maximum contaminant limits (MCLs) for total trihalomethanes (THM4) and the group of five haloacetic acids (HAA5). Under simulated distribution system (SDS) conditions, THM4 formation potential averaged less then 0.005 mg/L while HAA5 formation potential averaged less than 0.007 mg/L. TOC was removed to an average concentration of 0.40 mg/L as C in the permeate down from an average raw water value of 8.06 mg/L as C.

Total hardness (TH) and alkalinity values were also significantly decreased in the permeate water from raw water values. The permeate water concentrations of 28 and 23 mg/L as $CaCO_3$ for alkalinity and TH, respectively, were significantly less than the raw water values (138 and 203 mg/L, respectively) and the current Hialeah WTP finished water values (53 and 55 mg/L, respectively). The permeate water was concluded to be suitable for blending with lime softened water with the potential ability to lime soften to a lesser degree due to the relatively lower permeate water quality concentrations.

1.1.3 Economic Conclusions

In terms of capital cost, three sets of Capital cost estimates were developed, as follows:

First Alternative: Membrane facilities would be located at the Hialeah /Preston WTP site and sized to meet Stage 1 D/DBPR regulations and sized to meet anticipated Stage 2 D/DBPR regulations. In the first scenario, part of the Hialeah WTP capacity would be replaced with membrane capacity. In the second scenario Hialeah WTP lime softening capacity would be completely replaced with membrane capacity as well as a significant portion of the Preston WTP lime softening capacity.

Second alternative: Membrane facilities would be located at the remote Northwest Wellfield site and sized as described above.

Third alternative: Same as described in the Second Alternative except ozone would be utilized in conjunction with the remaining lime softening facilities to meet the Stage 2 requirements.

The capital and O&M costs for the alternatives are summarized below:

Alternative	Stage	Capital Cost ($)	O&M Cost ($/1000 gal)
First	1	58,490,000	NA
First	2	229,690,000	0.82
Second	1	157,600,000	NA
Second	2	278,200,000	0.61
Third	1	157,600,000	NA
Third	2	180,400,000	0.61

1.2 Recommendations

In reviewing the recommendations, it should be noted that MDWASD has and is still at the time of this report submission, evaluating other process alternatives to meet the D/DBPR and meet internal goals relating to finished water color. The following recommendations would only be applicable if a membrane process was selected by MDWASD as the process of choice. At the time of this report submission it would appear that other, lower cost alternatives are available to MDWASD to meet the D/DBPR and the internal finished water color goals.

1.2.1 Operational Recommendations

Based upon the ICR-related membrane studies at the Hialeah WTP and concurrently performed membrane pilot studies at the Preston WTP, the following operational recommendation can be made.

1. Membrane operation using nanofiltration membranes at an 84 to 85 percent recovery rate, a feed pressure of 100 psi, a 3rd Stage feel pressure of 125 psi, and an overall average flux of 15.1 gfd coupled with elimination of air entrainment in the raw water would be an appropriate treatment method.

2. To suppress bacteriological fouling from the use of relatively higher organic source water from the Northwest Wellfield, it is recommended that a feedwater pH of 5.5 or lower be utilized.

3. A well remediation program to eliminate air entrainment at the wellheads and a well rehabilitation program to minimize bacterial growth would be highly recommended to reduce bacterial fouling potential.

1.2.2 Water Quality Recommendations

Due to the cost of constructing new membrane facilities and the fact that MDWASD has existing facilities which still have considerable design life remaining, the best treatment alternative utilizing membranes most likely involves a blending scenario. MDWASD's existing lime softening facilities would produce water which could be blended with permeate water at a ratio which would allow compliance with D/DBPR and meet other water quality goals.

Specific recommendations relating to permeate water quality and blend water ratios are as follows:

1. Utilization of softening membranes or even low pressure reverse osmosis membrane that provide relatively low permeate water hardness, alkalinity and TOC would be recommended to allow less restrictive lime softening condition while meeting water quality goals.

2. To meet the Stage 1 D/DBPR a membrane permeate to lime soft water ratio of 25 mgd to 210 mgd (or 1.0:8.4) is recommended.

3. To meet Stage 2 D/DBPR regulations, a membrane permeate to lime softened water ratio of 140 mgd to 95 mgd (or 1.47:1.00) is recommended.

1.2.3 Economic Recommendations

The following recommendations are based upon the developed capital as well as O&M cost estimates.

1. If it is desired or anticipated that only Stage 1 D/DBPR regulations will be set, the first alternative, a 25 mgd membrane facility at the Hialeah/Preston WTP area, would be recommended.

2. If it is desired or anticipated that Stage 2 D/DBPR regulations are to be met, the Third Alternative, a 25 mgd membrane facility located at the Northwest Wellfield with ozonation of the remaining lime softening capacity, would be recommended.

Section 2
Background Information

This section summarizes the treatment processes, historical water quality and quality data, and treatment challenges for the Hialeah Water Treatment Plant (Hialeah WTP).

2.1 Hialeah Water Treatment Plant Description

The Hialeah Water Treatment Plant (WTP) is located at 200 W. 2nd Avenue in Hialeah, Florida and is adjacent to the Preston WTP. The two plants share some source water and storage capacity. These two plants serve the Hialeah-Preston Service Area, generally considered to be the Miami Dade Water and Sewer Department (MDWASD) Service area north of Flagler Street. The two plants have similar treatment processes. The Hialeah WTP is considered to be a traditional softening plant and is described in more detail below.

The Hialeah WTP receives its source water primarily from the Hialeah-Miami Springs Wellfield, supplemented by the Northwest Wellfield. This plant has a current rated capacity of 60 million gallons per day (mgd) and a basic treatment regimen which includes lime softening with sodium silicate activated by chlorine, recarbonation, chlorination, ammoniation, fluoridation, filtration and air stripping. The plant site is relatively small and built up, and is surrounded by residential areas, leaving little room for expansion. The Hialeah WTP was originally designed in 1924 with a total capacity of 10 mgd. This capacity was doubled later that year and then again in 1935 to reach a total capacity of 40 mgd. In 1946, treatment capacity was increased to 60 mgd, the plant's current capacity. In 1991, air strippers with a capacity of 84 mgd were added to the Hialeah treatment process to remove volatile organic compounds from the finished water. A reservoir providing 3.2 million gallons (MG) of storage for both the Hialeah and Preston WTPs was also added in 1991. Plans exist to upgrade Hialeah to a capacity of 70 to 80 mgd in the near future (1999).

2.1.1 Design Information and Process Schematic

The Hialeah WTP treatment process includes lime softening, disinfection and filtration. The primary components of the Hialeah WTP treatment train are provided below with a brief description of each process and associated equipment.

- Sand Traps - Mixing chamber for return sludge and raw water. Two split tanks with 24 feet (ft.) average water depth and 6.4 minute detention time at 60 mgd.

- Mixing Tanks - Application of sodium silicate and sodium silicofluoride at 1.2 mg/L. Two baffled tanks with average water depth of 23 ft. and 3.3 minute detention time at 60 mgd.

- Flocculators - Addition of lime at an approximate dose of 179 mg/L for softening. Two flocculation tanks with three vertical flocculators per tank for agitation.

- Clarifiers - Solids settling and sludge collection. Three units with two rectangular tanks with average water depth 16.5 ft. and one circular tank with average water depth of 17.5 ft. Total detention time of the three clarifiers is 1.75 hours at 60 mgd. All units have center column drive with continuous operation sludge collection. Sludge pumps transfer spent lime either to repump station or to lime recalcination (kiln) plant.

- Recarbonation - Addition of 24 mg/L carbon dioxide for stabilization. Three units with average water depth 16.3 ft. and detention time of 5.4 minutes at 60 mgd. Carbon dioxide control is manual and is kept proportional to raw water flow.

- Disinfection - Addition of chlorine at 5.0 mg/L dose, followed by ammonia at 0.5 mg/L to form monochloramine for primary and distribution system disinfection. Three chlorinators with 10,000 lb/day capacity and two chlorinators with 500 lb/day capacity. Three amoniators with 1,000 lb/day capacity. Chlorine and ammonia flow are kept proportional to raw water flow. Chlorine contact basins with 62.8 minute detention time at 60 mgd.

- Fluoridation - Addition of fluoride at 0.5 mg/L dose rate. Control is manual, and is kept proportional to raw water flow.

- Corrosion Control - Addition of sodium polyphosphate at 0.6 mg/L dose rate. Control is manual and kept proportional to raw water flow.

- Filtration - Rapid sand filtration with center gullet. 16 dual media filters with 10 ft. average water depth above filter bottom.

- Water Storage - Clear wells for treated water storage. Located under pump rooms and filters with a volume of 1.7 MG. One reservoir with volume of 3 MG.

- Low Lift Pump Stations - Pump water to air stripping towers. Two centrifugal pumps with 30 mgd pump capacity at 42 ft total dynamic head (TDH) and two vertical turbine pumps with 30 mgd pump capacity at 42 ft. TDH.

- Air Stripping - Packed columns with counter current flow pattern for removal of volatile organic compounds (VOCs). Twenty towers with 14 ft. inner diameter (I.D) and packing depth of 20.5 ft.

A process flow schematic for these components including the location of the membrane pilot plant is provided in **Figure 2-1**. The specifics of the design criteria for the individual components of the Hialeah WTP treatment train are provided in **Table 2-1.**

2.1.2 Raw Water Supply

The source of supply water for the Hialeah WTP is the Hialeah-Miami Springs Wellfield which is comprised of separate upper and lower wellfields and several wells onsite at the Hialeah WTP. The Lower Wellfield includes eight wells (No. 1 through 8) and is situated in a residential area of Miami Springs just south of the Miami River and the WTP. Pump motors at these wells range from 40 to 100 horsepower (hp) and produce 3.6 to 7.2 mgd each of raw water. The total Lower Wellfield capacity is 33.8 mgd. The Upper Wellfield is made up of 12 wells (Nos. 9, 10, 14, 15, 16, 17, 18, 19, 21, 22 and 23) with pump motors also ranging from 40 to 100 hp. The capacity per well ranges from 3.6 to 6 mgd with a total Upper Wellfield capacity of 46.2 mgd. There are three wells (Nos. 11, 12, and 13) located at the Hialeah WTP with 40 hp pumps providing 4.2 mgd each for a combined capacity of 12.6 mgd. The total (rated) pump capacity for the entire Miami Springs Wellfield is 92.6 mgd.

The Preston WTP obtains its source water from the Northwest Wellfield which is located several miles west of the Preston WTP in an undeveloped area. The wellfield is made up of 15 wells with two speed pumps capable of providing a total capacity of 150 mgd at low speed and 165 mgd at high speed. This Northwest Wellfield water is also used to supplement the raw water for the Hialeah WTP. There are six additional wells onsite at the Preston WTP which are capable of supplying another 54 mgd of capacity but are used for stand-by purposes only.

MDWASD currently holds a water use permit for the Hialeah-Preston facility with the South Florida Water Management district (SFWMD) for an annual allocation of 60.20 billion gallons of groundwater from the Biscayne Aquifer. Maximum daily withdrawals are not to exceed 197.91 mgd and the annual allocation is not to exceed 164.93 mgd.

2.1.3 Historical Flow Data

Historical raw and finished water flow data for the Hialeah WTP for the past four fiscal years (from October 1994 through September 1998) are provided in **Table 2-2**. These data are taken from monthly operating reports (MORs) generated by operators at each of the WTPs. Average daily flow (ADF) for raw water ranged from 53.7 mgd to 55.8 mgd. Finished water ADF ranged from 67.4 mgd to 71.0 mgd, above the Hialeah WTP's rated capacity of 60 mgd because of combined finished water flow from the Preston WTP. Maximum day flow (MDF) for raw water varied from 60 mgd to 70 mgd. For finished water flows, the MDF ranged from 80.9 mgd to 98.7 mgd. MDF is typically about 10 percent more than ADF with the MDF to ADF ratio for raw water ranging from 1.02 to 1.29 and for finished water from 1.04 to 1.36. For each

Figure 2-1

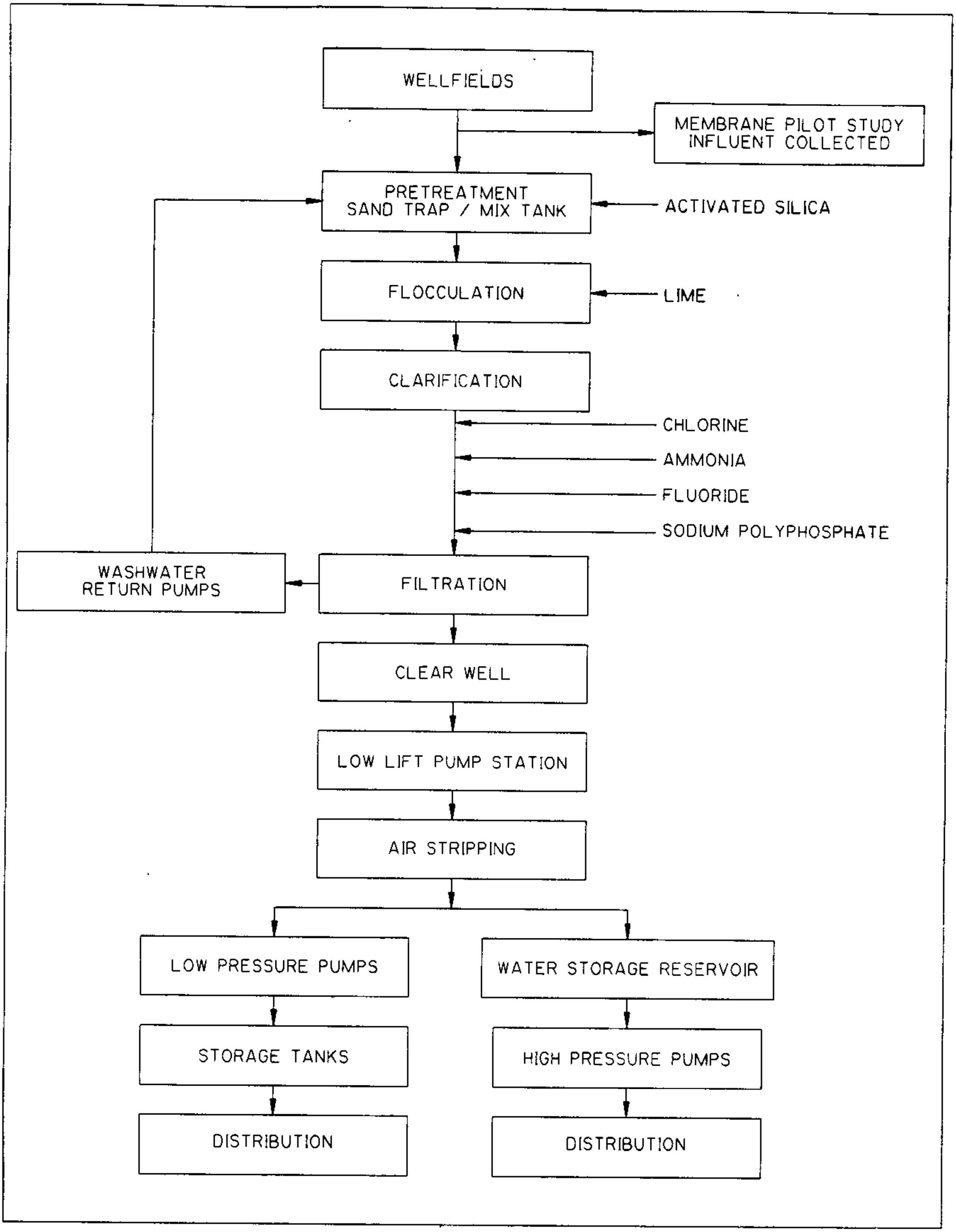


Figure No. 2-1
MIAMI-DADE WATER & SEWER DEPARTMENT
ICR TREATMENT STUDY SUMMARY REPORT
HIALEAH WTP PROCESS SCHEMATIC

CDM Camp Dresser & McKee

TABLE 2-1

Hialeah Water Treatment Plant
Design Criteria

Operational Parameter	Description
Raw Water Pumping	
Number of Wells (upper and lower wellfields)	23
Well Diameter/Well Depth	14"/80-90 feet
Transmission Main Length (from farthest well)	7,600 feet
Well Pump Capacity	92.6 mgd
Pretreatment	
Sand Trap Number/Volume	Two/35,328 cubic feet (ft^3) (264,253 gals)
Mixing Tank Number/Volume	Two/18,400 ft^3 (137,632 gals)
Lime Softening	
Lime Dose	175 ppm
Sodium Silicate Dose	1.2 ppm
Flocculator Number/Volume	Two/123,200 ft^3 (921,536 gals)
Flocculator Detention Time	22.1 min.
Clarifier Number/Volume	Three/585,000 ft^3 (4,375,800 gals)
Disinfection	
Chlorine Dose	5 ppm
Ammonia Dose	0.5 ppm
Chlorine Contact Basin Volume	350,000 ft^3 (2,618,000 gals)
Chlorine Contact Basin Detention Time	62.8 minutes
Filtration	
Filtration Type	Multimedia
Design Filtration Rate	4 gpm/ft^2
Filter Cells/Capacity	Sixteen/80 mgd
Filter Area (dimensions per Filter Cell)	880 ft^2 (44 feet X 20 feet)
Washwater Return Pump Number/Capacity	Five/6,700 gpm
Lime Recalcination Plant	
Thickener Number/Capacity	Two/170,000 gallons
Slurry Holding Tank Number/Capacity	One/1.0 MG
Chemical Feed	
Lime slaker Number/Capacity	Two/10,000 lbs/hr
Lime Storage	1,735 tons
Sodium Polyphosphate Dose	0.5 ppm
Sodium Polyphosphate Storage Tank Number/Capacity	Two/16,000 gals
Sodium Polyphosphate Metering Pump Number/Capacity	Two/ 26 gph
Sodium Silicate Storage Tank Capacity	10,000 gals
Sodium-Silicofluoride Dose	0.6 ppm - 0.8 ppm
Air Stripping	
Air Stripper Type	Packed Column, Counter Current Flow Pattern
Air Stripper Number/Capacity	Twenty/64 mgd
Air Stripper Inside Diameter/Height	14 feet/35.5 feet
Low Lift Pump Number/Capacity	Four/120 mgd at 42 ft. TDH

TABLE 2-2

HIALEAH WATER TREATMENT PLANT
HISTORICAL FLOW DATA

	RAW WATER				FINISHED WATER			
Month-Year	Annual Average Daily Flow (mgd)	Maximum Day Flow (mgd)	MDF/ADF Factor	12 Month Running Average ADF	Annual Average Daily Flow (mgd)	Maximum Day Flow (mgd)	MDF/ADF Factor	12 Month Running Average ADF
Oct-94	59.2	65.0	1.10	—	74.2	81.5	1.10	—
Nov-94	52.6	55.0	1.05	—	70.0	75.3	1.08	—
Dec-94	55.1	67.0	1.22	—	68.3	78.0	1.14	—
Jan-95	54.9	66.0	1.20	—	62.7	69.2	1.10	—
Feb-95	57.6	64.0	1.11	—	63.7	76.7	1.20	—
Mar-95	53.5	61.0	1.14	—	67.4	82.1	1.22	—
Apr-95	57.8	64.0	1.11	—	72.7	98.7	1.36	—
May-95	60.1	63.0	1.05	—	73.2	81.0	1.11	—
Jun-95	55.1	59.0	1.07	—	65.8	76.5	1.16	—
Jul-95	54.6	59.0	1.08	—	66.0	73.7	1.12	—
Aug-95	50.9	54.0	1.06	—	61.2	68.8	1.12	—
Sep-95	57.7	64.0	1.11	—	63.5	70.6	1.11	—
FY 94/95	55.8	67.0	1.11		67.4	98.7	1.15	
Oct-95	56.3	60.0	1.07	55.52	65.4	70.8	1.08	66.66
Nov-95	58.5	62.0	1.06	56.01	68.9	74.3	1.08	66.57
Dec-95	61.4	64.0	1.04	56.53	68.0	75.3	1.11	66.54
Jan-96	56.0	63.0	1.13	56.63	66.4	74.9	1.13	66.85
Feb-96	50.0	62.0	1.24	55.99	70.9	76.9	1.08	67.45
Mar-96	53.1	63.0	1.19	55.96	68.1	76.6	1.12	67.51
Apr-96	51.3	56.0	1.09	55.42	71.0	75.9	1.07	67.37
May-96	54.7	70.0	1.28	54.97	70.2	77.1	1.10	67.12
Jun-96	54.6	59.0	1.08	54.93	70.3	77.1	1.10	67.49
Jul-96	52.2	56.0	1.07	54.73	71.8	79.0	1.10	67.98
Aug-96	54.6	58.0	1.06	55.03	72.5	76.7	1.06	68.92
Sep-96	53.0	57.0	1.08	54.64	71.2	80.9	1.14	69.56
FY 95/96	54.6	70.0	1.12		69.6	80.9	1.10	
Oct-96	50.2	54.0	1.08	54.13	68.0	73.5	1.08	69.78
Nov-96	51.0	53.0	1.04	53.51	69.0	72.8	1.06	69.78
Dec-96	48.7	56.0	1.15	52.45	68.1	87.6	1.29	69.79
Jan-97	52.9	54.0	1.02	52.19	69.4	74.0	1.07	70.04
Feb-97	46.4	60.0	1.29	51.89	63.1	73.3	1.16	69.39
Mar-97	57.9	60.0	1.04	52.29	71.4	75.8	1.06	69.67
Apr-97	57.2	60.0	1.05	52.78	70.3	74.1	1.05	69.61
May-97	58.1	59.0	1.02	53.07	70.4	75.5	1.07	69.63
Jun-97	56.7	59.0	1.04	53.24	71.5	77.9	1.09	69.73
Jul-97	56.5	58.0	1.03	53.60	72.1	77.6	1.08	69.75
Aug-97	55.3	58.0	1.05	53.66	72.0	75.0	1.04	69.71
Sep-97	53.1	54.0	1.02	53.67	71.6	82.6	1.15	69.74
FY 96/97	53.7	60.0	1.07		69.7	87.6	1.10	
Oct-97	52.4	54.0	1.03	53.85	69.8	77.4	1.11	69.89
Nov-97	51.8	54.0	1.04	53.92	70.3	77.3	1.10	70.00
Dec-97	52.4	58.0	1.11	54.23	68.6	74.6	1.09	70.04
Jan-98	51.3	53.0	1.03	54.09	68.1	73.5	1.08	69.93
Feb-98	50.8	53.0	1.04	54.46	67.1	73.0	1.09	70.27
Mar-98	51.3	54.0	1.05	53.91	68.6	71.4	1.04	70.03
Apr-98	54.8	59.0	1.08	53.71	71.5	76.6	1.07	70.13
May-98	54.6	57.0	1.04	53.42	69.5	77.2	1.11	70.06
Jun-98	58.9	65.0	1.10	53.60	77.6	87.2	1.12	70.57
Jul-98	57.5	62.0	1.08	53.68	79.1	85.7	1.08	71.15
Aug-98	55.5	57.0	1.03	53.70	71.1	76.5	1.08	71.08
Sep-98	53.2	55.0	1.03	53.71	70.7	76.2	1.08	71.00
FY 97/98	53.7	65.0	1.06		71.0	87.2	1.09	

fiscal year of data, the ADF, the MDF and the average MDF/ADF factor are provided.

2.1.4 Water Quality Characteristics

Average water quality data for 1995 through 1998 for raw and finished water at the Hialeah WTP are provided in **Table 2-3** and include analyses of physical, chemical, and microbiological parameters. These data are a compilation of water quality analyses performed throughout the year (beginning June, ending May) for internal purposes and to meet the Dade County Department of Environmental Resources Management (DERM) and State of Florida Department of Health (DOH) requirements. Concentrations of all of the parameters tested are below the maximum contaminant levels (MCLs) set by the United States Environmental Protection Agency (EPA), indicating the plant is in compliance. These typical water quality analyses are made available to MDWASD’s consumers.

An item of particular concern at the Hialeah WTP is the presence of small amounts of vinyl chloride in the Miami Springs Wellfield raw water. The average amount of vinyl chloride found in the raw water during the past three years is 0.004 mg/L, which is removed to below detectable limits by the air stripping towers. Trihalomethanes formed by chlorine contact are removed to a significant degree by the air stripping towers.

2.1.5 Treatment Challenges Facing Plant

The Hialeah WTP is fed from source water from the Hialeah/Miami Springs Wellfield, sometimes supplemented by the Northwest Wellfied. These wellfields contain relatively high levels of TOC and color. Due to a very short free chlorine contact time and the use of air stripping towers, the Hialeah WTP produces below detectable limits of THM4, and approximately 0.010 mg/L of HAA5 (which are not removed by air stripping). The current finished water color is approximately 13 CU, generally considered a visibly detectable level of color. In order to lower this color level, the free chlorine contact time could be increased to oxidize humic and fulvic acids responsible for color. In addition any increase in free chlorine contact time to provide a four-log virus inactivation under potential regulations associated with the anticipated Groundwater Disinfection Rule (GWDR) would result in an increase in the formation of disinfection by-products. A balance between these issues, which allows compliance with the DBP Rule while providing consumers with an aesthetically appealing water, will play a major role in any upcoming upgrades to the water treatment facilities. Any modifications made to the Hialeah WTP will be made in conjunction with the neighboring Preston WTP since there are several interconnections between the plants.

TABLE 2-3

HIALEAH WATER TREATMENT PLANT
HISTORICAL WATER QUALITY SUMMARY

	units	1995 Raw Water	1995 Finished Water	1996 Raw Water	1996 Finished Water	1997 Raw Water	1997 Finished Water	1998 Raw Water	1998 Finished Water	4-yr Average Raw Water	4-yr Average Finished Water
METALS											
Barium	mg/L	0	0	0	0	0	0	0	0	0	0
Calcium	mg/L	85	20	85	20	82	19	80	19	83	20
Iron	mg/L	0.7	0.0	0.7	0.0	0.9	0.0	0.7	0.0	0.8	0.0
Magnesium	mg/L	7.6	4.2	7.6	4.2	6.2	3.6	7.5	4.2	7.2	4.1
Manganese	mg/L	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00	0.01	0.00
Potassium	mg/L	2.3	2.4	2.3	2.4	1.4	1.9	2.6	2.6	2.2	2.3
Sodium	mg/L	37	33	32	34	29	23	31	29	32	30
ANIONS											
Bromide	mg/L					0.2	0.1	0.14	0.14	0.17	0.12
Chlorides	mg/L	54	55	51	53	53	54	51	51	52	53
Fluoride	mg/L	0.2	0.8	0.2	0.8	0.2	0.8	0.22	0.66	0.21	0.77
Sulfates	mg/L	13	13	5	7	6	9	5	8	7	9
PHYSICAL & CHEMICAL PROPERTIES											
Alkalinity											
Phenolphthalein	mg/L	0	6	0	5	0	4	0	5	0	5
Total	mg/L	235	54	229	51	228	53	225	54	229	53
Ammonia	mg/L			0.6	0.8	0.6	0.3	0.73	0.69	0.64	0.60
Carbon Dioxide	mg/L	22	<0.1	20	<0.1	28	<0.1	26	< 0.1	24	< 0.1
Chlorine Residual at Plant (as Cl_2)	mg/L	0.0/0.0	1.1/3.8	0.0/0.0	1.1/3.8	0.0/0.0	0.0/3.9	0.0/0.0	0.1/3.6	0.0/0.0	0.6/3.8
Color	PCU	39	14	39	14	41	10	42	10	40	12
Conductivity	umhos/cm	631	320	602	304	608	302	569	292	603	305
Hardness											
Total	mg/L	241	68	234	65	235	66	230	64	235	66
Non-carbonate	mg/L	6	14	5	14	8	12	5	11	6	13
Oxygen, dissolved	mg/L	4.8	9.1	2.3	9	2.2	8.9	4.2	10	3.4	9.3
pH	pH	7.3	9.1	7.3	9.2	7.2	9.1	7.2	9.1	7.3	9.1
Silica	mg/L	8.26	9	5.6	6.1	7.7	8.8	7	8.2	7.1	8.0
Temperature	°C	26	26	26	26.5	26	26.5	26	26	26.0	26.3
Threshold Odor Number	mg/L	10	2	8	1	8	1	2	0	7	1
Total Dissolved Solids	mg/L	376	183	340	168	362	186	334	191	353	182
Total Organic Carbon	mg/L					14	9.1	12.5	7.3	13.3	8.2
Turbidity	mg/L	1.0	0.3	0.2	0.2	0.5	0.2	0.59	0.13	0.57	0.21
MICROBIOLOGY											
Cryptosporidium/Giardia	#/100L					ND	-	ND	-	ND	-
Total Coliform	Present/Absent	A	A	A	A	A	A	A	A	A	A
ORGANICS											
Total Trihalomethanes	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Haloacetic Acid	mg/L						0.01		0.01		0.01
VOLATILE ORGANICS											
Vinyl Chloride	mg/L	0.004	0.000	0.005	0.000	0.003	0.000	0.003	0.000	0.00	0.00

Section 3
Materials and Methods

This section describes the materials and methods utilized in the Hialeah Water Treatment Plant (WTP) membrane pilot plant study to partially fulfill the requirements of the Information Collection Rule (ICR) for the Miami-Dade Water & Sewer Department (MDWASD). The description of materials includes a description of the membrane treatment process including pretreatment and cleaning. The description of methodology includes the experimental design, analytical methods including total dissolved solids and conductivity correlation and preparation of the ICR mandates spreadsheets.

3.1 Pretreatment Processes

For the first five months of the study, influent water for the membrane pilot plant was obtained from the composite raw water main entering the main Hialeah WTP prior to any chemical additions or water recycle. In order to eliminate iron hydroxide fouling resulting from the introduction of air into the raw water line, an on-site Hialeah WTP well, Well No.12, was utilized. The well was fitted with a submersible well pump that eliminated air. Water from this well was pumped directly to the membrane pilot plant unit. In both cases, the supplied raw water was not pretreated in any manner prior to the membrane pilot plant.

The pilot-scale pretreatment processes are summarized in **Table 3-1** and included the addition of an antiscalant and sulfuric acid followed by cartridge filtration. A schematic of this pilot-scale pretreatment is included in the process flow diagram for the membrane pilot plant. Sulfuric acid was utilized to lower the carbonate ion concentration to prevent calcium carbonate deposition, particularly in the third stage. Sulfuric acid at a strength of 93 percent, was pumped directly from a 55 gallon drum into the raw water stream at a rate sufficient to maintain a feedwater pH value of approximately 6.5. For the Miami Springs/Hialeah Wellfield raw water, a dose of approximately 85 milligrams per liter (mg/L) was necessary.

A scale inhibitor was fed at a rate of 2 mg/L as pure product solution to control scale formation of sulfate and chloride salts. For this study, Pretreat Plus 100, manufactured by King Lee Technologies, was utilized.

To eliminate sand and silt particles that are inevitably present in raw water from older surficial aquifer wells tapping the Biscayne Aquifer, 5-micron cartridge filtration was used. The filters were operated at an approximate flow of 3.25 to 3.50 gallons per minute (gpm) per 10 inches of filter length, a standard flow rate for cartridge filters in a membrane process.

Table 3-1
Hialeah Membrane Pilot Plant
Pretreatment Design Data

Unit Process	Process Description
Scale Control (Pilot-Scale)	Chemical Type: Antiscalant (PreTreat Plus 100) Dose Rate (mg/L): 2
Scale Control (Pilot-Scale)	Chemical Type: Sulfuric Acid Adjusted pH: ~6.5 Dose Rate (mg/L): 85
Cartridge Filtration (Pilot-Scale)	Number: 6 Surface Area: ~ 0.5 sq. ft. Nominal Pore Size (um): 5.0 Filter Material: Polypropylene Filter Life (gallons of processed water): ~1,000,000

3.2 Advanced Treatment

3.2.1 Membrane Pilot Plant Process

The membrane pilot plant was set up as a three stage system with a target 80 to 85 percent permeate recovery rate. The initial feed flow rate was set near 20 gpm. Of this feedwater rate, about 16 to 17 gpm of permeate was produced while approximately 3 gpm of concentrate water was produced. A process schematic of the Hialeah pilot plant is presented as **Figure 3-1. Table 3-2** summaries the major equipment used in the Hialeah membrane pilot plant unit. As shown in the diagram, the raw water initially passed through the raw water booster pump which increased the water pressure from approximately 10 pounds per square inch (psi) to approximately 30 psi. As discussed previously, pretreatment prior to membranes included antiscalant and sulfuric acid injection. The feed stream then went through six, 5-micron cartridge filters installed in parallel. Following the cartridge filters, the feedwater entered the R/O pump used to increase the feed pressure to approximately 100 psi prior to entering the 1st Stage of membrane elements. The speed of this pump and thus feed pressure and feed water flow was regulated by a variable frequency drive (VFD).

The 1st Stage of membranes consisted of four pressure vessels with two parallel trains, each with two pressure vessels in series. Each pressure vessel contained three membrane elements and one spacer. These elements had a nominal four inch outside diameter and a length of 40 inches. The concentrate stream from the 1st Stage continued through the 2nd Stage which was comprised of two pressure vessels in series, each containing three elements and one spacer. The 2nd Stage concentrate water passed through an interstage booster pump to increase the feed pressure of the water being fed to the 3rd Stage. The 3rd Stage of the system consisted of two vessels with three elements each. TFCS elements were used in this stage which had an outside diameter of 2.5 inches and a length of 40 inches. The final discharges from the pilot unit were a permeate stream containing approximately 85 percent of the original flow and a concentrate stream comprising 15 percent of the original flow. These streams were routed into the Hialeah WTP sand trap where they would re-enter the WTP treatment train.

Nanofiltration (NF) membranes manufactured by Hydranautics, Fluid Systems and Filmtec were considered for use based upon histories of use in South Florida on similar raw water qualities. The Fluid Systems Model TFC 4921S (1st and 2nd Stages) and Fluid Systems Model SC 2540S (3rd Stage) were selected for use based upon expected finished water hardness levels, prior use in the Phase 1 bench-scale studies, overall operational criteria, and participation of Fluid Systems in supplying one of the MPPUs. It should be noted that the 3rd Stage element model (SC2540S) is very similar in characteristics to the element (TFC 4921S) used in the 1st and 2nd Stages.

It should be noted that utilization of this particular membrane element would in no way preclude the future use of other NF membranes from other manufacturers.

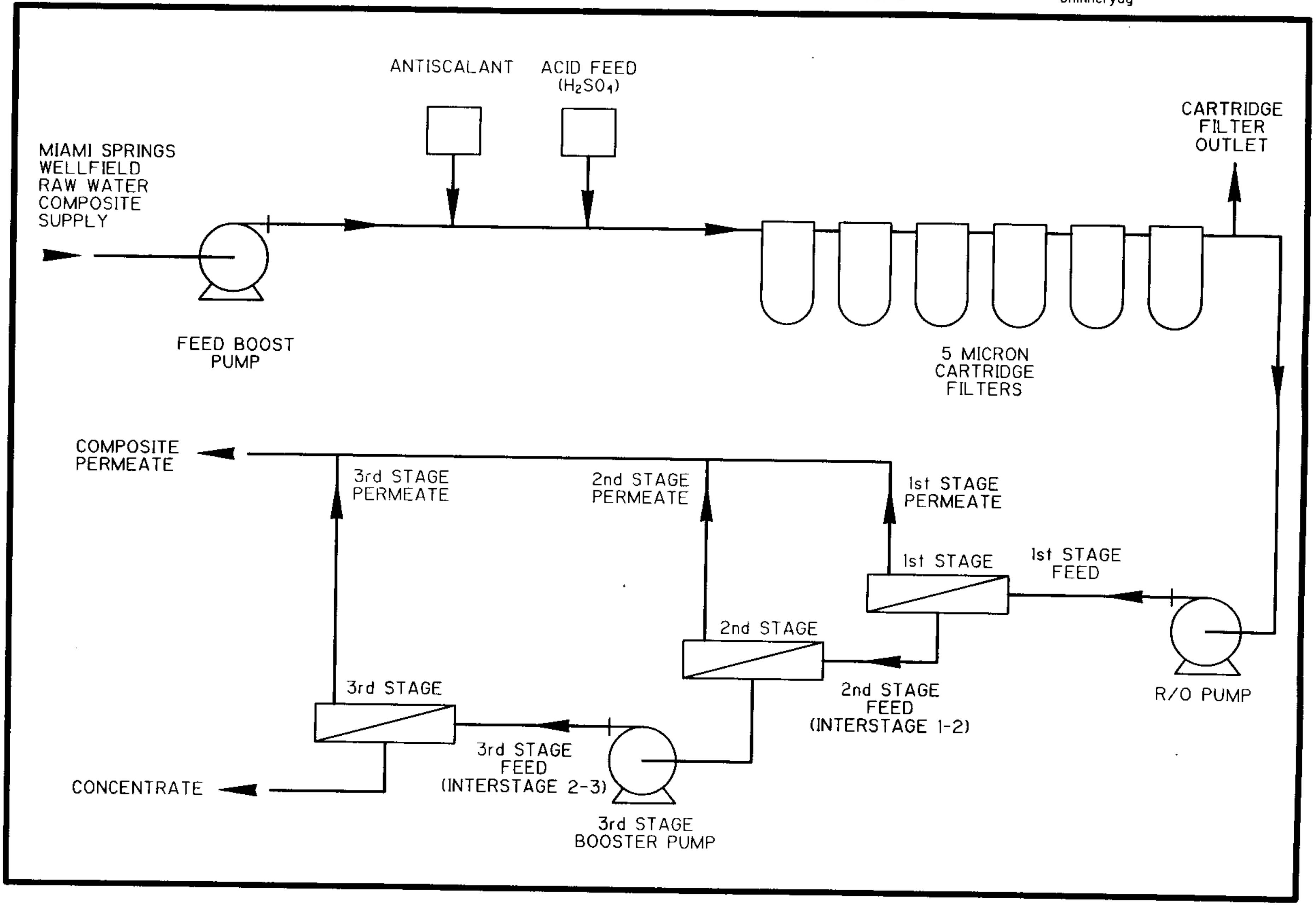


Figure No. 3-1
MAIMI-DADE WATER & SEWER DEPARTMENT
HIALEAH MEMBRANE PILOT PLANT
PROCESS FLOW DIAGRAM

CDM Camp Dresser & McKee

TABLE 3-2
Hialeah Membrane Pilot Plant
Advanced Treatment Design Data

Unit Process	Equipment Process Description
Membranes	Type: TFC 4921S (1st and 2nd stages), SC 2540S (3rd Stage) Size: 4" x 40" (1st and 2nd Stages) 2.5" x 40" (3rd Stage)
R/O Pump	Type: Grundfos, Multi-stage Centrifugal Pump with VFD
Pressure Vessels	Type: Advanced Structures (1st and 2nd Stages), Codeline (3rd Stage) Material: Stainless Steel (1st and 2nd Stages) Fiberglass (3rd Stage)
3rd Stage Boost Pump	Type: Grundfos, Vertical, Multistage Centrifugal Pump

3.2.2 Membrane Cleaning Procedures

Membrane cleanings were performed on an as-needed basis. In general, cleaning was performed when the differential pressure between the feed pressure and the concentrate pressure (delta p) within the first stage increased significantly (approximately 50 percent).

Two types of cleaning solutions are typically used: (1) a low pH solution to remove acid soluble substances such as metal hydroxides and calcium carbonate and (2) a high pH solution to remove organic substances and microbiological slimes. The only type of fouling experienced at the Hialeah membrane pilot plant was related to inorganics and therefore only the low pH solution was used. The solution was prepared in accordance with the membrane manufacturer's (Fluid Systems) recommendations. The low pH solution was made by mixing granular anhydrous citric acid with permeate water to achieve a solution with a pH of approximately 2.5. Ammonium hydroxide was used to elevate the pH to 2.5, if necessary. All chemicals used were commercial grade.

The cleaning skid was comprised of an 85 gallon mix tank where chemical solutions were prepared, a ½ hp centrifugal pump to pump solutions through the pressure vessels, a 5-micron cartridge filter to capture suspended solids and particulate foulants released during cleaning, two 55 gallon tanks to hold permeate water and approximately 100 feet of braided hose to direct flows. The cleaning stream was always in the same flow direction as normal feed flow to the system.

The typical operation of the cleaning skid was as follows. The cleaning solution was pumped from the mixing tank through 3/4-inch braided hose through the cartridge filter into the inlet of the first pressure vessel to be cleaned. After passing through the intended pressure vessel(s), the majority of the reject solution was returned to the mixing tank for recirculation.

Membranes were cleaned by isolating a single stage or by isolating only two pressure vessels. For example, the 1st Stage influent and effluent lines were isolated, one bank of membranes cleaned completely and then that stage resealed. The 2nd and 3rd Stages were then done individually. The vessels were first flushed thoroughly with approximately 55 gallons of permeate water. Approximately 60 gallons of cleaning solution was prepared depending on the stage being cleaned. The cleaning solution was circulated through the vessels with the first 20 percent of the concentrate and permeate flow going to waste and the remainder recirculated through the bank of membranes for 30 to 60 minutes. After cleaning, the solution was drained to waste and another 55 gallons of permeate solution was pumped through the system to flush out any residual cleaning solution.

3.3 Experimental Design

For the nanofiltration membranes utilized in the membrane study, performance in terms of permeate water quality can be easily predicted based upon previous studies and membrane characteristics. The true goal of pilot scale studies is to assess long term operating characteristics in terms of fouling potential, and resulting impacts on water mass transfer coefficient (MTCw) also known as specific water flux, feedside pressure loss and salt passage. Therefore the ICR Study at the Hialeah WTP focused on meeting the experimental objectives of the ICR while assessing membrane performance as it would relate to a full-scale process application. The following subsections summarize the experimental plan and operations of the membrane pilot plant.

3.3.1 Information Collection Rule Compliance at Hialeah WTP

The experimental objectives for the treatability study using pilot-scale membrane units may be summarized as follows:

Pilot-Scale Membrane Study Requirements

- Evaluate one membrane with a molecular weight cutoff value less than 1000 Daltons.

- Evaluate a minimum element size of 2.5" x 40"
- Operate the system at a recovery of a least 75 percent
- Operate the system for at least 6600 hours over the course of one calendar year
- The system must consist of at least two stages with at least two pressure vessels in the first stage and at least one pressure vessel in the second stage (i.e., 2-1 array)
- Each pressure vessel must contain at least three elements.

Monitoring Membrane Systems

- The productivity of membrane systems must be assessed in terms of water flux, required net driving pressure and cleaning frequency.
- The feed and permeate streams must be analyzed for pH, temperature, turbidity, total dissolved solids, alkalinity, total hardness, calcium hardness, total organic carbon (TOC), Ultraviolet light absorbance at 254 nanometers (UV_{254}) and bromide.
- Simulated distribution system tests must be conducted on the feed and permeate streams to evaluate the chlorine demand and the formation of total organic halides (TOX), total trihalomethanes (THM4) and a group of six haloacetic acids (HAA6).

3.3.2 Membrane Performance Evaluation at Hialeah WTP

While the ICR work plan focused on meeting the specific aspects of the ICR, primarily water quality parameters focused on disinfection by-products (DBP) and TOC removal, the membrane performance work plan focused on the water production aspects of membrane treatment at the Hialeah WTP. The membrane performance portion of the study focused on the following major aspects.

1. Permeate water quality in terms of color, hardness, and DBP formation potential.

2. Water production/specific flux to assess production of water per unit of applied pressure.

3. Rate and nature of fouling, efficiency of cleaning, and efficiency of fouling prevention measures.

4. Qualitative and quantitave assessment of operational modifications and subsequent membrane operations.

3.3.3 Initial Startup and Training Activities

The Hialeah pilot plant was sited at the Hialeah WTP in March 1997 at which time modifications to and startup of the pilot plant were initiated. A used set of NF membranes were installed to allow system testing without fear of damaging the membranes to be used for long- term testing.

Over the next month, problems encountered with pilot alarms and feed of sulfuric acid were resolved and WTP operators were trained. Permitting issues were also resolved at this time. The TFCS membrane elements were installed in the unit on June 30, 1997. Full time operation of the pilot plant began on July 7, 1997 and continued to the greatest extent possible thereafter.

Several months into the study, modifications were made to the raw water source in an attempt to eliminate the severe iron hydrozide fouling experienced during the initial months of operation. It was determined that air was entering the system probably at the Miami Springs Wellfield, causing iron to precipitate out and severely foul the membranes. The feed water supply was therefore switched from a composite raw water from the Miami Springs Wellfield to the designated onsite Hialeah WTP Well No. 12. MDWASD installed a submersible pump in Well No. 12 to minimize the introduction of air into the feed water. This change was completed in January 1998 and the MPPU did not show any signs of iron hydroxide after that modification.

To familiarize MDWASD staff at the Hialeah WTP with daily operation of the pilot plant and NF membrane processes, two training sessions were conducted. The first step of the process was an introduction to the theory behind NF membrane processes. A walk-through of the trailer was conducted for the purpose of familiarizing the operators with the equipment configuration of the unit, demonstrating the operational control features, and demonstrating proper instrument monitoring. Instructions were also given in proper data recording, elementary trouble shooting, and safety procedures. Two training sessions were held to accommodate WTP operators on different shifts. Once the pilot testing started, additional training was provided by Camp Dresser & McKee (CDM) personnel.

Further operational assistance with the pilot was provided through the Operating Protocol Document which was distributed to MDWASD staff and also kept in the pilot trailer for reference. This protocol contained information on several aspects of the pilot unit. Discussions occurred with reference to making an initial inspection and performing a startup and shutdown of the unit. A procedure for mixing the antiscalant and handling acid were given. Information on data collection and points of contact were also provided. Checks of the system were recommended for safe and successful operation. The pilot alarms were discussed and several troubleshooting tips were given.

3.3.4 Daily Operational Monitoring and Water Quality Testing

MDWASD staff were responsible for collecting data once each shift, assisting with minor maintenance and notifying CDM of alarm conditions. Data readings were scheduled to be recorded at eight hour intervals resulting in data being recorded three times each day. **Table 3-3** lists the parameters sampled or monitored per 8-hour shift. The primary parameters which were recorded were the system pressures, system flowrates and conductivity levels. In addition, pH and temperature readings were monitored. These data were then used to create normalized graphs of key operational criteria for all three stages of the pilot plant.

Conductivity, temperature, pH and Silt Density Index (SDI) readings were scheduled to be taken

Table 3-3

Table 3-3

Hialeah Membrane Pilot Plant
Per Shift Operational and Water Quality Monitoring

No.	Sample Point
1	Pre-Micron Pressure
2	Post-Micron Pressure
3	R/O Feed Pressure
4	Stage 1-Stage 2 Interstage Pressure
5	Stage 2 - Stage 3 Interstage Pressure
6	3rd Stage Feed Pressure
7	1st & 2nd Stage Concentrate Pressure
8	3rd Stage Concentrate Pressure
9	1st Stage Permeate Pressure
10	2nd Stage Permeate Pressure
11	3rd Stage Permeate Pressure
12	Total Permeate Pressure
13	1st & 2nd Stage Concentrate Flow
14	3rd Stage Concentrate Flow
15	Feedwater pH (Continuous Monitor)
16	Permeate Conductivity (Continuous Monitor)
17	Feedwater Temperature (Gauge)
18	Raw Water Conductivity (Hand-Held Instrument)
19	Post Micron Conductivity (Hand-Held Instrument)
20	1st Stage-2nd Stage Interstage Conductivity (Hand-Held Instrument)
21	3rd Stage Feed Conductivity (Hand-Held Instrument)
22	1st Stage Permeate Conductivity (Hand-Held Instrument)
23	2nd Stage Permeate Conductivity (Hand-Held Instrument
24	3rd Stage Permeate Conductivity (Hand-Held Instrument)
25	Total Permeate Conductivity (hand-Held Instrument)
26	3rd Stage Concentrate Conductivity (Hand-Held Instrument)
27	Raw Water pH Concentrate Conductivity (Hand-Held Instrument)
28	3rd Stage pH concentrate Conductivity (Hand-Held Instrument)
29	3rd Stage Feed Water Temperature (Hand-Held Instrument)
30	Pre-Micron Silt Density Index (Hand Held Device)

on a per shift basis during the testing period. Conductivity measurements were taken on the feedwater, product and concentrate waters for the entire unit and for the individual stages. Temperature readings were taken after the cartridge filters and on the 3rd Stage feed water. A hand-held conductivity meter capable of reading both conductivity and temperature was used for this purpose. Sampling of pH was conducted on the raw water and on the system concentrate. SDIs were taken on the raw water through a port located outside the trailer.

3.3.5 Weekly Pilot Plant Operations Monitoring

Routine checks of pilot plant operations were conducted weekly to monitor data and maintain chemical feeds to the unit. During these visits, antiscalant and acid levels were checked and replenished if necessary, change in pressure across the cartridge filters was monitored, and conductivity and pH meters were calibrated. Daily operations data were reviewed for potential problems and hard copies were collected for input into an electronic spreadsheet.

3.3.6 Bi-Weekly Water Quality Sampling

Testing for a set list of water quality parameters was undertaken every two weeks to comply with the ICR. The primary purpose of this testing was to determine if these parameters were effectively being rejected from the feedwater. **Table 3-4** summarizes the water quality parameters and sampling locations for the ICR . Samples were taken from nine sample locations: raw water, feed downstream of the cartridge filters, 1st Stage permeate, 2nd Stage permeate, 3rd Stage permeate, system permeate, 1st Stage-2nd Stage interstage (1st stage concentrate), 2nd Stage-3rd Stage interstage (2nd Stage concentrate) and system concentrate.

3.3.7 Monthly Water Quality Sampling

Water quality sampling was also performed on a monthly basis to coincide with the second ICR sampling event to evaluate pilot plant performance. Sampling was performed on raw and permeate waters and, on occasion, the post cartridge filter stream. The majority of the laboratory analyses were performed by Precision Environmental Laboratory in Miramar, Florida. Several analyses, including TOC, bromide, THM4 - SDS and HAA5 - SDS, were performed by CDM Laboratories in Cambridge, Massachusetts.

Table 3-5 summarizes the sampled parameters and the sampling locations for the performance - based sampling. Once during the study, a set of samples was taken on the concentrate water. Similarly, once during the study, a complete Chapter 62-550 Florida Administrative Code (FAC) (including primary and secondary standards and unregulated contaminants) set of samples was taken on the permeate stream.

Table 3-4

Table 3-4

Hialeah Membrane Pilot Plant
ICR Water Quality Sampling Summary

PARAMETER	SAMPLING LOCATIONS								
	System Permeate (SP)	Cartridge Filter Outlet (CFO)	Interstage 1-2 (IS1-2)	Interstage 2-3 (IS2-3)	1st Stage Permeate (P1)	2nd Stage Permeate (P2)	3rd Stage Permeate (P3)	System Concentrate (SC)	Raw (R)
Field Temperature	X(1)	X	X	X	X	X	X	X	
pH	X	X	X	X	X	X	X	X	
Turbidity	X	X	X	X	X	X	X	X	
Alkalinity	X	X	X	X	X	X	X	X	
Total Hardness	X	X	X	X	X	X	X	X	
Calcium Hardness	X	X	X	X	X	X	X	X	
TDS	X	X	X	X	X	X	X	X	
UV254	X	X	X	X	X	X	X	X	X
TOC	X	X	X	X	X	X	X	X	
Bromide	X	X							
THM4-SDS	X	X							
HAA5-SDS	X	X							
TOX-SDS	X	X							

NOTES:
1. X = Parameter sampled at that sampling location every two weeks

Table 3-5

Hialeah and Preston Membrane Pilot Plants
Performance Water Quality Sampling Summary

PARAMETER	SAMPLING LOCATION	
	System Permeate	Feedwater (1)
Calcium	X (2)	X
Magnesium	X	X
Manganese	X	X
Sodium	X	X
Potassium	X	X
Iron	X	X
Strontium	X	X
Barium	X	X
Ammonia	X	X
Sulfide	X	X
Carbonate	X	X
Bicarbonate	X	X
Sulfate	X	X
Chloride	X	X
Fluoride	X	X
Silica	X	X
Color	X	X
Fecal Coliform	X	X
Total Coliform	X	X
Heterotrophic Plate Count	X	X
TOC	X	X
Bromide	X	X
THM4-SDS	X	
HAA5-SDS	X	

NOTES:
1. Either Raw or Cartridge Filter Outlet
2. X = Parameter sampled at that sampling location once per month

3.4 Analytical Methods

Table 3-6 lists all of the parameters analyzed as a part of the ICR study, the units of measurement, the analytical method used, and the laboratory which performed the analysis.
In this case, the majority of the analyses were performed by MDWASD's laboratory.
Those samples which could not be accommodated in house, TOX and HAA, were sent to Montgomery Watson Laboratory in California. Sampling was conducted every other Wednesday beginning at approximately 7:00 a.m.

Contact information for the two laboratories which conducted the ICR water quality analyses is presented below:

MDWASD Laboratory:
Marjorie Jolly
Preston Water Quality Laboratory
1100 W. 2nd Avenue
Hialeah, FL 33010
(305) 887-2007 Telephone
(305) 882-5767 Fax
ICR Lab ID Number: ICRFL025

Montgomery Watson Laboratories:
Jim Hein
555 East Walnut Street
Pasadena, CA 91101
(626) 568-6400 Telephone
(626) 568-6324 Fax
ICR Lab ID Number: ICRCA013

3.4.1 Total Dissolved Solids - Conductivity Correlation

Through discussions with the Environmental Protection Agency (EPA) prior to commencement of the ICR membrane pilot studies, it was agreed that conductivity readings could be taken in the field using a hand-held meter in lieu of the more complicated and costly total dissolved solids (TDS) readings. In order to correlate these two measurements, an analysis of conductivity and TDS measurements was conducted during four months of the pilot study. During regularly scheduled ICR water quality sampling events, conductivity readings were taken on the same samples which were to undergo the laboratory TDS analysis. Results of this correlation study are presented in **Table 3-7**. As can be seen from the data, the TDS - conductivity correlation varies depending on the stream being analyzed. The streams with higher TDS and conductivity readings had higher TDS to conductivity ratios with a range from 1st Stage Permeate at 0.59 to system

Table 3-6
Hialeah Membrane Pilot Plant
ICR Analytical Methods

Parameters	Units	Method	Minimum Reporting Level	Analytical Laboratory
Alkalinity	mg/L as $CaCO_3$	SM 2320 B	0.15 mg/L	MDWASD
Total Dissolved Solids	mg/L	SM2540 C	0.004 mgL	MDWASD
Total Hardness	mg/L as $CaCO_3$	EPA 130.2	0.70 mg/L	MDWASD
Calcium Hardness	mg/L as $CaCO_3$	SM 3500 CaD	1.00 mg/L	MDWASD
Turbidity	NTU	SM 2130 B	0.03 NTU	MDWASD
Total Organic Carbon	mg/L	SM 5310 B	0.269 mg/L	MDWASD
pH	units	SM 4500 H+	NA	MDWASD
Temperature	°C	SM 2550 B	NA	MDWASD
UV_{254}	cm^{-1}	SM 5910	0.001 cm^{-1}	MDWASD
Chlorine Residual	mg/L	SM 4500 - Cl F	0.02 mg/L	MDWASD
Bromide	ug/L	EPA 300.0	0.46 ug/L	MDWASD
SDS - TOX	ug/L	SM 5320	25 ug/L	Montgomery Watson
SDS - THM4	ug/L	EPA 55.1	0.17 ug/L for CHCl3 0.21 ug/L for BDCM 0.19 ug/L for DBCM 0.19 ug/L for CHBr3	MDWASD
SDS - HAA5	ug/L	S6251B	1.0 ug/L for each analyte (2.0 ug/L for MCAA)	Montgomery Watson

TABLE 3-7

Hialeah Membrane Pilot Plant
TDS-Conductivity Correlation

Stream I.D.	Parameter	Sampling Event Identification No./ Sampling Date									Average TDS/Cond.	Standard Deviation
		HI-15 4/22/98	HI-16 5/6/98	HI-17 5/20/98	HI-18 6/3/98	HI-19 6/17/98	HI-20 6/29/98	HI-21 7/15/98	HI-22 7/29/98	HI-23 8/12/98		
SP	TDS	35	37	36	38	35	36.2	36	37	39		
SP	Cond.	62	51.2	54.5	57.7	50.2	59.1	54.4	52	53		
SP	Corr	0.56	0.72	0.66	0.66	0.70	0.61	0.66	0.71	0.74	0.67	0.06
CFO	TDS	331	331	311	337	328	327	324	333	330		
CFO	Cond.	420	420	409	367	362	353	395	462	346		
CFO	Corr	0.79	0.79	0.76	0.92	0.91	0.93	0.82	0.72	0.95	0.84	0.08
IS1-2	TDS	605	625	592	640	612	601	607	603	598		
IS1-2	Cond.	647	690	666	633	554	632	586	690	490		
IS1-2	Corr	0.94	0.91	0.89	1.01	1.10	0.95	1.04	0.87	1.22	0.99	0.11
IS2-3	TDS	1015	1040	983	1067	1019	963	1001	992	983		
IS2-3	Cond.	890	1043	917	866	712	819	729	857	620		
IS2-3	Corr	1.14	1.00	1.07	1.23	1.43	1.18	1.37	1.16	1.59	1.24	0.19
P1	TDS	33	34	32	37	32	37.5	34	34	38		
P1	Cond.	66.7	52.6	58.9	64.1	59	64.4	54.6	52.1	60.1		
P1	Corr	0.49	0.65	0.54	0.58	0.54	0.58	0.62	0.65	0.63	0.59	0.05
P2	TDS	41	42	38	45	41	41.9	44	42	43		
P2	Cond.	64.9	56.8	60.1	61.4	58.4	66.1	57.7	60.9	58.4		
P2	Corr	0.63	0.74	0.63	0.73	0.70	0.63	0.76	0.69	0.74	0.70	0.05
P3	TDS	69	71	69	105	65	64.1	68	65	68		
P3	Cond.	99.1	78.4	96.4	125.3	85.6	90.5	87.4	88.3	86.7		
P3	Corr	0.70	0.91	0.72	0.84	0.76	0.71	0.78	0.74	0.78	0.77	0.07
SC	TDS	1422	1392	1367	1306	1355	1379	1334	1322	1410		
SC	Cond.	1085	1208	1051	917	815	945	884	1013	795		
SC	Corr	1.31	1.15	1.30	1.42	1.66	1.46	1.51	1.31	1.77	1.43	0.19
R	TDS	326	324	320	335	318	318	318	322	320		
R	Cond.	409	420	398	385	354	377	393	456	344		
R	Corr	0.80	0.77	0.80	0.87	0.90	0.84	0.81	0.71	0.93	0.83	0.07

concentrate at 1.43. The individual correlations for each stream were used to convert the field conductivity readings into TDS units. These TDS data are reported in the ICR spreadsheets.

3.5 ICR Spreadsheets

This section explains briefly how the operations and water quality data are organized within the Treatment Study Spreadsheets. Due to pilot plant downtime and timing of some of the field duplicates, data did not always fall into the pre-determined increments of the ICR spreadsheets. **Table 3-8** shows how the Hialeah data corresponds with the ICR spreadsheets.

It should be noted that personnel from CDM worked with EPA staff to modify the existing two-stage based spreadsheets into a spreadsheet capable of incorporating data from a three-stage operation.

Table 3-8
Treatment Study Spreadsheets Organization

EPA Spreadsheets	Dates of Operation	Water Quality Sampling Event No.
Wks. 1-10	7/7/97-9/5/97	1,2,3
Wks. 11-20	10/3/97 - 1/16/98	4,5,6,7,8
Wks. 21-30	1/17/98 - 3/27/98	9,10, 10 DUP, 11,12,13
Wks. 31-40	3/38/98 - 6/5/98	14, 15, 15 DUP, 16,17,18
Wks. 41-50	6/6/98 - 8/14/98	19, 20, 20 DUP, 21, 22,23
23 DUP	8/12/98	23 DUP

DUP = field duplicate

Section 4
Results and Discussion

4.1 Problems Encountered

With the notable exception of three separate periods of severe fouling caused by iron hydroxide, relatively few operational problems were encountered during the 13 month operational period of the Hialeah membrane pilot plant. However, each of the iron hydroxide fouling episodes was sufficiently severe to cause unit shutdown and necessitate remedial action as described in this section. The buildup of the iron hydroxide was rapid and severe in terms of feedside pressure loss. During each event, significant amounts of air were observed in the various feedwater, interstage, and concentrate stream rotameters. This entrained air reacted with the significant, ambient raw water iron content to form relatively insoluble iron hydroxide. The exact source of air was never definitively identified. However, the general consensus by the MDWASD staff and CDM project personnel was that air was probably entrained at the well pumps. It is recognized that horizontal centrifugal well pumps, as currently utilized at the Hialeah WTP, can introduce air during startup- and shutdown-related water column surges. In addition, leaks into corroded well column piping can introduce air into the raw water stream.

The observations and actions during each iron hydroxide fouling episode are summarized below.

1. August 1997- Very rapid increase in cartridge filter differential pressure was observed. Cartridge filters were replaced after tentative visual confirmation of iron hydroxide. A low pH flush was performed but was not effective at removing iron hydroxide from cartridge filters.

2. September 1997- Very rapid increase in cartridge filter differential pressure was observed. Cartridge filters were replaced. One filter was sent to King Lee Technologies who performed a foulant analysis which confirmed that the foulant was predominantly iron but did contain about 32.9 percent organic matter. A lack of “putrid” smell indicated the organic material was naturally occurring organic material as opposed to bacterial matter.

   After restart of the pilot plant, excessive fouling was evident within two days. Air was observed in several rotameters. Cartridge filters were replaced, a low pH (<4.0) flush with sulfuric acid was performed, and then a cleaning with citric acid was performed. Discoloration of the cleaning solutions indicated significant amounts of iron in the membrane system. 1st and 2nd stage membranes were removed and inspected for damage. Twisted brine seals were replaced in the first pressure vessels in series for both the 1st and 2nd stage. It was theorized that brine seals were twisted by iron hydroxide solids forced under pressure through the seals or that the seals were deformed by an area of high flow velocity due to foulant blockage. Dissolved oxygen readings taken at this time in the various Miami Springs wells did not indicate continuous air entrainment during steady operation.

3. November 1997-Cartridge filter differential pressure again showed rapid increase which upon visual inspection confirmed iron hydroxide. The membranes were cleaned using low pH citric acid solutions as well as high pH EDTA/ polyphosphate solutions. Upon restart it was determined that the unit had severe membrane damage and it was not possible to reach nominal operation. Subsequently it was determined that four membranes were irreparably damaged and required replacement.

Subsequent to the third iron hydroxide fouling episode, it was recommended that a submersible well pump be installed at the on-site production Well No. 12. It was decided that this remedy would minimize air entrainment. This recommended action was implemented in early January 1998. From that period of time until the end of testing, no indication of iron hydroxide fouling was observed.

The only other significant operational problem was a tendency for the acid pump to lose prime and cause the pilot plant to shutdown on a high pH alarm. In future applications, decreasing the acid solution suction lift and distance would be advisable.

4.2 Operational Data

The three primary performance parameters which were used to evaluate the performance of membrane pilot systems are as follows:

- Water Mass Transfer Coefficient (Specific Flux)
- Delta P (change in feedside pressure)
- Salt Passage

These parameters are normalized to give an indication of the membrane performance that is independent of the osmotic pressure, temperature, net driving pressure, etc.

Water mass transfer coefficient (MTCw) or specific flux is a means of measuring normalized productivity of the membranes. MTCw is defined as the applied flux across the membrane [gallons/day/square feet of membranes surface (gfd)] divided by the net driving pressure of the particular stage (NDP in psi). This mass transfer coefficient of the membrane is an intrinsic characteristic of the membrane material, but apparently can be altered due to fouling.

"Delta P" is the hydraulic friction loss of the feedwater as it flows from the inlet of the membrane through the membrane spacers in the feedwater channel and to the concentrate end of the element. The water flow follows a path parallel to the membrane surface but not through the surface. Delta P is a function of the flowrate and the spacing between adjacent leaves in the membrane. It is denoted as a parasitic loss since it removes energy which might otherwise be used to force feed water through the membrane to become permeate. Delta P also serves as an indicator of membrane fouling. If the membrane is not fouled, delta P will stay relatively constant over time provided that the flows are also constant.

Salt passage relates to the performance of the membrane to reject salts. Salt passage is a normalized indicator of the membrane's ability to reject contaminants. Factors such as temperature, flux and recovery rates impact the salt passage and permeate water quality during testing and must therefore be normalized. Calculation of salt passage may be made on the basis of TDS, conductivity or any individual ion or contaminant. It is simply the permeate concentration divided by the average feed concentration as shown below:

$$SP = C_p / C_{favg}$$

where: SP = salt passage
C_p = permeate concentration
C_{favg} = average feed concentration = $(C_f + C_c)/2$
C_f = feed concentration
C_c = concentrate concentration

Salt passage was determined based on the conductivity levels which were recorded for each stage. Since three membrane stages were involved, the concentrate for the 1st Stage was the feedwater for the 2nd Stage and the concentrate for the 2nd stage was the 3rd Stage feedwater. In this report salt passage is reported as a percentage rather than a fraction for ease of understanding.

The "salt rejection" or "contaminant rejection" is another commonly accepted method for reporting the ability of the membrane to reject salts. This is the inverse of salt passage and is determined by:

$$SR = 100 - SP$$

$$= \frac{C_f - C_p}{C_f} \times 100$$

where: SR = salt rejection = "contaminant rejection"

Salt rejection will vary with the particular membrane used, recovery rate, feedwater concentration as well as other factors. Rejection also applies to organic parameters such as THMFP, TOC, etc.

4.2.1 Water Mass Transfer Coefficients

Figures 4-1, 4-2, and **4-3** provide MTCw versus time of operation data for the 1st, 2nd, and 3rd Stages respectively. Projections provided by Fluid Systems indicated that the MTCw for the 1st and 2nd Stages should have been approximately 0.235 gfd/psi while the 3rd Stage should exhibit a MTCw of 0.348 gfd/psi. The membrane used in the 1st and 2nd Stages, TFC 4921S, is the same softening membrane element model material used for large-scale production facilities where permeate water quality must be balanced with permeate water quantity production. Hence, the membranes are formulated to be "tighter" which improves solute rejection but results in less permeate water production per unit area of membrane and unit of applied pressure. In contrast, the SC 2540S membrane used in the 3rd Stage is typically used in single-element applications where, due to inherent recovery rate limitations, water production is favored over water quality concerns. Hence, the membrane are formulated to be "looser" which improves water flux, but increases salt passage.

Figure 4-1 indicates three interesting situations that were observed for the 1st Stage MTCw data. First, during the initial 1000 hours of operation, MTCw valves were at or above the 0.235 gfd/psi prediction level and demonstrated fairly consistent values. Second, at the onset of the previously noted iron hydroxide fouling episode, a sharp step decrease in MTCw was observed due to membrane fouling. This decrease was followed by a very significant increase in MTCw, probably caused by physical damage to the first elements in the lead pressure vessels that allowed direct passage of feed water into the permeate stream. This great increase in permeate flow due to membrane damage is reflected in the flux rate and, thus, the MTCw. Third, subsequent to utilization of the submersible well pump in the dedicated Well No.12, the MTCw declined relatively slowly over the last approximate 4000 hours (210 days) of operation from approximately 0.23 gpd/psi to 0.21 gfd/psi for a decline rate of 5.0 x10^{-6}gfd/psi-hr. In a practical sense, this decline was negligible and represents normal fouling resulting from the use of surficial aquifers in South Florida. Under the noted conditions, it would appear that membrane cleaning would only be required once every six to eight months using Miami Springs well water. The noted slow decline also demonstrates that the use of submersible pumps was instrumental in reducing fouling due to iron hydroxide. It should, however, be noted that the MTCw was slightly below the initial values (0.24 gfd/psi) and the predicted (0.235 gfd/psi) values. This situation could have resulted form some minor irreversible fouling in the 1st Stage membranes from the iron hydroxide or resulted from lower inherent MTCw values on the four replacement membranes installed after the severe iron hydroxide fouling episode.

Figure 4-1
Hialeah
1st Stage TMCw

Figure 4-1
Hialeah Membrane Pilot Plant
1st Stage MTCw vs. Time of Operation

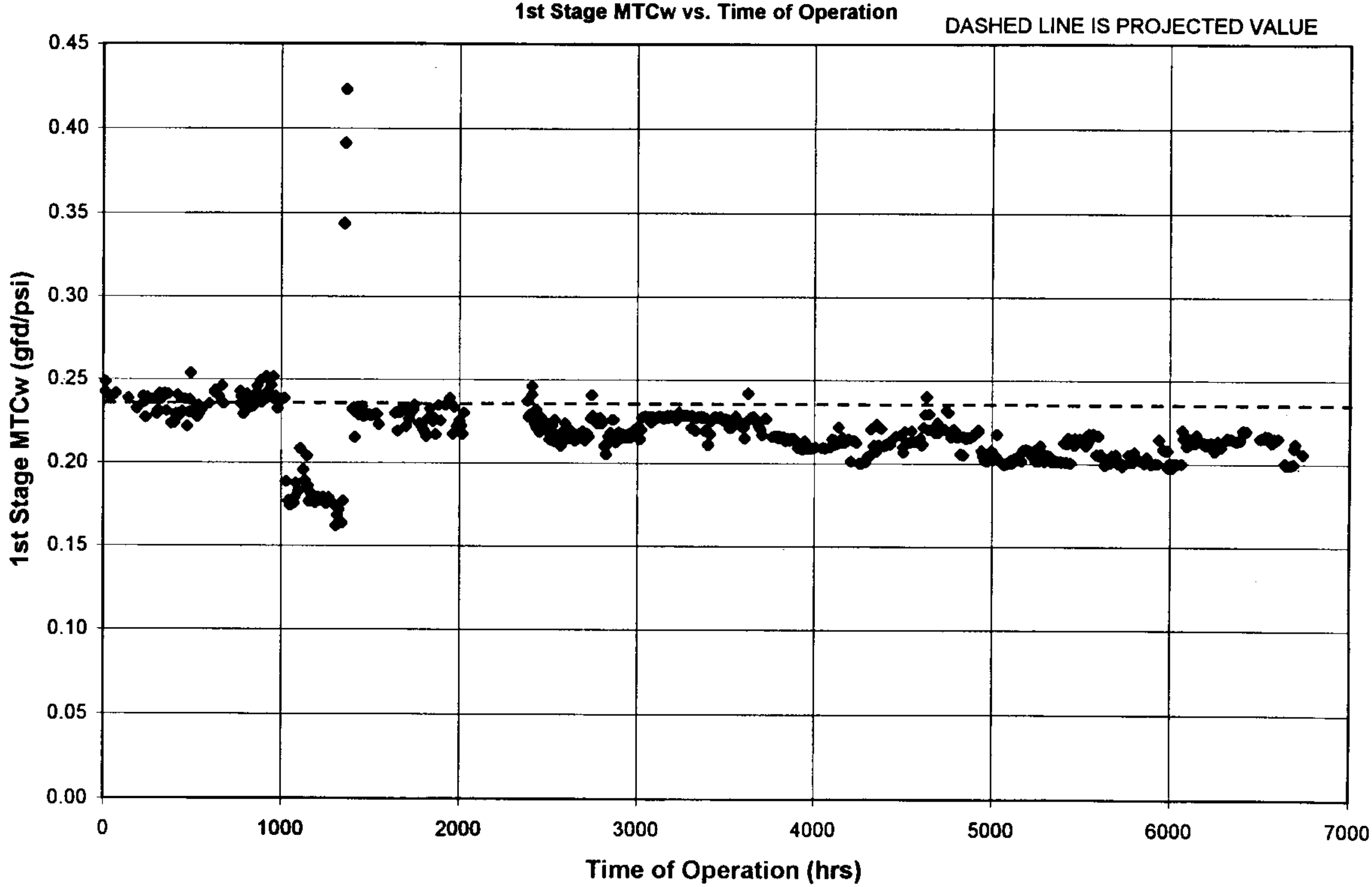


Figure 4-2
Hialeah Membrane Pilot Plant
2st Stage MTCw vs. Time of Operation

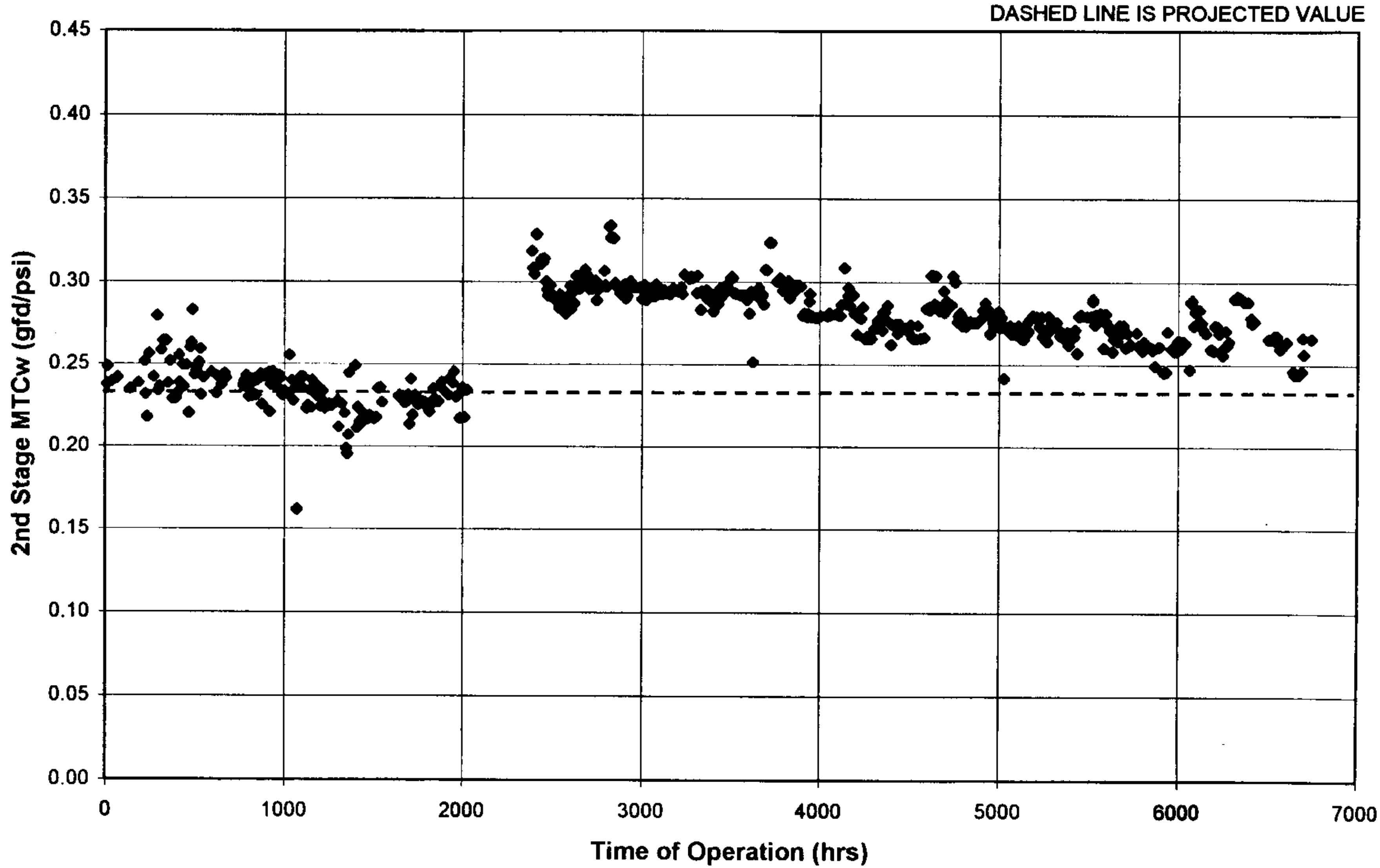


Figure 4-3
Hialeah Membrane Pilot Plant
3st Stage MTCw vs. Time of Operation

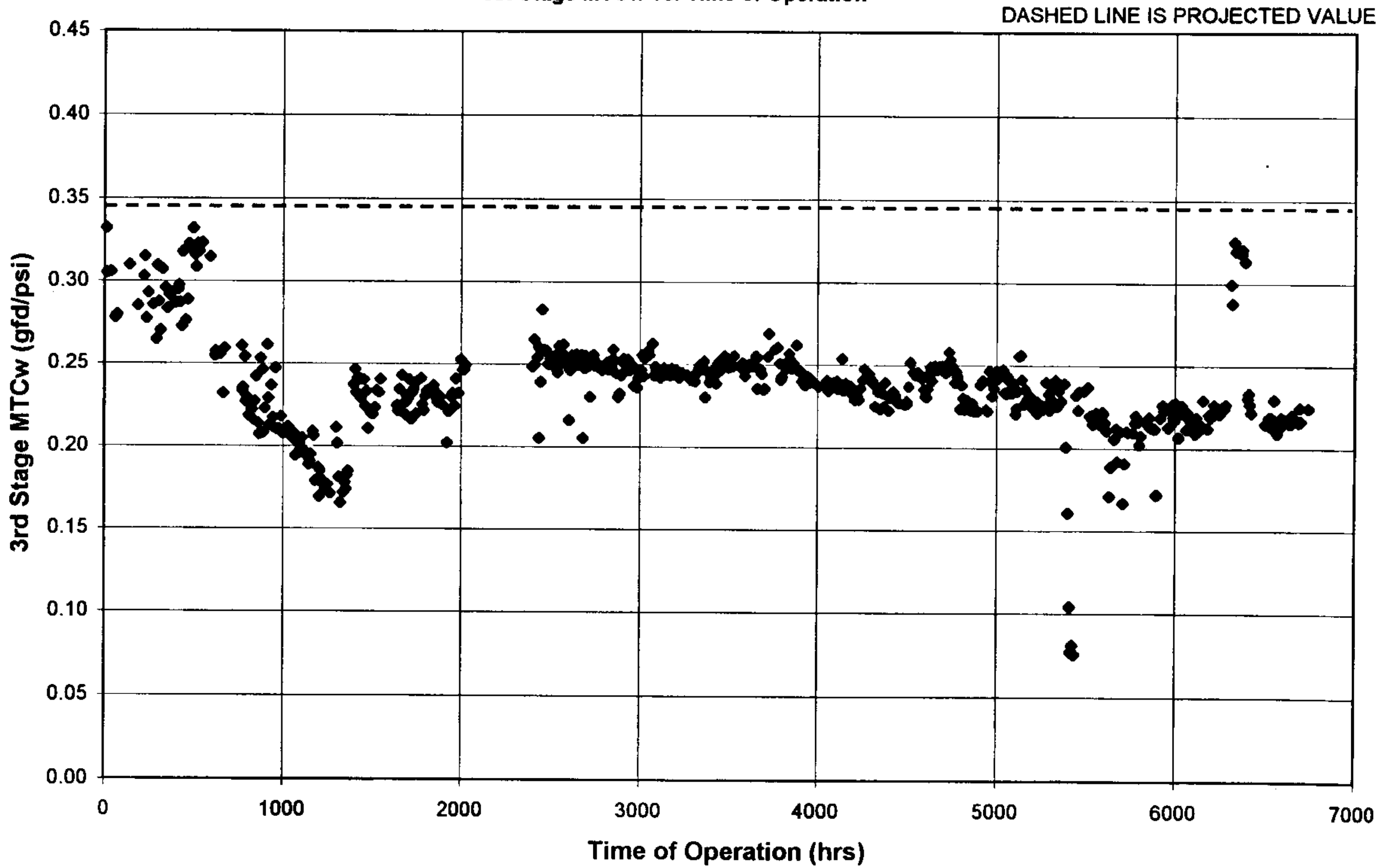


Figure 4-2 provides the plot of MTCw with time of operation for the 2nd Stage. The 2nd Stage MTCw data demonstrate two interesting situations. First, the 2nd Stage was relatively unaffected by the noted iron hydroxide fouling situation with no sustained dramatic decreases in MTCw. A slight decrease was noted and could be attributed to some dissolved iron passing to this stage prior to oxidation to the insoluble hydroxide form. However, the noted decreases were slight. Second, due to a simultaneous fouling problem at the Preston MPPU, membranes were removed from the Hialeah MPPU for installation into the Preston MPPU. In turn, three new membranes were installed into the 2nd Stage of the Hialeah MPPU prior to restart of operations around the 2400 hours of operation mark. After the restart of operation, a distinct improvement in MTCw was observed with initial values near 0.32 gfd/psi decreasing over 100 hours of operation to approximately 0.30 gfd/psi. Over the next 4000 hours of operation, a slight and steady decrease to approximately 0.275 gfd/psi was noted. This decline of 6.25×10^{-6} gfd/psi-hr was about 25 percent greater than observed for the 1st Stage. However, again the noted decline was less than 10 percent from initial values over a 4000 hour period. This slight decline in MTCw did not indicate serve fouling potential. It should be noted that the apparent difference in membrane characteristics in the new group of membranes was not unexpected. Membrane formulation and production is still somewhat an “art” rather than “science” and Fluid Systems Inc. confirmed that such variations are normal.

Figure 4-3 provides the 3rd Stage MTCw with time of operation data. Several operational observations were readily obvious for this stage. First, the 3rd Stage MTCw values were always less than the initial predicted value of 0.348 gfd/psi. Except for the initial 500 hours of operation where values in the 0.26 to 0.34 gfd/psi range were noted, the remaining, non-fouled situation values were in the 0.21 to 0.25 gfd/psi range. Fluid Systems was queried on this situation and replied as follows in a written transmission:

> “This fax is in regards to the letter you had sent me on February 11, 1998. The Spiral Composites (SC) line of elements are typically used in small systems that require only a single element. That being the case, many of the customers who purchase these elements are primarily interested in high flow elements. In order for Fluid Systems to accommodate the customers utilizing the SC-S elements we use a softening membrane which is higher in
>
> flux than the TFC-S product line. The materials and constructions, except for the outer wrap, are the same for the TFC 4921S and the SC 2540S.
>
> The characteristic values I had supplied you are based on nominal performance of the respective elements and may vary slightly from the supplied elements. Based on the average wet test data, the SC 2540S elements shipped to CDM should have a MTC_w of 0.348 gfd/psi. This discrepancy in the MTCw might not fully account for the reason the elements appear to be performing in an unexpected manner. Testing has shown that the brine flow from 4" diameter elements to 2.5" diameter elements can cause excessive

pressure loss in the feed/brine piping. If this pressure loss is not taken into account the net driving pressure may be artificially high. If you have any questions regarding this fax please contact me."

Subsequent measurements of the 3rd Stage feed piping pressure loss indicated that excessive feed pressure loss was occurring in the 5/8-inch interconnecting tubing that was not properly measured by the existing pressure gauge locations. It was estimated that the actual net driving pressure (NDP) was actually 10 to 15 psi less than indicated. This change in NDP does bring the overall values closer to the anticipated value of 0.348 gfd/psi with a corrected range of 0.275 to 0.400 gfd/psi. It would appear that at a new, clean condition, the membranes had MTCw values at or above the predicted value. Subsequent to the severe iron hydroxide fouling episodes, a certain portion of the MTCw was irreversibly lost.

Please note that the reported values in Figure 4-3 are uncorrected values. It was decided that relocation of the pressure gauges in mid-study would confuse data interpretation. In the present study, relative, rather than absolute changes in MTCw were considered critical. In a full scale operation, 8-inch diameter TFCS model elements would be used as well as full size piping designed to minimize head loss.

Second, during the initial iron hydroxide fouling episode, the 3rd Stage demonstrated a very severe decrease in MTCw values over a short operating time. A decrease in MTC of 1.0×10^{-4} gfd/psi-hr was noted, over an order of magnitude greater than noticed for any other stage. It would appear that iron hydroxide dissolved due to acid addition was carried to the 3rd Stage where redeposition occurred due to concentration effects.

Third, over the last 4000 hours of operation, a decline in MTCw from approximately 0.26 to approximately 0.215 gfd/psi was noted. This decline was equal to approximately 1.13×10^{-5} gfd/psi-hr, or approximately 126 percent greater than the 1st Stage decline and 88 percent greater than the 2nd Stage decline. This increase in 3rd Stage MTCw decline could probably be partially attributed to calcium carbonate scale buildup which occurred during the previously noted acid pump failures. It would appear that, for Miami Springs/Hialeah WTP wellfield water, 3rd Stage fouling, probably attributed to mineral scales, would govern the time between cleaning as opposed to biological or organic fouling which would mainly manifest itself in the 1st Stage and the 2nd Stage to a lesser extent.

4.2.2 Feedside Pressure Loss (Delta P)

Figures 4-4, 4-5, and 4-6 provide graphs of delta P with time of operation for the 1st, 2nd, and 3rd Stages. Delta P, or the feedside pressure loss, is an operational indicator of fouling as previously discussed. In full-scale facility operations, it is customary to initiate cleaning operations when the delta P value increases to a value greater than 150 percent of the original

Figure 4-4
Hialeah Membrane Pilot Plant
1st Stage Delta P vs. Time of Operation

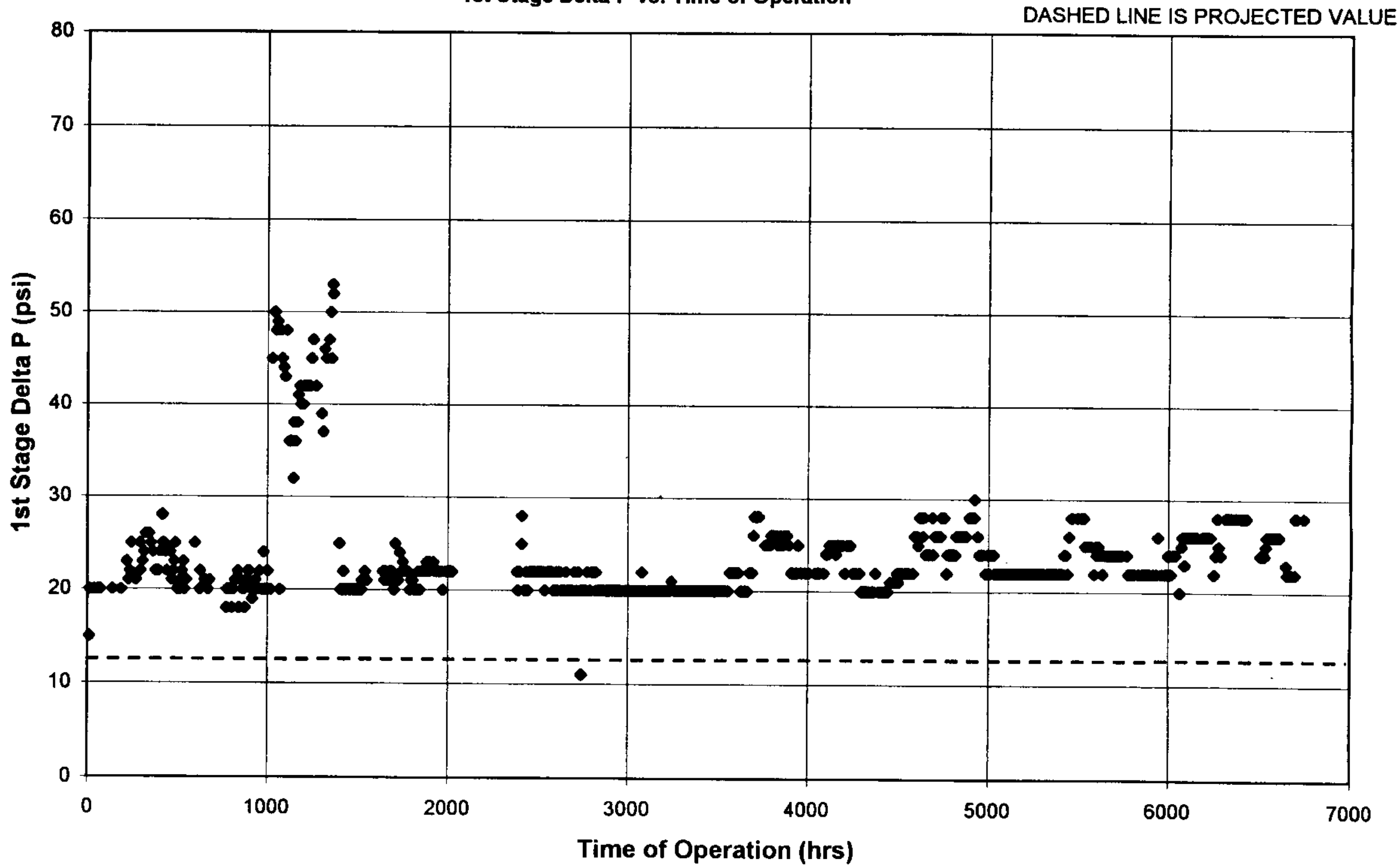


Figure 4-5
Hialeah Membrane Pilot Plant
2nd Stage Delta P vs. Time of Operation

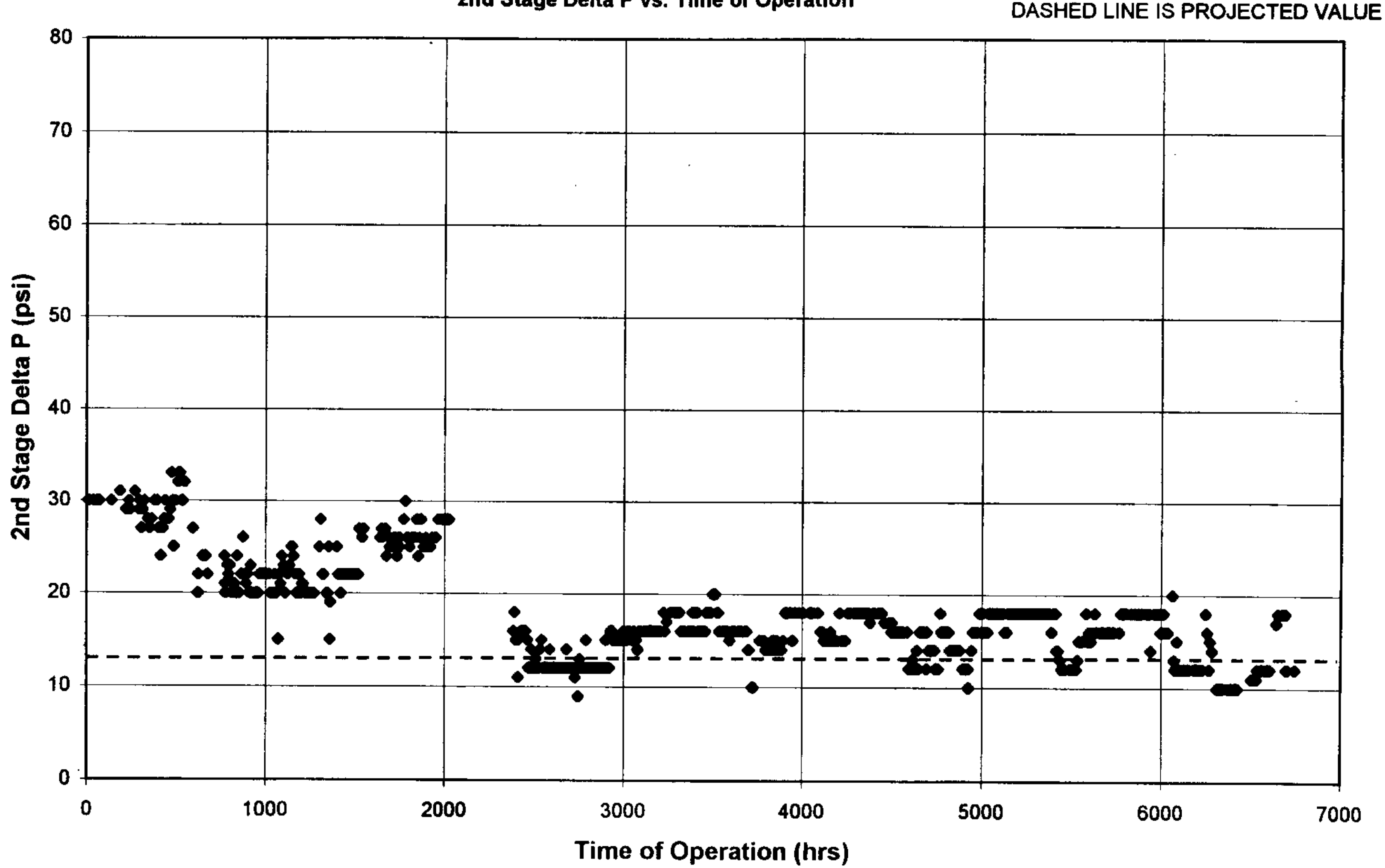
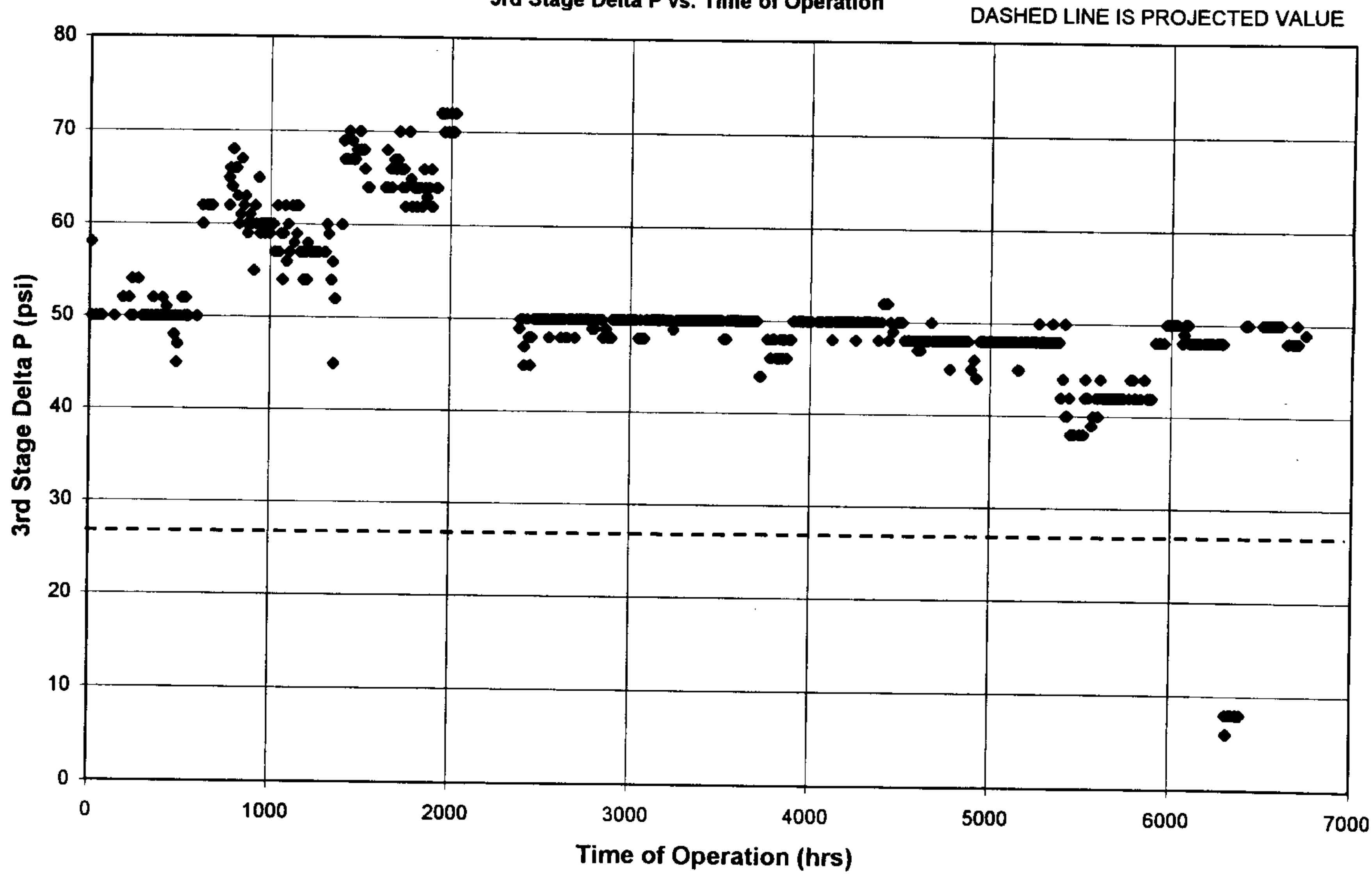


Figure 4-6
Hialeah Membrane Pilot Plant
3rd Stage Delta P vs. Time of Operation



value. The actual clean membrane delta P can be accurately estimated by the membrane manufacturer. However, it is difficult to estimate pressure loss in the manifold piping and tubing in pilot plants. As such, it is important to assess delta P values against the initial clean membrane delta P values.

Figure 4-4 clearly indicates three significant situations occurring for the 1st Stage Delta P data. First, initial clean membrane delta P in the 1st Stage was approximately 20 psi. The membrane system projection indicated a pressure loss of approximately 14 psi which indicates that the additional manifold pressure losses were approximately 6 psi. Second, the onset of iron hydroxide fouling is clearly evident with a step increase after 300 hours of operations and a very significant increase after the 1000 hour mark. At the noted delta P values of 40 to 50 psi, membrane damage is expected, and did occur, in this stage. Third, subsequent to the installation of the submersible well pump and use of a dedicated well, increases in delta P values were very gradual and sporadic over the final 4,000 hour of operation. This situation mirrors the MTCw data trends.

The 2nd Stage delta P data trends shown in Figure 4-5 show two interesting trends. First, during initial operations, a decrease in delta P was observed. It is theorized that a brine seal moved during this period allowing some flow to bypass the membrane feedwater channel. With less flow velocity, pressure loss was decreased. At the same time, a decrease in MTCw was noted due to lowered permeate flux partially caused by fouling and partially caused by less feedwater flow. Second, it was noted that a significant decrease in initial clean membrane delta P was observed after the installation of new membranes. The new membranes appeared to provide superior water quantity and quality characteristics by lowering the delta P and, thus, the necessary feed pressure while also providing a higher MTCw (see Figure 4-2) and a lower salt passage percentage (to be discussed later in this Section). The lack of significant fouling over the final 4000 hours of operation was obvious given the relatively narrow band of noted delta P values during that period.

The 3rd Stage delta P data somewhat mirror the 1st Stage data. Figure 4-6 shows that an initial 50 psi delta P value was observed. The membrane projection indicated a clean membrane pressure loss of 28 psi for this bank of membranes. As earlier discussed in the MTCw data section, it would appear that significant pressure loss was occurring in the stage transitions as measured by the pressure gauges. It was determined that actual membrane delta P values were closer to the 30 psi mark when certain temporary pressure gauge readings were taken as close to the pressure vessel ends as possible with each pressure vessel measured separately. It should be again emphasized that manifold pressure losses would be significantly less in a full scale facility using larger diameter pipe to flow ratios.

As in the 1st Stage, the 3rd Stage showed significant impacts from iron hydroxide fouling. It is thought that significant fouling occurred in this stage due to the dissolution of iron hydroxide solids due to the acid feed in the 1st Stage followed by redeposition of iron compounds due to concentration effects in the 3rd Stage. However, once the dedicated well and submersible well pump concept was initiated, delta P values remained essentially unchanged over the final 4,000 hours of operations.

4.2.3 Salt Passage

Figures 4-7, 4-8, and 4-9 provide the graphs of salt passage based on conductivity for the 1st Stage, 2nd Stage, and 3rd Stage, respectively. The salt passages predicted by the Fluid Systems software was 14.6 percent. Except for the previously described iron hydroxide fouling episodes, the 1st Stage salt passage was well below the 15 percent mark. As expected, the onset of the iron hydroxide fouling resulted in significantly higher salt passage probably due to the physical passage of solute through the damaged membranes. After the initiation of the use of the submersible well pump, the increase in salt passage was $1x10^{-3}$ percentage point per hour (percent/hr).

As with the 1st Stage, the 2nd Stage salt passage data (see Figure 4-8) clearly indicate the impact of the iron hydroxide fouling. After initial operation at the expected 15 percent salt passage level, a period of elevated values was observed coinciding with the periods of severe fouling. After the replacement of the original membranes by the new membranes (same model), a significantly lower initial salt passage value was observed. The new salt passage values of 6.0 to 7.0 percent were one-third to one-half the original values. As previously stated, the replacement membranes appeared to have superior salt passage i.e., contaminant rejection characteristics. After remediation of the iron hydroxide fouling episode, a slight and steady increase in percent salt passage was observed at an approximate slope of 7.5×10^{-4} percent/hr or only 75 percent of the 1st Stage rate.

The 3rd Stage salt passage data demonstrated relatively few impacts from the iron hydroxide fouling. The fouling that occurred in this stage that was clearly shown in the MTCw data, and delta P data had only few short term impacts on salt passage. After restart of the Hialeah pilot plant with the submersible well pump and the dedicated well, the increase in percent salt passage was very similar to that found for the 1st Stage, approximately 1.0×10^{-3} percent/hr.

4.2.4 Other Operational Parameters

The previously discussed operational parameters of MTCw, delta P, and salt passage adequately describe the membrane performance. However, several other operational parameters are of interest from a design standpoint. These operational parameters include the membrane feed pressure, 3rd Stage boost pump pressure, total average water flux, individual stage water flux, and permeate water recovery rate. The performance of each parameter is summarized below.

Figure 4-7
Hialeah Membrane Pilot Plant
1st Stage Salt Passage vs. Time of Operation

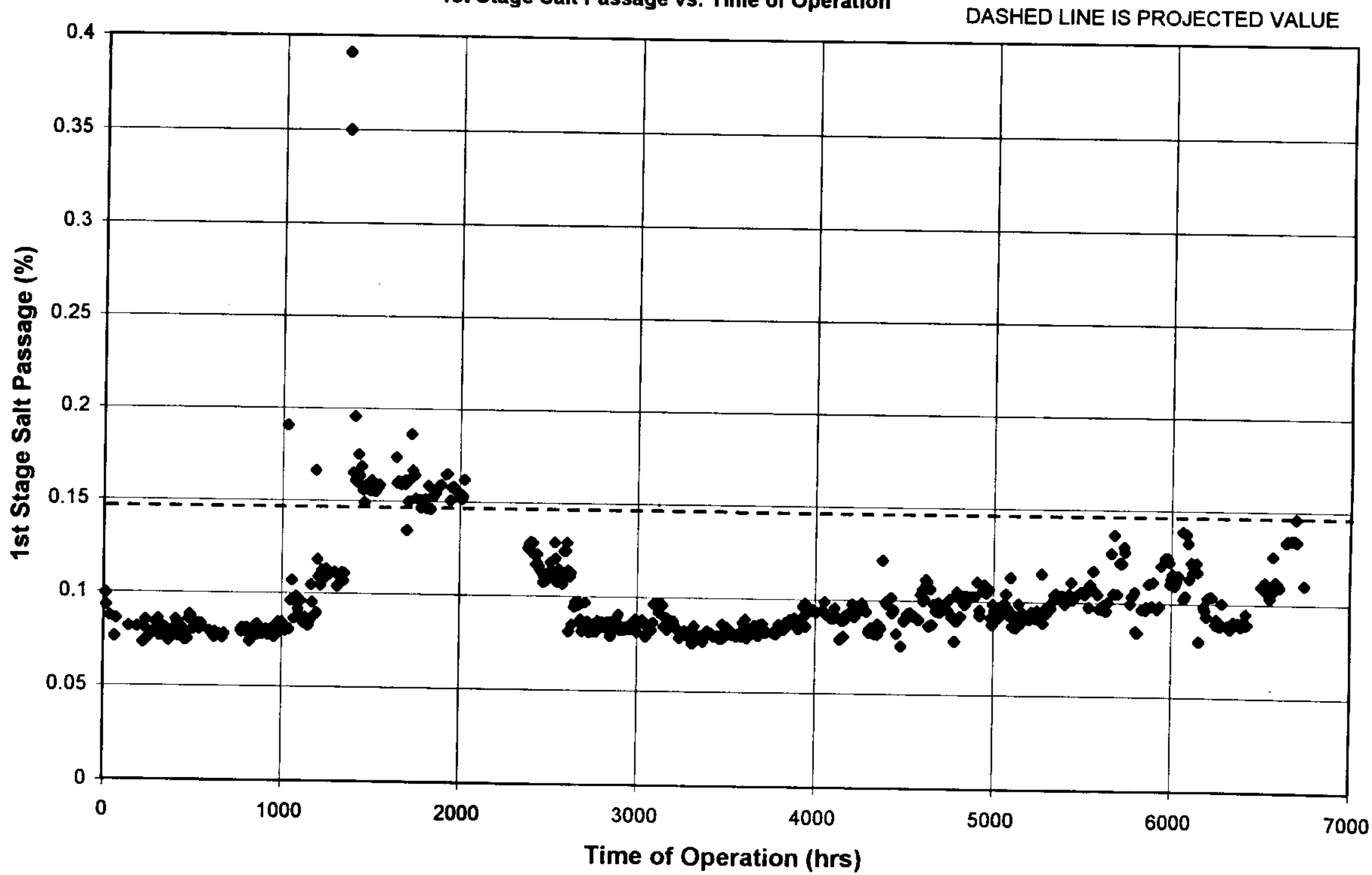


Figure 4-8
Hialeah Membrane Pilot Plant
2nd Stage Salt Passage vs. Time of Operation

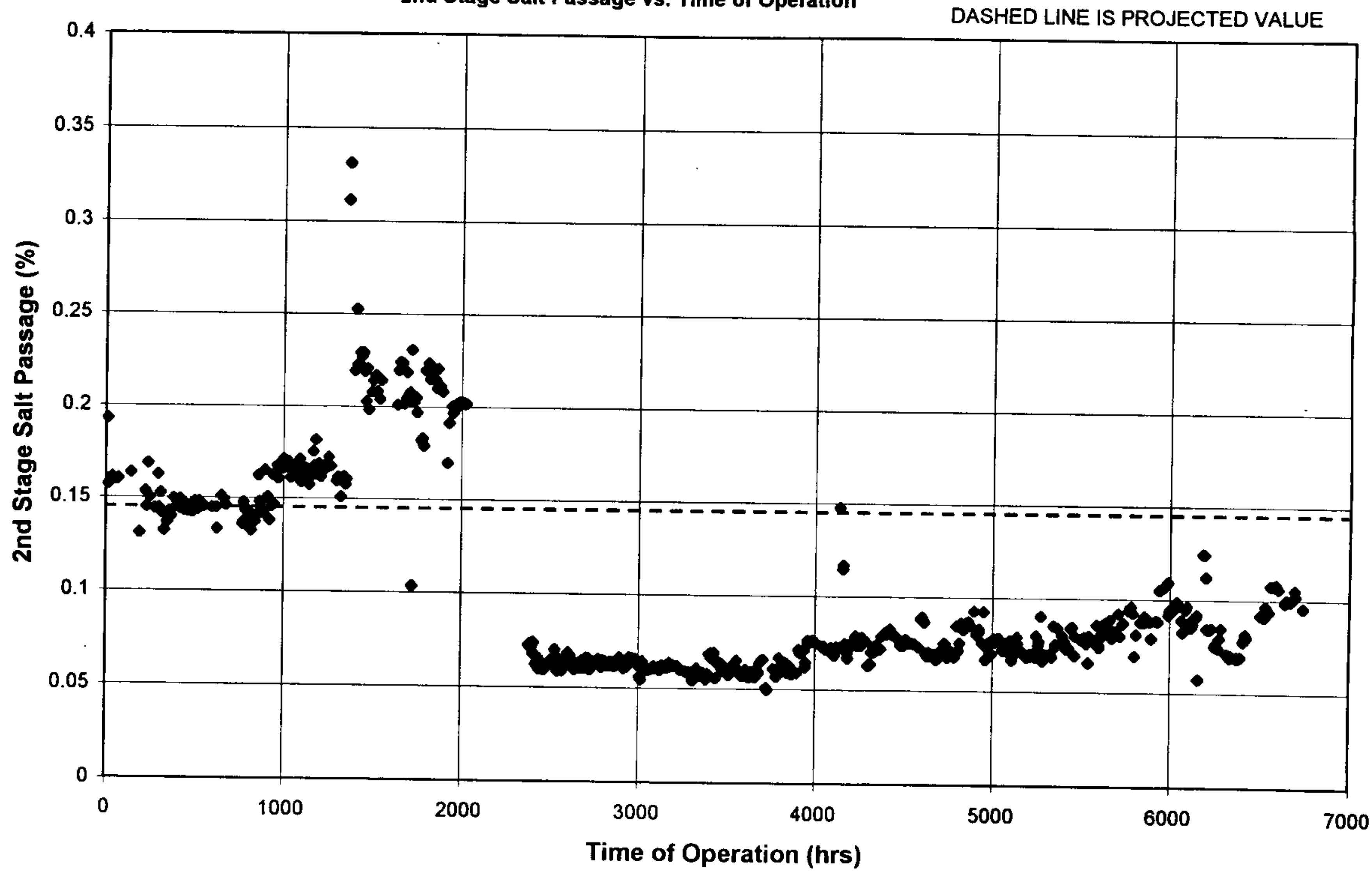
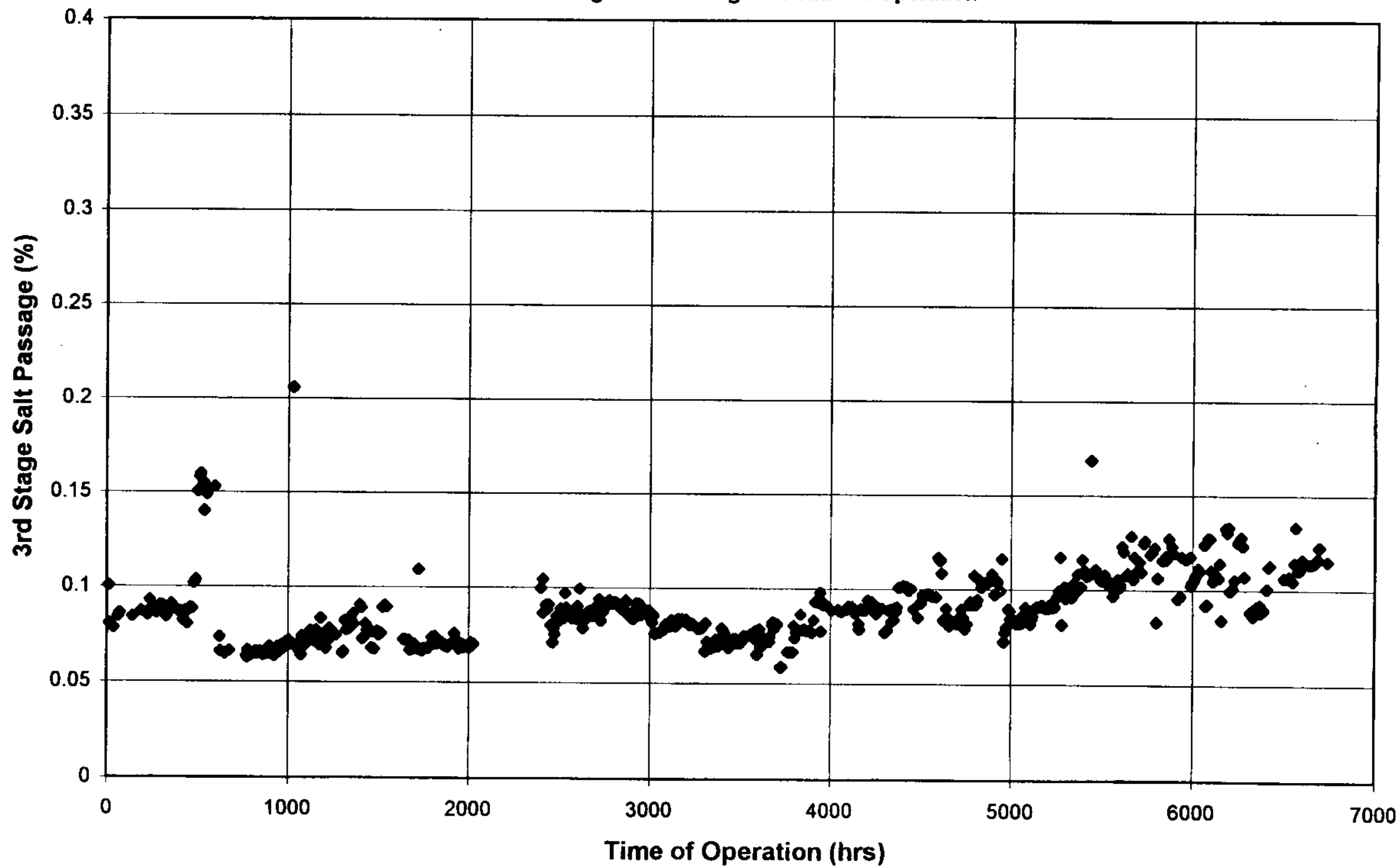


Figure 4-9
Hialeah Membrane Pilot Plant
3rd Stage Salt Passage vs. Time of Operation



- Membrane Feed Pressure: The average value was 100 psi with a maximum and minimum value of 120 psi and 80 psi, respectively. The noted pressure range accommodated the fouling impacts while allowing suitable water quality production. Subsequent to mitigation of the iron hydroxide fouling problem, essentially no variation was observed in the membrane feed pressure.

- 3rd Stage Boost Pressure: The average 3rd Stage boost pressure was 68 psi to provide an average 3rd Stage feed pressure of 125 psi to allow a respectable 43 percent product water recovery rate in the 3rd Stage. Over the final 4000 hours of operation, essentially no variation occurred in the 3rd Stage feed pressure.

- Average Total Water Flux: Operational experience with membrane softening facilities indicates that an overall average water flux no greater than approximately 15.0 gfd is sufficient to minimize fouling from concentration polarization impacts. In the present case, the use of 15.1 gfd overall average total water flux showed minimized fouling during the last 4000 hours of operation.

- Individual Stage Water Flux: To prevent concentration polarization induced fouling, it is advisable not to exceed an 18 to 20 gfd flux rate in any individual stage. Usually the highest flux occurs in the 1st Stage due to lower osmotic pressure and lower mineral scale formation. However, in this case, the 3rd Stage membranes had a higher flux due to the previously discussed differences in the 3rd Stage membrane elements (SC-model for single-element application versus TFCS model for full-scale facilities). The average flux was below the 18 to 20 gfd range but did on occasion greatly exceed this range. Again essentially no change in the individual flux values were observed over the last 4000 hours of operation.

- Permeate Water Recovery Rate: The average was 84 percent, very close to the desired 85 percent recovery rate target. Due to a lack of significant fouling over the last 4,000 hours of operation, it would appear this permeate water recovery rate would be sustainable for a full-scale continuous operation facility.

4.3 Water Quality Data

Water quality data for the ICR Study are summarized in the following tables. These data provide a compilation of all of the data acquired for the twenty-three sampling events including the quality of the pretreated influent (cartridge filter outlet (CFO)) and the results of the disinfection by-product (DBP) formation potential analyses. **Table 4-1** summarizes the water quality data by sample location. **Table 4-2** provides the average value for each water quality parameter by location. **Table 4-3** shows the average percent reduction for each parameter by stage.

Table 4-1

TABLE 4-1
Hialeah Membrane Pilot Plant Unit
ICR-Related Parameters
Water Quality Summary

PARAMETER	LOCATION								
	Raw	System Permeate	Prefilter Outlet	System Concentrate	1st Stage Permeate	2nd Stage Permeate	Interstage 1-2	3rd Stage Permeate	Interstage 2-3
Alkalinity (mg/L as $CaCO_3$)									
No. of Observations	NS[1]	27	27	27	27	27	27	27	27
Average	NA[2]	28	138	639	19	29	268	28	432
Maximum	NA	214	224	996	46	67	444	47	639
Minimum	NA	15	107	145	10	17	201	17	299
Standard Deviation	NA	38	34	168	7	17	74	7	91
TDS (mg/L)									
No. of Observations	26	27	27	27	27	27	27	27	27
Average	338	59	345	1365	45	68	631	75	979
Maximum	388	371	398	1477	88	181	722	114	1109
Minimum	314	34	311	1224	31	38	573	34	835
Standard Deviation	27	65	25	62	19	45	41	17	71
Total Hardness (mg/L as $CaCO_3$)									
No. of Observations	NS	27	27	27	27	27	27	27	27
Average	NA	23	203	1074	15	21	414	20	689
Maximum	NA	222	235	1161	39	58	505	38	759
Minimum	NA	10	185	923	10	9	376	14	568
Standard Deviation	NA	40	16	70	7	17	35	6	48
Calcium Hardness (mg/L as $CaCO_3$)									
No. of Observations	NS	27	27	27	27	27	27	27	27
Average	NA	19	186	991	13	19	380	18	624
Maximum	NA	170	204	1105	35	52	425	33	730
Minimum	NA	8	178	801	8	8	349	12	341
Standard Deviation	NA	31	8	81	6	16	19	5	83
Turbidity (NTU)									
No. of Observations	NS	27	27	27	27	27	27	27	27
Average	NA	0.05	0.08	30.52	0.04	0.03	0.82	0.01	9.96
Maximum	NA	0.94	0.38	40.00	0.47	0.22	4.10	0.04	20.00
Minimum	NA	0.00	0.03	0.60	0.00	0.00	0.03	0.00	0.22
Standard Deviation	NA	0.18	0.07	8.43	0.09	0.04	1.11	0.01	6.06
TOC (mg/L)									
No. of Observations	NS	27	27	27	27	27	27	27	27
Average	NA	0.40	8.06	39.68	0.41	0.70	15.06	0.33	24.44
Maximum	NA	1.48	23.8	77.9	1.29	3.00	32.40	1.19	51.80
Minimum	NA	0.09	1.89	28.6	0.10	0.11	9.70	0.04	17.55
Standard Deviation	NA	0.36	5.05	14.93	0.26	0.78	6.66	0.22	9.44

TABLE 4-1
Hialeah Membrane Pilot Plant Unit
ICR-Related Parameters
Water Quality Summary
(continued)

PARAMETER	LOCATION								
	Raw	System Permeate	Prefilter Outlet	System Concentrate	1st Stage Permeate	2nd Stage Permeate	Interstage 1-2	3rd Stage Permeate	Interstage 2-3
UV_{254} (cm^{-1})									
No. of Observations	NS	27	27	27	27	27	27	27	27
Average	NA	0.007	0.285	1.088	0.007	0.009	0.547	0.005	0.777
Maximum	NA	0.038	0.669	1.962	0.031	0.058	0.857	0.02	1.209
Minimum	NA	0.000	0.205	0.443	0.000	0.000	0.450	0.001	0.669
Standard Deviation	NA	0.010	0.127	0.275	0.008	0.015	0.144	0.005	0.129
Bromide (ug/L)									
No. of Observations	NS	27	27	NS	NS	NS	NS	NS	NS
Average	NA	23.1	82.9	NS	NS	NS	NS	NS	NS
Maximum	NA	97.4	179.9	NS	NS	NS	NS	NS	NS
Minimum	NA	6.0	12.0	NS	NS	NS	NS	NS	NS
Standard Deviation	NA	21.0	51.8	NS	NS	NS	NS	NS	NS
SDS-TOX (ug/L)									
No. of Observations	NS	25	25	NS	NS	NS	NS	NS	NS
Average	NA	< 29	422	NS	NS	NS	NS	NS	NS
Maximum	NA	66	1160	NS	NS	NS	NS	NS	NS
Minimum	NA	< 25	145	NS	NS	NS	NS	NS	NS
Standard Deviation	NA	11.30	211	NS	NS	NS	NS	NS	NS
SDS-THM4 (ug/L)									
No. of Observations	NS	24	24	NS	NS	NS	NS	NS	NS
Average	NA	< 4.90	< 72.11	NS	NS	NS	NS	NS	NS
Maximum	NA	10.62	< 177	NS	NS	NS	NS	NS	NS
Minimum	NA	< 4.0	< 39.11	NS	NS	NS	NS	NS	NS
Standard Deviation	NA	2.07	33.08	NS	NS	NS	NS	NS	NS
SDS-HAA5 (ug/L)									
No. of Observations	NS	25	25	NS	NS	NS	NS	NS	NS
Average	NA	< 6.8	< 77.5	NS	NS	NS	NS	NS	NS
Maximum	NA	15.0	190	NS	NS	NS	NS	NS	NS
Minimum	NA	< 6.0	< 41.0	NS	NS	NS	NS	NS	NS
Standard Deviation	NA	1.97	42.28	NS	NS	NS	NS	NS	NS

Notes: 1. NS = Not Sampled
2. NA = Not Applicable

TABLE 4-2
Hialeah Membrane Pilot Plant Unit
ICR - Related Parameters
Average Value Water Quality Summary

Parameter	Units	Raw	Prefilter Outlet	Interstage 1-2	Interstage 2-3	1st Stage Permeate	2nd Stage Permeate	3rd Stage Permeate	Total Permeate	Concentrate
Alkalinity	mg/L as $CaCO_3$	NS [1]	138	268	432	19	29	28	28	639
TDS	mg/L	338	345	631	979	45	68	75	59	1365
Total Hardness	mg/L as $CaCO_3$	NS	203	414	689	15	21	20	23	1074
Calcium Hardness	mg/L as $CaCO_3$	NS	186	380	624	13	19	18	19	991
Turbidity	NTU	NS	0.08	0.82	9.96	0.04	0.03	0.01	0.05	30.52
TOC	mg/L	NS	8.06	15.06	24.44	0.41	0.70	0.33	0.40	39.68
UV_{254}	cm^{-1}	NS	0.285	0.547	0.777	0.007	0.009	0.005	0.007	1.088
Bromide	ug/L	NS	83	NS	NS	NS	NS	NS	23.1	NS
SDS-TOX	ug/L	NS	422	NS	NS	NS	NS	NS	< 29	NS
SDS-THM4	ug/L	NS	< 72.11	NS	NS	NS	NS	NS	< 4.90	NS
SDS-HAA5	ug/L	NS	< 77.5	NS	NS	NS	NS	NS	< 6.8	NS

Notes: 1. NS = Not Sampled

Table 4-3
Hialeah Membrane Pilot Plant Unit
ICR-Related Parameters
Average Percent Reduction

Parameter	1st Stage[1]	2nd Stage[2]	3rd Stage[3]	Overall[4]
Alkalinity	90%	92%	95%	93%
TDS	91%	92%	94%	93%
Total Hardness	95%	96%	98%	96%
Calcium Hardness	95%	96%	98%	97%
Turbidity	90%	99%	100%	100%
TOC	96%	96%	99%	98%
UV_{254}	98%	99%	99%	99%
Bromide	NS[(5)]	NS	NS	72%
SDS-TOX	NS	NS	NS	93%
SDS-THM4	NS	NS	NS	93%
SDS-HAA5	NS	NS	NS	91%

Notes:
1. Prefilter Outlet to Interstage 1-2
2. Interstage 1-2 to Interstage 2-3
3. Interstage 2-3 to Concentrate
4. Prefilter Outlet to Concentrate
5. NS = Not Sampled

These data confirm the ability of the softening membranes to reduce both organic and inorganic parameters to very low values. Essentially all parameters are reduced by well over 90 percent in the 1st stage only. Also, under the standard distribution system conditions, very low THM4 and HAA5 formation potential were present, not surpursing given the average TOC level of 0.43 mg/L as C in the permeate.

4.4 Impact of Seasonal Variability

The ICR pilot studies at the Hialeah WTP lasted for over 12 months due to downtime for cleaning and maintenance. **Figures 4-10** and **4-11** show feedwater (post cartridge filter) data for alkalinity and total hardness over the course of the study. Although the values fluctuate somewhat, there are no apparent seasonal trends. Note that in January of 1998 the raw water source was changed from a composite source, to a dedicated well. This would explain the lower alkalinity and hardness values seen after the first of the year.

4.5 Cost Information

As part of the DBP study, being conducted in conjunction with the ICR studies, several different full-scale treatment alternatives were developed for MDWASD based on the pilot and full-scale testing conducted at the Hialeah-Preston water treatment facilities. All of the alternatives developed would allow MDWASD to meet Stage 1 of the DBP Rule and then make modifications to meet Stage 2 of the DBP Rule when necessary. All of the alternatives include both the Hialeah and adjacent Preston facilities. Some alternatives include developing a remote site at MDWASD’s Northwest Wellfield.

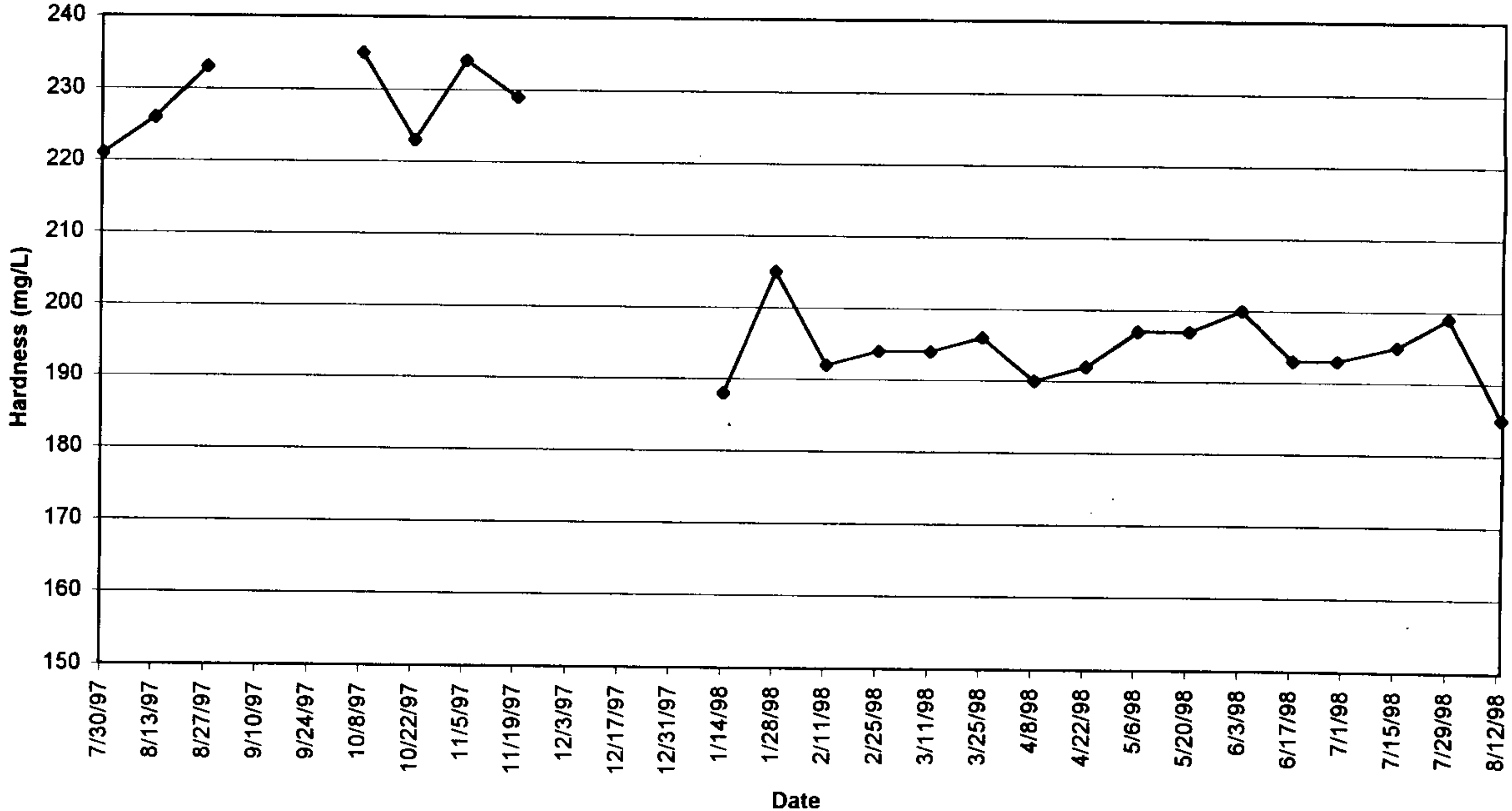
Three of the alternatives evaluated included membrane nanofiltration treatment similar to that piloted in the ICR study. All three of these membrane options involve blending membrane-treated water with lime-softened water at varying ratios to achieve DBP and color targets. One alternative also includes the addition of ozone. Capital and operations and maintenance (O&M) cost estimates were performed for each of these three alternatives. Capital cost estimates were structured to provide modifications to meet the Stage 1 DBP Rule and then incremental costs to meet Stage 2. The total present worth cost analysis for the three membrane alternatives is summarized in **Table 4-4.** An estimation of the existing O&M costs was also performed for comparison purposes and is presented in **Table 4-5** for both the Hialeah and Preston WTPs.

The first alternative includes adding membrane softening facilities to replace a portion of the existing Hialeah WTP capacity and blending the permeate with lime softened water from the existing Preston WTP site. The membrane flow rate would be increased in the future to allow compliance with Stage 2 of the DBP Rule. The detailed capital and O&M cost estimates for this alternative are provided in **Tables 4-6,**
4-6A and **4-6B**

Table 4-4
Present Worth of Membrane Treatment Alternatives

Alternative	Level 1 Total (Million $)	Level H2 Total (Million $)
Membrane Softening at Hialeah blended with Lime Softening at Preston	432.0	566.2
Membrane Softening at Northwest Wellfield blended with Lime Softening at Hialeah- Preston	514.9	609.4
Membrane Softening at Northwest Wellfield blended with Lime Softening at Hialeah-Preston Plus Ozonation	491.6	515.8

Figure 4-10
Hiealeah Pilot Plant
Seasonal Hardness Data
Cartridge Filter Outlet



Camp Dresser & McKee
Season, 12/23/98

Figure 4-11
Hialeah Pilot Plant
Seasonal Alkalinity Data
Cartridge Filter Outlet

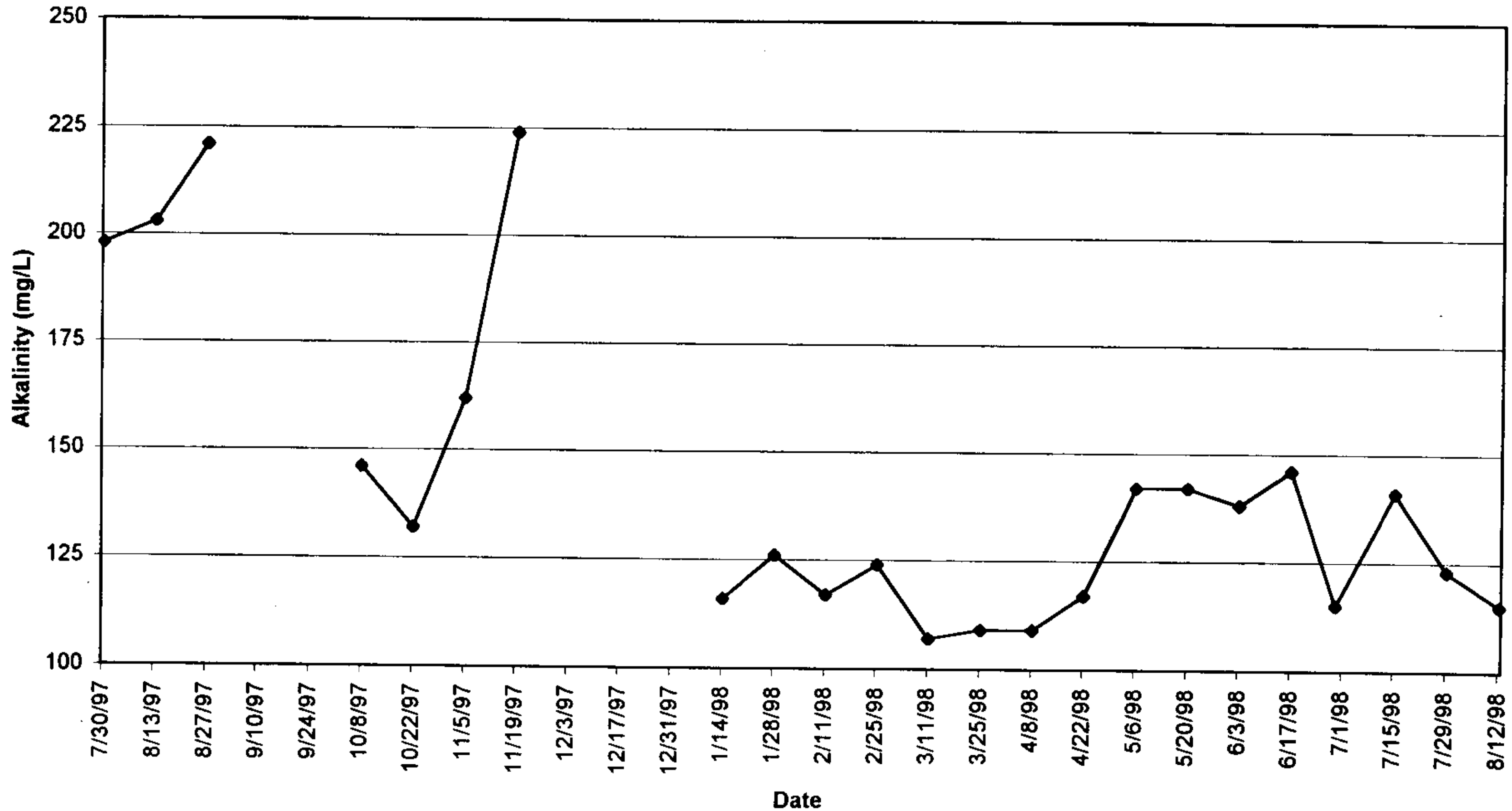


TABLE 4-5

MIAMI-DADE WASD
HIALEAH-PRESTON WTPs D/DBPs CONCEPTUAL DESIGN
EXISTING LIME SOFTENING O&M COSTS ($/1000 GAL)

O&M Cost Object	Hialeah WTP (CC510)	Preston WTP (CC520)
Chemicals		
Activated Silica	$0.003	$0.003
Ammonia	$0.001	$0.001
Chlorine	$0.008	$0.022
Fluoride	$0.001	$0.002
Lime (1)	$0.090	$0.090
Sodium Hex.	$0.004	$0.004
Other Chemicals	$0.001	$0.001
Air Stripping	$0.007	$0.005
Power/Electricity	$0.036	$0.038
Fuel and Oil	$0.001	$0.003
Staffing/Labor	$0.040	$0.022
Misc. Costs (2)	$0.017	$0.006
TOTAL O&M ($/1,000 gal.)	$0.209	$0.197

Notes:

(1) Includes the cost of operating the Hialeah lime recalcination plant and producing lime and carbon dioxide for existing operations.

(2) Miscellaneous costs are expenses associated with operation of the water treatment plants. Expenses include other utilities, materials, travel, vehicles, and other operating expenses. Based on Fiscal Year 1996, 1997 and 1998 (YTD 6/98) actual data and the corresponding raw water treated flows for the Hialeah and Preston WTPs.

TABLE 4-6

MIAMI-DADE WASD
HIALEAH-PRESTON WATER TREATMENT PLANTS D/DBPs CONCEPTUAL DESIGN
ALTERNATIVE 4 CAPITAL COSTS FOR 1998 (LEVEL 1)
OPTIMIZED LIME/MEMBRANE SOFTENING BLEND

Capital Cost Component	Hialeah WTP	Preston WTP	New WTP	Comments
aw Water Line Rerouting		$0	$150,000	Assume 48-inch diameter and 500 feet
hemical Storage/Feed Systems				
Ferric Coagulant System	$0	$500,000	$0	At 20 mg/L and 60,000 gals. storage, 30 days
Anionic Polymer System	$95,000	$220,000	$0	At 0.15 mg/L (LT-25), dry feeder, 30 days, both WTPs
Carbon Dioxide	$0	$910,000	$0	Increase dosage by 22 mg/L to 40 mg/L, 30 days
Lime System	$0	$670,000	$0	Additional 330 tons storage, 30 days
Sulfuric Acid System	$0	$0	$300,000	At 180 mg/L and 40,000 gal storage, 14 days
Antiscalant System	$0	$0	$220,000	
Chemical Cleaning	$0	$0	$400,000	
Misc. Chemicals	$0	$2,000	$5,000	Relocate chlorine and ammonia addition points
retreatment				
Cartridge Filters	$0	$0	$400,000	
lembrane Treatment				
Building	$0	$0	$2,900,000	Membrane capacity of 25 mgd in 26,000 sf area
RO Skids/Membranes w/Piping and Valves	$0	$0	$9,300,000	
umps				
Feed Booster Pumps w/ VFD Drives	$0	$0	$2,600,000	
Transfer Pumps	$0	$0	$400,000	
iping				
Process Piping	$0	$0	$1,350,000	
Yard Piping	$0	$0	$900,000	
oncentrate Piping and Pump Station	$0	$0	$350,000	
oncentrate Disposal Wells	$0	$0	$4,000,000	Using one 18"- diameter tube and packer injection wells
ludge Management	$0	$3,700,000	$0	
lending Box	$0	$0	$150,000	
ite Work @ 5 %	$5,000	$300,000	$1,200,000	
lectrical @ 12 %	$11,000	$700,000	$2,800,000	
strumentation and Controls @ 10 %	$10,000	$600,000	$2,300,000	
ubtotal	$120,000	$7,600,000	$29,700,000	
eneral Conditions @ 25% Mobiliz., bonds, insurance, permits, censes, overhead, profit, etc.)	$30,000	$1,900,000	$7,400,000	
otal Estimated Construction Costs	$150,000	$9,500,000	$37,100,000	
ontingency @ 10 %	$20,000	$1,000,000	$3,700,000	
elated Technical/Other Services @ 15 %	$20,000	$1,400,000	$5,600,000	
ubtotal Project Cost (1998)	$190,000	$11,900,000	$46,400,000	
OTAL ESTIMATED PROJECT COST (1998)		$58,490,000		

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TABLE 4-6A

MIAMI-DADE WASD
HIALEAH-PRESTON WATER TREATMENT PLANTS D/DBPs CONCEPTUAL DESIGN
ALTERNATIVE 4 CAPITAL COSTS FOR 1998 (LEVEL 2)
OPTIMIZED LIME/MEMBRANE SOFTENING BLEND

Capital Cost Component	Preston WTP	New WTP	Comments
Raw Water Line Rerouting	$0	$300,000	Assume 84-inch diameter and 500 feet
Chemical Storage/Feed Systems			
Sulfuric Acid System	$0	$1,400,000	At 180 mg/L and 190,000 gal., 14 days
Antiscalant System	$0	$600,000	
Chemical Cleaning	$0	$500,000	
Pretreatment			
Cartridge Filters	$0	$980,000	
Membrane Treatment			
Building	$0	$11,400,000	Increase membrane capacity by 115 mgd to 140 mgd
Membranes	$0	$13,300,000	
RO Skids w/Piping and Valves	$0	$28,200,000	
Pumps			
Feed Booster Pumps w/ VFD	$0	$8,700,000	
Transfer Pumps	$0	$1,800,000	
Piping			
Process Piping	$0	$6,500,000	
Yard Piping	$0	$2,700,000	
Concentrate Piping and Pump Station	$0	$1,300,000	
Concentrate Disposal Wells	$0	$8,000,000	Addition of two 24"- diameter tube and packer injection wells
Demolition (Hialeah WTP)	$500,000	$0	
Site Work @ 5 %	$0	$4,300,000	
Electrical @ 12 %	$100,000	$10,300,000	
Instrumentation and Controls @ 10 %	$100,000	$8,600,000	
Subtotal	$700,000	$108,900,000	
General Conditions @ 25% (Mobiliz., bonds, insurance, permits, licenses, overhead, profit, etc.)	$200,000	$27,200,000	
Total Estimated Construction Cost	$900,000	$136,100,000	
Contingency @ 10 %	$100,000	$13,600,000	
Related Tech./Other Services @ 15 %	$100,000	$20,400,000	
Subtotal Project Cost (1998)	$1,100,000	$170,100,000	
TOTAL ESTIMATED PROJECT COST (1998)	$171,200,000		

TABLE 4-6B

MIAMI-DADE WASD
HIALEAH-PRESTON WATER TREATMENT PLANTS D/DBPs CONCEPTUAL DESIGN
ALTERNATIVE 4 O&M COSTS ($/1000 GAL)
OPTIMIZED LIME/MEMBRANE SOFTENING BLEND

O&M Cost Object	Hialeah WTP	New MS WTP	Preston WTP
Chemicals			
Activated Silica	$0.000	$0.000	$0.000
Ammonia	$0.001	$0.001	$0.001
Antiscalant	$0.000	$0.017	$0.000
Carbon Dioxide	$0.000	$0.000	$0.011
Chlorine	$0.008	$0.008	$0.008
Ferric Coagulant	$0.000	$0.000	$0.012
Fluoride	$0.001	$0.002	$0.002
Lime (1)	$0.090	$0.000	$0.121
Polymer	$0.001	$0.000	$0.001
Sodium Hex.	$0.004	$0.004	$0.004
Other Chemicals	$0.001	$0.001	$0.001
Sulfuric Acid	$0.000	$0.053	$0.000
Cleaning Chemicals	$0.000	$0.010	$0.000
Air Stripping	$0.007	$0.007	$0.005
Power/Electricity	$0.036	$0.130	$0.038
Fuel and Oil	$0.001	$0.001	$0.003
Sludge/Concentrate Disposal	$0.000	$0.003	$0.010
Staffing/Labor	$0.040	$0.040	$0.022
Misc. Costs (2)	$0.017	$0.020	$0.006
Membrane/Cartridge Filter Replacement	$0.000	$0.070	$0.000
LEVEL 1 & 2 TOTAL O&M ($/1,000 gal.)	$0.207	$0.367	$0.245

Notes:

(1) Includes the cost of operating the Hialeah lime recalcination plant and producing lime and carbon dioxide for existing operations.

(2) Miscellaneous costs are expenses associated with operation of the water treatment plants. Expenses include other utilities, materials, travel, vehicles, and other operating expenses.

Table 4-4
Present Worth of Membrane Treatment Alternatives

Alternative	Level 1 Total (Million $)	Level H2 Total (Million $)
Membrane Softening at Hialeah blended with Lime Softening at Preston	432.0	566.2
Membrane Softening at Northwest Wellfield blended with Lime Softening at Hialeah- Preston	514.9	609.4
Membrane Softening at Northwest Wellfield blended with Lime Softening at Hialeah-Preston Plus Ozonation	491.6	515.8

The second alternative includes a membrane softening plant at a remote location (to replace the Hialeah WTP capacity) producing permeate water which would be blended with an optimized lime-softened water produced at the Hialeah-Preston site. Again the existing Hialeah facilities would be abandoned but Hialeah source water would feed the upgraded Preston facilities.

The third alternative is similar to the second with a membrane softening and optimized lime softening blend but includes the addition of ozone at the existing facilities in place of an increased membrane capacity to meet Stage 2.

4.6 Summary of Results

In terms of performance (operational) criteria, the following conclusions may be made:

1. Subsequent to utilization of a submersible well pump in a dedicated well, operation at 84 to 84 percent permeate water recovery rate, a feed pressure of 100 psi, a 3rd Stage feed pressure of 125 psi and an overall average flux of 15.1 gfd resulted in minimal performance loss from fouling over a 4000 hour period or essentially a six month period.

2. The introduction of air into the feed stream, probably from the horizontal centrifugal well pump column surges and leaks, led to rapid and severe fouling from iron hydroxide.

3. Vinyl chloride in the composite raw water did not result in any discernable membrane damage over a six month period.

In terms of water quality, the following conclusions may be made:

1. The resulting permeate water may be characterized as a very soft water with little mineral content and little buffering capacity. The permeate water would require addition of carbonate alkalinity, calcium hardness, and pH adjustment to match the existing lime softened water and reduce corrosion potential. This past treatment adjustment could be lime softened water from the current treatment process or Upper Floridan Aquifer raw water.

2. Color and TOC were reduced to low levels in the permeate. The TOC reduction to less than 1.0 mg/L as C was sufficient to reduce the formation potentials of THM4 and HAA5 to less than 0.010 mg/L on average.

3. The permeate water with appropriate disinfection and degasification (air stripping) would meet all Chapter 62-550 FAC primary and secondary drinking water standards.

4. The permeate water met both Water Quality Goal Levels set by MDWASD. They are as follows:

   Level 1: THM4 = 0.080 mg/L, HAA5= 0.060 mg/L and color = 10 CU

   Level 1: THM4 = 0.040 mg/L, HAA5 = 0.030 mg/L and color = 5 CU.

Section 5
QA/QC Summary

Quality Assurance/Quality Control (QA/QC) procedures used during the ICR membrane pilot plant study are described below. These include field duplicates of water quality samples which were required by the ICR every 10 weeks. Additionally, the ICR prescribes that all water quality analyses be performed according to QA/QC procedures described in the *DBP/ICR Analytical Methods Manual.*

5.1 Field Duplicates

A total of 23 water quality sampling events were conducted over the course of the membrane ICR pilot study and for four of these events a complete set of field duplicate samples was taken. The results of these field duplicates are reported in the *Data Collection Spreadsheets*.

5.2 Laboratory QA/QC

This section outlines the QA/AC procedures used by MDWASD and Montgomery Watson Laboratories including laboratory duplicates, laboratory fortified matrix sample analyses, results of PE samples and a summary of calibration procedures for DBP, bromide and TOC analyses. This data is presented in conjunction with additional information shown in the attached supplemental QA/QC spreadsheets from EPA.

5.2.1 Laboratory Duplicates and Fortified Matrix

The summary of the results of all laboratory duplicates and all laboratory fortified matrix sample analyses are summarized in the following tables. **Table 5-1** presents the results for Montgomery Watson's analyses related to haloacetic acids (HAAs) and total organic halides (TOX). **Table 5-2** presents similar results for the balance of the analyses performed by MDWASD.

5.2.2 PE Samples

The results of the laboratory performed PE samples (independent QC checks) are presented in **Table 5-3** for Montgomery Watson and **Table 5-4** for MDWASD.

Table 5-1
Duplicate and Fortified Matrix Results
Montgomery Watson Laboratories

SAMPLE DATE	SAMPLE NUMBER	RPE of Analytical Duplicates BCAA (ug/L)	DBAA (ug/L)	DCAA (ug/L)	MBAA (ug/L)	MCAA (ug/L)	TCAA (ug/L)	HAA5 (ug/L)	HAA6 (ug/L)	TOX (ug/L)	% Recovery Lab Fortified Matrix BCAA (ug/L)	DBAA (ug/L)	DCAA (ug/L)	MBAA (ug/L)	MCAA (ug/L)	TCAA (ug/L)	HAA5 (ug/L)	HAA6 (ug/L)	TOX (ug/L)
30-Jul-97	HI-1	0.0	0.0	ND	ND	2.3	1.3	1.2	0.9	2.8	94.0	97.0	98.0	91.0	91.0	84.0	90.2	47.3	129.0
13-Aug-97	HI-2									9.0									
13-Aug-97	HI-2									4.9									
27-Aug-97	HI-3	ND	ND	ND	ND	ND	ND			1.2	93.8	93.8	93.8	90.6	87.5	93.8	91.9	70.7	99.6
8-Oct-97	HI-4	ND	8.7	ND	ND	ND	ND	8.7	8.7	0.0	95.0	95.0	100.0	105.0	105.0	95.0	100.0	51.2	92.0
8-Oct-97	HI-4									6.3									100.0
22-Oct-97	HI-5	ND	ND	ND	ND	ND	6.9	6.9	6.9	5.7	103.1	100.0	103.1	103.1	109.4	103.1	103.7	54.3	93.0
5-Nov-97	HI-6																		
19-Nov-97	HI-7	ND	9.5	ND	ND	ND	ND	9.5	9.5	0.0	103.1	100.0	100.0	106.2	109.4	100.0	103.1	53.7	142.5
19-Nov-97	HI-7									3.2									96.2
14-Jan-98	HI-8	ND	ND	ND	ND	ND	ND			9.2	120.0	80.0	110.0	120.0	175.0	90.0	115.0	79.8	104.0
28-Jan-98	HI-9	0.0	ND	3.0	ND	ND	1.9	1.6	1.6	0.0	105.0	110.0	105.0	100.0	100.0	100.0	103.0	53.9	90.0
28-Jan-98	HI-9									18.0									86.8
11-Feb-98	HI-10	0.0	ND	0.0	ND	ND	4.3	1.4	1.4	4.1	110.0	100.0	120.0	160.0	120.0	190.0	138.0	56.2	96.5
25-Feb-98	HI-11	0.0	ND	0.0	ND	ND	0.0	0.0	0.0	8.3									25.2
25-Feb-98	HI-11									4.9									85.6
11-Mar-98	HI-12	2.3	0.0	0.0	ND	ND	2.2	1.1	1.1	22.0	100.0	130.0	100.0	100.0	85.0	90.0	101.0	59.0	140.8
25-Mar-98	HI-13	ND	ND	ND	ND	ND	ND			4.5	100.0	130.0	100.0	110.0	125.0	100.0	113.0	83.6	90.8
8-Apr-98	HI-14	9.5	9.5	0.0	ND	ND	ND	6.3	6.3	2.8	95.0	95.0	100.0	105.0	100.0	110.0	102.0	50.9	89.0
22-Apr-98	HI-15	2.1	1.7	0.0	6.9	0.0	10.0	3.5	3.5	2.1	100.0	105.0	100.0	110.0	110.0	95.0	104.0	52.3	92.5
6-May-98	HI-16	6.9	0.0	ND	ND	ND	0.0	2.3	2.3	11.0	106.2	100.0	93.8	106.2	96.9	90.6	97.5	52.6	101.0
6-May-98	HI-16									1.0									108.0
20-May-98	HI-17	3.2	9.5	0.0	6.5	ND	ND	4.8	4.8	0.6	100.0	90.0	100.0	90.0	95.0	100.0	95.0	50.0	103.0
3-Jun-98	HI-18	ND	ND	ND	ND	ND	ND			1.1	100.0	110.0	100.0	170.0	195.0	100.0	135.0	77.8	90.0
17-Jun-98	HI-19	5.7	ND	0.0	ND	ND	6.9	4.2	4.2	1.2	103.1	103.1	96.9	103.1	96.9	96.9	99.4	52.1	99.8
29-Jun-98	HI-20	2.9	0.0	3.4	ND	ND	3.5	2.5	2.5	1.8	100.0	105.0	100.0	105.0	120.0	100.0	106.0	52.0	110.0
15-Jul-98	HI-21	3.7	3.0	5.3	ND	ND	ND	4.0	4.0	20.0	95.0	90.0	100.0	100.0	105.0	100.0	99.0	52.2	90.6
29-Jul-98	HI-22	13.0	12.1	9.1	ND	48.6	11.1	18.8	18.8	6.9	109.4	103.1	115.6	103.1	103.1	103.1	105.6	62.1	60.0
12-Aug-98	HI-23	1.9	0.0	2.6	ND	ND	0.0	1.1	1.1	3.9	93.8	96.9	90.6	96.9	81.2	96.9	92.5	47.9	100.5
12-Aug-98	HI-23									3.9									100.5
12-Aug-98	HI-23									11.0									90.0
Count		14	12	12	2	3	12	8.2	9.2	30									
Count											20	20	20	20	20	20	20	20	28
AVG RPE		3.7	4.5	2.0	6.7	16.9	4.0	6.8	6.3	5.7									
AVG % Rec.											101.3	101.7	100.8	108.8	110.5	101.9	104.7	104.2	96.7
Std. Dev.		3.9	4.9	2.9	0.3	27.4	3.9	7.9	7.2	5.8									
Std. Dev.											6.6	12.0	7.5	20.6	28.2	21.5	17.9	16.1	21.6
75th Percentile		5.2	9.5	3.1	6.8	25.4	6.9	10.34	9.5	8.0									
50th Percentile		2.6	2.4	0.0	6.7	2.3	2.9	2.84	2.8	4.0									
25th Percentile		0.5	0.0	0.0	6.6	1.2	1.0	1.745	1.5	1.4									
75th Percentile											103.6	105.0	100.8	107.2	112.5	100.0	105.1	104.8	101.6
50th Percentile											100.0	100.0	100.0	104.1	104.1	100.0	101.6	101.4	96.4
25th Percentile											95.0	95.0	99.2	100.0	96.4	94.7	97.1	96.7	90.0

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Table 5-2
Duplicate and Fortified Matrix Results
Miami-Dade Water & Sewer Department

SAMPLE DATE	SAMPLE NUMBER	RPE of Analytical Duplicates: Bromide (ug/L)	UV254 (1/cm)	TOC (mg/L)	CHCl3 (ug/L)	BDCM (ug/L)	DBCM (ug/L)	CHBr3 (ug/L)	THM4 (ug/L)	% Recovery Lab Fortified Matrix: Bromide (ug/L)	UV254 (1/cm)	TOC (mg/L)	CHCl3 (ug/L)	BDCM (ug/L)	DBCM (ug/L)	CHBr3 (ug/L)	THM4 (ug/L)
30-Jul-97	HI-1	2.70		29.58						97.38	NA	109.0					
13-Aug-97	HI-2	0.61	0.50	0.53						106.42	NA	104.0					
13-Aug-97	HI-2			0.27							NA	112.5					
27-Aug-97	HI-3	1.18	8.00	0.43	2.71	2.88	2.99	0.25	2.21	99.24	NA	96.5	95.0	95.0	91.0	106.0	96.8
8-Oct-97	HI-4	0.88	0.00	12.30	2.70	2.57	1.96	0.23	1.87	100.19	NA	121.3	102.0	83.5	103.0	108.0	99.1
22-Oct-97	HI-5	0.01	0.00	0.37	3.04	3.01	153.00	0.00	39.76	101.38	NA	101.0	99.0	124.0	110.0	110.0	110.8
5-Nov-97	HI-6	1.30		2.67	1.31	1.07	1.17	0.00	0.89	105.73	NA	99.8	99.0	124.0	110.0	110.0	110.8
19-Nov-97	HI-7	2.27	0.00	0.33	3.31	31.50	7.52	0.00	10.58	106.66	NA	101.5	113.0	107.0	95.0	82.0	99.3
19-Nov-97	HI-7			2.36							NA	95.3					
14-Jan-98	HI-8	4.40	40.00	8.42	0.82	0.44	0.18	0.00	0.36	94.16	NA	101.5	111.0	102.0	97.0	85.0	98.8
28-Jan-98	HI-9	1.69	0.00	0.51	0.00	0.00	0.00	0.00	0.00	101.26	NA	107.2	84.0	83.6	101.0	81.4	87.5
11-Feb-98	HI-10	6.86	0.00	1.22	0.00	0.00	0.00	0.00	0.00	96.12	NA	99.3	84.0	83.6	101.0	81.4	87.5
11-Feb-98	HI-10DUP	27.96	1.87	5.13	0.00	0.00	0.00	0.00	0.00	96.12	NA	100.0	100.0	79.0	83.0	75.0	84.3
25-Feb-98	HI-11	13.87	0.91	9.68	0.00	0.00	0.00	0.00	0.00	88.56	NA	100.8	90.4	72.3	82.5	78.9	81.0
11-Mar-98	HI-12	4.44	0.00	15.38	0.00	0.00	0.00	0.00	0.00	88.56	NA	113.0	95.8	87.4	104.0	105.0	98.1
25-Mar-98	HI-13	4.44	0.19	88.89	0.00	0.00	0.00	0.00	0.00	85.05	NA	81.5	114.0	99.1	96.5	83.5	98.3
8-Apr-98	HI-14	11.17	0.00	0.82	0.00	0.00	0.00	0.00	0.00	95.22	NA	95.3	91.0	97.0	106.0	116.0	102.5
22-Apr-98	HI-15	4.97	0.00	6.47	0.00	0.00	0.00	0.00	0.00	95.22	NA	91.0	118.0	114.0	114.0	112.0	114.5
23-Apr-98	HI-15 DUP	0.63	0.00	0.45						78.30	NA	92.0					
6-May-98	HI-16	5.75	0.00	68.09	0.00	0.23	0.00	0.00	0.06	78.30	NA	117.0	118.0	114.0	114.0	112.0	114.5
6-May-98	HI-16			11.54							NA	121.5					
20-May-98	HI-17	21.82	0.00	2.11	0.00	0.28	0.00	0.00	0.07	78.30	NA	100.0	98.5	97.5	110.0	97.0	100.8
3-Jun-98	HI-18	0.56	0.00	11.76	3.92	0.16	0.00	0.00	1.02	62.96	NA	107.0	82.5	82.5	80.5	69.0	78.6
17-Jun-98	HI-19	0.56	0.00	15.00	0.20	0.11	0.00	0.00	0.08	62.96	NA	108.0	74.9	80.4	77.5	68.4	75.3
29-Jun-98	HI-20	20.45	0.00	10.26	0.29	0.11	0.00	0.00	0.10	107.13	NA	109.0	96.0	99.0	97.5	104.0	99.1
29-Jun-98	HI-20DUP			2.15	0.57	0.25	0.00	0.00	0.21	107.13	NA	102.5	90.0	91.0	97.5	90.0	92.1
15-Jul-98	HI-21	11.13	0.00	61.90	0.25	0.00	0.00	0.00	0.06	68.20	NA	121.0	94.4	93.0	86.0	87.0	90.1
29-Jul-98	HI-22	11.13	0.91	2.49	0.00	0.00	0.00	0.00	0.00	68.20	NA	98.0	98.0	104.0	103.0	92.0	99.3
12-Aug-98	HI-23	6.51	0.00	12.00	0.39	0.14	0.00	0.00	0.13	117.54	NA	104.5	103.0	104.0	99.0	93.0	99.8
12-Aug-98	HI-23DUP	17.61		2.42	0.46	0.00	0.00	0.00	0.12	117.54	NA	103.5	103.0	104.0	99.0	93.0	99.8
Count		26	23	30	24	24	24	24	24								
Count										27	0	30	24	24	24	24	24
AVG RPE		7.11	2.28	12.85	0.83	1.78	6.95	0.02	2.40								
AVG % Rec.										92.73	NA	103.81	98.10	96.70	98.25	93.32	96.59
Std. Dev.		7.65	8.39	21.73	1.27	6.40	31.15	0.07	9.72								
Std. Dev.										15.44	NA	9.24	11.21	13.87	10.45	14.44	12.49
75th Percentile		11.13	0.35	11.94	0.94	0.32	0.05	0.00	0.33								
50th Percentile		4.44	0.00	3.90	0.23	0.11	0.00	0.00	0.08								
25th Percentile		1.21	0.00	0.92	0.00	0.00	0.00	0.00	0.00								
75th Percentile										103.56	NA	108.75	103.00	104.00	104.50	106.50	104.50
50th Percentile										96.12	NA	102.00	98.25	97.25	99.00	92.50	96.75
25th Percentile										81.68	NA	99.38	90.85	83.60	94.00	81.85	87.58

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Table 5-3
PE Sample Results
Montgomery Watson Laboratories

SAMPLE DATE	PE STUDY NUMBER	% Recovery of PE Samples								
		BCAA (ug/L)	DBAA (ug/L)	DCAA (ug/L)	MBAA (ug/L)	MCAA (ug/L)	TCAA (ug/L)	TOX (ug/L)	HAA5 (ug/L)	HAA6 (ug/L)
Mar-94	1	97	91	111	85	96	85	73	93.6	94.2
Mar-95	2	95	98	99	98	108	85	85	97.6	97.2
Jul-96	3	98	96	97	NA	105	100	93	99.5	99.2
Apr-97	4	92	93	88	NA	96	85	90	90.5	90.8
Sep-97	5	87	86	83	84	91	89	102	86.6	86.7
Jan-98	6	90	95	88	94	98	92	85	93.4	92.8
Apr-98	7	92	94	88	94	93	93	88	92.4	92.3
Jul-98	8	91	91	85	80	85	90	80	86.2	87.0
AVG % Recovery of PE Samples		92.8	93.0	92.4	89.2	96.5	89.9	87.0	92.2	92.3
Count		8	8	8	6	8	8	8	7.6	7.7
Std Deviation		3.7	3.7	9.3	7.1	7.4	5.2	8.7	6.5	6.1
75th Percentile		95.5	95.3	97.5	94.0	99.8	92.3	90.8	95.8	95.7
50th Percentile		92.0	93.5	88.0	89.5	96.0	89.5	86.5	91.3	91.4
25th Percentile		90.5	92.0	86.5	84.0	92.0	87.0	85.0	88.3	88.7

Table 5-4
PE Sample Results
Miami-Dade Water and Sewer Department Laboratories

SAMPLE DATE	PE STUDY NUMBER	% Recovery of PE Samples							
		Bromide (ug/L)	UV254 (ug/L)	TOC (ug/L)	CHCl3 (ug/L)	BDCM (ug/L)	DBCM (ug/L)	CHBr3 (ug/L)	THM4 (ug/L)
Mar-94	1	NA	NA	NA	NA	NA	NA	NA	NA
Mar-95	2	NA	NA	NA	NA	NA	NA	NA	NA
Jul-96	3	98.7	108.99	113.9	NA	NA	NA	NA	107.20
Apr-97	4	94.1	93.2	104.4	91	104	106	123*	100.33
Sep-97	5	99.4	94.3	105.1	110	96	98	*	101.33
Jan-98	6	94.9	99	113	98	89	93	95	93.75
Apr-98	7	96.4	107.5	104.1	92	92	97	92	93.25
Jul-98	8	111.1	98.6	108.4	91	93	89	78	87.75
Nov-98	9	94.5	107.2	102.6	96	92	86	105	94.75
AVG % Recovery of PE Samples		99.10	100.27	108.15	96.40	94.80	96.60	88.33	94.03
Count		6	6	6	5	5	5	3	4.50
Std Deviation		6.23	6.61	4.39	8.14	5.72	6.35	9.07	7.32
75th Percentile		99.2	105.4	111.9	98.0	96.0	98.0	93.5	96.38
50th Percentile		97.6	98.8	106.8	92.0	93.0	97.0	92.0	93.50
25th Percentile		94.7	96.5	104.3	91.3	92.0	90.0	88.5	90.44

*EPA admitted problems with CHBr3
No results for Study 5

5.2.3 Calibration Procedures

Calibration verification and other QC procedures are presented in **Table 5-5** for the parameters analyzed by Montgomery Watson Laboratories. Similarly, **Table 5-6** contains procedures used by MDWASD.

Table 5-5
Calibration Verification and QC Procedures for HAA and TOX
Montgomery Watson Laboratories

Performance Criteria	**Method**	**SM 6251B Haloacetic Acids**	**TOX SM 5320B**
	Analytes **Target Analytes**	***(HAA)*** Monochloroacetic (MCAA) Dichloroacetic acid (DCAA) Dibromoacetic acid(TCAA) Trichloroacetic acid (TCAA) Monobromoacetic acid (MBAA) Bromochloroacetic acid (BCAA)	***TOX*** **Total Organic Halide** **(Dissolved Organic Halogen)** **(DOX)**
1.0 IDC			
1.1 IDLSB	**Method Blank**	< 1/2 MRL	< 1/2 MRL
1.2 IDA	**QC check sample**	+/- 20% of true value	+/- 20% of true value
1.3 IDP	**No. of replicates** **Spike conc.** **% RSD** **% Recovery**	5 20 < 20 80-120 7 1/2 MRL	5 TOX 250 ug/L < 20 80-120
1.4 MDL	**No. of replicates** **Spike conc.** **% Recovery**	7 1/2 MRL 50-150	7 1/2 MRL 50-150
2.0 MRL		MCAA: 2.0 ug/L Others:1.0 ug/L	50 ug Cl^-/L 25 ug Cl^-/L (during treatment studies)

Table 5-5
Calibration Verification and QC Procedures for HAA and TOX
Montgomery Watson Laboratories
(continued)

	Performance Criteria	Method	SM 6251B Haloacetic Acids	TOX SM 5320B
		Analytes	*(HAA)*	*TOX*
3.0	Calibration Verification	Verification Frequency	Lowest level std. analyzed at the beginning of each 24 hour- before first sample run Mid level and high level analyzed alternately after 10th sample and after the last sample.	3 microcoulometer titration cell checks with NaCl std at start of 8-10 hr. work shift. Lowest level std. analyzed before the first sample. Mid level and high level analyzed alternately after every 7th sample and last sample
	Conc. and QC criteria (%rec)		***MCAA*** ***(ug/L) (% rec.)***	***TOX*** (ug Cl-/L) (% rec)
		Low	2.0 50-150	50 (25) 75-125
		Mid-level	20 80-120	200 85-115
		High	32 80-120	500 85-115
			All others ***(ug/L) (% rec.)***	
		Low	1 50-150	
		Mid-level	20 80-120	
		High	32 80-120	
4.0	Reagent (Method) Blank	*Frequency*	one per analysis batch (one per extraction batch)	2 nitrate-washed activated carbon at the start of ea analysis batch, then 1 after every 7 samples (run in duplicate)- minimum of 3 per day; Analyze 1 system blank per analysis batch.
	QC criteria		< 1/2 of MRL	<0.80 ug/Cl-/40 mg of activated carbon; < 1/2 of MRL, <25 or < 12.5
5.0	Shipping Blank Criteria	Travel Blank	NA NA	NA

Table 5-5
Calibration Verification and QC Procedures for HAA and TOX
Montgomery Watson Laboratories
(continued)

Performance Criteria	Method	SM 6251B Haloacetic Acids	TOX SM 5320B
	Analytes	*(HAA)*	*TOX*
6.0 LFM	*Fortified Sample*		
Frequency		one sample per extraction batch	at least 5% of all ICR samples analyzed each quarter (fortified sample analyzed in duplicate
Matrix spike level		same concentration as cal verification. If no historical data for sample level, rotate low, mid, high as spike conc.	same concentration as cal verification. If no historical data for sample level, rotate low, mid, high as spike conc.
QC criteria	% Recovery	NA	NA
7.0 Lab (Field) Duplicate			lab duplicate
Frequency		one lab duplicate per extraction batch	
QC Criteria	% RPD	NA	NA
8.0 Internal Std.		1,2-dibromopropane or 1,2,3-trichloropropane in each extract	NA
QC Criteria	IS Recoveries	+/- 30% of calibration curve AVG IS response 70-130 %	NA
9.0 Surrogate QC Standards		2,3-dibromopropionic acid or 2,3,5,6-tetrafluorobenzoic acid in each sample	NA
	Surrogate Recoveries	70-130 %	NA
10.0 Method Calibration Procedures	Initial Calibration Curve	MCAA Concentration (ug/L)	
Trihalomethane	Standard 1	2	
	Standard 2	5	
	Standard 3	10	
	Standard 4	20	
	Standard 5	40	
	Standard 6	-	
		All others Concentration (ug/L)	
	Standard 1	1	
	Standard 2	2	
	Standard 3	5	
	Standard 4	10	
	Standard 5	20	
	Standard 6	40	

Table 5-6
Calibration Verification and QC Procedures for UV54, TOC, Bromide and THM4
Miami-Dade Water & Sewer Department Laboratories

Performance Criteria	Method	UV254 SM 5910	TOC SM 5310 B	BROMIDE EPA 300.0	TRIHALOMETHANES
	Analytes **Target Analytes**	*UV 254* **UV Absorbance at 254 nm**	*TOC* **Total Organic Carbon**	*BROMIDE (Br)* **Bromide (Br)**	*(THM)* **Chloroform** **Dichlorobromomethane** **Dibromochloromethane** **Bromoform**
1.0 IDC					
1.1 IDLSB	**Method Blank**	< 1/2 MRL	< 1/2 MRL	< 1/2 MRL	<BDL
1.2 IDA **1.3 IDP**	**QC check sample** **No. of replicates** **Spike conc.** **% RSD** **% Recovery**	+/- 20% of true value 5 6.5 mg/L+0.5 mg/L DOC (Dissolved Organic Carbon) < 20 80-120	+/- 20% of true value 5 TOC 4 mg/L < 20 80-120	+/-20% of true value 5 Br. 0.10 mg/L < 20 80-120	+/-20% of true value 7 2 <20 80-120
1.4 MDL	**No. of replicates** **Spike conc.** **% Recovery**	7 0.5mg/L DOC (Dissolved Organic Carbon) = 0.009cm-1 50-150	7 1 50-150	7 1/2 MRL 50-150	7 5 times EDL 60-140
2.0 MRL		0.009cm-1	0.70 mg/L 0.50 mg/L (during treatment studies)	Br. 0.020 mg/L	
3.0 Calibration Verification **Conc. and QC criteria (%rec)**	**Verification Frequency** **Low** **Mid-level** **High**	Lowest level std. analyzed at the beginning of each 24 hr before the first sample Mid level and high level analyzed alternately after every 10th sample and last sample *UV 254* *(cm-1)* *(% Rec)* *(RPD)* 0.009 75-125 </= 20 0.088 85-115 </= 10 0.866 85-115 </= 10	Lowest level std. analyzed at the beginning of each 24 hr before the first sample Mid level and high level analyzed alternately after every 10th sample and last sample *TOC* *(mg/L)* *(% Rec)* 0.7 (0.5) 50-150 4 90-110 9 90-110	Lowest level std analyzed at the beginning of each 24 hour before first sample run . Mid Level and high level analyzed alternately after 10th sample and after the last sample. *Bromide* *(mg/L)* *(% Rec)* 20 50-150 100 90-110 300 90-110	Lowest-, mid-and high-levels analyzed at the beginning of each run *(ug/L)* *(% Rec)* 2 80-120 10 80-120 30 80-120
4.0 Reagent (Method) Blank **QC criteria**	*Frequency*	Initial zero; Check after each 10 samples < 1/2 of MRL (<0.0045cm -1)	One per analysis batch < 1/2 of MRL, < 0.35, or< 0.25	One per analysis batch < 1/2 of MRL	One per analysis batch
5.0 Shipping Blank Criteria	**Travel Blank**	NA	NA	NA	NA

Table 5-6
Calibration Verification and QC Procedures for UV54, TOC, Bromide and THM4
Miami-Dade Water & Sewer Department Laboratories
(continued)

6.0	**LFM**	***Fortified Sample***				
	Frequency		N/A	at least 5% of ICR samples in an analysis batch (fortified sample analyzed in duplicate) same concentration as cal verification. If no historical data for sample level, rotate low, mid, high as spike conc.	at least 5% of all ICR samples analyzed each quarter (fortified sample analyzed in duplicate same concentration as cal verification. If no historical data for sample level, rotate low, mid, high as spike conc.	at least 5% of all ICR samples analyzed each quarter (fortified sample analyzed in duplicate same concentration as cal verification. If no historical data for sample level, rotate low, mid, high as spike conc.
	Matrix spike level		N/A			
	QC criteria	**% Recovery**	NA	NA	NA	80-120
7.0	**Lab (Field) Duplicate**		Lab. duplicate	lab duplicate	lab duplicate	lab duplicate
	Frequency		all samples analyzed in duplicate			
	QC Criteria	**% RPD**	< = 20 % (UV254 </=0.045) < = 10 % (UV254 > 0.045)	</= 10 % (TOC conc > 2.0 mg/L) </= 20 % (TOC conc </= 2.0 mg/L)	NA	< 1
8.0	**Internal Std.**		N/A	NA	NA	NA
	QC Criteria	**IS Recoveries**	N/A	NA	NA	80-120%
9.0	**Surrogate QC Standards**		N/A	NA	NA	NA
		Surrogate Recoveries		NA	NA	NA
10.0	**Method Calibration Procedures Trihalomethane**	**Initial Calibration Curve**	N/A	Conc. (mg/L)	Bromide Concentration (mg/L)	
		Standard 1		0.5	0	5
		Standard 2		1.0	0	10
		Standard 3		5	0	15
		Standard 4		10	0	20
		Standard 5		20	0	30
		Standard 6			1	
		Standard 7				
		Standard 8				
		Standard 9				