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The SMART™ Solution to Real-Time Performance Optimization & Fouling Management of Membrane Desalination & Filtration Plants



A Presentation by:

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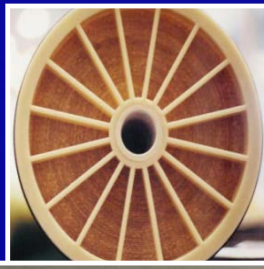
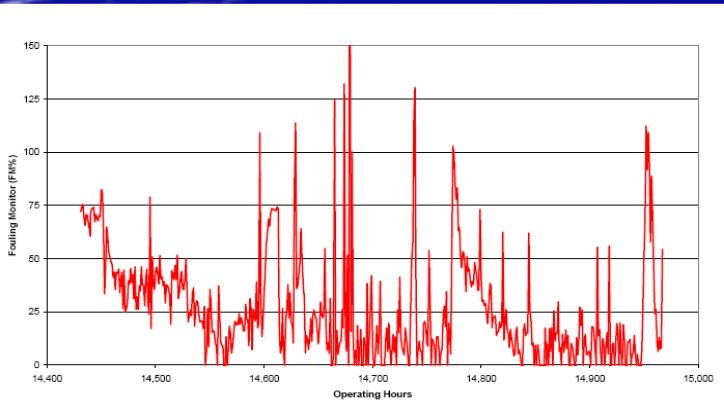



STATUS OF MEMBRANE DESALINATION

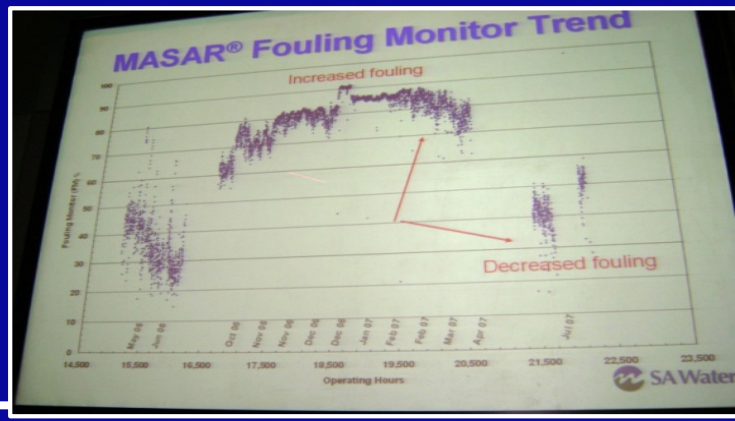
- *WATER DESALINATION AND FILTRATION IS A $BILLION 18.0-20.0 MARKET WORLDWIDE, AND FORECASTED TO REACH $BILLION 52.5 IN 2020, UP 320% FROM $B12.5 IN 2010 AND AVERAGE ANNUAL GROWTH RATE OF 12-15%.*
- *US REPRESENTS $BILLION 4.2 OR 33% OF GLOBAL DESALINATION EQUIPMENT MARKET TOTALING $BILLION 12.7 BY 2025 .*
- *MIDDLE EASTERN COUNTRIES, WHICH PRODUCE 50% OF WORLD'S CAPACITY WILL SPEND $B 70-100 THROUGH 2030 ON NEW PLANTS; 25-40% WILL BE SPENT ON MEMBRANE PLANTS, MAINLY SWRO.*
- *SAUDI ARABIA PLANS TO SPEND $BILLION 500 ON SOLAR-POWERED AND OIL-INDEPENDENT DESALINATION PLANTS BY 2030.*

WHY MONITOR ?

- OPTIMIZE PLANT OPERATION & PERFORMANCE
- MAXIMIZE PLANT AVAILABILITY & EFFICIENCY
- MINIMIZE & MITIGATE OPERATIONAL AND PERFORMANCE PROBLEMS
- DETECT & TROUBLE-SHOOT RO MEMBRANE FOULING & SCALING AND UF/MF PERMEABILITY EARLY.
- PLAN MAINTENANCE, SYSTEM REFURBISHMENTS & UPGRADES

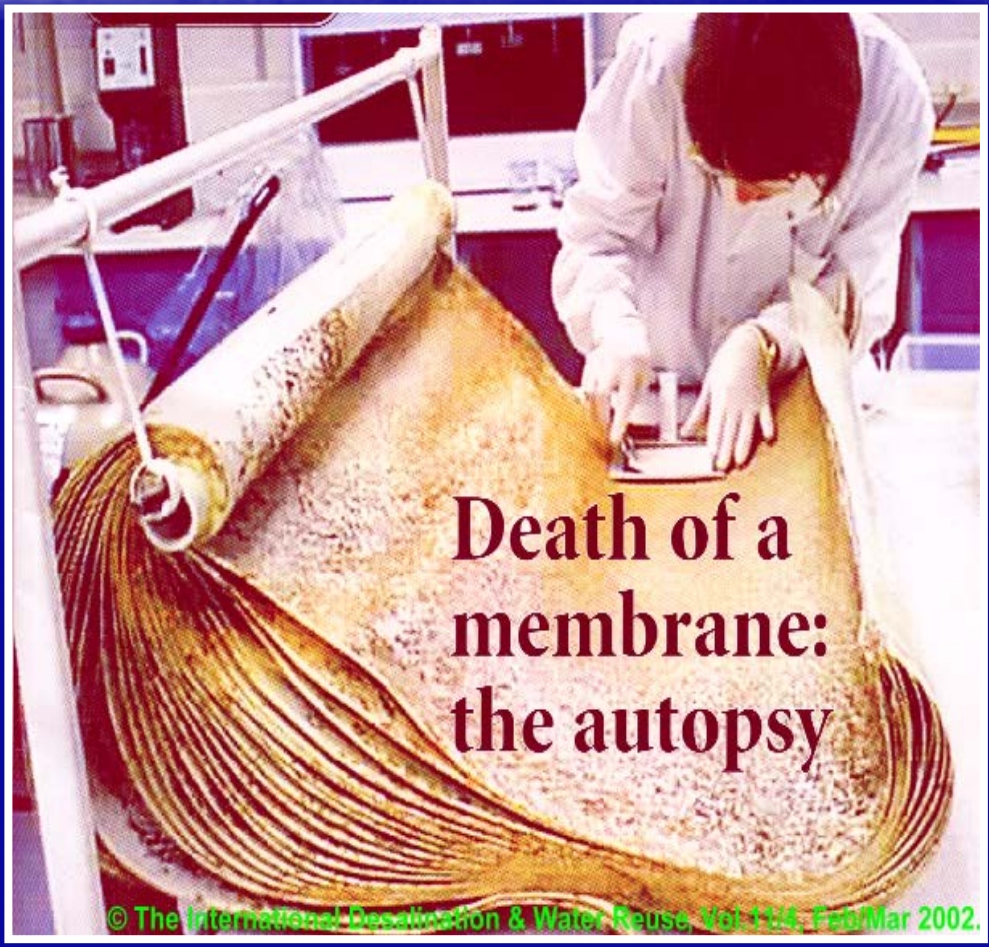


✓ MINIMIZE COST OF WATER



WHY MONITOR ?

ULTIMATE FATE WITHOUT PROPER MONITORING



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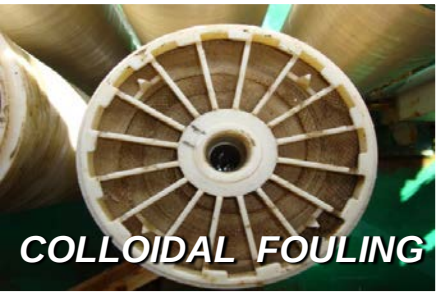
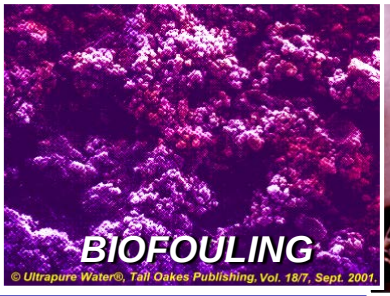
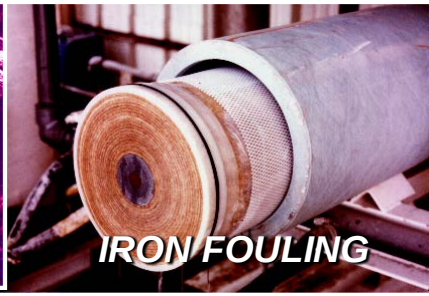
THE ISSUES

- MEMBRANE FOULING , CANCER OF THE MEMBRANE, IS MOST CRITICAL ISSUE IN DESALINATION TECHNOLOGY APPLICATIONS SINCE 1980
- NO SYSTEM DESIGN MODEL/ PROJECTION CAN PREDICT FOULING IN DESIGN STAGE, UNLIKE CHEMICAL SCALING
- EARLY DETECTION , IDENTIFICATION AND MEASUREMENT OF FOULING MAGNITUDE AND OPTIMIZATION OF OPERATION AL EFFICIENCY & COST N REAL-TIME CRITICAL TO SYSTEM HEALTH







HOW TO MONITOR ?

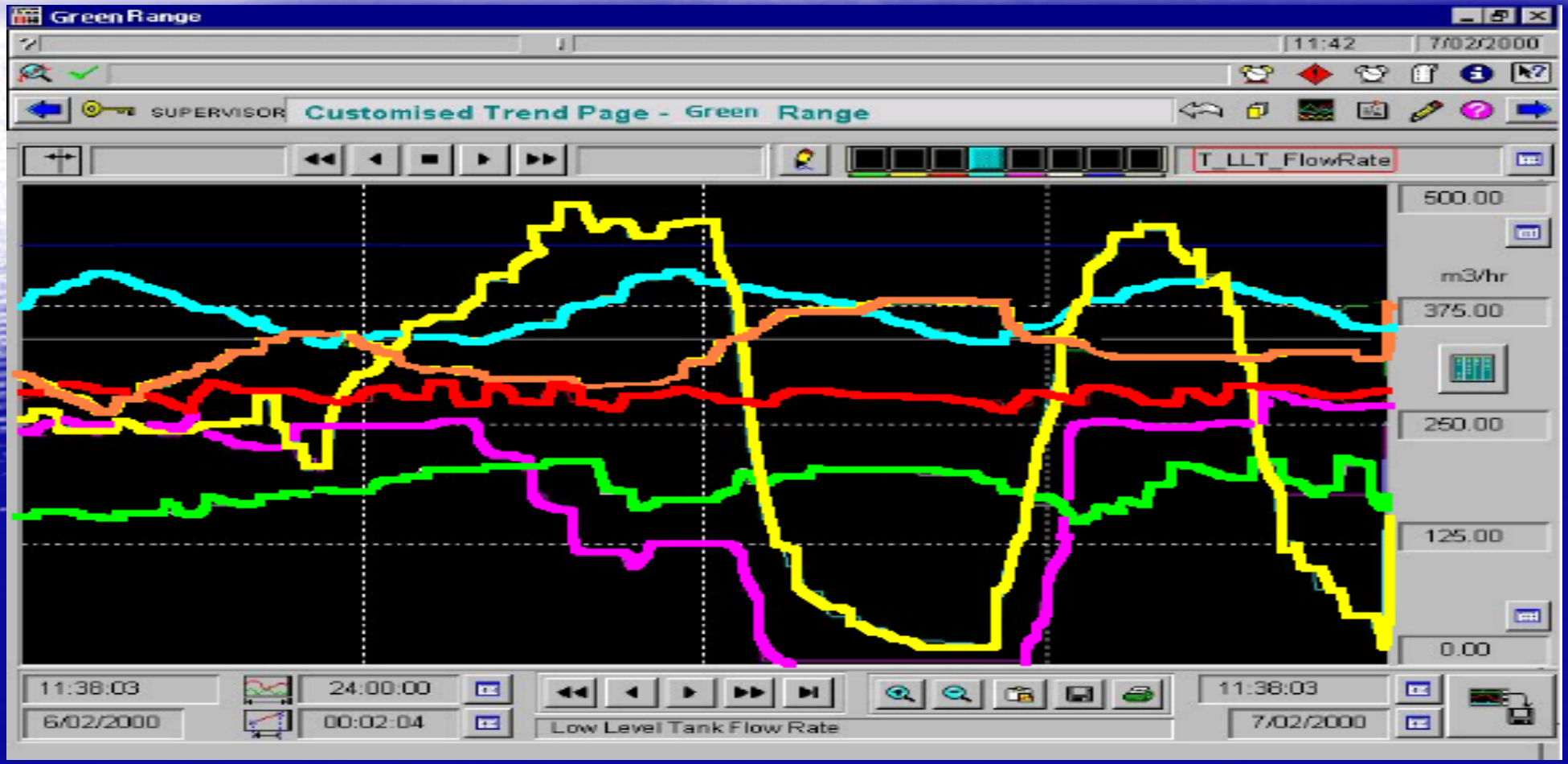
- TRACK CHANGES IN WATER QUALITY
- TRACK CHANGES IN CHEMICAL & ENERGY USAGE
- EVALUATE PRETREATMENT EFFICIENCY
- COLLECT PLANT & SYSTEM OPERATING DATA PARAMETERS MANUALLY OR VIA SENSORS (SCADA)
- EVAUATE MEMBRANE SYSTEM FLUX & SALT PASSAGE PERFORMANCE TRENDING VIA ASTM NORMALIZATION OF DATA TO TAKE "APPROPRIATE" ACTION (MOSTLY MEMBRANE CLEANINGS & REPLACEMENTS) AND TRY TO MAINTAIN PLANT PRODUCTIVITY AND AVAILABILITY.

HOW TO ANALYZE?

- ASTM D 4516 STANDARD NORMALIZATION METHOD
  - ONLY AVAILABLE METHOD IN INDUSTRY, DEVELOPED BY DUPONT SINCE 1974 TO EVALUATE MEMBRANE SYSTEM FLUX AND SALT PASSAGE PERFORMANCE CHARACTERISTICS
  - BASED ON ESTABLISHING LONG-TERM TREND, NOT REAL TIME MONITORING
  - BASED ON LIMITED LAB TESTING OF MEMBRANE PERFORMANCE OF STATISTICAL SAMPLES UNDER I IDEAL, NON-EMPIRICAL CONDITIONS (NO FOULING).

AUTOMATED ON-LINE REMOTE MONITORING

SCADA TRENDING OF WATER SUPPLY SYSTEM

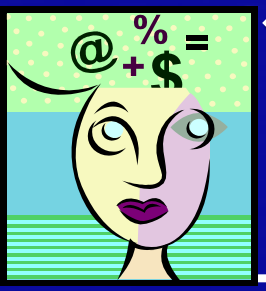


ASTM D 4516 STANDARD NORMALIZATION METHOD

- SET "STANDARD" CONDITIONS AS BASIS FOR NORMALIZATION, CALCULATE CORRECTION FACTORS (DESIGN TO OPERATION):
  - ✓TEMPERATURE CORRECTION FACTOR: $TCF=M^{(T-25)}$ M=1.028-1.03
  - ✓PRESSURE CORRECTION FACTOR:
    $PCF=FEED\ P - \Delta P_{fb}/2 - PRODUCT\ P$ fb= Feed-Brine Avg.
  - ✓NET DRIVING FORCE PER MEMBRANE:
    $NDFM = (PCF - NET\ OSMOTIC\ PRESSURE_{fb}) * TCF$
- **NORMALIZED FLOW**: $Q_{ps} = [NDFM_s / NDFM_a] X\ Q_a$
- **NORMALIZED SALT PASSAGE**:

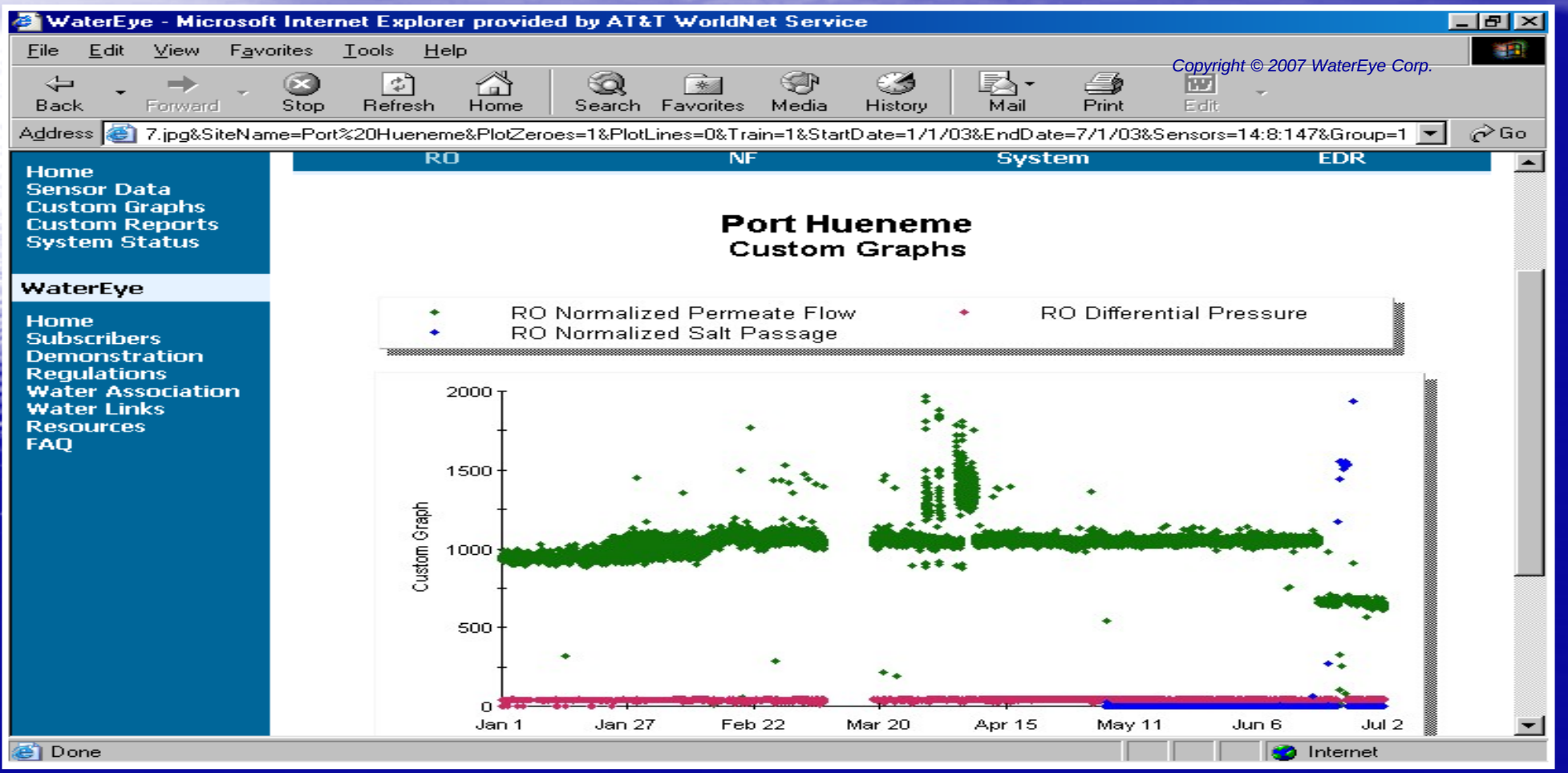
$$\%SP_{ps} = [NDFM_s / NDFM_a] X\ [\ C_{fbs} X\ C_{fa}\ ] / [\ C_{fba} X\ C_{fs}\ ] x\ \%Sp_a$$

C_{fa} = Actual Feed Conc. (ppm NaCl)

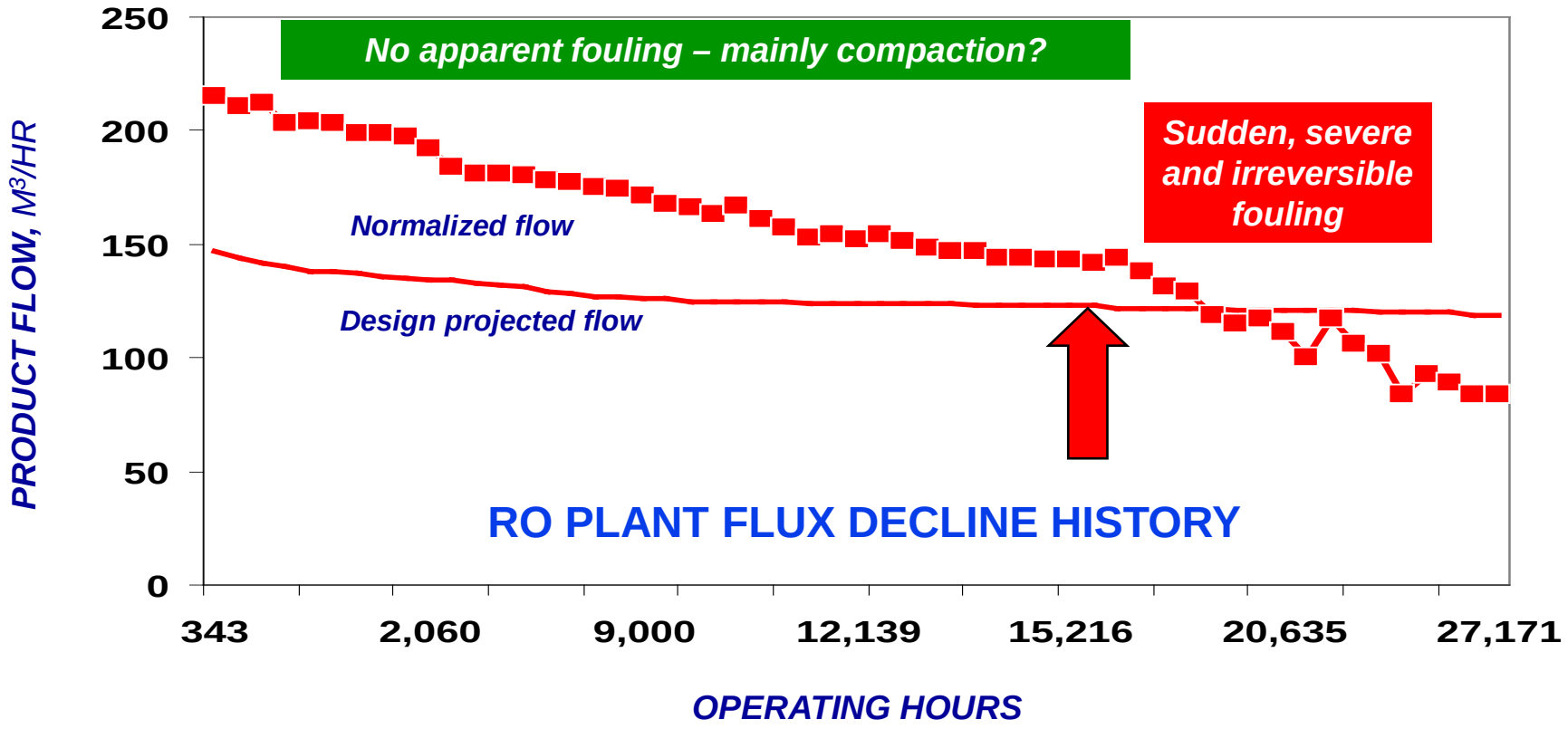


AUTOMATED ONLINE REMOTE MONITORING

ASTM-NORMALIZED RO PLANT DATA



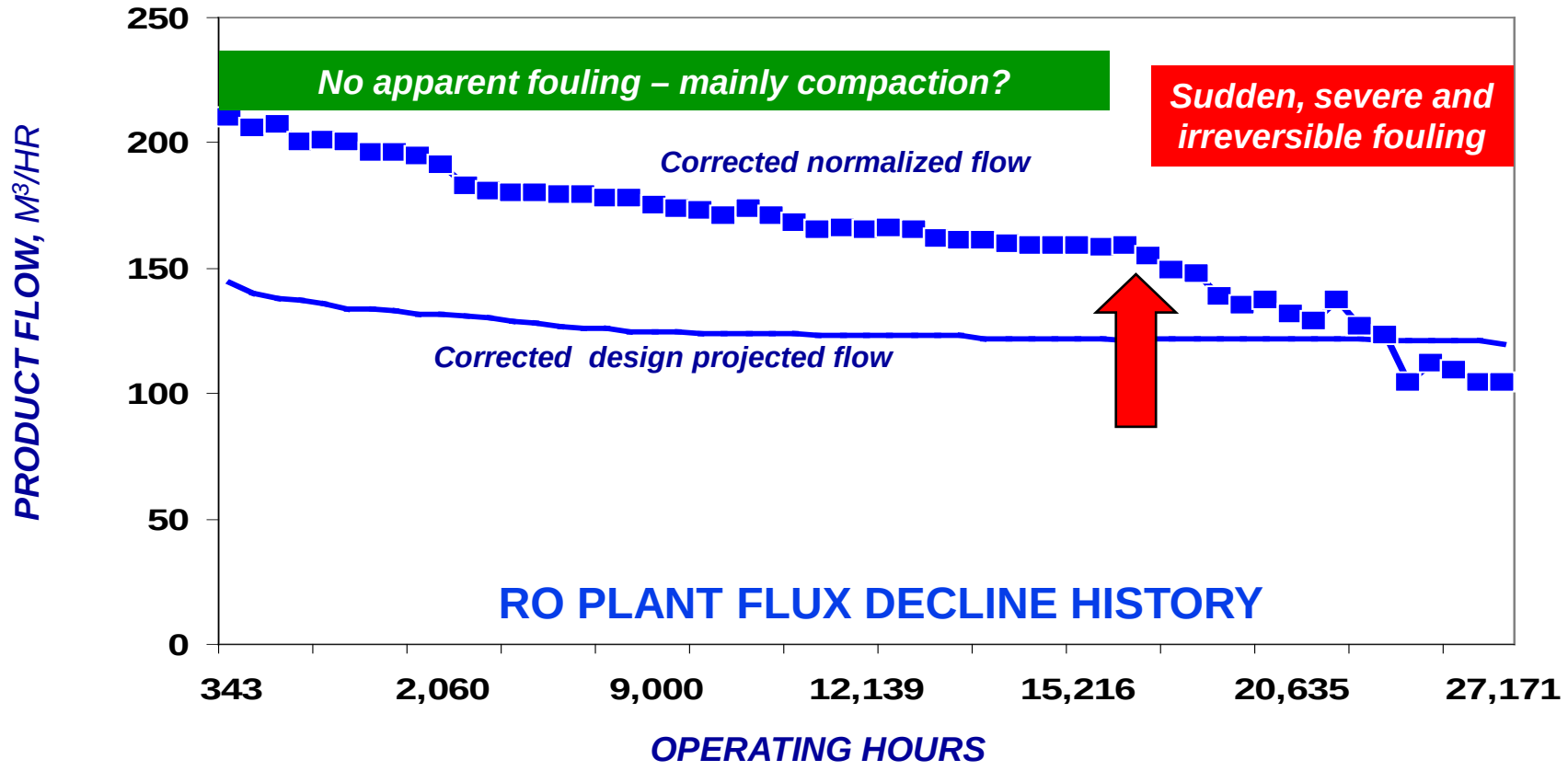
ASTM D 4516 NORMALIZED PERFORMANCE TRENDING



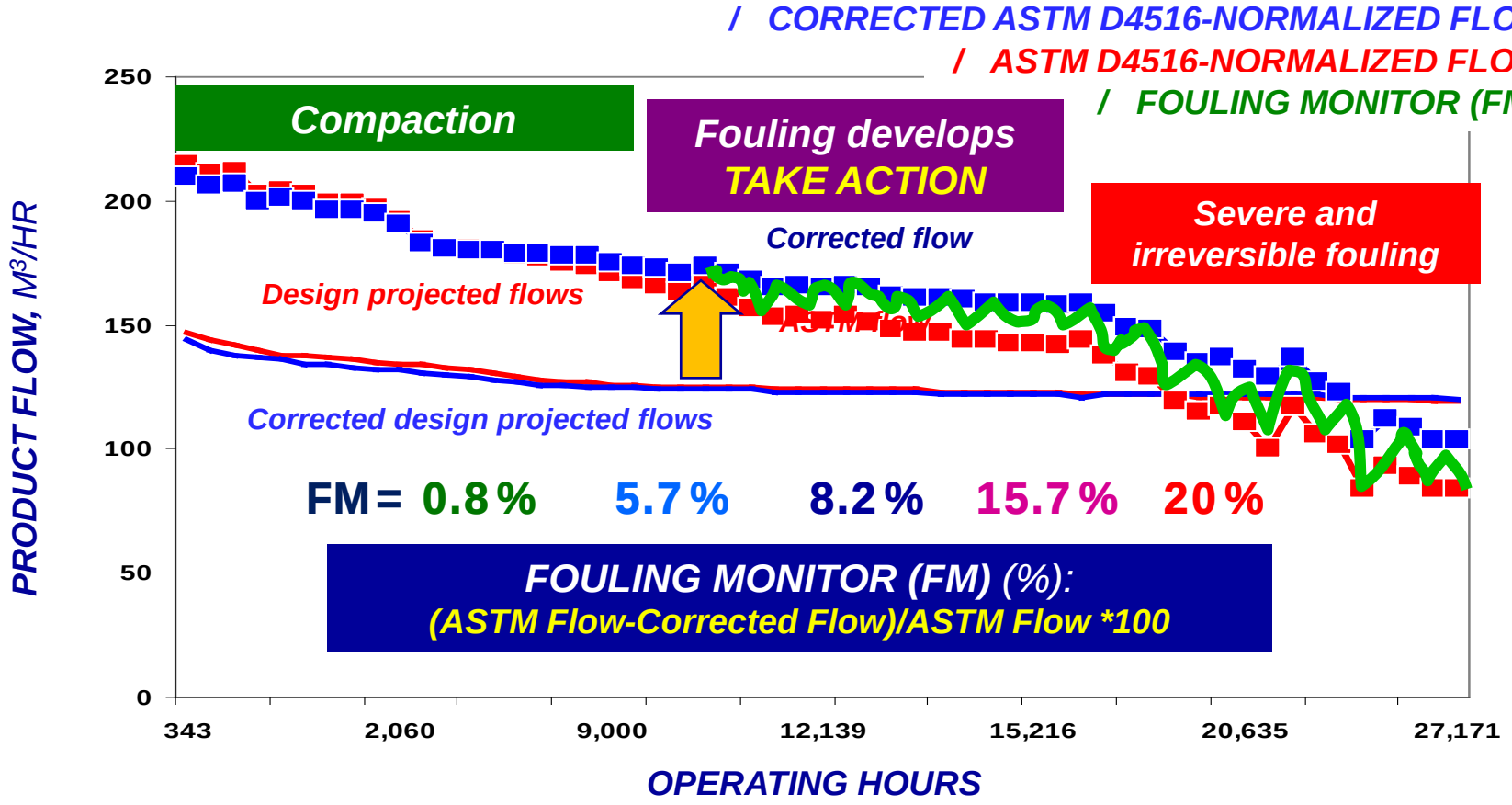
WHAT'S WRONG WITH MEMBRANE SYSTEMS' TRENDING?

- NON-RESPONSIVE AS A LONG-TERM FUNCTION
- REPRESENTS ONLY THE MEMBRANE BEHAVIOR, NOT RELATED TO REAL PLANT DYNAMICS & SITE FACTORS
- CAN BE MISLEADING & SUBJECT TO WIDE INTERPRETATION
- MEANINGFUL ONLY IF PLANT IS RUNNING WELL OR FOULING SEVERELY
- CANNOT PREDICT, DETECT OR MEASURE FOULING DEVELOPMENT EARLY
- CANNOT DISTINGUISH IF DETERIORATION IN PERFORMANCE IS DUE TO FOULING OR OTHER CAUSES

ASTM-CORRECTED NORMALIZED PERFORMANCE TRENDING



THE SMART™ SOLUTION



CRITERIA OF A SMART SYSTEM

As defined by Wikipedia, a SMART System must be:

- ***Specific***: Significant, Simple, Sustainable, Smart!
- ***Measurable***: Motivational, Manageable, Meaningful.
- ***Actionable***: Attainable, Achievable, Adjustable, Acceptable, Alert-based.
- ***Real-time***: Relevant, Resourceful, Realistic, Results-based, Reproducible.
- ***Time-bound***: Time-sensitive/limited, Testable, Traceable.

WHY IS IT SMARTER THAN TRENDING?

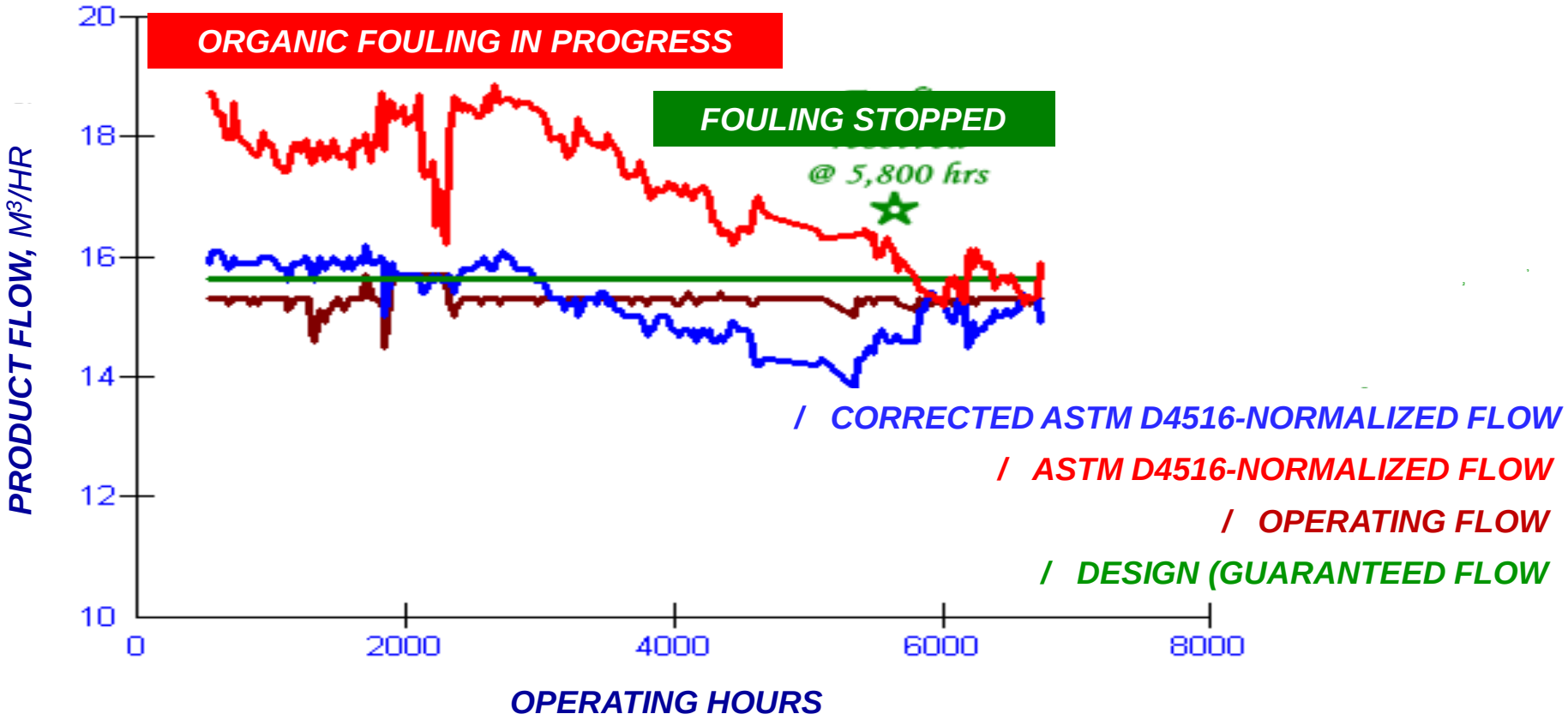
- ✓ ALLOWS EARLY, REAL-TIME DETECTION AND MEASUREMENT OF FOULING & SCALING DEVELOPMENT OR POTENTIAL
- ✓ ALLOWS EFFECTIVE RESPONSE TO "SILENT" ALARMS AND MAXIMIZES PROBABILITY OF ADDRESSING PERFORMANCE PROBLEMS IN A TIMELY MANNER
- ✓ DISTINGUISES BETWEEN FOULING/SCALING AND OTHER CAUSES OF PERFORMANCE DETERIORATION SO THAT CORRECT RESPONSE IS IMPLEMENTED
- ✓ ALLOWSS DYNAMIC, PLANT-SPECIFIC ASSESSMENT OF TRUE EFFECT OF MEMBRANE CLEANINGS, REPLACEMENTS, ADDITIONS, PROCESS, CHEMICALS AND OTHER CHANGES
- ✓ CONTINUOUSLY OPTIMIZES PLANT O&M COSTS

SMART™ TECHNOLOGY SWRO FM MONITORING GUIDELINES

FM RANGE	FOULING STATUS	RECMMENDED ACTION
0%-5%	No significant fouling.	Good operation. Continue to monitor.
5%-15%	Low to moderate fouling may be starting to develop.	Monitor more closely. Consider trouble-shooting if FM trend continues to rise.
15%-25%	Moderate to heavy fouling is in progress.	Start trouble-shooting immediately to identify and eliminate source of fouling.
> 25%	Heavy to irreversible fouling is occurring.	Significant membrane replacements and/or additions required due to extensive loss of performance.

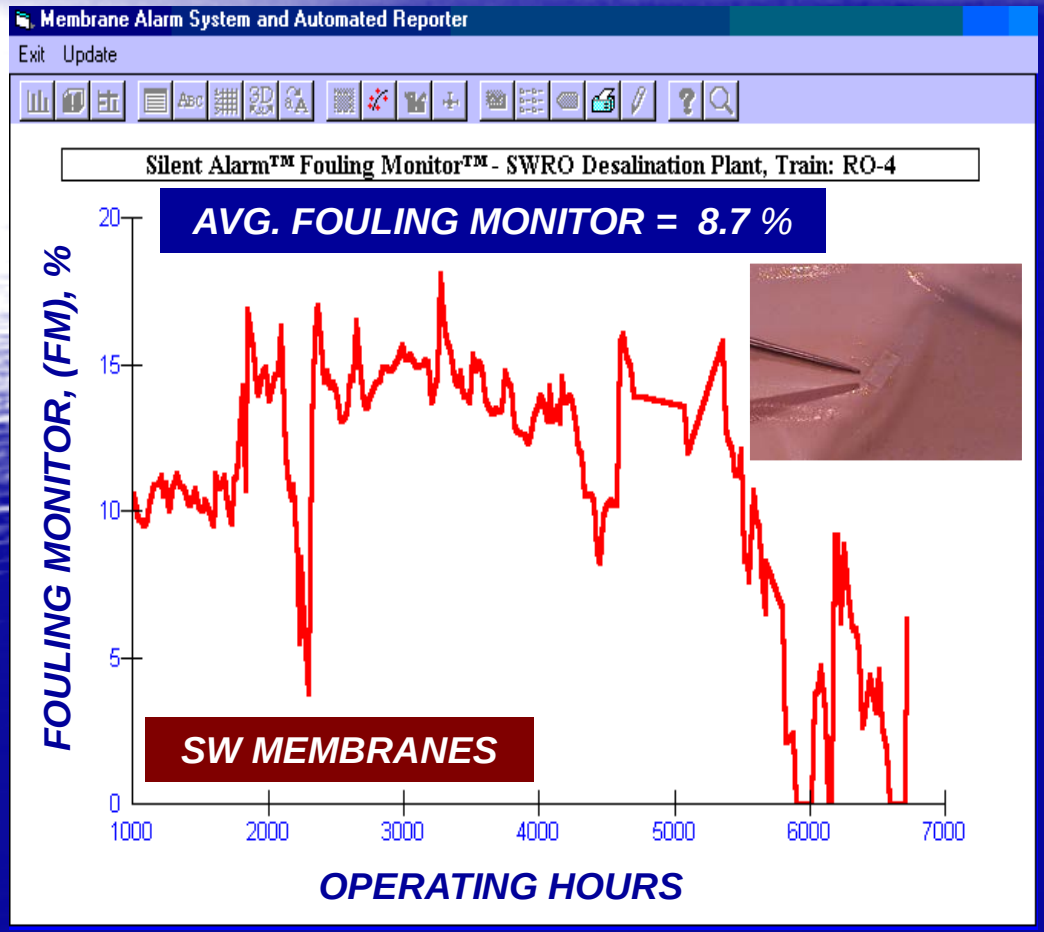
SMART™ TECHNOLOGY PLANT CASE STUDY

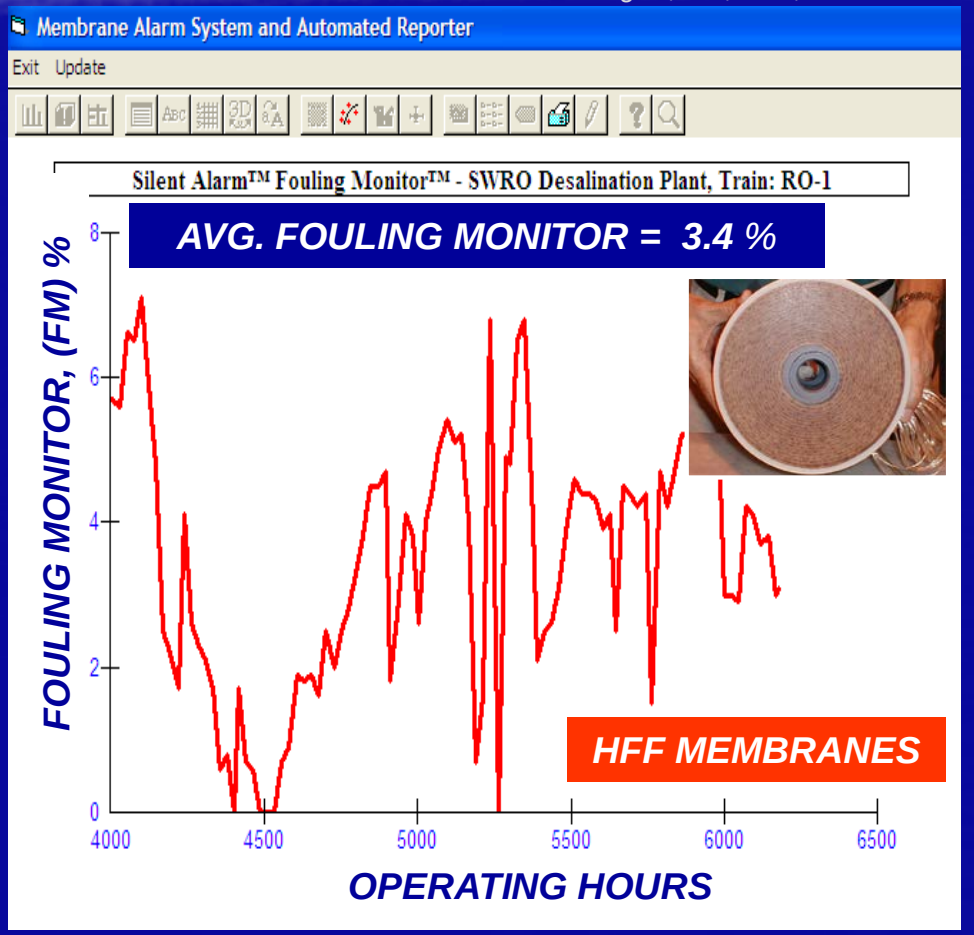
CASE A: FOULING SEAWATER RO PLANT



SMART™ TECHNOLOGY PLANT CASE STUDY

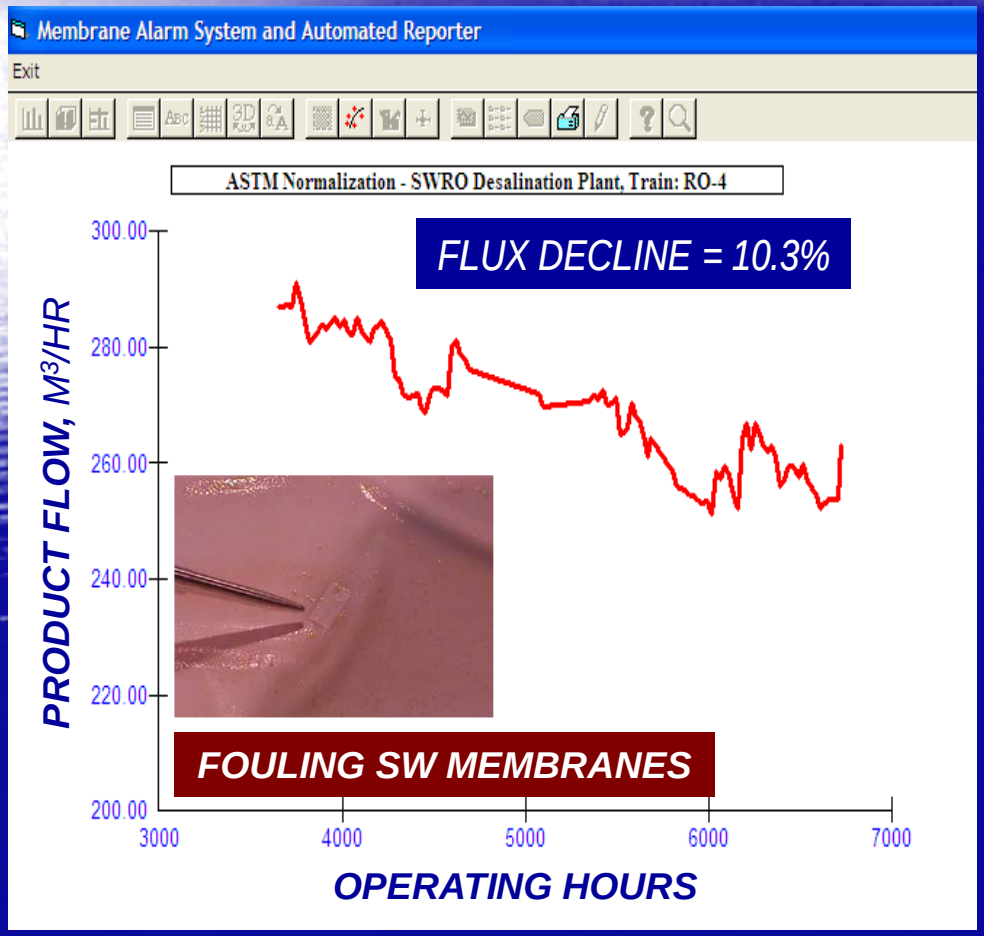
CASE A: FOULING SEAWATER RO PLANT

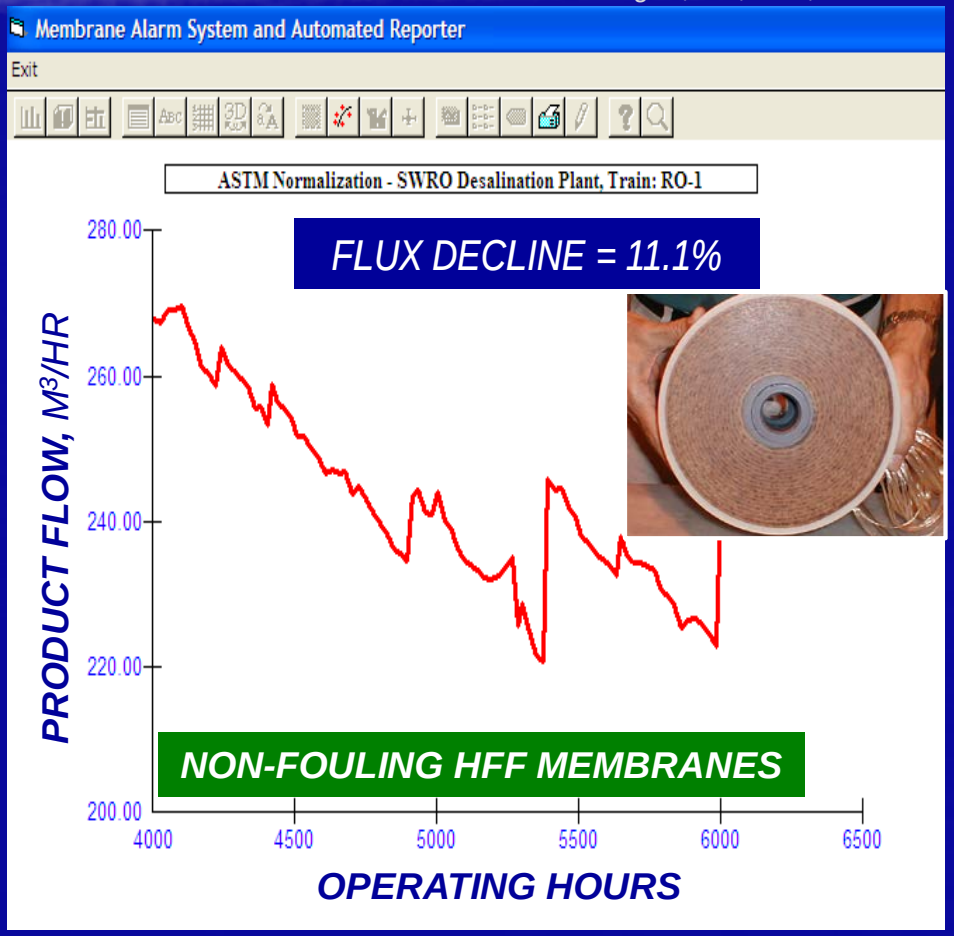




SMART™ TECHNOLOGY PLANT CASE STUDY

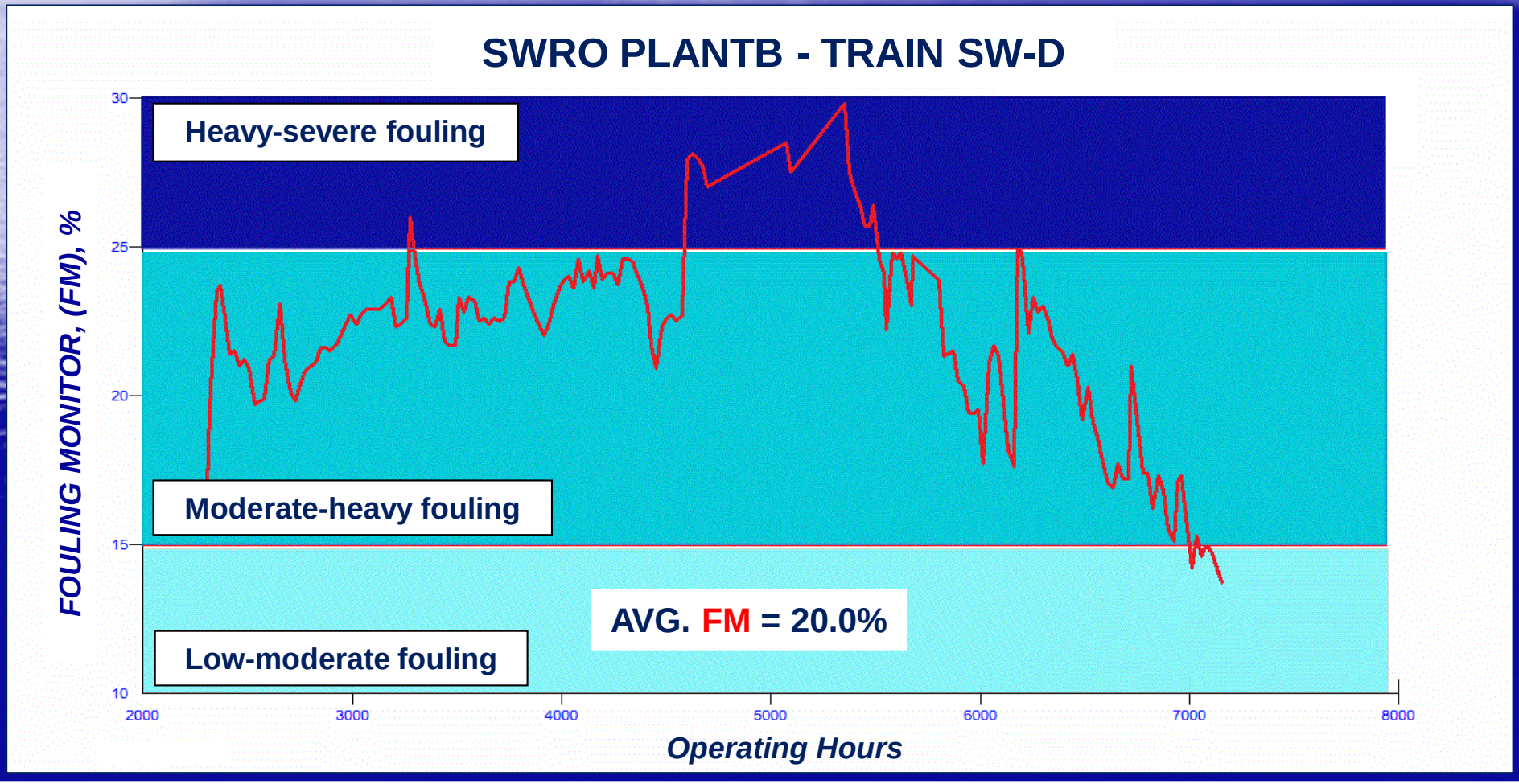
CASE A: FOULING/NON-FOULING SEAWATER RO PLANT





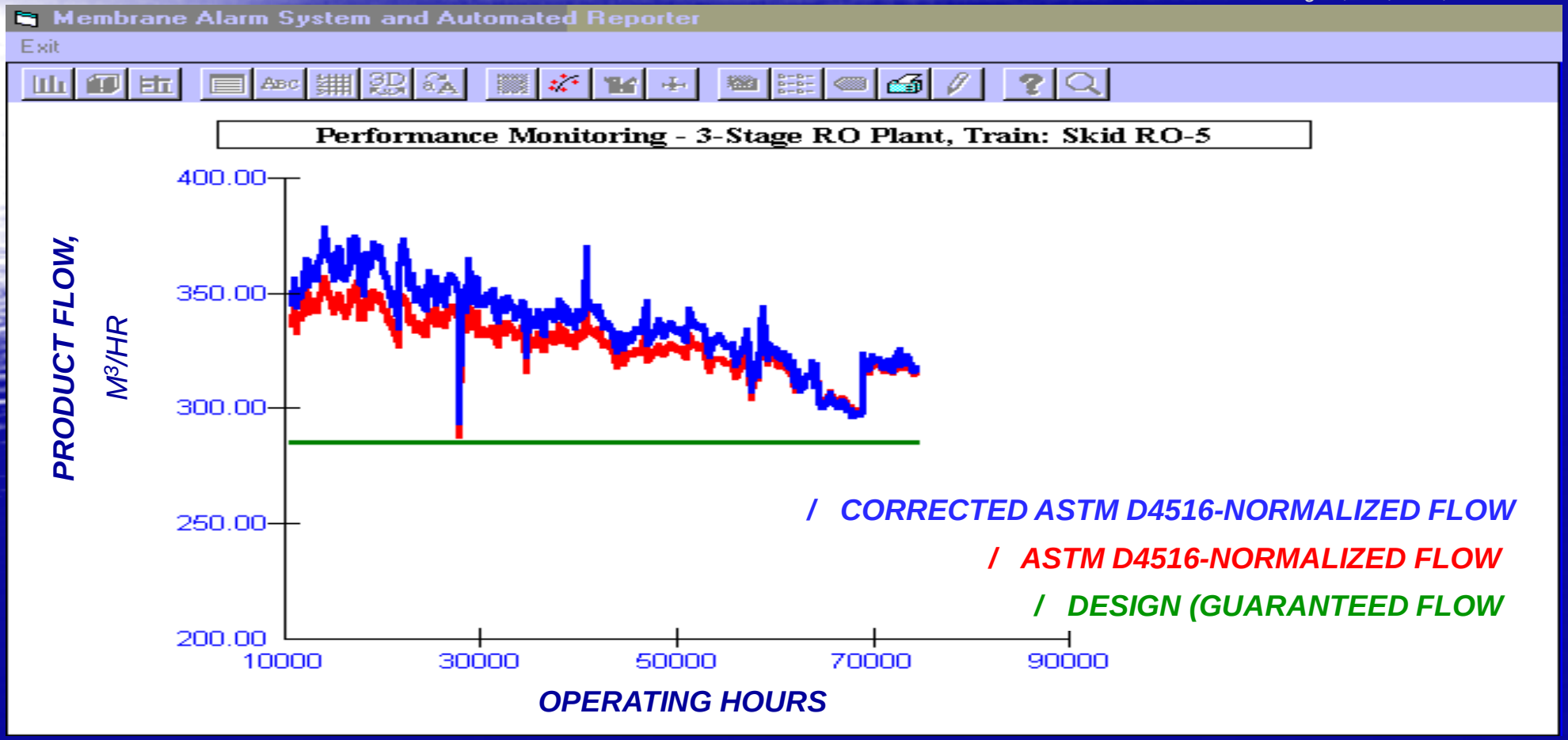
SMART™ TECHNOLOGY PLANT CASE STUDY

CASE B: FOULING SEAWATER RO PLANT



SMART™ TECHNOLOGY PLANT CASE STUDY

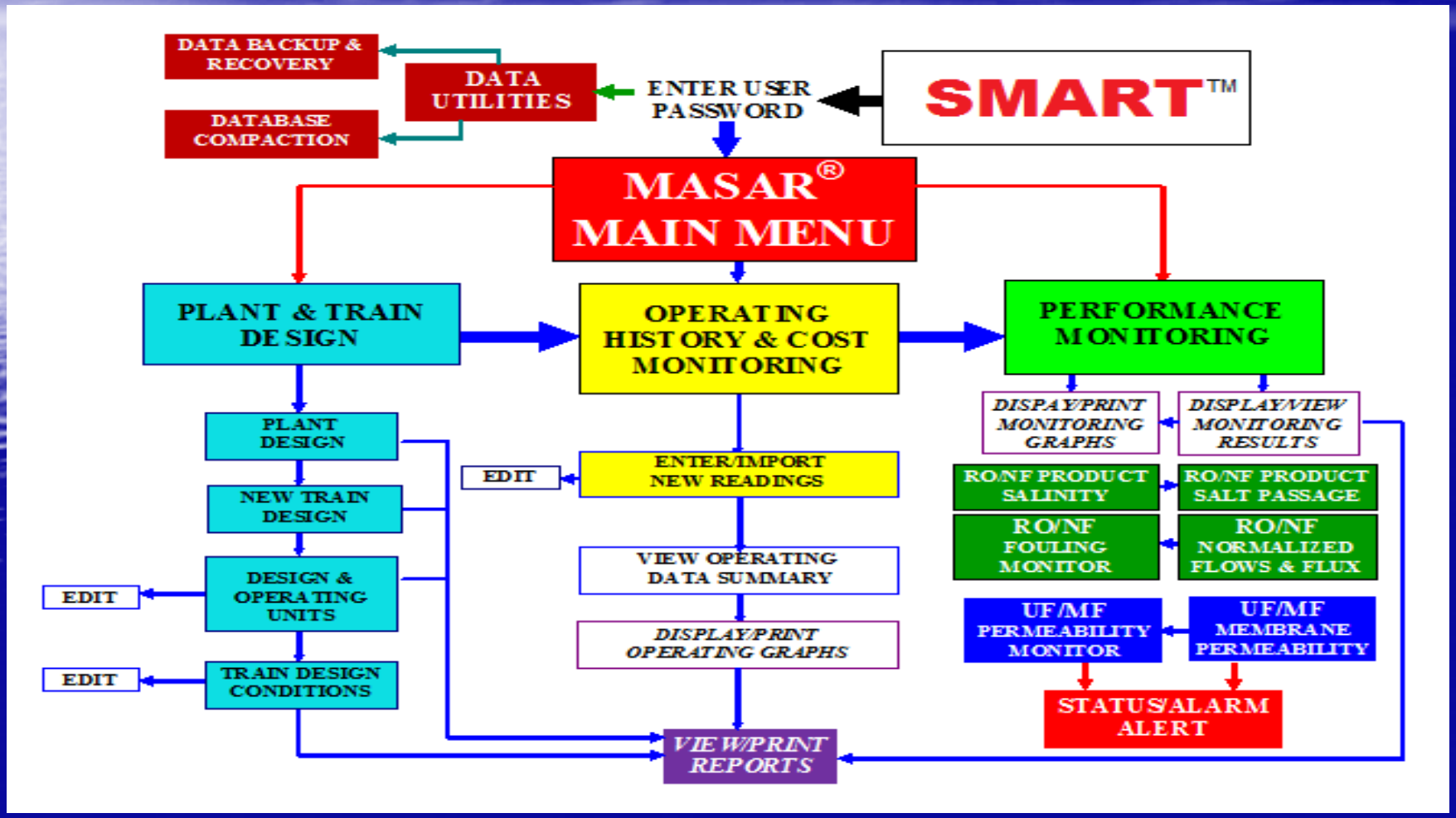
CASE C: NON-FOULING HIGH BRACKISH WATER RO PLANT



MEMBRANE ALARAM SYSTEM & AUTOMATED REPORTER - MASAR® Program Applications

- *PROPRIETARY CUSTOM SOFTWARE VALIDATED BY EXTENSIVE FIELD DATA AND EVALUATIONS.*
- *TESTED AND APPROVED BY WORLD'S PIONEER MEMBRANE MANUFACTURER, DUPONT, AUTHOR OF ASTM D-4516 STANDARD NORMALIZATION METHOD.*
- *REQUIRES SAME INPUT AS REQUIRED BY ASTM D-4516 STANDARD NORMALIZATION METHOD.*
- *APPLICABLE TO ALL MEMBRANE-BASED DESALINATION (RO/NF) AND WATER PURIFICATION (UF/MF) SYSTEMS OF ANY FEED SOURCE, QUALITY, SALINITY, MEMBRANE MANUFACTURE AND DESIGN CONFIGURATION.*

MASAR® PROGRAM'S FLOW CHART



CONCLUSIONS

- *INDUSTRY NEEDS TO ADOPT NEW APPROACHES, STANDARDS AND PROCEDURES IN THE DESIGN, OPERATION, MAINTENANCE AND EVALUATION OF THE PERFORMANCE OF MEMBRANE DESALINATION & FILTRATION SYSTEMS TO MINIMIZE THE TOTAL COST OF WATER.*
- *THE SMART TECHNOLOGY IS A UNIQUE, INNOVATIVE, RELIABLE FIELD-TESTED AND EARLY-WARNING SOLUTION TO DETECTING AND MONITORING MEMBRANE FOULING AND OPTIMIZING THE OPERATION, PERFORMANCE AND COSTS OF REAL PLANTS IN REAL-TIME.*
- *TECHNOLOGY TESTED & APPROVED BY WORLD'S MEMBRANE MANUFACTURERS PIONEER, DUPONT, AND KEY PLANT ENDUSERS.*

GET SMART

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SILENT MEMBRANE ALARM in REAL TIME TECHNOLOGY