BRINGING WATER TREATMENT IN HOUSE - MONITORING AND CONTROL STRATEGIES AND IMPROVED RESULTS AT NRG PHOENIX

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AGENDA

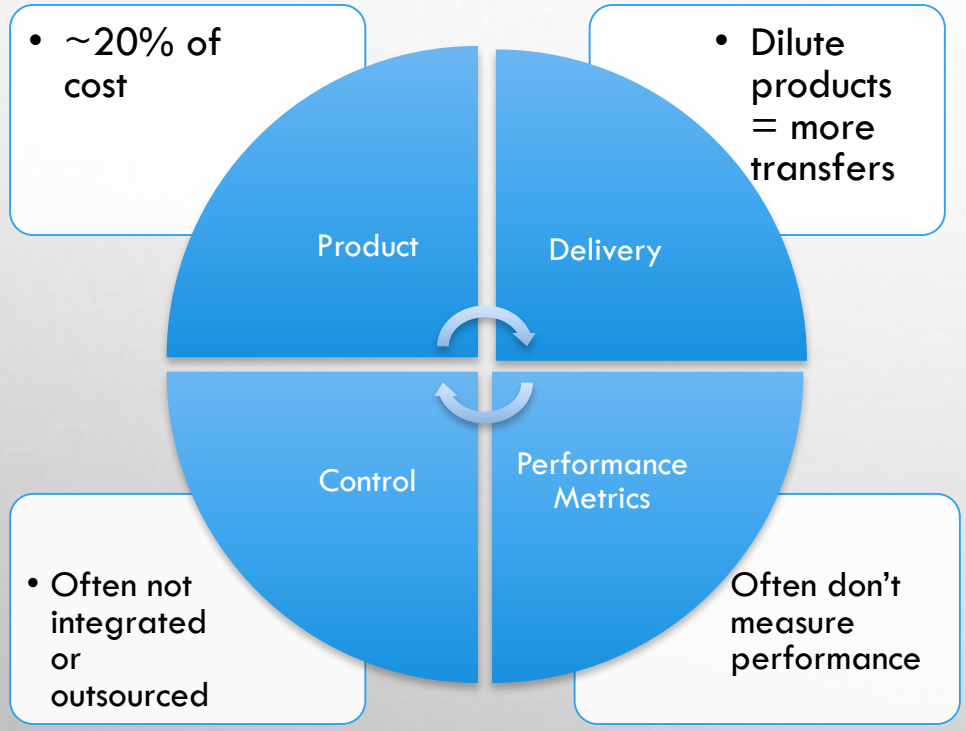
- A VERY BRIEF HISTORY OF COOLING WATER TREATMENT CHEMISTRY
- MOTIVATIONS FOR BRINGING CHEMISTRY IN HOUSE
- CHARTING A COURSE
  - IDENTIFYING THE CHALLENGES AND POTENTIAL PITFALLS
- IMPLEMENTATION
- FACILITY FEEDBACK

A VERY BRIEF HISTORY OF COOLING WATER TREATMENT CHEMISTRY

- INNOVATION (NEW MOLECULES) HAS DRAMATICALLY SLOWED DOWN OVER THE PAST 30 YEARS
  - WORK HORSE CHEMISTRY HASN'T CHANGED SIGNIFICANTLY FOR MOST CUSTOMERS THAT DISCHARGE TO A POTW
    - SCALE INHIBITORS (PBTC AND HEDP) - DEVELOPED IN THE 1970'S AND 1980'S
    - POLYMER (MULTIPLE – BUT GENERALLY FUNCTIONALLY EQUIVALENT) – DEVELOPED IN THE 1980'S AND 1990'S
    - YELLOW METAL CORROSION INHIBITOR - TOLYLTRIAZOLE/BENZOTRIAZOLE - DEVELOPED IN THE 1970'S
    - MILD STEEL CORROSION INHIBITORS - ZINC, PHOSPHATE, MOLYBDATE ,CARBOXYLATES - DEVELOPED IN THE 1970'S TO 1990'S.
    - PH CONTROL, NO PH CONTROL, SOFT WATER FEED…..DEPENDS ON SOURCE WATER
  - THESE CHEMISTRIES ARE THEN "BLENDED" TOGETHER TO FORM A PRODUCT DESIGNED TO TREAT A "TYPE" OF WATER
    - NO TECHNICAL BENEFIT TO BLENDING
    - RESULTS IN DILUTE PRODUCTS (SHIPPING MORE WATER)
    - MAKES IT DIFFICULT TO UNDERSTAND WHAT IS IN THE PRODUCT/RESULTS IN INEFFICIENT USE OF CHEMICALS

A VERY BRIEF HISTORY OF COOLING WATER TREATMENT CHEMISTRY

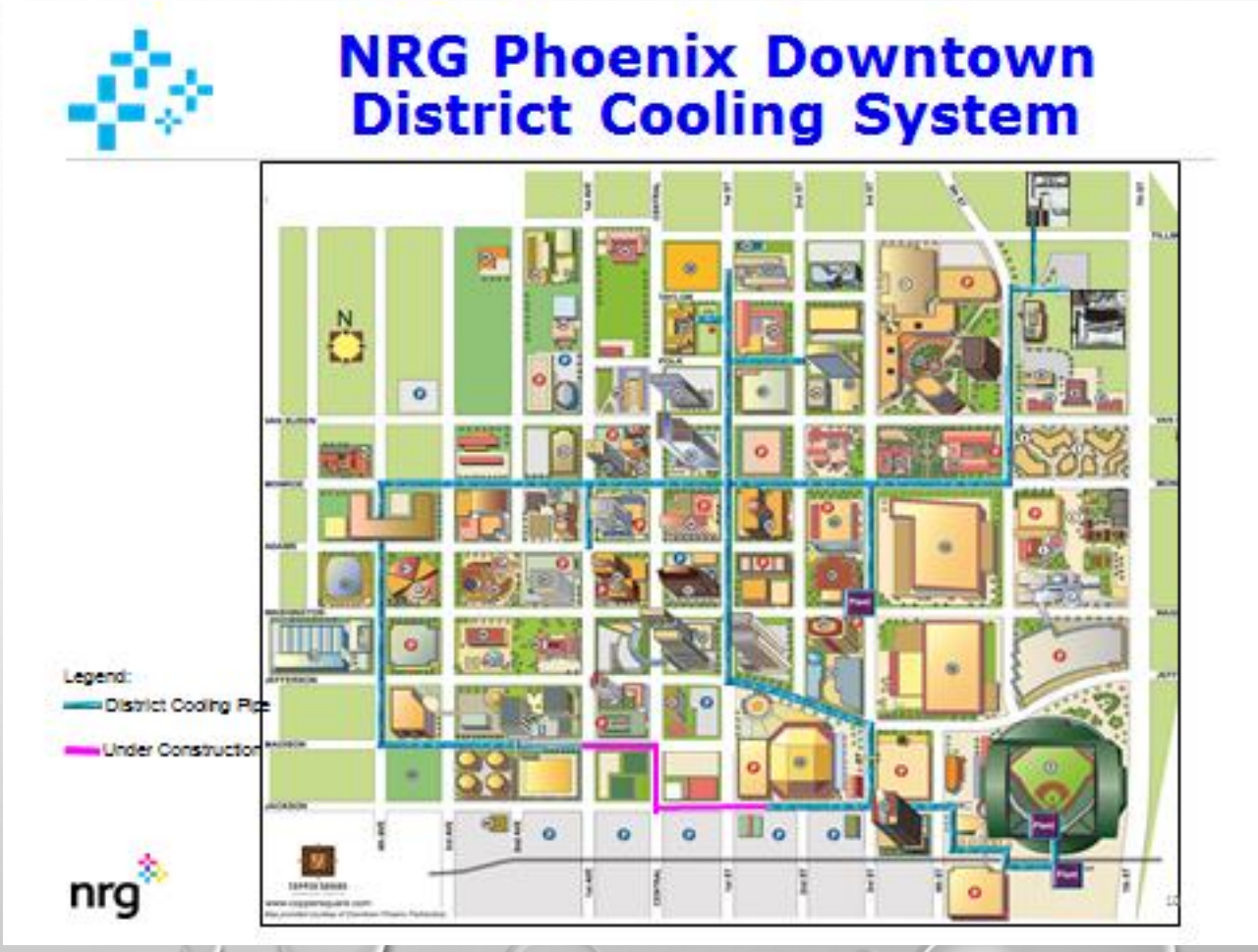
Components of a Standard Program



- PROS
  - DON'T' HAVE TO THINK ABOUT THE CHEMISTRY OR HANDLING ANYTHING
  - LESS OPERATOR RESPONSIBILITY
- CONS
  - PLANT HAS VERY LITTLE CONTROL OR "SAY" IN CHEMICALS SELECTED (TRUST)
  - HARD TO UNDERSTAND COSTS

NRG PHOENIX

- 3 SEPARATE COOLING PLANTS WITH 40,000 TONS OF TOTAL CAPACITY
- 1 INTEGRATED COOLING LOOP WITH ICE STORAGE
  - APPROXIMATELY 3.5 MILLION GALLONS
- SERVING 38 CUSTOMERS IN 43 BUILDINGS



WATER TREATMENT SITUATION – INCEPTION OF PLANT TO 2014

- OUTSOURCED WATER TREATMENT CHEMISTRY TO VARIETY OF 3RD PARTIES
  - IN THEORY THIS MEANT "LESS" OPERATOR INVOLVEMENT (LESS MANPOWER COMMITTED)
  - IN REALITY FOUND THAT LACK OF OWNERSHIP BY OPERATORS TRANSLATED TO NOT UNDERSTANDING WHAT WAS REALLY HAPPENING AND ULTIMATELY POOR PERFORMANCE
- MAINTENANCE COSTS WERE INCREASING
  - BASIN CLEANING/FILL CLEANING NECESSARY 2 TIMES A YEAR
  - PREMATURE FILL REPLACEMENT DUE TO SCALE FORMATION
  - ALGAE/BIOLOGICAL MATERIAL IN BASINS

DECISION POINT

Path 1 – Choose a different supplier
- Could improve situation
- Could be more of the same

Path 2 – Take the water treatment chemistry entirely in house.
- What resources necessary internally to handle the potential increased Work load?
- Nobody to blame but the plant if it doesn't work (and of course the Consultant)

TAKING CHEMISTRY IN HOUSE

IF NRG Phoenix was going to take chemistry in house they would need to understand why failures were occurring

Potential Reasons for Failure

- Wrong chemistry
- Poor/inadequate control
- Poor or inadequate limits
- Poor operations

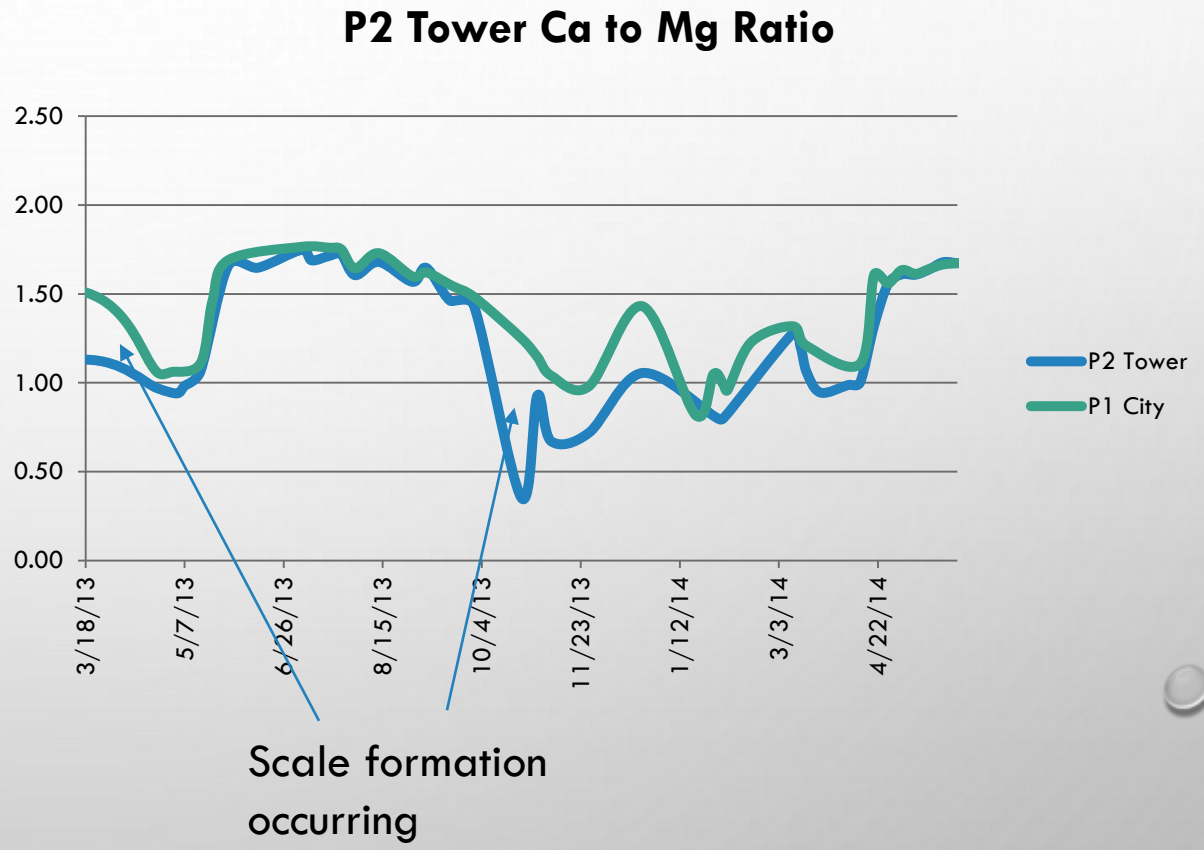
Begin Benchmarking

- Collect weekly samples
- Samples analyzed
- Results reviewed with facility

Can this approach also reduce water usage and save money (provide a payback)

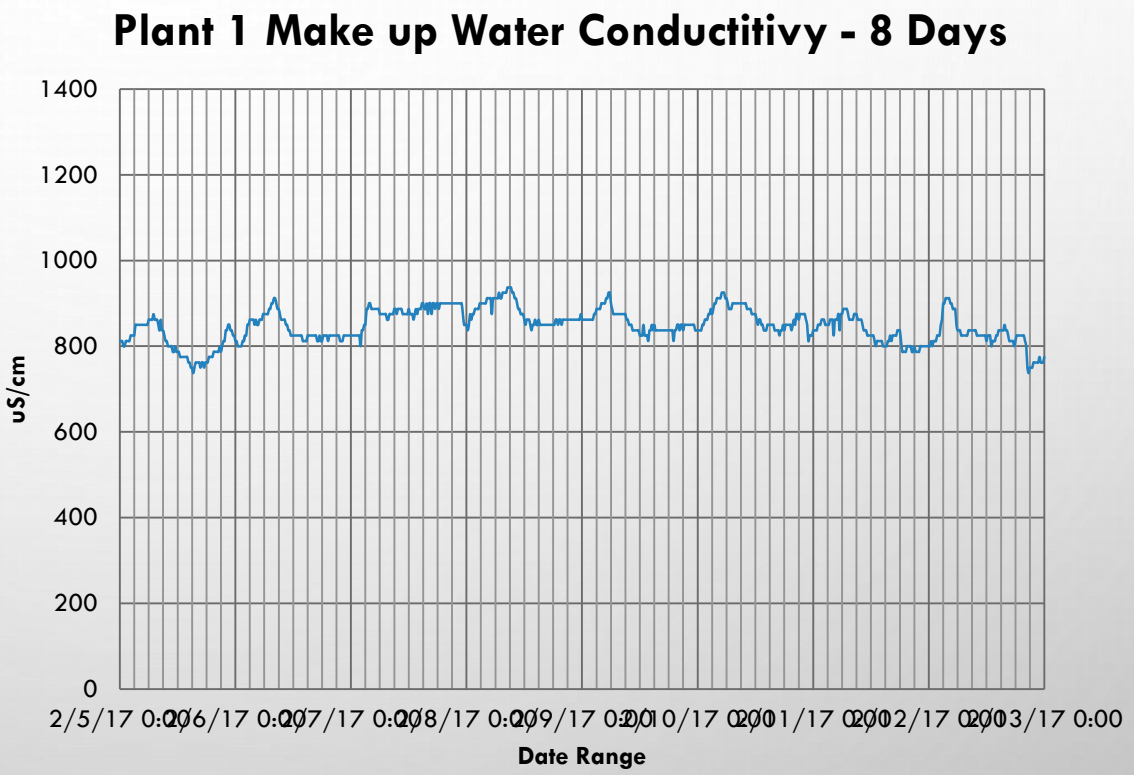
BENCHMARKING THE SYSTEM – THE SMOKING GUN

- PRIMARY METRICS (CHEMISTRY INDEPENDENT)
  - SCALE CONTROL METRIC - THE RATIO OF CA TO MG IN THE MAKE UP WATER SHOULD TRACK (WITHIN 5%) THE CA TO MG RATIO IN THE TOWER WATER.
    - MAGNESIUM IS NOT SENSITIVE TO PRECIPITATION UNDER NORMAL WATER CHEMISTRY AND CAN BE USED TO TRACK HOW MUCH CALCIUM SHOULD BE IN THE TOWER WATER IF SCALE FORMATION IS BEING CONTROLLED.



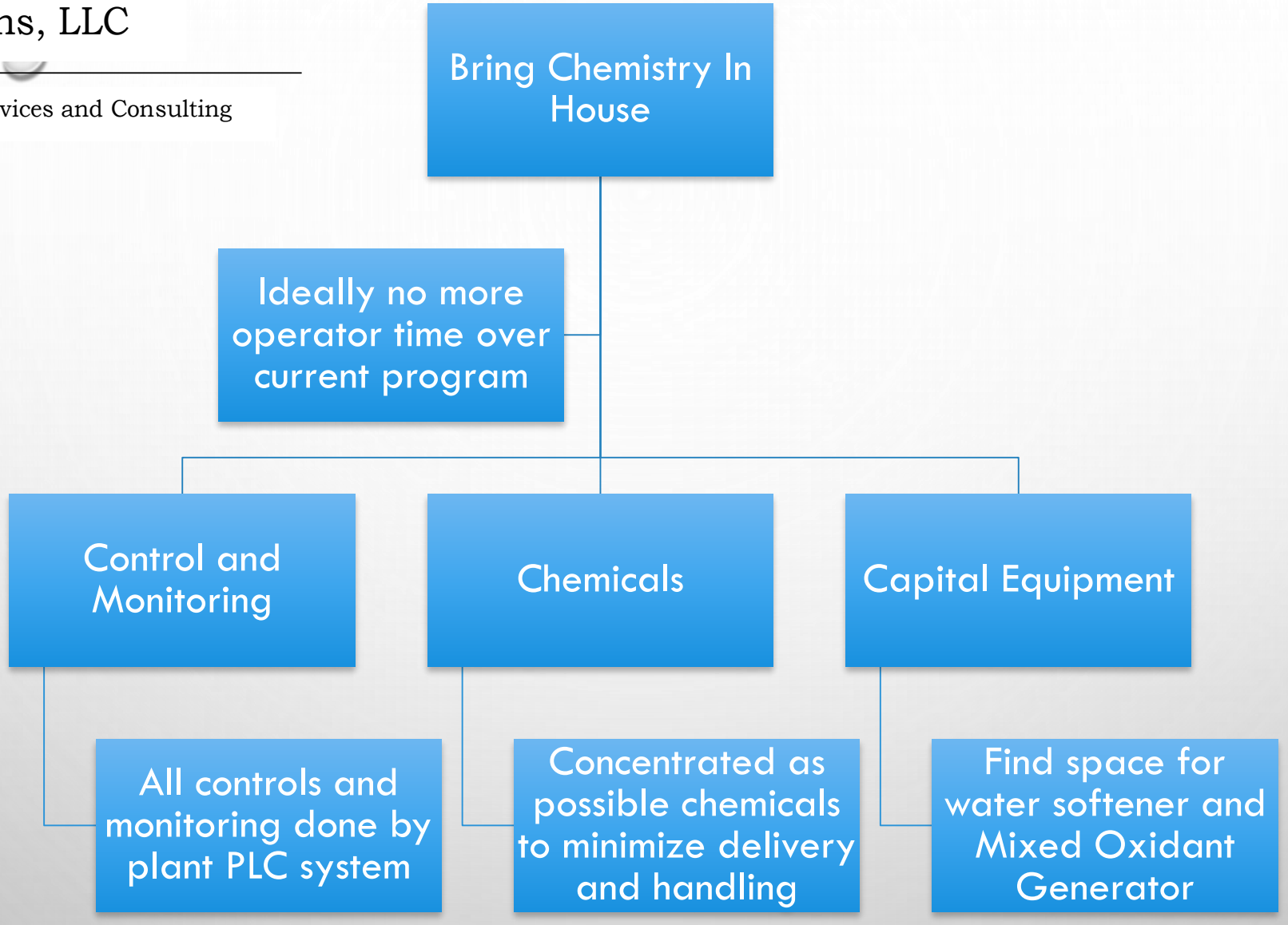
DETERMINING ROOT CAUSE OF SCALE FORMATION

- INVESTIGATION FOUND
  - PHOENIX CITY WATER CHANGES CONDUCTIVITY DRAMATICALLY – SOMETIMES HOURLY
    - SUMMER CAN SEE CONDUCTIVITY AS HIGH AS 1,800 MICRO SIEMENS
    - WINTER CAN SEE CONDUCTIVITY AS LOW AS 450 MICRO SIEMENS



HOW CAN THIS BE SOLVED?

- CONSIDERED THE THREE MOST COMMON METHODS
  - MONITOR INCOMING CONDUCTIVITY AND ADJUST BLOWDOWN SET POINT BASED ON CHANGES
    - WON'T RESULT IN SUBSTANTIAL WATER SAVINGS BUT WILL PREVENT GROSS SCALE FORMATION
  - FEED ACID TO CONTROL PH
    - PLANT HAD DONE THIS PREVIOUSLY
      - ISSUES WITH LEAKS
      - PLANT 2 IS UNDER THE CONVENTION CENTER - ANY CHEMICAL DELIVERY IS CHALLENGING
  - SOFTEN WATER TO REMOVE CALCIUM AND MAGNESIUM
    - CAPITAL INVESTMENT – BUT ALLOWS FOR HIGHER OVERALL CYCLES OF CONCENTRATION
    - SAFER VERSUS ACID HANDLING
    - **THIS APPROACH WAS SELECTED BECAUSE IT GAVE THE BEST PAYBACK COUPLED WITH THE LEAST OVERALL RISK**


Bring Chemistry In House
Ideally no more operator time over current program
Control and Monitoring
Chemicals
Capital Equipment
All controls and monitoring done by plant PLC system
Concentrated as possible chemicals to minimize delivery and handling
Find space for water softener and Mixed Oxidant Generator

SCALE AND CORROSION CONTROL CHEMICALS

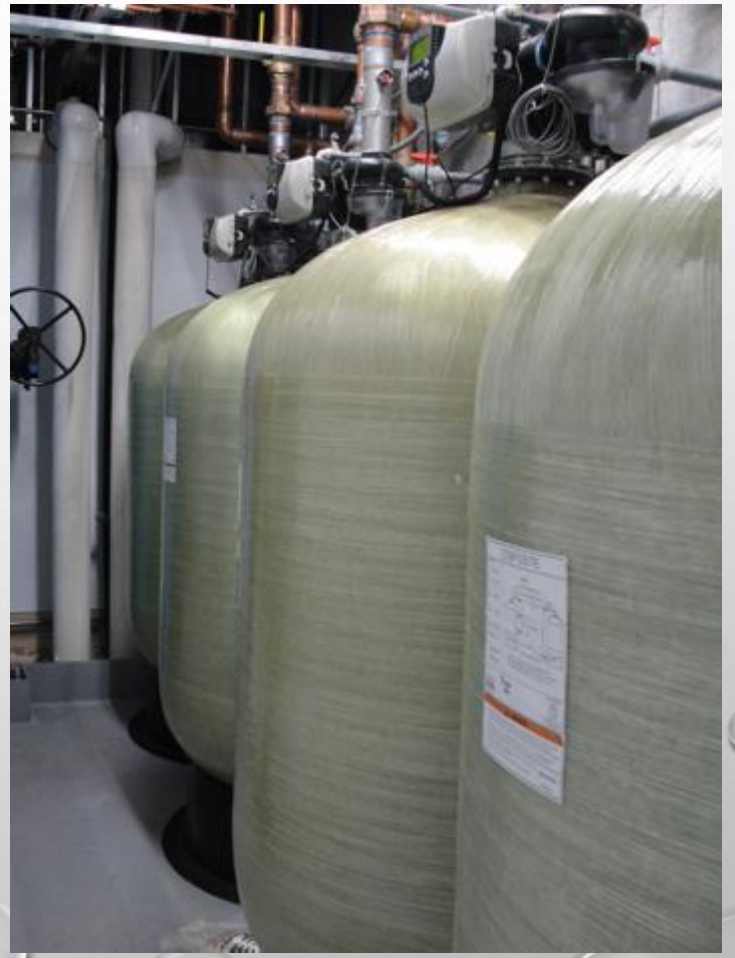
- CONSULTANT SPECIFIED CHEMISTRY DURING TRANSITION AND WHEN ON SOFT WATER
  - DURING TRANSITION - CALCIUM CARBONATE INHIBITION PRIMARY CONCERN (PBTC – 10 PPM POLYMER – 10 PPM)
  - AFTER TRANSITION – MILD STEEL CORROSION PRIMARY CONCERN (PBTC – 5 PPM, POLYMER – 10 PPM, HYDROXYL PHOSPHONO ACETIC ACID – 2 PPM,PYRO PHOSPHATE – 2 TO 4 PPM)
  - TOLYLTRIAZOLE USED DURING BOTH PERIODS FOR COPPER CORROSION CONTROL (1 TO 3 PPM)

BIOLOGICAL CONTROL CHEMICALS

- MOST BIOCIDES ARE ALREADY SOLD AS CONCENTRATED AS POSSIBLE
  - BLEACH (12.5%)
  - STABILIZED BROMINE (12%)
  - BROMINE DONORS (SOLID TABLETS)
- THESE REQUIRE EXTENSIVE HANDLING AND ARE AMONG THE MOST HAZARDOUS OF CHEMICALS
- ALTERNATIVE IS TO GENERATE BIOCIDE ON-SITE USING SODIUM CHLORIDE (NACL) AS THE PRECURSOR.
  - THIS ELECTROLYTIC PROCESS GENERATES A DILUTE SOLUTION OF BLEACH (0.45%) AND HYDROGEN PEROXIDE
  - MIOX MANUFACTURERS UNIT
  - A SEPARATE TALK DETAILING THIS UNIT WILL ALSO BE GIVEN
- THE SITE CAN GENERATE 30 LBS OF CHLORINE PER DAY.
  - HAVE FOUND THAT THEY ONLY NEED TO GENERATE 6 TO 20 LBS PER DAY TO MAINTAIN 0.5 TO 1.0 PPM FAC IN TOWER SYSTEM

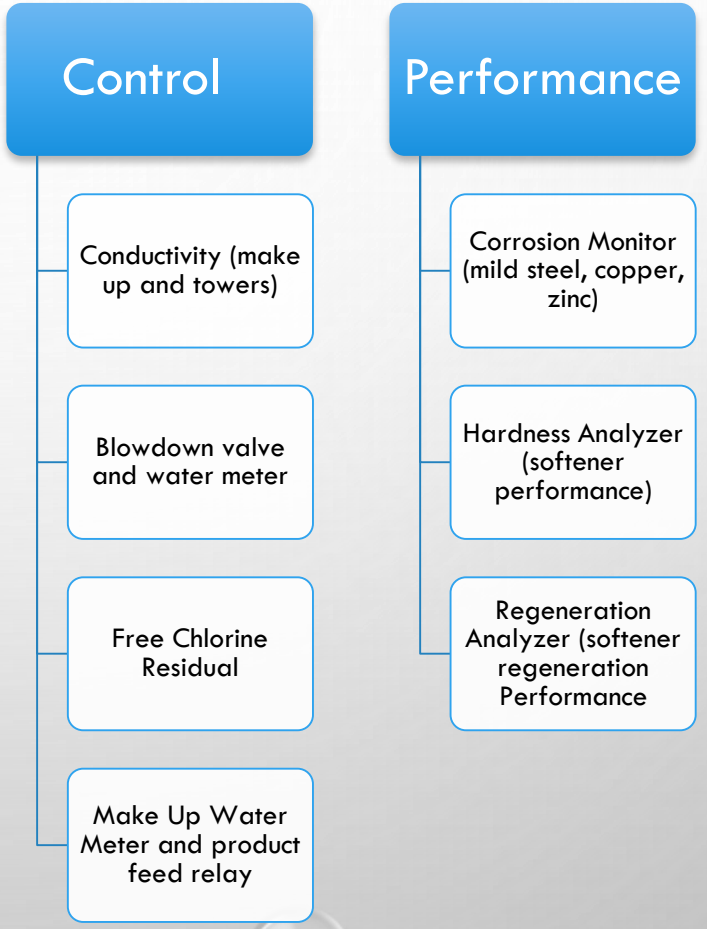
CAPITAL - WATER SOFTENERS

- THE BASIC EQUATION FOR SCALE FORMATION IS
  - $CA^{+2} + CO_3^{2-} \rightarrow CACO_3$
  - REMOVING THE CALCIUM (BY EXCHANGING FOR SODIUM) REMOVES ABILITY TO FORM SCALE
  - FOR OUR APPLICATION A WATER SOFTENER SYSTEM WAS MOST ECONOMICAL
  - SIZING
    - PLANT MAKE UP RATE MAXIMUM IS 650 GPM
    - THREE TANKS CAN HANDLE THIS FLOW WHILE THE FOURTH ONE REGENERATES
    - ~ 60 CUBIC FEET OF RESIN PER VESSEL. EACH VESSEL CAN FLOW AT A MAXIMUM OF 250 GPM
  - SALT USAGE
    - PLANT 2 USES APPROXIMATELY 300 TONS OF SALT PER YEAR WHILE PLANT 1 AND 3 USE 120 TONS PER YEAR.
    - COST OF SALT IS $200/TON
      - BULK DELIVERY IS $140/TON BUT REQUIRES BRINE SILOS WHICH ARE DIFFICULT TO HIDE IN DOWNTOWN PHOENIX



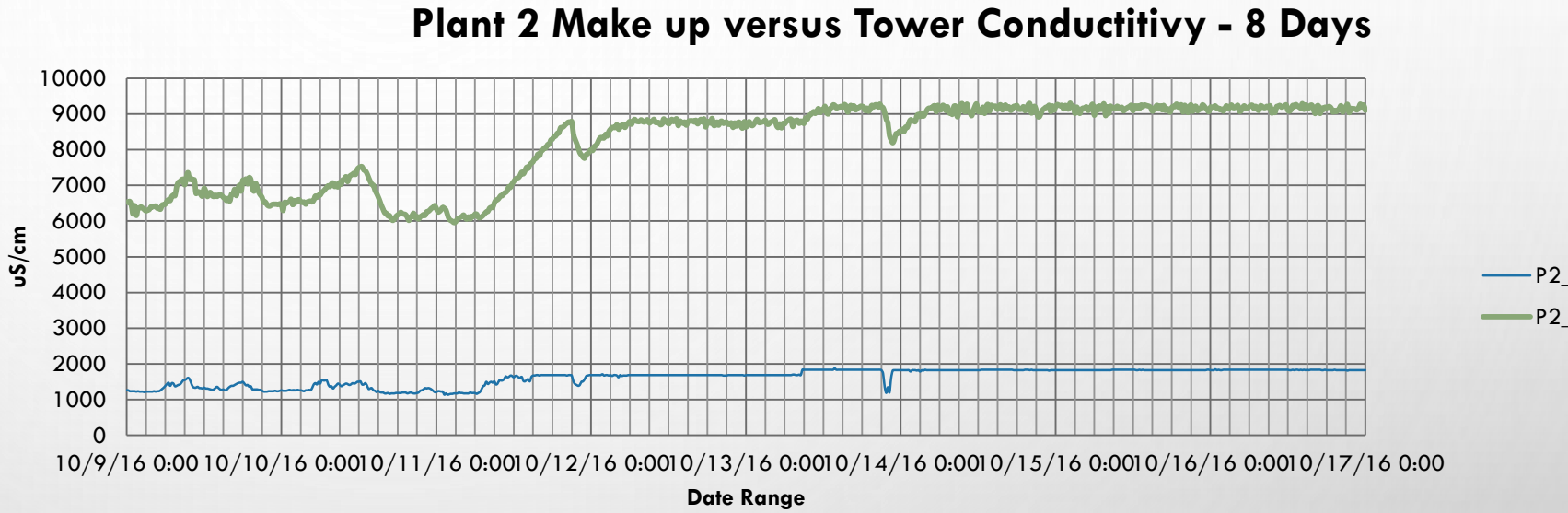
MONITORING AND CONTROL

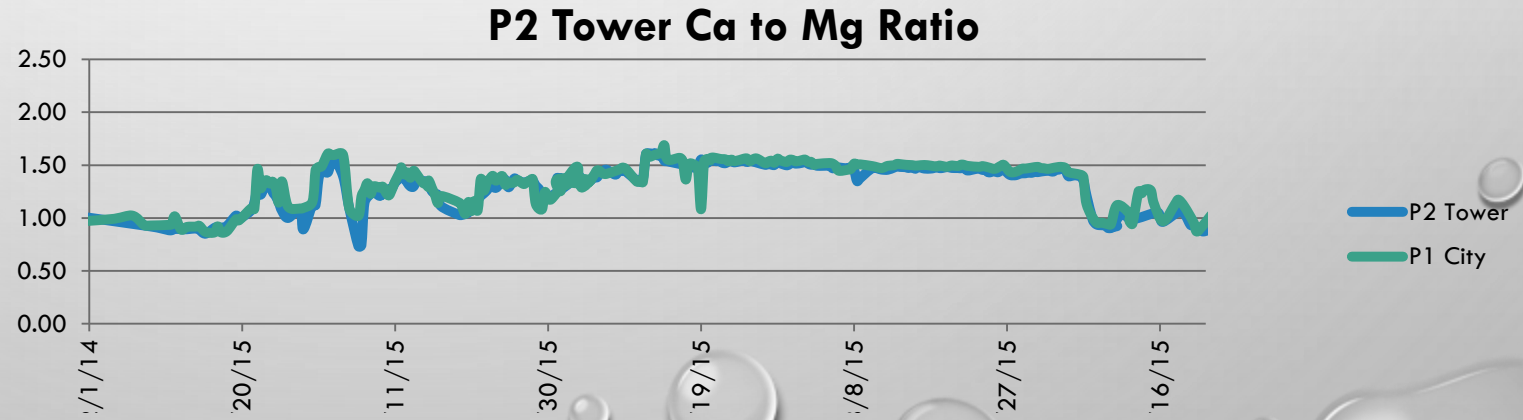
- IT IS COMMON TO UTILIZE A SINGLE CONTROLLER TO CONTROL WATER TREATMENT CHEMISTRY HOWEVER IT WAS CRITICAL TO HAVE THE DATA, ALARMS AND CONTROLS IN ONE PLACE FOR THE OPERATORS.
- THESE CONTROLLERS DID NOT FIT OUR NEEDS IN TERMS OF NUMBER OF INPUTS/OUTPUTS AND ABILITY FOR OPERATORS TO EASILY CONTROL



MONITORING AND CONTROL PROCESS – DID WE CORRECT SCALE FORMATION?

- CONTROL TOWER CONDUCTIVITY BASED ON A MULTIPLIER OF INCOMING WATER CONDUCTIVITY
  - ACCOUNTS AND CORRECTS FOR CHANGES IN INCOMING WATER CONDUCTIVITY AND PREVENTS LONG TERM OVER AND UNDER-CYCLING

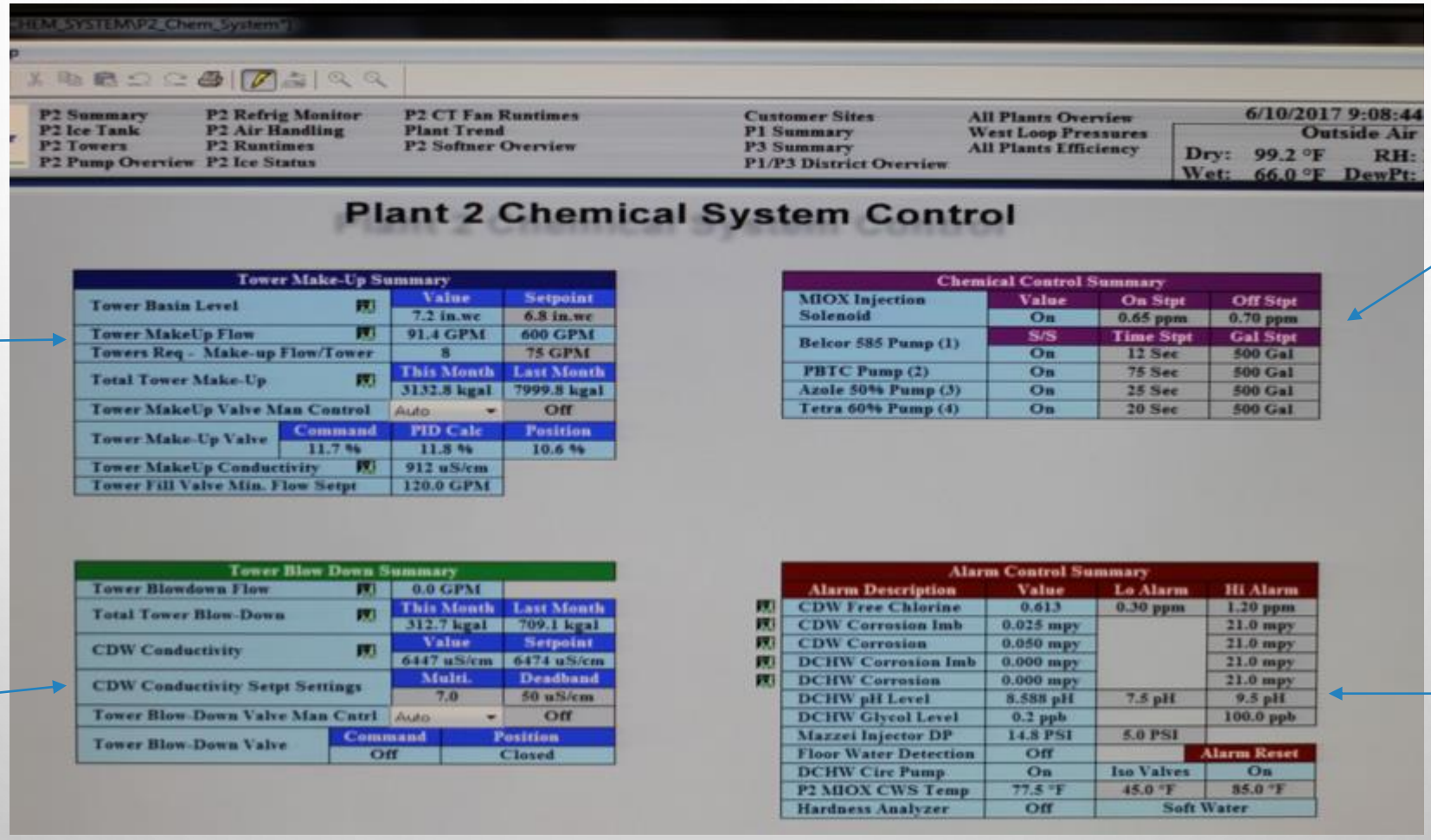




OPERATOR SCREEN

Tower Make up Section –insures they don't use too little water per cell

Tower Blowdown Section –note we have both valve position and blowdown flow. If valve is supposed to be open and there is no flow then valve issue

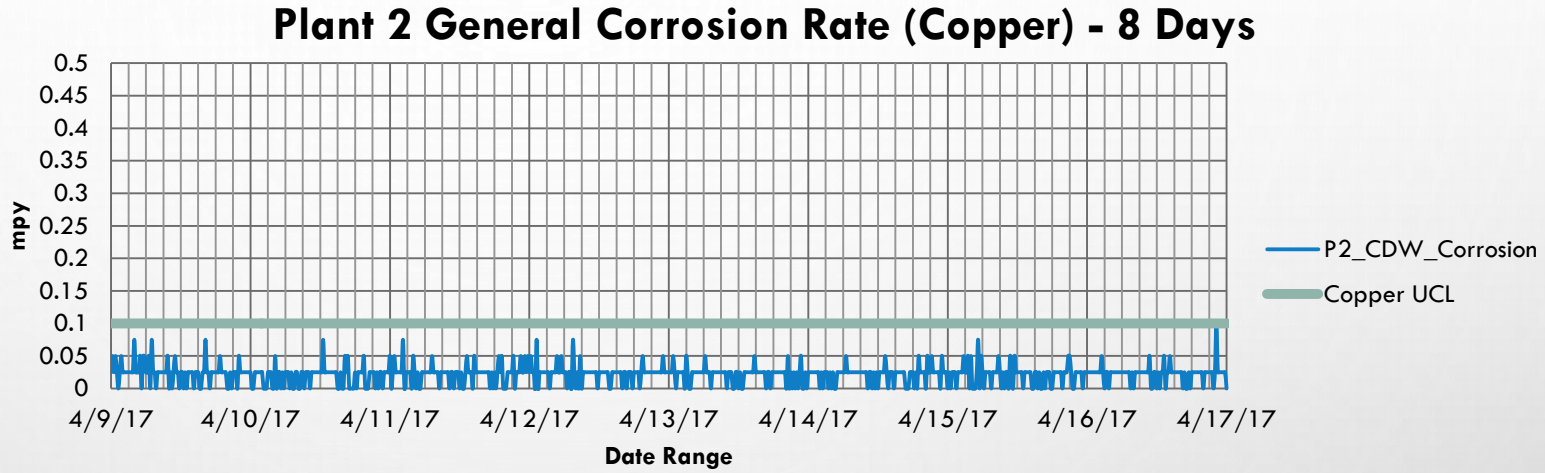


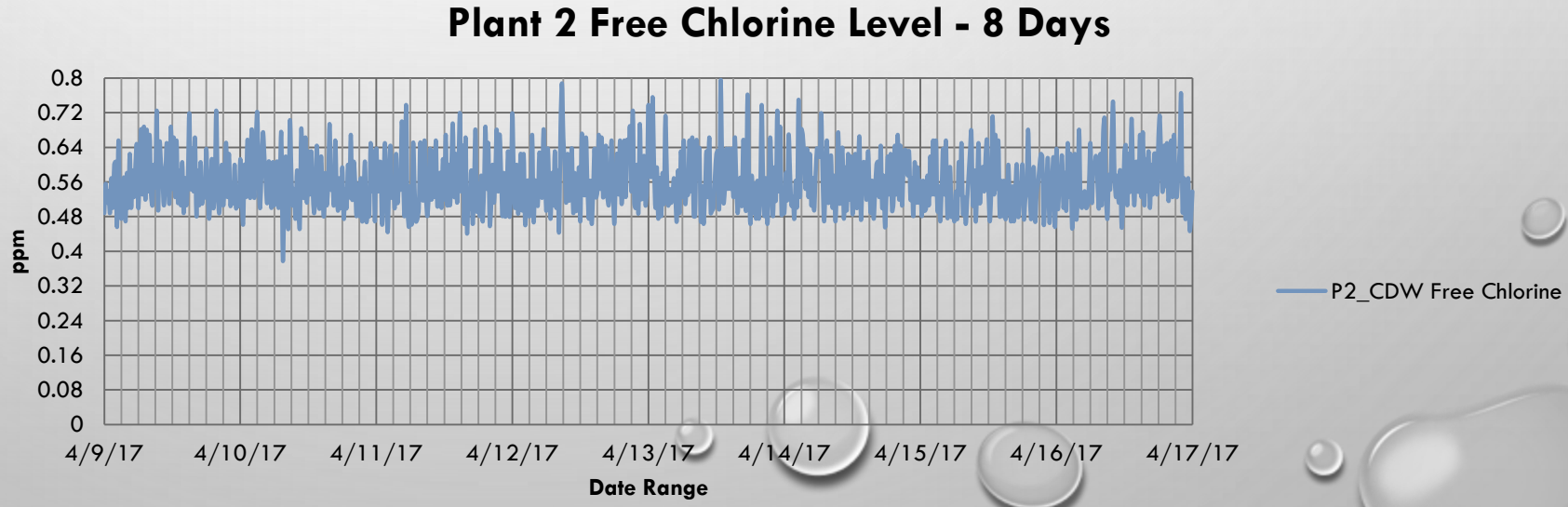
Chemical Control - based on make up flow rates or free chlorine analyzer

System alarms and performance alarms

OUTPUT AND TRENDING

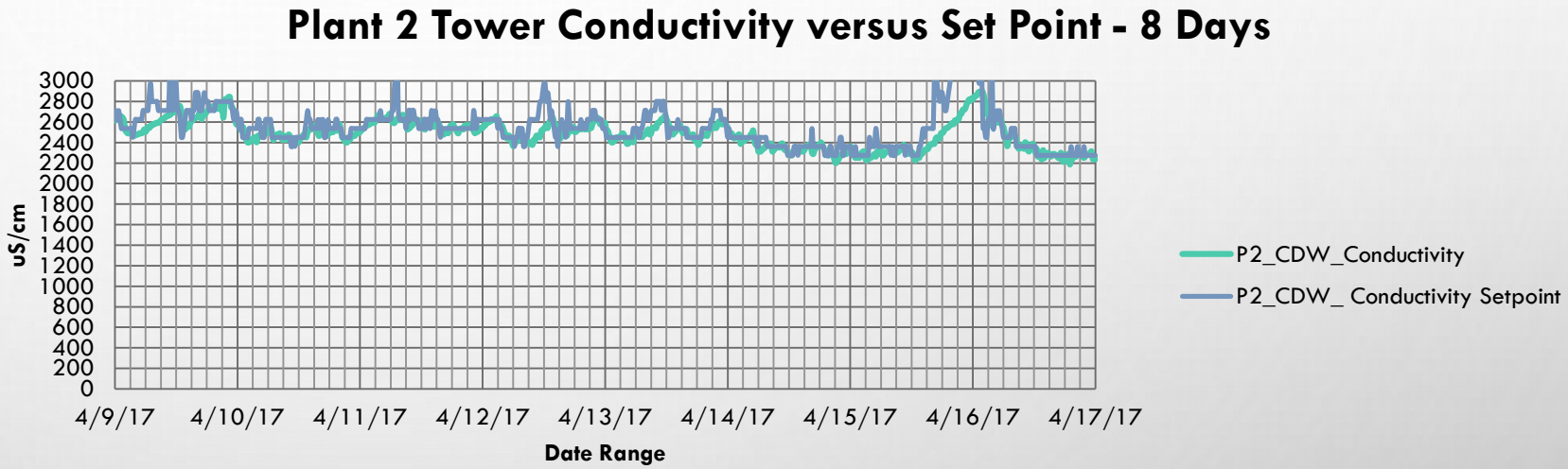
- THIS ALLOWS US TO MONITOR PERFORMANCE AND FOR MANAGEMENT REVIEW





OUTPUT AND TRENDING

- IN ADDITION WE GET INFORMATION ON NUMBER OF REGENERATIONS AND REGENERANT USAGE
- OTHER DIAGNOSTIC FEATURES ARE INCLUDED



SUSTAINABILITY

- IMPLEMENTATION OF THIS PROGRAM RESULTED IN THE FOLLOWING
  - 3,500 TO 8,500 LBS OF BIOCIDE NOT DELIVERED
  - 3,500 LBS OF SCALE AND CORROSION INHIBITOR (ALL WATER) NOT BEING DELIVERED
  - 37.5 MILLION GALLONS OF WATER SAVED PER YEAR

ECONOMICS

- THE PAYBACK FOR THE PROJECT AVERAGED OVER ALL THREE PLANTS (SOFTENERS, MIOX, CONTROLS) IS BETWEEN 2.5 TO 3.0 YEARS AND INCLUDES:
  - CHEMICAL SAVINGS
  - WATER SAVINGS
  - REDUCED MAINTENANCE COSTS (THIRD PARTY TOWER CLEANING)

PLANT PERSPECTIVE/QUESTIONS