Long-term Sustainability in Thermal Drying Facility Operations Through Strategic Capital Improvements and Innovative Asset Management

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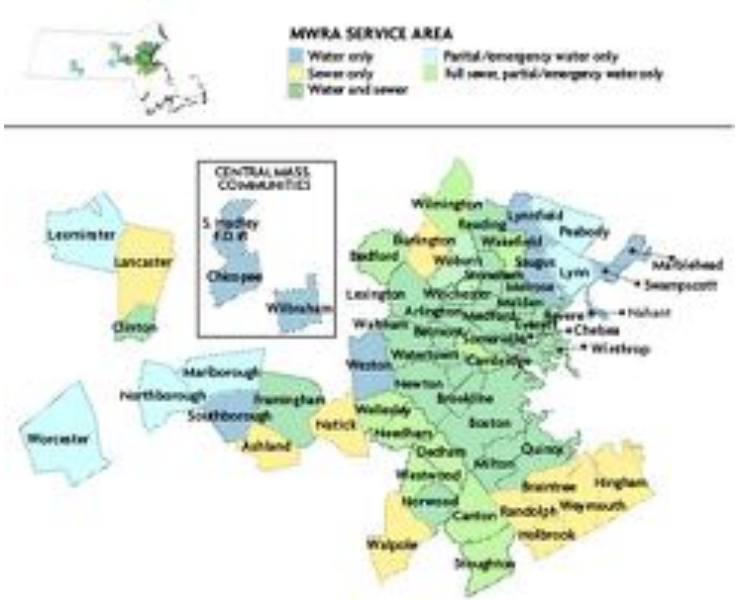
MWRA History & Background

- Massachusetts Water Resources Authority (MWRA) established in 1984
- MWRA assets are located in an area of more than 800 square miles, spanning from the Chicopee Valley to Boston Harbor
- Delivers an average of 200 MGD to its water customers
- Collects and treats an average of 350 MGD of wastewater, with a peak capacity of over 1,200 MGD



MWRA provides wholesale water and wastewater services to over 3.1 million people in 61 communities

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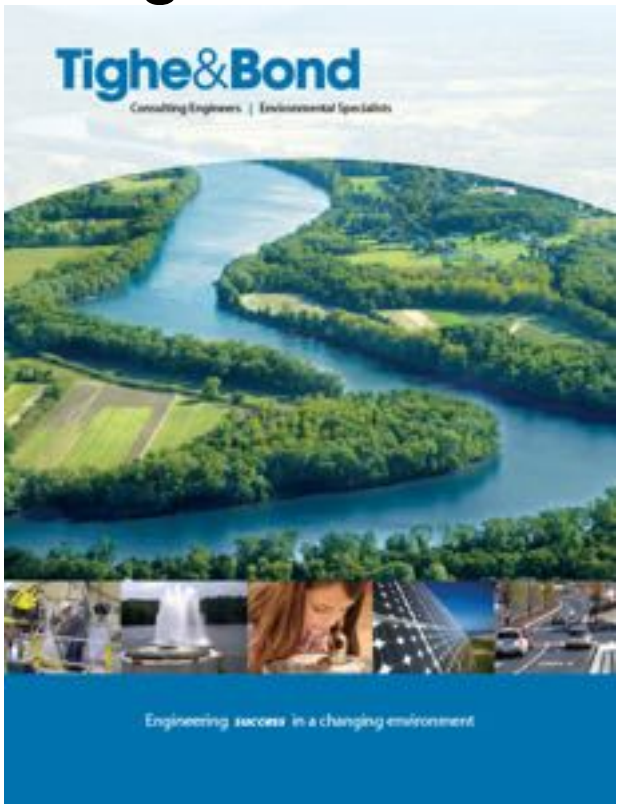
History of MWRA/NEFCO Partnership

- 1982-1983, claims that the Massachusetts Clean Waters Act had been violated
- Biosolids drying project initiated as part of efforts to clean Boston Harbor
- 1986 – Daniel O'Connell's Sons (DOC) wins contract for Biosolids Pelletizing Facility (BPF)
  - NEFCO is created for the operation of the BPF
- 1991 – startup and operation of BPF begins
- Over 28+ years of BPF operations:
  - ~7 Billion Gallons of sludge received
  - ~800,000 dry tons of biosolids processed

Tighe & Bond History and Background

- Tighe & Bond support of NEFCO projects:
  - Quincy, MA MWRA (original) – 140 DTPD
  - Quincy, MA MWRA (upgrade) – 280 DTPD (rebuilt 4 original trains and added 2 more)
  - Cumberland, MD – 15 DTPD
  - Detroit, MI – 420 DTPD
  - West Palm Beach, FL – facility support and upgrades
  - Shakopee, MN – engineering assistance
- Additional Tighe & Bond thermal drying experience:
  - Nashville, TN – 137 DTPD
  - Ocean County, NJ – 50 DTPD



Quincy Biosolids Processing Facility (BPF)

Liquid Sludge Overview

- 4-5 days/week, 2 MGD of anaerobically digested sludge is pumped to NEFCO from MWRA's Deer Island Treatment Plant (DITP)
- 4 one-million-gallon concrete sludge storage tanks
- 12 dewatering centrifuges produce sludge cake of 25 to 30% solids

Drying Process Overview

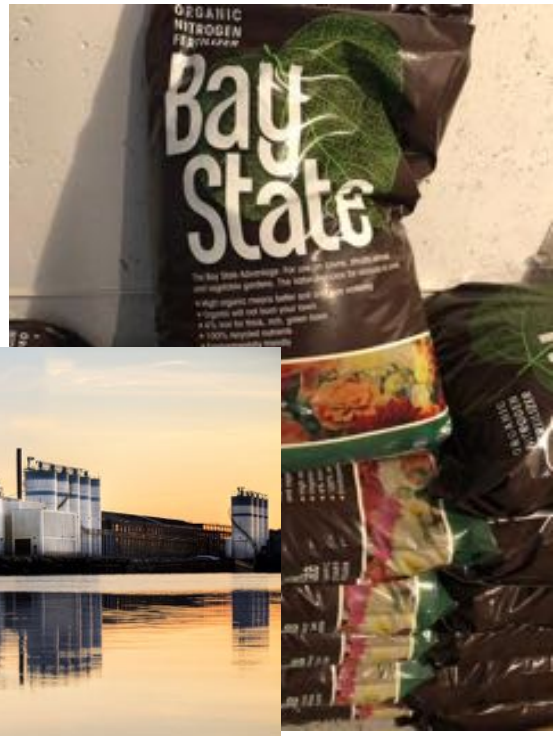
- 6 dryer process trains, typically 3 operate at a time
- Each train permitted for 6,500 lb/hr of sludge (78 DTPD)
- 3 trains operating = 234 DTPD

Dry Product Storage

- 9 product storage silos onsite
- Each silo capable of storing 600 tons of product
- 99% of product shipped to customers, 1% is bag MWRA

Breakdown of bulk product usage:

- Land application for agricultural uses (55-70%)
- Fertilizer blending (30-35%)
- Alternative fuel (0-25%)



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BPF Upgrade History

- Original Plant Design: four dryer trains, dewatering using belt filter presses
- Upgrades to the BPF over the previous contracts:
  - Belt filter presses replaced with centrifuges for dewatering
  - Two additional dryer trains added
  - Original dryers upgraded to include process air recirculation
  - Pipeline for pumping sludge constructed
  - Dryer drum for Train #2 replaced in 2012

Capital Improvement Projects at MWRA BPF

- Designed and managed by NEFCO and Tighe & Bond
- Based on budgeted Capital Improvements Plan developed by NEFCO and approved by MWRA
- Competitively bid in accordance with Mass. General Law Chapter 149
- Sometimes the old saying of “Don’t fix what’s not broken” is not the best approach!
- Being proactive and making selective and timely improvements is often most beneficial

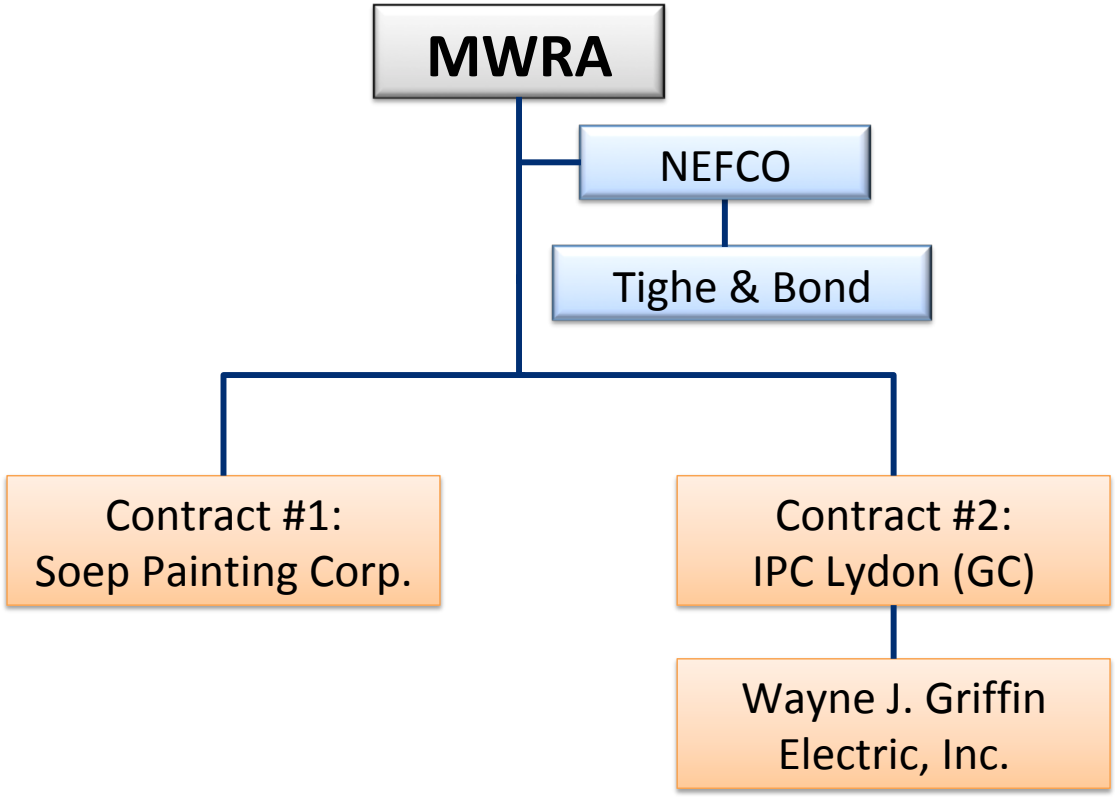
Capital Improvement Projects at MWRA BPF

- Proactive – fix it before it breaks!
- Why be proactive? A few examples:
  - Safety
  - System reliability
  - Extend useful life of overall facility
  - Spare part/replacement availability
- Protect your investments!
  - Close to $0.5 Billion invested into BPF
  - CIP cost of $9.3 Million, <2% of overall investment

Capital Improvement Projects at MWRA BPF

- Strategic improvements selectively chosen between MWRA & NEFCO aimed at promoting long-term sustainable solutions
- Originally broken out into three separate contracts:
  - Painting, electrical, and mechanical improvements
- During design, dryer drum reliability and useful life of three of six trains became a concern
- Final design included two separate contracts:
  - Contract #1 – Painting ($650k)
  - Contract #2 – Electrical & mechanical improvements, replacement of three dryer drums, main fans and burner housings ($8.68 Million)

Capital Improvement Projects – Org Chart



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Contract #1 – Painting

Scope: Silos – five (original) of nine silos onsite repainted

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Contract #1 – Painting

Scope: Exterior of concrete sludge holding tanks and select interior office and entrance space

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Contract #2 – Mechanical Improvements

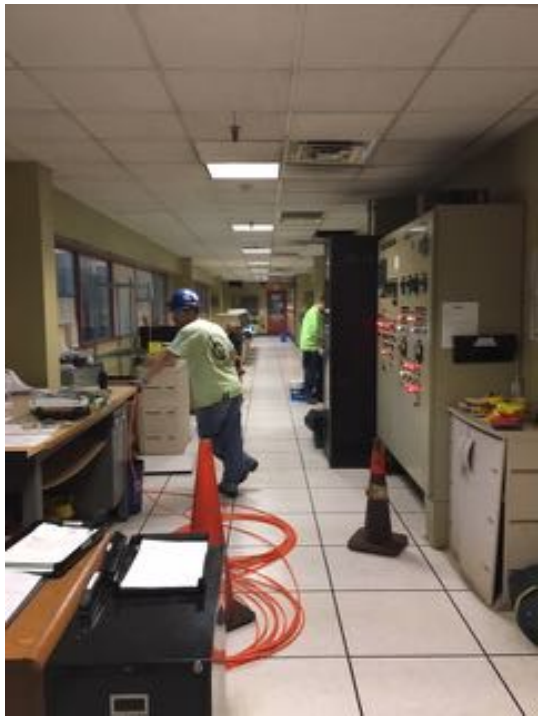
- Currently in construction – 3 interim milestones with substantial completion in August 2020
- Dryer Drums: replaced remaining three original drums
- Burner and Main ID Fan Housings
  - Stainless Steel instead of Carbon Steel
- Screw Conveyors
  - Six vertical conveyors replaced
  - Three inclined conveyors replaced

Contract #2 – Mechanical Improvements (Continued)

- Additional Safety Upgrades
  - Replacement of aging nitrogen generator with new larger unit
  - Replacement of aging 50 HP air compressor with 100 HP unit
    - Helps meet facility air usage demand, allows dedicating existing 150 HP compressor to the new higher capacity nitrogen generator
  - Replacement of aging loading and un-loading dust collectors on product storage silos
- Replacement of aging 30-ton bridge crane hoist with travel limitations used for maintenance activities and dryer drum replacements

Contract #2 – Electrical Improvements

- Full replacement of MCCs for three trains, upgrades to two facility wide shared MCCs
- Communications Upgrade – Coax replaced with Fiber
- Programming Updates – SCADA
- PLC Upgrades – Silo thermocouple PLCs
- VFD upgrades on two of the four RTOs



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Upgrade Outcomes

- Extended life of the plant
  - Silos: full exterior coating will help slow metal loss to corrosion extending useful life of silos
  - Concrete storage tanks: continued protection of concrete and improved aesthetics
  - Dryer Trains: replacement of critical, long lead time, and difficult to replace equipment
- Improved reliability for operations
- Safety improvements

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Now that MWRA and NEFCO have further invested into the facility, how do we ensure continued successful operations?

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NEFCO's Asset Management Plans

- NEFCO is a steward of MWRA's assets, proper asset management is critical
- High-level, coordinated plan developed for overseeing the asset management process
- Goal of delivering a desired standard of service in a way that combines multi-disciplinary management techniques
- NEFCO uses several guidelines for development of AMPs
  - WERF SIMPLE
  - Uptime® Elements™

- 1. Asset Registration
- 2. Asset Inventory Management
- 3. Asset Condition Assessment
- 4. Asset Failure Mode Analysis
- 5. Determination of Asset Residual Life
- 6. Determination of Asset Life Cycle & Replacement Costs
- 7. Determination of Levels of Service (LOS)
- 8. Determination of Business Risk ("Asset Criticality")
- 9. Optimize O&M Investment in Assets
- 10. Optimize Capital Investment in Assets
- 11. Leverage eMaint® CMMS for Asset Management

Criticality Assessment

- Goal is to identify which equipment has greatest potential impact on operations
- Used to development maintenance & operations strategies, capital improvement plans, etc.
- Many factors considered in grading:
  - Safety
  - Environmental
  - Quality
  - Throughput
  - Operational Cost
- Drives further Asset Management activities:
  - Critical Spare Parts
  - Maintenance Optimization
  - Condition Monitoring

NEFCO Weighting Factor	Description
1.00	A failure of this asset will highly likely result in catastrophic equipment damage, injury (or fatalities) or catastrophic environmental release. Likely Failure to meet customer contractual Level of Service, resulting in high operating cost and / or difficult and costly repairs
0.75	A failure of this asset will result in the potential for major equipment damage, injury or environmental release. Inability to meet customer contractual Level of Service for a prolonged period without high cost, high operating cost and or high cost to repair
0.50	A failure of this asset will result in the potential for recoverable equipment damage, injury or manageable environmental release. Interrupted ability to meet customer contractual Level of Service, high operating cost and or cost to repair
0.25	A failure of this asset will result in an increased risk of injuries or minor environmental impact or releases, no throughput, Level of service impact or cost impact, asset easily and cost neutral to repair
0.00	A failure of this asset will result in no injuries or environmental impact or releases, no throughput, Level of service impact or cost impact, asset easily and cost neutral to repair

Condition Monitoring

- Goal is to make sure that the most critical equipment never has a major failure
- Traditional monitoring during routine operations and maintenance activities
- More advanced real-time monitoring can be a fantastic investment

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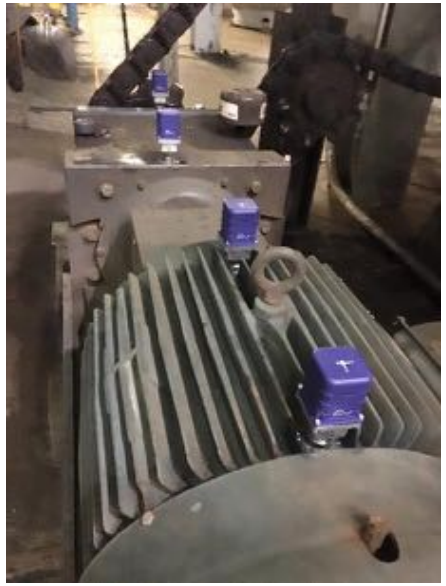
Vibration Analysis

AUGURY SYSTEMS

- Partnered with Augury Systems to look at real-time vibration monitoring and analysis on critical equipment
- Initially piloted at the MCES Final Stabilization Facility in Shakopee, MN
- Single drying train with no built-in redundancy, so availability and uptime are crucial for operations



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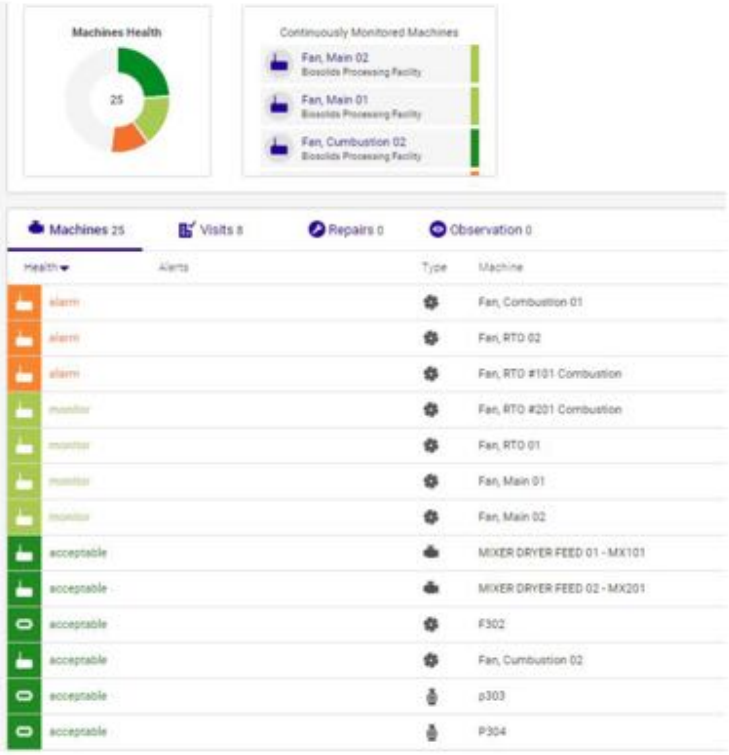
Vibration Analysis – What do we see?

Figure 2: Pre-repair spectral data and the vibrations associated with the defect are clearly identified.



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Vibration Analysis – What are we catching?

BUSINESS CASE: WEST PALM BEACH, FLORIDA

Repair Made	Machine Name	Cost of Repair	Cost Avoided
Align the shafts	Mixer Dryer Feed 101	$370	$35,000
Pressure wash fan blades	RTO Fan 2	$640	$40,000
Bearings replaced	Fan Main 01	$7500	$40,000
Total		**$8,510**	**$115,000**

Augury Cost: $20,000 **NEFCO WPB Savings: $115,000+** **ROI: 303%**

IN LESS THAN 6 MONTHS

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Temperature Monitoring

- Key component of all plant operations
- Temperatures monitored at multiple points throughout the process using thermocouples
- For additional monitoring, plant managers are equipped with thermal imaging cameras

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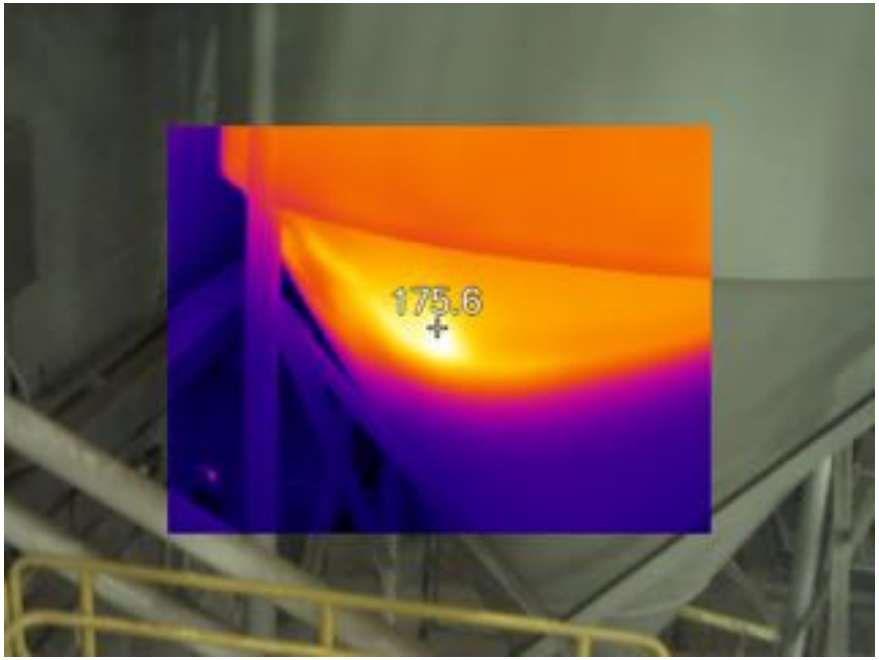
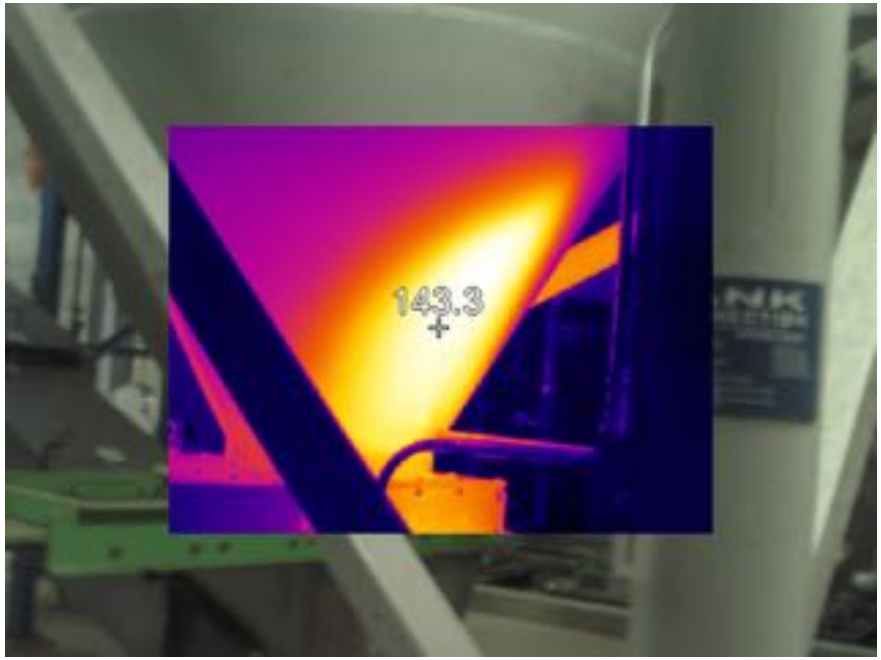
Temperature Monitoring – What do we see?





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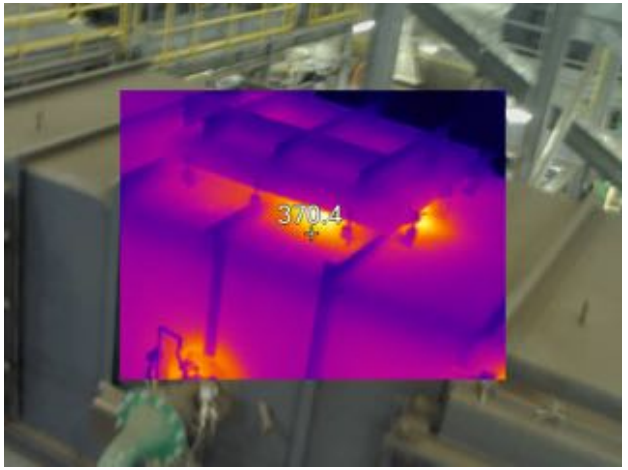
Temperature Monitoring – What are we catching?

- Important maintenance items from both an operational and safety perspective:
  - Wearing of ductwork and insulation
  - Material buildup and bridging issues
  - “Hot spots” in the process



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Utilizing Computerized Maintenance Management Systems (CMMS)

Central Storage of Data

Gain visibility into maintenance activities to comply with regulatory standards & increase accountability

Work Order & Scheduling

Standardize processes, eliminate manual entry, manage materials usage, improve work completion rates

Extend Life of Assets

Track Maintenance Activities over the lifecycle of an asset, make informed repair vs replace decisions

Reduce Maintenance Costs

Reduce overtime hours, waste spoilage, equipment downtime, reduction in inventory

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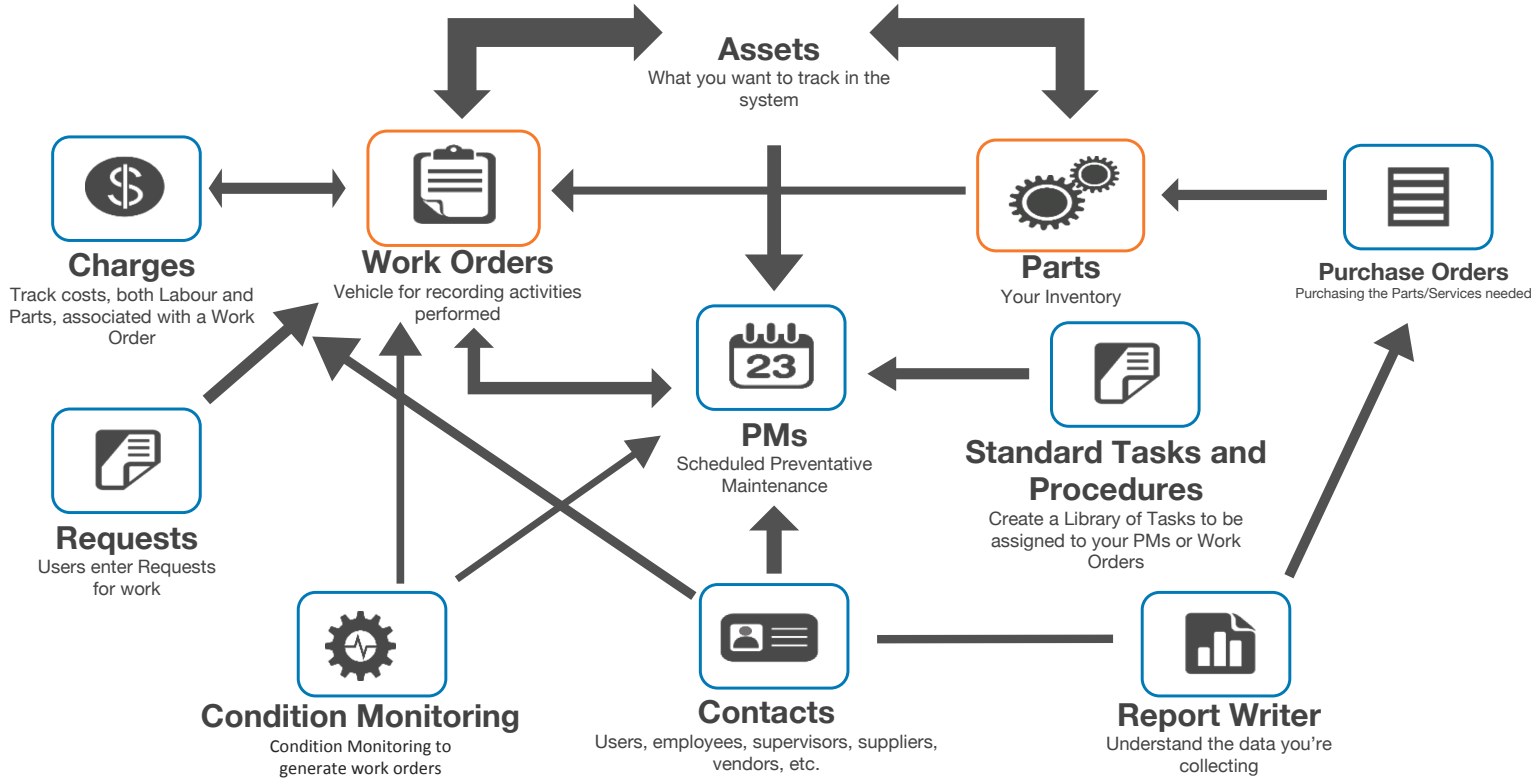
CMMS Diagram



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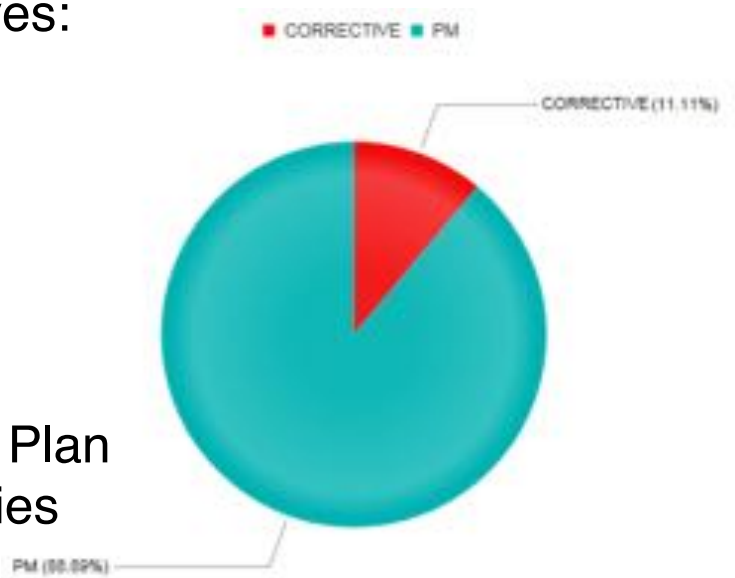
Maintenance Scheduling

- Look at maintenance from three perspectives:
  - Predictive
  - Preventative
  - Unplanned
- Increased availability of the facility when unplanned maintenance is reduced
- Reliability improves as Asset Management Plan shifts to predictive and preventative activities



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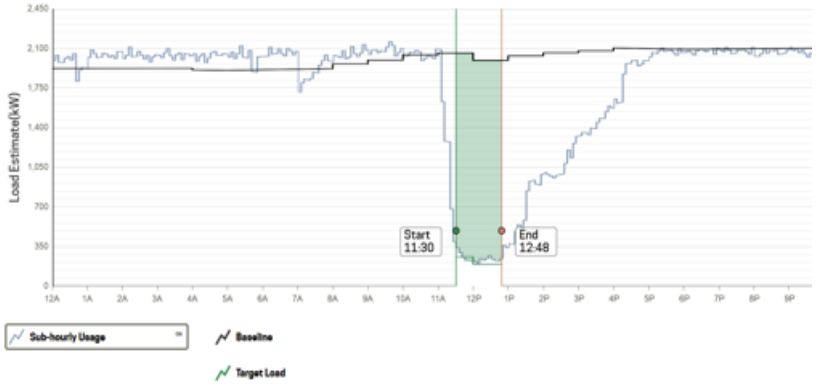
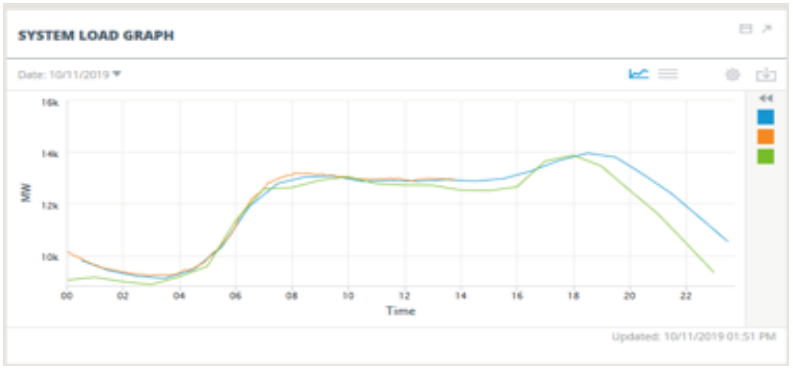
Benefits of Flexibility in Scheduling





WEATHER	DAY 2 SAT 10/12	DAY 3 SUN 10/13	DAY 4 MON 10/14	DAY 5 TUE 10/15	DAY 6 WED 10/16	DAY 7 THU 10/17
High Temperature - Boston	58	65	64	62	62	58
Dew Point - Boston	49	45	53	41	53	38
High Temperature - Hartford	65	65	67	62	60	54
Dew Point - Hartford	49	40	48	38	53	35

GENERATING CAPACITY POSITION						
Total Capacity Supply Obligation (CSO)	31,704	31,704	31,704	31,704	31,704	31,704
Anticipated Cold Weather Outages	0	0	0	0	0	0
Other Generation Outages	8,905	8,621	8,755	8,956	8,284	8,300
Anticipated De-List MW Offered	1,066	1,066	1,066	1,066	1,066	1,066
Total Generation Available	23,865	24,149	24,015	23,814	24,486	24,470
Import at Time of Peak	1,895	1,895	3,625	3,625	3,625	3,625
Total Available Generation and Imports	25,760	26,044	27,640	27,439	28,111	28,095
Projected Peak Load	13,000	13,250	14,250	14,250	14,500	14,250
Replacement Reserve Requirement	160	160	160	160	160	160
Required Reserve	2,303	2,303	2,303	2,303	2,303	2,303
Required Reserve including Replacement	2,463	2,463	2,463	2,463	2,463	2,463
Total Load plus Required Reserve	15,463	15,713	16,713	16,713	16,963	16,713
Projected Surplus or Deficiency	10,297	10,331	10,927	10,726	11,148	11,382
Available Demand Response Resources	409	409	409	409	409	409

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Impacts on Facility Sustainability

- Environmental & Financial
  - Reduce the need for investment in new infrastructure and equipment
  - Improve efficiency of operations
- Social
  - Improved safety for employees and community
  - Continue reliable operations with no nuisances to public

Innovative and proactive asset management, along with targeted capital improvements, will help ensure that the Biosolids Processing Facility in Quincy will continue to serve the MWRA for another 30 years!

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Questions?