Asset Replacement Strategies at the MWRA

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MWRA Overview

The Massachusetts Water Resources Authority (MWRA) is in the process of implementing a comprehensive, multi-phased Facilities Asset Management Program (FAMP) for the Deer Island Treatment Plant and Field Operations (water treatment and distribution and wastewater collection) facilities. This is a comprehensive effort designed to plan, manage, and coordinate the engineering, maintenance, operation, and financing required maintaining these facilities to regulatory requirements. FAMP can be further described as having two objectives:

1. Cost effectively replace the less durable capital components of the facilities at the appropriate time to ensure reliable plant operation and preserve the value of the original investment.

2. Prolong the equipment life and control the rate of replacement (i.e. avoid large spending spikes for consolidated retrofit or rehabilitation projects).

The Authority has initiated this project to develop the most efficient strategy to integrate maintenance, operations, and engineering activities to support the FAMP objectives.

One program element includes the development of a comprehensive and consistent Agency strategy to identify and prioritize asset replacement needs, resulting in more accurate spending forecasts and determination of appropriate funding sources. This challenge has been accepted by the Asset Replacement Task Team (ARTT) that is made up of representatives from the maintenance, engineering, planning and finance departments.

Information Management

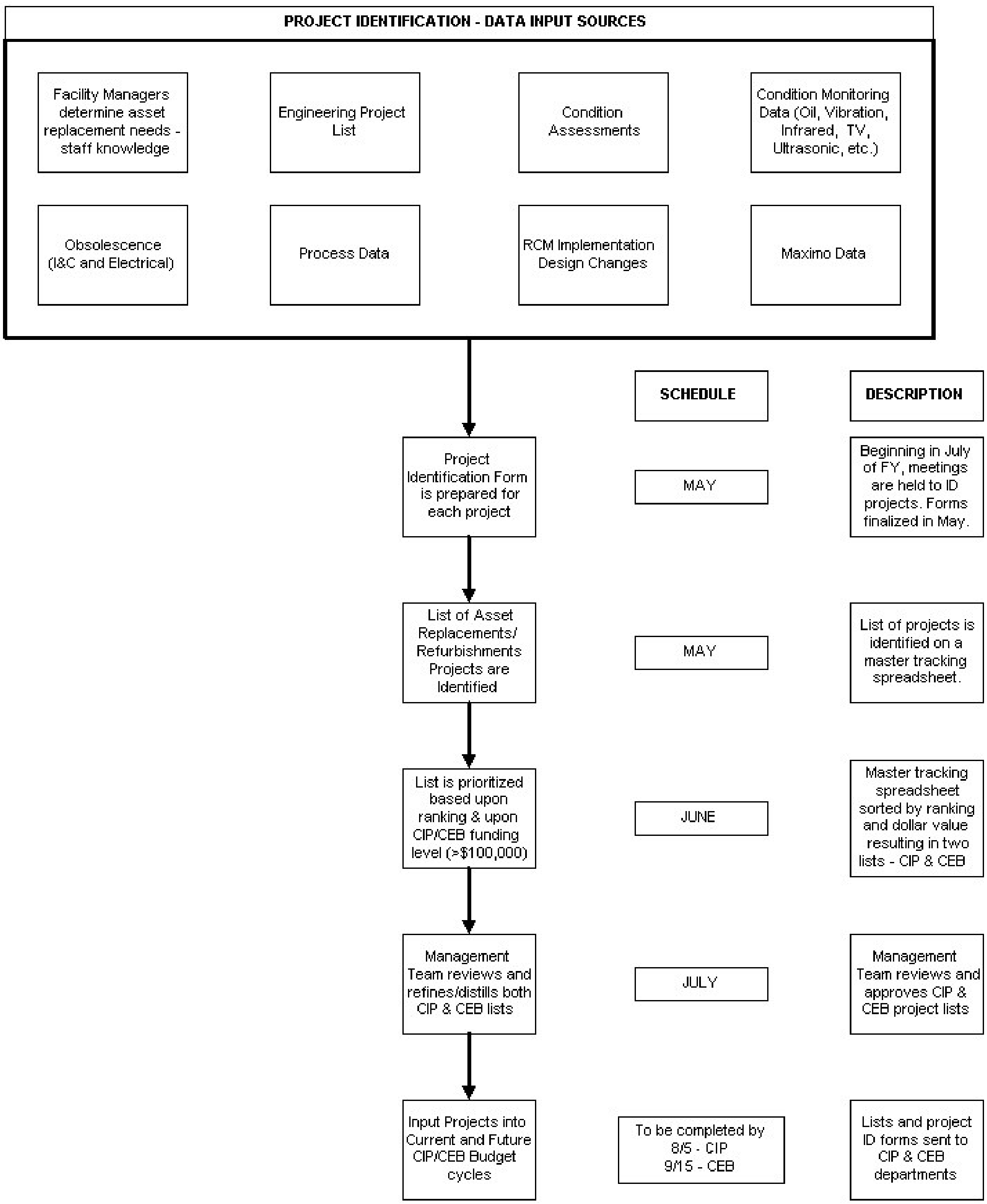
The MWRA is responsible for $7 billion worth of assets and has invested in a variety of means, methods and programs to collect and store critical asset information. From process and performance to maintenance and finance, there is a wide variety of information available to help facilitate and plan for timely asset replacement. Computers and associated software allow staff to monitor and trend both operational performance and maintenance spending providing advance warning of required asset replacements. Staff knowledge is the other key information source. Today, the breakdown for asset replacement decisions are - staff knowledge 80% and databases 20%. It is projected that in 5 years, the trend will be reversed by improved use of maintenance and process data. So, it is important for a utility to have a program/process in place to enable the “mining” of this critical information to support business decisions in the asset replacement planning process.

The MWRA’s Strategy

There is a variety of approaches, tools and techniques, ***that when combined***, offer an efficient strategy for the planning of short and long-term asset replacement.

Approaches

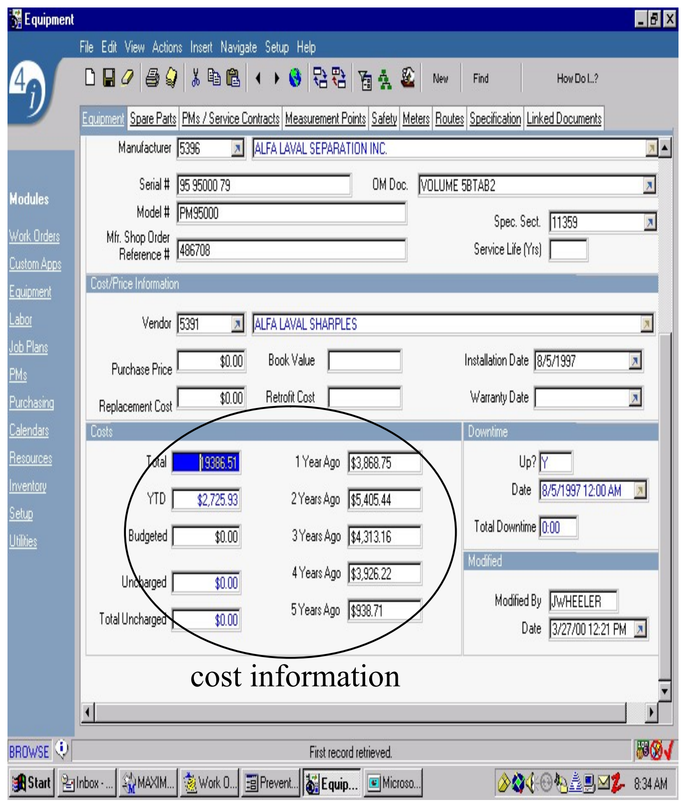
A new process termed Project Identification and Prioritization (PI&P) was developed to facilitate the collection of asset performance information renewal/replacement projects to be captured and included in both the current expense budget (CEB) and capital improvement program (CIP) budgets. As noted below, asset information is available from multiple data sources (i.e. staff knowledge, engineering, oil and vibration analysis, process, Maximo-CMMS) and there is a need to ensure that the information is "mined" and then "funneled" into the current and future budgeting cycles. The ARTT identified asset data input sources and a process flow diagram for the new PI&P process - see Figure 1 below.



A PI&P form was also developed as a means for staff to formerly submit projects for consideration. The form includes basic project information (i.e. title, description of work, cost estimate) and also includes a prioritization section with weighted questions concerning risk (remaining life, redundancy, obsolescence), consequence of failure (health, safety and environmental) and O&M improvements (cost savings, operational) – see Attachment 1. As projects are identified, managers assist staff in completing the form and the project's total points are assigned to assist senior management in their final analysis. The format and weighting assignments were tested on a few known projects prior to implementation.

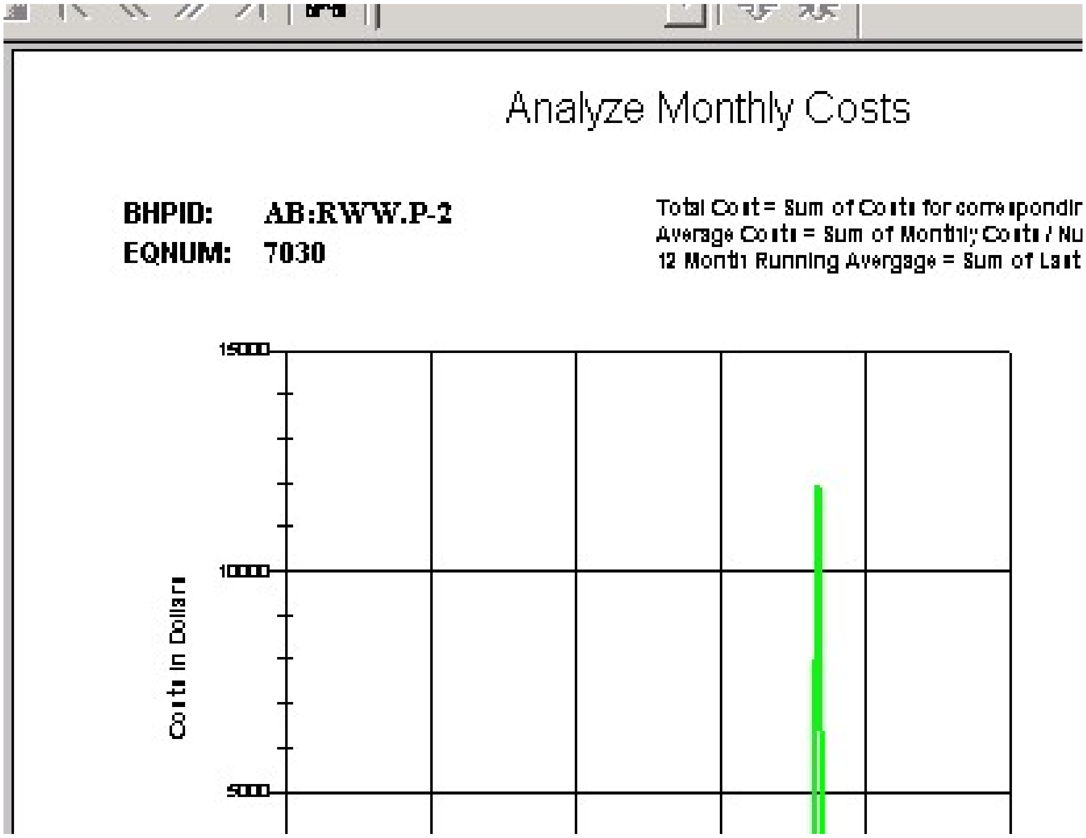
Tools

Tools include the use of powerful databases known as Computerized Maintenance Management Systems (CMMS) that can generate reports that compare current yearly spending against historical spending for each asset, process area, and facility. This may indicate that an asset is nearing the end of its useful life (maintenance spending is increasing significantly) and can provide advance warning to initiate the replacement planning process.



As part of the FAMP consultant support services, several reports and features were added to Maximo to assist in the budgeting process. Maximo's functionality was improved to include a history of yearly costs for all 30,000 pieces of equipment at DITP (see screen shot at right). This new feature allows the development of two reports that assist in identifying high maintenance expenditures for specific equipment and repeated equipment failures. These reports were used to assist in project identification.

The first report developed using Maximo historical cost data trends the monthly cost expenditures, yearly running average of cost, and a historical average of costs (since 1996). The report identifies a list of equipment that have a yearly running average significantly higher than the historical average of costs. The graph below shows the data for one raw wastewater pump. This report is useful to identify equipment that have had higher than average spending for the previous year that may be candidates for replacement projects or improvements.



The second set of reports developed follow the Paredo method to identify the top 20% of equipment that require 80% of costs. Two reports were developed, one to determine the highest cost equipment and the second to determine equipment with the highest number of corrective maintenance work orders. A sample of the reports generated by Maximo follows. These reports again highlight plant areas where additional resources (design improvements, root cause analysis, RCM analysis) may be required to resolve maintenance issues.

There are three steps required to complete the example Paredo review that follows. These steps or "drilldown review" include running three reports - 1) by Area, 2) by System and finally 3) by Component. In each step, the report data is analyzed and guides the review process to identify high cost and high number of work order equipment that need to be targeted for improvement or replacement. The following summary (and tables) details the process done for the Gravity Thickener Complex at DITP.

- Step 1 Area Review
  - Highest Number of Work Orders
  - Highest Yearly Cost to Date
  - Result = Gravity Thickener Complex
- Step 2 System Review
  - Highest Number of Work Orders
  - Highest Yearly Cost to Date
  - Result = Thickened Primary Sludge System
- Step 3 Component Review
  - Thickened Primary Sludge Pumps

Step 1- Area Review
Ordered by Highest Number of Work Orders

BHPID	WO Count	Labor Hours	Labor Cost	Material Cost	YTD Cost
CENTRIFUGE THICKENING	370	7,235	$183,266.95	$3,775.50	$187,042.45
VEHICLE MAINTENANCE	339	2,513	$58,006.06	$64.96	$58,071.02
POWER PLANT	326	4,834	$120,644.26	$805.10	$121,449.36
GRAVITY THICKENER COMPLEX	318	8,235	$206,180.54	$7,323.44	$213,503.98
NORTH MAIN PUMPING STATION	207	4,503	$107,684.04	$9,829.16	$117,513.20
GRIT FACILITY	203	5,771	$131,434.86	$16,547.18	$147,982.04
ADMINISTRATION/LABORATORY	198	2,172	$51,160.56	$4,353.67	$55,514.23
PRIMARY CLARIFIER BATTERY A	169	3,924	$94,888.65	$4,533.20	$99,421.85
WINTHROP TERMINAL FACILITY	153	2,595	$64,634.65	$404.20	$65,038.85
PRIMARY EAST ODOR CONTROL	144	1,546	$38,766.60	$6,015.69	$44,782.29
PRIMARY CLARIFIER BATTERY B	140	3,849	$90,120.01	$1,811.36	$91,931.37
CRYOGENIC FACILITY	134	3,551	$90,477.65	$9,273.97	$99,751.62

Area Review
Ordered by Highest Yearly Cost to Date

BHPID	WO Count	Labor Hours	Labor Cost	Material Cost	YTD Cost
GRAVITY THICKENER COMPLEX	318	8,235	$206,180.54	$7,323.44	$213,503.98
CENTRIFUGE THICKENING FACILITY	370	7,235	$183,266.95	$3,775.50	$187,042.45
GRIT FACILITY	203	5,771	$131,434.86	$16,547.18	$147,982.04
POWER PLANT	326	4,834	$120,644.26	$805.10	$121,449.36
NORTH MAIN PUMPING STATION	207	4,503	$107,684.04	$9,829.16	$117,513.20
CHLORINATION	129	3,590	$90,867.58	$23,650.87	$114,518.45
SOUTH SYSTEM PUMPING STATION	132	3,855	$94,005.96	$9,541.61	$103,547.57
CRYOGENIC FACILITY	134	3,551	$90,477.65	$9,273.97	$99,751.62
PRIMARY CLARIFIER BATTERY A	169	3,924	$94,888.65	$4,533.20	$99,421.85
SECONDARY CLARIFIER BATTERY A	128	3,678	$91,083.49	$4,167.22	$95,250.71
PRIMARY CLARIFIER BATTERY B	140	3,849	$90,120.01	$1,811.36	$91,931.37
PRIMARY CLARIFIER BATTERY D	133	3,514	$80,837.82	$2,071.58	$82,909.40

From this output there is one area that has high spending and a high number of work orders - the Gravity Thickener Complex (bolded).

Step 2 - System Review
Ordered by Highest Number of Work Orders

BHPID	WO Count	Labor Hours	Labor Cost	Material Cost	YTD Cost
GRIT SYSTEM	94	4,476	$101,273.63	$9,928.85	$111,202.48
DIGESTED SLUDGE	109	2,975	$78,525.01	$2,351.98	$80,876.99
THICKENED PRIMARY SLUDGE	133	3,038	$77,577.77	$2,444.67	$80,022.44
CLARIFIERS, PRIMARY BATTERY B	95	2,745	$62,737.43	$1,541.78	$64,279.21
CLARIFIERS, PRIMARY BATTERY D	83	2,730	$61,651.95	$98.13	$61,750.08
CLARIFIERS, PRIMARY BATTERY C	90	2,512	$59,994.22	$1,370.11	$61,364.33
RAW WASTE WATER (PARENT)	59	2,150	$52,038.97	$5,972.39	$58,011.36
CLARIFIERS, PRIMARY BATTERY A	105	2,122	$51,869.86	$877.21	$52,747.07
WASTE SLUDGE	92	1,791	$44,232.81	$99.08	$44,331.89
CLARIFIERS, SECONDARY BATTERY	79	1,561	$38,747.10	$3,420.59	$42,167.69
RAW WASTE WATER	52	1,664	$40,920.68	$412.05	$41,332.73
SECONDARY RETURN SLUDGE	87	1,396	$34,341.69	$6,916.84	$41,258.53

System Review
Ordered by Highest Yearly Cost to Date

BHPID	WO Count	Labor Hours	Labor Cost	Material Cost	YTD Cost
THICKENED PRIMARY SLUDGE	133	3,038	$77,577.77	$2,444.67	$80,022.44
DIGESTED SLUDGE	109	2,975	$78,525.01	$2,351.98	$80,876.99
CLARIFIERS, PRIMARY BATTERY A	105	2,122	$51,869.86	$877.21	$52,747.07
GRIT SYSTEM	95	4,480	$101,367.15	$9,928.85	$111,296.00
CLARIFIERS, PRIMARY BATTERY B	95	2,745	$62,737.43	$1,541.78	$64,279.21
WASTE SLUDGE	92	1,791	$44,232.81	$99.08	$44,331.89
CLARIFIERS, PRIMARY BATTERY C	90	2,512	$59,994.22	$1,370.11	$61,364.33
SECONDARY RETURN SLUDGE	87	1,396	$34,341.69	$6,916.84	$41,258.53
CLARIFIERS, PRIMARY BATTERY D	83	2,730	$61,651.95	$98.13	$61,750.08
CLARIFIERS, SECONDARY BATTERY	79	1,561	$38,747.10	$3,420.59	$42,167.69
RAW WASTE WATER	67	1,462	$35,574.09	$275.74	$35,849.83

From this output there is a system that has high spending and a high number of work orders – the Thickened Primary Sludge system that is part of the Gravity Thickener Complex.

Step 3 - Component Review
Work Orders and Yearly Cost to Date

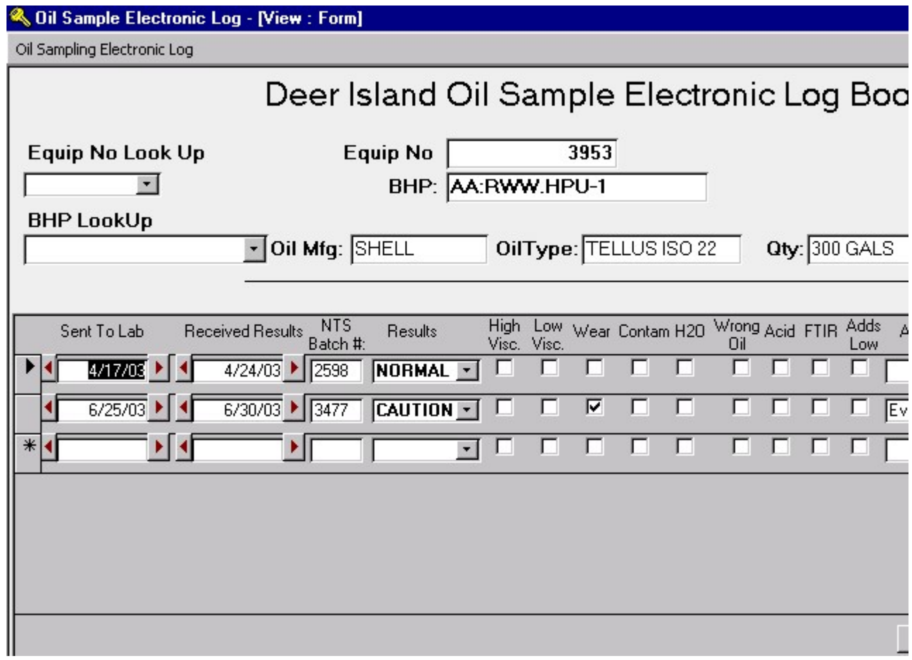
BHPID	WO Count	Labor Hours	Labor Cost	Material Cost	YTD Cost
EJ:TPS	133	3,038	$77,577.77	$2,444.67	$80,022.44
EJ:TPS.P-1	10	504	$12,582.40	$339.36	$12,921.76
EJ:TPS.P-1/P	9	499	$12,465.50	$339.36	$12,804.86
EJ:TPS.P-5	13	446	$11,089.20	$863.85	$11,953.05
EJ:TPS.P-5/P	13	446	$11,089.20	$863.85	$11,953.05
EJ:TPS.P-2	18	339	$9,669.66	$369.02	$10,038.68
EJ:TPS.P-6	17	399	$10,013.43	$0.00	$10,013.43
EJ:TPS.P-6/P	16	392	$9,849.77	$0.00	$9,849.77
EJ:TPS.P-2/P	17	326	$9,358.46	$369.02	$9,727.48
EJ:TPS.P-4	17	253	$6,893.13	$0.00	$6,893.13
EJ:TPS.P-10	6	280	$6,708.95	$0.00	$6,708.95
EJ:TPS.P-10/P	5	265	$6,358.25	$0.00	$6,358.25
EJ:TPS.P-4/P	15	237	$6,295.71	$0.00	$6,295.71
EJ:TPS.P-9	4	164	$4,433.76	$793.76	$5,227.52
EJ:TPS.P-9/P	4	164	$4,433.76	$793.76	$5,227.52
EJ:TPS.P-7	15	211	$5,193.71	$0.00	$5,193.71
EJ:TPS.P-7/P	15	211	$5,193.71	$0.00	$5,193.71
EJ:TPS.P-8	13	115	$2,989.21	$0.00	$2,989.21
EJ:TPS.P-8/P	13	115	$2,989.21	$0.00	$2,989.21
EJ:TPS.GRI-2	3	39	$1,077.12	$0.00	$1,077.12

Further analysis of the Thickened Primary Sludge system, reveals that a substantial effort (cost and # work orders) have been concentrated on the Thickened Primary Sludge Pumps. This is one item that will be targeted for improvement or replacement.

Techniques

Techniques such as condition assessments and predictive maintenance (PdM) programs can be employed as a means to proactively identify potential failure conditions. Expansion of both programs has been initiated under the FAMP efforts.

As part of the condition assessment strategy, a condition assessment sub-committee (ARTT-CA) has also been created and has initiated a review of all key MWRA asset classes (active and static) to ensure programs are in place. In addition a formal PdM program expansion effort (oil, vibration and infrared) is underway and being monitored by the Condition Monitoring and Lubrication task teams.



The Lubrication team is expanding the Oil Sampling and Analysis program that results in large amounts of data collection. As part of the FAMP consultant support services, an oil sampling database was created (right) that is used to track and trend laboratory results. Equipment replacements can be identified prior to failure that are added to the list of projects.

The Condition Monitoring task team efforts are focused on expanding the PdM program over a multi-year period. One example includes electrical testing at the DITP that identified potential bus duct failures. Projects were added to the CIP and replacements were made before failures occurred.

In addition to these techniques, the Reliability Centered Maintenance (RCM) program identifies projects. The RCM effort involves a structured system review process that considers failure modes and consequences of failure as a means of optimizing the preventive maintenance program. In many cases, projects are identified for further engineering staff review if safety or the environment is impacted. This review process provides another data source for project identification.

Case Study at DITP

During the early stages of PI&P development, the process was piloted at the DITP. In an effort to take advantage of staff knowledge of plant conditions, problematic equipment, problematic processes, and recurring projects, a series of meetings with trade supervisors, managers, engineering, operations and process control were held for the FY04 and FY05 CEB/CIP budgets. In these brainstorming meetings, staff identified a host of projects for the upcoming fiscal year as well as long-term projects for future years. The table below (populated with several example projects) was used to document information from staff during the meetings.

Brainstorming Session – Project Information Table

Project Title	**Phase** - Study - Design - Construction	**In-house or Contract**	**Cost Estimate**	**Schedule** - Next FY - Frequency	**Why Needed?** - Safety - Obsolete - Savings - Regulatory
Main Hypo Pump Replacement	Design & Construction	In-house	16,000	FY04	safety
Obsolete VFDs	Design & Construction	Both	500,000	FY05/06 then budget $1M every 10 years	obsolete
HVAC Units	Construction	Contract	135,000	FY04 then budget $135K every 5 years	savings
Damper Replacement	Design & Construction	Contract	100,000	FY05	regulatory

In FY04 over 200 individual projects were identified up from 12 in the previous year. The projects were then sorted into CEB or CIP categories and then prioritized by a small team of engineering, operations, and maintenance staff. The proposed list was then presented to management for approval where additional refinements were made. Fourteen new CIP projects were identified and forty of the highest priority CEB projects were proposed for inclusion in the budget. The Operations Division review and approval for CEB and CIP projects were then completed that further refined the budget proposal.

During the FY05 PI&P review, the remaining projects identified in the FY04 PI&P process were reviewed and new projects were identified. Again the projects were prioritized and added to the budget as appropriate. In addition, during FY05, Maximo data (spending trends) was also used in the FY05 budgeting process.

Conclusion

Accurate and timely asset replacements are key components to a utility's economic survival and rate stabilization. The MWRA asset replacement strategy is built on a team approach and the effective use of technology. The following represent several benefits noted to date:

- Proactive budget development
- More accurate spending plan
- Identify and plan for the highest priority replacements
- Defensible projects and budget
- Recurring projects are identified that can then be used in forecasting long term needs
- Projects identified are proactive replacements of assets prior to failure
- Staff work and purchases are planned for the upcoming year

MWRA's Asset Replacement Task Team Members - Representatives from planning, finance, engineering, construction and maintenance included: John Colbert, John Fortin, Ted Regan, Dan O'Brien, Dede Vittori, Phil Moffitt, Jim Long, John Barranco, Dave Whelan, Ron Zizza, Susan McAree, Tony Schepis, Gerry Gallinaro, Mark Johnson and Lise Marx

Proposed Project Title: ____

Attachment 1 - PI&P Prioritization Data Form

Risk of Failure

1. What is the remaining useful life of the existing asset?
- Less than 1 Year ☐
- 1-2 Years ☐
- 2-5 Years ☐
- 5-10 Years ☐
- > 10 Years ☐
- N/A ☐

Describe ________________________________
____

2. Is the existing asset obsolete, or will it become obsolete in the near future?
(See Note #1 below for examples)
- No ☐
- Yes ☐
- N/A ☐

If "Yes", Describe __________________________
____

3. Does the project add or maintain redundancy for a critical asset *(see Note #2 for a definition of "critical")* , and if the project is not completed will the risk of asset failure be increased to an intolerable level.
(See Note #2 below for examples)
- No ☐
- <u>**Yes**</u>, the project **adds** redundancy, and if it is not completed, the risk of asset failure increases to an intolerable level. ☐
- <u>**Yes**</u>, the project **maintains** redundancy, and if it is not completed, the risk of asset failure increases to an intolerable level. ☐

If "Yes", Describe __________________________
____

Consequence of Failure

4. Does the project have health or safety implications for either staff or customers of the MWRA?
- No ☐
- If "Yes", are health or safety implications the
  - **primary justification** for the project or ☐
  - the **ancillary benefits** of the project? ☐

If "Yes", Describe __________________________
____

5. Does the project have regulatory implications?
- No ☐
- Yes ☐
- If "Yes", is it Court Ordered? ☐

If "Yes", Describe __________________________
____

6. Does the project have environmental implications?
- No ☐
- If "Yes", are environmental implications the
  - **primary justification** for the project or ☐
  - the **ancillary benefits** of the project? ☐

If "Yes", Describe __________________________
____

7. What is the service impact of the project?
- 0 - 1000 customers ☐
- > 1000 Customers ☐

If > 1000 customers, Describe ___________________
____

8. Does the project have security implications?
- No ☐
- If "Yes", are security implications the
  - **primary justification** for the project or ☐
  - the **ancillary benefits** of the project? ☐

If "Yes", Describe ______________________________
____

9. Will the project prevent collateral damage to other MWRA assets?
- No ☐
- Yes ☐

If "Yes", Describe ______________________________
____

Improvements

10. Will the project produce O&M cost savings (other tha
- No ☐
- If "Yes",
  - **One Time** savings, or ☐
  - **Recurring** savings? ☐

Annual Savings Estimate: $ ________________
If "Yes", Describe ____________________________
____

11. Will the project produce energy cost savings?
- No ☐
- If "Yes",
  - **One Time** savings, or ☐
  - **Recurring** savings? ☐

Annual Savings Estimate: $ ________________
If "Yes", Describe ____________________________
____

12. Will the project produce operational improvements?
(See Note #3 below for examples)
- No ☐
- Yes ☐

If "Yes", Describe ____________________________
____

13. Is this project a top priority for the OED, MWRA Boar
- No ☐
- Yes ☐

If "Yes", Describe ____________________________
____

Notes:
1) Examples of obsolescence inlcude: parts no longer available, no longer supported by MWRA, vendor out of business, discontinued item, advances in technology make it incompatible with other
2) An asset is defined as "critical" if its failure will directly and immediately prevent MWRA from delivering basic water and/or wastewater services.
An example of "adding" redundancy is the MetroWest water supply tunnel. An example of "maintaining" redundancy is repairing or replacing a critical pump for which there is already a backup pu
3) Examples include: automating valve operation in the clarifiers to accomodate changes in flow, new software to improve the accuracy of collection system condition assessment, etc.