CREATING A SUCCESSFUL ASSET MANAGEMENT PROGRAM AT THE MWRA

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INTRODUCTION

The Massachusetts Water Resources Authority (MWRA) is responsible for providing wholesale water and sewerage services, in whole or in part, to sixty-one communities, and 2.6 million people. In addition to its operating responsibilities, MWRA is responsible for rehabilitating, repairing and maintaining the regional water and sewerage systems. Since its assumption of the ownership and operations of these systems in 1985, MWRA has undertaken an ambitious program of water and wastewater system capital improvements with estimated expenditures for fiscal years 1986 through 2009 of over $7 billion. Under one massive construction effort, the Boston Harbor Project, the MWRA assumed maintenance responsibility of the $3.8 billion dollar Deer Island Treatment Plant (DITP). As the second largest wastewater treatment facility in the nation, it is designed to treat 1.2 billion-gallons-per-day.

Aerial Photo - Deer Island Treatment Plant

In addition, the Agency had embarked on several other large capital projects that would require similar asset care including a new water filtration plant.

Given the significant value and critical nature of the MWRA assets, maintenance is of paramount importance. In 1996 the Facilities Asset Management Program (FAMP) initiative was created as a comprehensive, agency-wide effort to most efficiently and effectively manage the region's water and sewer infrastructure.

OBJECTIVES

The purpose of the FAMP initiative is to optimize the efficiency and effectiveness of MWRA maintenance practices (i.e. minimize critical equipment failures, minimize unnecessary maintenance practices, improve equipment reliability, heighten system knowledge and lower overall maintenance costs). In summary, the program is focused on standardization of maintenance practices, adoption of best practices and optimization of labor and material resources. The program is a phased approach as shown on Figure 1.

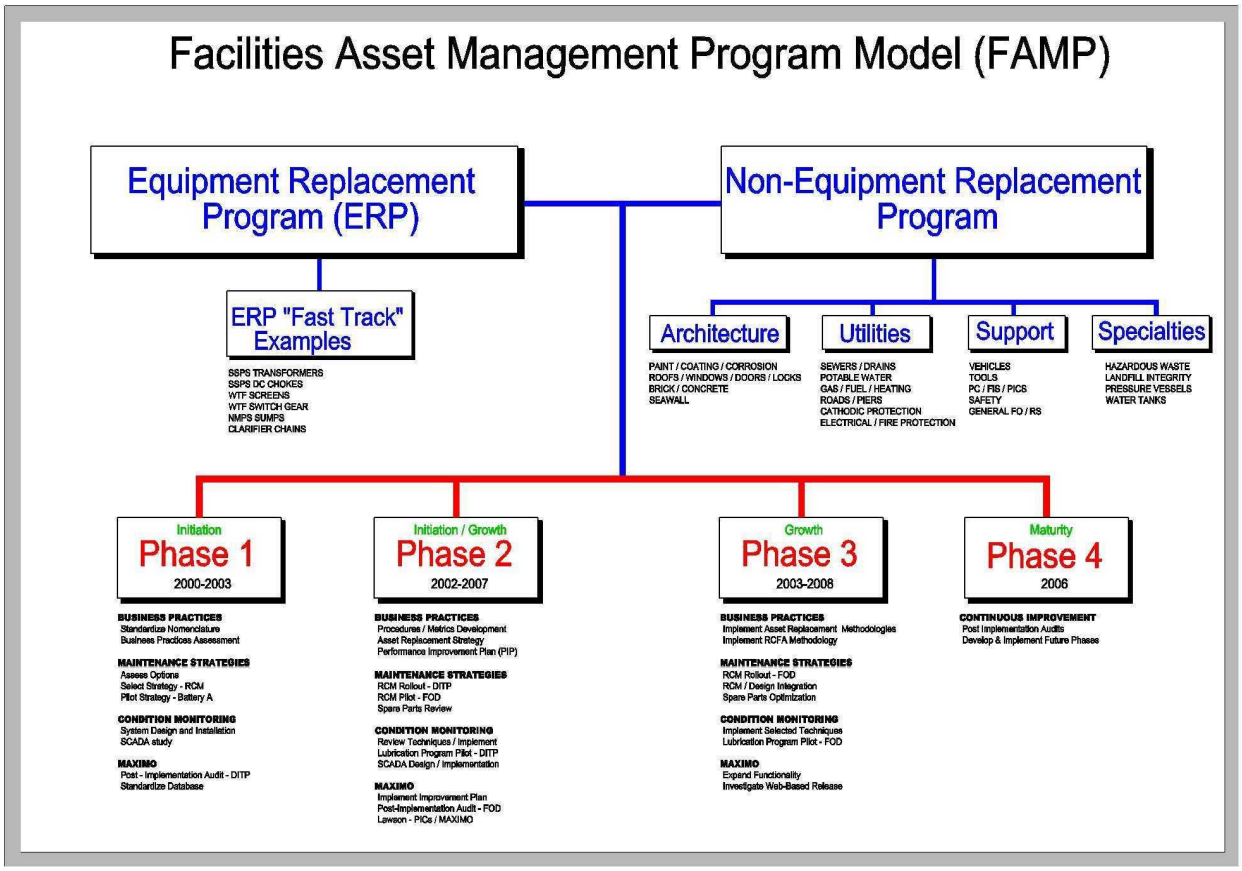


Figure 1 – FAMP Model

In 1999, the MWRA initiated Phase I activities in an effort to facilitate change in MWRA maintenance practices. The changes included implementing a Reliability Centered Maintenance strategy instead of the current time-based maintenance strategy, advancing the use and quality of the computerized maintenance management system (MAXIMO by MRO, Incorporated), and developing a design for the installation of permanent vibration and temperature monitoring for critical process equipment.

CHANGE MANAGEMENT TECHNIQUES

As one of the Agency's top priorities, the FAMP initiative is being implemented across all operating divisions. To support the initiative an organizational structure composed of a Steering Committee, Project Team and Implementation Teams was formed. The groups comprised of a good mix of staff from the various operating divisions including senior management, union leaders, procurement, engineering, maintenance trades, operators and consultant support. This team approach was effective implementing change and facilitating staff buy-in.

During Phase I, weekly meetings were held to facilitate the project schedule and monthly steering committee meetings were held to communicate progress and program direction. A communication plan was developed that included regular informational presentations, newsletter articles, and all-staff memorandums. In addition, status posters are strategically displayed throughout the facility for staff and visitors. The adoption of a communication plan has supported the culture change and conveyed to staff that senior management is committed to the project.

A key component to the change momentum was through research. At various stages of the program, teams of in-house staff collaborated with outside companies and organizations to understand time and cost saving approaches, views and benefits. The focus was put on other organizations of similar size and complexity. It was quickly determined that advanced knowledge in the area of asset management was limited within the water quality facilities arena, so the need to look at outside entities was needed. Collaboration efforts were initiated at leading industries including a steel mill in Canada, a manufacturer in Massachusetts and a process plant in Colorado. In addition, several team members attended and subsequently joined a new professional maintenance association, the Society for Maintenance and Reliability Professionals (SMRP). SMRP offers an opportunity to gather best practice information from a large network of maintenance and operation professionals at Fortune 500 companies. Research helped team members communicate the benefits of a comprehensive asset management program to all levels of staff through the use of real life success stories.

PHASE I - SCOPE OF WORK AND CURRENT STATUS

In order to facilitate the Phase I program and obtain expertise in the area of asset management a consultant was selected to support MWRA staff. The Phase I work was broken down into four (4) tasks: Inventory and Evaluation, Condition Monitoring System Design/Installation, CMMS Post-Implementation Audit and Maintenance Optimization Pilot Study. The scope and current status follow:

Inventory / Evaluation Task:

Scope: Gathered technical data (nameplate data, technical data and supplier information) and equipment condition information for 18 Field Operation Division (FOD) wastewater facilities comprising of over 3,800 assets including mechanical, electrical and instrumentation equipment. The collection of nameplate data is necessary to populate the computerized maintenance management system with equipment data so that preventive and corrective maintenance work can be scheduled, performed and tracked.

Current Status:

Inventory/Tagging: Tagging of equipment with a unique nomenclature/numbering system (consistent within the MWRA) was also included in this task. Temporary tags were initially installed and correct nomenclature verified prior to ordering and installation of the permanent tags. This task was completed with a mixed crew of MWRA and consultant staff.

The traditional method of gathering data on paper forms was eliminated by the use of hand-held (*Palm Pilot*) devices. The use of these units facilitated the work and helped meet the schedule for data input into the Field Operations Division's new CMMS. The reasonably priced *Palm Pilot*s were programmed with drop-down menus to accept all the required data and automatically generate the correct tag name. In addition, the correct permanent tag sizes (3 inch or 4 inch) and type (no hole, one or two hole) was also identified by design for ease of ordering.

Populate CMMS: The Authority selected MAXIMO as its standard computerized maintenance management system (CMMS). Although the DITP began using MAXIMO in 1995, the Field Operations Department only began using MAXIMO in March 2001. Again, the use of hand-held devices in the data collection efforts supported the ability to electronically load the newly collected technical data into MAXIMO, ahead of schedule.

Evaluate Equipment Condition: During the inventory /tagging exercise, the team conducted a cursory overview of the equipment's condition (visual, audible and discussions with facility staff) and summarized the general condition findings in a detailed report. The report categorized the condition into various pre-defined categories: Excellent, Good, Poor, Temporary and Failed. This information is assisting in corrective action planning and budgeting.

In a concurrent effort, a MAXIMO Steering Committee facilitated the MAXIMO standardization effort. Policies and procedures are being shared between operating divisions resulting in improved data quality and consistent performance reporting.

Condition Monitoring Design / Installation Task:

Scope: The Authority recognized that the project's maintenance optimization process would require predictive maintenance tasks, including vibration and temperature trending and analysis.

In Phase I, the MWRA identified seventy (70) pieces of rotating equipment as critical or of sufficient capital cost to warrant dedicated, permanent vibration monitoring equipment. The list of equipment such as pumps, motors, compressors and turbines is located at both DITP and FOD sites. Since these vibration-monitoring systems also rely on other machine conditions (such as temperature) to augment the vibration analysis, they are more appropriately called condition-monitoring systems.

Current Status: Currently the new condition monitoring system is in final stages of design and equipment installation is anticipated in 2003. Upon completion of the construction phase, vibration analysis training and establishment of equipment baseline vibration signatures will be conducted.

CMMS Post Implementation Audit / Survey:

An accurate and maintained computer maintenance management system (CMMS) is an essential component of a successful Asset Management Program. Deer Island has been using MAXIMO as its automated maintenance management software since 1995. This software package is a powerful maintenance management tool that is used by the Work Coordination Group to manage all aspects of the Deer Island maintenance program. MAXIMO is used for work order management, preventive maintenance, an equipment database, planning and scheduling, asset management, recording maintenance costs, and generating reports.

The scope and current status is presented below by category.

Scope: The objective of the DITP MAXIMO database post-implementation audit was to conduct a survey of DITP's computerized maintenance management system, MAXIMO, (for Primary Clarifier Battery "A" - a representative area of plant equipment data) and determine the status of its data quality, administrative review, its present utilization and training.

Post-Implementation Audit: A post-implementation audit was conducted on all equipment data stored in the MAXIMO system for Primary Clarifier Battery "A" totaling some 1,250 pieces of equipment. The equipment data was compared and reconciled with the source data (Source Data is the equipment nameplate/specification information provided by project contractors and their suppliers as part of the construction turnover requirements) to evaluate the quality, completeness, and accuracy of the data. The MAXIMO data modules surveyed included; Equipment, Inventory, Preventive Maintenance and Work Orders.

Additionally the MAXIMO and Source data was compared to the hard copies of all data located in the Deer Island Library. The review required a cross-reference included reviewing documentation such as vendor manuals, drawings, relevant process and instrumentation diagrams (P&ID) and some field verification.

MAXIMO Utilization: The project also included a review to determine the degree to which the MAXIMO system was being utilized by staff and identified areas where MAXIMO was under or over utilized. The review included the utilization of all program functions including the following:

- Cross-Links to Inventory.

- Performance reporting metrics. Identified unnecessary or ineffective maintenance reports and unused or underutilized performance reporting features.

- Identified appropriate performance metrics to be monitored by various levels in the management, maintenance, engineering, operations and budget departments.

- Reviewed existing MAXIMO procedures and interviewed staff regarding use and quality of equipment data and database performance.

- Reviewed the adherence and proficiency of labor and material charges to the appropriate equipment tag.

Training: A recommendation of the required training for users and planners was to be provided as part of the project.

Current Status:

A detailed corrective action plan (CAP) was created where deficient or substandard data and MAXIMO utilization was documented including detailed recommendations and estimated resources required. A summary of the findings follows.

Post Implementation Audit Results: The MAXIMO survey report details the following maintenance issues.

MAXIMO Data Quality - The quality of data in MAXIMO needs improvement. The MAXIMO survey completed an audit of Primary Battery A. Examples of areas needing improvement include the following:

- Missing Equipment – MAXIMO lists 1,247 equipment items for Primary Battery A, however, the DITP technical library actually has equipment data on 1,646 items – a 32% difference. Conversely, 100 pieces of equipment in MAXIMO were not in the Deer Island technical library. While the differences generally did not involve major equipment, it did include certain valves, pumps, and instrumentation. The omission of data in MAXIMO could possibly result in equipment not receiving the proper preventative maintenance.

- Missing Equipment Data - Incomplete equipment data was originally supplied as part of system turnover. A typical Equipment Data Form has approximately 30 data entry fields. Some of the data is obviously more critical than others. However, for the 1,247 pieces of equipment reviewed, the manufacturer's name was not provided for 313 items, the installation date was not provided for 327 items, and the installation cost and replacement cost was not provided for any of the equipment items. Omission of this cost data impedes 1) life cycle costing to be determined in an effort to predict future capital expenditures and 2) utilizing MAXIMO to its full capabilities.

- Tagging and Equipment Hierarchy - 196 equipment items had conflicting tags names or hierarchy. An accurate equipment hierarchy allows maintenance costs to be allocated (rolled-up) to the individual areas. Reports can then be generated to highlight which equipment, system, or plant areas required the most maintenance resources.

In order to correct the deficiencies noted above, an update of equipment data is planned in Phase II of the program. The update will ensure that the information triangle is complete and will include comparing and updating 1) installed equipment nameplate data, 2) MAXIMO data, and 3) the equipment technical library information. Currently, the 95% of the pilot's equipment data have been corrected. The remaining pilot data and balance of plant data will be updated in Phase II of the program.

Administrative Review: The report recommends the development of comprehensive maintenance policies and procedures to ensure the highest level of data quality to support a strong asset management program. This data is converted into useful information assisting in making accurate and timely maintenance decisions. These procedures would include maintenance planning workflow, MAXIMO database quality assurance, and procedures to formalize changes to the MAXIMO equipment, job plans, and preventative maintenance databases, as well as, a link to technical documentation.

Procedures to formalize the maintenance program are in development. The procedures developed under this task will be used Authority-wide to ensure a consistent approach for all maintenance activities. These procedures include Equipment Replacement/Maintenance Configuration Control and Workflow Process Procedures. A Work Planning Desk Guide has been completed and is in use at Deer Island and being reviewed for use throughout the MWRA. In addition, maintenance performance metrics are under development that will focus on reliability based maintenance.

MAXIMO Utilization: Deer Island currently utilizes approximately two thirds of the capability of the MAXIMO system that, reportedly, is the case with most other maintenance organizations. Additional utilization of specific MAXIMO modules and programming enhancements were recommended including Failure Reporting, Safety Plans and Required Fields. Programming changes are in the process of being implemented to increase the functionality of MAXIMO. An example includes development of the Condition Monitoring application to collect equipment health data (such as vibration and temperature points) which links that data to MAXIMO.

Training: Specific training guidelines were provided to ensure procedures and MAXIMO are used correctly. Specific MAXIMO training recommends included: All personnel - 4 hours/year and Planner/Scheduler staff – 40 hours/year. In addition, maintenance procedures training included: All personnel - 4 hours/year. Development of a formalized training program is in progress and will support the current cross-functional training program as well as enhance the widespread use of MAXIMO throughout the MWRA.

Maintenance Optimization Study:

In an effort to optimize agency-wide maintenance efforts various maintenance optimization strategies and various equipment replacement strategies required evaluation. The selected strategies would be included in a pilot study on DITP, Primary Clarifier Battery "A" equipment. Upon completion, the pilot results would be analyzed and conclusions and recommendations presented to senior staff for possible adoption throughout the MWRA.

The scope and current status is presented below by category.

Scope: The DITP currently utilizes calendar based preventive maintenance. All the equipment maintenance tasks and frequencies were provided by the Original Equipment Manufacturers (OEM) and their representatives as part of the Boston Harbor Project.

Maintenance Strategy Review: A review of various industry-wide maintenance optimization strategies (i.e. Total Productive Maintenance and Reliability Centered Maintenance) was conducted to gain efficiency of maintenance resources while maintaining or increasing plant reliability. The maintenance strategies were evaluated for the following:

1. Ability to establish or revise maintenance tasks based on the following (Maintenance tasks included Preventive, Predictive, and Proactive maintenance);

- Technical basis established for each equipment maintenance task.
- Clear cost benefit established for each equipment maintenance task.
- Maintenance practices established for equipment individually based on its specific application in the plant (i.e. its criticality to the plant or system process and the consequences of failure).

2. Ability to reduce overall maintenance man-hours (emergency, corrective, preventive) and maintenance material costs with no decrease in plant reliability.

3. Ability to identify hidden failures in plant systems or equipment.

4. Ability to establish Mean Time To Repair and Mean Time Between Failure for equipment.

5. Ability to extend the useful life of the equipment or plant systems as a whole.

6. Ability to provide feedback to the Facilities Asset Management Program to aid in the planning for equipment replacement.

7. Ability to work in conjunction with, support, or be integrated with the various Equipment Lifecycle methods evaluated.

8. Estimated cost of implementation (estimated time and effort of Consultant and Authority staff) for each maintenance strategy compared with the estimated maintenance savings (manpower, materials, extended equipment life etc.) for its respective strategy.

9. Ability to address and improve DITP maintenance metric benchmarks.

Benchmarking: In addition, an industry maintenance benchmarking exercise was included as part of the project.

Current Status:

Maintenance Strategy Review: The consultant reviewed various maintenance optimization strategies including Reliability Centered Maintenance (RCM), Total Productive Maintenance (TPM) and Failure Mode Effect and Criticality Analysis (FMECA) for use in the wastewater treatment industry. A detailed report recommended the DITP pilot the use of the maintenance strategy, RCM.

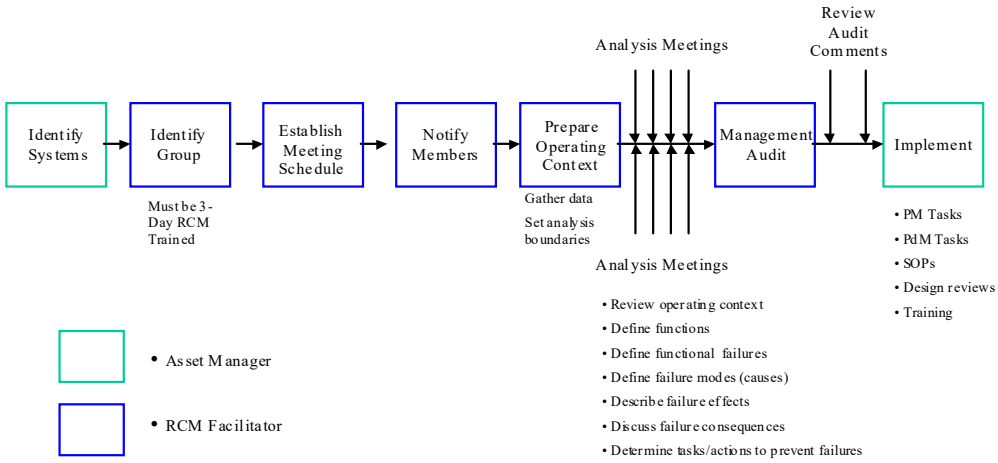
RCM was selected to pilot because it is capable of answering many of the questions and concerns posed above including the review of impacts to safety and the environment. In addition, the RCM process is historically, more effective in process plants where the TPM strategy better supports a manufacturing (close operator to machine interface) environment. Over all, RCM is able to meet the MWRA's main objective - gain efficiency of maintenance resources while maintaining or increasing plant reliability.

Twelve (12) pre-selected systems were identified within an area of the plant (a cross section of equipment located in the Primary Clarifier Battery "A" area) where the use of the RCM methodology would be piloted and performance metrics compared to adjacent equipment (which use OEM based PM tasks and frequencies) for a six month period.

RCM is a process where through the use of structured questions and a "decision tree" maintenance and operations staff jointly recommend the most appropriate maintenance requirements (including tasks, frequencies and trades) of a physical asset (system or component) as it is operated at each facility. History has shown that the equipment vendor's preventive maintenance (PM) recommendations tend to be conservative and do not always adjust for varying operating scenarios (i.e. does the pump run continuously for 24 hours or cycle on-off every 40 minutes, or run once a week for 10 minutes).

Presently the RCM pilot program has completed implementation of the twelve (12) system reviews using the RCM process (illustrated below) and monitoring of results continues with a full analysis report anticipated in early 2002.

RCM Review Process



The pilot results to date include a significant decrease in PM hours (25% reduction in PM labor hours) and 10% overall decrease in maintenance costs. In addition, the pilot area has resulted in higher equipment availability and overall improved performance. While the results to-date are preliminary and somewhat narrowly focused, they are encouraging. The RCM process provides a mechanism to optimize an organization's maintenance program. The major outcome is a revised, optimal mix of predictive and preventive maintenance tasks and frequencies that best meet the plant's operating goals

The vast majority of operations and maintenance staff that at the outset were resistant to utilizing the RCM approach have now embraced the process. The change in attitude is attributed to improved knowledge of the system and greater participation in the decision making process. RCM promises to be an integral part of MWRA's ongoing effort to improve organizational efficiency and effectiveness, and optimally maintain the assets under its stewardship.

Benchmarking: The maintenance strategy review also included the following benchmarking activities:

Telephone Survey: The survey included results of discussion with six large facilities (five public utilities supplying water and wastewater services in a manner broadly equivalent to the MWRA operation, and a steel mill that is striving to be at the forefront of asset management/maintenance management technology).

The set of questions prepared for the survey addressed:

- Business strategy;
- Organizational structure, roles and responsibilities;
- Maintenance strategy;
- Works orders;
- Maintenance management systems;
- Asset management policies;
- Maintenance staffing;
- Procurement;
- Warehousing.

The results include that, in general, the unionized and public (utility) facilities have further to go to achieve world-class asset management when compared to private, non-union counterparts. Private facilities also acknowledge that there are opportunities to improve. Benchmarking has shown that private organizations often have within their asset management program "pockets of excellence" and areas of relative weakness.

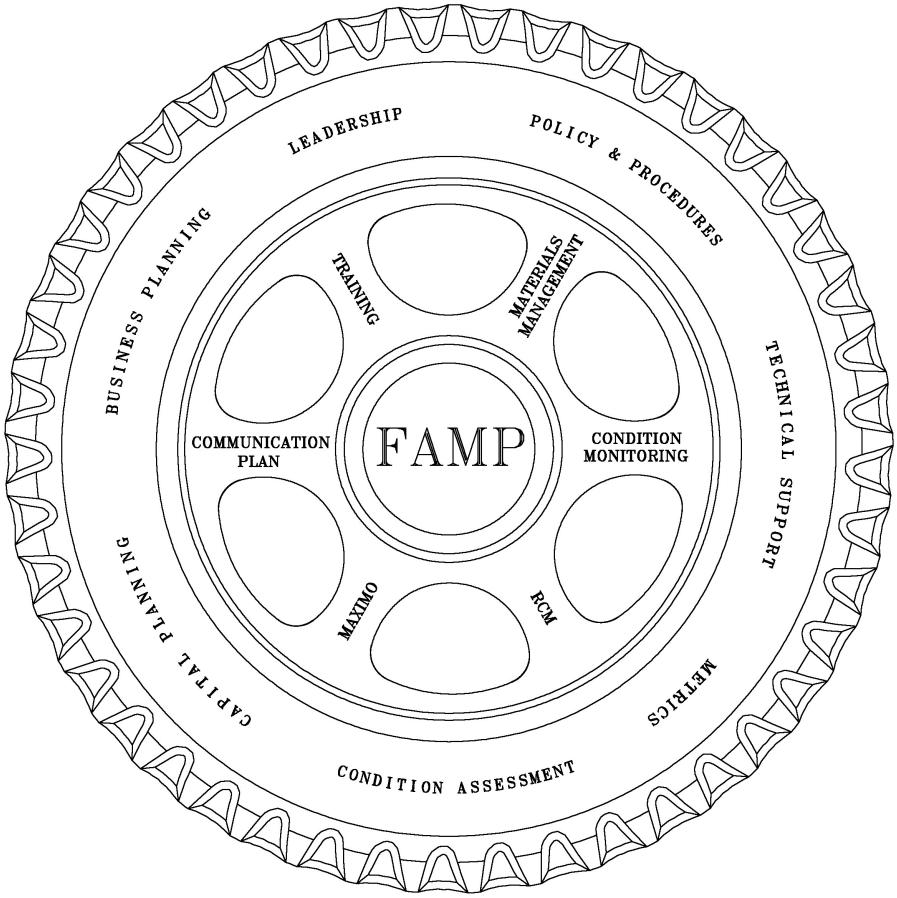
Site Visits: Two site visits at other facilities were conducted for the purpose of observing and investigating any implemented (in progress) maintenance optimization strategies/programs considered for the FAMP project.

For many reasons the timing of the site visit was perfect and a turning point for the project for the following reasons.

- Confirmed the use of RCM as a viable maintenance strategy,
- Confirmed the need for a comprehensive Condition Monitoring program,
- Helped set the roadmap for future activities,
- Served as a workshop empowering staff to consolidate the valuable lessons learned by others and add them to the recipe for a successful program,
- Validated that a comprehensive asset management program at a Company can achieve world-class status.

Key Lessons Learned from Site Visits:

- Treat the program as a capital project (dedicated staff, schedule with milestones, involvement from all business functions),
- The Computerized Maintenance Management System must be populated with accurate data,
- RCM is a proven maintenance strategy and can build a strong operations and maintenance workforce,
- Identified the underlying need for Executive Sponsorship and a Communication Plan to effect culture change,
- There are many spokes to the asset management wheel as indicated below.
- Communicate "short-term wins" to show program impact and sustain implementation momentum.



FAMP Wheel

PHASE I - RESULTS AND BENEFITS

In the development of a strong Asset Management program it is important to reach out to all available resources. Program successes need to be documented and shared to guide your organization through short-term wins on its way to achieving world-class status. Here are some of our milestones.

The program has had early success because of the changes initiated from the site visit activities and resulting "technology transfer". These successes were possible only with the support and dedication of our staff that have balancing normal workloads while implementing the new maintenance practices. The results have been significant in many ways including:

National Award: In May 2002, the MWRA's FAMP initiative received national attention at the Association of Metropolitan Sewerage Agency's (AMSA) 2002 National Environmental Achievement Awards in the *Operations* category. It is clear that the MWRA is leading change in utility asset management as it demonstrated an "innovative and effective project developed and implemented in a cost-effective manner while achieving environmental compliance".

Staffing Reductions: The maintenance staff at Deer Island has decreased from a high of 176 in 1999 to 142 staff today. The reduction occurred even though more equipment required maintenance as each construction package was turned over. The staff reduction has not impacted the maintenance provided. The maintenance backlog is anticipated to remain within industry standards (3-6 weeks).

Work Schedule: Historically work orders were scheduled daily by the supervisors. The Work Coordination Group initiated scheduling work one week in advance to help our program move from reactive to proactive maintenance. The goal of this initiative is to have maintenance staff thinking about work one week in advance and plan for parts, tools and labor. In addition, each technician is assigned 8 hours of work for each day. In the first six months, the number of corrective maintenance and project work orders decreased from 2568 to 1586 or a 38% reduction. Work Order backlog has been reduced from 6 weeks to 3 weeks from the implementation of this scheduling initiative. The reduced backlog has resulted in higher equipment availability and improved plant performance.

Teamwork: Through the RCM effort and Task Team development teamwork is at its highest levels. The RCM effort has built bridges between the Operations and Maintenance staff. The task teams have resulted in a wider circle of MWRA staff being involved in the project and moving toward a common goal. In addition, the implementation of a cross-functional flexibility program includes multi-trade teams working together on maintenance activities.

RCM Pilot Results: The pilot results to date include a significant decrease in PM hours (25% reduction in PM labor hours) and 10% overall decrease in maintenance costs. In addition, the pilot area has resulted in higher equipment availability and overall improved performance.

Alliances Built: Industry site visits and conference attendance has allowed MWRA staff to build a network of asset management alliances. This network provides an on-going opportunity to share ideas and lessons-learned, helping those involved from travelling down the wrong road that could result in lost time and money. MWRA's goal is to continue developing alliances in its effort to reach world class status.

PHASE II – SCOPE AND ANTICIPATED BENEFITS

The asset management program is one of *continuous improvement* and is often quoted as "it is a journey – not a destination". As shown in the Model, FAMP is a multi-phase program and Phase II has been initiated. The Phase II program will begin to implement results of the Phase I efforts throughout the MWRA organization as summarized below.

Business Practices:

Scope	**Benefit**
Standardized procedures	Efficiency
Asset replacement methodology	Controlled spending
Performance Improvement Plan (PIP)	Efficiency

Maintenance Strategy:

Scope	Benefit
RCM Rollout at DITP	Optimization of O&M resources; asset reliability
RCM Rollout at Field Operations Division	Optimization of O&M resources; asset reliability
Spare Parts Optimization	Efficiency; cost control

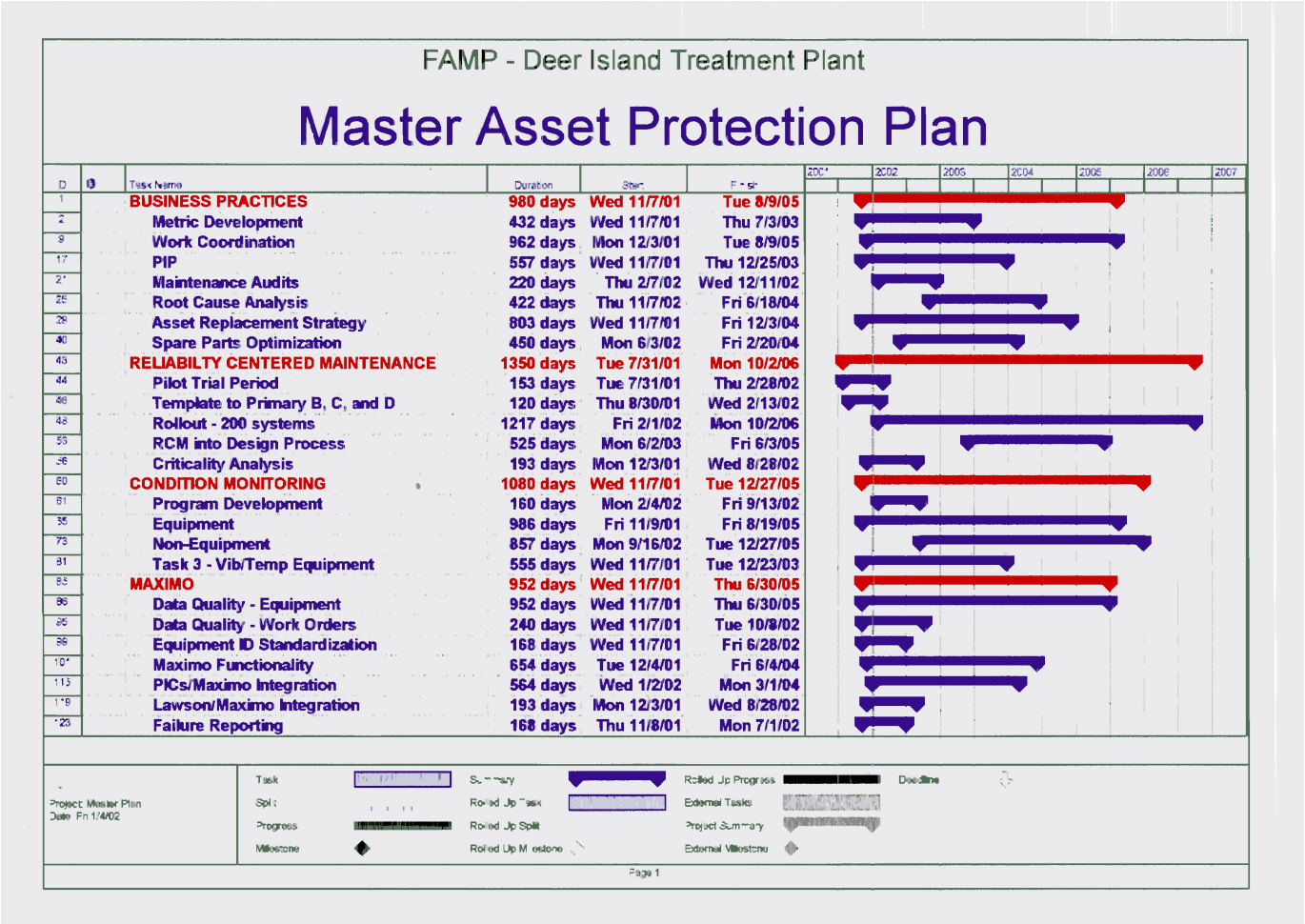
Condition Monitoring:

Scope	Benefit
Review Available Techniques	Proactive maintenance approach
Lubrication Program Pilot	Cost savings; higher equipment availability
SCADA & Condition Monitoring Installations	Automation; proactive maintenance

Maximo:

Scope	Benefit
Implement Improvement Plan	Data quality and integrity
Post Implementation Audit at FOD	Data quality and integrity
Integration with Financial system	Capture total costs for asset replacement decisions

In addition, a master schedule (or Master Asset Protection Plan – MAPP) has been developed to set implementation targets and monitor program progress.



Master Schedule - MAPP

To implement these new programs new Task Teams have been formed as follows:

- Metrics
- Reliability Centered Maintenance Implementation
- Criticality Analysis
- Condition Monitoring
- Permanent Condition Monitoring Equipment Installation
- Maintenance Procedures
- Asset Replacement Strategy
- Warehouse Optimization
- Work Coordination/Maximo

Team Charters were developed for each task team to facilitate the MAPP implementation plan of best practices throughout the organization. The task teams have support throughout the Authority and include representatives from maintenance, operations, process control, finance, budgeting, planning, warehouse, and management.

In order to continue with a successful program some basic elements will remain in place to maintain the momentum.

- Regular staff briefings,
- Team Building,
- Agency-wide coordination,
- Communication plans,
- Intranet site development,
- Industry-wide benchmarking,
- Maintenance performance monitoring.

CONCLUSION

The success of a comprehensive asset management program requires careful planning and a commitment of resources. This is a difficult task with pressures of normal workloads and competing corporate initiatives. Executive sponsorship, designated champions in each business unit and continuous communication at all organizational levels can facilitate the change required to maintain a successful asset management program.

The overall objective of asset management is to put an optimal program in place that includes the use of industry best practices. To be successful and fully realize maximum benefit, all components need to be fully integrated and implemented in a comprehensive initiate. Key components such as RCM, MAXIMO, Condition Monitoring, Materials Management linked with Training programs and a regular Communication Plan have led industry leaders to world-class results.

Based on our diligence and continuous research it is clear to us that the MWRA's strategic FAMP initiative for asset management practices will assist in protecting our ratepayer's investment and extending the life of our assets and facilitate our becoming more efficient and competitive in the changing world of privatization.