FINAL REPORT

Prepared for

Milwaukee Water Works

Safe, Abundant Drinking Water.

as part of the

ELECTRIC POWER RELIABILITY EVALUATION

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EXECUTIVE SUMMARY

INTRODUCTION

The Electric Power Reliability Evaluation was a multi-disciplined project that took a comprehensive look at Milwaukee Water Works' (MWW) power reliability on "both sides of the meter." The evaluation included an assessment of reliability of the local and regional power utilities' facilities as well as an evaluation into what MWW could do to improve reliability within their own system. The primary objectives of the evaluation were as follows:

- Provide MWW with benchmarking data and lessons learned from other water utilities pertaining to emergency power and ability to cope with a widespread power outage.
- Evaluate the local and regional reliability of the electric system that feeds MWW facilities.
- Determine realistic water demand scenarios and determine MWW facilities that are critical to treating and delivering safe drinking water to its customers.
- Evaluate MWW critical facilities to determine emergency power requirements and any deficiencies in the existing electrical system that would require modifications prior to implementing emergency power.
- Prepare conceptual designs for emergency power systems at each of MWW's critical facilities including conceptual layout and life cycle costs.

NORTHEAST BLACKOUT OF 2003

At 4:11 p.m. on August 14, 2003, power went out across a large portion of the Northeastern United States and Canada, throwing 50 million people into complete darkness; and it took nearly 30 hours to fully restore power to all customers in Cleveland, which was one of the hardest hit cities.

The Cleveland Division of Water (CDW) has published information and conducted meetings discussing their experience with the blackout. Black & Veatch contacted CDW as well as other utilities in the region, to gather additional information and lessons learned from their blackout experiences. Also Black & Veatch conducted a Water Utility Benchmarking survey as a means of assessing the norm within comparable water utilities throughout the United States.

WATER UTILITY BENCHMARKING

Water Utility Benchmarking survey questions were designed to gather critical system criteria for comparative analysis with in-depth questions focusing on emergency power provisions within each water utility. The information and data were obtained and used as a foundation for analyzing MWW power reliability. The following observations were made:

- Some utilities had various emergency power capabilities.
- Each had varying amounts of pumping and storage requirements.
- Each was dependent on the storage levels of the finished water tanks.
- Air entrainment in the system must be accounted for and released immediately upon restoration of service.
- Chlorine feed should be boosted for the first week after an extended outage to meet increased demands resulting from scouring of solids.
- Tank levels should be controlled to avoid pump tripping and permit use of system pumps upon start-up.

POWER FAILURE RISK ASSESSMENT

It is prudent for MWW to plan for the possibility of a regional outage similar to what occurred in the Northeast in 2003. Although a regional outage is less likely than a local outage, the effects of a regional outage could be much greater that an outage that occurs on a local level only. The Power Failure Risk Assessment Report (Appendix A) included review of available public information with regard to emergency preparedness and reliability audits that have been completed since the Northeast blackout. In addition, a face to face workshop between We Energies (WE), American Transmission Company (ATC), MWW and Black & Veatch took place to discuss the regional and local power system and the reliability of those systems as they relate to MWW. The conclusions of this phase of work are that the WE/ATC systems are generally reliable and a widespread power outage similar to the 2003 Northeast Blackout is not likely to originate from WE/ATC systems. However, neighboring systems on the grid could negatively affect the WE/ATC system and as such, a regional power outage similar to the 2003 Northeast Blackout is still possible.

EMERGENCY POWER NEEDS ASSESSMENT

Through internal discussions and prior emergency operations, MWW was able to determine the facilities within its system that are deemed critical for daily operation. The existing electrical systems of these critical facilities were then assessed for their ability to support emergency power operations. Concurrently, it was determined based on past pumping data, that five water demand scenarios would be used as bases for conceptual emergency power system designs for each critical facility. Minimum day demand equated to the minimum quantity of water used in recent years for a 24-hour period. Average day demand is a calculated value of the annual average quantity of water delivered to customers over a 24-hour period. High demand equates to historically high demands. Maximum day demand equates to a historical 24-hour peak demand period, whereas the maximum hour demand is a peak water demand seen in a one hour period.

We have assumed that the following water treatment processes would be operational:

- Coagulation and clarification
- Filtration
- Disinfection

Due to the power consumption of the ozone system, it was determined that any emergency power system would not power the ozone process. The above listed processes enable MWW to meet all current drinking water quality regulations.

EMERGENCY POWER CONCEPTUAL DESIGNS

Based on the reviews of existing electrical equipment at each critical facility and the electrical loads required to meet the four water demand scenarios, emergency power systems for each critical facility were developed on a conceptual level. Site layouts for the emergency power systems were produced and conceptual cost opinions were made for both initial capital expenditure as well as ongoing operation and maintenance costs. The life cycle costs for each demand scenario are shown in Table ES-1 below:

Table ES-1: Emergency Power Systems Project Costs

Demand Scenario	Water Demand, mgd	Project Cost, $	Annual O&M Cost, $	Present Value, $	Unit Cost of Water able to be Produced, $/mgd
Minimum Day Demand	95	$17,438,000	$30,900	$17,900,000	$0.19
Average Day Demand	120	$21,509,000	$38,600	$22,090,000	$0.18
High Day Demand	150	$23,780,000	$42,900	$24,420,000	$0.16
Maximum Day Demand	200	$46,390,000	$55,100	$47,210,000	$0.24
Maximum Hour Demand	250	$51,381,000	$64,700	$52,350,000	$0.21

CONCLUSIONS & RECOMMENDATIONS

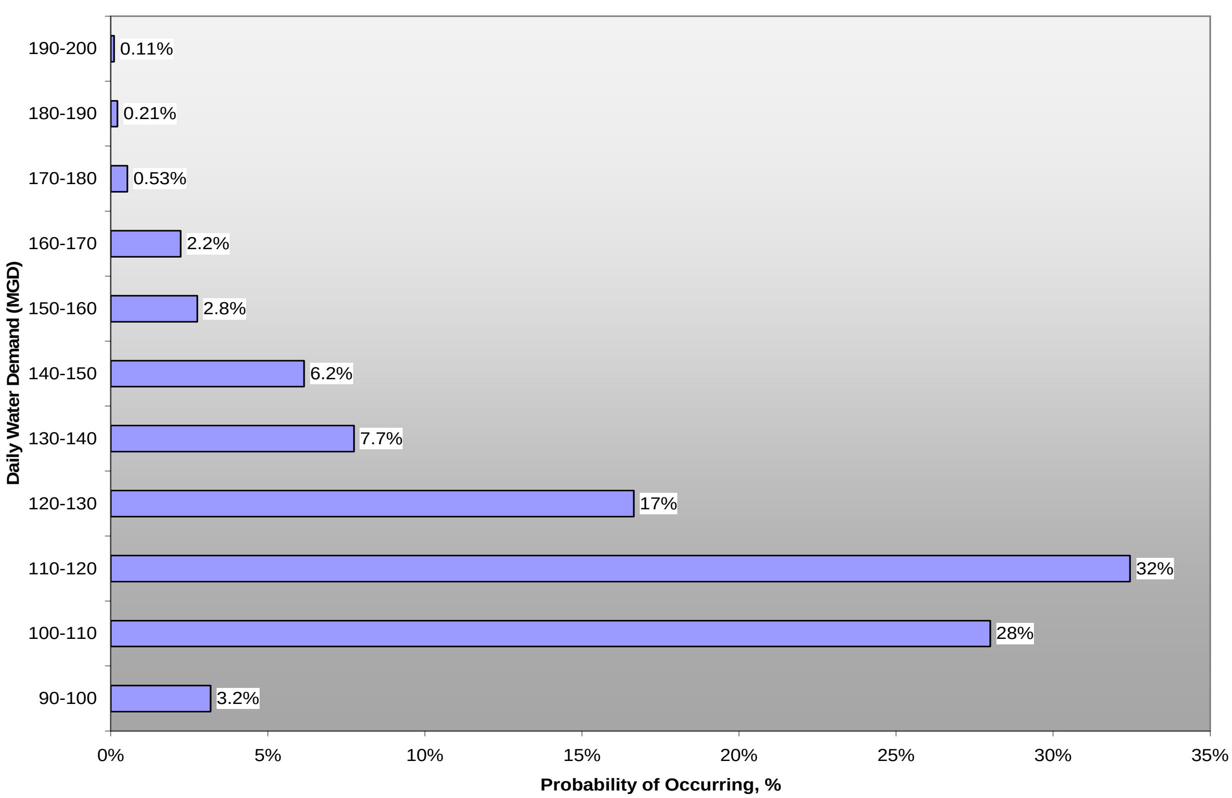
Through the assessment of MWW's potential for a local or regional power outage, it has been concluded that the electrical feeds to MWW's critical facilities are generally reliable. Although this is not to suggest that local or regional outages will not occur, their likelihood is minimal. In fact, in recent memory, none of MWW's critical facilities have experienced extended power outages due to local or regional power issues.

Although, the probability of a power outage may be low from both a technical and anecdotal point of view, the risks associated with not being able to provide water to the community during a local or regional power outage could be very high. MWW's distribution pumps are the primary mode of system pressurization due to the lack of elevated storage in the system and as such are critical for maintaining sufficient pressures in the distribution system.

The ability of MWW's pumps to maintain sufficient pressure in the system is absolutely critical for fire fighting, prevention of groundwater intrusion and other potential sources of contamination of the water in the distribution system. The minimum pressures in the distribution system below which boil orders must be issued is 20 psi and without emergency power during a prolonged power outage, this pressure would be difficult, if not impossible to maintain. Without emergency power generation capabilities at MWW's critical facilities, the city is vulnerable to fires as well as widespread water contamination and possible outbreak of disease.

Therefore, it is strongly recommended that MWW consider implementing emergency power at each of the critical facilities. Of the five demand scenarios evaluated, the emergency power improvements required to meet the high day demand of 150 mgd is the most cost effective in terms of the quantity of water produced per dollar spent. As can be seen from Figure ES-1, at this level, MWW would be able to provide adequate water to the community 94% of the time without restricting water usage while providing emergency power for 120 mgd only allows MWW to provide adequate water 63.5% of the time with restricting water usage. At the extreme ends of the spectrum, the minimum water demand of 95 mgd only occurs approximately 3% of the time and the maximum day and maximum hour demands only occur less than 0.1% of the time. Since the High Demand scenario of supplying 150 mgd during an emergency provides the biggest "bang for the buck" as well as allowing MWW to provide adequate water in an emergency up to 94% of the time, it is recommended that emergency power systems be implemented at MWW's critical facilities to provide for the high day water demand of 150 mgd.

Figure ES-1: Water Demand Probability



1.0 INTRODUCTION

The Electric Power Reliability Evaluation was a multi-disciplined project that took a comprehensive look at MWW's power reliability on "both sides of the meter." The evaluation included an assessment of reliability of the local and regional power utilities' facilities as well as an evaluation into what MWW could do to improve reliability within their own system. The primary objectives of the project were as follows and reference to the appropriate report located in the Appendices:

- Provide MWW with benchmarking data and lessons learned from other water utilities pertaining to emergency power and ability to cope with a widespread power outage.
- Evaluate the local and regional reliability of the electric system that feeds Milwaukee Water Works' facilities.
- Determine realistic water demand scenarios and determine MWW facility's that are critical to treating and delivering safe drinking water to its customers.
- Evaluate MWW critical facilities to determine emergency power requirements and any deficiencies in the existing electrical system that would require modifications prior to implementing emergency power.
- Prepare conceptual designs for emergency power systems at each of MWW's critical facilities including conceptual layout and costs.

2.0 NORTHEAST BLACKOUT OF 2003

At 4:11 p.m. on August 14, 2003, power went out across a large portion of the Northeastern United States and Canada, throwing 50 million people into complete darkness. Although power outages occur from time to time, the U.S. had never experienced a blackout of the magnitude experienced that day. For example, it took nearly 30 hours to fully restore power to all customers in Cleveland, which was one of the hardest hit cities.

2.1 BLACKOUT CAUSES AND EFFECTS

The 2003 Electric Power Blackout in the northeast U.S. was attributable to several factors that the U.S. - Canada Power System Outage Task Force classified into the following four groups:

Group 1: The inability of the triggering utility, First Energy (FE), to assess the condition of voltage instability and inadequacy on its system and to take appropriate remedial actions. While the North American Electric Reliability Council (NERC) has established planning and operational voltage requirements for utilities in the U.S., FE was found to have failed to conduct the studies of its system or to apply the appropriate operational criteria necessary to handle the multiple contingencies that occurred on August 14, 2003. In addition, the East Central Area Reliability Council (ECAR) within NERC was found not to have monitored FE's practices so as to identify and remedy the deficiencies. Finally, NERC's planning and operational requirements were found to be somewhat ambiguous allowing FE to interpret the requirements as including insufficient practices. As a result, FE allowed the voltage on its system to drop perilously low in places prior to the blackout's triggering events.

Group 2: Inadequate awareness of the actual situation on the FE system which led to FE's failure to recognize the rapidly deteriorating conditions on its system and to take remedial actions. FE was found to have insufficient system monitoring tools and communication systems to fully understand which and how many transmission facilities were operating outside normal limits. As a result they thought only two contingency conditions had occurred when in reality more lines were out of service. They were without sufficient additional or back-up system monitoring tools.

Group 3: FE failed to employ adequate tree trimming allowing three of its 345-kV and one 138kV transmission lines to sag into trees and fail during the hot weather condition.

Group 4: Failure of the interconnected grid to provide real-time diagnostic support so that the full cascade of the blackout could have been avoided. While the Midwest Independent System Operator (MISO) maintains a sophisticated computer model of much of the interconnected grid in the Midwest which it uses to run continuous contingency cases and to plan remedial actions, the information in the model was found to be inaccurate at the time of the blackout precluding the opportunity for MISO to provide diagnostic assistance to FE. The MISO coordinators were found to be using non-real-time data to support real-time monitoring. As a result they failed to detect a security violation on FE's system. Finally, MISO and the Pennsylvania, New Jersey and Maryland interconnect (PJM) were found to lack joint procedures to coordinate a response to the security violations that occurred.

As a result of the above conditions, the following events took place on August 14, 2003:

- The disturbance started in Cleveland on the FE system;
- Soon FE began pulling the equivalent of 20 percent of Detroit Edison's load from Michigan;
- Next, Michigan's two independent transmission companies automatically became separated in order to protect the system;
- As a result, the electrical flow around Lake Erie was reversed pulling power from New York and Ontario through Michigan. All the while, overloaded transmission lines were beginning to load up and sag; and
- Finally as generation in Southeast Michigan collapsed under the strain, the lights went out.

Details of the Task Force findings are contained in the NERC report titled "Final Report on the August 14, 2003 Blackout in the United States and Canada". A copy of the report can be obtained from the NERC website http://www.nerc.com/~filez/blackout.html. A listing of other NERC reports on the Blackout is also included on this website.

2.2 REGULATORY REACTION AND INDUSTRY RESPONSE

Regulatory reaction to the 2003 Blackout has been substantial. NERC and FERC are together implementing extensive measures aimed at significantly reducing the probability that another cascading blackout is triggered in the U.S. These measures include the issuance of operating procedures and standards to improve vegetation management, operator training, and communication and control systems such that the conditions and events that have triggered previous blackouts are not repeated.

These new operating procedures and standards address the following aspects of electric system operation:

- Control of the interconnected grid
- Monitoring of system conditions
- Interchange coordination
- Planned outage coordination
- System protection and contingency planning and coordination
- Disturbance reporting
- Normal operations and emergency operations planning
- System restoration planning
- Telecommunications
- Operator training

The purpose of these standards and procedures is to ensure that:

- All transmission owners, reliability coordinators, and interchange parties operate their interconnected systems in a way that maintains the reliability of the entire grid under normal, contingency and emergency conditions;
- The cascading impact of contingency or emergency conditions is limited by shedding load if necessary;
- Communication and reporting systems are required to enable an accurate evaluation of system conditions at all times and to allow for the prompt analysis of any system disturbances that do occur; and
- A restoration plan is developed that will re-establish the integrity of the interconnected grid as quickly and safely as possible should a partial or total shutdown occur. The accommodation of interchange transactions is included in these standards and procedures with the intent being to ensure that such commercial transactions are curtailed or modified before they are allowed to adversely impact the reliability of the grid. In addition, vegetation management (tree trimming) plans are also prescribed to reduce the

probability of outage triggering events like those that caused the last several regional outages in the U.S.

Prior to the August 2003 blackout, many of the standards and procedures described above were used by the transmission owners and operators in the Eastern Interconnect. However, coordination and compliance was on a voluntary basis and systems with good procedures and practices were still subject to the outages caused by systems with less than good practices. The intent of the new standards is a concerted effort by NERC and FERC to not repeat past mistakes and to ensure that minimum reliability standards are maintained by all the interconnected systems.

In addition, while the evolution of the Midwest Independent System Operator (MISO) will undoubtedly encourage even greater commercial transactions and power flows on the regional grid serving MWW, the standards and procedures described above are designed to enable the maximum use of transmission facilities without compromising reliability. MISO is continually improving its simulation model of the entire MISO and interconnected grids known as the State Estimator. The State Estimator is a hardware/software model built from smaller, tested sub-regional models of the grid that receives extensive load, transaction and system condition data in "real time" and performs numerous contingency analyses on an ongoing basis in order to produce effective measures to correct and contain system disturbances, contingencies or emergencies and to simultaneously provide accurate evaluations of the impacts of commercial transactions.

While the potential for another regional blackout cannot be eliminated, the implementation of the new NERC standards should improve the overall reliability of the interconnected grid relative to its reliability in the absence of such standards. At this time, it is impossible to predict whether this will result in an increase in regional reliability in absolute terms or just maintenance of current regional reliability levels in the presence of increased transactions without significant increases in transmission infrastructure investment.

In summary, regulators have developed an extensive set of new operating standards and procedures aimed at eliminating the causes of the 2003 and previous blackouts with the hope of averting future blackouts. Many of these recommendations have been implemented and many others are in progress.

In addition, the Energy Policy Act of 2005 was signed into law on August 8, 2005. Implementation of the requirements in the Act, also known as the U.S. Energy Bill, will require significant resources and persistent oversight. The Act encourages investment into a reliable energy infrastructure through the following requirements:

- Requires the creation of an independent electric reliability organization (ERO) that will have the ability to establish and fairly enforce mandatory reliability standards governing the use of its transmission grid in North America. On July 20, 2006, FERC certified NERC as the nation's ERO.
- Mandates the adoption of reliability standards for the electricity transmission grid. As the ERO, NERC will be responsible for developing and enforcing mandatory electric reliability standards under FERC oversight. The standards apply to all users, owners, and operators of the bulk power system.
- Support and funding for the enforcement of recommended standards and procedures. In anticipation of becoming the ERO, NERC submitted 102 reliability standards for FERC review. FERC has announced subsequent rulemaking sessions to be held later in 2006 where these standards will be reviewed. Once the standards are in place, NERC will have responsibility for enforcement. As the ERO, NERC will direct violators to comply with the standard and impose penalties for violations.
- Provides incentives for grid improvement and reform of transmission authorization rules.
- Establishment of clear lines of responsibility between the reliability councils, regional transmission organizations (RTOs) and other organizations with a stake in the electric industry.

The Power Failure Risk Assessment Report, included in Appendix A, summarizes the risk of a regional power outage occurring in Wisconsin similar to what occurred in the 2003 Northeast Blackout.

2.3 WATER UTILITY EXPERIENCES

Cleveland was one of the primary cities which was affected by the 2003 blackout, and as such, the Cleveland Division of Water (CDW) has published information and conducted meetings discussing their experience with the blackout. Apart from referencing their published information, titled "Blackout 2003 – The Cleveland Division of Water's Experience," Black & Veatch personnel also contacted the CDW to gather additional information from them and lessons learned from their experience. The section presented below discusses and summarizes the information obtained from Cleveland. In addition, various other utilities within the August 2003 blackout region were contacted to primarily obtain information regarding the utilities "predicted demand" for the days of the blackout and the "actual demand" experienced during the extended outage. It was hoped that the survey would provide some guidance on the demand level that MWW should anticipate in their system in case of a similar future blackout.

2.3.1 Cleveland Experience

CDW provides a treated water supply to 1.5 million people in the greater Cleveland area. The CDW system is heavily dependent upon pumping treated water to its customers. The requirement for pumping is due to the fact that Lake Erie, CDW's source of water, is at the lowest elevation in the system. Therefore, when the blackout occurred, CDW lost the ability to produce and distribute drinking water. However, water service was maintained in some areas of the distribution system throughout the crisis due to stored water, diesel-driven pumps and local topography.

Some basic statistics of the CDW system are as follows:

- Serves 1.5 million people over 640 sq. mi.
- Four water treatment plants (total 537 mgd)
- Four primary and 11 secondary pump stations
- Three reservoirs, 11 elevated tanks, seven ground storage tanks (total 492 MG)
- Approximately 4800 miles of mains
- Historic maximum day demand was 476 mgd (1988)
- Average day demand is 240 mgd

The blackout severely impacted CDW's ability to provide water service to its customers. Approximately 80% of CDW's distribution system experienced partial water outages, with some areas harder hit than others. Although the worst hour of the impact varied among service districts, overall, the most critical period was at 4:00 am August 15, 2003, when 14% of CDW's customer accounts were without water and another 23% experienced pressure less than 20 psi. The longest duration any customer was without service was 21 hours. As a result of the lack of water and compromised water quality in the remainder of the distribution system, CDW issued a boil advisory that affected approximately 80% of its customers.

Black & Veatch personnel contacted Mr. Rolfe Porter, Assistant Commissioner of Cleveland Division of Water to discuss first-hand CDW's experience with the blackout of 2003. The important points are summarized below:

- CDW was without incoming power for about 12 hours. Power went down at about 4 pm on Thursday, August 14, and came back up at about 4 am the next morning for one plant and by 8 am that same morning for the other plants.
- CDW has standby power at their plants that can run their control systems and HVAC. They could not run their raw water or finished water pumps, so there was no water going into the distribution system. They have about 20 mg of storage at each plant and a 135 mg finished water reservoir in their low service area.
- CDW went on a boil water notice.
- During the outage, CDW sent personnel to different sites in the system to measure pressures and tank levels as they had no SCADA system. CDW did not conduct any extra water quality monitoring.
- System pressures dropped, but gradual enough that it did not create any major problems.
- CDW did not lose chlorine residual in the system, and did not have any positive coliforms. There were a few discolored water complaints.
- CDW took about one to two hours to start up the plants after power returned. Coincidentally at that point in time, several major construction projects were ongoing at the plants. CDW personnel had been conducting major plant shut-downs and start-ups and therefore were very familiar with the steps to be taken to bring the plants online. Some of the plant filters had dried up, and had to be backwashed before being started-up. At no time did CDW have to waste water leaving the plant as they were able to meet regulations immediately. They experienced some transient odor problems upon start-up because of the sudden influx of water through the intakes.
- CDW did not boost chlorine feed upon start-up, but in hind sight they should have because after several days to a week, they began to lose chlorine residuals because of higher demands at the extremities of the system. Another factor was probably because of the sediment that had been scoured up in the pipes.
- One of the problems CDW encountered upon start-up was entrained air in the system. CDW personnel had to conduct extensive flushing to remove the entrained air. Flushing was performed at high points in the system and also based on customer complaints.

- Another issue CDW faced was restarting distribution system pumps. Tanks that had been almost emptied did not have sufficient water levels for the pumps, and so it took a while to repressurize the system as pumps were constantly tripping out.

For planning purposes, one of the most important items of information obtained from CDW's experience was the actual demand experienced in the system (e., did customers start using and storing more water in the anticipation of a long outage, thereby increasing demand, or was demand as anticipated or lower than usual due to the outage?). The following summary statistics and chart obtained from the publication "Blackout 2003 – The Cleveland Division of Water's Experience," addresses this question.

Projected CDW demands:

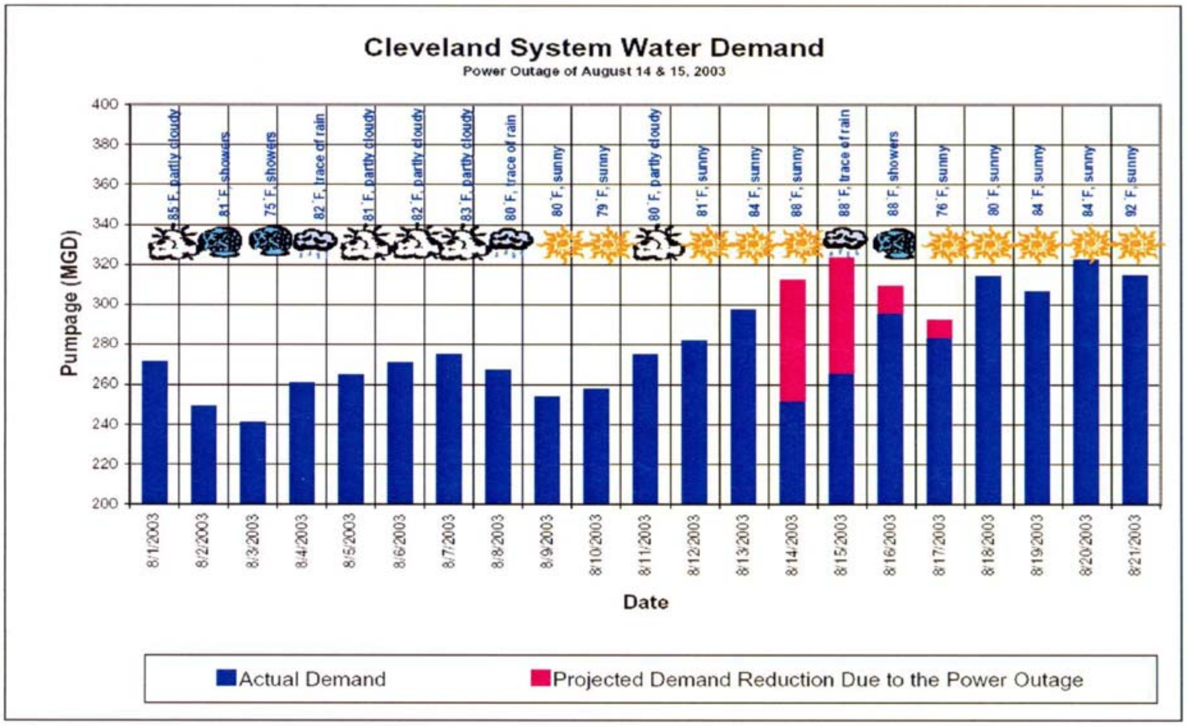
August 14 - 311 mgd
August 15 - 322 mgd

Actual demands (means of calculation unknown):

August 14 - 250 mgd (80%)
August 15 - 264 mgd (82%)

Figure 2-1 illustrates Cleveland's actual and projected water demands for the month of August 2003.

Figure 2-1: Cleveland System Water Demand



Source: Blackout 2003 – The Cleveland Division of Water's Experience

2.3.2 Other Utility Experiences during the Blackout

A survey was conducted to evaluate how other water utilities within the 2003 blackout region were affected. The survey was carried out by contacting several utilities within this region and obtaining information primarily regarding the utilities "predicted demand" for the days of the blackout and the "actual demand" experienced during the extended outage.

Although the 2003 blackout was an extensive regional power disruption that affected the majority of Northeastern U.S. and portions of Southeast Canada, the conditions or the effects of the outage varied among the utilities surveyed. The following seven utilities were contacted as part of the survey.

- Buffalo, NY
- New York, NY
- Erie County, NY

- Detroit, MI
- Philadelphia, PA
- Toronto, Canada
- Region of Peel, Canada

Some utilities, though located within the blackout region, never lost electrical power due to electrical inter-connections with power utilities that remained operational during the power outage. Other utilities were fortunate to have a gravity fed distribution system in which case the outage had a negligible impact on their system. Most utilities that encountered the power loss experienced a complete loss or partial loss of electric service. Many water utilities did not have any available data to evaluate the effects of the power outage on their system because of the loss of instrument signals, computer systems or simply unreliable data from SCADA system interruptions.

Erie County, NY and Toronto, Canada were the only utilities contacted that had reliable data available for the comparison of the “predicted demand” verses “actual blackout demand”. The results in both cases showed only a small, approximately 5 to 15 percent, reduction in the water service demands experienced during the period that they were without power, compared to their predicted demands for those periods. The following figures, Figure 2–2 and Figure 2–3, show the line and bar plots of the water service demand for these two utilities.

Figure 2-2: Erie County, NY Water Demand

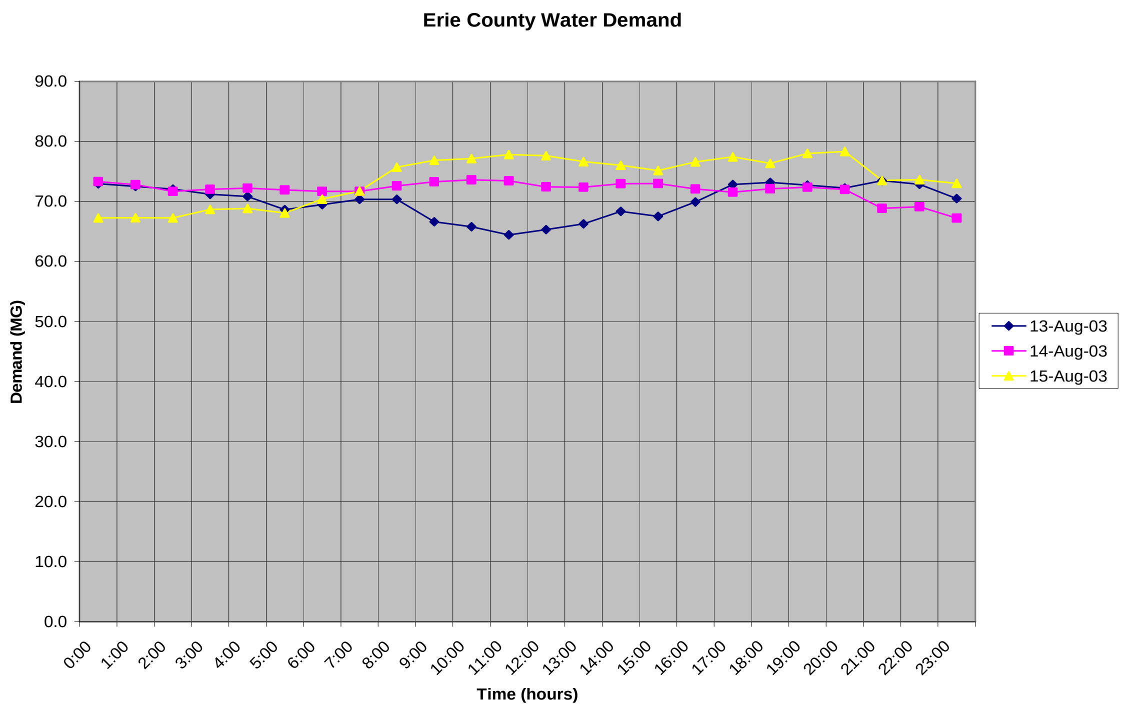
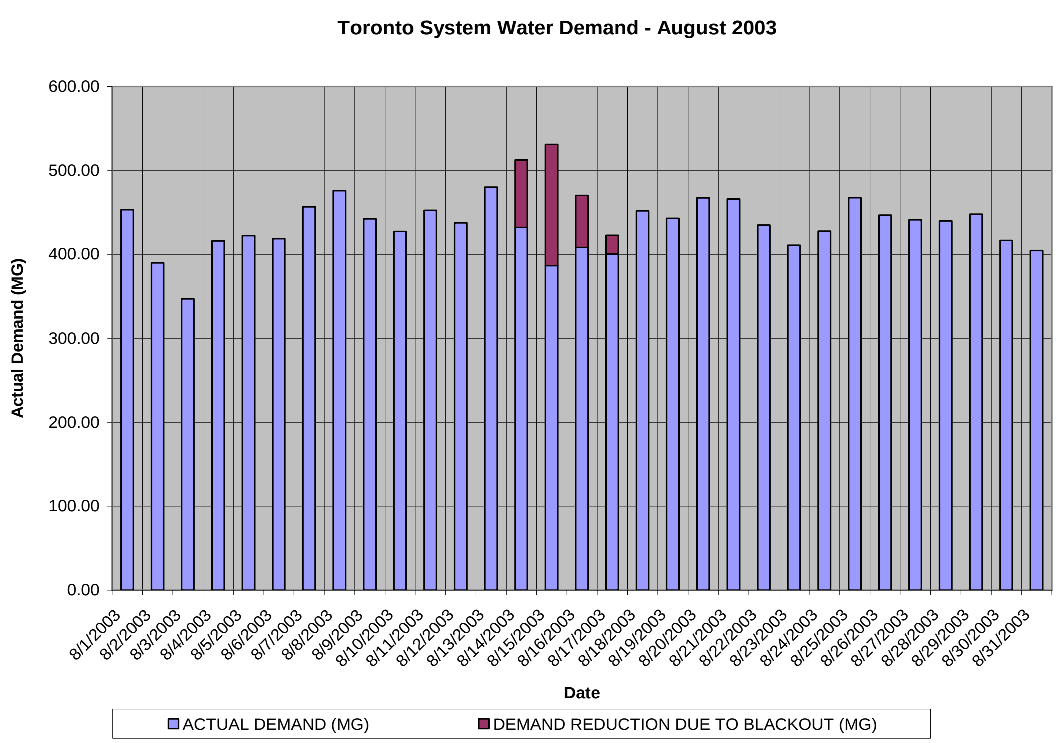


Figure 2-3: Toronto, Canada Water Demand



2.4 CONCLUSIONS

The data and information obtained from the water utilities that experienced the 2003 blackout are as follows:

- The power outage each utility encountered was relatively short depending on the utility's location and varied in duration from 12 to 24 hours.
- Some utilities had varying emergency power capabilities.
- Each of the utilities had varying amounts of pumping and storage requirements.
- Each utility's service was dependent on the storage levels of the finished water tanks when power was lost.
- Air entrainment in the system must be accounted for and released immediately upon restoration of service.
- Chlorine feed should be boosted for the first week to meet increased demands resulting from scouring of solids.
- Tank levels should be controlled to avoid pump tripping and permit use of system pumps upon start-up.
- Actual water demands during the outage ranged from 5% to 15% less than the predicted water demands for that period.

3.0 WATER UTILITY BENCHMARKING

As a means of assessing the norm within comparable water utilities throughout the United States, Black & Veatch conducted a Water Utility Benchmarking survey. The survey questions were designed to gather critical system criteria for comparative analysis with in-depth questions focusing on emergency power provisions within each water utility. The survey includes a series of questions related to system configuration, emergency preparedness, normal and emergency power systems, and the various methods by which on-site generation equipment is used by water utilities. A detailed presentation of the Water Utility Benchmarking survey results is presented in Appendix C: Demand Scenario Workshop Report

3.1 UTILITY CONTACTS

Initial attempts of contacting multiple large- and medium-sized water utilities throughout the United States yielded few results due to heightened security concerns. Utilities were cautious about releasing system information that would allow a Benchmarking Survey to be useful. The project team utilized Black & Veatch's Project Management corps to establish contact with a sufficient number of water utilities to make the Benchmarking Survey useful. Given the assurance that they will not be specifically identified in the survey results, the survey was able to move forward. Seventeen water utilities were contacted and thirteen completed the survey.

3.2 SURVEY GOALS AND QUESTIONS

The Benchmarking Survey was conducted to establish comparative information among other large and medium-sized water utilities. A questionnaire was developed that would provide pertinent information about each utility's system parameters and power supply arrangement. Each utility was asked a series of questions about their system size, average day demand, resale vs. wholesale percentage, primary and secondary power sources, electric utility rate structures, and emergency response planning. In each case, the respondents to the survey held administrative and planning-level positions within the utility and had overall responsibilities for plant energy management and operations reliability. The utilities that participated were given assurance that the information they provided would be held in confidence. This allowed for an open dialogue concerning issues of system configuration and emergency preparedness.

3.3 FINDINGS AND CONCLUSIONS

The findings of the Benchmarking Survey provide a basis for MWW to compare their operating philosophies with other utilities. A comparison can be made with regard to overall system reliability as it is affected by normal and emergency power system implementation. The survey participants are generally comparable to MWW in operating interests and service goals. Each considered uninterrupted customer service an operating goal of their respective utility and would align with the following American Water Works Association policy statement:

"Uninterrupted utility service is an operating goal of public water … utilities. To achieve this goal, each public water supply … utility first must determine the local probabilities of complete or partial electric utility power outages expressed in terms of frequency, duration, and percentage of requirements, and second, assess its own capabilities to provide water … service from storage, alternate supply, or other source, similarly expressed in terms of frequency, duration, and percentage of requirements, when there is an electric power interruption." (Policy statement as adopted by the AWWA Board of Directors on January 29, 1973 and reaffirmed January 19, 2003.)

Following are statistical representations of the Benchmarking Survey respondents:

Number of Respondents – 13
Average Day Demand Range – 32 mgd to 1200 mgd
Average Capacity – 236 mgd
Average Capacity after subtracting largest and smallest – 160 mgd

Following are key findings from the Benchmarking Survey: (Note, the total number of answers for each question varies, as a response was not provided by all respondents to every question.)

Sustainable supply during an outage through gravity and/or elevated storage

- 1 of 11 can sustain flows indefinitely
- 5 of 11 can sustain flows for at least 24 hours
- 5 of 11 can sustain flows for 12 hours or less
- 3 of 11 can sustain flows for 4 hours or less

Water restoration plan

- 9 of 10 have a water restoration plan in place

- 5 of 10 rehearse their water restoration plan
- 2 of 10 have not rehearsed but intend to begin soon

Communication plan to alert customers to system problems

- 11 of 11 have a communication plan that utilizes local media outlets

Emergency response plan

- 11 of 12 have some form of emergency response plan in place
- 7 of 12 have provisions that directly relate to power outages
- 2 of 12 have specific provisions that maximize the use of available storage in the event of a power outage

Normal (primary) and emergency power provisions

- 1 of 13 self-generate power for normal power usage
- 11 of 13 utilize on-site emergency power generation equipment somewhere within their treatment or distribution system
- 9 of 12 utilize emergency power generation within their treatment facilities
- 1 of 12 utilize emergency power generation for chemical feed systems only
- 7 of 12 utilize emergency power generation for distribution pumping systems
- 7 of 7 utilize emergency systems powered by internal combustion diesel engines
- 2 of 7 utilize other fuel sources in addition to diesel engines

Responsiveness of electric utility to water utility during a power outage

- 6 of 11 are confident that the electric utility considers the water utility a high priority customer
- 3 of 11 are unsure of their priority with the electric utility
- 2 of 11 believe they are not a high priority for the electric utility

Load shedding programs and self-imposed peak shaving

- 4 of 11 operate emergency generation systems under electric utility load curtailment programs as a cost reduction method
- 2 of 11 utilize self-imposed peak shaving techniques to offset costs

Following are important conclusions drawn from the Benchmarking Survey:

- Water utilities that have service areas and customer bases similar to MWW maintain similar service reliability criteria. These water utilities place a high value on, and make capital investments to ensure, uninterrupted water service.

- Water utilities across the United States understand the risks involved with one utility (water) being dependent upon another utility (electric) for their level of service reliability.

- It is common for utilities to deploy on-site generation systems to mitigate the risks of being interdependent with the electric utility.

- The results indicate a high level of water utility preparedness in responding to water service disruptions due to power outages. This conclusion is supported by the fact that the majority of the utilities have active emergency response, communication, and water restoration plans. Nearly half of the respondents are capable of sustaining adequate water supplies during a power outage by either having sufficient gravity fed systems or elevated storage. Nearly all respondents can either withstand a moderate disruption of electrical power – approximately twelve hours – by gravity feed or have invested in on-site generation to provide either reduced service capacity or full operating capacity in the event of a power failure.

- The majority of water utilities do not utilize their power generation systems to reduce their energy costs. The results suggest that the value on-site generation equipment provides to a water utility goes beyond any economic benefit that may be realized.

4.0 POWER FAILURE RISK ASSESSMENT

The power failure risk assessment was conducted to evaluate the electrical systems that currently supply power to Milwaukee Water Works (MWW) and to determine their effectiveness in the event of a regional as well as local power outage. The information provided in this assessment came from the following sources:

- Load flow analysis of the We Energies (WE)/American Transmission Company LLC (ATC) electric system and surrounding systems conducted by Black & Veatch (B&V). ATC is the owner and operator of the transmission system that serves WE.
- The meeting between B&V, MWW, WE, and ATC which discussed the status and recovery capabilities of WE's electric system.
- "Control Area Readiness Audit Report of We Energies" and "Readiness Audit of American Transmission Company LLC" conducted by the North American Electric Reliability Council (NERC) with a Federal Energy Regulatory Commission (FERC) representative.
- Literature search of response planning activities generated after the 2003 blackout, including measures taken by NERC and the FERC, descriptions of WE's on-site generation programs, and a survey of the electrical back-up and contingency planning activities of other water works systems

Utilizing the information gathered from the above sources, five pertinent matters are detailed in the following discussion. A detailed discussion of the Power Failure Risk Assessment is presented in Appendix A: Power Failure Risk Assessment Report.

4.1 POTENTIAL FOR FUTURE REGIONAL POWER BLACKOUTS

To understand the potential for additional regional blackouts in the United States, it is helpful to first understand the physical system in which WE/ATC operate and how that system is controlled for the benefit of all the electric customers, generators, and transmission utilities contained within its boundaries. The electric system in the continental U.S. is composed of three major interconnected system networks. Each transmission system within these interconnects is operated in phase with all the other transmission systems, allowing power to flow among all the interconnected systems.

Various regional authorities within these interconnect systems maintain responsibility for distributing power. These authorities ensure that the combined facilities respond appropriately to unanticipated changes and are responsible for taking the view of the bulk electric system and preventing emergencies on a next-day basis.

4.2 BLACKOUT RISKS FOR WE ENERGIES AND MWW

The load flow analysis conducted by Black & Veatch indicated that the WE/ATC system is a robust system that has not exceeded its capacity under one single contingency condition. It is not unusual for systems to have at least five facilities with single contingency conditions. Both ATC and WE were audited by the NERC and were commended for their best practices. WE was complemented on its level of staffing and availability of training programs, while ATC was told its Blackstart System Restoration Plan exemplifies industry standard. Even though the WE/ATC system is a robust system and the NERC audit findings are favorable towards system reliability aspects, their system has no control over outside systems and will not likely prevent a local blackout if triggered from or propagating through a neighboring interconnected system. Therefore, the WE/ATC system, like all other systems, is vulnerable to outside influences and does not actively plan for regional outage prevention.

4.3 MWW'S POSITION IN THE WE CRITICAL CUSTOMER QUEUE

WE/ATC do not have a critical customer queue and in the event of a regional power outage, nuclear plants would be the first to be restored, followed by other power plants, and then natural gas generation and pumping facilities. The remainder of the loads are restored incrementally. Due to its dual feeds, MWW would more likely be restored earlier. MWW facilities are on an emergency response list, which could also assist in prompt restoration.

4.4 WE ENERGIES ON-SITE POWER GENERATION PROGRAMS

WE does not have an on-site power generation program available; however, WE does have load management programs that identify and give credit to loads that are interruptible or can be curtailed. While these WE programs would allow MWW to receive financial benefits for the generation it supplies, these benefits alone would not be sufficient to economically justify adding generation at any one, or multiple, MWW facilities.

4.5 CONCLUSIONS

It is prudent for MWW to assume that a regional outage could occur and that its electric supplier, WE, may not be able to avoid involvement in such a regional outage. While the best practices of ATC and WE are reassuring with regard to service restoration, the need to safely and systematically restore the entire grid could result in an outage duration of three to seven days or longer. At this time, it would seem prudent for MWW to develop a restart plan based upon a complete loss of electrical power to prepare for a regional outage while planning on a more probable local power outage in which MWW systems may need to operate on emergency power for up to a period of 2 days.

5.0 EMERGENCY POWER NEEDS ASSESSMENT

The Facilities Review Report presented the findings from an assessment of critical power needs for MWW's critical facilities. The assessment included the following:

- A site audit report of each critical facility that provided verification of electrical load information and an evaluation of the electrical equipment condition at each facility.
- An emergency power system evaluation that considered the equipment and infrastructure assets that would require emergency power to sustain operation during a regional power outage.

The information used to develop this report includes detailed facility information provided by MWW and individual site inspections of each MWW critical facility. A detailed discussion of MWW's facilities emergency power needs assessment is presented in Appendix B: Facilities Review Report.

5.1 SITE AUDIT SUMMARY AND EVALUATIONS

Site visits to the MWW critical facilities were conducted to verify information on the MWW one-line drawings and to collect additional information on the existing electrical conditions of the facility. Information collected will be utilized in the overall evaluation of each facility relative to the possible implementation of emergency power systems.

Facilities visited were those designated as "critical" to the MWW system during the Project Initiation Meeting. Site visits focused on determining the electrical load requirements associated with full or partial operation of the facilities and possible configurations for emergency power systems.

5.2 EMERGENCY POWER SYSTEM EVALUATION

In an effort to provide MWW with several alternatives for providing emergency power for their water system, five demand scenarios were determined at the Project Initiation Meeting. The scenarios were as follows:

- Minimum Day Demand = 95 mgd, which equates to daily demand seen at historically low demand periods

- Average Day Demand = 120 mgd, which equates to the annual average daily demand for recent years
- Maximum Day Demand = 200 mgd, which equates to historical daily maximum demands
- Maximum Hour Demand = 250 mgd, which equates to a historical maximum water demand over a given hour.

During the course of the study, a fifth demand scenario was included based on analysis of historical water demand:

- High Demand = 150 mgd, which equates to a historical high demand level that has only been exceeded 6% of the time over the past three years

The maximum hour demand option was included due to MWW's relatively small amount of water in elevated storage. This requires MWW pumping facilities to meet the maximum hour demands of the system. If the MWW system contained a greater amount of water in elevated storage, these pumping facilities could be operated at lower rates during peak water demand periods.

In general, MWW water demand has decreased over recent years and growth in demand is not anticipated over the next several years. Therefore, current values for minimum, average, and maximum demands were used as a basis for determining emergency power system requirements.

5.2.1 Demand per Service Area

To determine emergency power requirements for each critical facility, an estimate of water demand in each service area was made based on recent trends in water usage. The percentage of water consumed in each service area was applied to the overall system demand to estimate demand in each service area for each demand scenario.

5.2.2 Pump Requirements for Meeting Demand

Discussions were held with MWW staff to determine operational preferences for pump usage at each demand scenario. The pump stations were then analyzed to determine how the service area water demands could be met most economically.

5.2.3 Treatment Processes Required to Meet Drinking Water Regulations

At the Linnwood and Howard Avenue Purification Plants, it has been assumed that the following water treatment processes would be operational:

- Coagulation and clarification
- Filtration
- Disinfection

Due to the power consumption of the ozone system at both plants, it was determined at our Project Initiation Meeting that any emergency power system considered would not power the ozone processes at either purification plant. The above listed processes, without ozone, allow MWW to meet all current drinking water quality regulations.

6.0 EMERGENCY POWER CONCEPTUAL DESIGNS

This section provides a summary of the conceptual design development for emergency power at each critical facility. A detailed discussion of emergency power system needs and conceptual designs at MWW's critical facilities is presented in Appendix C: Demand Scenario Workshop Report.

6.1 ENGINE GENERATORS

Selection of on-site emergency power generation equipment at each critical facility was based on the electrical load characteristics of the required pumping units along with an analysis of each facility's specific characteristics including electric utility, water process, mechanical equipment, physical site constraints, and an electrical load assessment.

Diesel powered engine-generators (EG) were selected as the emergency power equipment to provide backup electrical power at all critical facilities and at all demand scenarios. Although there are various types of emergency power equipment (natural gas power EG, gas turbines, etc), diesel powered EG units are most common for emergency power applications due to their cost effectiveness, minimal maintenance, reliability, and wide spread availability of the fuel source. Natural gas fired EG units are much more expensive than their diesel fired counterparts. There are applications in which the natural gas fired EG units are more suitable, such as when the units are intended to run for long periods of time or are used for other than emergency purposes. Gas turbines units are slow starting units, not typically suited for emergency applications. These units also tend to be much more expensive than diesel fired EGs.

It was recommended MMW consider providing up to 24 hours of fuel storage at each critical facility. This duration of fuel storage would allow MWW to maintain power at each of their critical facilities for this duration without outside re-supply of diesel fuel. In the event of an emergency, MWW should have agreements in place with diesel suppliers to resupply diesel fuel within this 24 hour period. In addition, 24 hours of fuel storage would provide MWW with sufficient fuel each year for exercising of the generators, which is recommended to be one to two hours per month per generator. Based on Black & Veatch's discussions with other utilities and our experience working with other utilities on emergency power issues, this falls within the typical range of fuel storage durations seen across the country.

Although peak shaving is possible with engine generators and is one of the first questions by utilities when investigating emergency power, Black & Veatch has found through numerous cost analyses across the country that unless the water utility is burdened with extremely high peak demand charges, the use of emergency generators for peak shaving is not cost effective. The idea of cogeneration is another popular question when evaluating emergency power at water utilities. Again, through numerous evaluations at water utilities across the country, cogeneration does not prove to be cost effective under almost every circumstance. This is primarily due to the fact that a small generation facility, such as one that would be installed at a water utility's facilities, cannot produce electricity on a cost competitive basis with a large power generating facility that enjoys large economies of scale. Neither peak shaving nor cogeneration would be a cost effective option for implementation at any of MWW's facilities.

Evaluating the power supply system required a phased approach. That approach included drawing and data review, site audits, load analysis, a review of available system options, and equipment sizing analysis.

6.2 ELECTRICAL EQUIPMENT

Selection of on-site emergency power generation equipment at each critical facility was based on the electrical load characteristics of the required pumping units along with an analysis of each facility's specific site characteristics including electric utility, water process, mechanical equipment, and an electrical load assessment.

In general, the installation of emergency power systems for each critical facility will require a new lineup of switchgear that provides transfer capability between the electric utility and the on-site generators. The switchgear assembly will require automatic transfer capability to connect the generation equipment and is typically designed so that it could be monitored and controlled from the plant control system. The incoming service feeds from WE and equipment locations vary from facility to facility.

6.3 LAYOUT

For each demand scenario, a conceptual emergency power systems design was developed at each critical facility. For each critical facility, the engine generators required, fuel storage, and electrical equipment necessary to hookup to the existing facility electrical system were included. Due to the number of alternatives, certain general assumptions were made that were included in each design such as sidewalk locations, diesel fuel pipe routing, and access platform design.

6.4 CONCEPTUAL COST OPINION

This section provides a summary of the conceptual cost opinions for installing emergency power equipment to operate MWW's supply, treatment, and distribution facilities in the event there was a loss of electrical power. The opinions of probable costs were completed for each individual facility within the MWW system that was identified in the hydraulic analyses as a critical facility, thereby required to operate during a power outage.

The conceptual cost opinions were based on the conceptual emergency power systems designs described in the previous section. The estimated cost for each system includes the installation costs and all associated electrical interconnecting switchgear and equipment costs for a complete emergency power system. In addition, the project costs shown in Table 6-1 includes contingency, engineering, and escalation to estimated mid-point of construction (assumed 10% annual inflation in construction cost and mid point of construction in 2008).

Table 6-1: Emergency Power Construction Costs

Critical Facility	Opinion of Probable Project Cost, 2008$				
	Minimum Day Demand, 95 mgd	Average Day Demand, 120 mgd	High Day Demand, 150 mgd	Maximum Day Demand, 200 mgd	Maximum Hour Demand, 250 mgd
Linnwood PP	$3,434,000	$4,374,000	$4,374,000	$5,099,000	$5,099,000
Riverside PS	$6,910,000	$10,057,000	$12,328,000	$13,330,000	$18,321,000
Northpoint PS	$6,074,000	$6,074,000	$6,074,000	$9,263,000	$9,263,000
Texas Ave PS	$0	$0	$0	$8,250,000	$8,250,000
Howard Ave PS	$0	$0	$0	$8,359,000	$8,359,000
Grange PS	$521,000	$521,000	$521,000	$1,333,000	$1,333,000
Florist PS	$499,000	$483,000	$483,000	$756,000	$756,000
Total Project Cost	**$17,438,000**	**$21,509,000**	**$23,780,000**	**$46,390,000**	**$51,381,000**

Table 6-2 presents annual operation and maintenance costs for each critical facility at each demand scenario. These costs include estimated fuel cost required for monthly exercising of each generator as well as an estimated cost for general maintenance (oil changes, miscellaneous repairs, labor for exercising, etc.). For this evaluation, a diesel fuel cost of $3.00 per gallon and 24 hours of generator exercising per year at the recommended 50% loading were assumed.

Table 6-2: Emergency Power Annual O&M Costs

Critical Facility	Estimated Annual O&M Cost, 2006$				
	Minimum Day Demand, 95 mgd	Average Day Demand, 120 mgd	High Day Demand, 150 mgd	Maximum Day Demand, 200 mgd	Maximum Hour Demand, 250 mgd
Linnwood PP	$6,100	$8,500	$8,500	$9,600	$9,600
Riverside PS	$10,700	$16,000	$20,300	$24,200	$33,800
Northpoint PS	$10,700	$10,700	$10,700	$16,000	$16,000
Texas Ave PS	$0	$0	$0	$0	$0
Howard Ave PS	$0	$0	$0	$0	$0
Grange PS	$1,700	$1,700	$1,700	$3,000	$3,000
Florist PS	$1,700	$1,700	$1,700	$2,300	$2,300
Est. Annual O&M Cost	**$30,900**	**$38,600**	**$42,900**	**$55,100**	**$64,700**

The total estimated emergency power costs to provide sufficient water to satisfy the five demand scenarios discussed above are shown in Table 6-3 as follows:

Table 6-3: Emergency Power Project Costs

Demand Scenario	Water Demand, mgd	Project Cost, $	Annual O&M Cost, $	Present Value, $	Unit Cost of Water able to be Produced, $/mgd
Minimum Day Demand	95	$17,438,000	$30,900	$17,900,000	$0.19
Average Day Demand	120	$21,509,000	$38,600	$22,090,000	$0.18
High Day Demand	150	$23,780,000	$42,900	$24,420,000	$0.16
Maximum Day Demand	200	$46,390,000	$55,100	$47,210,000	$0.24
Maximum Hour Demand	250	$51,381,000	$64,700	$52,350,000	$0.21

6.5 COST/BENEFIT ANALYSIS

The costs for providing emergency power for MWW facilities are easily defined, but assigning a monetary value to many of the primary benefits of maintaining water supply during power outages can be difficult, if not impossible. These benefits include:

- Public Safety (due to the ability to fight fires),
- Public Health,
- Public Confidence

Another benefit of providing water during a power outage, though not nearly as critical in the overall scheme of things as public safety, health, and confidence, is the ability to maintain some level of industrial and commercial output. This is true during a wide scale outage assuming certain industries have emergency power backup themselves but also true of more local outages that may affect one or two of MWW's critical facilities.

The best option is to make a value decision on whether providing for public safety, health, and confidence is worth the costs of implementing emergency power for MWW facilities.

In looking at Table 6-3 above, the unit costs of water able to be produced versus the emergency power costs to provide that water range from $0.16 per gallon up to $0.24 per gallon for the five demand scenarios. This parameter attempts to estimate which demand scenario provides the biggest "bang for the buck" or in other words, which scenario provides the greatest quantity of water at the least possible cost. From this standpoint, the high day demand scenario is the most cost effective option at $0.16 per gallon of water able to be produced. The unit cost to provide maximum day demand being the most expensive option per quantity of water produced.

Typical economies of scale would indicate that the larger emergency generation facilities would be less expensive on a unit cost basis than the smaller emergency generation facilities. The primary reason for the lack of apparent economies of scale is that engine generators can only be obtained up to 2,250 kW units economically. So, at the larger electrical loads required to meet the maximum day and maximum hour demands, multiple units are required instead of being able to use a smaller number of larger units. This results in an increase in the cost per kW generated and thus the cost per MGD of water produced.

Due to the discreet sizes of the generators as well as the discreet sizes of the pumping units at many of MWW's critical facilities, the maximum hour demand is less expensive per unit cost of water than the maximum day demand.

The primary disadvantage of providing emergency power for only minimum or average day demands is the possibility that a wide scale power outage will occur during periods of higher water demands than what the system is capable of providing. During times of greater than average day demand, water demand must be reduced in order for the system to maintain pressure for public health and safety. Furthermore, during a regional power outage, many industrial and commercial customers will not be using water unless they themselves have provisions for providing their own emergency power.

One potential problem with counting on water restrictions while on emergency power, is the fact that the current plan for emergency communications of water information is through the use of radio, television, and the internet, which may not be effective during a regional or even widespread local power outage.

Based on analysis of historical daily water demands, water demands less than the high demand scenario of 150 mgd occur 94% of the time, therefore, the probability of having to restrict water usage during an emergency if the 150 mgd demand scenario were implemented would be small. Figure 6-1 present to probability of occurrence of different water demands while Figure 6-2 present daily water demands over the last 2.5 years.

Figure 6-1: Water Demand Probability

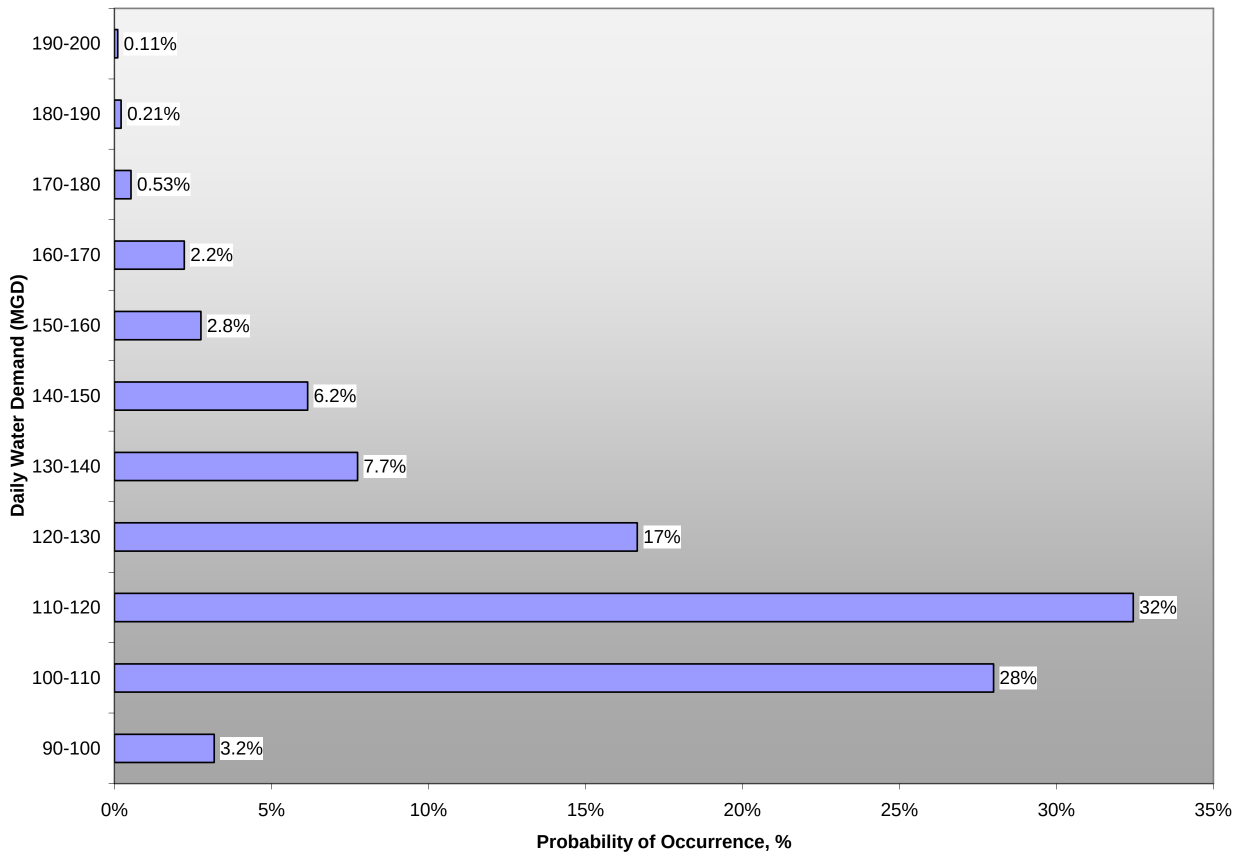
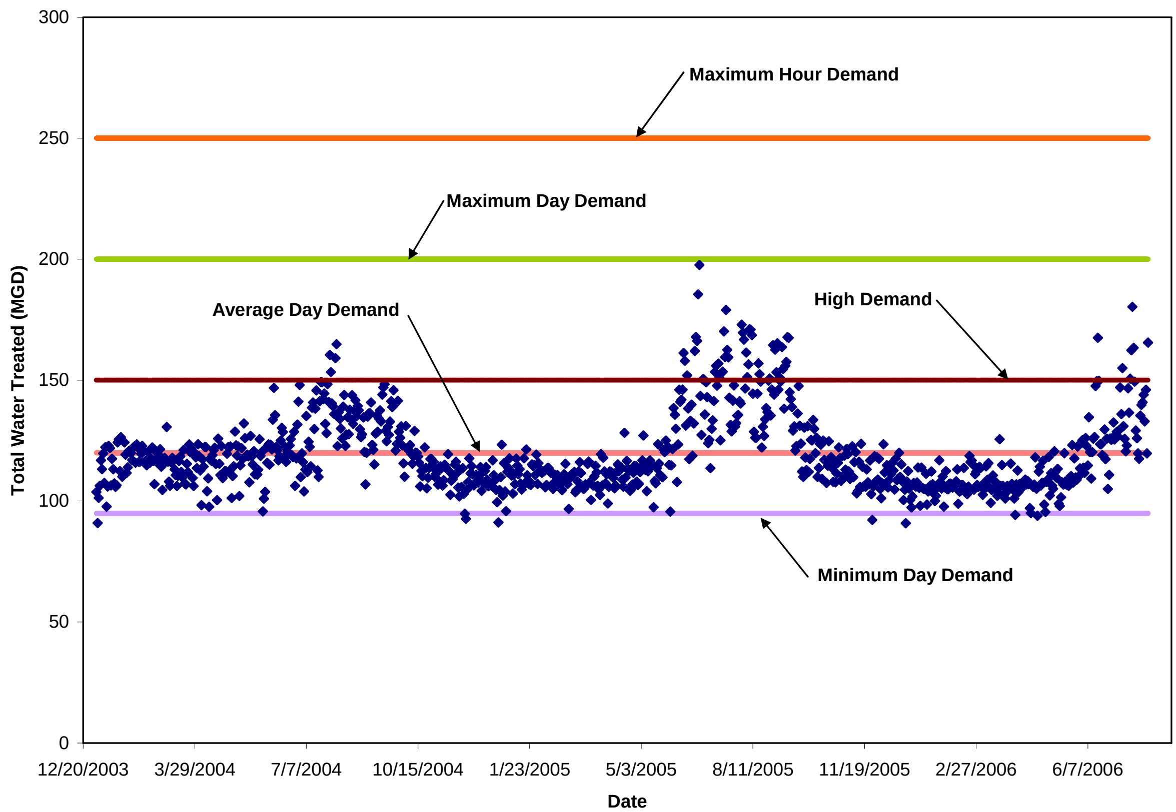


Figure 6-2: Daily Water Demands



7.0 CONCLUSIONS & RECOMMENDATIONS

Through the assessment of MWW's potential for a local or regional power outage, it has been concluded that the electrical feeds to MWW's critical facilities are generally reliable. Although this is not to suggest that local or regional outages will not occur, their likelihood is minimal. In fact, in recent memory, none of MWW's critical facilities have experienced extended power outages due to local or regional power issues.

Although the probability of a power outage may be low from both a technical and anecdotal point of view, the risks associated with not being able to provide water to the community during a local or regional power outage could be very high. MWW's distribution pumps are the primary mode of system pressurization due to the lack of elevated storage in the system, and as such, are critical for maintaining sufficient pressures in the distribution system. The ability of MWW's pumps to maintain sufficient pressure in the system is critical for fire fighting and the prevention of groundwater intrusion and other potential sources of contamination of the water in the distribution system. Without emergency power generation capabilities at MWW's critical facilities, the city is vulnerable to fires as well as widespread water contamination. If the distribution system experiences pressure below 20 psi, which is most likely without the pumps in operation, fire fighting will not be possible nor will the ability of the City to protect its citizens from health concerns due to contaminated water.

Therefore, it is strongly recommended that MWW consider implementing emergency power at each of the critical facilities. Of the five demand scenarios evaluated, the emergency power improvements required to meet the high day demand of 150 mgd is the most cost effective in terms of the quantity of water produced per dollar spent. As can be seen from Figure 6-1, at this level, MWW would be able to provide adequate water to the community without restricting water usage 94% of the time while providing emergency power for 120 mgd only allows MMW to provide adequate water 63.5% of the time. At the extreme ends of the spectrum, the minimum water demand of 95 mgd only occurs approximately 3% of the time and the maximum day and maximum hour demands only occur less than 0.1% of the time. Since the High Day Demand scenario of supplying 150 mgd during an emergency provides the biggest "bang for the buck" as well as allowing MWW to provide adequate water in an emergency up to 94% of the time, it is recommended that emergency power systems be implemented at MWW's critical facilities to provide for the high day water demand of 150 mgd.

7.1 POWER FAILURE RISK ASSESSMENT

The WE/ATC system, like all other systems, is vulnerable to outside influences and does not actively plan for regional outage prevention. Any type of outage, regional or local, that affects MWW would have similar restoration scenarios. Due to the WE/ATC restoration process, the MWW critical facilities will be restored incrementally. In preparation for such outages, MWW should consider providing emergency power generation to critical sites. Although WE does not offer on-site generation programs, the rate of return for these types of programs is relatively low. Emergency power generation is recommended to provide reliable and quality emergency service to MWW's infrastructure and to the community as a whole.

7.2 DEMAND SCENARIOS

To support the emergency power requirements, the percent of demand by service area was calculated. The majority of the demand is within the High Service District and the Low Service District. The High Service demand ranged from 64.9% to 72.8% across the maximum, average, and minimum scenarios and the Low Service demand ranged from 12.4% to 17.0% of the total water demand on the system. The Florist demand district ranged from 6.8% to 7.8%. This information was used to determine the required emergency operations for each of the critical facilities within the MWW system.

To meet the demands from specific pressure districts, the preferred pump operation methods at each of the critical facilities of each demand scenario was determined by MWW based on efficient operations of each pump station. These pumping scenarios were the basis for preparing electrical loads for the emergency power conceptual designs at each critical facility.

7.3 CONCEPTUAL DESIGNS

The size of the engine-generators selected for each critical facility were based on the electrical load of the pumping units for various alternatives coupled with secondary loads for SCADA, HVAC, lighting, and security. Conceptual emergency power system designs were developed at each critical facility with 24 hours of fuel storage. The electrical equipment requirements for each of the critical facilities are similar with the exception of size and location. Site layouts for the entire engine-generator design scenarios for each critical facility were produced and are available for review. Conceptual opinions of probable cost were prepared for each critical facility and demand scenario including capital and operating costs as well as life cycle costs.

7.4 IMPLEMENTATION

For the recommended alternative of supplying emergency power for the high demand of 150 mgd, the total project cost is $23,780,000. Financial constraints may prevent all of the projects from being implemented at the same time. Therefore, Black & Veatch has evaluated each of the projects to determine an implementation schedule to allow projects to be completed in phases. The proposed phased implementation is shown in Table 7-1:

Table 7-1: Recommended Implementation Schedule (High Day Demand)

Projects	Phase I	Phase II
Linnwood Purification Plant	$4,374,000	$0
Riverside Pump Station	$12,328,000	$0
Northpoint Pump Station	$0	$6,074,000
Florist Pump Station	$521,000	$0
Grange Pump Station	$0	$483,000
Total Project Cost	**$17,223,000**	**$6,557,000**

APPENDIX A

Power Failure Risk Assessment Report
(confidential - under separate cover)

APPENDIX B

Facilities Review Report
(confidential - under separate cover)

APPENDIX C

Demand Scenario Workshop Report
(confidential - under separate cover)