Recovery Practices Primer for Natural Disasters

Produced under the
Water Infrastructure Security Enhancements (WISE)
Initiative

September 2008

American Society of Civil Engineers

American Water Works Association
The Authoritative Resource on Safe Water

Water Environment Federation
Preserving & Enhancing the Global Water Environment

Disclaimer

Although the information in this document has been funded wholly or in part by US EPA under assistance agreement X-83128301-0 with ASCE, it may not necessarily reflect the views of the Agency and no official endorsement should be inferred.

TABLE OF CONTENTS

APPENDICES

A. Focus Group Workshop Presentation Briefs

1. Porter (Greenville Utilities Commission, NC) - Hurricane Floyd (1999)
2. Van Hoose (Rocky Mount, NC) - Hurricane Floyd (1999)
3. Reeves (Louisiana RWA) - Hurricanes Katrina and Rita (2005)
4. Huber (Charlotte-Mecklenburg, NC) - Hurricane Floyd (1999)
5. Jacobs (Cedar Rapids, IA) - 2008 flooding
6. McVay (Florida RWA) - FlaWARN Best Management Practices Manual
7. Stuhr (Portland Water Bureau, OR) - Mutual Aid response to Sewer and Water Board of New Orleans for Hurricane Katrina (2005)
8. Ford (Arkansas RWA) - Mutual Aid response to Louisiana for Hurricanes Katrina and Rita (2005)
9. Goodson (East Bay MUD) - Northridge Earthquake (1994)

B. Case Studies

1. "Start-Up of the Sunset Avenue WTP after Hurricane Floyd Flooding" (Jay Van Hoose, Rocky Mount, NC)
2. "Wildfire in the Lake Tahoe Basin – South Tahoe Public Utility District Disaster Response" - (Paul A. Sciuto, South Tahoe Public Utility District, presented at 2008 AWWA ACE)
3. "Preparation: Key to Hurricane Damage Restoration" 2004, a set of three articles that review Florida water utility impacts from Hurricanes Charley, Frances, Ivan and Jeanne (Prentiss and Vanlandingham, Florida Water Resources Journal, 2005)

C. Supplemental Reference Resources

1. "Flood Preparation and Restoration," American Water, 2003.
2. "Sandbagging Techniques" brochure from USACE, Northwest Div, 2004
3. "Innovative Naples Generator Design Replaces Large Units in Temporary Power Restoration Following Hurricane Wilma" (a paper by Bob McVay of FRWA describing use of VFD and small single phase generators for powering up lift stations in sequence)
4. "Electrical Retrofit Aids in Hurricane Response" (FEMA article on a "Best Practice" story)
5. "Recovering From Disaster" (Paper by C Yung, EASA, on electrical motor restoration from floods) - 2005 (after Katrina) - (first published in Uptime Magazine - January, 2006)

1. Introduction

This Recovery Practices Primer is a product of the Water Infrastructure Security Enhancement (WISE) project, a collaborative partnership of the American Society of Civil Engineers (ASCE), American Water Works Association (AWWA), and the Water Environment Federation (WEF). The objectives of the WISE project are to develop guidelines and training material for enhancing the physical security of the nation's water and wastewater infrastructure. The activities under the WISE project are funded through a Cooperative Agreement with the U.S. Environmental Protection Agency (US EPA) as a joint effort of ASCE, AWWA, and WEF.

Past WISE project efforts include guidance documents and training materials for design of security elements of water and wastewater/stormwater facilities. These documents have focused on how to incorporate appropriate security measures into new facilities or into facility retrofits, as the appropriate opportunities arise. The objectives of this current document are significantly different. As opposed to the planning and design elements of disaster preparedness, this primer reviews recent utility disaster experiences to document actions that can be or have been successfully undertaken to mitigate disaster impact or expediently restore service operations. It is not comprehensive in nature, rather is intended to supplement other guidance that has been issued in recent years on emergency preparedness planning and response.

This guide is informed by the experience of utility managers who have had to respond to natural disaster situations, their reports on the types of system impacts that they found to be characteristic of the emergency contingency they faced and how they dealt with these situations.

A primary source of information gathered in this project was a two-day workshop that was conducted on August 5 - 6, 2008, at the offices of the American Society of Civil Engineers in Reston, Virginia. The meeting consisted of a series of presentations by invited utility managers who focused on their utilities' disaster experiences, followed by a general discussion. The workshop discussion was supplemented by other research and outreach to other utilities and agencies.

The results of the workshop discussion and other research are summarized in Chapter 2 (pre-event mitigation measures), Chapter 3 (post-event response) and Chapter 4 (emergency management issues). Supplementing the report are three appendices, which cover the following:

- Brief summaries of the presentations made at the project workshop,
- Case studies, some reprinted from other sources, and
- Other particularly relevant technical references.

1.1 Acknowledgements

As noted above, this project was conducted under the sponsorship of the American Society of Civil Engineers (ASCE) under the ASCE/AWWA/WEF Water Infrastructure Security Enhancement (WISE) project. A WISE subcommittee, the Response Primer Working Group (RPWG), was established to oversee the project, consisting of:

Patricia Lamb, CUSA, Emergency Preparedness Manager, Charlotte-Mecklenburg Utilities, NC;
Erica Michaels Brown, Director of Regulatory Affairs, Association of Metropolitan Water Agencies;
Daniel Lynch, PE BCEE, Utility Director, City of Janesville, WI; and
John W. McLaughlin, PE, Senior Associate, Jordan, Jones & Goulding.

The ASCE project manager was Muhammad Amer, M. ASCE.

Of critical importance to the project was the participation in the focus group workshop by several experienced disaster responders. In addition to the RPWG members, the workshop participants included:

Steven Porter, PE F.ASCE, Water Resources Systems Engineer, Greenville Utilities, NC;
Jay Van Hoose, Superintendent, Water Treatment Plants, City of Rocky Mount, NC;
William "Rusty" Reeves, CET, Water Circuit Rider, Louisiana Rural Water Association;
John Huber, Water Plant Superintendent, Charlotte-Mecklenburg Utilities, NC;
Bruce Jacobs, PE, Utilities Engineering Manager, Cedar Rapids, IA;
Robert McVay, PE, Drinking Water Trainer, Florida Rural Water Association;
Michael Stuhr, PE, Director of Engineering Services, Portland Water Bureau, OR;
Jeffrey Ford, Deputy Director, Arkansas Rural Water Association;
Allen Goodson, Manager of Operations and Maintenance Planning, East Bay Municipal Utility District, CA.;
Gregory Spraul, US Environmental Protection Agency; Washington, DC;
Joshua Novikoff, US Environmental Protection Agency; Washington, DC;
Richard Moser, water industry consultant, Collegeville, PA;
Kay Hathaway, ASCE; and
Leslie Twohig, O'Brien & Gere.

In addition, generous contributions were made through phone conversations and e-mail correspondence by other utility managers and agency officials, including: Steven Dennis (Alameda County Water Authority), Shane Fast (Chlorine Institute), Gary Trojak (chlorine consultant), John Kolb (San Diego County Hazardous Materials Division), Gregory Larson (CB&I Constructors), Paul Sciuto (South Tahoe Public Utility District), Hubert Tomlinson (City of Palm Coast, Florida), Chuck Young (Electrical Apparatus Service Association), Chris Roeder (FlaWARN), Ralph McIntosh (Ramona Municipal Water District), Mike Page (Fallbrook Public Utility District), Mike Abbott (Emerald Coast Utilities Authority), Robert Berg (Long Beach Water Department), and Sean Sterchi (California Department of Public Health), John Dunn (New York State Department of Health), John Whitler (US Environmental Protection Agency), Ray Riordan (Emergency Manager for City of San Ramon, and CalWARN chair), George Rest (O'Brien & Gere), John Kerrigan (O'Brien & Gere), and Gary Stoddard (O'Brien & Gere).

Report Author: Gregory Welter, PE BCEE
O'Brien & Gere

2. Preparing for Disaster Type - Activities to Do in Advance

This chapter discusses preparedness measures that should be implemented prior to an emergency event. Many of these measures are appropriate once advance warning of a disaster has been received, and operators are preparing the facilities to mitigate damage and maintain service during the event. However, some of the measures require significant planning and resources for implementation, and thus must be incorporated into normal operations rather than last minute preparation.

The first subsection discusses measures that would be generally applicable, and is then followed a review of measures that are specific to certain disaster types:

- River floods and coastal hurricanes,
- Wildfires, and
- Earthquakes.

2.1 Generally Applicable Preparedness Planning

There were some preparedness measures that were identified by the workshop participants as essential for all water and wastewater utilities.

2.1.1 Critical System Records

Utilities need to identify critical system records, and store a backup copy of such records in a secure location that would be known to be accessible during any likely disaster that the utility might face. Managers need to determine what format (e.g., paper, electronic, etc.) the records need to be in to be useful during the disaster and in recovery. In addition to business continuity records (e.g. chartering documents, personnel, accounting, etc.), engineering and operational plans are needed specific to the organization. Selected examples would include:

- A system "backbone map" displaying the large diameter distribution mains or sewer trunks, including pertinent pipe sizes, locations and other critical information. Keep in storage at strategic locations the spare parts and clamps necessary to repair pipes of all sizes defined as critical in this map. This concept applies for all utility systems, but has been found particularly essential for systems that are prone to seismic events, so this discussion is revisited in the Section 2.4.1 on Earthquakes.
- GPS records of underground infrastructure. This is especially required for systems that are potentially exposed to disasters that can violently erase or rearrange all landmark features, such as coastal hurricane surge and wildfire conflagration.
- Drawings and specifications of critical equipment, particularly those that would be subject to long-lead-time manufacturer restoration, such as electrical switchgear and motor control centers. Maintain critical spare parts for rebuilding such equipment.
- List of critical resources required to maintain operations (e.g. treatment chemicals), vendors, locations of where resources come from, and alternative sources.

2.1.2 Manual Facility Operations Training

Workshop participants noted that during disaster events, the SCADA and other control systems typically used to operate utility systems were often not available. In such cases, the water or wastewater system had to be run by the operators without benefit of these automated systems and had to resort to the basics, including dispatching employees to remote facilities to check on water levels and report back by phone or radio. Workshop participants emphasized the importance in disaster planning drills to include manual operations of the system without benefit of SCADA or other instrumentation as a critical functional skill requirement for utilities. Maintain a list of employees that have been trained, and a list of potential alternate sources (e.g. retired employees, or utilities with similar critical systems) if the current employees are not available in the emergency.

2.2 River Floods and Coastal Hurricanes

River flooding usually occurs with a few days of warning, which is usually enough time to make some provision to prepare for an event. But some utilities have been impacted by damaging floods even when their facilities have been located above the defined flood plain, and presumably out of harm's way. In many instances, the fact that the facilities have been historically outside the flood plain have naturally reduced the extent of flood mitigation incorporated into the plant design, and the extent of preplanned event mitigation practices. Another relevant characteristic of river flooding is that the recession of floodwaters is often slow, so the facility may have to be operated for a sustained period in high water conditions.

Similar to river floods, a utility will likely have several days advance warning of the onset of a hurricane. However, the precision and accuracy of the prediction will be much less than what would typically be available for upland river flooding. Also, the wind effects and storm surge flooding will likely be much more violent than a river flood scenario, and the surge waters are saline rather than fresh. For most communities subject to coastal hurricane impacts, this is a known risk and mitigation may have been incorporated into the original design and construction of the facilities.

2.2.1 Securing the Facility Prior to the Flood

Several participants in this study emphasized the importance of taking advantage of any advance warning of the flood to prepare and secure the facility. Many utilities that may face a flood condition (or have in the past) have developed a Standard Operating Procedure for flood preparation. One succinct and effective checklist for this purpose was developed by American Water, and is reprinted by permission in Appendix C (American Water, 2003). Some particular preparation measures are further discussed below.

<u>Expedient flood-proofing of critical structures</u>

A recurrent theme in flood experiences is the implementation of sandbagging operations, as shown in Figure 2-1. An adequate supply of sandbags and sand to fill them must be procured ahead of time. The U.S. Army Corps of Engineers recommends that sandbag levees be constructed to provide about six inches of freeboard above the predicted flood level (USACE-NW Div, 2004; see reprinted pamphlet in Appendix C). The barrier would be constructed with a triangular cross-section, with plastic sheeting applied on the side of the levee facing the river, weighted by the sandbags. Recommended fill weight of a single bag is 30 pounds (approximately 1/3 to 1/2 full) for effective handling. The number of bags required per 100 ft length of levee is suggested as:

Table 2-1 *Number of sandbags required per 100 foot length of levee*

Height of levee	Number of sandbags
1 ft	600
2 ft	2100
3 ft	4500
4 ft	7800

USACE-NW Div, 2004

Maintain plant drawings of where to place sandbags if necessary, including information on number of sandbags required at the location. If a location is known to be vulnerable to flooding, consider use of permanent flood walls or berms so that the quantity of sandbags needed might be minimized to those needed to cover the entrance.

In addition to sandbagging around the structures and at building entrances, it is necessary to plug floor drains to prevent entrance of water from the drain system. Preferably inflatable plumbing plugs should be used, but if they are not available some utilities have used water plug cement for the purpose. (Note: this would require effort to restore the drain following the event.)

Fig. 2-1a. Sandbag operations at Greenville Utilities, NC - Hurricane Floyd, 1999 (S. Porter, Greenville Utilities)

Fig 2-1b. Sandbag operations at Cedar Rapids, IA - 2008 (B. Jacobs, Cedar Rapids)

Securing water and chemical tanks

Water and chemical storage tanks must be secured prior to the flood onset to prevent flotation, which could damage nearby equipment as well as the tanks themselves. The Rocky Mount, NC, water treatment plant had three of six chemical storage tanks dislodged by flotation in the floodwaters from the Tar River in 1999. Consensus recommendation of the participants in the workshop is that vented chemical tanks should be filled with product, or with water if necessary, in order to ballast them for the flood.

Water storage tanks should also be filled with water so as to be ballasted against flotation. Figure 2-2a shows the damage that was incurred by a water tank in Cameron, LA, due to Hurricane Rita in 2005. This recommendation also applies to elevated tanks, as covered in a WaterISAC bulletin entitled "Lessons learned from Katrina" (WaterISAC, 2005), and reaffirmed in a personal telephone call with the chair of the AWWA D-100 standards committee on Steel Tanks (Larson, 2008).

Pressurized chlorine cylinder containers must be secured. A one-ton chlorine container will float if empty or near empty, as evidenced by the experience of the Rocky Mount, NC, treatment plant personnel during the 1999 Hurricane Floyd flood. When operators conducted their initial condition assessment while the plant was still flooded, they found two chlorine containers floating upside down tethered in over 7 feet of water in the flooded chemical room, precariously attached only by their pigtail connections to the manifold. The Chlorine

Institute advises that chlorine containers should be removed from areas of imminent flooding if at all possible. The Institute says that "if any chlorine containers must remain in a flood warning area, they should be disconnected from any piping, the containers closed, and process piping closed and secured. Any open ended joints should be capped or blinded. Any equipment vulnerable to floating containers must be secured so that no chemicals are released and equipment damaged is minimized" (Fast, 2008a). Tethering the chlorine containers against flotation will need to resist the buoyant forces of "empty" containers (i.e. empty of adequately pressurized product, although still containing chlorine gas.) The buoyant uplift force on an empty container can be estimated based on the tare weight of the container (between 1300 and 1650 pounds, depending on the manufacturer), and the weight of displaced water (estimated at 1900 pounds, based on a container design capacity of 1800 pounds of water) to be between 250 and 600 pounds (weights per Chlorine Institute, 1997, and Columbiana Boiler, 1995.)

Fig 2-2a. Cameron, LA, water storage tank at well house, destroyed by Hurricane Rita (R. Reeves, LRWA)

Fig 2-2b. Ton chlorine containers at Rocky Mount, NC, WTP (after the flooding) (J. Van Hoose, Rocky Mount)

Securing electrical assets

The referenced American Water protocol on "Flood Preparation and Restoration" includes a provision to remove motors not in use to a safe location, and to "make preparations for a possible quick removal of those in service." Project workshop participants recommended that such motors be equipped to accommodate this with disconnect fittings rather than conventional pigtails.

Workshop participants also noted that protective power shutdown to SCADA system components, programmable logic controllers (PLCs) and other field instrumentation needs to include shutdown of backup uninterruptible power supply (UPS) systems, or the UPS will maintain sufficient current to the equipment to destroy the instrumentation package when inundated by the flood waters.

Water well preparation

Workshop participants recommended that flood preparation should include the plugging of casing vents of supply wells that are in the predicted flood zone in an effort to prevent contamination of the well. The British Columbia Ministry of the Environment has a number of fact sheets on well sanitation, including pre-flood preparation and post-flood disinfection, mostly oriented toward smaller wells but still of general utility applicability, on its web site at <http://www.env.gov.bc.ca/wsd/plan_protect_sustain/groundwater/wells/factsheets/index.html>.

2.3 Wildfires

Wildfire situations can develop very rapidly, and sometimes with very little direct warning. Extended drought and extreme dry fuel conditions that give rise to wildfires develop over some months, giving a reasonable time for preparation of potential wildfire initiation. Another characteristic of this disaster type is that in the midst of a wildfire situation water utility operators may find themselves almost in the front lines, with the critical task of supplying suppression water for fire fighter operations. Summarized below are two incidents "lessons learned" specific to wildfire contingency.

2.3.1 Use of Integral Sprinkler Heads for Protection of Wellhead Facilities

In 1998, northeastern Florida was subjected to extreme wildfire conditions, and personnel from Palm Coast Utilities implemented a novel protective measure for their groundwater well supply system. The utility department is also responsible for wastewater disposal, and a significant portion of the wastewater is disposed of with spray irrigation. When they found that several of their well fields were threatened, they implemented an expedient protective modification to their endangered well fields. They took several spare sprinkler heads from the irrigation program, disinfected them and installed them on the headers of individual wells. This measure was successful in saving several of the wells from destruction by the fire, and the sprinklers have since been made a permanent feature of the well installations (Tomlinson, 2008).

Note that this use of irrigation sprinklers as a property protection measure in wildfires is also used by customers, sometimes not wholly appropriately. In the 2007 wildfire season in California, the "Witch Fire" overtook the power supply to one of the main pump stations for the Ramona Municipal Water District, resulting in loss of pressure to a large part of the system. When pump station operations were resumed with the provision of portable generators on loan from mutual aid sources, there was difficulty in restoring pressure because a large number of customer sprinkler systems had been installed on building rooftops and left open when the mandatory evacuation order was issued. Emergency management officials would not permit repopulation of the area until water pressure was restored out of concern for the possibility of renewed fire, and the District had to dispatch crews to turn off service connections to all customers in order to restore satisfactory pressure. In the course of this detailed field activity, the operators found several connections in which the customer meters were running backwards, and they determined that this was caused by unauthorized private wells connected to the system. These customer connections were locked out until the unauthorized well connections could be appropriately resolved, and a "Do not use" order was issued for the returning population because of concerns over possible biological or chemical contamination from the wells (Wilsman and Robinson, 2007).

2.3.2 Maintaining Defensible Fire Breaks (Chlorine Gas Hazards)

Another water utility that was significantly impacted by the 2007 wildfires was the Fallbrook Public Utility District (FPUD). The "Rice Fire" overran the FPUD's Red Mountain Chlorination Facility, a remote facility providing booster treatment for finished water from the Red Mountain Reservoir. In the course of the conflagration, four one-ton chlorine gas containers were heavily damaged. The fusible metal plugs in the container ends melted, as designed, and in the high heat of the fire the escaping chlorine gas violently oxidized the container steel itself, enlarging the fusible plug ¾-inch orifice openings several times larger, as shown in Figure 2-3. A positive outcome for the incident is that the FPUD was able to restore disinfection treatment within a relatively short period of time after the fire through implementation of a hypochlorination system with assistance from utility mutual aid.

As noted above in the discussion about flooding, the Chlorine Institute advises that if at all possible, chlorine containers and cylinders should be removed from danger if flood or wildfire are imminent. However, the San Diego County emergency managers report that in both 2003 and 2007 when they were confronted by the situation of chlorine tankage in imminent danger, that they did not consider that removal of the containers was a practical, implementable option (Kolb, 2008). However, these emergency managers emphasized the importance of establishing and maintaining a noncombustible buffer surrounding hazardous material storage areas. This is consistent with recommendations given in the Chlorine Institute's Chlorine Manual (Chlorine Institute, 1997), which goes on to state:

> "If a non-leaking container or equipment cannot be moved, it should be kept cool by applying water on it. Water should not be used directly on a chlorine leak. Chlorine and water react forming acids and the leak quickly will get worse. However, where several containers are involved and some are leaking, it may be prudent to use a water spray to help prevent over-pressurization of the non-leaking containers. Whenever containers have been exposed to flames, cooling water should be applied until well after the fire is out and the containers are cooled."

In a wildfire situation such a water spray operation could not be applied manually for reasons of personnel safety. An automated or remotely controlled spray system might be considered, but the recommended maintenance of a non-combustible buffer around the facility, particularly during drought conditions, is probably the most important line of defense. Recommended fire buffer around facilities in California should include 30 feet cleared of vegetation, and nearby trees should be pruned and lower vegetation trimmed to prevent development of "fuel ladders" that could lead into the facility (Riordan, 2008).

Fig. 2-3. One-ton chlorine containers burned by the 2007 "Rice Fire" at the Red Mountain Chlorination Facility (photos courtesy of Mike Page, Fallbrook Public Utility District.)

2.4 Earthquakes

While utilities might receive advance warnings for upland flooding and coastal hurricanes, and should be aware of drought conditions with high potential for wildfires, earthquakes have effectively no advance warning. Utilities that are located in high seismic areas need to always be in a state of readiness. Allen Goodson, from East Bay Municipal Utility District (EBMUD), advised that another characteristic of this disaster type is the probability of aftershocks. Consequently, he recommended use of sloped and unshored excavations for pipe repairs to avoid injury to repair workers.

Water supply systems are of critical importance in all disaster situations, but particularly so for earthquakes due to the potential for large conflagration fires in the immediate aftermath. A substantial body of literature has been developed regarding design approaches for utility infrastructure to make the components more seismic resistant (Eidinger and Avila, 1999; Heubach, 2002; Scawthorn, et al., 2005.) These design mitigation measures include all elements of the system (i.e. treatment facilities, storage, distribution, etc.). One measure noted by Heubach is that "liquid chlorine cylinders need to be restrained to prevent them from moving and severing connections that would result in chlorine release."

Damage to large buried pipelines is particularly characteristic of seismic disasters. Eidinger and Avila (1999) review the nature of seismic impacts on water transmission facilities in a number of historic earthquake events. They note that field repairs to steel pipe transmission mains can be accomplished through welding. In pipelines large enough to permit human access, use of internal joint seals (referred to in the Eidinger/Avila reference by the proprietary name "WEKO seals," although there are also other manufacturers of this product) proved a successful repair strategy.

2.4.1 System Backbone Protection

One concept recommended by the participants in the focus group workshop was developing a detailed map of the utility system backbone, along with provisions and equipment (i.e. clamps, etc.) to make prompt repairs to all sizes of pipes in that system. Damage to large buried pipelines is particularly characteristic of seismic disasters, and a number of utilities located in active seismic areas have highly developed systems to address this challenge. One particular approach is to make provisions to lay an above ground temporary hose line to span a major pipe break. Following the Loma Prieta and Northridge Earthquakes, the Alameda County Water District (ACWD) has worked in partnership with fire departments of the communities it serves (Fremont, Newark and Union City) and the waste hauler Browning-Ferris Industries (BFI) to establish a cache of large diameter (5-inch) hose and associated equipment stored in readily deployable containers positioned at five fire stations (DHS/LLIS, 2008; Dennis, 2008). The concept is illustrated in Figure 2-4.

Other cities have made somewhat similar arrangements for temporary above-ground water distribution patches in times of emergency (notably San Francisco, Oakland, Berkeley and Vallejo in California; and Vancouver, B.C.) (Scawthorn, et al., 2005). In some of the cities, special hydrant fittings have been built at the crossings of major transmission pipelines and historic seismic faults to accommodate bridging a pipeline break at the fault. Typically the appurtenant equipment includes hose ramps, which can accommodate hose sizes up to 5-inch diameter, and maintain very low speed vehicle traffic with close supervision over the hose crossing at street level. Typically 5-inch hose is used in these systems and is as large as can be reasonably handled manually by fire fighters; but some cities have employed *ultra* large diameter hose (ULDH), as large as 12-inch diameter, using special deployment equipment.

These hose systems for emergency bypassing of main breaks require regular training and exercises to be sure the equipment remains where it is supposed to be located, to maintain the inventory of items, to maintain familiarity with the equipment, and most importantly to coordinate with outside agencies to know what to expect and how to assist (Riordan, 2008).

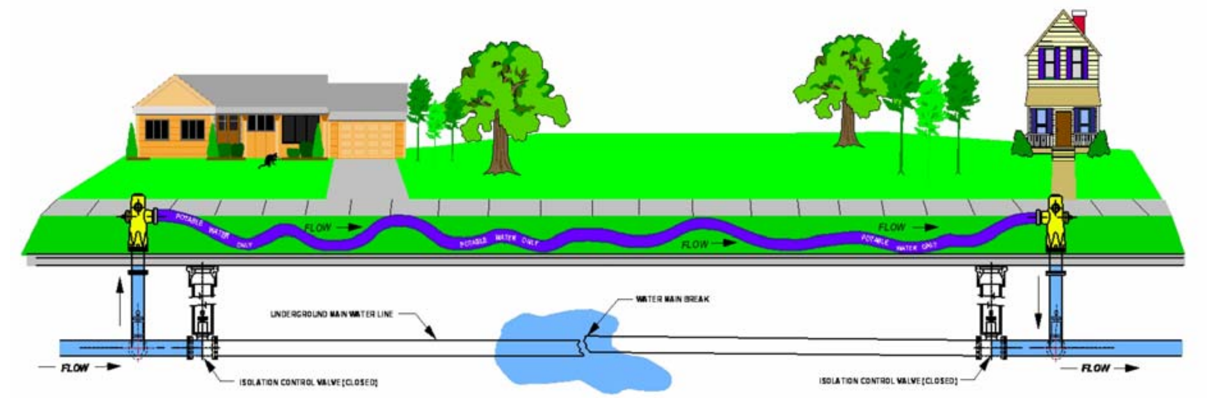


Fig. 2-4a. Conceptual illustration of Alameda County Water District scheme for temporary hose repair spanning below-grade pipe break. Hose and ancillary equipment for implementing the repair are stockpiled in Disaster Preparedness Containers at five locations throughout the service area.

Fig. 2-4b. Disaster Preparedness Containers deployed a partnership of Alameda County Water District (ACWD); the cities of Fremont, Newark and Union City; and Browning Ferris Industries (S. Dennis, ACWD).

2.4.2 Deployment of Distribution System Repair Depots

One notable feature of earthquake impacts that was highlighted by Allen Goodson of EBMUD is the literal collapse of the ground transportation system. He advised that this characteristic argues strongly for widely distributed maintenance depots throughout the service area so that utility workers can access necessary repair equipment and replacement parts as needed. See Figure 2-5 for graphic example of the types of transportation disruption that field workers could be faced with.

Fig. 2-5. Earthquake impacts on surface transportation (Photos from A. Goodson, EBMUD). Note in the right photo the truck trapped in mid-span by the collapse of the upper deck segments both in front and behind.

2.5 References

American Water, 2003, Flood Preparation and Restoration, emergency response protocol prepared by Maintenance Services, (original date: 3/1994; revision date: 9/2003).

Chlorine Institute, 1997, Chlorine Manual, 6th Edition, 2nd printing 2000. <http://www.chlorineinstitute.org/Bookstore/ProductDetail.cfm?ItemNumber=2216> (accessed 8/29/08).

Columbiana Boiler, 1995, "DOT 106A500X Ton Container," Reference CBCO. DWG. NO. 12660.

Dennis, Steve, 2008, Emergency Services Supervisor - Alameda County Water District, e-mail 8/28/08.

Department of Homeland Security / Lessons Learned Information Sharing, 2008, "Fremont, California's Disaster Preparedness Container Program," <https://www.llis.dhs.gov/docdetails/details.do?contentID=10177> (accessed 9/2/08).

Eidinger, John, and Ernesto Avila, 1999, Guidelines of the Seismic Evaluation and Upgrade of Water Transmission Facilities, ASCE Technical Council on Lifeline Earthquake Engineering Monograph No. 15, January 1999.

Fast, Shane, 2008a, Vice-President for Customer Stewardship and Technical Services of the Chlorine Institute, (personal e-mail 8/15/2008).

Heubach, William, 2002, Seismic Screening Checklists for Water and Wastewater Facilities, ASCE Technical Council on Lifeline Earthquake Engineering Monograph No. 22, September 2002.

Kolb, John, 2008, Supervisor - San Diego County Hazardous Materials Division, (personal telephone call with report author 8/26/08).

Larson, Gregory, 2008, chair of AWWA D-100 committee on Steel Tank standards representing producer member CB&I Constructors, (personal telephone call with report author 8/18/08.)

Riordan, Ray, 2008, Emergency Manager for the City of San Ramon and Chair of the California Water/Wastewater Agency Response Network (CalWARN), (personal e-mail to author 9/28/08).

Scawthorn, Charles, John Eidinger, and Anshel Schiff, 2005, Fire Following Earthquake, ASCE Technical Council on Lifeline Earthquake Engineering Monograph No. 26, January 2005.

Tomlinson, Hubert, 2008, City of Palm Coast Florida Chief Operator, e-mail 7/16/08.

US Army Corps of Engineers - Northwestern Division, 2004, Sandbagging Techniques, <http://www.nwk.usace.army.mil/Flood2007/NWD_Sandbag_Pamphlet.pdf> (accessed 8/29/08).

WaterISAC, 2005. Hurricane Preparations-- Lessons Learned from Katrina, Email Bulletin, 9/21/2005, archived at http://www.waterisac.org/cs/basic_subscriber_area, http://portal.waterisac.org/clearspace_community/docs/DOC-13505, available after user login to WaterISAC-Basic (accessed 9/23/08).

Wilsman, D, and J Robinson, 2007, Ramona Municipal Water District (RMWD) actions during the Witch Fire, report by RMWD Board of Directors dated 12/13/07.

3. Disaster Response Workarounds

3.1 Plant Operations Under Flood Conditions

Continued treatment plant operations and supply to the distribution system to maintain adequate system pressure is of paramount importance, for both potable water supply and sanitation as well as support of fire fighting. Workshop participants noted that there might need to be some triage of treatment plant processes, with disinfection and filtration being given priority over such processes as fluoridation and addition of corrosion inhibitors.

3.1.1 Expedient Filter Backwash Operations

During the 1999 flooding induced by Hurricane Floyd, Greenville Utilities employed several expedient measures to maintain treatment plant operations. The water treatment plant's filter backwash operations are normally operated automatically, with backwash water directed by gravity through a subsurface drain line to a lagoon. When the flood waters crested, the filter building floor was above the flood water level; however, the lagoon area was completely inundated, such that gravity discharge of the backwash water through the drain was no longer possible. Under these conditions, the plant operators had to run the backwash to an elevation in which the water overflowed the top of the filters onto the floor, with sandbags arranged around the filter perimeter so as to direct the overflow away from the other filters. With typically two backwash cycles per day, this mode of operation required fairly continuous work rearranging the diversionary sandbags. This arduous effort was sustained for approximately one week under the continued high water.

Fig 3-1. Use of sandbags to divert filter backwash water overflow onto floor and away from other filters. (Porter, Greenville Utilities).

After approximately one week of the sandbag operations at the filters, the floodwaters had receded sufficiently to arrange a different mode of backwash water disposal. Although the floodwaters at the lagoon were no longer above its banks, the water in the lagoon was still well above normal operating levels that would permit normal gravity backwash. The operators were able to make use of two manholes along the drain line between the filters and the lagoon to implement a different mode of operation. The downstream manhole near the lagoon was plugged with concrete in order to isolate the filters and lagoon, and a pump was installed in the upstream manhole so that spent backwash water could be pumped overland to the lagoon. This enabled operators to resume the normally controlled backwash operation, in particular discontinuing the labor involved in frequent rearrangement of the diversion sandbags. Of course, it also required abandonment of the plugged manhole and reconstruction of a replacement after the flood event in order to restore the normal gravity flow in the drain line.

3.1.2 Alternative Disinfection Operations

As noted previously, participants in the workshop noted that it may be necessary to sacrifice some treatment processes, but disinfection should be maintained if at all possible. Alternative methods of feeding solutions of sodium hypochlorite were discussed, with the primary expedient of using a small chemical metering pump of the type typically used in swimming pool treatment applications recommended.

An alternative system that has been employed if electrical power to run the metering pump is not available is shown at right. The World Health Organization characterizes it as "a simple but reliable device for discharging a batch-mixed hypochlorite solution into a tank, open conduit, etc. When the device is used in conjunction with a water-seal tank and float valve, the solution can be discharged into the suction side of a pump. When the liquid level in the water-seal tank is above the hydraulic gradient, stock solution can be fed into a closed conduit. The wooden float maintains a constant head at the orifice, which can be made large enough to prevent clogging" (Assar, 1971).

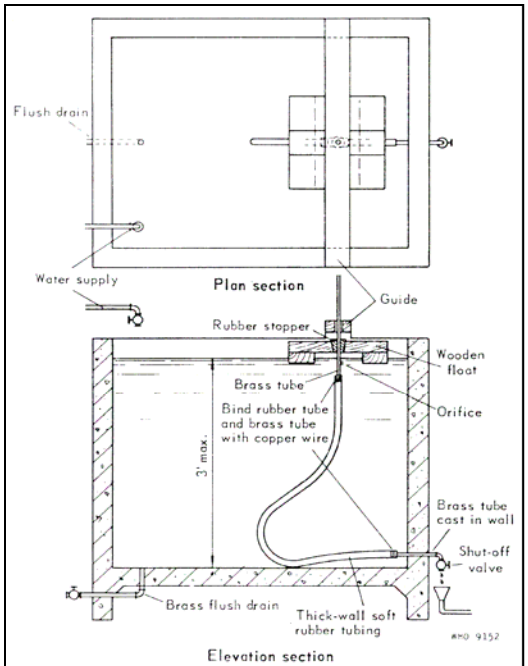


Fig. 3-2. Emergency constant head hypochlorite feeder. (Assar, WHO, 1971; originally from NYS DOH Bulletin

3.1.2 Alternative Modes of Chemical Delivery

The Greenville Utilities' water treatment plant normally receives liquid chemicals (e.g. aluminum sulfate and caustic) by tanker truck. During the sustained flood conditions, the plant was not accessible due to high water on the roadways and the plant grounds. As an alternative the chemical supply vendor was able to provide the chemicals in 330-gallon "tote" containers, which were then shuttled into the plant by high capacity dump trucks that had been volunteered for the flood relief effort from a local quarry. These dump trucks were equipped with large diameter tires, which enabled them to operate in the high waters that were not navigable by the tankers.

Fig. 3-3. High rise dump truck (on loan from local quarry) used to deliver liquid chemicals in 330-gallon tote containers through high flood waters. (S. Porter, Greenville Utilities)

3.2 Restoring Power

A commonly reported impact from may natural disasters is the loss of electrical power for the normal utility supplier. Most critical larger facilities are equipped with permanent stationary emergency generators that are designed to automatically take over the load. However, should this backup power source fail, or for smaller facilities not so equipped, the utility will have to provide temporary backup power.

3.2.1 Portable Generator Rotation to Service Multiple Lift Stations

The flat terrain of many coastal communities results in wastewater collection systems with numerous lift stations, sometimes numbering in the hundreds. Typically, they are not equipped with permanent stationary backup power, and must be serviced by portable generators in the event of power loss. The Florida Rural Water Association (FWRA) has worked with a number of its utility members to develop innovative protocols for more efficient application of personnel and resources in hurricane response operations. Two noteworthy procedures are described below.

- Generator "hopping" - This is a procedure for estimating the number of generators that would be required to service a group of lift stations, based on the estimated time it takes for each lift station wet well to fill up, the time needed to pump out the wet well, and travel times. As noted by FRWA, the protocol could also be used for coordinating the servicing of the lift stations using portable pumps to "pump around" the lift station, or emptying the wet well to a tanker truck.
- Use of variable frequency drives (VFDs) to enable smaller single phase generators to power larger three-phase motors - This novel technique was developed by the city of Naples, FL, (and documented by FRWA) VFD units are used as a "soft start" device to overcome the initial high starting loads of a motor. It enables use of a smaller single phase generator (5KW to 15KW range) to power larger pump motors (greater than 20KW). FRWA indicates that there is a substantial cost savings for the equipment, and that the smaller units are much easier to transport and can be serviced by a smaller operating crew. A qualified electrician is needed to set up the system, but it is then much easier to run, particularly under emergency conditions when resources would be in high demand.

Detailed descriptions of these approaches are documented in several resources available at FRWA's web site (<http://www.frwa.net/MainPages/MainPageEmergencyPreparedness.htm>), in particular the "FlaWARN Best Management Practices" guide for hurricane preparedness and response. A more detailed overview of the generator hopping and VFD/single-phase-generator procedures in provided in a FWRA paper printed in Appendix C of this report.

3.2.2 Upgrade of Lift Station Electrical Systems for Portable Generator Connections

Unless special provisions have been made, connecting a portable generator to a lift station electrical system entails direct connection to the control panel terminals, an operation of significant hazard that should only be undertaken by qualified electrical personnel. The Emerald Coast Utilities Authority implemented an upgrade to its lift stations to a power transfer switch and connector receptacles specifically mated for its fleet of portable generators are permanently installed at the stations. This promotes a more efficient and less hazardous generator deployment operation. This project received support funding from the Federal Emergency Management Agency (FEMA) and a special recognition as a best practice example (<http://www.fema.gov/mitigationbp/brief.do?mitssId=1885>). Some electrical equipment manufacturers offer pre-engineered "quick connect switchboards" specifically designed for this application.

3.2.3 Use of Unconventional Alternative Energy Sources

In the mutual aid response in Louisiana following Hurricane Rita in 2005, the Arkansas Rural Water Association (ARWA) supported a number of smaller utility operations. One system included a ground level storage tank that was filled from a pump powered by an electric motor with a natural gas fueled engine backup. Both electrical power and the natural gas supply to the community were disrupted. A circuit rider crew was able to utilize a bottled propane source to fuel the engine, using an adjustable regulator from a fish/turkey cooker to regulate the flow of gas to the engine. The first attempt at this operation failed because the 5-gallon propane bottle ran out, but after borrowing a 20-gallon tank they were able to run the system until a portable generator could be provided for the motor.

3.3 Electrical Apparatus Rehabilitation

A common element of upland flooding and coastal hurricanes is the necessity of drying out and restoring flooded electrical equipment. Several utilities reported that their electrical service workers restored to service electrical panels and components by hosing them down with fresh water to remove silt and debris, supplemented by use of tooth brushes for detailing of fine surfaces. This was followed by drying operations using hair dryers, or installing a dehumidifier installed inside the enclosure. Jeff Ford from ARWA also reported using compressed CO_2 as a method of drying out a flooded motor. Use of standard lockout/tagout procedures is a prerequisite safety precaution for these operations.

Flooding with salt water from a coastal hurricane surge introduces further complications in rehabilitating electrical equipment. Since dried salt deposition would be extremely difficult to remove and would be extremely destructive, it is important that the motors are not allowed to dry until they had been adequately flushed with fresh water. It is best to keep the equipment in a flooded state until provision for adequate flushing can be made. In the aftermath of Hurricane Katrina the Electrical Apparatus Service Association (EASA) published an article on expedient measures that could be employed to address the large numbers of motors and other equipment requiring repair, including the field fabrication of flushing vats and motor baking ovens. This article (Yung, 2006) is reprinted in Appendix C in this report.

3.4 Alternative Transport

Several utilities reported on transportation assistance they received from other agencies in during flood conditions. Typically, this involved use of boats loaned from other agencies to move staff in and out of the flooded facilities.

The 2008 flooding in Cedar Rapids, IA, involved some more exotic methods of transport for access to some of its critical facilities. The principal water supply for this system is a series of high capacity wells that are situated along the banks of the Cedar River. As shown in Figure 3-4, the July 2008 flood of the river totally engulfed the wells, which were equipped with top-mounted motors, such that only one well remained operational. Once the floodwaters had receded sufficiently that access to the wells was possible, a National Guard helicopter was used to lift and remove the disabled motors. The helicopter was not capable of sufficiently precise positioning such that it could be used for bringing in the repaired motors. The reinstallation was accomplished by boat equipped with a small crane. A regional diving company provided the crane-equipped boat. It was found that there was a window of time in which there is no feasible mode of transport into the well field along the river. Once the floodwaters had receded to a depth below which the crane-boats could operate, access could not be obtained until the ground had dried sufficiently to permit wheeled truck transport. It was noted that a prior GPS survey of that utility's ground water wells was useful to the helicopter flight crew in locating the well motors to be recovered.

Fig. 3-4. Repair operations for flooded wells in Cedar Rapids - July, 2008 (Jacobs, Cedar Rapids)
Upper right - Location of well fields inundated by flood swollen Cedar River
Upper left - Flooded well platform and power transformer (note top of motor above flood waters on right)
Lower left - Flood waters partially receded (note work platform above "normal" flood height)
Lower middle - National Guard helicopter used for removal of flooded motors for repair.
Lower right - Crane mounted boat used for installation of replacement motors.

Riordan (2008) reports on other instances of emergency coordination with National Guard and state police resources for transportation assistance, including escorted avoidance of transportation scales in order to speed delivery of critical chemical or equipment stocks.

3.5 Post Flood Sewer System Assessments

Some workshop participants reported difficulties at their wastewater treatment plants in handling the greatly increased volumes of extraneous inflow entering the sewage collection systems through damaged lines. They emphasized the necessity of walking the river and stream banks to detect and perform expedient repairs to damaged manholes and other structures. This includes checking the conditions of mobile home parks, which are sometimes built near river valleys and prone to damage, leaving behind disconnected sewer services. Visits to these developments in anticipation of a flood event is also useful because mobile homes may have been moved without proper capping of the sewer service connection.

3.6 Post Wildfire Response Actions

The experiences of the South Tahoe Public Utility District in the "Angora Fire" of 2007 are documented in the case study presentation in Appendix B of this report. Paul Sciuto, the Assistant General Manager for the STPUD, noted the following particular elements as noteworthy in that utility's immediate response actions (Sciuto, 2008):

1. Repair and/or replacement of 66 fire hydrants, which suffered particular damage to gaskets and lubricants,
2. Capping sewer laterals at 254 heavily damaged customer connections, so as to avoid heavy sediment and ash loads to the wastewater treatment system that would result from subsequent rains, and
3. Ground stabilization and hazard tree removal at four distribution system tanks.

3.7 References

Assar, M., 1971, Guide to Sanitation in Natural Disasters, World Health Organization. (emergency hypochlorite feeder diagram originally published in New York State Dept of Health Bulletin 22, as cited by Assar.)

Riordan, Ray, 2008, Emergency Manager for the City of San Ramon and Chair of the California Water/Wastewater Agency Response Network (CalWARN), (personal e-mail to author 9/28/08).

Sciuto, Paul, 2008. "Wildfire in the Lake Tahoe Basin – South Tahoe Public Utility District Disaster Response," presentation made at 2008 AWWA Annual Conference and Exposition.

Yung, Chuck, 2006, "Recovering from disaster," Uptime Magazine, January 2006.

4. Management Considerations in Natural Disaster Response

In addition to the more technical issues that are discussed in Chapters 2 and 3 of this report, the focus group workshop participants identified a number of management considerations useful in dealing with natural disaster response.

4.1 Taking Care of Employees

Multiple participants noted the importance of making appropriate measures to take care of the personal needs of employees and their families, whether the disaster situation is local or the utility is responding on a mutual aid mission. This recommendation is found in most emergency response guidance.

Paul Sciuto, reporting on South Tahoe Public Utility District's experience with the "Angora Fire," noted a somewhat more unusual aspect of this issue (Sciuto, 2008). Utility workers may find themselves working alongside other first responders, most typically fire fighters, and it is logical that they should be as appropriately equipped with personal protective equipment (PPE) as the firefighters. Air quality concerns in particular, including particulates and toxic gases in a general wildfire environment, may pose a serious hazard to all responders. Sciuto noted that even if the EOC advises that protective gear is not needed, utility employees are likely to notice the discrepancy if such protection is not provided. Sciuto also recommended not waiting to be invited to participate at the Emergency Operations Center (EOC) for an incident. His experience was that even though a request did not come from the EOC when it was established, his utility took the initiative to "invite itself" and its participation was then welcome.

4.2 Access for Utility Employees into Disaster Areas

Several of the workshop participants noted that in some cases their employees had difficulty in getting access to the affected disaster area if a mandatory evacuation order had been given. Typically, response workers would have to go through a checkpoint at their first entry to the area at the beginning of the day, and would have to leave the proscribed area at the end of the work period, and there would be delays on entry for each day's work. This was true for local utility workers as well as mutual aid responders from outside the area.

The WaterISAC issued a bulletin during the 2008 Hurricane Gustav event that summarized the credentialing and re-entry procedures state-by-state for the Gulf Coast area (WaterISAC, 2008). The report shows little consistency among the states, in terms of what documentation was required or what agency administered the credentialing/re-entry process (i.e. state, local or even a private entity). Given that access control is specific to local conditions, and may be managed by mutual aid resources, there is good reason that there would not be consistency. Outside mutual aid responders must verify arrangements, as they may not be similar to what they are familiar with. Also such procedures are quite changeable and would need to be rechecked in each specific future event.

In the evacuation zone of the "Angora Fire," Sciuto observed that utility vehicles that happened to be equipped with top-mounted flashers were generally waived on past the checkpoints with little formality while those vehicles not so equipped, even if marked as utility owned, would have to stop for a credential review (Sciuto, 2008).

4.3 Drinking Water Quality Notifications

Several participants in this project noted that public notifications on drinking water quality, including both "Boil Water" and "Do Not Use" orders, have often been a source of confusion following natural disasters. In several instances there has been confusion between state and local responsibility and authority, including questions as to which agency had the authority to issue an end to the restriction. Handling of these emergency notifications requires particular coordination between the state and local agencies and utilities.

Another complicating matter for such official notifications is the delay and uncertainty of receipt of the message by the public, and whether it is understood or acted upon (Bristow and Brumbelow, 2005).

4.4 Communications

All workshop participants noted the importance of provision for reliable communications during disasters. Several, particularly Mike Stuhr reporting on the Portland Water Bureau (PWB) mutual aid response to New Orleans after Hurricane Katrina, emphasized the importance of multiple forms of communication to overcome problems due to overload or outage of communication support infrastructure. Stuhr noted that PWB came equipped to make use of 800MHz radios, satellite telephones, cellular phones, and couriers.

Riordan (2008) notes that text communications on cell phones operated on a separate frequency from voice communication, and therefore worked more effectively than established radio systems that were wiped out in Hurricanes Katrina and Gustav. Local law enforcement, fire, public works and public health agencies were able to maintain a level of communication via text messaging. Amateur radio (or "ham" radio) was also very effective in Katrina, and some utilities have found it appropriate to install amateur radio equipment at some of their critical locations and train operators on their staff.

Jeff Ford reported that the Arkansas Rural Water Association, while on a mutual aid mission to Louisiana following Hurricanes Katrina and Rita, had good success with a two-way mobile repeater system. He indicated that the radio system that they used came with programming software that enabled them to add frequencies to match the host utilities that they were working with using their laptop computer. They also used a field-portable push pole antenna system, which got them a range of about 23 miles between the two field radios supported by the antenna at a 20-foot height. Greater range is achieved with the antenna raised to a higher level.

In disaster situations, the success of telephone communications can be enhanced by subscription to the Governmental Emergency Telephone System (GETS) for land line systems and its companion, the Wireless Priority System (WPS), for cell service. These two systems, operated by the DHS National Communications System (NCS), operate to provide priority service by expediting subscriber calls over other call traffic carried in the two systems. The NCS reported that both systems performed well during Hurricanes Katrina and Rita and subsequent events (like the Highway 35 bridge collapse in Minnesota in 2007), although neither system would be able provide telephone support if the basic supporting infrastructure has been destroyed (Martinez, 2008).

4.5 Disaster Aid Reimbursement

Several workshop participants noted the importance of thorough documentation of activities and expenses in order to qualify for reimbursement under Federal Emergency Management Administration (FEMA) rules. Stuhr described in particular the remarkable mutual aid response that was mounted by the Portland Water Bureau, consisting of two successive task force teams of 35 personnel, each deployed for 30 day tours. He noted that Portland had substantial emergency preparedness experience prior to this operation, but that the New Orleans deployment substantially increased the capabilities of the Portland staff. He indicated that Portland considered the experience well worth the effort, but he did note some significant frustration in the effort and time that it had taken to be reimbursed for the effort. In addition to the need for detailed expense and activity documentation, he noted that clear written prior authorization by all parties, including the recipient EMAC state agency, is an important element in getting approval from the review auditors (Portland, 2007).

4.6 Additional Water/Wastewater Response Resources

Primary additional resources available for water/wastewater utility response to natural disasters include:

- Participation in the state WARN (Water and Wastewater Agency Response Networks), current information on which can be obtained online at www.nationalwarn.org; and
- Utilization of the AWWA Resource Typing Manual, a system to facilitate clear, consistent terminology for personnel and equipment resources that are requested and shared in an emergency. The current update of the manual is also available online at www.nationalwarn.org.
- Training and exercise in Incident Command System (ICS) principles, which is available from FEMA and from most state emergency management agencies (http://training.fema.gov/IS/crslist.asp and http://www.fema.gov/emergency/nims/nims_training.shtm).
- The Water Information Sharing and Analysis Center, WaterISAC, at http://www.waterisac.org.

4.7 References

Bristow, Elizabeth, and Kelly Brumbelow, 2005, "Modeling Delay in Response to Water Contamination Events," poster presentation at "Working Together: R & D Partnerships in Homeland Security," Boston Massachusetts, April 2005.

Martinez, Nilsa, 2008, NCS Priority Communications Support, personal e-mail on 8/7/98.

Portland Bureau of Water Works, 2007, 2005 Hurricane Response and Recovery, Contract 35636 - Task Order 1, November 2007.

Riordan, Ray, 2008, Emergency Manager for the City of San Ramon and Chair of the California Water/Wastewater Agency Response Network (CalWARN), (personal e-mail to author 9/28/08).

Sciuto, Paul, 2008. "Wildfire in the Lake Tahoe Basin – South Tahoe Public Utility District Disaster Response," presentation made at 2008 AWWA Annual Conference and Exposition.

WaterISAC, 2008, "WaterISAC Advisory: Hurricane Gustav Update," e-mail dated 8/31/08.

Topical Index / Matrix

Topic / Incident	Page	General preparedness	Incident preparation	Response	Management measures	Flooding / hurricane	Earthquake	Wildfire	Treatment operations	Water distribution system	Wastewater collection
Access	18			X	X						
Angora Fire	17,18			X	X			X			
"Backbone" system mapping	3,9	X					X				
Chemical delivery	13			X		X			X		
Chlorine tank vulnerability	5,7,8		X			X	X	X	X		
Communications	19				X						
Disinfection - expedient methods	13			X					X		
Electrical asset preparation	6		X								
Excavation safety	8			X			X			X	X
FEMA - cost reimbursement	20				X						
Filtration operations	12			X		X			X		
Firebreaks for facility protection	8	X	X					X			
Generators	14	X		X					X	X	X
Generators - connection boards	14	X		X						X	X
GETS (Government Emergency Telephone System)	19				X						
GPS mapping	3	X				X		X		X	
Helicopter transport	15			X		X					
Large diameter hose	9	X		X			X			X	
Manual operations training	3	X		X	X				X		
Motors - rehabilitation after flood	14			X		X					

Topic / Incident	Page	General preparedness	Incident preparation	Response	Management measures	Flooding / hurricane	Earthquake	Wildfire	Treatment operations	Water distribution system	Wastewater collection
Personal protection equipment	18	X		X	X			X			
PLC (programmable logic controller)	6		X								
Propane - fueling a gas engine	15			X							
Records	3	X			X					X	X
Resource Typing	19				X						
Rice Fire	7							X	X		
Sandbag operations	4,12			X		X			X		
SCADA	6		X								
Sewer lateral plugging	16,17		X	X		X		X			X
Sprinklers - customer use	7			X				X		X	
Sprinklers for well protection	7	X	X	X				X			
Tanks - incident preparation	5		X			X					
Text message communications	19				X						
Transmission main repairs	8			X			X			X	
Transportation	13			X		X					
UPS (uninterruptible power source)	6		X								
VFDs (variable frequency drives)	14	X	X	X							
Warning (advance)	4,6,8		X			X	X	X			
WARNs	19				X						
Well vent plugging	6		X								
Witch Fire	7			X				X		X	

APPENDIX - A

Focus Group Workshop Presentation Synopses
WISE Natural Disaster Response Primer

1. **Steven Porter, Systems Engineer, Greenville Utilities, NC**
   - Hurricane Floyd (1999)

2. **Jay Van Hoose, Superintendent, Water Treatment Plants, City of Rocky Mount, NC**
   - Hurricane Floyd (1999)

3. **William "Rusty" Reeves, Water Circuit Rider, Louisiana Rural Water Association**
   - Hurricanes Katrina and Rita (2005)

4. **John Huber, Treatment Operations, Charlotte-Mecklenburg Utilities, NC**
   - Hurricanes

5. **Bruce Jacobs, Utilities Engineering Manager, Cedar Rapids, IA)**
   - Cedar River flooding (2008)

6. **Robert McVay, Drinking Water Trainer, Florida Rural Water Association**
   - FlaWARN Best Management Practices Manual

7. **Michael Stuhr, Chief Engineer, Portland Water Bureau, OR**
   - Mutual Aid response to New Orleans for Hurricane Katrina (2005)

8. **Jeff Ford, Deputy Director, Arkansas Rural Water Association**
   - Mutual Aid response to Louisiana for Hurricanes Katrina and Rita (2005)

9. **Allen Goodson, Manager of O&M Planning, East Bay Municipal Utility District**
   - Northridge Earthquake (1994)

1. **Steven Porter, Systems Engineer, Greenville Utilities, NC**
   - Hurricane Floyd (1999)

   Greenville Utilities provides power, natural gas, water and wastewater services to the city of Greenville and 75% of Pitt County, North Carolina. Hurricane Floyd struck in September 1999, dropping from 15 to 30 inches of rain in the area. The Tarr River, which as a recognized flood stage of 13.0 ft. and a previous flood record of 17.3 ft., was projected to crest at elevation 23.9 ft., but the actual peak due to Hurricane Floyd was 29.73 ft. During the peak of the flooding, electrical service was lost for less than 24 hours; however, water, wastewater and natural gas services were not interrupted, although they were substantially strained. Floodwaters did inundate various Utilities facilities, including the water treatment plant. The presentation reviewed impacts of the flooding on the water and wastewater plant operations.

2. **Jay Van Hoose, Superintendent, Water Treatment Plants, City of Rocky Mount, NC**
   - Hurricane Floyd (1999)

   Van Hoose reviewed the impacts of Hurricane Floyd on Rocky Mount's Sunset Avenue Water Treatment Plant and its restoration to operations. Major impacts at the WTP from the storm were felt on September 16th , beginning with loss of power at 6:30 a.m., progressing to entry of flood waters which rose to chest deep by noon, resulting in plant evacuation by 2:30 p.m. Operators returned to the plant while still in flood condition to assess damages and tend to immediate needs, including a pair of floating chlorine containers tethered by their connections to the disinfection manifold. After 36 hours the floodwaters had receded to a point where re-entry was possible and a strategy was implemented for plant restoration/rehabilitation organized by teams (motors, pumps, electrical, bulk chemical, and chlorination). In total, the plant was out of service for 196 hours.

3. **William "Rusty" Reeves, Water Circuit Rider, Louisiana Rural Water Association**
   - Hurricanes Katrina and Rita (2005)

   Reeves described efforts of the LRWA to assist several smaller utilities in the wake of the two hurricanes. In addition to plant operations restoration efforts, work included assistance in coordinating alternative water supply operations via tanker trucks (including testing for water quality, and coordination of permits), location and repair of customer service connections, and lookout for alligators in fresh water flood areas.

4. **John Huber, Treatment Operations, Charlotte-Mecklenburg Utilities, NC**
   - Hurricanes

   Huber related personal lessons learned from several past hurricanes. He noted first priorities are typically initial steps toward rehabilitation of electrical apparatus, particularly if flooded by salt water. He noted steps appropriate for preparing for a flood situation should include removal of motors to a safe elevations (with appropriate connectors and anchors to enable their removal), and de-energizing SCADA and instrumentation (including UPS) to avoid damage during the flood. He emphasized the importance of preplanning and premapping the critical "backbone" pipeline elements of the system and having in stock necessary clamps of each size in order to make prompt repairs.

5. Bruce Jacobs, Utilities Engineering Manager, Cedar Rapids, IA)
- Cedar River flooding (2008)

Similar to the North Carolina floods, the Cedar River flood shattered previous records for historical flood crest: 31.12 ft. on June13, 2008, compared to previous record of 20.0 ft. in 1929. Presentation included account of the impacts and response to flooding of the water treatment plant, the source water well fields, and the wastewater treatment facilties.

6. Robert McVay, Drinking Water Trainer, Florida Rural Water Association
- FlaWARN Best Management Practices Manual

McVay's presentation gave an overview of the Hurricane Best Management Practices manual that has been developed by the Florida Rural Water Association, FlaWARN, and various utilities around the state. The manual documents FlaWARN procedures in preparation for a hurricane, implementing mutual aid (including demobilizing after the end of the event) and various technical issues. McVay noted the importance of appropriate qualification and training for safe implementation of some of the electrical power techniques outlined in the manual, and described training resources offered by FRWA and the University of Florida TREEO Center.

7. Michael Stuhr, Chief Engineer, Portland Water Bureau, OR
- Mutual Aid response to New Orleans for Hurricane Katrina (2005)

Stuhr described the mutual aid mission that was undertaken by the Portland Water Bureau in support of the Sewer and Water Board of New Orleans (SWBNO)in the wake of Hurricane Katrina. Portland's response effort was organized as a task force with two successive deployments for 30 days of two different 35-person teams. The teams were dispatched equipped to be self-sufficient, both in terms of resources to do their work and facilities to house and feed the personnel (although when they arrived it was found expedient to house them in a tent city that had been established at one of the SWBNO's treatment facilities.) The task force worked along side of and took direction from the SWBNO's workforce, undertaking facility damage assessments, distribution system repairs, mechanical and electrical equipment overhauls, and motor vehicle fleet services. The effort was specifically coordinated through the interstate Emergency Management Assistance Compact (EMAC) process; however, one of the reported "lessons learned" is the need to streamline the paperwork and documentation necessary to offer and receive aid in this process, including facilitation of the initial written authorization process in order to provide for appropriate cost reimbursement.

8. Jeff Ford, Deputy Director, Arkansas Rural Water Association
- Mutual Aid response to Louisiana for Hurricanes Katrina and Rita (2005)

Ford related experience of the Arkansas Rural Water Association in providing mutual aid support to its sister association, Louisiana Rural Water Association, following the 2005 hurricanes. Issues dealt with included restoration of power with emergency generators, and other prime mover backup (for instance substitution of bottled propane with an expedient regulator device as a substitute for a natural gas for driving an engine), portable communications, and field coordination and communication amongst widely dispersed field teams.

9. Allen Goodson, Manager of O&M Planning, East Bay Municipal Utility District
- Northridge Earthquake (1994)

Goodson gave a visual presentation highlighting the characteristic types of damage that is experienced by water system infrastructure due to seismic events, illustrated photographically from the Northridge Earthquake.

APPENDIX - B

Case Studies
WISE Natural Disaster Response Primer

1. **"Start-Up of the Sunset Avenue WTP after Hurricane Floyd Flooding" (Jay Van Hoose)**
2. **"Wildfire in the Lake Tahoe Basin – South Tahoe Public Utility District Disaster Response" - (Paul A. Sciuto, presented at 2008 AWWA ACE)**
3. **"Preparation: Key to Hurricane Damage Restoration" 2004, a set of three articles that review Florida water utility impacts from Hurricanes Charley, Frances, Ivan and Jeanne (Florida Water Resources Journal, 2005)**

Readers of this report and of these case studies would also find of interest a compilation of case study reports published by the American Academy of Environmental Engineers (AAEE), entitled Natural Disaster Experiences: How to Prepare Environmental Facilities for the Worst (1995). It consists of eight reports focusing on experiences of water and wastewater facilities during the 1994 Northridge Earthquake and 1993 river floods in the Midwest, plus a chapter of suggestions for disaster preparedness, based on these case studies. It is available for purchase from the AAEE Bookstore <http://eebookstore.com/default.cfm>.

Another very useful source for case study natural disaster accounts the Water Library service of the American Water Works Association, specifically archived articles from the Journal AWWA, which can be accessed at <http://www.awwa.org/AWWA/WaterLibrary/Search.aspx> Among the accounts that can be downloaded from this site are:

- **"Water Quality after a Disaster" 1971 Sylmar Earthquake in Los Angeles (Adrian, JAWWA, 1972)**
- **"Lessons Learned from the Loma Prieta Earthquake" 1989 Loma Prieta Earthquake in San Francisco (Pickett, et al., JAWWA, 1991)**
- **"Earthquake lessons pay off in Southern California" 1994 Northridge Earthquake in Los Angeles (Young and Means, JAWWA, 1995)**
- **"Surviving the Flood: Teamwork Pays off in Des Moines" 1993 river flood, (McMullen, JAWWA, 1994)**
- **"Shaken into Action," 1994 Northridge Earthquake in Los Angeles, (Tanaka, JAWWA, 1995)**
- **"Weathering the Storm: Water Systems Versus Hurricanes," 1994 Hurricane Andrew in Florida, (Murphy, JAWWA, 1994)**

Start-Up of the Sunset Avenue WTP after Hurricane Floyd Flooding

Jay W. Van Hoose, Superintendent*
City of Rocky Mount
Water Treatment Plants
1 Government Plaza
Rocky Mount, NC 27802-1180

ABSTRACT

This paper will discuss what steps were necessary for restarting the Sunset Ave. water treatment plant after it was flooded with 4 to 8 feet of water from Hurricane Floyd. This information may help those who may experience a catastrophic event.

INTRODUCTION

The Sunset Ave. water treatment plant is located 370 feet east of the Tar River. It was originally constructed in 1934 with a capacity of 3 MGD. Since then the plant has been expanded twice. Once in 1942 to 9 MGD and in 1956 to a total capacity of 12 MGD. In 1989 the plant was renovated and upgraded to a capacity of 18 MGD. This process included rebuilding all 15 filters and converting from single media sand filters to dual media of sand and anthracite filters. New electrical systems were installed, new filter control systems, installation of filter sweeps, new turbidity meters on all filters, renovations of all office spaces and modernizing of the drinking water lab located at the plant. In 1995 an ozone system was added as a pretreatment of TTHM's.

TIME LINE OF THE FLOOD

On September 16th the plant was operational until we lost power for the electrical substation across from the plant. The plant called for the generator technician to start the peak shaving generator so they could start the plant back up. When the technician arrived the water level in the Tar River had started to enter the substation and it was decided not to start the generator due to the apparent danger. It was 6:30 AM when the plant was notified of the situation with the generator by the electric department.

The river continued to rise and by 10:30 AM that morning the water began entering the water plant. By 12:00 noon the water had risen to over four feet in the main lobby of the plant and to chest deep in other areas within the plant. At 2:30 PM that afternoon the plant personal were evacuated out of the plant via boat from the back door. During that time we had to travel to the bulk chlorine storage building behind the plant by boat and turn off the two ton cylinders that were still hooked up the chlorine header and still in operation. The cylinders were hanging upside down by their pigtails to the header. Gary Weeks, Lead Mechanic, entered the building and standing on the frame of the chlorine header turned off the ton cylinders at the tanks.

FIRST INSPECTION

We entered the plant on Saturday the 18th in waist deep water to retrieve supplies form the lab. We had reactivated the lab at our second water plant so the lab personal could begin taking water samples through the city. During that time the Lead Mechanic, Gary Weeks, and I made a quick inspection of the plant and began planning our attack of what we had to do to get the plant back operational.

That first inspection revealed some startling discoveries. Water depth in the bulk chlorine storage building was 7'11". In our bulk chemical storage building 3 out of 6 bulk tanks had floated and broken the pipes attached to them. One 20,000 gallon schedule 80 black iron caustic tank and caused damage to the roof of the building along with the end panel of the building and had come to rest by pushing a 20,000 gallon alum tank off its base. We later discovered that the caustic tank had hit the fiberglass alum tank so hard that it had factored the windings in the tank. This caused us to replace the tank.

Our 10,000-gallon bulk fluoride and phosphate had also floated and were lying on their sides inside the building.

SUNDAY SEPTEMBER 18TH THE WORK BEGINS

We decided the best way to handle the different systems was to set up teams to tackle each problem. Each team would be made up or outside contractors headed up by water plant personnel. This was felt the be the best solution because we did not have the available resources to get the plant operational in a timely manner. So the following teams were developed:

- Motors
- Pumps
- Electrical
  - Main Switch Gear
  - Bulk Chemical Electrical for chemical transfer to day tanks
- Bulk Chemical Building and Tanks
  - Right Tanks and Re-pipe
- Chlorinators

TEAM MOTORS

Because the crane in the main plant was not operational all of the motors had to remove by hand. This task was completed on September 19th. All of the motors were inspected by the motor shop, cleaned, backed, MEGED, rewound if needed and new berings installed in all motors. The motors were returned on September 22nd and installed in the following order. Backwash first, then the low duty pumps that transfer water from the filter flumes to the clearwells and finally the finished water pumps.

TEAM ELECTRICAL

Because the main electrical distribution had 4 plus feet of water in it we were advised that the main gear had to be rebuilt and that two 2000 amp distribution breakers, a 1200 amp breaker for low power distribution and a 600 amp breaker all had to be replaced. Work started on September 21st and was completed on September 22nd at 9:30 PM. We had main power back in the plant.

TEAM BULK CHEMICAL BUILDING AND ELECTRICAL

The first order of business was to right the tanks that had broken loose. This was accomplished by removing the roof of the building and attaching a crane to the tanks and removing them from the building. After this temporary connections were made to the tanks remaining in the building so we could get chemicals into the day tanks located on the third floor of the main building. We also had to make temporary electrical connections to the transfer pumps with the use of a 430v 3 Ph generator. This setup allowed us to get chemicals into the main plant and be operational while we could plan for more permeate repairs to the chemical handling system. We had the chemical transfer pump and motors repaired and installed by September 21st.

TEAM CHLORINE

We contacted and outside contractor to perform a de-watering of the chlorine system and to replace and or repair any part they felt necessary to insure safety and safe handling of the system. The system was available on September 22nd.

PUMP WELLS AND CLEARWELLS

Because of the flooding of the plant we had no choice but to pump out the filter wells in the plant. We also inspected the clearwells across the road from the plant and discovered evidence that the water inside had become contaminated so we pump them out also. This was performed during the night. This process started on September 19th and was completed on September 21st.

WEDNESDAY SEPTEMBER 22ND, 1999 - ALL SYSTEMS GO!!

By 11:00 PM that night we began operating the plant again at the rate of 6 MGD. We started the chlorine feed to give us 5 mg/l of free chlorine in the filter flumes. When the flumes were full we began filling the clearwells. This process continued until Thursday September 23rd when we started back washing filters and filling the clearwells.

THURSDAY SEPTEMBER 23RD

We continued to operate and monitor the plant with out and problems except we had filter rate controls fail on two of the fifteen filter. However we were able to maintain a filtration rate of 6 MGD per day with the remaining filters.

FRIDAY SEPTEMBER 24TH

On Friday we took bacteriological samples off each filter, from the filter flumes and the clearwells and lowered the free chlorine level from 5.0 to 4.0 mg/l. We continued to operate and monitor the plant with out and problems except we had filter rate controls fail on three more of the filters. This left us only 10n operational filters. However we were able to maintain a filtration rate of 6 MGD per day with the remaining filters.

SATURDAY SEPTEMBER 25TH

On Saturday we read the bacteriological samples and all returned negative. At 11:00 Am we started the finish water pump and began pumping 6 MGD of water back into the system. The plant was out of service for a total of 196 hours or 8 days. It was the first time since 1934 that the plant had missed a day providing water to the City.

HEROES

I would like to mention what I feel are the true heroes who got the Sunset plant operational in such a short period of time.

- Gary Weeks - Lead Mechanic. Gary worked closely with me in getting outside contractors on site and supervising the individual teams to see that all of the necessary work was being performed.
- Jack Evans - Chief Operator, Sunset Ave. WTP. Jack was at the plant when the flooding started. He and the operators protected as many systems in the plant before they were stopped by rising water.
- J.C. Spell - Chief Operator, Tar River WTP. J.C. worked round the clock in keeping the Tar River plant operating during the storm and flood. During this time he had to be taken to the hospital because of a kidney stone. After a short visit to the emergency room he returned to the plant to aid his operators during the time when the Sunset plant was offline.

- Greg Mann, Jason Friedrich, Emanuel Shell and Joe Arrington, Operators at the Sunset Ave. WTP. All of them worked around the clock without complaint to get the plant back operational.
- Paul Dages, Ronnie Taylor, William Tucker, Robert Tisdale Jr., and Jimmy Lynch, Operators at the Tar River WTP. All worked around the clock without complaint at the Tar River WTP. Some of them had to drive 1 or more hours to get to the plant to relieve their fellow operators. No one missed a shift.
- Butch Smith, Raymond Ingram, William Bridges, Ben James and Earl Manley, Maintenance Staff. All worked around the clock not only at the Sunset WTP but also at the Tar River WTP to keep it operational during the flood.
- Mike Hicks, Superintendent of Kerr Lake Regional Water Plant. Because we were unable to get alum from our supplier Mike arranged transportation from his plant to our Tar River plant so we could still operate. With out his aid we would have run out of alum and had to shut down the Tar River plant.

CONCLUSIONS

We feel that we were able to get the Sunset Ave. plant back on line as quickly as we did for several reasons. We were the first to have the flood water recede. This allowed suppliers, vendors and contractors to call on us and to volunteer their help and resources.

We also overlooked two very important areas when you are dealing with a disaster of this magnitude. One is feeding your people on site. Providing a hot meal is very important if you expect you employees to perform at their best. We decided that the best thing to do was to assign one person to be a cook and go and gather all the supplies they needed to cook for all of the employees. This worked out very well.

We also learned that getting sleep is always over looked. For the first 24 to 48 hours you are running on pure adrenaline. After that time you power to reason and to make good decisions becomes very suspect. Getting sleep is very important. You will be surprised how fast people will go to sleep after 48 hours of no sleep.

Wildfire in the Lake Tahoe Basin – South Tahoe Public Utility District Disaster Response

Paul A. Sciuto, P.E. – Assistant General Manager, South Tahoe Public Utility District

INTRODUCTION

On June 24, 2007, the worst fear for generations of Lake Tahoe residents became a painful reality as the Angora Fire roared through a portion of the Lake Tahoe Basin (refer to Photo 1) and left in its wake 3,100 acres charred, 254 homes destroyed, 35 other structures severely damaged, and thousands of residents evacuated from their homes. Critical to the containment and extinguishing of the fire was the quick and decisive work of South Tahoe Public Utility District (District) to keep water moving from several pressure zones so it could be distributed to the fire fighting personnel. After the fire was contained, the District continued working to mitigate potential infrastructure damage and environmental concerns. There were many lessons learned concerning disaster response through this experience that are directly applicable to other public agencies and districts.

The Angora Fire swept quickly through a mountainous forest-urban interface in South Lake Tahoe and required 2,174 people, 164 fire engines, 21 helicopters, and 15 water tenders to contain the fire. In order to keep water flowing to the fire fighting crews in this challenging terrain, the District worked 24 hours per day in the fire zone until the fire was contained. Critical facilities in the fire area included 6 water tanks, three booster stations, numerous system valves, and associated appurtenances.

THE DISTRICT

The District provides water and wastewater services in the South Lake Tahoe area from the Stateline with Nevada to Fallen Leaf Lake and has approximately 14,000 water customers and 17,000 wastewater customers. The water system has 15 pressure zones, 253 miles of waterlines, 22 water tanks, 15 wells, 16 booster stations, and 23 pressure reducing valves. There are 114 employees of which 47 worked on fire related activities. These employees expended almost 3,000 regular hours and 900 overtime hours on fire and post-fire activities.

CHALLENGES AND ISSUES DURING THE DISASTER

In addition to the obvious challenges of working in a fire area and distributing water to the 180 fire vehicles, there was a variety of other issues faced during this disaster response.

Access and Communication

Accessing the Districts facilities was hindered by the fire itself, downed power lines, and traffic from evacuating residents. Communicating with District employees was critical to insure coverage at all facilities particularly with the access difficulties. We primarily utilized two-way radios with our radio base always manned at the wastewater treatment plant.

Communicating with the emergency service personnel was also important throughout the duration of the fire. Initially the District did not have an open channel of communication with emergency services, but upon initiating contact with the Incident Command Post we were well integrated into the communication channel.

Another challenge was we did not know exactly the magnitude of the fire or the response of emergency personnel. There was not reliable media source in town for the first few days of the fire.

Worker Safety

Worker safety is of the utmost importance to the District particularly in unusual circumstances such as this. Some of the issues included air quality due to particulates and toxic gases emanating from the burning structures. Therefore, appropriate personal protective equipment was important for both air quality as well as working in close proximity to a major conflagration.

Another item to track was the number of hours worked by each employee. The highly dedicated nature of the District's employees often resulted in people working in excess of 18 hours straight. Although this was curbed after the first day, such hours can often results in fatigue induced mistakes or oversights. While people are working those hours providing adequate food and water is critical.

Many of our employees lived in or near the fire zone, so providing updates on family location or status of their house helped to alleviate concerns.

Water Distribution

In addition to difficult access the first problem faced was the loss of electric power to all facilities within the fire area. In addition to loss of pumping, instrumentation including tank levels and flows were not available without power. With no power to facilities, emergency power had to be maintained 24 hours a day while the fire was ongoing. This meant constantly checking and filling the diesel tanks of generators and engine driven fire pumps.

Concurrently with keeping water in the distribution system, shutting off water services to houses that were burned became critical so as not to drain the water system. This meant finding and shutting off valves at 254 homes that were completely burned out (see Photo 2).

With 15 pressure zones and the demand for water moving with the fire numerous system valves and interties were exercised. Tracking these actions was critical as personnel changed on a daily basis. Without an adequate tracking procedure, tanks could be drained or pressure lost at critical moments.

Incident Command Post (ICP)

The Office of Emergency Services (OES) instituted the National Incident Command System (NIMS) protocol and structure to manage the emergency services fighting the fire. Although

District personnel have trained in NIMS, integrating into a full scale emergency resulted in numerous challenges.

Initiating communication with ICP was critical in integrating the District with the ICP. Decisions such as where water was being used helped in directing District resources to the correct areas and tasks.

The Incident Command Post (ICP) was established in the parking lot at Heavenly Ski resort. This essentially became a small "city" housing and feeding almost 2,000 people making supplying water and wastewater services to the ICP a logistical challenge.

RESPONDING TO THE AFTERMATH

After the fire was contained, significant work was performed to insure the integrity of the District's infrastructure and reduce potential damage to the wastewater treatment plant and the environment.

Capping of Sewer Laterals

From the Oakland Hills fire we learned that burned out foundations with open sewer laterals acted like a funnel allowing storm water and fire debris into the wastewater collection system Therefore, the District excavated and capped off all sewer laterals to destroyed buildings to mitigate stormwater draining through the sewer cleanout that could result in an overflow of the sewer system or an upset of the wastewater treatment plant. In total 254 sewer laterals were capped.

Test, Repair, and Replace Hydrants

It was estimated that the fire burnd in excess of 1800 degrees Fahrenheit. Therefore, the District tested and then rebuilt or replaced 77 fire hydrants in the fire zone that had been damaged by the intense heat of the fire.

Site Work

In a mountainous area many of the District facilities are on severely sloped land. With the fire destroying all vegetation up to each tank and booster station future slope stabilization was needed. Ultimately 5 tank sites were evaluated and two tank sites were stabilized. In addition hazard trees were cut and removed at two sites.

Tank and Booster Station Condition Assessment

In addition to the site evaluations, each structure was evaluated for damage. One booster station and one tank were found to have fire damage. The cost of repair for these structures was submitted to the District's insurance company for reimbursement.

Capital Improvement Project Selection Methodology

The District follows an asset management protocol to determine the Capital Improvement Projects (CIP)for the 10-year budget. In looking at the probability of failure and the consequence of failure while considering a forest/urban wildfire many of our priorities changed. Thereofore, the fire resulted in a reconsideration of Capital Improvement Projects throughout the District's service area.

Emergency Response Plan

In addition to a change in the CIP, the District promptly updated its Emergency Response Plan with the correct personnel in different functions.

Fire Related Ordinances

Within one week of the fire the District's Board passed ordinances that addressed customer concerns regarding paying for water and sewer services during the rebuilding time.

REIMBURSEMENT

Having only 14,000 water customers resulted costs per customer for the fire response to be significant. Therefore, cost recovery was very important to the District. The District's Grant Coordinator was the point person for both Office of Emergency (OES) grant requests and insurance requests. Through OES and the District's insurance we have submitted for reimbursement of about $1 million.

To strengthen your position to obtain reimbursement it is important to track all time expended on fire related activities and to correlate expenditures to the impact of fire.

LESSONS LEARNED

Although the District performed admirably during and after the Angora Fire, there are lessons learned from the experience. The following guidelines can be used by public agencies and districts during emergencies:

- Immediately Contact ICP – Don't wait for an invitation
- Insist on being integrated into the Strategic Planning Meetings
- Provide Appropriate PPE even if ICP says it is not required
- Consider and Plan for loss of power, loss of SCADA, limited access, redundancy
- Start thinking about post-emergency implications even before the situation is under control
- Critically revisit Emergency Response Procedures
- Get Trained in NIMS/SEMS
- Notify OES and Immediately Apply for Potential Reimbursement

- Track all costs for potential reimbursement
- Document as you go so you remember later
- Set up the EOC at the District
- Track and Log all Actions
- All Employees Should have ID's with Pictures
- Have Beacons for Every Truck
- Coordinate our Emergency Response Plan with our Business Continuity Plan
- Address customer concerns through changes to the administrative code

CONCLUSIONS

The community is rebuilding and there is an increased awareness of fire prevention and defensible space around structures. Throughout the fire no District personnel were injured and the District had water flowing during the entire fire. We were commended publicly by the local fire chiefs for responding to emergency personnel needs and helping the fire fighting effort. But this experience has provided many insights to the District and we will modify some procedures to better prepare for the next emergency

Photo 1

Start of the Angora Fire in South Lake Tahoe

Photo 2

Burned House with Open Sanitary Sewer Lateral

Preparation: Key to Hurricane Damage Restoration

By Douglas B. Prentiss
Utility Training Coordinator • Gainesville Regional Utilities

There were many heroes during the hurricane season of 2004, and the water/wastewater industry was fortunate to have a great safety record during and after the four hurricanes that struck our state. Some of these brave men and women risked life and limb while working tirelessly in dangerous conditions. All of them demonstrated that the spirit of volunteerism is alive and well in Florida.

Many of the same professionals shared the lessons they learned last year for this article and other emergency preparedness articles to be published in the *Journal* over the next few months. So we open with comments from our contributors about advance preparation.

Types of Damage to Anticipate

Based on the answers from participants in our survey, the following types of damages were initially found during post-storm assessments of facilities:

<u>Wastewater Treatment Plant</u>
1) Trees down.
2) Equipment damaged by falling trees.
3) Equipment bent by wind.
4) Equipment damaged by wind-driven debris.
5) Plant building destroyed or damaged.
6) Lines broken.
7) Electric line short circuited.
8) Damage to control panel.
9) Flooding by storm surge.

<u>Lift Station/Collection System</u>
1) Above-grade lift station piping damaged by fallen trees.
2) Lift stations without power.
3) Portable generator failures.
4) Lift station telemetry antennae blown down.
5) Lift station power supplies damaged.
6) Sanitary sewer overflows.
7) Flooded lift station.

<u>Water Treatment Plants</u>
1) Generator failure, causing system-wide pressure to drop.

<u>Water Distribution System</u>
1) Broken water mains
2) Service line breaks

The majority of reported water and sewer line breaks, except two, were related to fallen trees. In some coastal communities, significant sections of lines were washed away by wave action.

<u>Administration Complex (Office, Operations, and Fleet Areas)</u>
1) Trees down.
2) Roof leaks.
3) Telephones out of service.
4) Local flooding.

Monitoring the Storm Path

Several areas, including Orlando, had only a few hours to prepare because a storm made an abrupt turn to head directly at them. What was good news for some was devastating to others. Two storms followed the same path, and the utilities in that path were hit twice, while the coastal system took brutal winds and waves.

One water plant on an island was running again in a few hours after a direct hit, but blue tarps still cover many houses and one wastewater plant will never be rebuilt. The lesson: Secure your facilities based on all possible storm paths.

Communications

The ability to communicate with our system, our coworkers, and our customers is a critical component to the success of our restoration effort. Plans must be put in place in advance of events and every contingency must be considered. The following are communication lessons learned by utilities across the state:

- Pre-hurricane public notices on local government access channels should address how you are preparing for the storm and how operations may change after the storm.
- Boil-water notices must be developed in coordination with county health department input before storms, since communications might be down afterward.
- Coordinate with local radio, television, and print media prior to storm events.
- Customer education programs should assist in preparing customers.
- Pre-hurricane public notices need to address how long to boil water and provide alternate methods for water disinfection with bleach.
- Older analog phones may be the only ones that work when the power is out.
- Radios and cell phones did well overall, and generally the repeater towers survived the winds. Where towers were down, service was interrupted.
- Radios equipped with multiple channels were most useful.
- Ham radios may be the only form of communication available. Know who your ham operators are and include them in your emergency response plan.

John Jones Sr., an instrument technician and licensed electrician who works for GRU, troubleshoots what is left of a lift station control panel in the aftermath of Hurricane Frances.. Workers such as Jones, who has extensive lift station and plant experience, proved invaluable during the 2004 hurricane season.

- Plan for post-storm increases in customer-service communication requests. Customers want information concerning service interruptions. A critical part of the public perception of your response to the emergency is based on the timeliness and accuracy of the information you provide them.

Emergency Preparedness Planning

Plans need to include the possibility of isolating high-risk areas before storms arrive and locating emergency operations centers and shelters in low-risk areas.

Arrangements need to be made prior to storms for cash needed for recovery. Additional comments concerning emergency planning included:

- Emergency response plans (ERPs) must address emergency generator needs and personnel.
- Mutual aid agreements need to be in place prior to storm events. (FlaWARN went into effect on April 24, 2005).
- ERPs must be updated annually and staff trained to use the plan.
- Industry workshops should be held to share the lessons learned (Hurricane Survival and Restoration workshop at FWRC, 04/05).
- Consultant-written ERPs are not as effective because operations staff is left out of the process.
- ERP must reflect what staff is trained to do and provide resource information

Emergency Operations Centers

Some water and wastewater utilities did not receive the level of priority needed from emergency operations centers (EOCs) when requesting assistance during post-hurricane response. Suggestions for improving this situation include:

1. Establish a relationship with the power company and EOC.
2. Place utility staff in the EOC to coordinate your issues.
3. Communicate to the EOC that certain lift stations or water systems must be powered for water to be supplied to hospitals and special-care shelters and for toilets to remain operational at these facilities.
4. Utilities should be proactive communicating with the county EOC before the incident.
5. Power companies respond to the lift station power meter number—addresses are not much help to them, forcing them to search their data base, which causes delay.

Facilities Locations

1. Targeting information is a security issue for utilities, but GPS locations on wells, plants, and lift stations, may be critical for others to find facilities following major events. Consider security issues when developing this planning tool.
2. Develop alternative systems to locate facilities, such as driving directions to lift stations.
3. Be prepared to provide local staff to serve as guides for mutual aid responders in areas of high wind or flooding during restoration efforts.
4. Getting to lift stations with mobile generators/bypass pumps was a real issue in the face of downed trees, limbs, debris, and no street signs.

Fuel

1. Refueling is a critical issue that requires advance planning.
2. Portable generator refueling becomes an important logistic task.
3. Consider a larger fuel storage tank for service truck.
4. Revise emergency plans to include refueling issues.
5. Refueling mutual aid agreements with contractors should be in place prior to storm events.

Food

1. Ensure adequate food and water for recovery workers.
2. Purchase and store adequate amounts of emergency food supplies.
3. Prepare and provide adequate amounts of drinking water for workers.

GRU treatment plant operator Tom Mikell and construction inspector John Worley team up to rewire a storm-damaged control panel while pumping down a lift station following Hurricane Frances.

PHOTO COURTESY GRU

Generators

1. Test all generators under load before hurricane season.
2. Evaluate the number of generators available for your lift stations.
3. Evaluate the generators on hand, identifying wheels vs. skids or hard wired, and include this information in your ERP.
4. Anticipate generator failures at about 10 percent—as much as 50 percent if old or used.
5. Establish an in-house goal for generator self-sufficiency, and include mutual aid resources for the remaining balance.
6. Additional factors to consider when determining generator needs are:
   a. The number of generators needed goes down if a system has adequate SCADA.
   b. Bypass pumps may be a good alternative if system pressures allow.
   c. Vacuum trucks or septic pump trucks can reduce the need for generators.
   d. Emergency interconnects or flow diversion may reduce the need for generators.
7. Coordinate the use and placement of generators.
8. Develop a method for determining the size and number of generators needed.
9. Standardize the types of plugs or connections for generators.
10. Hot wiring is dangerous but was the customary condition during the recent hurricanes. Ensure that your generators are handled by competent personnel.
11. Experienced electricians were in high demand.
12. One system used 13 generators to keep 1,100 lift stations in operation until power was restored.
13. Maintaining generators includes:
    a. Maintenance & services contracts.
    b. Storage.
    c. Rotating equipment.
    d. Capital replacement issues.
14. Consider generators for fleet and administration buildings needed for support operations.
15. Consider generators as annual budget item.
16. Work with local EOC coordinators to site generators placed at shelters and EOC lift stations.
17. Formalize water distribution plans for emergency water sites.

Continued on page 22

Continued from page 19

Repair Parts

Identifying what parts are needed is the first step in determining what is necessary. Repair parts for generators may be dramatically reduced if all generators are standard items. Basic supplies such as plugs for generators may vary. Where possible, work toward standard connections, plugs, and support parts. In general, increase your spare parts inventory for critical parts.

The standardization of the emergency connectors will be a goal for FlaWARN, but will be a difficult task. Many additional considerations will be included in next month's article.

Hazardous Chemicals during Hurricanes

The safe storage and handling of hazardous chemicals during storm events presents special challenges to water and wastewater facilities. Large tanks and containers may be displaced by winds, tornados, or flooding. Review your worst-case and most likely storm scenarios and develop a plan to continue treatment while allowing for the highest level of security. Examples of these procedures may be, but are not limited to:

1. Securing containers and tanks.
2. Moving containers to safer locations.
3. Temporarily removing containers from dangerous locations.
4. Reducing inventory if feed points are vulnerable to wind or flooding.
5. Increasing inventory if post-storm delivery delays may develop.
6. Increased monitoring of hazardous materials areas.
7. Setting up a temporary process to reduce hazards.
8. Reviewing hazardous materials response plans.
9. Inventorying emergency response equipment and materials.

Pump Trucks

Skilled drivers and operational trucks are among the options to be considered when evaluating the need for generators and portable pumps. These trucks can be borrowed from other departments, rented from contractors, or obtained through mutual aid agreements with other utilities. Several utilities rented trucks and drivers from the septic tank pumping companies who dump at their facilities. These agreements should be part of your emergency operations plan with terms and availability already worked out prior to the storm.

Pay Issues

Pay issues, such as hours of work and overtime status, must be established prior to storm events. Operational supervisors and managers must clearly understand how long and under what conditions employees may work. Some of the lessons learned on this issue are:

1. Consider pay issues for overtime exempt employees.
2. List specific pay issues that are approved or not approved, such as:
   a. Straight time.
   b. Overtime eligibility and rates.
   c. Total hours allowed.
   d. Vacation and sick pay issues.
   e. Holiday pay.
   f. Pay issues related to sheltering in place at facilities.
   g. Compensatory time rules.

Plan for Spouse in Facilities

An organizational decision must be made concerning employee families at utility facilities. Some participants were overwhelmed by families in hard-hit areas, and their presence complicated facility capabilities. Other facilities experienced an added benefit of having family safe and close by.

One outstanding suggestion during the FWRC Workshop was a designated shelter for family members. It is important to review these needs prior to storm events and determine sheltering capabilities. Responders must have confidence in the security of their loved ones to be able to perform their jobs safely and efficiently.

Restoring Service

Restoration needs were driven by the severity of the storm; however, the primary issues included on almost everyone's list included:

1. Fixing leaks.
2. Replacing service lines.
3. Removing trees.
4. Removing debris to access facilities.
5. Attempting to prevent leaks from being caused by debris removal equipment.
6. Sanitary sewer overflows.
7. Keeping lift stations operational.

SCADA

Depending upon the severity of the storm and the condition of the towers in the area, telemetry provided a vital link to prevent SSOs. The type of information provided by SCADA may include:

1. Status of power to a station.
2. Status of a wet well.
3. The number of pumps running.
4. Run times on pumps.
5. Which stations need generators first.
6. Which stations may need trucks to pump them down.
7. Which station may need pumps around.

A common weakness of SCADA was the antennas being blown down, but generally the battery-powered control and communications units weather the storms well. Following the storms, the replacement of antennas should be a high priority to communicate with lift stations and maximize resources.

Severity of Event

For those utilities on the coast where the storms came ashore, the actual force of nature may never be absolutely known. Sustained winds of 190 miles per hour were recorded in some areas. Tornados are also commonly born from the winds that swirl around a hurricane.

While hurricane predictions improve each year, hazardous weather changes can happen so fast that we must simply prepare for the worst. It is important that utility managers use existing warnings as keys to operational responses. Specific wind speeds and other public information should be used to determine when workers may be dispatched to begin repairs. This can not be left up to individual managers and supervisors.

Restoration work can not begin until the storm has passed. Workers should be clearly informed when they are expected to return to work following a storm. Multiple communications should be established prior to the event so workers can determine when and where to report.

Trained Personnel

A common request through our informal mutual aid group during the 2004 storms was the need for trained personnel to connect the generators. The skills needed during the restoration were a cross between plant operator, mechanic, and electrician, with just enough computer geek mixed in to keep computers talking to motors.

One utility director told us after visiting a hard-hit area that, "What you absolutely need are master electricians experienced with stand-by generators." That was certainly the case for many utilities in Florida during September and October of 2004.

The restoration effort has been very successful and continues. The quality of the people in the field restoring power and bringing plants back on line provides an accurate picture of how well the operator certification and training programs are working.

Training pays, and well-trained workers make it work safely.

Many of the most severely hit facilities were not able to respond to our survey because they are still trying to rebuild. For many, the devastation of 2004 is not over. A number of these professionals were able to attend the hurricane workshop during the Florida Water Resources Conference in April, and their comments will be featured in next month's Journal. *Our thanks to those who participated.*

Hurricane Preparation: Lessons Learned from 2004

By Douglas B. Prentiss

Utility Training Coordinator • Gainesville Regional Utilities

On April 24 a workshop was held during the Florida Water Resources Conference that focused on hurricane survival and restoration. A full day of facilitated discussion identified what worked and what didn't during the hurricane season of 2004. Water and wastewater professionals from many of the heaviest-hit areas participated and provided real insight into surviving and restoring service after they had experienced catastrophic damage to their facilities.

This article builds on the information presented in the June issue of the *Journal*, but includes additional information from those facilities operators who received the most severe damage. Both articles will be combined and posted on the FlaWARN Web site.

Since many of the participants at the workshop experienced worst-case damage, they also posed new issues not previously considered. One interesting exchange started off the morning when a utility representative asked our emergency operations center representative why the interstate highways and not been turned into evacuation routes on both lanes. For most of us the idea had never even been considered, but for those communities facing the full force of a hurricane, the availability of additional roads to allow citizens to evacuate seemed not only reasonable but absolutely needed.

Leo Lachat, operations manager for the emergency operations centers all over the state of Florida, answered the question. According to Leo, there is such a plan, but we will almost never see a reverse-lane evacuation on the interstates because of the potential for serious accidents and deaths. When you evaluate the deaths associated with last year's storms, compared to the potential deaths and injuries anticipated by this action, it is simply not reasonable. The fact that the state actually has such a plan is in itself impressive.

With the hurricane season just opening and our first tropical storm already having hit, the constant theme echoed throughout the workshop—plan, prepare, and practice—seems to make a lot of sense.

Communications

1. After taking a direct hit last year, people in Charlotte County found that the only communication devices that worked were ham radios.
2. Much of the information provided to the radio stations in that area was provided by ham radio operators.

Continued on page 9

Continued from page 4

3. Additional information about ham radios and how to obtain portable ham radios can be obtained from the American Radio Relay League or David Schloblhm in Port Charlotte.
4. Identify ham radio operators in your community and coordinate your response activities with them.
5. Runners were used to communicate when technology was not available.
6. Several participants indicated that the all-in-one Blackberrys communication devices seemed to have priority during storms.
7. Many comments reflected the opinion that the public appreciates their elected officials giving updates and status reports in the media, even if they are tentative and change often.
8. Users of Nextel phones indicated they were told Nextel only had eight generators but now has over 400 and is gearing up.
9. Governments should develop daily information packets for operational departments:
   a. Include updates for all areas.
   b. Include routes to government locations.
   c. The public will call any number they can reach.
   d. The public expects us to know.
   e. They do not care if you're a water plant or wastewater plant.
10. Make sure you are prepared for customers who do not speak English.
11. Use multi-dimensional communications; do not depend on one form of communication.
12. Use professional networks for assistance:
    a. FWEA
    b. AWWA
    c. FWPCOA
    d. FRWA
    e. FDEP
13. Unified command can work.
14. Important measures include pre-hurricane boil-water notices and instructions on how to disinfect without electricity by adding eight drops of bleach to one gallon of water and let it sit for 30 minutes.
15. Resolve the question of when you put people in the field and when you pull them back in. Forty-mile-per-hour sustained winds was the common answer.

Emergency Preparedness Planning & Emergency Operations Centers

1. Reference cards with contact information need to be laminated.
2. FPL is aware of their issues and are changing. They will be putting a person in each EOC.
3. Maps for critical facilities must be accurate and include meter numbers, billing account numbers, and physical address (electric companies may change meters and not tell you).
4. Define operational levels.

Facilities Locations

1. Divide the utility into routes considering the shortest point; have hard copies prearranged to the routes.
2. Workers will want to leave to check on families and some will not be able to return.
3. Provide location of facilities, not just addresses.

Families in Facilities

1. Some facilities reported that families in operational facilities created problems.
2. Separate shelter for worker families was offered as a solution.
3. 120 family members stayed in one plant.
4. Establish guidelines for family members:
   a. No pets
   b. No alcohol
   c. Establish checkout times
5. It is critical to establish a safe location for families.
6. A majority of attendees allowed families.

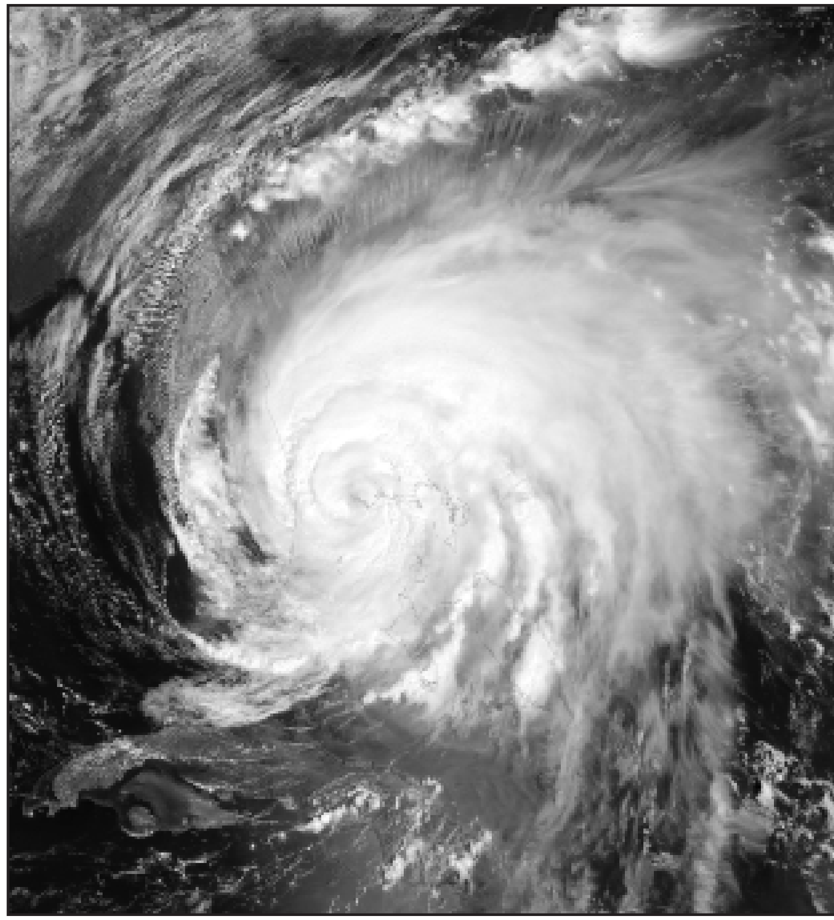
Fuel

1. Fuel for generators becomes critical.
2. Filter fuel.
3. Refuel before tank reaches one-half empty.
4. Coordinate with local contractors; they may have tanks they are not using and are able to bring in.
5. Do not forget about horse trading.
6. During emergencies, placards and normal

Continued on page 10

A flooded Gainesville lift station following Hurricane Frances.

PHOTO COURTESY GRU



Hurricane Frances arrives in Florida in September 2004.

PHOTO COURTESY NOAA.
Electronic enhancement by Kimley-Horn & Associates.

Continued from page 9

hazmat requirements may be relaxed.

7. Toll booths were allowing responders to pass without pay.
8. Some utilities provided employees with fuel but made them pay for it.
9. Place generators on trailer in advance.
10. Have generator cords prepared in advance.
11. Don't forget fuel for bypass pumps.
12. You must know what your fuel consumption is.

Food

1. Food tickets issued daily seemed to work well for several utilities.
2. Pre-planning with local restaurants worked well for many.
3. Family member who are sheltering can help cook.
4. Employees not involved in the response can be used to deliver food.

Generators

1. When equipment is loaned during storms it sometimes comes back in bad shape.
2. Borrowed generators may show up with no cords and no hook-ups.
3. Find out when borrowing what type of trailer connection is on the unit.
4. Standardize phase rotation.
5. Install generator receptacles in control panels.
6. Proper placement of generators is critical; make sure this is coordinated.

Hazardous Chemicals During Hurricanes

1. Secure containers.
2. Plan for delayed deliveries in advance.
3. Rail car deliveries may be delayed to re-packagers.
4. Roads may be closed.
5. Consider increasing or decreasing chemicals.
6. Super chlorinating water system.

Recovery Issues

1. Accessibility to facilities.
2. Roads.
3. Debris removal.
4. Damage after the storm from clean-up operation.
5. Support for special needs facilities:
   a. Shelters
   b. EOCs
   c. Hospitals
   d. Jails
6. Restoration of water plant and distribution system prior to electricity restoration may cause sanitary sewer overflows.
7. Request cash in advance of storms for recovery efforts.
8. Mark important systems to prevent additional damage, such as painting the street.
9. Use zones to restore pressure and coordinate with electric providers.
10. Pressure-reading devices provide critical planning information.
11. Local contacts not affected as badly as the utility are the quickest response/relief sources.
12. Ask customers to shut down at water meters.
13. Provide hurricane shutters for facilities.
14. Keep a sense of humor.
15. Regulatory flexible considerations.
16. Obtain tracking numbers.
17. Involve payroll in recovery efforts.
18. Mobile pit crews.
19. Operator safety.
20. Evaluate alternate antennas for SCADA.
21. Ensure that areas are clear by electric crews before dispatching repair crews.
22. National Guard is very expensive.
23. Damage assessment is critical after a storm.
24. Photos are an important documentation method.
25. Cots, freezers, gas grills all affect the positive morale of workers and are essential.
26. First-in teams need special training and equipment.

No one can predict what the hurricane season of 2005 will bring, but by being better prepared, we can improve our survival chances and reduce our restoration time. My personal thanks to all who provided lessons learned for this article.

Hurricane Preparation: More Lessons Learned

By Brad Vanlandingham • Black & Veatch Corporation

Editor's note: As we enter the heart of the hurricane season in Florida, the Journal offers the following article as the final installment of our summer series on hurricane preparation for water and wastewater utilities. The information comes from a presentation titled "Hurricane Planning—Lessons from 2004" by Brad Vanlandingham, P.E., a project manager with Black & Veatch Corporation, during the recent Florida Water Resources Conference.

A few of the following 13 headings also appeared in our earlier installments published in June and July, but most of the information under each heading was not previously published. Here are more words of wisdom from professionals who restored water/wastewater service after each of the four hurricanes that struck Florida last year:

Lift Stations

Having contracts with vendors to provide portable generators did not always provide the desired result. Having a performance bond or some type of contractual penalty if they do not deliver could improve the reliability.

- FEMA will not distribute resources to a utility until the damage has been assessed and priorities have been established.
- Don't overlook the need for vehicles large enough to tow portable generators.
- Mutual aid agreements may also include local law enforcement and fire departments to check on lift station sites. They could determine if the stations are overflowing and if they have utility power.
- Have an information data base for lift stations that includes:
  - ❑ An address for each station and general site location information, such as the nearest cross streets. This allows outside agencies quick access to information that can be used to locate the sites.
  - ❑ The electric utility's meter number. This allows the electric utility to identify the site in their system and respond to the location.
  - ❑ Electric motor sizes and the size of the generator required to power the station.
- Develop plans to allow people who offer assistance but are not familiar with the system to be able to locate and pump the stations in the correct order.
- Use scouts to determine if the roads to the lift stations are blocked by downed trees before sending a generator.
- Having one brand or fewer brands of generators makes it easier to have the spare parts you need if one breaks down. Maintaining a spare parts inventory for many different types of units is difficult. Having one type allows parts to be scavenged from one to fix another.
- Extend the tops of the lift station wet wells above flood plains.

Create signs to urge residents to limit running water down drains and flushing toilets during power outages.

Fuel Supplies

- Document the sizes of the generator fuel tanks and the consumption rates in gallons per hour of each unit so that deliveries can be scheduled.
- Plans should identify multiple sources of fuel as back-up.
- Communicate through EOC to arrange for re-fueling to ensure priorities are met.
- Create agreements with local gas stations that allow you to bring your portable generator to power their pumps so you can fuel your vehicles.
- Diesel fuel was more available than gasoline in some cases. Having utility vehicles with diesel engines was an advantage.
- Have fuel spill response plan and a contract with a vendor for clean-up.

Permanent On-Site Engine Generators

- Have spare parts available, including several fuel filters.
- Have the tanks pumped and filtered by vendors who offer that service.
- Protect fuel lines from uprooted trees, falling objects, or windborne debris.
- Have a plan to determine when emergency generators will be started. Some utilities go to generator power before electric utility power is lost and others wait to conserve fuel and allow auto transfer.
- Check frequently when operating. Look for low fuel pressure due to clogged filter or lines.

Response Management Tools

- Having a GIS system for the potable water distribution system is helpful in that it allows you to record locations of breaks, color code areas under boil-water notices, and use the addresses of callers to be able to tell them if they are in an affected area.
- It is also helpful to have collection system and lift stations in a GIS system because it allows you to record which stations are down. This information can be given to the electric utility so they can establish priorities for restoring power and enables you to respond to callers inquiring about the status of the wastewater service.
- Be prepared in advance by programming the system so that it is helpful in dealing with emergency situations. This does require some time to accomplish, so it is best to do so prior to storm season and to put it through trial tests to verify it can do what you need it to do.
- Printing and distributing large GIS maps helps ensure that people have as much useful information as possible at hand.
- Re-route SCADA information to the EOC for quicker response.
- Flood plain maps can be used to anticipate what areas will be flooded.

Communications

- Use an all-clear indication from any media source as a trigger for employees to report back to work after a hurricane has struck.
- Have a single public information officer in charge of communicating with television and radio media and Web site communications.

Staffing Issues

- Verify that you have current addresses, phone numbers, and e-mail addresses for your personnel.
- Ask each employee to create a map showing the location of his or her home. This makes it easier to send someone to pick up people who can not make it in to work on their own.
- Encourage employees to have their emergency preparations in order. Provide draft or model plans for their use.
- Be sure all employees know where they are supposed to report for work when the all-clear has been given.
- Have team meetings to set reporting protocols and to establish who controls the resources, including manpower and equipment.
- Don't expect personnel to work 18 hours every day for a week. About 18 hours a day is the max and this could not be sustained. The fatigue and lack of sleep will catch up to them and productivity will suffer. Some have reported that 12 hours on and 12 hours off worked well.
- Clearly communicate to employees the emergency response requirements of their jobs so potential disciplinary actions resulting from not meeting the requirements are understood.
- Practice hurricane training two to three times a year. Incorporate hardships such as mock radio failures and fuel shortages.
- Plan to provide food and water at each facility so personnel do not have to leave.
- Have first-aid supplies available at all facilities where personnel will be working.

Facilities Hardening

- Have material on site for covering the windows and other wall openings.
- Remove trees within the plant perimeter.
- Chemical Tanks for Treatment Processes
- Top off tanks.
- Know tank sizes and chemical usage rates so that deliveries can be scheduled.
- Have a spill response plan and a contract with a vendor for clean-up.
- Shut down nonessential chemical systems and isolate them:
- Fluoride systems for potable water systems
- Chlorine gas at WWTPs

Vehicles

Disburse resources by having employees take utility vehicles home before the storm hits, even if the employees are not typically provided with a vehicle. This prevents having a large number of vehicles become damaged due to a catastrophic event in one location. It also allows personnel to come to work during curfew periods without being stopped by law enforcement.

Water Line Breaks

- The majority of the breaks were in the individual service lines between the utility's line and the home.
- Most system pressure losses were the result of breaks in a radial line, not a looped portion of the distribution system.
- Be prepared to decide if a plant should be shut down if a large main is broken.

Notices to Public

- Typically, boil-water notices are reported to FDEP, but during high-wind periods of storms the FDEP offices are closed, so people can not rely on them to compile and report the areas subject to boil-water notices.
- Within a county, all boil-water notices could be issued through the Emergency Operations Center (EOC). Otherwise, numerous utilities would use numerous sources, such as different radio or TV stations, to report the notices, and the media would end up reporting incomplete and inconsistent information.

Emergency Water Supplies

- Be prepared to distribute water to the public in gallon containers. This requires having a large number of containers in storage.
- Having a water buffalo (tanker truck) is helpful in providing emergency water supplies to the public.
- Buying water from a bottled water company can be cost effective. Bottlers may also provide a customized label you can use to provide instructions to the public.
- Emergency supply manifolds connected to fire hydrants allow public to get water from taps on the manifold.

Special Needs Facilities

- Document the pipelines and the valving in the area of special needs facilities such as hospitals and assisted living centers. This allows line breaks to be isolated and service to be restored as quickly as possible.

Designated Scribes

- Designated scribes are necessary to document hurricane-related costs such as man-hours, emergency supplies, and emergency vendor expenses in order to get reimbursed by FEMA.
- Long hours and hectic conditions make it difficult to remember afterwards.
- Having a designated scribe helps during post-storm evaluations and in determining what changes need to be made to SOPs.

This article will be posted with the previous installments on the *Florida Water Resources Journal* Web site. Our thanks to the Florida water and wastewater professionals who provided information for all the articles in this series, in hopes that the information will help utilities make effective preparations for future hurricane seasons.

Supplemental Reference Sources
WISE Natural Disaster Response Primer

1. **"Flood Preparation and Restoration," American Water, 2003.**
2. **"Sandbagging Techniques" brochure from USACE, Northwest Div, 2004**
3. **"Innovative Naples Generator Design Replaces Large Units in Temporary Power Restoration Following Hurricane Wilma" (a paper by Bob McVay of FRWA describing use of VFD and small single phase generators for powering up lift stations in sequence)**
4. **"Electrical Retrofit Aids in Hurricane Response" (FEMA article on a "Best Practice" story)**
5. **"Recovering From Disaster" (Paper by C Yung, EASA, on electrical motor restoration from floods) - 2005 (after Katrina) - (first published in Uptime Magazine - January, 2006)**

FLOOD PREPARATION AND RESTORATION

Origination Date: 3/1994
Revision Date: 9/2003
Prepared by: Maintenance Services
(RJD, SNP)

FLOOD PREPARATION AND RESTORATION

Prepare a Disaster Response Plan: The plan should have different levels of contingency. Review documentation from previous flood experiences.

Organize a Disaster Response Team: Assign responsibilities to experience and skills.

OUTSIDE CONTACTS, ORGANIZATIONS OR DEPARTMENT

Obtain names and phone numbers for 24 x 7 access to Emergency Response Officials, company representatives and the Media, (for public notification). Try to establish a priority relationship with these individuals. Discuss potential needs and response times. Create a telephone directory of names and numbers. Update periodically.

Emergency Response Officials:

- **Emergency Management Coordinator**
- **Federal, State, County, City, Municipal and Township Agencies and Authorities.**
- **Fire, Police**
- **Medical, Health Department, EMS**
- **National Guard**
- **Red Cross**

Media: USE ONE SPOKESPERSON.

- **For public notification i.e., progress reports, water distribution centers.**
- **For public support and possible assistance, i.e., sandbagging etc.**

Utilities:

Electrical: For immediate power shutdown, temporary equipment needs or the service department.
Gas: For the service department, turnoff, etc.
Telephone: For the service department.
Water: For shutdown of distribution valves if necessary. Record sequence of valves closed and record levels and pressures at time of shutdown.

Service Organizations:

- **Engineering Services, i.e., Army Corps of Engineers, consultants etc.**
- **Repair shops (motors, pumps, valves, transformers, motor starter, switchgear, instrumentation, stand-by generators etc.)**
- **Underwater repair specialist, (divers)**
- **Lifting services, ((ground cranes and air cranes, (helicopters)).**
- **Water transportation Services (barges, boats)**
- **Water Haulers**

Contractors:

- **Electrical, Mechanical, Instrumentation and Structural.**

Manufacturers Representatives, Vendors and Suppliers:

- **New Equipment**
- **Used Equipment Dealers**
- **Equipment Rental Dealers**
- **Spare and Repair Parts**
- **Supplies**

TEMPORARY OFFICE AND LABORATORY

Set-up an organized temporary office and laboratory in a safe place, well out of the flood plane. A construction trailer can be used for this.

Communications:	**Have temporary phone lines installed. Obtain portable phones, radios walkie-talkies, fax, copier, extra batteries etc.**
Computers	**Move computer equipment, software, etc.**
Records:	**Move records, files, drawings, instruction books, test records etc.**
Equipment:	**Move laboratory instruments, spare parts, tools, supplies etc.**

EQUIPMENT PREPARATION

Take inventory, acquire nameplate information, and locate the information to a safe area.

Identify and locate equipment (new and used) and parts suppliers. Make contact with company representatives.

Identify and locate Service Companies. Make contact with company's representatives.

Special structural modifications, rigging, and lifting equipment may be necessary to remove equipment from the building, plant i.e., boats, cranes, helicopters. Etc.

Begin procuring equipment and supplies.

Move existing spare parts, tools, supplies, etc. to a safe area. Consider storing and on site trailer truck that can be moved quickly.

Block all floor drains.

Motors:
- **Remove those not used to a safe area.**
- **Make preparations for a possible quick removal of those in service.**
- **If possible, have a controlled shut-down of equipment.**

Transformers: - **Locate possible temporary and replacement equipment.**
- **Shutdown before flooding.**

Pumps:
- **Remove chemical feed pumps not being used.**
- **Remove rotating elements of spare pumps that have roller bearings.**
- **Extend shafts on vertical pumps.**
- **Procure packing and gasket materials.**
- **Procure proper lubrication.**

Valves:
- **Identify valves that need operated when flooding occurs. Install a standpipe or marker for locating valves in high water.**
- **Seal conduits and openings in the actuators with a silicone sealant.**
- **Acquire spare parts or actuators.**

Motor Starters and Switchgear:
- **Remove unused contactors, relays, fuses etc. to a safe place.**
- **Procure spare fuses, relays and operating coils.**
- **Procure new batteries and battery chargers for and switchgear controlled voltage.**
- **Practice electrical shut-downs.**

Standby Generators:
- **Seal and block vents.**
- **Remove the starting batteries and battery charger to a safe area.**
- **Procure filters and lubricants.**

Instruments:
- **Move instruments to a safe area, e.g., higher level on wall. This depends on expected crest levels.**
- **Remove instruments that are not critical to operations or compliance.**
- **Install plug in power cords on instruments for quick removal.**
- **Seal conduits and opening with silicone sealant, (RTV).**
- **Procure spare parts and equipment.**

Fuses and Coils:
- **Take inventory and procure spares. Especially fuses with cardboard type cartridges and coils with paper type cores.**

Tanks:
- **Fill with fluid to keep from floating.**
- **Raise height of tank.**
- **Strengthen anchoring of a tank to its base.**

Chemical Cylinders:

- **Remove empty and spare cylinders to a safe area.**
- **Anchor cylinders being used.**
- **Shut down tank valves when flooding is eminent.**
- **Disconnect piping to cylinder.**

Chemicals: (Dry):

- **Remove bag chemicals to a safe area.**

PLANT SHUTDOWN

Determine actions to be performed at associated water levels. Determine the condition for plant shutdown and communicate this to all personnel. Prepare a shutdown check list.

Consider alternative means of access to the plant depending upon water levels, i.e., boat, rail, helicopter, etc.

****** EVERY ATTEMPT should be made to shutdown the electrical power distribution system prior to flooding of the electrical equipment. DO NOT allow the plant to go down HOT! Consider the options below:**

- **Orderly systematic shutdown. Train operators and supervisors to perform and orderly and systematic shutdown. Provide a check list. Practice often.**
- **Quick shutdown (main circuit breakers). Train operators and supervisors which MAIN circuit breakers and switches to shut off in the event it becomes necessary.**
- **Utility shutdown, (incoming power). Notify the Electric Utility Provider ASAP.**

EQUIPMENT RESTORATION

Develop an orderly restoration plan and organize a team of Management personnel to coordinate the restoration efforts. Establish clear paths of communication and chains of command. Assign group leaders to head specific areas of restoration according to their abilities and skills. Determine staffing requirements. Assign a person the responsibility of expediting repair parts, services and supplies. Conduct progress meetings with group leaders and provide progress updates to management.

- **Set up temporary power sources**
- **Set up temporary pumping for dewatering**
- **All equipment should be washed down with clean water as soon as practical following dewatering. Do not allow the flood waters dirt and silt to dry on equipment. Dehumidify and dry with open widows, fans, heat etc. Dewater conduits, junction boxes, panel boards, etc. (drain or blow out water with air).**

Motors: - Clean, dry and (bake), replace lubricants and test.
- Send to repair shop for reconditioning.
- Clean and prepare motor base, Perform alignment using new shims.
- Check motor rotation.
- Dewater the conduits and test.

Transformers:
- Clean, dry (bake) and test.
- Send to repair shop for reconditioning.
- Test insulating oil for moisture content.
- Dewater the conduits and test cables.

Pumps: - Inspect and replace ball or roller bearings.
- Flush and replace lubricant in sleeve bearing.
- Reinstall rotating elements and pump parts that were removed prior to flooding.

Valves: - Clean, dry (bake) and test actuators, limit switches and feedback potentiometers.
- Dewater the conduits and test wires.

Motor Starters and Switchgear:
- Clean, dry (bake) and test.
- Send to a repair shop for reconditioning.
- Replace insulating oils.
- Dewater the conduits and test cables.

Standby Generators:
- Clean, dry and test.
- Change lubricants and filters.
- Dewater conduits and test cables.
- Contact the service company for restoration of the driver. (internal combustion engine)

Circuit Breakers: (molded case)
- Clean, dry and test panel boards.
- Replace small panel board type molded case circuit breakers.
- Send large breakers to a repair shop for reconditioning and test.
- Dewater conduits and test cables.

Instruments:
- Clean, dry and test.
- Dewater conduits and test wires.

Fuses: - Replace all fuses with cardboard type cartridges.
- Dry and test all other, (glass and fiberglass cartridges).

Coils: - **Clean, dry, (bake) and test.**
- **Replace coils that have paper type cores.**

Miscellaneous Items Check List

- **Insulating tape**
- **Wire markers**
- **Magic Markers**
- **Electrical Solvents**
- **Cleaning Solvents**
- **Lubricants**
- **Pump Packing material**
- **Bearing lubrications**
- **Clean Rags**
- **Boots, Waders, Gloves**
- **Rain gear**
- **Portable pumps**
- **Shovels, mops,**
- **Temporary Lights**
- **Batteries, flashlights**
- **Air compressors**
- **Heaters, (torpedo type)**
- **Fans**
- **Extension cords, GFCI,s**
- **Portable generators**
- **Medical and Health Supplies**
    - **Bandages**
    - **Antiseptics**
    - **Waterless hand cleaners**
    - **Pain Relievers**
    - **Eye Wash**
    - **Porta-toilets**
    - **Tetanus Shots**
    - **Potable Water**
    - **Food**

Portland District
P.O. Box 2946
Portland, OR 97208-2946
(503) 808-4400

Seattle District
P.O. Box 3755
Seattle, WA 98124-3755
(206) 764-3406

Kansas City District
700 Federal Building, 601 East 12th Street
Kansas City, MO 64106-2896
(816) 389-3282

Omaha District
215 North 17th Street
Omaha, NE 68102-49978
(402) 221-4259

Walla Walla District
201 North 3rd Street
Walla Walla, WA 99362-1876
(509) 527-7144

US Army Corps
of Engineers
Northwestern Division

Sandbagging Techniques

Printed on recycled paper 2004.

The use of sandbags is a centuries old, tried and true method for flood fighting. See procedures and safety tips inside on efficient bagging operations.

Sandbags:

a steadfast tool for flood fighting

Sandbagging is one of the most versatile of flood fighting tools and is a simple, effective way to prevent or reduce flood water damage.

Although sandbags do not guarantee a watertight seal, they are a proven deterrent to costly water damage.

Sandbags have been used to:

- prevent overtopping of levees.
- direct a river's current flow to specific areas.
- construct ring dikes around boils on levee back slopes, levee toes or behind levees.
- use as weight on back slopes of saturated levees.
- weigh down visquine and straw bales.
- build buttresses on back slopes and the toes of saturated levees.
- reduce seepage at closure structures.

Read this brochure to learn proper filling and placement methods aimed at increasing productivity of sandbagging operations. Included are hints, safety tips and correct procedures which will minimize work-related injuries and strain and will maximize essential time.

THE FIRST LINE OF DEFENSE

Sandbag construction is a centuries old technique that has changed little. Bags are made from different materials including treated burlap and plastic. They measure approximately 14 inches wide and 24 inches long.

Sandbags filled one-half to two-thirds full should generally be left untied. Tied bags, filled slightly fuller, have specific purposes: filling holes, holding visquine or straw bales in place, or forming barriers backed by supportive planks or aluminum sheet piles.

If access to the flood site is limited to boat, tractor or helicopter, then pallets and forklifts may be needed to load and off-load sandbags.

Unused empty bags can be stockpiled for emergency and will be serviceable for years if kept dry and properly stored.

FILL MATERIALS

Sand is by far the easiest material for filling and shaping sandbags and becomes heavier when saturated from rain or moisture.

In emergencies, other materials such as silt, clay, gravel or a mixture of these may be used, but none work as well as sand.

When vehicle access is cut off to the flood site, and you have no other choice, use the back side of the levee or an adjacent field to find whatever material is available to fill sandbags.

Here are pros and cons on use of other materials:

- Silty soils get soft when wet and are more difficult to shape, and finer particles leak through the weave in the material.
- Clay materials are difficult to shape and to bag.
- Coarse-grained gravels are pervious and are also difficult to shape but can be used for redirecting the main stream flow while allowing seepage through bags.

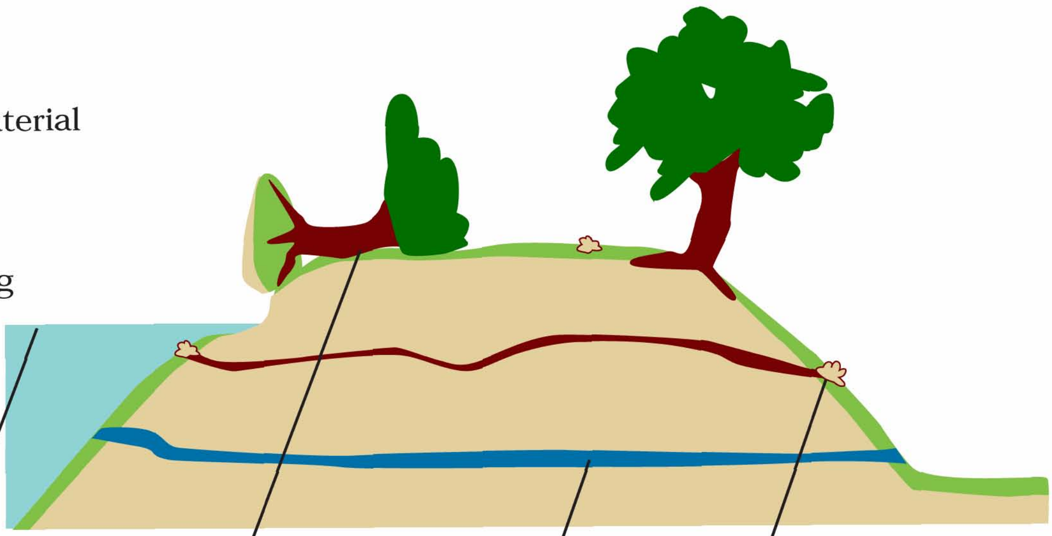
ALTERNATIVES

Other methods and remedies for flood fighting are as follows:

- Readily available, straw bales are an economical alternative. They range in size from 18 inches high by 30 inches long to 4 by 4 by 8 foot long blocks. Secure the bales by driving 4 to 10 foot stakes (or rebar) through the straw into the levee top, and weight down with filled sandbags. Water swells the straw, making the bales heavier and watertight.
- Concrete Jersey Barriers or Ecology Blocks can be used to divert water and can be cost effective solutions.
- Plastic sheeting can be used effectively by placing sand along a fold.

CAUSES OF LEVEE FAILURE

- Overtopping
- Downed trees on levee slope
- Gopher holes
- Seepage through pervious levee material
- Saturated levee embankments
- Seepage following tree root paths



CORRECT FILLING PROCEDURES

Filling sandbags is normally a two or three person operation. One member of the team, while crouching with feet apart and arms extended, should place the bottom of the empty bag on the ground.

The opening of the bag is folded outward about 1-1/2 inches to form a collar and held open to allow the second team member to empty a fully rounded No. 2 shovel of material into the open end of the bag.

Don't hurry. Haste can result in undue spillage and added work. The third team member stockpiles or stacks the open sacks. The three team members should rotate duties often to reduce job-specific muscle fatigue.

This two-member team uses correct positions for sandbag filling.

Untied bags should be filled approximately one-half to two-thirds full. Tied bags can be filled slightly more, but with enough room left at the top to tie the bag off properly.

Always use gloves to protect your hands during the filling operation. After handling treated bags, avoid contact with your eyes and mouth.

Dress appropriately and layer clothing. Safety goggles should be used on dry and windy days. Sandbag filling operations are done either near the actual placement site or at centrally located filling sites such as fire stations, diking districts or sand pits.

If the bags are filled at a distant location, vehicle transportation and access to the flood site are primary planning considerations.

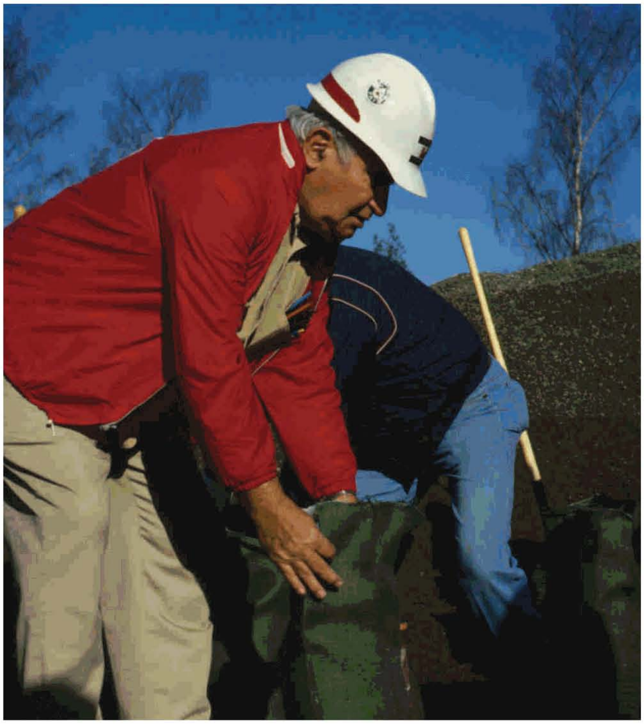
For large scale operations, a variety of specialized filling equipment - such as funnels on the back of dump trucks - is commercially available.

Such equipment is not always available during an emergency and may be best suited for a staging area where bags can be filled and then delivered to the site.

PROPER PLACEMENT

Remove any debris from the areas where bags are to be placed. Place the bags lengthwise and parallel to the direction of flow. Fill the low spots first before placing bags the full length of the area to be raised.

Start at approximately 1 foot landward from the river or levee's edge. Fold the open end of the bag under the filled portion. Folded end of bag should face upstream. Place succeeding bags with the bottom of the bag tightly and partially overlapping the previous bag.



Veteran flood engineer Ernie Sabo demonstrates that the sandbag should be two-thirds full, folded at the top.

Place each succeeding bag tightly against and parially overlapping the previous one. Compact and shape each bag by walking on it.

Offset adjacent rows or layers by one-half bag length to avoid continuous joints.

To eliminate voids and form a tight seal, compact and shape each bag by walking on it and continue the process as each layer is placed.

This flattens the top of the bag and prevents slippage between succeeding layers.

SINGLE STACK PLACEMENT

Single stack placement

Sandbags stacked in a single row work well in flood areas where there is no streamflow velocity or danger from floating debris, such as logs and tree stumps, or from wave action which could topple the bags.

Although generally not recommended to be above three courses or layers in height (approximately 1 foot), higher single stack placement can be effectively used as a barricade to protect structures from impending water damage as shown in the photo.

PYRAMID PLACEMENT METHOD

Use pyramid placement to increase the height of sandbag protection; however, use caution when rasing the levee height. Determine the height of the sandbag raise by using the best available forecasts of flood conditions.

An example: When the water level is currently 1 foot below the top of the levee and is predicted to rise 3 more feet, construct a 2-1/2 foot sandbag operation which includes one-half foot of height as a safety factor.

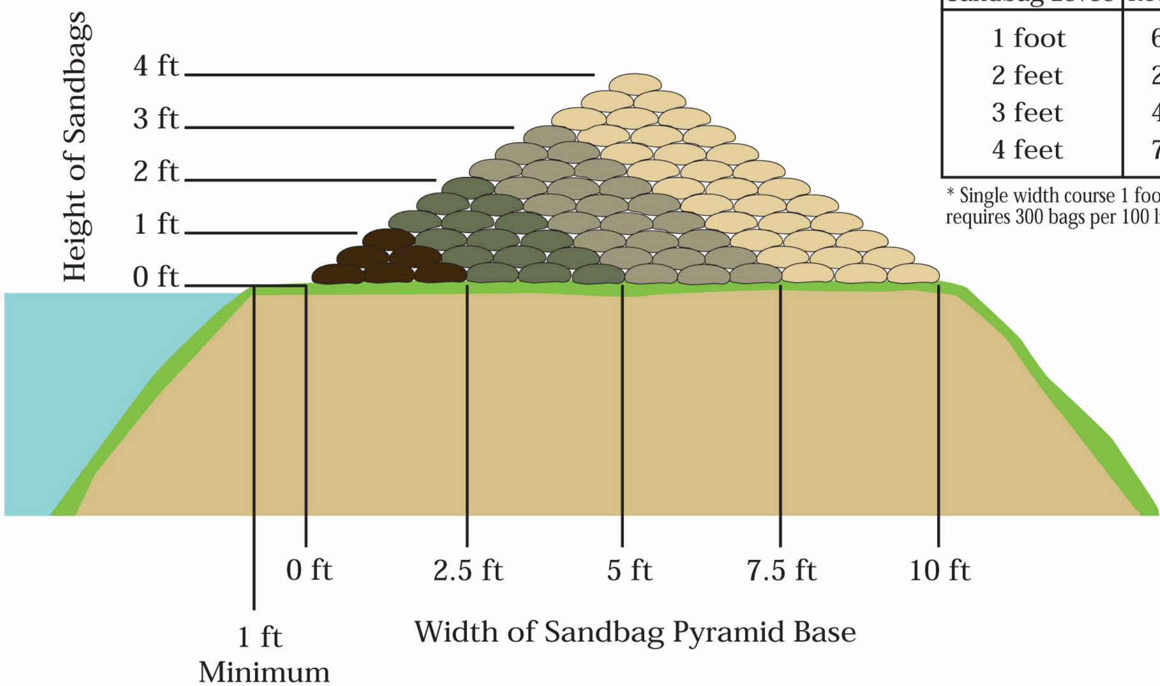
It's important to compact each bag in place by walking on it, butting the ends of the sacks toether, maintaining a staggered joint placement and folding under all loose ends.

Watch for flooding elsewhere, and watch for boils on the landward side of the levee due to the increased water elevation.

TYPICAL PYRAMID SANDBAG PLACEMENT

Bags Required Per 100 Linear Feet of Levee	
Height of Sandbag Levee	Bags Required
1 foot	600*
2 feet	2100
3 feet	4500
4 feet	7800

* Single width course 1 foot high requires 300 bags per 100 linear feet.



The pyramid placement method issued to increase the height of sandbag protection.

Use this rule of thumb in determining dimensions of the pyramid:

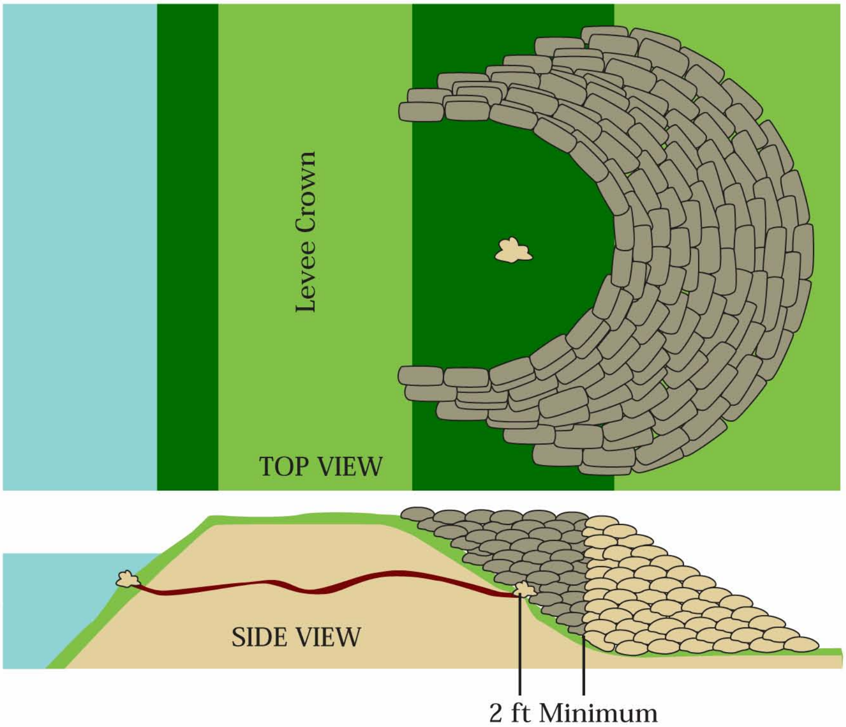
- 1 bag in length equals about 1 foot
- 3 bags in width equals about 2-1/2 feet.
- 3 bags in height equals about 1 foot.

Place the sandbags by laying an equal number of horizontal rows on the bottom as there are vertical layers.

It's important to compact each bag in place by walking on it, butting the ends of the sacks together, maintaining a staggered joint placement and folding under loose ends.

RINGING SAND BOILS

- Minimum 2 ft. radius from center of boil to edge of ring dike.
- Tie into levee if boil is near toe of levee
- Build half-moon shaped ring dike if boil is on levee slope.



RINGING SAND BOIL METHOD

A sand boil is created by water seepage through the levee foundation or embankment. When that seepage transports dirty water, the levee's integrity is threatened.

Corps employees demonstrate building a ring dike.

It's generally not necessary to build a ring dike around a boil that is not transporting soils but monitor the boil for any change in condition.

Don't attempt to place sandbags directly on the boil. Pressure applied to plug the boil will cause water seeping through the levee to seek other avenues to follow and could cause levee failure.

As a minimum, there should be a 2 to 3 foot radius from the center of the boil to the inside edge of the ring dike. Take care to contain the entire area experiencing boils within the ring dike.

Build a spillway section in the dike so water runs out in a controlled manner. This diverts the overflow water away from the dike and reduces erosion on the levee slope. Once the spillway water runs clear, and is not transporting soils, then the ring dike is completed.

U.S. ARMY CORPS OF ENGINEERS

The U.S. Army Corps of Engineers is the nation's oldest engineering organization and one of its oldest military branches. It dates back to the Revolutionary War when, in 1775, George Washington appointed Col. Richard Gridley as Chief Engineer of the Continental Army.

The Corps' water resource program began in 1824 when Congress appropriated money for improving river navigation. In the following decade, the involvement in civil works mushroomed, including new roads, railroads and bridges, and assistance to local communities during flood disasters.

Annually Congress sets aside funds for disaster response flood work. This gives the Corps the ability

SAFETY FIRST

Tip#1: Use proper lifting techniques to avoid injury and fatigue. Lift with your legs and bend at the knees to save your back.

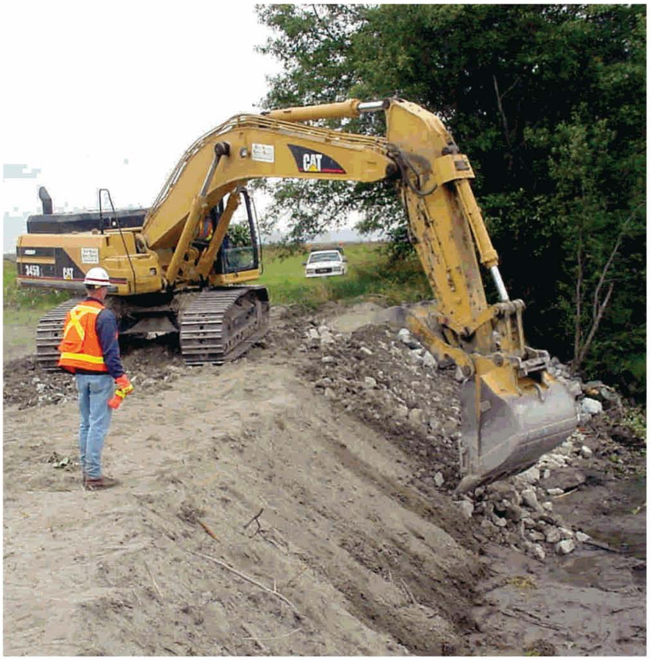
Tip #2: Sandbags are treated to prevent deterioration when stored. Use work gloves and avoid contact with your eyes and mouth.

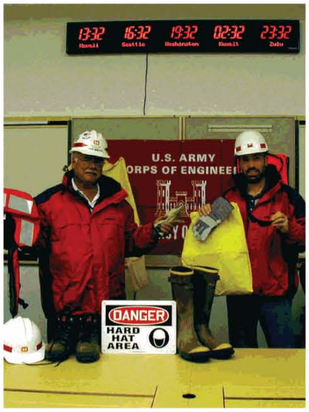
Tip #3: Stay in eye contact with heavy equipment operators and keep alert for truck backup alarms.

Tip#4: Flood waters can be polluted. Use rubber gloves and appropriate clothing if contact with water is unavoidable.

Tip#5: Wear adequate clothing in layers and watertight boots. Reflective material on outer clothing is essential for night work.

Tip#6: Rotate team members frequently to avoid fatigue.





Starting at the top, going clockwise: Watch for trucks and other heavy equipment frequently at flood sites; boots, clothing and other items are necessary for flood fighting; and heavy gloves are protection from treated burlap bags.

This classic shot shows conditions frequently are not even close to perfect. In the early '50s, flood fighters moved fast and furious to contain the swollen Snohomish River at Ebey island - a major flood event.

THE CORPS (continued from page 7)

to provide preparation, response and recovery measures concerned with flood fighting.

Public Law 84-99 today authorizes the Corps to engage in flood fighting and rescue operations if the emergency is beyond local and state capabilities. The Corps is there to perform a basic mandate as set down by the Corps' forefathers.

During a flood the corps has the authority to:

- inspect and, if necessary, strengthen flood control structures,
- make temporary levee raises,
- provide supplies and 24-hour technical assistance, and
- assist in the evacuation of people and livestock.

The Army Corps of Engineers conducts flood fight training every year which includes sandbagging techniques. The Corps' districts maintain a limited supply of sandbags and other flood fighting materials intended to augment the stocks of state and local jurisdictions during actual flood emergency situations.

Local jurisdictions should first use their supplies and then request additional sandbags from the state.

If the state supplies become depleted, then the Corps supplies are available for use when requested by state or local officials.

Innovative Naples Generator Design Replaces Large Units in Temporary Power Restoration Following Hurricane Wilma

Introduction

Utilities in Florida heavily rely on the electric infrastructure to power water and wastewater treatment plants and facilities such as storage facilities, repump stations and lift stations. Without power, water supply and wastewater treatment, both essential and critical needs for maintaining quality of life and public health are severely impacted. With four of Florida's most powerful and damaging hurricanes occurring in a span of two years, timely restoration of electrical power essential for maintaining these critical utility facilities in a few days can no longer be taken for granted. When power line devastation occurs in wide swaths of heavily populated areas, restoration of power can take several weeks or longer.

When electric power is lost, and in most cases, utilities must quickly turn to electric generators to keep critical water and wastewater (W/WW) facilities operating. Although every medium and large Florida W/WW utility will maintain a number of stationary and mobile generators, the number of generators required to service every W/WW facility and lift station is enormous, impractical and not necessarily the most efficient means of providing temporary service. The number of lift stations alone in a mid-sized Florida city can exceed 500 and in several larger cities the count can be in the thousands.

Hurricane Wilma damaged a considerable amount of electric infrastructure, with the most severe damage occurring on both the East and West Coasts of South Florida. In the aftermath of a storm of this destructive power, W/WW utilities for the first time worked through a coordinated network called FlaWarn. FlaWarn provided a State network for identifying utility W/WW needs and provided a mechanism for organizing and sending resources quickly to the areas in most critical need. In some instances, generators were not only provided by the 40 Florida utilities that assisted with this effort, but by FEMA working through the Army Corps of Engineers who provided large commercial 3 phase generators through the FlaWarn network.

The most significant need in the aftermath of Hurricane Wilma, was the transport and installation of these large mobile generators. Most of the generators came from W/WW utilities in North Florida not affected by the Hurricane who sent equipment and manpower to W/WW utilities in South Florida. The FlaWarn network continued to function several weeks after the storm had passed ensuring that the resources went to areas most in need.

Providing this type of assistance after a hurricane is the most common method of providing timely temporary restoration of power to W/WW utilities. This requires that W/WW utilities transport and install large generators from remote areas. These generators typically range from a smaller 240/480V, 40KW unit to units in the 240/480V, 125KW class. Generators in these sizes are extremely flexible and can power up the majority of the motors that are used in W/WW utility installations. These generators typically require a truck in the 1 ton range for hauling and must be matched to power needs that are appropriate, delivered to the site and connected in the field by an electrician experienced with W/WW installations.

Large Commercial Generator Used to Power City of Kirbyville Texas Repump Station in aftermath of Hurricane Rita

The work accomplished by FlaWarn was the first coordinated W/WW utility effort on this scale ever used for a major hurricane. It was accomplished by utilities working cooperatively together and sharing considerable resources. This was a monumental task involving 40 Florida W/WW utilities and over 200 Central and North Florida professional. For this reason any system that can expedite the installation of generators at W/WW facilities and minimize the need for their lengthy transport and requirements for specialized personnel for sizing and field connecting is highly desirable. The ability to reduce the need for outside resources and to allow available scarce resources to be moved quickly to those utilities most in need, provides the greatest advantage offered by these recommendations.

Innovative Generator Design Developed by the City of Naples

The City of Naples is a mid-size Florida city, located on the Gulf of Mexico in South Florida, the farthest Western point on Alligator Alley. The City of Naples, Department of Public Works, is responsible for providing water service to a population of 65,000 people. The City's Water and Wastewater Division is responsible for the operation of a 30 MGD Water Treatment Plant, a 10 MGD Wastewater Treatment Plant, 115 lift stations and 51 water production wells. In 2004, the City listed 12 standby generators as critical assets. This accounted for backup capacity for about 10% of the City's lift stations in an electrical power outage.

In the aftermath of Hurricane Charley that hit the area in 2005, City W/WW personnel under the direction of Robert Thomas, Wastewater Manager, began experimenting the use of Variable Frequency Drive (VFD) control systems for converting electrical power from small, single phase generators, to three phase power, the type of power required to supply the City's lift stations. It was quickly determined that the much smaller generators, in the ranges of 5 KW to 15 KW could be used in combination with the VFD to provide power to motors in the 5 HP to 20 HP range. Additionally, Mr. Thomas determined, that the horsepower requirements for most pump units at the City's lift stations were typically significantly oversized. With the VFD control unit, Mr. Thomas was able to provide sufficient power at ratings of up to a 25% less than the motor size. For example a 20 horsepower motor could be operated successfully at 15 horsepower, while still providing the needed pumping energy to keep the station in a full pumping mode.

Based on these initial trials, the City constructed a mobile 15 KW trailer mounted generator, a VFD and a level transducer. The transducer can be placed in the wet well replacing the need for the lift station controls. These controls are housed in a control panel that is frequently damaged hurricane events. Furthermore, this smaller trailer mounted unit, can be easily transported using a ½ ton pick-up or any utility vehicle with a ball type hitch. Electrical hook-up is a simple four wire set-up that the City is in the process of converting to a standard 30 amp receptacle, similar to the one used for an electric stove connection in a home. This generator unit is fully capable of moving from one lift station to another, allowing the lift station's wastewater to be evacuated and using the wet well and pipeline storage to refill, while moving it to another lift station or stations rotation, much like current pumper trucks now used in these kinds of emergencies.

This application of VFDs in combinations with smaller generators for use with lift stations and small water wells in the 5 horsepower to 20 horsepower range is a significant breakthrough when compared to existing generator applications. Smaller generators in the range of 5 KW to 15 KW are a stock item at building supply stores such as Lowes and Home Depot. The cost of a three phase generator in the 20 KW range is over $13,000 or approximately 10 times the expense for 15 KW single phase generator that can be used in this application. And there are other advantages.

Assessment of the Potential Use of the Naples Solution (NS) to Other Utilities

To determine the potential for using the NS for other utilities, we must first go back to Naples and examine their hurricane response. Like other utilities in the path of Hurricane Wilma, Naples found themselves with more than 90% of their system without power. This was met with the deployment of 30 single phase/VFD controlled generators to lift stations in the 5 HP to 20 HP class. One pick up truck can easily transport 6 of these small generators its bed and one employee can deploy them to critical need stations, providing a hook up using a standard plug. Transport of 6 commercial generators South, for a North Florida utility would be a significant undertaking, requiring six special utility vehicles, 6 drivers and an additional 6 personnel for equipment set up and installation. The City of Naples, as directed by Mr. Thomas, demonstrated the use of this very innovative generator alternative. It worked in the aftermath of Wilma, in the very place where she made landfall.

The question quickly becomes, how effective would the use of the NS be for mid-sized or larger utilities that may require larger equipment? To answer this question a typical mid-size North Florida W/WW utility system was analyzed to determine applicability. The analysis was also used to expand it to the applicability of other W/WW utilities in the aftermath of a significant hurricane event with some very surprising results! The details of the full analysis is included in the next section.

Analysis of Typical Mid-Sized Utility for NS Application to Other W/WW Utilities

This analysis assumes that emergency conditions are such that complete loss of power occurs for an extended period exceeding 3 days. The analysis assumes that lift stations that utilize pumps 20 HP and smaller are of the duplex variety. A duplex lift station is a lift station that includes two pumps, with one pump designed to handle incoming flow with the other pump out of service. The analysis considers that in an emergency situation a lift station smaller than 20 HP (uses two, 20 HP pumps) can handle incoming flow for an extended period of electrical outages with an emergency generator using only one of the two pumps available at the station.

The data that was used for this analysis was taken from GRU a mid-sized North Central Florida wastewater utility with approximately 50,000 wastewater customers. The generator requirements that have been developed are likely conservative, that is the percentage of smaller stations in the GRU system is likely less than that of similar systems in coastal South Florida where the terrain is flatter and the water table is higher, dictating a higher number of smaller lift stations. The numbers developed in the analysis are thus conservative and for most systems the number of generators that are required following a hurricane and long-term power outage can be reduced further.

The following table illustrates the lift station distribution for Gainesville Regional Utilities W/WW System:

Table 1: Lift Station Data Gainesville Regional Utilities

Size of Pump Unit (HP)	No. of Lift Stations in Category	% of Entire System for Lift Stations	Rolling Average % ↓	Number of Permanent Generators	Rolling Average Perm. Gen. ↑
0 to 5 HP	57	***37%***	37%	0	06%
7.5 HP	1	***1%***	38%	0	11%
9.4 & 10 HP	46	***29%***	67%	1	11%
15 HP	3	***2%***	69%	1	15%
20 HP	32	***21%***	90%	1	14%
30 to 40 HP	5	3%	***93%***	***1***	***35%***
47 HP	10	6%	***99%***	***4***	***42%***
Above 50 HP	2	1%	***100%***	***1***	***50%***

The numbers in blue are a rolling average from the smallest station to the largest. The numbers in red are a rolling average from the largest system to the smallest. These figures were used to develop sensitivities for how lift stations might be serviced by generators using those owned by the Utility. From the above table several facts can be discerned:

1. **Approximately 90% of the GRU lift stations use 20 HP and smaller pumps.**
2. **Only 10% of the GRU system (17 stations) consists of lift stations that require generators that are larger than 30 KW.**
3. Of the 17 lift stations that are larger than 20 HP, 6 have permanent generators at the lift station site. If we were to include GRU's 6 portable generators, then 71% or 12 of GRU's 17 lift stations that use 30 HP pumps and above, would have auxiliary power in an emergency situation.

In the case of a system such as illustrated above, the NS would meet 90% of the systems need. Combined with existing resources, NS is substantially capable of handling an extended power outage resulting in major hurricane damage!

For most all mid to large utilities this case would be directly applicable!

Using VFD Controller s for Small Generator Application

VFDs may be used to convert single phase power directly from small generators, to three phase power to power one pump at a lift station in three ways. In the simplest method for emergency applications, the VFD output is connected directly to one of the submersible pumps at the lift station control panel. All other equipment is locked out.

In this configuration the VFD can be used to adjust the frequency applied to one submersible pump motor downward to achieve an acceptable operating condition that allows the pump to maintain a desired wet well level range. This condition is ideal for the VFD application because the motor horsepower is reduced to the value actually required to move wastewater continuously. This allows the one pump at the lift station to maintain a desirable water level range in the wet well while preventing the lift station from overflowing. In these VFD applications, it is recommended that the horsepower controlled by the VFD be 75% of the VFD rating. In other words for a 10 HP VFD rating, 7.5 HP should be the maximum controlled by the VFD. In testing conducted in many applications over the past year in Naples Florida, this condition has not been found to be a problem. In all VFD installations, the horsepower supplied by a pump at a lift station was considerably more than the horsepower actually required to overcome the total dynamic head at the site.

Although the lower pumping rate typically protects the pump from ever running completely dry, in some installations in the aftermath of Hurricane Wilma at mobile home parks in Broward County where the VFD-generator combination were used, the generator was shut off late at night and the collection system used as for storage. The generator was then restarted in the morning and allowed to run during daylight hours and the cycle repeated. In most instances after a severe hurricane many residents have not returned and the water supply is restricted greatly reducing wastewater flow.

In the second configuration a VFD is connected in the same way as above to one submersible pump motor but uses a float ball and transducer combination to actually control the start and stop of the VFD unit. All VFDs used by the City of Naples, include a 4 – 20 ma input that allows programming of a start and stop signals. This configuration protects the pump from running in a dry condition and provides full protection to the submersible pump motor where this is thought to be needed.

This type of configuration also lends itself for use as a mobile pump-down unit where the VFD-generator combination can easily moved from site to site. The VFD-generator combination is used much like one would use a pumper truck, except in this instance, no transport of wastewater is required since a pump at the lift station is being used for evacuating wastewater in the conventional manner.

Although the third method of using the VFD-generator combination is not recommended by the manufacturer, is was used in the City of Sunrise in the aftermath of Hurricane Wilma, with limited success. In this application the VFD-generator combination is used directly to run one pump at a lift station directly as an alternative power source. This application requires that both the generator and the VFD be oversized for the application. The VFD must be operated at 60 hertz and can not be turned down.

Basic VFD-Generator Set-Up

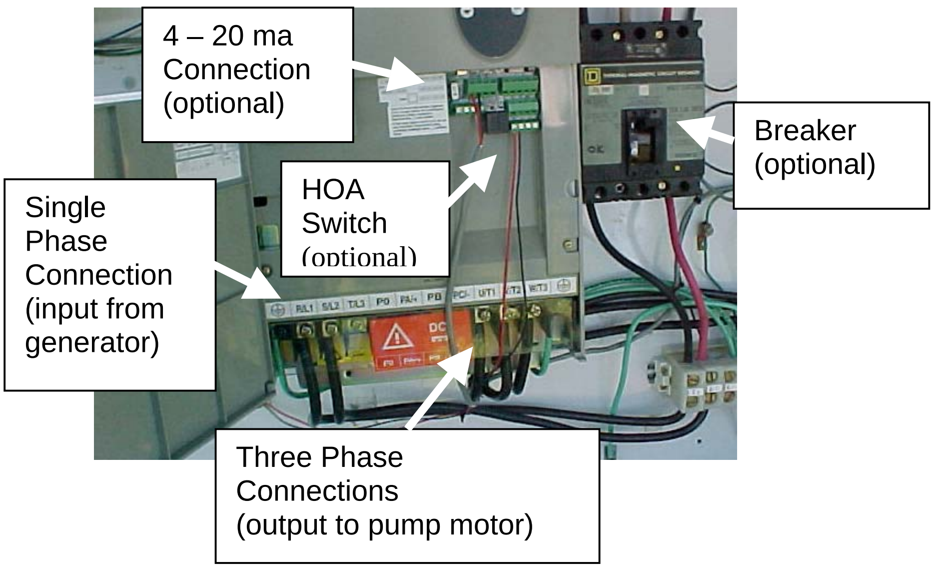
The VFD comes in various stock sizes that handle motors in the 3 HP to 10 HP sizes. These use an Altivar 31, Adjustable Speed Drive Controller, manufactured by Telemacanique. For larger sizes, a VFD model rated at 20 HP and manufactured by Sqaure D, model ATV31HD15M3X, can be special ordered. Prices for the smaller units are in the $750 range and the larger unit is priced around $1400. It is always necessary to derate the VFD horsepower by 25%. The larger VFD units are downward (smaller horsepower) compatible.

VFD units are easy to configure, are extremely versatile and can be used in a wide variety of applications. The basic set up requires two input connections from the single phase generator and three output connections and a ground connection. The second motor-pump must always be de-energized at the breaker to protect the VFD from an overload where both motors are running.

Setting up the VFD unit requires only a few selected menu settings to account for the Full Load Amperage draw required by the motor. The VFD may be set to ramp up in speed to prevent high starting amperage. The unit also has a setting for current overload protection.

For the preferred installations where the VFD is connected directly to power a motor-pump combination, the speed of the pump is reduced to meet flow demands at the lift station. The speed or pumping capacity of the pump is controlled by adjusting the frequency of the motor to below 60 hertz. Full speed is 60 hertz and half speed (50% pumping capacity) is approximately 45 hertz. The speed that the motor runs is directly proportional to the horsepower draw. This allows smaller generators to be used to power larger motors while still evacuating enough wastewater from the lift station to prevent spilling.

The VFD has connections for installing a breaker, fuse protection and for a standard HOA switch as well as a connection for a 4 – 20 ma controller if these are desired are all provided. Input and output connections for a typical Altivar 31, VFD/single phase generator connection is shown below.



Wiring Schematic for Single Phase to Three Phase Conversion using Altivar 31 VFD

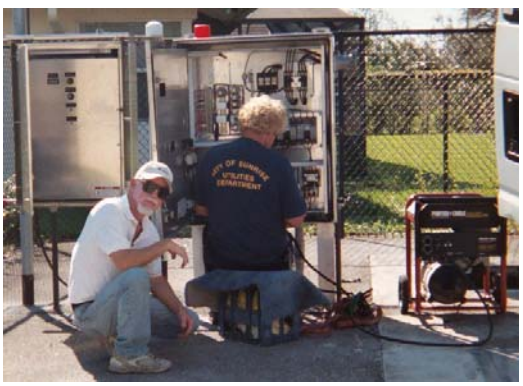
The City of Naples has found it convenient to house the VFD in a cabinet attached to the portable generator to protect the unit from the weather.

The City of Naples has replace some starters in lift stations with VFD units. In this configuration the only connection required at the station is to the single phase generator and lock-out of all other lift station equipment. Future plans call for permanently installing additional VFDs at smaller lift stations and using them to reduce energy requirements. The payback period in electrical cost savings compared to the cost of the VFD, are projected to be less than 3 years for a typical station. Because the VFD can better match the flow conditions, motor stops and starts are reduced extending the service life of the motor.

NS Comparison to Existing Generator Use For Lift Stations 20 HP and Smaller

NO.	NS (Small 1 PH Generator & VFD)	Conventional 3 PH. Generator
1.	Generator Cost and VFD cost less than $2,500	Generator for 30 KW Cost $13,000 to $15,000. Larger units can approach $30,000.
2.	Generators in 5 HP range available locally.	Generator for 5 HP station special order large trailer mounted item.
3.	Several Small generators can be transported in the bed of a conventional pick up truck.	Each generator must be pulled by a recommended ¾ ton vehicle.
4.	Generator set up can be performed by maintenance personnel.	Generator set up requires the services of a commercial electrician
5.	Generators run on gasoline that is generally in adequate supply locally.	Generators run on diesel fuel. Obtaining fuel and fueling in emergency situations can be difficult and require fueling vehicles
6.	VFDs are extremely versatile and can handle ranges of smaller HP sizes.	Generators costs vary slightly in smaller sizes, thus larger sized units are frequently used at small lift stations.
7.	Small generators are portable and can be handled easily by two employees	Large generators typically require crew of two to three people to set up and require special electrical skills
8.	Small generators require minimal maintenance and can be considered depreciated in 3 to 5 years	Large generators require considerable specialized maintenance, frequent exercise (recommended monthly under load) and require protected storage. Service life is 20 years.
9.	Generators can be obtained and deployed easily by affected utility	Transport of large generators to emergency areas requires outside crews to housed in the areas for extended periods
10.	Emergency response is immediate protecting health and meeting needs of citizens for water and wastewater service	Emergency response lags as assessments of areas and movement of equipment from long distances progresses.
11.	Generators can be carried through back yards and placed in areas that are inaccessible to utility vehicles	Utility vehicles can not access some areas immediately after storms because of the amount of debris and trees that are knocked down.
12.	Use of these generators frees larger units for deployment elsewhere	Large generators supply is limited and priority application results in some areas waiting extended periods for help.

Lift Station 207 - City of Sunrise aftermath of Wilma
Access to this lift station is severely impeded in the aftermath of Hurricane Wilma. Lift Stations such as these can be operated with the use of portable generators like the one shown in the installation below.



Dave Hutchinson, FRWA assists Greg Graham, City of Sunrise, in installing a single phase portable generator/VFD combination to power a small three phase lift station.
Small generators like the one shown at right can be easily transported by two employees and quickly deployed to a residential lift station site. The VFD unit can often be placed directly inside existing lift station control panel as shown above.

Conclusion and Recommendations

The NS is certainly applicable for a large number of Florida Utilities and would improve the ability of W/WW utilities to respond to a major hurricane in the future. The greatest advantage to the NS solution is for the smaller utilities in Florida that do not have the resources of the larger communities but provide utility services to many Florida residents. There are approximately 7,000 water systems in Florida. If the statistics generated above are applied, there are some 6,000 locations that could benefit from this innovative technique. The systems works and was applied not only in Naples, but was used in several W/WW installations in Brevard County and in the City of Plantation following Hurricane Wilama.

Florida Rural Water Association will be working with these systems to encourage them to use this technique in providing water immediate after a destructive hurricane. The cost of these VFD/generator combinations is within most small utility budgets and it is anticipated that the concept will be used extensively in the future.

Florida Rural Water Association will be providing the design for these units on its WEB Site at frwa.net.

Bibliography

Bob McVay is a Registered Professional Engineer and was formerly the Assistant General Manager for Water and Wastewater Systems for Gainesville Regional Utilities. Bob has spent considerable amounts of time in 2005 in hurricane restoration efforts assisting water and wastewater utilities in Mississippi, Texas and Florida. He is the full time water trainer for Florida Rural Water Association.

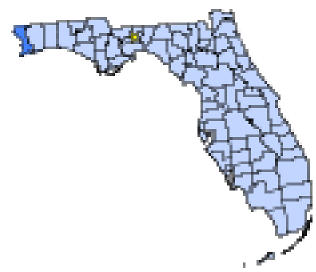
The Director of Florida Rural Water Association, Gary Williams, is also a director of FlaWarn, the W/WW utility coordinating group referred to in this paper. Florida Rural Water Association has 1,476 members with W/WW utilities serving a population of over 9 million people in Florida.

Bob Thomas is the Manager of the Wastewater System for the City of Naples and has spent considerable time in building, installing and troubleshooting the VFD/Generator units described in this article. Bob provided 7 operating VFD/Generator units to Florida Rural Water Association who used the equipment in various utility locations in South Florida in the aftermath of Hurricane Wilma.

Electrical Retrofit Aids in Hurricane Response

Full Mitigation Best Practice Story

Escambia County, Florida



Pensacola, FL - When the lights go out, seemingly small things take on a much larger significance. During a major power outage, valuable time is saved through the ability to plug in a generator without having to hotwire it into an electrical panel. This is especially important when quickly connecting power will prevent damage to homes from sewer backup.

Over the course of four years, the Pensacola-based Emerald Coast Utilities Authority (ECUA) has been retrofitting its sanitary sewer lift stations with electrical connections for portable generators. So far, 300 of the 332 lift stations have been retrofitted. ECUA plans to retrofit the remaining lift stations within the next year.

Because the retrofit helps reduce damages during a disaster, a portion of the cost of the project was eligible for a grant provided by the Department of Homeland Security's Federal Emergency Management Agency, under the Hazard Mitigation Grant Program (HMGP) managed by the Florida Department of Community Affairs. The HMGP grant funded the retrofitting of 41 lift stations with a transfer switch and an electrical receptacle connection, along with the flood-proofing of 26 electrical panels located in low-lying areas. The rest was funded by ECUA.

William Ellis, Utility Maintenance Manager for ECUA, estimates that power outages lasting 24 hours at just one lift station can result in a sewer backup costing up to $5,000 in damages.

Lift stations pump waste from lower to higher elevations for eventual delivery into a wastewater treatment plant. When there is a loss of power, these lift stations stop working. The sewer lines intended to carry sewage away from homes to the lift station may instead cause a backup of effluents into homes. Residents returning to hurricane-damaged or flooded homes will then find an additional, and possibly contaminated, mess to cleanup.

In the past, ECUA workers responded to power outages by using portable pumps loaded onto trucks to bypass lift station pumps, or rewired the lift station electric panels to connect portable generators. To streamline the process, ECUA electricians placed power cable connector receptacles (plug-ins for the generators) on the above-ground electrical systems. They installed transfer switches to make it easy to transfer power from the power company line to the portable generator. In the event of a power failure, ECUA workers can now operate a generator without having to rewire the electrical panels. Likewise, they can unplug and transfer a generator to another lift station in need of power.

"If you get the generator in there quick enough, you can do it before the tank fills in the lift station and it's business as usual," said Utility Equipment Supervisor Wayne Lister.

Electrical Supervisor Alfred A. Spencer explained that the old method of hardwiring the generator was dangerous and took a lot of time. "Workers have to get inside the box, work with the wires to hook up the generator, then put it all back when you move the generators."

To prevent sewer backups, ECUA uses a sophisticated communication system to monitor lift station activity. Workers monitoring the system know immediately when there is a power failure at any one of the 320 lift stations in service. When storms approach, bringing the possibility of a loss of power, workers are at the ready to put the generators into service.

"(Hurricane) Ivan was a great teacher," said Spencer. "The system was put to the test."

ECUA workers learned where to strategically stage generators in order to bring them first to critical facilities and main hub lift stations. With experience, they also learned the most efficient ways to move generators between lift stations. To promote better communication when responding to a power outage, the area that handles the mechanical aspect of the lift stations and the area that handles the electrical aspect merged into the same unit and are housed in the same facility.

When Hurricane Dennis hit and the lights went out, staff at ECUA's emergency control center directed generators to the affected areas. The majority of lift stations had a receptacle in place, and within a few minutes the generator was hooked up.

“[Compared to Ivan,] our response time to Dennis was cut way down,” said Lister.

Activity/Project Location

Geographical Area:	**Single County (County-wide)**
FEMA Region:	**Region IV**
State:	**Florida**
County:	**Escambia County**

Key Activity/Project Information

Sector:	**Public**
Hazard Type:	**Flooding; Hurricane/Tropical Storm**
Activity/Project Type:	**Retrofitting, Non-structural; Elevation, Utilities**
Activity/Project Start Date:	**01/2001**
Activity/Project End Date:	**Ongoing**
Funding Source:	**Hazard Mitigation Grant Program (HMGP)**
Application/Project Number:	**9999**

Activity/Project Economic Analysis

Cost:	**$100,043.00 (Actual)**

Activity/Project Disaster Information

Mitigation Resulted From Federal Disaster?	**Yes**
Federal Disaster #:	**1344 , 10/03/2000**
Federal Disaster Year:	**2000**
Value Tested By Disaster?	**Yes**
Tested By Federal Disaster #:	**No Federal Disaster specified**
Year First Tested:	**2004**
Repetitive Loss Property?	**Unknown**

Reference URLs

Reference URL 1: **http://www.fema.gov/government/grant/hmgp/index.shtm**

Reference URL 2: **http://www.ecua.org/**

Main Points

- The Pensacola-based Emerald Coast Utilities Authority is retrofitting its sanitary sewer lift stations with electrical connections for portable generators.
- Use of generators during a power outage will prevent damage to homes from sewer backup.
- 300 of the 332 lift stations have been retrofitted.
- An HMGP grant funded the retrofitting of 41 lift stations with a transfer switch and an electrical receptacle connection, along with the flood-proofing of 26 electrical panels located in low-lying areas.

ECUA Electrical Supervisor Alfred A. Spencer displays a lift station electrical box.

Recovering From Disaster

By Chuck Yung

Flooding in the aftermath of hurricanes Katrina, Rita and Wilma shut down hundreds of plants along the Gulf Coast from Florida to Texas. To get them up and running again, maintenance departments and motor repairers face the daunting task of cleaning muck and moisture from thousands upon thousands of electric motors and generators. The process will take weeks, if not months, and will require special clean-up procedures for motors contaminated by saltwater.

Although the problems are huge, affected plants can get back in production more quickly by working closely with service center professionals and following a few tips that will make the cleanup more manageable. These include prioritizing motors and generators for repair or replacement, storing contaminated machines properly, and using special procedures to flush away saltwater contamination. Constructing temporary ovens on site or at the service center can also add capacity for drying the insulation systems of flooded motors.

In the wake of the recent hurricanes, maintenance professionals and motor repairers need creative solutions to speed the removal of moisture and contamination from thousands upon thousands of swamped motors.

Understanding the problem

The harm done to motors and generators by flooding extends beyond rusted shafts and contaminated bearings and lubricants. Even brief intrusion of moisture can compromise the electrical insulation system, making the windings vulnerable to ground failures. Saltwater flooding poses additional problems. Unless thoroughly flushed from the equipment before it dries, the residual salt usually will rust the steel laminations of the stator and rotor cores. It also may corrode the copper windings and aluminum or copper rotor cages. The result, predictably, will be lots of motor failures.

How to proceed
Begin by prioritizing motors by size and availability. Older motors are often good candidates for replacement with more energy efficient EPAct or NEMA Premium® models. The horsepower break will vary from plant to plant, depending on the application, annual usage, energy costs, and other factors. But, considering the real possibility that your regular vendors may be backlogged with work, somewhere between 100 and 200 hp may be a reasonable place to draw the repair-replace line. By replacing those smaller motors with readily available energy-efficient models, you'll free up capacity for your service center to concentrate on the larger ones that it makes more sense to repair.

Two ways to clean
Once you decide which motors to save, ask your service center to process those with open enclosures first. In cases of freshwater contamination, have them disassemble the motor and clean the stator windings and rotor with a pressure-washer. If the insulation resistance is acceptable after the windings have been thoroughly dried, the service center should apply a fresh coat of varnish and process the motor as usual (new bearings, balance the rotor, etc.). Windings that fail the insulation resistance test should be put though another cleaning and drying cycle and tested again. Stators that fail the second insulation resistance test should be rewound.

Saltwater contamination requires a more thorough cleaning process to reduce the possibility that salt residue will rust the laminations or corrode the windings. To accomplish this, have your service center clean the stator and rotor windings and insulation systems using the "Saltwater flush procedure" described below. For best results, they should immerse stators and rotors in the freshwater tank before the saltwater dries.

For the same reason, do not disassemble contaminated TEFC or explosion-proof motors until there is room for them in the immersion tank. This will keep them full of water and prevent salt from drying on internal parts. If it will be a while before these motors can be cleaned, place them on their sides, with the lead openings up, and keep them filled with water.

Saltwater flush procedure
This procedure offers the best chance for removing saltwater from contaminated windings. As mentioned earlier, it works best if you do not allow the windings to dry first. The sooner the windings are immersed in the tank, the better the results.

The process is straightforward:

- Immerse stators and rotors in freshwater for 8 hours.
- Continuously agitate the water.
- Exchange water in the tank with freshwater at rate of at least 20 - 50 gallons per minute.

Tank construction. Select a dumpster or similar container that will hold enough water to completely immerse a good number of stators and rotors and drill a drain hole of at least 2" in diameter near the top. Weld a pipe nipple to the drain hole and plumb it to a storm drain or other suitable place.

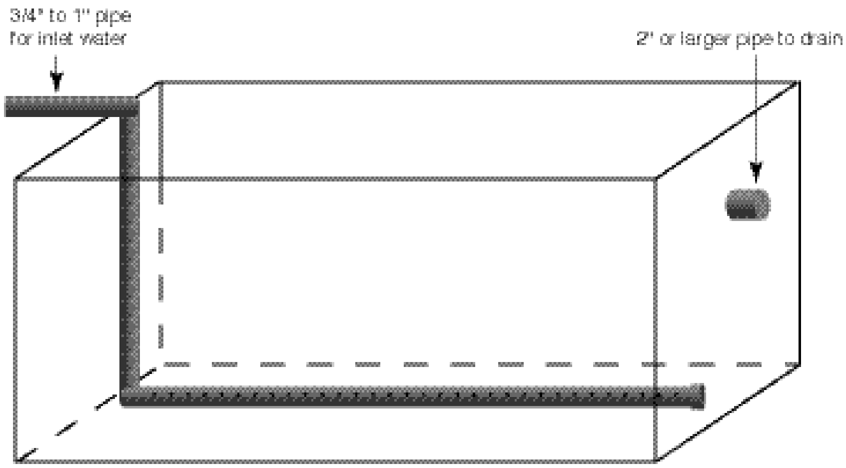


Figure 1. Tank for flushing saltwater from windings

Next, route a 3/4" or larger supply pipe into the top of the tank (roughly centered), down the inside wall, and across the length of the bottom. Cap the end of the pipe and then drill holes at a slight upward angle along both sides of pipe to serve as water jets. The hole size should be appropriate for the available water pressure, but no more than 1/8" in diameter. The more holes you drill, the smaller they will have to be (see Figure 1).

Flush procedure. Place the stators and rotors in the tank and fill it with freshwater. Process each batch for 8 hours, continuously exchanging the water in the tank at a rate of at least 20 - 50 gallons per minute. At the end of the cycle, remove and pressure-wash the stators and rotors, and then dry them thoroughly in a bake oven or temporary field oven (see below).

Finally, test the insulation resistance to ground. If the test results are acceptable, have the service center apply a dip-and-bake varnish treatment before reassembling the motor. If the motor fails the insulation resistance test, bake it again and repeat the insulation test. Motors that fail the insulation resistance test a second time should be rewound. Per IEEE Std. 43-2000, the minimum resistance to ground is 5 megohms for random windings, or 100 megohms for form coil windings.

The bottleneck

For most service centers, the bake oven is the single biggest bottleneck. Even the largest oven will only hold so many motors, and the drying time for each batch can take 12 hours or longer. Imagine the backlog after a disaster, when they have hundreds of motors to process!

Of course, it's possible (but not very efficient) to dry windings by draping larger motors with tarps and applying external heat sources. Another way is to dry the windings is to energize them with a welder or other DC power source. The drawback here is that someone has to monitor the current and winding temperature and periodically move the welder leads to heat all three phases evenly. Welding machines also have a duty cycle that's a lot shorter than the two or three days it might take to dry out a large motor.

A better way to increase baking capacity is to build one or more temporary ovens that can dry motor and generator windings safely and efficiently. This approach is especially useful for drying large stators, which take a long time to heat to the required temperature, occupy the entire oven, and delay the processing of other motors. If necessary, temporary ovens can even be constructed on site. This can save the time and labor required to remove the motor from service, transport it, and later reinstall it.

Materials. Energy-shield (the hard-sided foam insulation that home builders install between the exterior frame and siding/brick) and aluminum duct tape are ideal for building temporary ovens–no matter what size or shape you might need. A stock item at most construction-supply super stores, energy-shield has a layer of aluminum foil on both sides and exceptionally good insulating value (R-29) for its thickness. The 4' x 8' sheets are lightweight and easy to cut with a safety knife. They 're also reusable–as long as you store them where they won't be damaged.

Oven construction. For motors with very large frames, box the motor by placing energy-shield directly on the frame, including the top. Seal the joints with aluminum duct-tape.

Placing the energy-shield directly on the frame also minimizes the volume of air that must be heated. This also reduces drying time because the insulation minimizes heat loss.

Heat sources. To heat the temporary oven, force air through it from an alternate heat source. If you use a torpedo heater (see Figure 2), position it to blow hot air directly into the center of the bore. Energy calculations for oven design are complex. For this purpose, 100,000 BTU per 1200 cubic feet of oven volume will be adequate to heat the oven and contents within a reasonable time.

Temperature control. For an accurate record of winding temperature, directly monitor the motor's RTDs, if it has them. If RTDs are not readily available, use HVAC instruments or candy thermometers to monitor temperature in each quadrant of the oven. The key is to keep the heat uniform within the motor, and not to exceed part temperatures of 250° F (121° C**)**.

Because heat rises, it might seem reasonable to open exhaust ports at the top to let it out. But as those familiar with old-fashioned wood stoves can tell you, the best way to control oven temperature is to open or close dampers (exhaust ports) near all four corners on both sides (see Figure 2).

To raise the temperature at one corner, for instance, open that damper farther. The increased flow of hot air through that area will raise the temperature. The ability to regulate temperature in this way greatly improves the drying process as compared with traditional methods such as a DC current source or tarps.

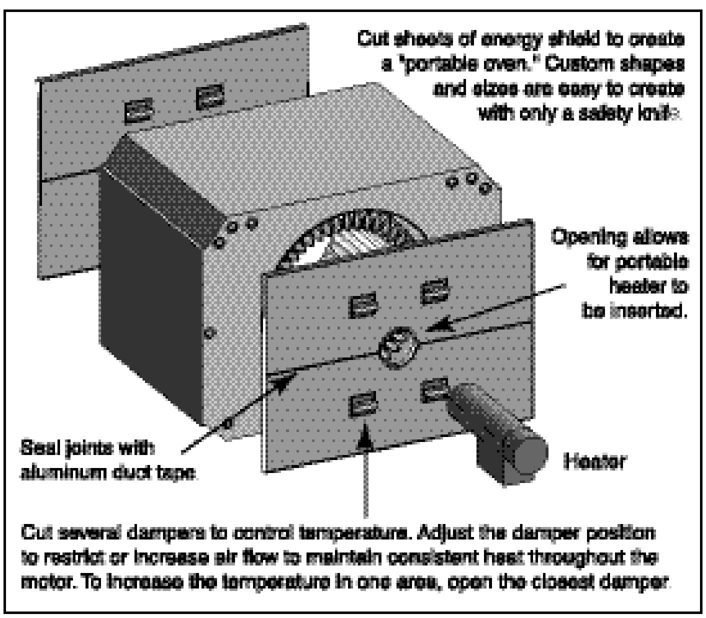


Figure 2. Temporary oven.

How long to bake?

The bake cycle should be long enough to dry the windings completely. If it's too short, you'll need to repeat the process. If it's too long, you'll waste both time and energy. If the windings has RTDs, 6 - 8 hours at 200° F (93° C) should be sufficient. For windings not equipped with RTDs, here's a foolproof way to determine how long the bake cycle should be.

All you need are two lengths of RTD wire or similar small lead wire long enough to reach out of the oven and a DC voltmeter capable of reading millivolts. With the wet winding on the oven cart, attach one lead to the stator frame and the other to a winding lead. Finally, connect the free end of each lead to the DC voltmeter. You can be sure the windings are completely dry when the voltage on the millivolt scale reaches zero.

This procedure is one that many service centers use when they have large rush jobs to process. It often cuts hours from expected drying times, even for normal work. It also reduces the chance of damage that might result from excessive temperatures.

How it works. Like the setup, the principle behind this procedure is fairly simple. The iron frame and copper windings function as two plates of a crude battery. Electrolytic action across the wet insulation causes current to flow. As long as the cell is “wet”, it produces voltage. When the “cell” is dry, so is the insulation.

Note: This procedure works for everything except some form coil VPI insulation systems. Some of these windings are sealed so well that they may exclude moisture from the insulation, keeping the “wet cell” battery from developing.

Conclusion

No one could have been fully prepared to deal with a back-to-back series of disasters like hurricanes Katrina, Rita and Wima. Hopefully, though, the procedures outlined here will speed the recovery for the plants in affected areas, as well as for the local populations that depend upon them both for employment and products. In better times, these procedures also can facilitate plant-service center partnerships and maximize uptime.

Side Bar

Common Misconceptions About How To Dry Wet Motors

Two mistaken ideas about how to dry wet windings have persisted for years. The first is that heating the windings with a welding machine is good way to dry out an electric motor. Before using a welder or other DC power source for this purpose, make sure you know what you're getting into.

For starters most electric motors large enough to warrant consideration have three leads–one per phase. Internally, they are connected either wye (Y) or delta (Δ), as shown in Figure 3. (Incidentally, the terms wye and delta come from the Greek letters that they resemble.)

If you apply DC current to any two leads of a delta winding, two phases will be in series, and the third will be in parallel with them. That means one phase will carry twice as

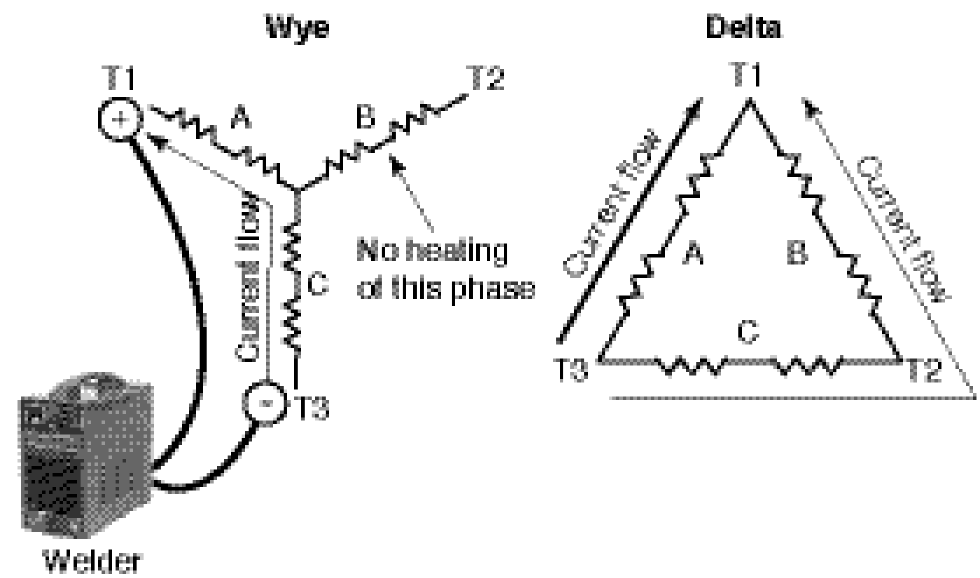


Figure 3. Drying windings with a welder or other DC power source.

With the welder applying current from T1 to T3, only two phases of a wye-connected motor are heaed. If the internal connection is delta, one phase is heated with four times the wattage of the other two phases. In both cases, the welder leads must be periodically moved to heat the entire winding evenly.

much current as the series pair, so it will get much hotter. For the wye connection, only two phases carry current, leaving the third phase cold.

Whether the winding is connected wye or delta, someone must monitor the current and winding temperature, and periodically move the welder leads. Otherwise, parts of the winding may not dry completely, if at all. Welding machines also have a duty cycle that's a lot shorter than the two or three days it might take to dry out one winding!

Welding machines are useful when both ends of each phase are brought out as six leads. An ohmmeter will confirm three separate circuits. In that case, the three phases can be connected in parallel or series, depending on the capacity of the welding machine, and dried simultaneously.

Another misconception holds that windings should not be dried at oven temperatures above 180º F (82° C), for fear that trapped moisture will burst the insulation. That might be a valid concern if we could somehow heat a winding instantly to above boiling temperature. The reality is that windings, like anything else placed in an oven, heat up very slowly. Moisture will get out the same way it got in. As the temperature of the winding slowly increases, the moisture (just as slowly) will evaporate. Although IEEE Standard 43 (1974) included an annex with information that may have perpetuated this belief, it was dropped in the next revision cycle.

Every day more than 2,000 EASA service centers steam-clean and then bake stator windings–mostly at oven temperatures of 250 - 300º F (~ 120 - 150°C). Even though many of them repair thousands of motors annually, there is no evidence that this process has damaged a single winding. Burst insulation due to oven temperatures above 212 º F (100° C) is simply not a concern.

About the Author

Chuck Yung is a technical support specialist at the Electrical Apparatus Service Association (EASA), St. Louis, MO; 314-993-2220; 314-993-1269 (fax); www.easa.com. EASA is an international trade association of more than 2,150 firms in 50 countries that sell and service electrical, electronic, and mechanical apparatus.