

ASSOCIATION OF MINNESOTA EMERGENCY MANAGERS

**Outdoor Warning Siren
Best Practices
Recommendation**

Adopted February 8, 2015

Association of Minnesota Emergency Managers Outdoor Warning Siren Best Practices Recommendation

Background. Outdoor warning sirens are a tool used by emergency officials to warn the public of an immediate threat to life safety from many types of hazards and threats. Originally designed to warn residents of large cities to take shelter because of incoming enemy bombers during World War II, the siren system was later upgraded and expanded during the Cold War for warning of incoming missiles. In 1965, Minnesota outdoor warning sirens were used for the first time to warn people of an unprecedented outbreak of powerful tornadoes that struck the Twin Cities on May 6th. Since then, sirens in Minnesota have warned people of many types of dangers and have grown in coverage and capability.

Public Warning System. Outdoor warning sirens are just one element in an integrated public warning system that uses many methods to provide immediate, life-saving warning to the public as quickly as possible. Other elements of this integrated public warning system include the National Oceanic and Atmospheric Administration's NOAA Weather Radio (NWR); broadcast radio, television, and cable providers that use the Emergency Alert System (EAS); Wireless Emergency Alert (WEA) systems; telephonic notification services; and digital message boards along highways. No single piece of public warning technology is capable of alerting all people all the time. People engage in various activities throughout the day and these warning tools may or may not be effective at reaching an individual at any particular moment. Having a lot of warning tools also provides redundancy and resilience against failure of key systems such as cell phone towers, the internet, or the power grid which happens often when disaster strikes.

Siren Organization. Outdoor warning sirens in Minnesota are not part of a centralized statewide system. Siren site selection, equipment choice, installation, maintenance and upgrades are typically the responsibility of cities, and sometimes counties. In rare instances special jurisdictions, such as major airports, or private industries, such as nuclear power plants own and operate sirens. Siren policies have never before been coordinated in Minnesota. Policy scope ranges from operators that own a single siren, to city-wide policies, to county-wide policies. Due to the variety of siren equipment used and differences in organization and capabilities between jurisdictions, siren activation methods vary. Some sirens must be manually activated at each location. Other siren networks are automated and can be activated from a single control point which is often a Public Safety Alerting Point (PSAP) or dispatch center. The result has been that vital public warning signals are very different across the state.

Siren Capabilities. Outdoor warning sirens are quite simply tools to warn people who are outdoors to take immediate, potentially life-saving action by finding shelter from an imminent deadly threat. Though some people who are very close to an outdoor warning siren may hear it while they are inside a building, the sirens are really supposed to warn those people who may be outside of a dangerous threat. Most old siren systems are mechanical, while many newer varieties are electronic. Either type works well to provide outdoor warning. The planning range for hearing most outdoor sirens is $\frac{1}{2}$ to 1 mile from the siren location. In addition to differences in sirens' models, many other factors may increase or decrease the distance over which the sound may carry, including wind, vegetation, hills, and other noise in the area.

Siren Education. Most outdoor warning sirens now in use in Minnesota do not have the capability to provide a voice message. Even when voice messages can be provided, siren tones carry across much further distances than an amplified human voice. Therefore, people will need to know what to do when they hear a siren tone without any further explanation. Public education is an essential component of a successful outdoor warning siren capability. If people are unaware of what action to take when a siren sounds, some will seek shelter, others will run, and still others will stick around to find out what is going on. In the absence of any specific guidance provided for a special circumstance, emergency managers in Minnesota want the public to immediately move to shelter when outdoor warning sirens are heard, and then get information from a reliable source about the threat. People should always "***Get inside and get information***" when sirens go off. Education about sirens and other warning methods reduces public confusion, which is a major contributor to fatal actions when disaster strikes.

Forewarning. Another important part of public warning, especially with outdoor warning sirens, is forewarning. Forewarning is different than just knowing what to do when a siren sounds. Forewarning is when people are aware of the increase and decrease of hazards and threats over days and weeks. This is especially important during severe weather season. Advances in technology and the skills of National Weather Service meteorologists mean that typically there are **days of indications** that severe weather will form (*Hazardous Weather Outlook*). There are often **hours of alert** that the development of dangerous weather is imminent (*Tornado Watch*). Finally, there are usually only **minutes of warning** to take shelter (*Tornado Warning*). People should understand that *sirens are the last link in the warning chain*, not the first. A very small investment of a few minutes of time each day can ensure proper forewarning and better decision-making for the safety of families, groups and businesses. People should take a moment to check weather forecasts daily for any mention of severe weather. Extra attention should be paid days with severe weather potential. Forewarning prevents surprise. Surprise often causes unnecessary delay in taking appropriate life-saving action – sometimes with tragic results.

Intent, Principles and Recommended Standards

The Problem: While already useful, outdoor warning sirens can be made much more effective. Simple policy changes statewide would make sirens more trusted as a warning tool and improve public safety without requiring significant expense. Recent studies about public reactions to outdoor warning sirens in such deadly tornado events as Joplin (MO), Moore (OK), and Tuscaloosa (AL) show that many people don't trust sirens to be accurate, and therefore they do not take shelter when they hear them. Instead, many begin to call or text friends and family when sirens go off to verify conditions and discuss options before taking any further action. These studies show that overuse of sirens leads people to ignore them. Overuse includes testing them too often. It also includes using outdoor warning sirens for non-warning reasons, such as for lunch sirens, dinner sirens, curfew sirens, and fire hall sirens. People have difficulty sorting out all the sirens they hear and then just tune them out from frustration. Another problem has been sounding sirens in too large an area so people far from an actual threat have sirens activate near them. These so called 'blue sky warnings' do not match the smaller polygon warnings that are now possible. This produces a lack of confidence in outdoor warning sirens and results in a lack of urgency when they are heard.

AMEM Intent: The reason the Association of Minnesota Emergency Managers (AMEM) wants to create best practice recommendations for outdoor warning sirens is to improve public safety and public warning effectiveness in Minnesota by encouraging statewide adoption of one simple, clear, consistent and credible outdoor warning siren policy. The policy fosters statewide understanding of the purpose of outdoor warning sirens among both emergency personnel and the public. It also describes a standard way to employ them across Minnesota. The resulting reduction in individual confusion and siren fatigue should lead to increased confidence and trust in public warning systems in general and sirens in particular. These recommendations are offered for the use of emergency managers as a tool to influence local siren policy decisions. AMEM is not interested in standardizing practices and policies as they are now. Instead, AMEM aims to develop and promote a siren policy as we believe it should become in the future to promote a safer and more resilient Minnesota. These best practice recommendations are, therefore, goals that AMEM encourages jurisdictions to work towards. These recommendations are not mandatory. AMEM does not enforce. Rather, these ideas represent the professional judgment and advice of emergency managers gathered from every region of Minnesota, together with senior meteorologists from each National Weather Service office that serves Minnesota. Together, we think this is the best way ahead for outdoor warning sirens.

Principles: In order to move toward *one* simple, clear, consistent and credible outdoor warning siren policy in Minnesota, the following overarching principles are recommended as best practice.

- **Protection of Life.** The sole purpose of outdoor warning sirens is for the protection of life.
Sirens should be used to warn of immediate threats to life and limb. They should not sound when the predominant hazard is for property damage. They also should not be used for any non-life safety purpose such as time-of-day notification (“noon siren” or “curfew siren” for instance).

- **Public Warning.** In order to reduce public confusion, outdoor warning sirens should be sounded for public warning purposes only.
Using outdoor warning sirens for calling firefighters to the station results in significant public confusion because these sirens do not fit a predictable pattern. They often incorrectly use tones reserved for warning of attack. While using sirens to alert volunteer firefighters is traditional and it does have a life-safety objective, technology improvements make siren alerts to firefighters less and less effective. Many fire departments in Minnesota have phased out sirens for firefighter recall. Using sirens for fire calls has also dropped dramatically across the United States. Use of sirens for non-public warning purposes should be phased out.

- **Take Shelter.** The public should know that hearing an outdoor warning siren is a call to take immediate life-saving action. The desired individual action is to *take shelter*.
Shelter does not just mean going inside any structure or vehicle. It means finding a sturdy, permanent building in a place that offers the best possible protection. The phrase “*Get inside then get information*” are memorable words recommended to describe the essential actions that people should take when they hear an outdoor warning siren. There are a very few special circumstances in small areas where sirens may mean something else (described later in this recommendation). If people have no other information however, they should always take shelter when hearing a siren. Public education must also go further to give people tools to identify the most protective areas in buildings.

- **All Hazards. Outdoor Warning Sirens are not “Tornado Sirens.” Sirens may be used for all types of hazards where emergency officials want people in a defined area to “get inside then get information.”**

Besides severe weather, other situations such as the release of hazardous materials or an immediate security threat may require that sirens be used to tell people take shelter. Outdoor warning sirens are also an important part of the National Alert and Warning System (NAWAS) that warns of imminent attack and other national security emergencies.

- **Multi-Mode Warning. Sirens are just one element in a larger public warning system. No single warning element is effective at all times and in all circumstances. Many tools must be used to make sure that people get proper timely warning to take shelter. Outdoor warning sirens are the tool of choice to warn those people who are outside.**

According to a recent national survey, 20.9% percent of Americans prefer outdoor sirens as their method to get warning (Third Annual Public Safety Survey, 2012). This data shows a fundamental problem in perception of sirens and of public warning in general. Warning method is not a matter of favorites, but instead is a function of the activity a person is doing at the time of the warning. Sirens warn those outside. Television screen crawlers warn those watching TV. Digital message boards and radios warn those driving. Weather alert radio awakens those who are asleep or warn those doing work inside a home or office. Wireless Emergency Alerts warn those who are mobile and maybe outside of their local area. People always should have several warning systems available to them as they go about their day.

Operational Standards: Specific recommended operating standards and best practices for outdoor warning siren use in Minnesota...

- **Two Siren Tones.** There are two basic sounds or tones used by outdoor warning sirens; 1) alert and, 2) attack.

1) Alert is a steady ‘wail’ tone

2) Attack is a rising and falling ‘wavering’ tone

These long-established tones are a national standard under a system established by the Federal Government. Across Minnesota, the public should only have to understand the meaning of two separate siren sounds. Any other tones used are only for very specific circumstances inside small and often restricted areas (discussed later). People should understand that some jurisdictions are currently only able to offer the alert tone for public warning. It is also important to know that some fire services utilize the attack tone as their signal to notify firefighters of a call.

Best practice recommendation: Jurisdictions that operate outdoor warning sirens should aim to have both the alert and attack tones available for public warning. The alert tone should be used for local emergency warning. The attack tone should be reserved only for national defense warning. According to the National Warning System Operations Manual (FEMA Manual 1550.2, 2001), the attack signal "... will have no other meaning and will be used for no other purpose."

- **Use in Local Emergencies.** Local emergencies that may require siren activation include, but are not limited to dangerous weather events such as tornadoes or extreme winds; deadly chemical or hazardous material releases; or certain active security situations. The message that emergency officials want to tell the public by using outdoor warning sirens is to find protective shelter, using the catch-phrase "get inside then get information."

Best practice recommendation: When used for a public warning of local emergency, outdoor warning sirens should sound the alert tone only. During use for an actual warning (as opposed to a drill), the duration of the alert tone should be at least four (4) minutes. There is strong evidence that people take siren warning more seriously if the siren is sounded for a longer duration, or if the tone is quickly repeated.

- **Weather Triggers.** There are several types of extreme weather that should trigger activation of outdoor warning sirens (and many types that should not). Quick and effective use of sirens is especially important during violent weather events since sirens are designed to warn people engaged in outdoor activities. These are the people most vulnerable to weather impact. Use of sirens for weather warning should be for a clear and present danger to life-safety, not for conditions that threaten property. Of course, most stormy weather can increase safety risks that result in death or injuries. Slippery roads, standing water, lightning and other dangers are often part of storms. People should adjust their activities and come inside, but activation of sirens for general public warning is not used for routine storms. Siren activation should be taken only in cases when it is likely that the effects of weather would likely kill or injure unprotected people outdoors or hurt people in lightly constructed structures. When sirens are activated, protective action does not just mean going inside something, but actually finding safe shelter within structures or leaving unsafe structures (such as mobile homes) and vehicles and then finding good, solid protective shelter.

Best practice recommendation: Two types of violent weather events should trigger siren activation using the alert tone. These include 1) tornadoes and 2) extreme winds.

1) Tornadoes (NWS tornado warnings and/or trained spotter reported)

2) Extreme Winds (NWS measured or imminent at or above 70 MPH)

The wind speed of 70 miles per hour (MPH) was set since winds above that speed can topple large, healthy trees which can have life-threatening consequences when falling onto buildings, tents or vehicles. Structures, starting with mobile homes, are also at risk for significant damage above that wind speed, which endangers people inside. AMEM recommends that sirens should *not* be sounded for basic severe thunderstorm warnings because the NWS severe thunderstorm threshold is set for property damage. In addition, severe thunderstorm warnings occur so frequently in Minnesota that siren activation would likely happen many times each year – eroding public confidence in sirens and resulting in people ignoring sirens and not taking individual protective actions quickly enough.

- **Use in National Defense Emergencies.** There are several scenarios where national authorities may decide to warn the public directly through the National Alert and Warning System (NAWAS). Attack warning was the original purpose of the nation’s siren system. In the event of an imminent attack State and County Warning Points will be notified on the NAWAS Line to sound the “attack” warning under the four specified circumstances as well as other circumstances of national interest. These procedures are spelled out in FEMA Manual 1550.2 published in 2001.

1) Enemy Attack. The Attack Warning will be disseminated over NAWAS when the Commander, North American Aerospace Defense Command (NORAD) declares Air Defense Emergency (ADE) Warning RED. ADE RED signifies that an attack upon the United States is imminent or taking place. Only NORAD is authorized to declare ADEs. Additionally, there are limited threat scenarios by which terrorists or countries of concern may attempt to harm U.S. interests. These scenarios may require an announcement of a limited Attack Warning to a specific area or region of the United States. Warnings are based on tactical and strategic intelligence data gathered and evaluated by NORAD under its responsibility for the aerospace defense of North America.

2) Accidental Missile Launch. An agreement between the United States and Russia exists to reduce the risk of nuclear war because of an accidental, unauthorized, or any other unexplained incident involving a possible nuclear weapon detonation. In the unlikely event of such an incident (e.g., an accidental missile launch) that would threaten the United States or a particular area within the country with a possible nuclear detonation, an accidental launch-warning message will be transmitted over the NAWAS. The attack warning tone would be used.

3) Radioactive Fallout. NAWAS would be used to convey fallout information to the affected State(s). The State(s) would then pass this information on to local governments, which would issue fallout warnings and instructions to the public based on local observations and information received from the State. The attack warning tone would be used.

4) Domestic Errant Missile Launch. The United States space program launches a variety of missiles (military, government and civilian) from several launch locations within its borders. There is potential for these missiles to go errant and not reach proper altitude in outer space but instead fall back to Earth. The rocket launch facility, in conference with NORAD, which monitors all orbital activity, would issue a warning via NAWAS to the threatened the State Warning Point. States would then pass this information to affected local governments, which would sound the attack tone and issue instructions via media and other sources.

Best Practice Recommendation: AMEM recommends that counties and siren owner/operators participate in and support the NAWAS system by maintaining the capability to sound attack warnings for public safety in case of national defense emergency. While national defense emergencies are low probability, most carry high consequences and would result in many more casualties if the public did not get adequate advance warning.

- **Smallest Warning Area Possible.** Siren control technology in use in some places in Minnesota is unable to sound sirens in areas smaller than the entire county. This results in so-called ‘blue sky warnings.’ A blue sky warning happens when the public warning area where sirens sound is much larger than the actual area under threat. This results in people losing trust in siren accuracy and ignoring siren warnings.

Best Practice Recommendation: When repaired or replaced, siren controls should be upgraded with technology to allow only sirens within a specified NWS warning polygon to sound. Additional technology advancements that allow automatic siren activation upon receipt of a NWS tornado or wind message for pre-set conditions should also be considered.

- **Siren Resilience.** Severe weather can quickly make an outdoor warning siren system fail if it is totally dependent on the local power grid as its only power source. Power failures can happen well before a storm hits an area. Lightning or fallen trees can cut power and make critical outdoor warning sirens silent just when a town needs those most. Severe weather often comes in waves over the course of hours, or even days. If the first storm knocks power and therefore warning sirens off line, the public is at risk when new lines of storms approach.

Best Practice Recommendation: To ensure function during critical situations, outdoor warning sirens should not depend on the power grid as their sole source of their power. Backup power sources should be installed, including battery back-up, or connection to a generator that automatically starts when the grid power source shuts off. Other sirens are not connected to the grid at all and are capable of independent power through use of solar charged batteries.

- **No “All-Clear” Message.** A frequent question asked of emergency managers by the public is “what is the all-clear siren tone?” Of course the answer is that there is NO “all-clear” tone. The mistaken belief that there is such a signal comes from the all clear signal used to tell people that they could come out of bomb shelters after enemy bombers had passed in London during World War II. The all clear tone dropped from use in Civil Defense when bombs became nuclear and radioactive fallout became a concern. For weather events and hazardous material emergencies, the idea that there is an “all-clear” tone is dangerous. The “get inside and get information” concept is supposed to have people move inside to sturdy shelter and then connect with an information source, such as radio. The all clear will come from broadcasts and other sources while people remain in the sheltered location. People should not leave a safe shelter spot trying to hear an all clear siren tone outside that is supposed to tell them it is OK to leave shelter. That makes no sense and is unsafe. *Best practice recommendation:* Outdoor warning siren policies should not include any form of “all-clear” signal.

- **Purpose of Monthly Drills.** Monthly siren drills have several purposes. These include verification that the siren is functioning, enabling listeners to learn the sounds used by outdoor warning sirens, and providing a trigger for immediate action drills by people at home, work, school or other sites. It is important that people in listening range of outdoor warning sirens fully understand the intent behind monthly siren drills. Some cities depend upon resident reports to find out if a siren does not work. People in these locations should know that they are expected to notify the siren owner when it does not work during a drill. Information about siren tones and family and workplace immediate action drills are also essential to getting full value from the siren system. *Best practice recommendation:* Public education efforts should make it clear that siren drills are provided as a way for people to become familiar with the siren tones that they will hear for warning. They should learn how siren sounds carry to their yards, worksites, parks, playing fields, lakes and other outdoor spaces in various weather conditions. They should be given tools to have a brief home, workplace,

school or outdoor recreation action drill when sirens are heard. During these drills people can actually move to a place of shelter, or they can do a quick mental assessment of what they would do in an actual emergency. If people are expected to report siren outages, they must be provided contact methods to do so.

- **Conduct of Monthly Drills.** Emergency managers must balance several demands during siren drills. Sirens must be tested to verify that they work. The drill also satisfies the need to provide the public with opportunities to hear sirens before an actual emergency. The drills can also provide a trigger for brief action drills for people to practice protective measures. Too many tests and drills, especially when combined with non-public warning uses of outdoor sirens such as time notifications and fire calls, result in siren fatigue. In siren fatigue, people have become numb to siren sounds and their attention is no longer secured when a siren goes off. Siren drills must be limited to only those needed to meet objectives in order to not build siren fatigue among the public.

Best practice recommendation: A single audible siren drill protocol used across Minnesota will help reduce public confusion and familiarize people with tones they will hear in an emergency. AMEM best practice recommends one monthly audible siren drill. This drill should occur at 13:00 local time on the first Wednesday of each month. The goal for outdoor warning siren capability in Minnesota is to offer two separate siren tones to warn populations. Some jurisdictions in the state cannot yet provide warnings using two kinds of tones.

1) Two tone drill

Jurisdictions that have two siren tone capability should follow the protocol of one (1) minute of the alert (“wail”) tone starting at 13:00 local time; followed by one (1) minute of silence; followed by one (1) minute of the attack (“wavering”) tone.

2) Single tone drill

Jurisdictions that are not yet capable of signaling two different tones should conduct a single tone test using the alert (“wail”) tone starting at 13:00 local time, and lasting for one (1) minute.

- **Drill Day Severe Weather Threat.** During severe weather season there is a good chance that a siren drill may occur on a day with actual severe weather risk. Emergency managers do not want to be in a position where a monthly siren test is happening while actual severe weather is building in the same area. This kind of siren purpose conflict would only erode public confidence in the siren system and in emergency management decision-making. Looming severe weather or other developing emergency situations are appropriate reasons to cancel siren drills in

order to reduce public confusion. Cancellation also reassures people that officials are actively monitoring developing situations and making appropriate adjustments when needed.

Best practice recommendation: If, on the day of the siren drill, the National Weather Service forecasts a threat of actual severe weather in a specific county or counties, to occur within the six (6) hours prior (07:00) and through the six (6) hours following the siren drill (19:00), the drill should be cancelled in the county/counties described in the forecast. The six hour minus – six hour plus window allows time for variance in predicted storm development times and for counties with large geographic areas. Local media outlets should be advised that the test is cancelled due to an actual severe weather threat. This not only will notify the public of the cancelled drill, but is also another newsworthy method to highlight to the public the increased severe weather risk for that day.

- **Annual Statewide Tornado Drill.** The Minnesota Division of Homeland Security and Emergency Management coordinates a Statewide Tornado Drill each year in April as part of Minnesota’s Severe Weather Awareness Week. This is a valuable public education effort that gets a lot of concentrated media attention across the state in the weeks just before the onset of severe weather season in Minnesota. The use of outdoor warning sirens during an afternoon and an evening tornado warning scenario is important to the success of the education effort.

Best practice recommendation: Actively participate in Severe Weather Awareness Week and use outdoor warning sirens for the annual Statewide Tornado Drill.

- **Exemption for Nuclear Power Plant Areas.** Minnesota has two nuclear power plants. These plants are located at Monticello in Wright County and at Prairie Island in Goodhue County. Special public alert and warning procedures are used within the 10 mile radius Emergency Planning Zones (EPZ) surrounding the plants. Siren procedures in the EPZ are governed by federal regulations.

Best Practice Recommendation: Outdoor Warning Sirens serving the 10 mile Emergency Planning Zones (EPZ) around Minnesota’s two nuclear power plants at Monticello and Prairie Island are special use sirens and are beyond the scope of the AMEM outdoor warning siren recommendation.

- **Exemption for voice notification.** Some outdoor warning sirens are also capable of providing a voice message when used as a loudspeaker. Generally, the audible

range of a voice message is smaller than when using the speaker as a siren. Voice messages are able to provide more information than a simple tone, and can be much more specific about the threat and directive in actions to take.

Best Practice Recommendation: When used in a voice mode with a voice message, outdoor warning loudspeaker-sirens are outside the scope of this AMEM recommendation. When used as simple sirens, operators of loudspeakers should employ AMEM best practices.

Exemptions for Special Considerations. There are special environments or circumstances when outdoor warning sirens have a public warning value when used in different ways than described in this best practice recommendation. However, the large benefit of a simple and easily understood standard statewide siren practices will be lost if too many special exceptions are made. Emergency managers and siren owner/operators should use caution when thinking about exceptions to their siren policy. Public confusion could be the result. There are two main forms of special considerations....

1) Special Environments. A special environment for outdoor warning siren includes relatively small areas that have long-term, well-defined risk from a rapid onset emergency. A narrow ravine, for instance, which has homes or businesses within it, that is prone to flash flooding could be a special environment for outdoor warning sirens. The role of outdoor warning sirens in this limited case may be to trigger an evacuation (rather than to seek shelter).

2) Special Circumstances. A special circumstance for outdoor warning siren use includes a population in a relatively small area that are facing danger from a dynamic and immediate threat situation. For instance, an area engaged in a flood fight where a levee is at risk, may decide to use outdoor warning sirens as a means to alert those engaged in the fight that a failure has occurred. The role of outdoor warning sirens in this limited case is to trigger the rapid egress of responders and other flood fighters from the danger area.

Best practice recommendation: Use of outdoor warning sirens in special environments or circumstances should be very limited. The size of the area should be well defined and small. If possible, siren tones used should be different from the attack or alert tone. People who are expected to take action based on these siren warnings should be informed, well ahead of time, about the special signal and the actions that they should take when they hear it.

References

FEMA CPG 1-17, March 1980. Outdoor Warning Systems Guide.

FEMA Manual 1550.2, March 2001. National Warning System Operations Manual.

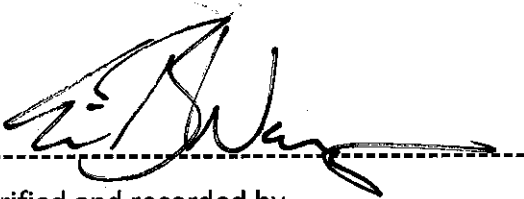
Improvement

Suggestions for improving the AMEM Outdoor Warning Siren Best Practices Recommendation should be sent to the current President of the Association of Minnesota Emergency Managers via contact information found at <http://amemminnesota.org/>

Approval

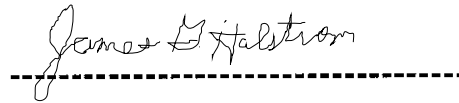
The AMEM Outdoor Warning Siren Best Practices Recommendation was recommended by the AMEM President and approved by a vote of the AMEM Board on February 8, 2015, while meeting in Brooklyn Park, Minnesota.

These recommendations remain in force as AMEM recommended best practices until rescinded or modified by subsequent AMEM Board action.



Verified and recorded by

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