

EVALUATION OF THE EMERGENCY EVACUATION PLAN FOR THE OYSTER CREEK NUCLEAR POWER PLANT

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ABSTRACT: *Oyster Creek Nuclear Power Plant in Lacey Township, Ocean County, New Jersey is the oldest commercial nuclear generating facility operating in the nation, and is also situated in one of the fastest growing counties in the nation's most densely populated state. In July of 2005, the owners of Oyster Creek submitted an application for license renewal, which will allow it to continue operations for another 20 years. Many local residents are concerned that the current emergency response and evacuation plans are inadequate. This opposition warrants a re-evaluation of the evacuation plan for current and future population scenarios. After a thorough evaluation of the current emergency response and evacuation plans for Oyster Creek nuclear power plant, this paper concludes that they are very thorough and comprehensive. However, due to the ongoing debate over the adequacy of the plans, this paper examines five specific concerns that residents have about the emergency evacuation plans and how the plans address each issue. These concerns are: (1) human evacuation behavior, (2) emergency exercises and drills, (3) reception centers, (4) transient population estimates, and (5) frequently updated population estimates. This paper also looks at the geography of Oyster Creek's evacuation plans and whether they are adequate to protect the health of the growing population in light of the site and situation of the plant location. Ultimately the problems inherent in the evacuation plan can likely be improved.*

Keywords: *Emergency management, Nuclear power, Evacuation*

INTRODUCTION

Do you know what to do if there is a nuclear emergency at your local nuclear power plant? Emergency planning and preparedness is extremely important for nuclear power plants because of the dangers associated with radioactive material. The United States has been using nuclear energy to provide electricity since the late 1960's. Since then, there has only been one accident that was serious enough to warrant the evacuation of the surrounding population, Three Mile Island (TMI) in 1979. According to Hirschberg, et.al, the nuclear energy industry is statistically one of the safest energy producing industries worldwide when it comes to severe accident related deaths. There are significantly more deaths per year related to coal and hydro power than there is related to nuclear power (1998). Nonetheless, preparations must be made for nuclear emergencies because of the potential consequences.

Nuclear power is the only industry in the US that the government requires an emergency response plan for each facility. In 1970 the Atomic Energy Commission (later abolished and replaced by the Nuclear Regulatory Commission in 1975) issued the first regulations for nuclear power plant operators to develop on-site emergency plans (Golding et al.,

1988). However, in 1979, many nuclear power plants, including the infamous Three Mile Island facility, did not have an emergency management or evacuation plan for the surrounding area outside the nuclear facility. In fact, at the time of the TMI accident only 11 of the 31 states with nuclear power plants had emergency management plans for off-site contamination on record with the Nuclear Regulatory Commission (NRC). The submission of these off-site plans was mainly voluntary (Cutter, 1984). After the TMI accident, the NRC implemented Title 10 of the Code of Federal Regulations Part 50.47 in 1979 which made it mandatory that all commercial nuclear power plants have a broad off-site emergency evacuation plan. Today, there are even more laws, such as NUREG-0654, that govern how nuclear power plants develop these emergency response and evacuation plans. According to NUREG-0654, it is the responsibility of the state to develop off-site emergency response and evacuation plans; whereas, the responsibility of on-site emergency response plans remain with the nuclear power plant operator.

Oyster Creek is located in Lacey Township, Ocean County, New Jersey, approximately 50 miles east of Philadelphia and 70 miles south of New York City (Figure 1). According to the plant's website, the construction of the facility began in January 1965 and

it started commercial operation in December 1969. This makes Oyster Creek the oldest nuclear power plant in the United States still operating.

In July of 2005, the owner of Oyster Creek, AmerGen Energy, submitted an application to renew its operating license which would allow the nuclear power plant to continue operating until 2029. Many Ocean County residents are concerned about allowing the nuclear power plant to continue operation. Aside from the aging nuclear facility, they claim that current emergency response and evacuation plans are inadequate for the surrounding area. This has sparked a fierce debate over the current emergency response and evacuation plans. Anti-nuclear advocacy groups such as the New Jersey Public Interest Research Group (NJPIRG) and Grandmothers, Mothers, and More for Energy Safety (GRMMES) often cite that a complete evacuation of Oyster Creek's 10-mile Emergency Planning Zone (EPZ) would take 9 ½ hours to complete. They are concerned that such a long evacuation time would pose an unacceptable risk to the evacuating population (NJPIRG, 2003). However, what they do not recognize is that the emergency response and evacuation plan states that this statistic is for the absolute worst case scenario. A majority of the evacuation time estimates calculated range from 1 to 4 hours (Scardino, 2008). The chances of a nuclear accident are already low. The chances of a worst case scenario nuclear accident are even lower.

The concerned citizens feel that the current emergency response and evacuation plans are inadequate because of the growing population around the nuclear power plant. They feel that because of the population increase, a timely evacuation will become increasingly impossible. According to population estimates from the US Census, Ocean County's population in 2007 was 561,394, nearly 5 times larger than what it was in 1960 (U.S. Census Bureau). Oyster Creek also has a very unique geography surrounding the facility mainly due to the Atlantic Ocean to the East and the New Jersey Pinelands to the West. Oyster Creek is also located along the New Jersey shore, is a popular tourist area in the summer which can also complicate the evacuation process.

This research highlights five major concerns that these anti-nuclear advocacy groups and other concerned citizens may have and investigates how the current emergency management and evacuation plans address each concern. It is important to realize that this is not a complete list of all concerns that have been expressed by anti-nuclear advocacy groups. This research only focuses on the main issues. In addition to the concerns, this research also looks at the geography of Oyster Creek and investigates whether they are the evacuation plans are adequate to

protect the health of the growing population in light of the site and situation of the plant location.

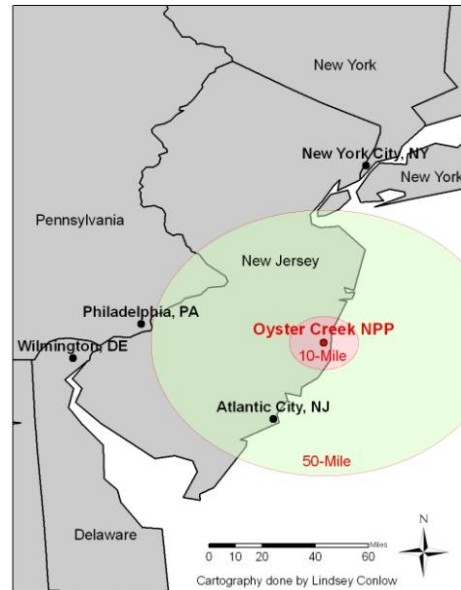


Figure 1. Locator map of Oyster Creek Nuclear Power Plant. Oyster Creek is within close proximity to four major U.S. cities (Data Source: ESRI database, 2007).

EMERGENCY EVACUATION CONCERNS

At least seven interest groups have publicly expressed concerns over license renewal for Oyster Creek. The five major criticisms that these groups have regarding emergency evacuation plans for the Oyster Creek nuclear power plant are:

- (1) The evacuation plan does not consider human evacuation behavior and the possibility of emergency personnel role abandonment.
- (2) Emergency exercises and drills are ineffective in improving and testing the adequacy of the emergency response and evacuation plans.
- (3) Tracking the evacuation process at reception centers can be cumbersome and will increase emergency evacuation times.
- (4) The evacuation plan cannot accurately determine transient population estimates.
- (5) Due to population growth in the local area, population estimates should be updated more frequently than every ten years with new U.S. Census data.

Each criticism is discussed in detail in the following sections.

Human Evacuation Behavior

Evacuations are largely affected by human behavior and how the overall population reacts to the emergency. Critics of the emergency response plans claim that they do not specifically address human behavior when planning for emergencies. Specifically, they claim the plans ignore the shadow evacuation phenomenon, role abandonment, and school evacuation behavior.

Emergency management personnel generally believe that emergency evacuations will work as long as everyone follows directions. However, research indicates that not everyone will do what they are told by emergency management authorities (Cutter, 1984, Lindell and Barnes, 1986, Zeigler and Johnson, 1984). One aspect of this problem is when a population overreacts and chooses to evacuate regardless of what authorities tell them to do. This is known as the “shadow evacuation” phenomenon. This over-response is a common characteristic of all hazardous material accident evacuations (Lindell and Barnes, 1986). For example, the TMI accident clearly demonstrated a shadow evacuation. On March 30, 1979 the governor of Pennsylvania advised all pre-school aged children and pregnant women to evacuate a 5 mile radius around TMI, everyone else within the 10-mile EPZ was told to stay indoors. Of this portion of the population, only 3,500 people were expected to evacuate. However, it was estimated that 200,000 people within a larger 25 mile radius chose to evacuate (Johnson and Zeigler, 1986).

It is believed that because of the lack of experience dealing with nuclear accidents, the public will naturally fear the unknown and become even more inclined to disregard orders and will take their own protective actions (Cutter and Barnes, 1982). According to an article from the Asbury Park Press from February 14, 2006 entitled, “Evacuation plan depends on many who lack key training”, it is also believed that the public will most likely panic in this sort of situation, though no one is certain what degree of panic will occur. Some people think that a large-scale nuclear accident would cause total chaos whereas others believe that no one will panic and everyone will be cooperative.

New Jersey State Police emergency management officials recognize the possibility of a shadow evacuation occurring during an emergency evacuation. They realize that a shadow evacuation can potentially affect how an evacuation will be carried out. According to Sgt. Tom Scardino (2008), assistant head of the New Jersey State Police

Radiological Emergency Response Planning and Technical Unit, they are very confident that the plan will account for additional evacuees resulting from a shadow evacuation.

According to a GIS buffer analysis using 2000 U.S. Census population data, there are 125,725 individuals within the 10-mile EPZ. In February of 2006, The Asbury Park Press investigated the effectiveness of the Oyster Creek Evacuation Plan. According to their article, “Evacuation plan depends on many who lack key training”, their investigation claims that the emergency response and evacuation plans for Oyster Creek are capable of evacuating 244,000 people. This suggests that the plan should be more than adequate to handle the current population plus additional shadow evacuees. Also, the evacuation plan is very flexible in order to handle a wide range of populations. In the event of an emergency, depending on certain meteorological conditions, only certain Emergency Response Planning Areas (ERPAs) and sectors can be evacuated (Figure 2).



Figure 2. Oyster Creek Nuclear Power Plant ERPAs. (Source: NJ Office of Emergency Management 10-mile EPZ Map. Downloaded from website Nov. 2008 <<http://www.state.nj.us/njoem/pdf/10%20mile%20epz.pdf>>).

For example, the plan has the flexibility to order an evacuation for populations living in select ERPAs in the North, North-West sectors up to 5 miles and shelter in place for those greater than 5 miles away. By evacuating certain sectors, only those populations that are affected would receive evacuation notification. This would cut down on the amount of people evacuating from the entire area thus

preventing a large scale shadow evacuation. In addition, to the plan's flexibility, it is extremely detailed with how to manage the emergency. For example, it has a detailed account of the various traffic control measures that would be implemented to direct traffic during an evacuation. According to an article in the Asbury Park Press from February 14, 2006 entitled "Mass Chaos Feared If Too Many Leave", the state evacuation plan compensates for shadow evacuations by having rigorous traffic control in the areas being evacuated.

Another aspect of human behavior in emergency evacuations is that people will evacuate as a family unit (Perry et al., 1981). If a nuclear accident were to occur when school is in session, individuals will typically ignore evacuation orders to locate loved ones. In a recent public opinion poll conducted by the Marist College Institute for Public Opinion, 63% of those surveyed said that they would disregard an evacuation order and go directly to their child's school in an attempt to locate their children and ensure that they are safe (Redlener, 2008). This is a big concern because most evacuation plans state that children will be evacuated by the school to a safe, predesignated reception center where parents can pick them up there rather than at the school. If parents try to locate their children at school it can cause a lot more confusion during an evacuation and cause evacuation time to be longer.

Emergency management personnel remedy this situation by distributing information to the parents and guardians of students enrolled at schools located within Oyster Creek's 10-mile EPZ in the beginning of every school year. This information describes evacuation procedures in the event of a nuclear emergency. The parents and guardians are told to meet with their children at a predesignated reception center, and clearly told not to pick them up at their school.

The last main concern with a nuclear related emergency evacuation and human behavior is that Oyster Creek's emergency response plan relies on state police, firefighters and other volunteers to protect the public health and ensure a safe evacuation. In the event of a nuclear emergency many volunteers expressed that their main concern would be to protect themselves and evacuate their families. They would abandon their role as an emergency volunteer, leaving the emergency personnel understaffed. There is no way to ensure that volunteer bus drivers would put themselves in harm's way to help evacuate individuals who have no means of transportation out of the hazardous area. In the case of Three Mile Island, even medical doctors who were expected to show up for their shifts did not show up for work that day (Golding et. al., 1988). According to a survey

conducted by Zeigler and Johnson Jr. in 1984, 68% of the 291 firefighters surveyed indicated that family obligations would take precedence over emergency duties. In addition, 73% of the 246 bus drivers surveyed had the same response (Zeigler and Johnson, 1984).

Oyster Creek emergency management personnel feel that this would not be a big issue. According to an interview with Sgt. Thomas Scardino (2008), bus drivers and other emergency volunteers are volunteering because they want to help. They confidently claim that when volunteers enter the EPZ they are equipped with nuclear radiation monitors and instructed to leave if the monitor reaches a certain level. The volunteers would also receive state police escorts into potentially dangerous areas. Emergency management personnel try to save human lives; they would not knowingly send more people into harm's way.

Practical Drills and Exercises

The main inadequacy of emergency exercises and drills is that they rarely involve the public. Therefore there is no way to test the adequacy of the evacuation plans and determine how a real evacuation would play out (Cutter, 1984). Instead, emergency plans rest upon a series of assumptions concerning evacuation behavior (Golding et. al., 1988). For example, during an emergency exercise at Indian Point Nuclear Power Plant in 2002, Westchester County, New York officials had evacuation time estimates (ETE) based on 1990 population data. To account for the outdated population data, the officials simply added a rough estimate of time to the previous ETE and based their Protective Action Responses upon the newly estimated ETE (James Lee Witt Assoc., 2003). According to Sgt. Scardino (2008), emergency exercises rarely involve the public because it is impractical to do so. A lot of resources and additional emergency personnel would be required to carry out an exercise evacuation. This can make the exercise very expensive. Also, an exercise evacuation involving the public could lead to a lot of confusion because it is only a test; it is not reasonable to stop everyone's daily activities (including economic activities) to conduct an exercise evacuation.

Oyster Creek Nuclear Power Plant is required by the NRC to conduct a full scale emergency exercise drill that includes all stakeholder involvement every two years. The state of New Jersey also requires Oyster Creek to conduct an exercise drill yearly. Additionally, Oyster Creek has several smaller offline demonstrations that they do several times a

year. These offline demonstrations involve only a small portion of the emergency response plan. For example, an offline demonstration can involve the New Jersey marine police and look at how an accident at Oyster Creek will affect those out in the ocean on boats and make sure the emergency response plan adequately addresses those populations.

The main reasons for having these exercise drills are to make sure every stakeholder knows what to do in the event of an emergency and to test the emergency response systems and adequacy of the plans. If emergency personnel know what they are responsible for, this alone makes emergency responses and evacuations more efficient. According to Sgt. Scardino (2008), conducting full scale exercises and offline demonstrations does in fact help to improve responses. After an exercise of offline demonstration, emergency personnel can then evaluate it and take note of any issues or confusion that came up during the exercise and take necessary steps to address the issue. In any case, it is better to have prepared and practiced for these emergencies than to have done nothing at all and waited for a real nuclear accident to occur in order to test the adequacy of the plans.

Reception Centers

In the event of an emergency evacuation at Oyster Creek, evacuees are directed to one of eight different reception centers located outside the 10 mile EPZ. These reception centers are usually located at large schools or firehouses. During an evacuation, all traffic control measures direct evacuation traffic towards these reception centers. These reception centers act as evacuation checkpoints.

At the reception center, all individuals are scanned for radioactive contamination. If the evacuee is free of nuclear contaminant, they are then registered and allowed to leave the reception center and seek shelter outside the EPZ. If an evacuee is found to have radioactive contamination, they are directed to a decontamination area where they may shower and try to remove the contamination. If unsuccessful at removing the contamination, it is then assumed the contamination is already in their system. If that is the case, they are then transported to a nearby hospital to receive necessary medical attention.

The process of going through these reception centers takes time. Evacuees don't want to worry about getting to the nearest reception center. Their main focus is to simply get out of the area as soon as possible. Some evacuees could be in such a hurry to get to safety that they will become uncooperative with administration at the reception centers trying to

help them. This can lead to further delays and could ultimately cause people to panic. Even though individuals may become uncooperative, the state plan makes the point that it is important to realize that these reception centers are essential to ensure that everyone is safe and free of radioactive contamination. As evacuees register at the reception center, emergency personnel are able to monitor the evacuation process and estimate if the entire population has safely evacuated. According to Sgt. Thomas Scardino (2008), New Jersey State emergency management personnel have conducted several tests of the reception center process and claim that individuals will be scanned for harmful radiation and processed very quickly. They are confident that this process will not be a hindrance to evacuation.

Transient Population Estimates

One of the main components of an emergency response plan is the *evacuation time estimates* (ETEs). These estimates calculate how long it would take to evacuate an entire population in the event of a nuclear emergency. It is very important to have accurate population estimates to calculate ETEs. ETEs are used to help emergency management personnel to determine the correct protective action response; whether it is to order a full evacuation, partial evacuation or for residents to shelter in place. If the population data is incorrect, ETEs can be off by a significant amount. With wrong ETE data emergency management personnel could choose a protective action response that may not be the best choice to protect the public's health (James Lee Witt Assoc, 2003). Unfortunately, it is complex and difficult to estimate populations because they are time and space dependent. People will be in different locations throughout the day as they commute from home to work, or school, and back again. Populations also vary over the seasons of year, days of the week, and time of day. For example, a peak population scenario would most likely occur during the summer, on a weekend, mid- afternoon when tourism is at its greatest.

There are three main types of populations that are included in ETEs: permanent residents, transients and special facility populations. Permanent resident are those who live in the area year-round. Transients are visitors to the risk area who may be daily employees or tourists. Special facility populations are those who are in institutions such as schools, prisons, large employers, hotels and hospitals (Urbanik, 2000). It is easy to determine the population of permanent residents through US Census data. However special facility populations and transients are much more difficult to quantify.

Estimating the transient population is complicated because there is no established way of determining all visitors within a 10-mile radius of Oyster Creek.

The ETEs developed for Oyster Creek include population estimates for the permanent and special facility populations. It even includes estimates on populations who are dependent on public transportation and would therefore require assistance for evacuation. According to Sgt. Scardino (2008), New Jersey State Police emergency management officials estimate the transient population based on Ocean County's tourism estimates. They are certain that their emergency evacuation plans will be adequate enough to handle all transients in the 10-mile EPZ.

Up-to-date Population Estimates

Ocean County is densely populated and its population continues to grow. From 1970 to 2000, Ocean County's population experienced a 145% increase. In 1970, about the time when Oyster Creek began commercial operation, Lacey Township's population was 4,616. By 2000, the population had increased approximately 450% to 25,346 individuals. Figure 3 shows the percent increase in population for each municipality in Ocean County from 1970 to 2000. A majority of the large increases occurred within Oyster Creek's 10-mile EPZ. Figure 4 is a dot density map based on 2000 census blocks showing the distribution of the population in Ocean County with respect to Oyster Creek nuclear power plant.

As mentioned, having accurate and up-to-date population estimates are critical for emergency

response purposes. Aside from ETEs being affected by population estimates, the amount of traffic control officers, buses, and other resources are all based upon these population estimates. Therefore if the population estimate is not updated frequently, resulting in an underestimate of the total population, there can be a lack of resources available for an effective evacuation.

NUREG-0654, is the main document that outlines the requirements for emergency response and evacuation plans for the nuclear industry. It contains specific requirements of all nuclear power plants to develop and keep up-to-date maps showing the distribution and people around the facility. This document also requires the use of current population data to be used to develop ETEs (NUREG-0654, 1980). However, according to this document, Oyster Creek and the New Jersey State government are only required to update their population data for emergency response and evacuation plans during the decennial census. In addition to updating the population with every U.S. Census, emergency management personnel claimed that population estimates are also updated when there has been a significant population increase in the local area. Still, there is no official regulation requiring population estimates to be updated between U.S. Censuses (James Lee Witt Assoc, 2003). This is because other nuclear power plants nation wide may be located in areas where the population growth is minimal. For example, it may not be cost-efficient to update ETEs for nuclear power plants located in the mid-west if the local population only increases by one hundred individuals every five years.

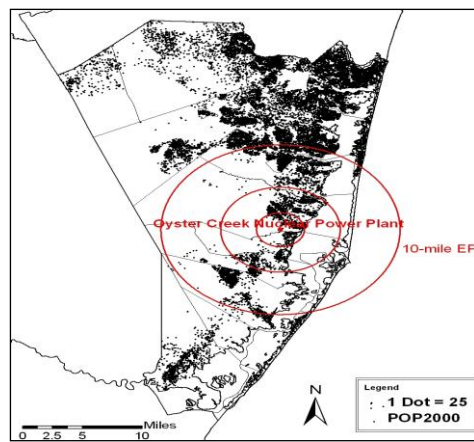
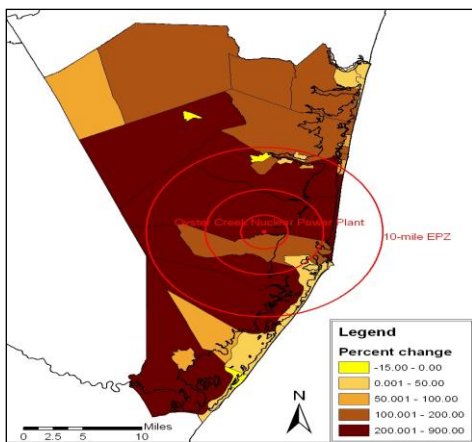


Figure 3. (Left) Percent change of population in Ocean County by municipality from 1970 to 2000. The municipalities that experienced the greatest growth are concentrated within Oyster Creek's 10-mile EPZ.

Figure 4. (Right) Dot density map of Ocean County for 2000. Large, dense populations are located north of Oyster Creek. (Data Source: ESRI database, 2007)

DISCUSSION

Geography is a critical element to be considered in the relicensing of Oyster Creek. Located in the most densely populated state in the nation, Oyster Creek is situated in a location with a number of advantages as well as disadvantages for a nuclear facility. One advantage is that the site itself is adjacent to a low-density vicinity of the New Jersey Pinelands, an area that is managed to substantially limit development. Without the Pinelands regulations, far more development would likely have already occurred within the 10-mile emergency evacuation zone. Likewise, to the east lies Island Beach State Park, one of the only barrier islands along the New Jersey coast that is undeveloped, flanked by the Atlantic Ocean which also limits the population that can locate near the plant. Located in such a population-limiting part of New Jersey while being relatively close to nearly nine million consumers of electricity in New Jersey entails a certain logic of locational efficiency.

On the other hand, the population that does exist in the 10 mile evacuation zone is highly concentrated in a linear pattern due to the other resort beaches on barrier islands along the coast which have residential densities higher than many other New Jersey suburbs. This ribbon of development running north and south and the limited number of east-west causeways to evacuate the islands may present serious choke points that could complicate evacuation especially during peak tourist periods. The location of the two main north-south road arteries, Route 9 and the Garden State Parkway (Figure 2), also run within a mile west of the plant making an incident likely to render north south travel impossible. Furthermore, the geographic situation of the plant is also a concern due to the prevailing winds of the New Jersey shore. In the winter, the prevailing winds come from the Northwest. However, during the summer the prevailing winds come from the Southwest (Ward, 1916). A few miles north of the evacuation zone is the rapidly growing population of Tom's River. With the prevailing winds, a radioactive plume could be carried right to this population center. On a regional scale, the most densely populated metro area in the nation, greater New York City with over 18 million people lies less than 50 miles north Oyster Creek Nuclear Power Plant.

The relicensing of Oyster Creek nuclear generating facility is a complicated and fascinating issue that involves many geographic themes. Nuclear power to date in the U.S. has demonstrated a remarkably safe track record. Nonetheless, in a post-911 era when terrorist attacks intent on causing high casualty results have become a major national

security concern, a nuclear facility in a high population corridor might be an attractive target. In light of this, the five concerns outlined in this paper regarding emergency evacuation plan gain added relevance. A terrorist-induced incident is likely to make human evacuation behavior even more unpredictable than an accident alone. Drills will likely be less reflective of an actual incident and the ability of reception centers to handle the added chaos associated with a terrorist attack may need to be reevaluated. Furthermore, population trends in Ocean County are likely to continue to bring more permanent population to the region further challenging the functionality of the plan.

CONCLUSION

Nuclear-related emergency management has come a long way since the accident at Three Mile Island in 1979, the most significant nuclear accident on U.S. soil. Oyster Creek's emergency response and evacuation plans seem to be well designed and substantially more comprehensive than Three Mile Islands' emergency plans in place at the time of the accident. However, Oyster Creek has a different geographic setting than many other operating American facilities, and these factors should be prudently emphasized in its evacuation plan. The five concerns of the groups opposing the relicensing can be better addressed by increasing residents' own confidence in the plans. There is always room for more improvement. There needs to be more research done to address shadow evacuations. For example, what kind of traffic control of evacuation methods can further reduce the impact of such phenomena. According to the James Lee Witt Associates Report on the emergency evacuation plans for Indian Point Nuclear Power Plant in New York, they recommend that emergency preparedness and evacuation information be distributed to residents beyond the 10 mile EPZ (James Lee Witt Assoc, 2003).

In addition to providing emergency information to more residents, there should be more public involvement in emergency exercises. Oyster Creek emergency management officials could plan several small scale mock evacuations when school is in session where parents would be instructed to pick up their children from the predesignated reception centers. This way the public can practice what to do in the event of an emergency and emergency management officials can determine if this is an effective way to evacuate students. It is also recommended that there be more than eight reception centers available during an emergency evacuation. Then the number of people passing through each

reception center is reduced which will also reduce the time it takes to scan and process the evacuees.

Lastly, because accurate, up-to-date population estimates are extremely important for emergency response purposes, it is recommended that the population estimates are updated every five years instead of ten. Also, more research needs to be done to develop methods to better estimate transient populations. Ocean County tourism alone cannot account for the transient populations. Daily commuters and other mobile populations within the 10-mile EPZ also need to be accounted for.

Ultimately the problems inherent in the evacuation plan can be improved. With the massive problems associated with climate change and a looming energy crisis, nuclear energy is probably a necessary part of the climate change solution. The decision to re-license Oyster Creek is not an easy one due to its geographic situation. Nevertheless, the American nuclear industry has proven to be relatively safe and reliable. Both the proponents and opponents would benefit from incorporating the geographic perspective into the discussion and finding common ground for the most prudent outcome.

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