A NEW LIFE: ADAPTIVE REUSE AND REDEVELOPMENT OF DECOMMISSIONED COMMERCIAL NUCLEAR POWER PLANTS

By

ELIZABETH CHAPIN FARROW

A THESIS PRESENTED TO THE GRADUATE SCHOOL
OF THE UNIVERSITY OF FLORIDA IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF SCIENCE IN ARCHITECTURAL STUDIES

UNIVERSITY OF FLORIDA

2008

To Josh for his unwavering support

ACKNOWLEDGMENTS

I thank my committee members (Peter Prugh, Sara Katherine Williams, and Alireza Haghighat) for their assistance and guidance. I also extend my gratitude to the professors and staff of the College of Design, Construction, and Planning at the University of Florida.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TERMS

Decommissioning	The process of closing down a facility followed by reducing residual radioactivity to a level that permits the release of the property for unrestricted use.
DECON	A method of decommissioning in which the equipment, structures, and portions of a facility and site containing radioactive contaminants are removed and safely buried in a low-level radioactive waste landfill or decontaminated to a level that permits the property to be released for unrestricted use shortly after cessation of operations.
ENTOMB	A method of decommissioning in which radioactive contaminants are encased in a structurally long-lived material, such as concrete. The entombment structure is appropriately maintained and continued surveillance is carried out until the radioactivity decays to a level permitting decommissioning and ultimate unrestricted release of the property.
Greenfield status	Endpoint in a process where an industrial site is restored to the conditions existing before the construction of the plant.
Historic preservation	Professional field that seeks to preserve the ability of older, or historic, objects to communicate an intended meaning.
Independent spent fuel storage	A complex designed and constructed for the interim storage of spent nuclear fuel, solid reactor-related GTCC waste, and other radioactive materials associated with spent fuel and reactor-related GTCC waste storage.
Nuclear energy	The energy liberated by a nuclear reaction (fission or fusion) or by radioactive decay.
Nuclear power plant	An electrical generating facility using a nuclear reactor as its heat source to provide steam to a turbine generator.
Nuclear reactor	A device in which nuclear fission may be sustained and controlled in a self-supporting nuclear reaction.
Preservation	Refers to the maintenance of a property without significant alteration to its current condition
Radiation (nuclear)	Particles (alpha, beta, neutrons) or photons (gamma) emitted from the nucleus of unstable radioactive atoms as a result of radioactive decay.

Reconstruction	The building of a historic structure using replicated design and/or materials.
Rehabilitation	Or *adaptive reuse*, refers to an approach where the existing historic features are damaged or deteriorated and modifications can be made to update portions of the structures.
Restoration	Refers to the process of returning a building to its conditions at a specific time period, often to its original construction.
SAFSTOR	A method of decommissioning in which the nuclear facility is placed and maintained in such condition that the nuclear facility can be safely stored and subsequently decontaminated to levels that permit release for unrestricted use.
Spent fuel pool	An underwater storage and cooling facility for spent (used) fuel elements that have been removed from a reactor.
Waste (radioactive)	Radioactive materials at the end of a useful life cycle or in a product that is no longer useful and should be properly disposed of.

Abstract of Thesis Presented to the Graduate School
of the University of Florida in Partial Fulfillment of the
Requirements for the Degree of Master of Science

A NEW LIFE: ADAPTIVE REUSE AND REDEVELOPMENT OF DECOMMISSIONED COMMERCIAL NUCLEAR POWER PLANTS

By

Elizabeth Chapin Farrow

December 2008

Chair: Peter Prugh
Cochair: Sara Katherine Williams
Major: Architecture

My study analyzed the challenges and opportunities faced in the historic preservation and adaptive reuse of decommissioned commercial nuclear power plants. While operating, these plants served as vital parts of their local communities, providing jobs and economic support. Their closures leave a vacant site, as well as a significant loss to the community. Historic preservation is an important consideration for these sites. Preservation of both structures and memories can continue the legacy of these plants, while adaptive reuse can allow for redevelopment and new use.

My study reviewed and analyzed existing nuclear power policy, regulations and public opinion. The history and context of commercial nuclear power are defined to establish a shared understanding. The history and formation of the nuclear field are reviewed and the unique characteristics and demands of this technology highlighted. Commercial nuclear power plants play a vital role in the formation of nuclear power and they are a valuable part of the story of nuclear technology. The public perception of nuclear power was explored; both positive and negative, and illustrated that nuclear power exists in a complex arena.

Preservation and adaptive reuse methods are reviewed, defined and explored. This overview shows the range of opportunities that exist for preserving nuclear sites, as well as the shortcomings of traditional preservation approaches. Challenges are addressed and researched to define the obstacles often encountered during preservation activities. Decommissioning activities are analyzed, showing their lack of attention to the importance of structures and memory of the site. New thinking for decommissioning activities is suggested and further explored in the study model at Crystal River Nuclear Power Plant.

A case study review of selected sites is used to show how preservation and adaptive reuse approaches are being applied at three decommissioned commercial nuclear power plants. This review illustrates ways that sites have been successful or failed in these attempts. This review is used to inform the study model at Crystal River Nuclear Power Plant.

Crystal River Nuclear Power Plant is used as a model and key issues are identified. These include memory, site-specific opportunities and constraints, preservation and reuse, interpretation, access, sustainability, diversity, phasing and transparency. Specific applications are proposed for each issue at Crystal River Nuclear Power Plant. This model can assist planners and designers in their planning for sites faced with decommissioning.

Research will provide a better understanding of preservation and adaptive reuse options for commercial nuclear power plants faced with decommissioning, and suggest how these opportunities can be applied at sites struggling with this issue. The commercial nuclear heritage is one that should be preserved and celebrated. My study concludes with suggestions for further research and study.

CHAPTER 1
INTRODUCTION

Overview

Historic preservation and its practitioners typically focus on the preservation of historic structures, valued for their architectural character and importance to society. These buildings, located in many communities throughout the country, are hallmarks of an earlier time and the achievement of man. The inclusions of older structures in our communities are tangible examples and reminders of bygone eras. In addition to preserving the physical structure, preservationists strive to tell the stories associated with these historic sites, and often the story is all that will be preserved. Many aging structures are important in our country's history, but not always that easy to preserve. Commercial nuclear power plants are a prime example of this dilemma. They are large, complex industrial structures, often unable to be safely saved. They are, however, an integral part in the story of nuclear power and the advancement of our society.

The arrival of commercial nuclear power plants was lauded as the end to the future power crisis and the role of nuclear power seemed secure. Plants were commissioned and construction sites dotted the country. This forward progress was halted by the occurrence of significant events that left many doubting the safety of nuclear power. Power plant incidents such as Three Mile Island and Chernobyl significantly effected the public's perception and governmental approval of new reactor licenses. It has been in recent years that nuclear power is being turned to once again for a viable source of sustainable power production.

With a typical lifespan regulated at 40 years, existing commercial power plants are aging rapidly and many have begun the process of closure and eventual decommissioning. This is a process that is carefully regulated and hard to deviate from. Buildings and characteristics of the site are altered and eliminated during decommissioning. Little care is given to the memory or

importance of the site. A site that could become useful is left once the decommissioning process has been completed. At this point though, planning has rarely been undertaken to think about ways that the site could be reused. Planning at this point is reactive, rather than proactive. Decommissioning planning should encompass a plan for site reuse, as well as a care for preservation, prior to plant closure. Thoughtful planning for the future of a decommissioned commercial power plant allows for careful reflection and consensus.

There are many possibilities for these sites, and not just as fenced, inaccessible industrial sites. Sites can become thriving redevelopment areas, with zoning for housing, industry and open space. They can continue the legacy of the site's previous use, through preservation of selected structures, or through interpretation and education. *A New Life* assesses current planning practices and suggests how proactive planning can be beneficial for a specific site, the Crystal River Nuclear Power Plant, whose eventual decommissioning will raise numerous challenges. It is through the thoughtful planning that commercial power plant sites can become useful sites for the community and continue to tell the story of nuclear power. This story is significant and it is important for future generations to be informed and aware of this heritage.

Methodology

First, a review of nuclear issues is presented. This includes a succinct history of nuclear power. This heritage is a long and varied one, and shows the uses of nuclear power through the ages. It illustrates the often-controversial role of nuclear power in society, but also the advances that are celebrated. Types of nuclear power sites are described and their unique characteristics presented. While all types are of interest, commercial power plants are the type focused on for the purpose of this thesis. Understanding what a commercial power plant is creates a shared vocabulary and basis for understanding what challenges are present when preserving and reusing the site.

Next, the public perceptions of nuclear power are analyzed and presented. These perceptions are created from numerous sources, such as television and print media. They are deep-seated and valid. They are often, however, formed from misinformation. Current public perceptions are an important part of planning for a commercial nuclear power plant's eventual closure. It is important to make the process as transparent as possible and include the public whenever possible in the planning and implementation.

Third, preservation issues and challenges for commercial nuclear power sites are presented. Traditional preservation and approaches are assessed for their applicability at commercial sites. Unlike other historic sites, new thinking is often needed and traditional methods customized for commercial plants. Reconstruction or restoration of a site might not be feasible or even desired, and rehabilitation and adaptive reuse might be a better choice. Preserving the memory is achievable at all sites, and ways to tell the story of a site should be studied. Current decommissioning approaches are analyzed for their shortcomings and lack of flexibility. It is important to think about these sites in a broader sense, and look at all possibilities, not just through a fixed lens. Benefits from the reuse of a site illustrate that it is an important undertaking and can be significant for the local community and economy. Preservation precedents are presented and illustrate these benefits and clearly illustrate that the public is able to accept new and unique approaches at post-industrial sites.

Next, three case studies further explore the potential futures of decommissioned commercial nuclear power plants. Each site has followed the regulated decommissioning process and is now at different stages of reuse. The sites chosen represent a broad geographic look at decommissioning, with one site on the East coast, one in the Midwest, and the final site located on the West coast. They represent a variety of decommissioning and reuse strategies and

have achieved varied degrees of success, but can be used to guide and suggest ways to plan at other commercial plants.

These case studies are used to inform a close study of a specific site, Crystal River Nuclear Power Plant in Crystal River, Florida. An aging nuclear and coal plant complex, this plant's future is finite. Although it may be a few decades before the plant enters decommissioning, it will occur in the near future. The power plant is integral to the local economy and way of life and its closure will have a significant effect on the community and surrounding areas. Proactive planning for the site now can make this closure and transition easier for the public and hopefully implement new ways that the site can be used.

Next, proposed preservation and adaptive reuse models are presented for the Crystal River Nuclear Power Plant. This model highlights key issues of memory, site-specific opportunities and constraints, preservation and reuse, interpretation, access, sustainability, diversity, phasing and transparency, and suggests different ways to approach these issues. This model lays the groundwork for future planners and designers to create a thriving preservation and reuse plan for Crystal River Nuclear Power Plant.

Research Outcomes

Finally, observations are presented and areas for further research suggested. Findings will show a variety of conclusions drawn from the forthcoming research. This thesis shows the importance of commercial nuclear power to the nation's heritage and collective memory. It also shows that the closure and decommissioning of these sites will have a profound and significant effect on the economic and daily life of the communities that they are located in. Overall, decommissioning methods are found to be inflexible and do not allow for the preservation or reuse of structures that could be. There is an overall lack of proactive planning for these sites and following decommissioning, no regulatory oversight to continue to guide these sites. The

following research will show the possibilities that exist for decommissioned commercial nuclear power plants. Proactive versus reactive planning, with sensitivity toward preservation, allows decommissioned sites to continue to thrive and illustrate history.

This thesis focuses on a small portion of the vast issue of nuclear power and the role of preservation. Further research should explore the other types of nuclear power, including wartime sites and maritime vessels. Each is an important part of national and international heritage and requires its own planning and attention. Continued research into former industrial site reuse will help to inform nuclear sites. Overall, research should continue to look into the possibilities with preserving the recent past.

CHAPTER 2
NUCLEAR ISSUES

Science and Technology of Nuclear Power

The atom is the basic building block of nuclear science.[1] An atom is composed of a charged nucleus, surrounded by negatively charged electrons. The nucleus is made up of two particles, positively charged protons and neutrally charged neutrons. Atoms can interact with other atoms through their electrons, allowing atoms to form a chemical interaction.[2] This interaction between atoms, and subsequently molecules, can release or absorb energy. Energy is endothermic if it occurs due to absorption and exothermic if it occurs due to release. If a particle or nucleus interacts with another nucleus, the new nuclei may be radioactive. During decay, waste that is given off is known as radiation. The rate of decay or half-life can influence the length of waste storage. Nuclear reactions are "processes in which changes in atomic nuclei occur as a result of a collision between nuclei and/or nuclear particles."[3] Nuclear reactions yield an enormous amount of energy that is harnessed by nuclear power facilities.

In commercial nuclear power plants, these nuclear reactions take place in the reactor, where the reactions are produced and controlled and the energy released is used to heat water to make steam that powers turbines that in turn generates electricity.[4] There are different types of reactors, but the most common is the pressurized-water reactor.

Radiation is normally occurring in our lives. We receive levels of radiation from the sun and other naturally occurring sources. Nuclear reactions release a large amount of radiation and safeguard measures are taken to prevent the release of this harmful radiation. Levels are constantly monitored to ensure that standards of radiation release are met. While nuclear power plants do release pollutants into the environment, it is significantly less than those released from a fossil-fuel power plant.

The nuclear fuel used in the reactor has a lifespan, and typically the reactor is refueled after a few years worth of use. This nuclear fuel still possesses the possibility for further use, but requires reprocessing to harness this power.[5] Reprocessing regulation will be discussed in further depth, but currently the United States is against the reprocessing of nuclear fuel. The spent fuel is currently stored on site or in storage facilities. If reprocessing were to be allowed, nuclear power would be more economical and sustainable and less waste would be generated.

History of the Development of Nuclear Power

The development of nuclear power has been a long process, marked by the advancement of scientists and researchers. The World Nuclear Association presents a concise overview of the history, which is:

> The science of atomic radiation, atomic change and nuclear fission was developed from 1895 to 1945, much of it in the last six of those years. Over 1939-45, most development was focused on the atomic bomb. From 1945 attention was given to harnessing this energy in a controlled fashion for naval propulsion and for making electricity. Since 1956 the prime focus has been on the technological evolution of reliable nuclear power plants.[6]

The wartime period is one of the best-known eras in the history of nuclear power. It was during this period that nuclear science was used for the development of a nuclear bomb. This government secret initiative was known as the Manhattan Project. As James Duderstadt notes in *Nuclear Power* "most of the effort involved in the Manhattan project was to design and build the enormous uranium enrichment and plutonium production facilities required to make a relatively small amount of material needed for the first nuclear weapons."[7]

The Manhattan Project included sites at Argonne, Oak Ridge, Hanford and Los Alamos. These sites were carefully selected, the existing residents quietly moved out and then structures built for production and housing of the huge working force needed to man these facilities. Most workers were not informed of what they were doing and lived under a veil of secrecy of the work that was taking place at these sites. Following numerous tests in the New Mexico desert, the first

atomic bomb was dropped on Hiroshima on August 6, 1945, and the second bomb was dropped on Nagasaki on August 9, 1945.

Following the wartime activities, attention turned to the possible peaceful use of the technology. The Atomic Energy Act of 1946, also known as the McMahon Act, established how the United States would control and manage nuclear technology. It decreed that management would be civilian, rather than military and established the U.S. Atomic Energy Commission. This was a debated topic, and many felt that control should still be under the military, as it had been during the wartime era.[8] The act also stipulated that four operational areas including research, production, engineering, and military application were to be established. Weapons were to put controlled by the Commission, but the President could request their use for military purposes. The act was signed by Harry Truman on August 1, 1946 and went into effect on January 1, 1946.

President Dwight D. Eisenhower delivered a landmark address to the United Nations General Assembly on December 8, 1953 entitled "Atoms for Peace." The fear of "atomic warfare" was the impetus for Eisenhower's speech and something that all American people were thinking about.[9] Eisenhower feared the growing stockpile of atomic weapons might be put to use in America and around the world. This issue had become a global one and needed to be addressed. Eisenhower foresaw the "annihilation of the irreplaceable heritage of mankind handed down to us generation from generation" if there was no halt to the weapons production.[10] He encouraged a move toward peace, where the technology of nuclear warfare could be put to peacetime use. He signed an amendment to the Atomic Energy Act of 1946 in 1954, further defining the regulation of nuclear power and allowing for the possibility of commercial use of nuclear power.

Post-War Uses for Nuclear Technology

After "Atoms for Peace," new uses for nuclear technology were explored. Eisenhower advocated for the construction of a commercial reactor. A call for bids was placed and the Duquesne Light Company was chosen and construction began at the Shippingport Atomic Power Station in Pennsylvania.[11] At the ground breaking ceremony on September 6, 1954, Eisenhower spoke via an electric hookup from Denver, Colorado and said, "…through knowledge we are sure to gain from this new plant we begin today, I am confident that the atom will not be devoted exclusively to the destruction of man, but will be his mighty servant and tireless benefactor."[12] Following his remarks, he waved a neutron wand over a neutron counter and sent a signal 1,200 to Shippingport, activating a highlight that started and dug the first scoop of dirt at the site. The station successfully operated from 1957 to 1982. The station was recognized as a National Historic Mechanical Engineering Landmark in 1980.

Another Eisenhower endeavor was the NS Savannah, the first nuclear-powered cargo-passenger ship and designed to showcase the "Atoms for Peace." It was "designed, constructed and operated as a joint research and development project of the Maritime Administration and the Atomic Energy Commission."[13] It was christened in 1959 and the reactor brought online in 1961. It was taken out of service in 1970 and served as a museum until 1994. It is now a National Historic Landmark and currently undergoing decommissioning efforts with a long-term plan of retention.

Worldwide Nuclear Power

Nuclear power is used worldwide and is overseen by the International Atomic Energy Agency (IAEA), which "works with its Member States and multiple partners worldwide to promote safe, secure and peaceful nuclear technologies."[14] The IAEA releases two annual reports on the growth of nuclear power. The fall 2007 report estimated that nuclear power would

continue to grow at an average rate of about 2.5% per year.[15] This steady growth is worldwide and nuclear power is continuing to be a major source of energy. As of the end of 2006, the IAEA found that there were 435 operating nuclear reactors around the globe and 29 additional reactors under construction. The United States has the most reactors, followed by France, Japan and Russia.[16] In France 78% of the country's electricity comes from nuclear power, the highest in the world, compared to 19% in the United States.

Regulatory and Policy

The United States has strict regulatory guidelines for the oversight of the nuclear power industry. These regulations have grown out of nuclear incidents at power plants in the recent decades. There are two main regulatory bodies for nuclear science, the Department of Energy and the Nuclear Regulatory Commission. These grew out of the Atomic Energy Commission, formed from the Atomic Energy Act of 1946. The AEC was divided into the Nuclear Regulatory Commission, to regulate the nuclear power industry, and the Energy Research and Development Administration to oversee the nuclear weapons, naval reactors, and energy development programs.[17] In 1977, the Department of Energy assumed the responsibility of the Energy Research and Development Administration, as well as other agencies including the Federal Energy Administration and the Federal Power Commission.

Department of Energy

The DOE's mission is to "advance the national, economic, and energy security of the United States; to promote scientific and technological innovation in support of that mission; and to ensure the environmental cleanup of the national nuclear weapons complex."[18] The responsibilities of the DOE are wide-ranging. The department oversees the management and clean up of sites related to the Manhattan Project and in recent years has focused on preservation efforts on these sites. As stated on their website, the DOE values historic preservation and

encourages the interpretation and preservation of its assets.[19] The Office of History and Heritage Resources, within the DOE, helps to interpret the history of the Manhattan Project sites.

The DOE is also responsible for organizing and opening a national repository for nuclear waste, and recent efforts have focused on the Yucca Mountain site. It is DOE's "congressionally mandated directive to develop, build, and operate a deep-underground facility that will safely isolate spent nuclear fuel and high-level radioactive waste from people and the environment for hundreds of thousands of years."[20] Located in the Yucca Mountain range in Nevada, this repository was intended to open and start accepting waste in 1998, but it remains unopened due to delayed approval and public disapproval. The NRC received an application from DOE on June 3, 2008 for a license to start construction at Yucca Mountain. The NRC has 4 years from this date to review and assess the application and then issue their decision.[21] From there, it is still a long way to go before construction begins and the eventual acceptance of nuclear waste. Numerous states have filed lawsuits against DOE because of money that was invested by the energy corporations in the Yucca Mountain repository.

Reprocessing of Spent Fuel

In understanding the need for a national repository for spent fuel, it is important to look at the practice of reprocessing nuclear fuel. Reprocessing refers to "the chemical separation of fissionable uranium and plutonium for irradiated nuclear fuel."[22] It was developed during the Manhattan Project era in an effort to build an atom bomb. Following the war, reprocessing was seen as necessary due to the perceived scarcity of uranium.[23] Commercial power plants began to use the reprocessing technology in Breeder reactors, but technical, regulatory and economic problems were encountered. In response to the growing threat of proliferation believe to be a result of reprocessing; President Jimmy Carter terminated federal support for commercial reprocessing.[24]

President Carter gave a press statement in 1977 saying, "We will defer indefinitely the commercial reprocessing and recycling of plutonium produced in the U.S. nuclear power programs."[25] This decision has had lasting effects on nuclear policy and practice. New thinking on reprocessing hopes to allow for the practice to begin once again. The Bush administration recommended in 2001 that the

> United States should also consider technologies (in collaboration with international partners with highly developed fuel cycles and a record of close cooperation) to develop reprocessing and fuel treatment technologies that are cleaner, more efficient, less waste intensive, and more proliferation-resistant.[26]

France reprocesses it own nuclear waste and has been doing so successfully for decades. Other countries including Belgium, Germany, the Netherlands, Switzerland and Japan also send, or have sent in the past, spent nuclear fuel to France for reprocessing.[27] High-level waste is stored for several decades, while it awaits storage in a geologic site, similar to Yucca Mountain.

Reprocessing gains an additional 25% more energy from the original uranium and reduces the volume of material to be disposed of as high-level waste to about 1/5th.[28] Reprocessing provides sustainability for nuclear power and will be an important consideration at commercial plants in the future. Reprocessing would allow for greater reuse of a decommissioning site because it would decrease the amount of spent fuel stored at a decommissioned site. Currently, spent fuel is stored on site in an Independent Spent Fuel Storage Installation (ISFS). The ISFS is a temporary storage facility for spent fuel that remains on site as long as there is the lack of a national repository.

Nuclear Regulatory Commission

The NRC's 1997-2002 Strategic Plan states the commission's mission is: "NRC's mission is to regulate the Nation's civilian use of by product, source, and special nuclear materials to ensure adequate protection of the public health and safety, to promote the common defense and

security, and to protect the environment."[29] The NRC reviews and grants licenses for nuclear reactors and oversees the construction, operation and decommissioning of commercial nuclear reactors. The commission is also responsible for issues related to nuclear fuel and waste. NRC regularly inspects commercial power plants to make sure that guidelines are being met. The NRC releases information to the public via their website and print materials, but also through public meetings and forums.

Types of Nuclear Sites

There are varied types of nuclear sites and each has its own requirements and characteristics. There are government, military, and civilian nuclear sites. Each type has active and decommissioned sites.

Government

Government sites are those typically overseen by the Department of Energy and are related to the research and production of the atomic bomb during wartime, as well as the research reactors used for government energy programs. The maintenance of the Manhattan Project sites is ongoing. Preservation and interpretation efforts at the Manhattan Project sites will be explored in the fourth chapter.

Military

Military nuclear assets are largely found in maritime vessels, including submarines and aircraft carriers. Following the wartime use of nuclear power, the navy successfully introduced nuclear reactors on submarines and aircraft carriers and has a long history of safety and achievement. The USS Nautilus became the first commissioned nuclear propulsion submarine in the United States Navy, launched on January 21, 1954. Her career was marked by naval achievements and she was finally decommissioned in 1980.

There are three types of naval submarines in operation: Attack Submarines, Ballistic Missile Submarines and Guided Missile Submarines.[30] Submarines are referred to by their United States Navy hull classifications system, such as SSN, "SS" meaning "Ship Submersible" and "N" denoting "Nuclear Powered." Attack Submarines serve a number of functions, such as seeking and destroying enemy subs and ships, as well as carrying tomahawk cruise missiles. There are three classes of Attack Submarines, including *Los Angeles, Seawolf,* and the *Virginia.* The *Virginia* class is in currently in production and has a number of advances over earlier classes. Ballistic Missile Submarines are often referred to as "Boomers" and "serve as an undetectable launch platform for intercontinental missiles. They are designed specifically for stealth and the precision delivery of nuclear warheads."[31] Guided Missile Submarines carry tactical missiles and are able to transport and support special operation forces.

Civilian

Civilian nuclear sites are related to the peaceful production and promotion of nuclear energy. These include university and research reactors and commercial nuclear power plants. A number of universities, including the University of Florida in Gainesville, Florida, have a test reactor for research and training. The DOE helps to maintain these reactors and assists universities in their programs. The NRC licenses and regulates these reactors, and they have to comply with regulations just as power plants are required to.

Commercial Nuclear Power Plants, the focus of this thesis, have been and continue to be built for the production of energy. They are monitored and regulated by the NRC. Commercial power plants are typically granted initial licenses of 40 years, with an option to renew and extend this license an additional 20 years. The Atomic Energy Act of 1954 mandated this time period and Congress selected a 40-year license because "this period was a typical amortization period for an electric power plant. The 40-year term was not based on safety, technical or

environmental factors."[32] Many of the original power plants first built are nearing the end of this 40-year period and evaluating a renewal of their licensures.

The option to renew is one that power companies assess and determine if it is economically viable for them to continue operating a plant. For many plants, this renewal is beneficial.

> At the end of a nuclear plant's 40-year license, initial capital costs for the plant will have been fully recovered and the decommissioning costs will have been fully funded. Any incremental cost incurred over the original license period could be amortized over a longer period of time because of license renewal, further reducing the cost of electricity. For many nuclear power plants, license renewal represents the most inexpensive option for future electricity generation.[33]

The choice to pursue a renewal may not to be chosen if there are costly repairs and other maintenance issues that will be too expensive. Extending a license does not prevent a site from needing decommissioning, and this renewal period would be an ideal time to undertake future planning for the site.

Features of a Commercial Nuclear Site

The commercial nuclear site can be different for each plant, but they all share common features. Understanding the site's features, including structures and landscape, shows the similarity and shared nature of these plants, and suggests that ideas and planning at one site could be useful and possible at other sites. Typically, the features and site of a commercial nuclear power plant are regulated by the NRC and must conform to their standards.

Site

Site selection for nuclear power plants is carefully undertaken and studied. Sites range in size from 500 to 1000 acres, although they may be larger, and are often located near bodies of water. This is necessary for the intake and outtake of water used in cooling. Sites are chosen to optimize their location on the existing grid and infrastructure.[34] This often has to be balanced

with the requirements of siting plants farther from larger population areas. It can be challenging to find a site that meets all of the needs of both consumers and owners.

Environmentally, an ideal site must have a high degree of geological stability. The presence of fault lines or other seismic activity should preclude the construction of a plant. Proper drainage is important, and a low-lying site would not be optimal. Natural disasters are always an issue, but structures are designed with stability in mind. Access to the site, either by land or water, is necessary as large equipment and supplies need to be able to reach the plant easily and often.

The NRC mandates that areas surrounding the plant structures are great enough to prevent exposure to radiation and then subsequent distances from major populated areas. Areas of low population are favored for locating a nuclear power plant. This approach "facilitates emergency planning and preparedness as well as reducing potential doses and property damage in the event of a severe accident."[35] The NRC does not only carefully review proposed sites, but they are also a topic for public debate and a source of debate.

Buildings and Structures

There are buildings and structures that are typical of a commercial nuclear power plant. They include the containment building, which houses the reactor and cooling systems. Designs will vary for this building, depending on the type and design of the reactor, but containment is key and the structure is largely comprised of steel. This may be covered with a layer of concrete.

Additional buildings act as support structures for this containment building. The auxiliary buildings house support equipment, the turbine building houses turbine and related systems, and the intake structure houses the intake systems that bring water into the plant. Additional buildings include a fuel storage, which might be a storage pool or onsite dry storage, depending

on the requirements of the site. There might be cooling towers present to minimize the released temperature of the water on the environment.

Administrative and personnel buildings provide offices and space for employees and workers. In addition, there are parking lots for employees, access roads to reach the plant, walk ways and other areas that provide access around the site for maintenance and security.

Protection Features

There are numerous features in place to protect commercial power plants, either from terrorism or trespass. These include limited access points with checkpoints. To gain access, one must be an authorized worker or visitor and show proper identification. There are secure entrances with checkpoints into structures, where identification is needed and screening is more rigorous. Certain areas and buildings are only accessible to limited staff, and security is increased. On the site, fencing and monitoring by security protects the site. Intake and outtakes are carefully monitored and all entrances to the plant are routinely screened and guarded. While these safeguards are necessary and required, the remote location of the plants acts as a natural protection feature that prevents casual visitors from accessing the site.

Decommissioned Sites

Decommissioned nuclear sites have been taken out of active use and their reactors and other nuclear components removed. Sites are taken out of use when they have served their purpose, are economically draining to maintain, or lived their regulated lifespan. While decommissioning activities may vary from case to case, the removal of nuclear fuel and waste is constant. In the case of the Manhattan Project sites, the function of the sites was to achieve an atomic bomb. Once this happened, these sites were abandoned and eventually portions were decommissioned. This is an ongoing process at many of the Manhattan Sites, due to the large size and complex structures housed there. Submarines and other vessels are decommissioned

when they become outdated or too old, and are dismantled. This is similar to commercial power plants, which will be discussed in greater detail. Plants are decommissioned at the end of their license period. As previously mentioned, the lack of a national repository means that the storage of waste from all types of nuclear decommissioned sites proves to be challenging.

As Martin Pasqualetti writes, "Decommissioning is the new territory of nuclear power, a territory of unexplored complexity which possesses multiple links to the rest of the world." [36] The implications of decommissioning are far-reaching and there are still a lot of unknowns about the influence that it has.

Decommissioning Regulations for Commercial Nuclear Power Plants

Decommissioning of commercial nuclear power plants is regulated by the NRC and follows established guidelines. Decommissioning is "safely removing a facility or site from service and reducing residual radioactivity to a level that permits either of the following actions: Release the property for unrestricted use, and terminate the license or release the property under restricted conditions, and terminate the license."[37] The NRC assists sites in their decommissioning activities and determines when the license is to be safely terminated.

The cost of decommissioning is built into the operating costs during the plant's lifetime. As previously mentioned, 40-years was selected because of the determination that costs would be covered at the end of this time period. Some plants have closed prior to this 40-year period, and their decommissioning costs have not been fully funded, placing the burden on consumers.

The NRC process of decommissioning follows this path: notification; submittal and review of the Post-Shutdown Decommissioning Activities Report (PSDAR); submittal and review of the license termination plan (LTP); implementation of the LTP; and the completion of decommissioning.[38] The power company first notifies the NRC of their intention to cease

operations. The company is then required to submit a PSDAR before or within two years following the cessation of operations.[39] This report includes[40]:

- A description and schedule of the planned decommissioning activities
- An estimate of the expected costs
- A discussion that provides the means for concluding that the environmental impacts associated with the decommissioning activities will be bounded by appropriately issued environmental impact statements (EISs).

The NRC does not approve the PSDAR, but makes it available to the public. The company can begin decommissioning activities 90 days after the NRC has received the PSDAR and cannot change this plan without informing the NRC in writing.

Following the PSDAR, the company is required to submit a LTP. This includes[41]:

- A site characterization
- Identification of remaining dismantlement activities
- Plans for site remediation
- Detailed plans for the final radiation survey
- A description of the end use of the site, if restricted
- An updated site-specific estimate of remaining decommissioning costs
- A supplement to the environmental report describing any new information or significant environmental change associated with the licensee's proposed termination activities

A post-decommissioning plan is not required or even suggested, leaving plants with no guidance following the successful termination of their licenses. In addition to no required planning, there is no regulatory body to enforce planning at a later date, leaving the future uses. As noted in the requirements for the LTP, a description of the end use is only required if it is to be restricted, meaning continued to be monitored by the NRC.

Decommissioning Methods

Decommissioning methods follow one of three methods, as outlined by the NRC. These methods are SAFSTOR, DECON, and ENTOMB. SAFSTOR is "a method of decommissioning in which the nuclear facility is placed and maintained in such condition that the nuclear facility can be safely stored and subsequently decontaminated to levels that permit release for unrestricted use."[42] DECON is defined as

> A method of decommissioning in which equipment, structures, and portions of a facility and site containing radioactive contaminants are removed and safely buried in a low-level radioactive waste landfill or decontaminated to a level that permits the property to be released for unrestricted use shortly after cessation of operations.[43]

ENTOMB is defined as

> A method of decommissioning in which radioactive contaminants are encased in a structurally long-lived material, such as concrete. The entombment structure is appropriately maintained and continued surveillance is carried out until the radioactive decays to a level permitting decommissioning and ultimate unrestricted release of the property.[44]

It is left to each individual site to choose which method is best suited for their individual needs. SAFSTOR, also known as "delayed DECON" may be chosen at a site that would rather monitor and allow the levels of radiation to decrease, rather than quickly dismantling the site. DECON is often favored because it allows for a faster release of the site and termination of the license, decreasing long-term costs and security. ENTOMB is a more permanent approach and creates a solid protective structure. Each method will be assessed for their historic preservation shortcomings in chapter 4.

After completing decommissioning activities, the licensee will submit a final radiation survey and the NRC will terminate the license if "the remaining dismantlement has been performed in accordance with the approved LTP; and the final radiation survey and associated documentation demonstrates that the facility and site are suitable for release in accordance with

the LTR."[45] If there is an ISFS on site, then this will continue to be regulated and monitored by the NRC. A site has 60 years within which to complete decommissioning.[46]

Once the NRC has terminated a site's license, this is the end of nuclear regulatory involvement. There should continue to be oversight on the part of a regulatory body, but one focused on the future use. This regulatory body should continue to help sites transition to a new purpose and provide assistance and guidelines when needed. This lack of post-decommissioning regulation is a significant problem and should be addressed through the creation of a new agency or regulatory body.

Cost of Decommissioning

The NRC estimates the cost of decommissioning a nuclear power plant at $280 to $612 million.[47] The licensee is required to provide evidence of financial assurance for decommissioning costs. [48] This is shown by:

- **Prepayment:** a deposit by the licensee at the start of operation in a separate account such as a trust fund
- **Surety, insurance, or parent company guarantee method:** assurance that the cost of decommissioning will be paid by another party should the licensee default.
- **External sinking fund:** a separate account outside of the licensee's control to accumulate decommissioning funds over time, if the reactor licensee recovers the cost of decommissioning through ratemaking regulation or non-bypassable charges.

Summary

Nuclear power is a significant part of the nation's advancement and heritage. The nuclear power field is diverse, with assets in nearly every state. Commercial nuclear power is a small, but vital portion of this field. With its formation during the wartime years, the peacetime use of nuclear power has benefited the entire country. As plants age and licenses are terminated, commercial plants enter the new world of decommissioning. This highly regulated process is costly and often long. This process is designed to restore a site to a previous appearance, but in

doing so, removes the presence and memory of what the site was used for. Decommissioning will continue to happen in the future, and review of existing policy is needed to allow for greater flexibility at commercial nuclear power plants.

---

[1] The following is a brief overview of the science of nuclear power. There are numerous sources available for further reading and this is only intended as a layman's introduction to the topic. The works cited list suggests other sources for further research.
[2] James J. Duderstadt, *Nuclear Power* (New York, NY: Marcel Dekker, Inc., 1979.), 51.
[3] Ibid., 73.
[4] World Nuclear Association, *Nuclear Power Reactors (*London, England: World Nuclear Association, June 2008; accessed 28 September 2008); available from http://www.world-nuclear.org/info/inf32.html; Internet.
[5] Duderstadt, *Nuclear Power*, 237.
[6] World Nuclear Association, *Outline History of Nuclear Energy* (London, England: World Nuclear Association, September 2005, accessed 28 September 2008); available from http://www.world-nuclear.org/info/inf54.htm; Internet.
[7] Duderstadt, *Nuclear Power*, 286.
[8] Department of Energy, *Civilian Control of Atomic Energy, 1945-1946* (Washington, D.C.: Department of Energy, last modified 2 April 2007, accessed 20 October 2008); available from http://www.cfo.doe.gov/me70/manhattan/civilian_control.htm; Internet.
[9] President Dwight D. Eisenhower, *Atoms For Peace* speech delivered to the United Nations General Assembly (New York City, December 8, 1953, accessed 28 September 2008); available from http://web.archive.org/web/20070524054513/http://www.eisenhower.archives.gov/atoms.htm; Internet.
[10] Ibid.
[11] The American Society of Mechanical Engineers, *Historic Achievement Recognized: Shippingport Atomic Power Station* (Shippingport, PA: The American Society of Mechanical Engineers, 20 May 1980, accessed 20 October 2008); available from http://files.asme.org/ASMEORG/Communities/History/Landmarks/5643.pdf; Internet.
[12] Ibid.
[13] U.S. Maritime Administration, *NS Savannah* (Washington, D.C.: U.S. Maritime Administration, last modified 2008, accessed 20 October 2008); available from https://voa.marad.dot.gov/programs/ns_savannah/index.asp; Internet.
[14] International Atomic Energy Agency, *The "Atoms for Peace"* Agency (Vienna, Austria: International Atomic Energy Agency, last modified 2008, accessed 28 September 2008); available from http://www.iaea.org/About/index.html; Internet.
15 International Atomic Energy Agency. *Nuclear Power Worldwide: Status and Outlook*. (Chevy Chase, MD: Science Daily, 24 October 2007, accessed 28 September 2008); available from http://www.sciencedaily.com/releases/2007/10/071023103052.htm; Internet.
[16] Ibid.

[17] U.S. Department of Energy, *Origins & Evolution of the Department of Energy* (Washington, D.C.: U.S. Department of Energy, last modified 19 June 2008, accessed 28 September 2008); available from http://www.energy.gov/about/origins.htm; Internet.
[18] U.S. Department of Energy, *About Doe* (Washington, D.C.: U.S. Department of Energy, last modified 23 October 2008, accessed 28 September 2008); available from http://www.energy.gov/about/index.htm; Internet.
[19] Ibid.
[20] U.S. Department of Energy, *The National Repository at Yucca Mountain* (Washington, D.C.: U.S. Department of Energy, last modified 06 October 2008, accessed 24 October 2008); available from http://www.ocrwm.doe.gov/; Internet.
[21] U.S. NRC, *Licensing Process for the Yucca Mountain Geologic Repository* (Washington, D.C.: U.S. NRC, 24 June 2008, accessed 28 September 2008); available from http://www.nrc.gov/waste/hlw-disposal/licensing/licensing-process.html; Internet.
[22] Anthony Andrews, Congressional Research Services Report for Congress. *Nuclear Fuel Reprocessing: U.S. Policy Development* (Washington, D.C.: Congressional Research Services, updated March 27, 2008, accessed 24 October 2008); available from www.fas.org/sgp/crs/nuke/RS22542.pdf; Internet.
[23] Ibid.
[24] Ibid.
[25] Jimmy Carter Library, Records of the Speech Writer's Office, *Statement on Nuclear Power Policy*, April 7, 1977.
[26] President George W Bush, *Report of the National Energy Policy Development Group*, Report # A171293, May 2001.
[27] U.S. Department of Energy, *France's Radioactive Waste Management Plan* (Washington, D.C.: U.S. Department of Energy, June 2001, accessed 23 October 2008); available from http://www.ocrwm.doe.gov/factsheets/doeymp0411.shtml; Internet.
[28] World Nuclear Association, *Processing of Used Nuclear Fuel for Recycle* (London, England: World Nuclear Association, October 2008, accessed 20 October 2008); available from http://www.world-nuclear.org/info/inf69.html; Internet.
[29] Jones, Cynthia G, U.S. NRC, *NUREG/BR-0256: The U.S. Nuclear Regulatory Commission and How It Works* (Washington, D.C.: U.S. NRC, August 2000, accessed 12 November 2008); available from http://www.nrc.gov/reading-rm/doc-collections/nuregs/brochures/br0256/; Internet, 1.
[30] United States Navy, *The Submarine*, (Washington, D.C.: United States Navy, last update 30 July 2008, accessed 20 October 2008); available from http://www.navy.mil/navydata/ships/subs/subs.asp; Internet.
[31] Ibid.
[32] Nuclear Energy Institute, *Nuclear Power Plant License Renewal* (Washington, D.C.: Nuclear Energy Institute, February 2008, accessed 20 October 2008); available from: http://www.nei.org/keyissues/reliableandaffordableenergy/factsheets/plantlicenserenewalpage2; Internet.
[33] Ibid.
[34] Duderstadt, 205.
[35] U.S. NRC, *Regulatory Guide 4.7: General Site Suitability Criteria for Nuclear Power Stations*, (Washington, D.C.: U.S. NRC, April 1998, updated 15 February 2007, accessed 28

September 2008); available from http://www.nrc.gov/reading-rm/doc-collections/reg-guides/environmental-siting/active/04-007/#_1_1; Internet.
[36] Pasqualetti, Martin J. ed, *Nuclear Decommissioning and Society: Public Links to a New Technology* (New York, NY: Routledge, 1990), 3.
[37] U.S. NRC, *Decommissioning of Nuclear Facilities: What We Regulate* (Washington, D.C.: U.S. NRC, 26 September 2008, accessed 22 October 2008); available from http://www.nrc.gov/about-nrc/regulatory/decommissioning.html; Internet.
[38] U.S. NRC, *Decommissioning Process* (Washington, D.C.: U.S. NRC, 17 April 2007, accessed 22 October 2008); available from http://www.nrc.gov/about-nrc/regulatory/decommissioning/process.html; Internet.
[39] Ibid.
[40] Ibid.
[41] Ibid.
[42] U.S. NRC: *Glossary: Safstor* (Washington, D.C.: U.S. NRC, 05 June 2007, accessed 24 October 2008); available from http://www.nrc.gov/reading-rm/basic-ref/glossary/safstor.html; Internet.
[43] U.S. NRC: *Glossary: Decon* (Washington, D.C.: U.S. NRC, 05 June 2007, accessed 24 October 2008); available from http://www.nrc.gov/reading-rm/basic-ref/glossary/decon.html; Internet.
[44] U.S. NRC: *Glossary: Entomb* (Washington, D.C.: U.S. NRC, 05 June 2007, accessed 24 October 2008); available from http://www.nrc.gov/reading-rm/basic-ref/glossary/entomb.html; Internet.
[45] Ibid.
[46] U.S. NRC, *Decommissioning Process*, (Washington, D.C.: U.S. NRC, 17 April 2007, accessed 22 October 2008); available from http://www.nrc.gov/about-nrc/regulatory/decommissioning/process.html; Internet.
[47] U.S. NRC, *Financial Assurance for Decommissioning* (Washington, D.C.: U.S. NRC, 17 April 2007, accessed 22 October 2008); available from http://www.nrc.gov/about-nrc/regulatory/decommissioning/finan-assur.html; Internet.
[48] Ibid.

CHAPTER 3
PUBLIC PERCEPTIONS REGARDING NUCLEAR POWER

The public's opinions and reactions to nuclear power are constantly changing and evolving. The perception of nuclear power began in a period of wartime secrecy, when it was unclear what the technology was being used for. The dropping of the atomic bomb forever changed this nation's history and psyche. Following the war, nuclear power was put to use for the peaceful generation of power. The public's reactions during this time period were largely positive, seeing the potential that this energy source had for the country. Renewed attention in the 1960's and fear of nuclear accidents brought the issues of nuclear power to the forefront of the public's thinking. Following the Three Mile Island incident and the accident at Chernobyl, the public's faith in nuclear power was questioned and negative reactions were common. A halt in the construction of commercial power plants followed and it is only in recent years that the public is receptive to the idea of new reactors and renewed spending on nuclear power.

Hazard and Risk Perception

To understand the context that public reaction to nuclear power is viewed in, it is important to look at hazard and risk perception in general and define these psychological issues. Paul Slovic highlights one irony of risk perception as "the paradox for those who study risk perception is that, as people in many industrialized nations have become healthier and safer on average, they have become more- rather than less- concerned about risk, and they feel increasingly vulnerable to the risks of modern life."[1] We have become a society that fears everything from illness and disease, to technology and pollution and climate change. It is not always clear why we fear some things, but not others. Aaron Wildavsky asks,

> Is it our environment or ourselves that have changed? Would people like us have had this sort of concern in the past?...Today, there are risks from numerous small dams far exceeding those from nuclear reactors. Why is the one feared and not the others? Is it just

> that we are used to the old or are some of us looking differently at essentially the same sorts of experience?[2]

Different theories to understand risk exist and include *the knowledge theory, personality theory, economic theory, political theory, and cultural theory.*[3] The knowledge theory suggests "people perceive technologies (and other things) to be dangerous because they *know* them to be dangerous."[4] This suggests that what people know, or do not know, is connected with what they perceive as risk. The personality theory purports that a person's perception is based on their own personality, that some are more inclined to take risks and not fear them, while others are afraid of any perceived risk and avoid them at all costs. The economic theory suggests that the perception of risk is tied to an individual's economic status, although this is rather difficult to assess. The political theory proposes that an individual's fears of risk are tied to politics and influenced by political parties and information from government sources. The cultural theory proposes, "Individuals chose what to fear (and how much to fear it), in order to support their way of life."[5] This choice of what to fear is tied to cultural biases and personal beliefs.

Other scientists and researchers suggest that advances in science and technology have contributed to the perception of risk. We have developed ways to detect minute chemical levels and toxic particles. These advances bring new awareness to perceived risks.

Perceived Fear of Nuclear Power

Nuclear power and accidents is something routinely mentioned as a commonly perceived fear amongst people. From research and review, it is clear that this perception is created from a number of sources, and there is no one cause for it. This fear is rational, as well as irrational. One source is knowledge, either lack of or abundance of. Historically, there has been an overall lack of knowledge at the public's level on nuclear power and often the information that has been released is sensationalized and not always factual. There has also been a lack of "transparency"

of information given to the public.[6] This secrecy was necessary during wartime efforts, and continues to influence the peacetime uses of nuclear energy. In recent years, when factual information is released, either from the NRC or the energy companies, it is often doubted and not trusted by the public. Recent attempts on the part of the NRC to involve the public throughout their processes has often increased the debate, and not provided any comfort.

Another cause for fear is the perceived health and environmental risks from nuclear power. With advances in technology, we are now able to detect minute amounts of toxins and chemicals being released.[7] However small, and perhaps safe, these numbers spark fear in neighbors of power plants and proposed plants. It is often hard to put information such as this in perspective, and it is combined with the overall lack of knowledge of the subject.

The perception of risk of nuclear power is also informed by events in our recent past, where accidents or mishaps led to disaster and loss of life. These include Chernobyl, Bhopal and the Challenger accident, among others. These, "get extensive media coverage that highlights the failure of supposedly "fail-safe" systems."[8] If these systems fail, the public lacks faith in them at other sites and plants. This lack of control goes against what the public has been told. They are encouraged in the media to control their personal risk by, "wearing seatbelts, changing our diets, getting more exercise, and so on."[9]

Although it has been shown that nuclear power is a safe and economical energy source, the negative reactions and fears often do not allow the public to see this positive side. The negative perceptions of nuclear power far outweigh the perceived value of it.

Historical Context

Public Response to Commercial Nuclear Power Plants

There was a sense of faith in commercial nuclear power plants when they were first proposed and constructed. There was often a sense of pride as well in the communities where

these plants were being built. This "initial acceptance of nuclear power can be seen as the response of people eager to anticipate and to welcome the benefits of a new technology."[10] Martin Pasqualetti writes, "During the "honeymoon" period of nuclear power, the emphasis was on how to get the plants operating as quickly as possible so that they could provide the electricity needed by an expanding economy."[11] There was little public controversy or debate with the construction of early commercial plants such as Yankee Rowe (1960), Indian Point (1962) and Humboldt Bay (1963).[12] Other sites were not as fortunate, and came under the scrutiny of public attention. The proposed construction of the Bodega Head Plant in San Francisco was strongly opposed by the public because of the existence of a nature reserve and an earthquake fault in the proposed site. The owners, Pacific Gas and Electricity Company became involved in a similar situation a few years later with a proposed site in Malibu.[13]

Lingering fears over the use of nuclear materials for atomic bomb creation also contributed to increased unease over commercial nuclear power. Lack of knowledge of the technology prevented the public from understanding the specific processes used in commercial plants, as opposed to those that had been used during the Manhattan Project to construct the atomic bombs.

During the late 1960's and early 1970's, interest in environmental issues and nuclear related questions were brought to the forefront of public attention. Earth Day in 1970 featured the issue of radioactive emissions, and Ralph Nadar and the Sierra Club focused on nuclear issues in 1973. [14]

The incident at Three Mile Island (TMI) in 1979 made nuclear safety a worldwide issue and shook the public's faith in the technology.

Three Mile Island Incident

On March 28, 1979, a chain of events happened at Three Mile Island Unit 2 nuclear power plant near Middletown, Pennsylvania, that caused the most serious accident in commercial

nuclear power history in the United States. Although no deaths or injuries occurred as a result of the incident, that did little to pacify the public's reaction following the events.

The problem on the morning of March 28th began in the non-nuclear portion of the plant, but it caused a chain reaction and increased pressure in the nuclear section. A valve to release pressure opened, but never closed, even when pressure had stabilized. Cooling water flowed out of this open valve and caused the core of the reactor to overheat. There were misreadings on the part of the operators, who failed to see that the core was overheating due to lack of coolant. A severe core meltdown occurred which caused the meltdown of nearly ½ of the core.[15] Although this was the worst core meltdown in the United States, it did not breach the walls of the containment building and high levels of radiation were not released. Although the situation appeared stable that evening, new worry arose on March 30, when it appeared that radiation had been released and area residents such as pregnant women and small children were advised to evacuate within a five-mile radius. Later tests would show that a very small level of radiation was released, but this did little to quell the public outrage.[16]

There was a positive outcome from TMI, although the public is probably not that aware of it. The NRC notes that it:

> …brought about sweeping changes involving emergency response planning, reactor operator training, human factor engineering, radiation protection, and many other areas of nuclear power plant operations. It also caused the U.S. Nuclear Regulatory Commission to tighten and heighten its regulatory oversight. Resultant changes in the nuclear power industry and the NRC had the effect of enhancing safety.[17]

The NRC now stringently monitors all activities and is more aware of worker responsibility. It is unfortunate that it took TMI and the resulting public outcry to create a stronger regulatory framework.

Role of the Media in Public Perceptions on Nuclear Power

Along with historical events, the role of media also influenced how people have perceived and reacted to nuclear power.

The media has played a vital role in the formation of public perceptions on nuclear power. The environmental efforts of the 1970s were featured prominently in print media, providing "widespread visibility" and attention to the issue of nuclear power and its effects on the environment.[18] As nuclear power issues became the focus of public debate and interest, so too did the issue increase in media coverage. An analysis by Rankin and Nealey (1978) of the coverage of nuclear power by newspapers and magazines found "a fivefold increase between 1972 and 1976."[19] A similar study for a "nine-fold increase between 1972 and 1977" of network television news coverage of nuclear power.[20] Following the TMI incident, there was a significant increase in media coverage and "the network-television coverage during the first two weeks after the accident exceeded the total coverage of nuclear power by network television in all the years since the atom was split."[21] Images found in the media, such as cooling towers and atomic tests, have become ingrained in our consciousness and associated with fear of nuclear power and accidents.

Movies have influenced and added to the public's unease about nuclear power. *The China Syndrome* tells the story of a news crew that witnesses safety cover-ups at the fictional Ventana nuclear power plant. This movie, ironically, was released on March 16, 1979, twelve days before the events of Three Mile Island were to occur. Following the TMI incident, the movie became even more popular and grossed $51,718,367 in the United States.[22]

Other movies such as *On the Beach*, 1959, illustrate the end of the world fear that is often associated with nuclear power. This movie features Gregory Peck and takes place following World War III. Nuclear bombing has decimated the entire northern hemisphere, and the floating

pollutants have made their way around the world. The only safe area is the far south of the globe. When a Morse code signal from the United States is received, USS Sawfish, captained by Peck's character, heads to investigate. Upon arriving at the source of the signal, it is discovered the it is in fact a coca-cola bottle tapping on a telegraph, rather than any living person.

Television shows such as the Simpsons, have included nuclear power in their stories. In the Simpson's town of Springfield, the Springfield Nuclear Power Plant is portrayed as an aging, unsafe facility operated by technicians who would rather sleep than do their job. Nuclear waste is often shown emitting from the plant, creating a three-eyed fish known as "Blinky." It is a satirical portrayal, but one that hits at the core of what the public knows and fears of nuclear power plants.

Current Perceptions of Nuclear Power

Public perceptions of nuclear power continue to be divided, but many now fear the long-term hazard of waste and waste storage. With the future of Yucca Mountain uncertain, and more plants storing waste onsite, this issue is at the forefront of many people's assessment of future nuclear power plants. It is hard for them to support new plants, when there is nearly 40 years worth of waste that seems to have no end resolution. Also, the legacy of this waste that will be left for future generations is worrisome. Remaining fears of plant safety as does the continued fear of nuclear proliferation are still considered as troublesome by many of the public.

Despite this, there are some indications that nuclear power is gaining in favor. With increased energy costs, nuclear power is looking like a viable source of economical energy for a country burdened with heavy oil prices. It is important to recognize that "of all the energy technologies, nuclear energy is probably the most misunderstood. Nuclear energy can be produced safely, and we understand the technology well enough to minimize the risk of even the worst-case accident."[23]

Summary

Commercial nuclear power plants exist in a complex arena, where public perception is often misinformed and hard to change. Understanding how these perceptions are formed highlights the need for continued communication and education on the part of regulators and power companies. Perceptions are formed through lack of information and transparency, as well as the fear of nuclear accidents and proliferation. These perceptions are long-held and can stand in the way of supporting the preservation and reuse of a decommissioned site. Through education and transparency, the safety and operations of a plant can be illustrated. As with all perceived risks and hazards, it is important to tell the truth and include the public in discussions and processes.

---

[1] Paul Slovic, "Perceptions of Risk: Paradox and Challenge," in *Future Risks and Risk Management*, ed. Berndt Brehmer and Nils-Eric Sahlin (Boston, MA: Kluwer Academic Publishers., 1994), 63.
[2] Ibid., 65
[3] Aaron Wildavsky and Karl Drake, *Theories of Risk Perception: Who Fears What and Why? (*Ann Arbor: University of Michigan Press, 1993), 42.
[4] Ibid., 42.
[5] Ibid., 43.
[6] OECD, "Nuclear Energy: Communicating with the Public." (Paris, France: OECD, 1991), 8.
[7] Slovic, 65.
[8] Ibid.
[9] Ibid.
[10] Nuclear Energy Agency, *Nuclear Power and Public Opinion* (Paris, France: Nuclear Energy Agency, 1984), 105.
[11] Martin J Pasqualetti, ed., *Nuclear Decommissioning and Society: Public Links to a New Technology* (New York, NY: Routledge, 1990), 5.
[12] Nuclear Energy Agency, *Nuclear Power and Public Opinion* (Paris, France: Nuclear Energy Agency, 1984), 90.
[13] NEA, 91.
[14]. Stanley M Nealey, Barbara D. Melber and William L. Rankin. *Public Opinion and Nuclear Energy*. (Lanham, MD: Lexington Books, 1983), 5.

[15] U.S. NRC, *Fact Sheet on the Three Mile Island Accident* (Washington, D.C.: U.S. NRC, 20 February 2007, accessed 1 October 2008); available from http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/3mile-isle.html; Internet.
[16] Ibid.
[17] Ibid.
[18] Nealey, p. 4.
[19] Ibid.
[20] Ibid.
[21] Ibid. p.5.
[22] The Internet Movie Database, *The China Syndrome* (Seattle, Washington: The Internet Movie Database, 1990-2008, accessed October 30 2008); available from http://www.imdb.com/title/tt0078966/business; Internet.
[23] Galen Suppes and Truman Storvick, *Sustainable Nuclear Power* (Boston, MA: Elsevier/Academic Press, 2006), 6.

CHAPTER 4
PRESERVATION ISSUES AND CONCERNS

The National Historic Preservation Act of 1966 was established for the preservation of historic properties throughout the United States and serves as the benchmark in understanding the goals of historic preservation. In this act, Congress declared that[1]:

- The spirit and direction of the Nation are founded on and reflected in its historic heritage
- Historical and cultural foundations of the nation should be preserved as a living part of our community life and development in order to give a sense of orientation to the American people
- Historic properties significant to the Nation's heritage are being lost or substantially altered, often inadvertently, with increasing frequency
- Preservation of this irreplaceable heritage is in the public interest so that its vital legacy of cultural, educational, aesthetic, inspirational, economic and energy benefits will be maintained and enriched for future generations of Americans

This significance applies to commercial nuclear power plants, and it is important to assess these properties in light of this. It is ironic that these properties are being lost or altered purposely, rather than "inadvertently." It is with direct purpose that power plant structures are demolished or altered, due to the existing regulations and lack of appreciation for these sites. These sites should be appreciated as part of this "irreplaceable heritage" and planning should incorporate preservation approaches and thinking.

Significance of First Generation Nuclear Power Plants

The heritage of the current generation of power plants is significant. These plants, built during the last few decades, represent a specific type and architecture of construction. These power plants, now nearing the end of their initial licenses, were designed with safety and permanence in mind. There construction took years to build and they are impressive features on the landscape. The next generation of plants will be different in design and appearance. They will be standardized and modular, taking less time to construct, but also creating a standardized

appearance.[2] This advancement signals a new shift in plant construction and design, but also illustrates the significance that the current generation holds. This generation of plants is the last of its kind and should be valued and preserved. Decommissioning could effectively remove all traces of this generation of plants, severing the ties to history.

Decommissioning Methods and Relation to Historic Preservation

As previously described in Chapter 2, there are three main methods of decommissioning: SAFSTOR, DECON, and ENTOMB. The main problem with all three approaches is that they do not value the structures or even consider them as necessary for retention. The ENTOMB method even encases structures in a permanent concrete shell, preventing future use and forever altering the physical appearance of the structure. The other two methods call for the demolition of the structures, with DECON operating on a faster timeline. None of these NRC regulated approaches make any options available for a building that could be saved. Even if there is public interest in saving a structure or part of one, there is limited flexibility within these methods to allow for this. As will be shown at Hanford, it took years and protests to achieve a better use for the site. There should be options in place that make the reuse of a site easier, rather than having to fight against an established method. New thinking needs to be applied to decommissioning methods to allow for preservation opportunities where possible. Decommissioning and Preservation Methods should be combined to allow for flexibility at sites facing decommissioning.

Traditional Preservation Approaches

Traditional preservation approaches follow accepted practices and generally focuses on the future of historic structures. The National Park Service (NPS) outlines four treatments for historic buildings. They are Preservation, Restoration, Reconstruction and Rehabilitation. Each

treatment focuses on different plans for the future of a site, with Preservation retaining the most historical character and Rehabilitation adding new designs and uses for a site.

It is important to look at each approach and assess it for its applicability to the future of commercial nuclear power plants. While some approaches may be favored over others, they can be useful in incorporating preservation methods in the decommissioning of commercial nuclear power plants.

Preservation

The NPS defines preservation as "the act or process of applying measures necessary to sustain the existing form, integrity, and materials of an historic property."[3] Measures to maintain and stabilize the site are chosen over new construction. Historic materials are saved or repaired, but this is done with great care and conservatively.

The standards for preservation outline a use for the site where the historical quality and features are of the utmost importance. These include "each property will be recognized as a physical record of its time, place, and use, " and "a property will be used as it was historically, or be given a new use that maximizes the retention of distinctive materials, features, spaces, and spatial relationships."[4]

This approach freezes the building in time, although limited upgrades to mechanical systems are allowed under the guidelines for preservation. Historic house museums often favor this approach because it allows them to accurately portray a specific time in history and retain historic fabric that is significant to the structure. Other sites would choose this approach if there are significant historic materials in place and it is relatively easy to maintain or stabilize these.

In a commercial nuclear power plant, preservation could be a useful approach, but challenging one to achieve on a large-scale. It would necessitate the retention of materials and structures that are typically removed as part of the decommissioning process. The materials,

often with contamination, would be challenging and expensive to maintain, stabilize or selectively repair with similar materials. Preserving a smaller portion, perhaps an outbuilding or a feature of the site may be feasible and this should be considered. The preservation of a plant's cooling tower, a main physical feature, could be an interesting legacy for a site that is looking at reuse. By saving this link to the past, the history of the site is

Reconstruction

The NPS defines reconstruction as "the act or process of depicting, by means of new construction, the form, features, and detailing of a non-surviving site, landscape, building, structure, or object for the purpose of replicating its appearance at a specific period of time in its historic location."[5] Reconstruction uses documentary evidence to closely restore a site to its original, significant time period. This approach requires substantial research and reports before any work can be undertaken. While a reconstruction closely replicates what was originally there, it is important to differentiate it from any original, historic structures.

This approach is favored when there is significant evidence for what was there, and this can be used to accurately recreate this absence. Traditionally, reconstruction is used at a site where change has occurred that has substantially changed the structures and site, so as to prevent the historic reading. The features that are reconstructed are believed to be of importance to the historic appearance and interpretation.

At a commercial nuclear power plant, this approach may be chosen if a significant feature has been removed during decommissioning, and then later deemed important. An upcoming case study will look at the Trojan Nuclear Power Plant in Oregon, where cooling towers were removed, despite public support for their retention. While it would be costly and impractical, these cooling towers could be reconstructed at a later date if it was felt to be significant.

Proactive planning now would prevent the later need for reconstruction of significant features. Rather than reconstruction, retention of important features would be a better approach.

Restoration

The NPS defines restoration as "the act or process of accurately depicting the form, features, and character of a property as it appeared at a particular period of time by means of the removal of features from other periods in its history and reconstruction of missing features from the restoration period."[6]

A period of restoration is chosen, and the structure and site is restored to its appearance during this time period. Prior to any work, the site is documented for its pre-restoration appearance, and any historical fabric is identified and preserved. Features that are not part of the restoration period are removed to provide a cohesive physical appearance and interpretative story. As in reconstruction, documentary evidence is used to support choices and "a false sense of history will not be created by adding conjectural features, features from other properties, or by combining features that never existed together historically."[7]

Restoration is useful when there is significant evidence for what existed during a chosen period of significance. A site where change has altered the appearance of a site significantly from this period of significance could chose restoration, but have to be willing to remove features that may later prove to be of interest.

Commercial nuclear power plants are always changing and evolving as technology changes. Upgrades are made to systems and structures often, and it would be difficult to determine when a period of significance would be. The plants purpose is to produce power and this will remain throughout its lifetime. It would be challenging to assess a time during this period of operation that was more significant than another. At a site such as Three Mile Island, there could be a number of periods of importance. One could be when the plant was first

constructed, prior to the incident. Another could be the day of the incident, and a third one may look at the plant after the incident. The period of significance would be chosen based on a specific interpretation plan. Using restoration at a commercial plant would necessitate picking a specific period of interpretation. This method should be used at a commercial nuclear plant if there is a specific event or time period that is of significance to the nation's heritage and can be accurately portrayed. Otherwise, the preservation of key features at the site as they are at the time of decommissioning would be a suitable and more cost-effective approach.

Rehabilitation

The NPS defines rehabilitation as "the act or process of making possible a compatible use for a property through repair, alterations, and additions while preserving those portions or features which convey its historical, cultural, or architectural values."[8] Historical features and fabric are retained, but new construction and new uses are allowed. This new construction has to harmonize with the existing structures and try to retain spatial relationships existing on the site. For example, building a massive building adjoining a small, historic farmhouse would not be allowed. The new construction could be removed at a later date, if needed, and it should be able to do so without detrimental effects to the historic structures.

Rehabilitation allows for more freedom than the other three approaches. This approach, with preservation, has the greatest applicability at a commercial nuclear power plant. The retention of an historic feature or structure at a site may be possible, and then the new construction of a visitor center or museum could add to this. The new construction could blend in materials and size, and allow for continued use of a site that would otherwise be unused.

The four traditional preservation methods provide a framework to begin thinking about incorporating preservation practices at commercial nuclear sites facing decommissioning. By

applying this thinking at sites facing decommissioning, sites can explore ways of preserving and retaining key features of a site, while allowing for new use.

This will require significant change in the way that decommissioning is regulated and mandated. It would require the NRC and other regulatory bodies to look at each site in a unique way, working with the public and owners to move past the three typical decommissioning approaches and incorporate new thinking that strives to preserve elements of the site for future generations. With the current end goal of decommissioning often being a return to "Greenfield Status," it will take a significant change in thinking and awareness at former nuclear sites. Using preservation and rehabilitation should be considered as alternatives to a return to Greenfield Status.

Preservation Designations for Nuclear Sites

The historic preservation field recognizes and designates sites, structures and objects for their achievements and influence on history. These designations are often symbolic in nature, rather than protective, and can be applied to nuclear sites. Designation as a National Historic Landmark is regulated by the National Park Service and the Secretary of the Interior recognizes them because "they possess exceptional value or quality in illustrating or interpreting the heritage of the United States."[9] All NHLs are listed on the National Register of Historic Places, which is "the official list of the Nation's historic places worthy of preservation."[10] The National Park Service administers and manages this list. Fewer than 2,500 historic places are designated as NHLs, as these sites are chosen for their national significance.

Designating a privately owned NHL may not prevent it from future changes. As noted on the National Park Service's website, "listing of private property as a National Historic Landmark or on the National Register does not prohibit under Federal law or regulations any actions which may otherwise be taken by the property owner with respect to the property."[11] The National

Park Service can recommend treatments, but cannot enforce them. State and Local laws may provide additional protection for a site that has been designated nationally.

In addition to national designations, there may be other groups or agencies that provide symbolic designation for sites. The American Nuclear Society recognizes "The Nuclear Historic Landmark Award," which "identifies and memorializes sites or facilities where outstanding physical accomplishments took place that were instrumental in the advancement and implementation of nuclear technology and in the peaceful uses of nuclear energy."[12] This designation is symbolic, rather than protective.

Factors to Consider for Reuse of Decommissioned Nuclear Power Plants

A report on the "Beneficial Re-use of Decommissioned Former Nuclear Facilities" was presented in 1997 and lists different factors to evaluate the feasibility of reusing a nuclear facility. [13] They are:

- Likely degree of structural degradation in the doing the D & D (decontamination and decommissioning)
- Cost savings to be realized and are they economically justifiable
- Age of structure and its current condition
- Plans for long-term site use
- Compliance with relevant codes for today's reuse versus yesterdays construction and operational standards
- Costs of performing any modifications to make the facility usable after D&D is completed
- Acceptable residual activation or contamination levels for the re-use mission

These factors are important to consider when reuse is being considered. As Boing notes, "the re-use of facilities after decommissioning is not only feasible, but has been done in numerous instances."[14]

At the time of closure and decommissioning, many commercial nuclear plants will be more than 40-50 years in age. The current condition will range from plant to plant but "a relatively new structure which has been used frequently up to shutdown and has not been left vacant for a prolonged period is a more likely candidate for reuse after decommissioning."[15] While the age at which a plant is closed will vary, the issue of vacancy can be addressed through planning. A plant that has a post-decommissioning plan in place will transition easier and more quickly into a new reuse project. This transition may allow for the reuse of an existing structure, or the preservation of a structure as a monument. Either way, reuse is possible and should be considered.

Challenges to Preserving Commercial Nuclear Sites

Despite the planning approaches that are available for commercial nuclear sites, there are a number of challenges that often prevent the reuse of a site. These challenges include current regulations, cost, public resistance, waste storage and inadequate planning.

Public concern and resistance can be significant and prevent the reuse of a site. This resistance can be caused by the sources covered in chapter 3. Local agencies and activists may be hesitant to reuse a perceived "dangerous" site, while others may see a new opportunity for their communities. It is important that public education and planning help offset this resistance. If planning is introduced gradually, and with the involvement of the public, it will allow for a plan to be in place prior to the closure of a plant.

There may be public acceptance and support for the reuse of a site, but regulations may prevent it from occurring. These regulations could be on the government level, or state and local. At the local level, zoning restrictions might prevent a site from being used for something other than a power plant or heavy industry.

The presence of waste stored on site can be a hindrance for the reuse of a site. As previously mentioned, NRC regulations will continue at sites were ISFS are still in place. This waste storage has to be maintained and guarded and inaccessible to outsiders. While it may not take up a large area of the site, its presence may impede new construction or other reuse projects. If, and when, Yucca Mountain storage opens, this may make onsite storage of waste a non-issue, but for the foreseeable future, each plant will have some degree of onsite storage to manage.

The cost of reusing a site is often great and the source for the money is not always agreed upon. Following decommissioning, many energy companies are hesitant to put any additional money into a site where there is no viable commercial plant operating. While they are still the legal owners of a site, they have already paid or are continuing to pay for decommissioning costs. It may not be their desire to continue supporting new ventures at a site when their focus is on the generation and sale of power. This leaves state and local sources to pick up the funding for new ventures. As seen in the upcoming case studies, it is often difficult for the management and funding to be agreed upon.

Planning needs to take place during the lifespan of the plant, rather than after decommissioning has taken place. Proactive planning prior to decommissioning can put a plan for the site in place that will make the transition to a useful site following decommissioning. Planning during this period can also put funding in place to help offset future costs. Building in the cost of decommissioning and subsequent reuse could be a part of a standard decommissioning method. With funds being raised during the plant's lifetime, any additional costs could be raised or matched to support a reuse or preservation project.

Many of these challenges to reuse could be addressed through proactive planning and study. Through careful planning and the involvement of the public, sites can make an easier transition to a new use than they would if a plan were not in place.

Benefits to Reusing Commercial Nuclear Power Plants

Despite the aforementioned challenges, there are many benefits from reusing a decommissioned commercial nuclear power plant. These include cost savings, local tourism or revenue source, improved public knowledge and awareness and a preservation of cultural history.

As previously noted, the cost of decommissioning is enormous. Structures that were designed to last and be impenetrable take time to be dismantled and at a great cost. The reuse of some of these structures saves this cost. This would allow power companies to earmark funds for new use or rehabilitation, as well as save ratepayers money during the lifetime of the plant.

Reusing these sites can create new areas for industry and living, and continue to provide the local community with economic support. The closure of these plants will greatly affect the local economy, but a redeveloped area can provide jobs and economic support that would otherwise not be there. Providing a range of employment opportunities can allow previous plant works the ability to stay in the community and transition to a new industry. New tourist attractions, such as a preserved cooling tower or control room tour, can bring in visitors to the community and support local businesses. Heritage tourism is a growing area that nuclear sites could join in.

The reuse and preservation of these sites help to provide information and knowledge to the public. As shown in chapter 3, the overall lack of knowledge and transparency creates anxiety about nuclear power. The reuse and opening of a site can combat this fear and anxiety, helping to foster a sense of involvement and pride in the nuclear power heritage.

The preservation and reuse of former nuclear power plants will benefit future generations as they continue to experience and see the hallmarks of this generation of commercial nuclear power plants. The tangible presence of these structures and stories will enrich the lives of the communities that they are found in, as well as those who visit the site.

Preservation Models

Preservation and adaptive reuse may be a new approach for commercial nuclear power sites, but there are numerous precedents that illustrate that it is possible and beneficial. The following examples are both nuclear and non-nuclear related, and show the flexibility that should be allowed at sites.

Looking first at the Manhattan Project sites, the Hanford B Reactor site serves as preservation model. A recent debate over preservation of a nuclear site took place at the Hanford B Reactor, in Hanford, Washington. The reactor is the world's first full-scale nuclear reactor, built to produce plutonium for the creation of the atom bomb.[16] It operated for over 25 years and was an integral part of the Manhattan Project. The site is owned and maintained by the Department of Energy, and since 2002 has allowed limited tours through the site until 2012.[17] The B Reactor was scheduled for decommissioning following the ENTOMB method, but many supporters of the site wanted to see public access and historical interpretation continue, rather than cocoon the reactor permanently in concrete.

A grassroots movement, led by groups such as the B Reactor Museum Association and other local agencies, called for the preservation and protection of this influential site.[18] Using congressional and local support, these agencies were able to highlight to need to prevent entombment. The Hanford B Reactor was designated a National Historic Landmark in August 2008. This designation "does not guarantee the reactor will never be torn down, but it opens the door for more public tours and moves it closer to becoming a museum."[19] Increased tours of the

reactor are set to start in early 2009. The preservation and increased access to this site are the direct result of an interest on local agency and members of the public. They had to work against the regulations that are currently in place. The Hanford site shows that there is an interest on saving and preserving nuclear sites, as well as the desire to tour and experience these sites.

The Nautilus Submarine, now permanently located in Groton, Connecticut, serves as a model of preservation of the nuclear age. Following decommissioning in 1980, the Nautilus was towed to Groton, Connecticut and the submarine opened as a floating exhibit in 1986.[20] The Nautilus exhibit is part of the U.S. Navy's submarine museum, The Submarine Force Museum, located on the Thames River in Groton, Connecticut. The preserved ship, which is open to the public, provides an interesting historic link to the operating Navy base and Electric Boat Shipyard that are located along the river as well. The Nautilus was constructed at Electric Boat between 1951 and 1954, with her keel being laid by President Harry S. Truman.[21] This shipyard continues to operate and produce submarines for the U.S. Navy. The Nautilus is a preserved and interpreted example of the legacy of nuclear power. The Nautilus also illustrates that the public has an interest in these sites and history, as well as experiencing the actual vessel. These precedents suggest that this thinking can be applied at commercial power plants.

Two non-nuclear sites provide interesting models for comparison. Gas Works Park in Seattle, Washington and Duisburg Nord in Duisburg, Germany are two former industrial sites that have incorporated preservation and adaptive reuse. These post-industrial sites suggest that thinking used there can be applied at commercial nuclear power sites and successfully integrate preservation and reuse, while providing access and opportunities for the public.

Gasworks Park is a 20-acre site that was used for a former Gas Plant that manufactured gas from coal and later converted to crude oil. With the closure of the plant in 1956, the city

acquired the site in 1962 and opened it to the public in 1975.[22] Richard Haag, a local landscape architect, designed the adaptive reuse of the site and his concept was "extremely progressive."[23] It features the retention of pieces of the former industrial complex as relics, and the reuse of portions of the original structures. The former boiler house was reused for a picnic shelter and the former exhauster-compressor building was adaptive for use as a children's play barn.[24] The transition from industrial site to new use was not an easy one and public discussion was intense.[25] As noted by Preservation Seattle, "Gas Works Park remains an unusual and progressive example of adaptive reuse, a noteworthy landscape design, and us undeniably one of Seattle's favorite places."[26] Gas Works Park incorporates sensitivity toward the industrial structures and heritage of the site, while providing for new use and experiences surrounding the plant structures. This illustrates the ability to retain features of an industrial site, while using the surrounding land in new ways. This thinking is applicable to commercial nuclear power plants.

Duisburg Nord in Germany was a Blast Furnace that operated until 1985.[27] Planning for the reuse and conversion of the site began in 1989 with the private sponsorship of the "Duisburg-Nord Country Park project."[28] The project focused on a new way of using this site, leaving the existing industrial structures and adding gardens and green space around these relics to an earlier time. Today, the park is open and visitors are able to climb and explore the furnace platforms and view the former industrial wasteland that has been transformed into a park. Nature combines with the relics of the site's industrial past and provides an exciting space in which to experience history and nature. Having opened to the public in 1994, the park now receives more than 500,000 visitors a year.[29] This precedent illustrates the importance of retaining features of the industrial site, while adding new space and features around it. Its success and popularity with the

public suggests that the public is interested in visiting sites that combine both industry and nature.

Summary

The nuclear field, of which commercial nuclear power plants are part of, is significant in the nation's history. Decommissioning practices do not allow for this significance to be shown and illustrated, but rather severs the tie to memory and history by obliterating the site and structures. Preservation thinking and approaches can and should be applied at sites faced with decommissioning, allowing for the retention of key features and allowing for the heritage of the site to be preserved. While there are many challenges to preserving and reusing structures, there are also benefits that far exceed these. These benefits include cost savings and economic support for the communities. The creation of new jobs and industry provides work for citizens and encourages people to remain in the community. The preservation and interpretation will provide countless benefits to future generations and allow for the appreciation of these sites. Four preservation precedents illustrate the opportunities for preservation and reuse that have been achieved at other industrial sites. At two nuclear sites, heritage and history has been preserved and access granted to allow visitors to experience the structure and history. Two non-nuclear sites illustrate that through the retention of structures and features, former industrial complexes can become thriving public arenas for visitors. All four examples show the influence and importance that these sites can continue to have, even after they have lived their lives as power plants and industrial complexes.

---

[1] Advisory Council on Historic Preservation, *National Historic Preservation Act of 1966* (Washington, D.C.: Advisory Council on Historic Preservation, 15 October 1966, accessed 22 October 2008, as amended through 2006); available from http://www.achp.gov/docs/nhpa%202008.pdf; Internet.

[2] U.S. NRC, *Backgrounder on New Nuclear Plant Designs* (Washington, D.C.: U.S. NRC, 10 June 2008, accessed 12 November 2008); available from http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/new-nuc-plant-des-bg.html; Internet.
[3] National Park Service, *Standards for Preservation and Guidelines for Preserving Historic Buildings* (Washington, D.C.: National Park Service, 31 July 2006, accessed 7 October 2008); available from http://www.nps.gov/hps/tps/standguide/preserve/preserve_index.htm; Internet.
[4] Ibid
[5] Ibid.
[6] Ibid.
[7] National Park Service, *Standards for Restoration* (Washington, D.C.: National Park Service, 31 July 2006, accessed 7 October 2008); available from http://www.nps.gov/hps/tps/standguide/restore/restore_standards.htm; Internet.
[8] National Park Service, *Rehabilitating* (Washington, D.C.: National Park Service, 31 July 2006, accessed 7 October 2008); available from http://www.nps.gov/hps/tps/standguide/rehab/rehab_index.htm; Internet.
[9] National Park Service, *National Historic Landmarks Program* (Washington, D.C.: National Park Service, last updated 03 November 2008, accessed 12 November 2008); available from http://www.nps.gov/history/nhl/; Internet.
[10] National Park Service, *National Register of Historic Places* (Washington, D.C.: National Park Service, last modified 28 October 2008, accessed 12 November 2008); available from http://www.nps.gov/nr/about.htm; Internet.
[11] National Park Service, *Questions and Answers* (Washington, D.C.: National Park Service, last updated 22 October 2008, accessed 12 November 2008); available from http://www.nps.gov/nhl/QA.htm; Internet.
[12] The American Nuclear Society, *Honors and Awards: Nuclear Historic Landmark Award* (La Grange Park, IL: The American Nuclear Society, last modified 2008, accessed 12 November 2008); available from http://www.ans.org/honors/va-nuclandmark; Internet.
[13] L.E Boing, *Beneficial Re-Use of Decommissioned Former Nuclear Facilities* (Argonne, IL: Argonne National Laboratory, June 1997, accessed 28 September 2008); available from http://www.osti.gov/bridge/servlets/purl/16141-3Q9VcA/native/16141.pdf; Internet.
[14] Ibid.
[15] Ibid.
[16] Tri-City Industrial Development Council, *Hanford's Historic Reactor* (Kennewick, WA: Tri-City Industrial Development Council, last modified 23 October 2007, accessed 22 October 2008); available from http://www.tridec.org/ftphome/Hanford%20B%20Reactor.htm; Internet.
[17] Ibid.
[18] See websites http://www.tridec.org/ftphome/Hanford%20B%20Reactor.htm and http://www.b-reactor.org/.
[19] Associated Press, *Washington: Reactor Now a Landmark* (New York, NY: The New York Times, 26 August 2008, accessed 12 November 2008); available from http://www.nytimes.com/2008/08/26/us/26brfs-REACTORNOWAL_BRF.html?_r=3&emc=tnt&tntemail1=y&oref=slogin&oref=slogin&oref=slogin; Internet.

[20] Historic Ship Nautilus and Submarine Force Museum; *History of USS Nautilus SSN571* (Groton, CT: Historic Ship Nautilus and Submarine Force Museum, 2004, accessed 22 October 2008); available from http://www.ussnautilus.org/history.html; Internet.
[21] Ibid.
[22] City of Seattle Washington, Seattle Parks and Recreation, *Gas Works Park* (Seattle: WA: City of Seattle Washington, 2005-2008, accessed 22 October 2008); available from http://www.seattle.gov/parks/park_detail.asp?id=293; Internet.
[23] Heather MacIntosh, Preservation Seattle, *Gas Works Park* (Seattle, WA: Preservation Seattle, 26 November 2005, accessed 22 October 2008); available from http://www.historicseattle.org/preservationseattle/preservationenv/defaultnovember.htm; Internet.
[24] City of Seattle Washington, Ibid.
[25] MacIntosh, Ibid.
[26] Ibid.
[27] Landschaftspark, *Duisburg-Nord Country Park- The Park- Evolution* (Duisburg, Germany: Landschaftspark, 23 May 2005, accessed 22 October 2008); available from http://www.landschaftspark.de/en/derpark/entstehung/index.html; Internet.
[28] Ibid.
[29] Ibid.

CHAPTER 5
CASE STUDIES

The following case studies look closer at the current decommissioning practices used at commercial nuclear power plants. The sites chosen represent a geographic selection, with one site on the East cost, one in the Midwest and one on the West Coast. The sites were operated by different power companies and followed similar courses of decommissioning. Their current uses, post-decommissioning differ greatly, and highlight different approaches that have been taken.

Maine Yankee Nuclear Power Plant, Maine

Located in Wiscasset, Maine, Maine Yankee Nuclear Power Plant operated from 1972 until 1997. During its operation, the plant provided 30% of the state's power needs. The containment dome became a "modern symbol of Maine." [1]

The decommissioning and clean-up for the site represents, "one of the first large-scale nuclear plant decommissioning projects in the country."[2] The decommissioning took place between 1997 and 2005, and all of the plant structures were removed to 3 feet below grade.[3] The containment dome was brought down with explosives, the first time that this had been done in the United States. An Independent Spent Fuel Storage Installation (ISFS) and an electrical switchyard remain on site. The storage will remain on site until the opening of the proposed DOE Yucca Mountain site. The ISFS sites on 12-acres, with a nearby security and administration building.

The plant was sited on an 820-acre site. Following decommissioning and the determination that the land was free from contamination, much of the land was transferred. In 2004, an area known as the "Backlands," comprising 670-acres, was transferred to Wiscasset for

potential redevelopment. 470-acres of this parcel were eventually transferred to the Town of Wiscasset, then sold to Point East and transferred to Ferry Road Development Co., LLC.

The property was eventually sold to "i.park Wiscasset" a subsidiary of National RE/sources, a Brownfield redevelopment corporation based in Greenwich, Connecticut.[4] National has branded the i.park redevelopment model and used it in other states such as Connecticut and New Jersey. The redevelopment plan is touted as a "high tech business/manufacturing campus featuring: 431 acres with road, rail and deep waterfront access; City water, sewer, 3-phase power and high speed Internet Business enterprise zone; and fully approved lots for purchase, lease, build-to-suit."[5] The acreage is conveniently located, with great access from land and water. I.park Wiscasset is located near another National RE/Sources redevelopment project in Wiscasset. The Point East Maritime Village is on the redeveloped site of the former Mason Station power plant. This 1940's era coal and oil-fired power plant was located on a 33.19-acre site. The site periodically produced power during peak times, but it was deemed not useful and the owners, Central Maine Power, sold it to National RE/sources in 2003. In 2006, National developed a master plan for the Point East Maritime Village, which adapts the existing power plant buildings into shops, offices and restaurants and then provides housing around this. The housing includes 80-single family homes and 160 condominiums.[6]

An additional 200-acres were transferred to the Chewonki Foundation in a separate transaction.[7] The foundation manages over 1,200 acres in Maine for conservation and education. With the 200-acres from Maine Yankee, Chewonki agreed to "create a nature preserve, maintain public access, foster stewardship of the estuarine environment, and provide a forum for dialogue on environmental policy issues."[8] A 4.5-mile trail was also created on the land and is the first section in a larger planned trail route.

The decommissioning of the Maine Yankee Nuclear power plant serves as one model for other power plants going through the decommissioning process. The reuse of the site represents a diversified approach, which combines sensitivity toward preserving the land and a focus on progress and redevelopment. While it is too early to tell how successful the redevelopment will be in terms of economic stimulus, it has a promising future and clear plan.

Big Rock Point Nuclear Power Plant, Michigan

Big Rock Point Nuclear Power Plant operated in Charlevoix, Michigan from 1962 to 1997. Known by many as "Big Rock," the plant was owned and operated by Consumers Energy (formerly Consumers Power Company).[9] Following its closure in 1997, Big Rock went through the process of decommissioning and returned the site to Greenfield status, with little indication of what was once there. Greenfield Status, related to nuclear power sites, is a process that "in principle, restores the site to the conditions existing before the construction of the plant."[10]

Big Rock did not start its life as a commercial power plant, but rather as a research and development facility to "demonstrate that nuclear plants could produce electricity economically, and also to study the reduction of fuel fabrication costs and how to increase the life of fuel."[11] By 1965, it began producing electricity for the surrounding communities, becoming the nation's fifth commercial nuclear power plant. In addition to providing power, Big Rock also produced cobalt-60 for the treatment of cancer patients. An estimated 120,000 people received treatment from the materials produced at Big Rock.[12] In June of 1991, the American Nuclear Society named Big Rock a "Nuclear Historic Landmark."

With an original license set to expire in 2000, it was deemed too costly and uneconomical to try to extend the lifespan of the plant and apply for an extended license. The decision was made in 1997 to cease operations at Big Rock. Despite the historic designations, decommissioning activities started promptly in 1997 and ran through 2005. The

decommissioning project became known as "the Big Rock Point Restoration Project."[13] Restoration would focus on the landscape, restoring the site to a pre-plant appearance.

The Michigan State Historic Preservation Officer declared the site eligible for the National Historic Register. Therefore, the removal of the buildings was seen as an adverse effect and a special memorandum was required for decommissioning to take place. This Memorandum of Agreement included the notification of any NRC plans to the SHPO, as well as documentation of the site using the Historic American Engineering Record System, and post-decommissioning access granted to the Native Americans who use the Big Rock as a historic gathering location.[14] The NRC, SHPO and Consumers Energy were able to work together to achieve these goals.

Big Rock chose to follow the DECON method of decommissioning, thereby dismantling all structures on site. The work was carried out by plant employees who transitioned to the new task of decommissioning. This allowed for a streamlined process and an economical approach. An ISFS was constructed to house the casks of spent fuel.

In 2005, with decommissioning successfully completed, the land was returned to a pre-plant appearance. Consumers Energy hosted a "Greenfield Celebration in 2006," celebrating the cleanup and restoration work that had taken place. Small plaques were located at the different locations of the former plant structures and informative posters described the activities that had taken place at the plant. The Charlevoix Depot Museum, a local historical museum, ran an exhibition in conjunction with the celebration that illustrated the plant's history and closure.

The Big Rock Achievement Landmark, a monument, was dedicated on the site in 2007, marking the achievements of the plant and its workers. Xibitz, a Michigan company, designed the landmark. It incorporates pieces of plant's containment steel and illustrates the achievements of the plant and workers. Funding for this landmark was from the plant's employees and

business friends. There is also a state historical marker installed in 2007, which marks the significance of the site. These markers are lasting testaments to the achievements and work done at the Big Rock Point Nuclear Power Plant.

435-acres now sit, waiting for use. There State of Michigan has shown some interest in purchasing the land and turning it into a state park. There have been numerous watchdog groups that still fear the presence of nuclear waste and contamination, and protest this purchase. The Reactor Watchdog Project refers to the proposed state park as "Plutonium State Park" in their press releases.[15] Currently, there have been no definitive plans made for the future of this site.

Trojan Nuclear Power Plant, Rainier, Oregon

Trojan Nuclear Power Plant, located in Rainier, Oregon, lived a relatively short life, approximately 17 years, nearly 20 years before the end of its intended lifespan. Commercial operations began at the plant in May 1976 and shutdown on November 9, 1992. The final shutdown came after leaks were discovered in a new steam generator tube, which had been repaired that year following a 1991 scheduled outage discovered numerous flaws in the system.[16] Portland General Electric (PGE) selected DECON as their decommissioning approach because it was "less expensive than other SAFSTOR options, and it minimized the potential for increased radioactive waste burial costs or unavailability of a burial site."[17]

PGE notified the NRC of their intention to decommission the Trojan Nuclear Plant on January 27, 1993. Per NRC regulations, PGE submitted Trojan Nuclear Plant Decommissioning Plan on January 26, 1995. This plan defined the decommissioning process, which would take the next ten years.

The major components of this decommissioning plan involved setting a schedule for the removal of any waste on site and the subsequent storage of waste that could not be removed from the site due to the lack of a federal repository. Each NRC regulation was described to have been

met and then reviewed and assessed to see if it has indeed been met. The decommissioning plan estimated the cost of decommissioning and the existence of funds to cover this expected cost.

The plan makes note of the desire to restore the site, but "does not address in detail additional site restoration activities beyond what is necessary to allow unrestricted access to the site."[18] No future plans for the site, either by the current owner PGE or another were proposed and they were not required to submit this type of future planning. This is a major shortcoming in the decommissioning process. Proactive planning for the future of this site should have taken place.

Decommissioning at the plant was completed in December of 2004, and on April 8, 2005, the Oregon Council on Energy Facility Siting found that decommissioning had been successfully completed and that the site met all criteria for unrestricted release. This release means, "The site can be safely used for any purpose, including residential use."[19]

The power plant site is divided into two areas, Industrial and Non-Industrial. The industrial area is located east of the railroad tracks and encompasses the area where the power plant structures stood. It is also the current location of the ISFS. PGE has no plans to develop this area until the spent fuel is removed. The non-industrial area is located to the west of the tracks and a day-use park operated by PGE is located here.[20]

The lack of a clear plan for the future use of Trojan Nuclear Plant meant that there were still a lot of issues that had to be dealt with following the approval of decommissioning. If a concise plan had been proposed and the public included, issues that came up following decommissioning might have been prevented. One of these issues was reuse of the land following decommissioning. There is an existing park adjacent to the nuclear facilities and the surrounding green-space. Trojan Park is a 75-acre park with a 29-acre lake for fishing and

boating that PGE has maintained since the site opened in 1976. The rest of the 634-acre site sits idle, with no clear plan for the future.

The State of Oregon had shown interest in acquiring a large portion of the property, nearly 500 acres, as well as the Trojan Park, and maintain it as a State Park. Under this plan, PGE would have retained the remaining 134-acres and the waste storage facility.[21]

Another issue that arose was the remaining cooling tower. The tower had been earmarked for demolition as part of the decommissioning process. There was, however, public interest in keeping the tower as a landmark and lasting remembrance. The cooling tower was "incorporated into the city seal, and residents- an estimated one in three of whom worked at the plant- came to ignore the evacuation-warning sirens and Geiger counters mounted on poles around town."[22]

The cooling tower had been found to be free of radiation contamination and could have been safely left standing.[23] Unfortunately the tower was demolished, due to regulations and lack of support from the owners of the plant, although an alternative could have been possible. The cooling tower was imploded on May 21, 2006, marking the first implosion of a cooling tower at a nuclear plant in the United States. The implosion was televised and shared on the Internet, making it a national event. Additional structures have been removed, and decommissioning activities at the site continue.

With much of the land sitting unused at the Trojan Nuclear Power Plant, it is unfortunate that no clear plan has been suggested or implemented. It illustrates a problem that other plants will undoubtedly encounter if more foresight is not taken.

Summary

The preceding case studies suggest that there is no single solution for decommissioning. Each site has a unique opportunity to reflect on its strengths and find new ways to engage the community and provide economic support. This is the new frontier in commercial nuclear power

and more attention needs to be given to proposing and assessing plans prior to decommissioning. As shown in the examples in Chapter 4, preservation and adaptive reuse has been used successfully at numerous industrial sites. These precedents should be considered in conjunction with decommissioning cases that have already taken place. As seen in Maine, a closed site can offer new opportunities for industry as well as nature. A site may also be restored to its pristine, Greenfield state, as seen in Michigan. Or, as will be the case if proactive planning is not implemented, a site can struggle, as is the case in Oregon. The following model for Crystal River Nuclear Power Plant suggests using a combination of approaches in thinking about the future of a site that will be faced with closure

---

[1] Time Magazine, "Yankee, Yes." (New York, NY: Time Magazine, 6 October 1980, last modified 2008, accessed 24 October 2008); available from http://www.time.com/time/magazine/article/0,9171,954555,00.html; Internet.
[2] CH2MHill, *Maine Yankee Atomic Power Plant Decommissioning.* (Englewood, CO: CH2MHill, last modified 2008, accessed 24 October 2008); available from http://www.ch2m.com/corporate/services/decontamination_and_decommissioning/assets/ProjectPortfolio/MaineYankee.pdf; Internet.
[3] Maine Yankee, *Maine Yankee* (Wiscasset, ME: Maine Yankee, last modified 16 September 2008, accessed 22 October 2008); available from http://www.maineyankee.com/; Internet.
[4] Paula Gibbs, "Dome to Disappear Friday, Sept. 17" (Boothbay Harbor, ME: Boothbay Register, 09 September 2004, Vol. 127, Number 37, accessed 12 November 2008); available from http://boothbayregister.maine.com/2004-09-09/dome_to_disappear.html; Internet.
[5] Sotheby's International Realty Affiliates, Inc, *I.Park* (Wisscasset, ME: Sotheby's International Realty Affiliates, Inc, Point East., 2007, accessed on 22 October 2008); available from http://www.pointeastmaine.com/ipark.html; Internet.
[6] Dennis Hoey, "Wiscasset Starts Something Big" (Portland, ME: Portland Press Herald, 27 July 2006, accessed 12 November 2008); available from http://www.pointeastmaine.com/news_WiscassetStartsBig.html; Internet.
[7] Ibid.
[8] The Chewonki Foundation, *Nature Preserves & Trails* (Wiscasset, ME: The Chewonki Foundation, last modified 2008, accessed 24 October 2008); available from http://www.chewonki.org/about/nature_trails.asp; Internet.
[9] Betsy Tomkins, "Big Rock Point: From Groundbreaking to Greenfield" (La Grange Park, IL: Nuclear News, November 2006, accessed 22 October 2008); available from http://www.ans.org/pubs/magazines/nn/docs/2006-11-3.pdf; Internet.

[10] Maurizio Cumo, *Experiences and Techniques in the Decommissioning of Old Nuclear Power Plants* (Rome, Italy: University of Rome, 2002, accessed 24 October 2008); available from http://users.ictp.trieste.it/~pub_off/lectures/lns020/Cumo/Cumo.pdf; Internet.
[11] Tompkins, Ibid.
[12] Tompkins, Ibid.
[13] Tompkins, Ibid.
[14] U.S. NRC, *Big Rock Point* (Washington, D.C.: U.S. NRC, 21 February 2007, accessed 23 October 2008); available from http://www.nrc.gov/info-finder/decommissioning/power-reactor/big-rock-point.html; Internet.
[15] Nuclear Information and Resource Service, *Press Statement, November 30, 2006*. (Takoma Park, MD: Nuclear Information and Resource Service, 30 November 2006, accessed 22 October 2008); available from http://www.nirs.org/press/11-30-2006/2; Internet.
[16] Oregon Department of Energy, *Review of PGE's Decommissioning Plan for the Trojan Nuclear Plant* (Salem, OR: Oregon Department of Energy, 22 January 1996, accessed 23 September 2008); available from http://www.oregon.gov/ENERGY/SITING/docs/decom.pdf; Internet.
[17] Ibid, 11.
[18] Ibid, 17.
[19] State of Oregon, *Energy Facility Siting: Trojan Nuclear Plant* (Rainer, OR: State of Oregon, last updated 01 August 2007, accessed 23 September 2008); available from http://www.oregon.gov/ENERGY/SITING/TRO.shtml; Internet.
[20] Portland General Electric, *Trojan Demolition* (Portland, OR: Portland General Electric, last modified 2008, accessed 22 October 2008); available from http://www.portlandgeneral.com/about_pge/corporate_info/trojan/; Internet.
[21] Martin John Brown, "From Nuclear Fuel to Nature Trails" (Paonia, CO: High Country News, Vol. 32, Issue 22, 20 November 2000, accessed 12 November 2008); available from http://martinjohnbrown.net/trojan-st-park.pdf; Internet.
[22] Jonathan Martin, "Vestige of Region's Nuclear Designs to be Imploded Sunday Morning" (Seattle, WA: The Seattle Times, 19 May 2006, accessed 12 November 2008); available from http://community.seattletimes.nwsource.com/archive/?date=20060519&slug=trojan19m; Internet.
[23] Ibid.

CHAPTER 6
CRYSTAL RIVER NUCLEAR POWER PLANT

Crystal River is a city located in Citrus County, Florida. The 2005 U.S. Census estimates the city's population at 3,600.[1] The city is approximately 6.3 sq. miles, with 5.7 of this being land and 0.6 water. During the 1900's it had a thriving cedar harvesting industry and manufactured pencil slats for the Dixon Pencil Company.[2] Crystal River is a popular tourist destination for fishing, boating and sightseeing. Manatee watching is a popular pastime and it is common to see the manatees in the warm gulf waters along the city's coastline.

Crystal River Nuclear Power Plant

The Crystal River Nuclear Power Plant (CR3) is sited within 4,738-acres that also features 4 coal-fired plants. The parcel is located in northwestern Citrus County, on Crystal Bay, an embayment of the Gulf of Mexico.[3] The plant is referred to as "CR3" because it was the third plant to be built on the site, with two coal plants preceding it and two plants following its construction. The nuclear plant and four fossil fuel plants lie in a developed area in the property. In this area there are also support facilities, office buildings, warehouses, oil tanks, coal storage areas, and ash storage basins.[4]

Owned by Progress Energy, the nuclear plant came online in 1977 and its current license expires in 2016. A license extension will be presented to NRC in early 2009, which would extend this lifespan an additional 20 years.[5] According to the Energy Information Administration, which provides statistics on the energy industry, the Crystal River Power Complex is the Nation's 8th largest producer of power.[6] As of 2001, the largest employer in Citrus County is Progress Energy, with roughly 1,600 employees. The Citrus Memorial Hospital system is the next largest employer with approximately 990 employees.[7]

In 1977, Florida Power Corporation owned the Crystal River Plant. The plant took 10 years to construct and was met with no public protest, except for limited environmental concerns. The county's population was estimated at 38,500 in 1977 and it has since tripled.[8] During the 1960's and 1970's, the city saw a boom in population and growth, directly related to the construction and influx of workers to the power plant complex. New strip malls and businesses were built along the main road, Highway 19, at a rapid rate. By the 1980's "construction has slowed down and this had an overall dampening effect on the local economy. The downtown area was caught between the threat of newer, flashy shopping areas to the north and south and the doldrums of an overall economic slowdown in the area."[9] To combat the growing vacancies and blight, The Community Redevelopment Agency (CRA) was established in 1988. The CRA is a designated Special District and the Redevelopment Area encompasses approximately 606-acres, which includes much of the downtown and 7500 feet of waterfront.[10]

Zoning for CR3

Existing land use guidelines in Citrus County designates a type called Transportation, Communication and Utilities (TCU).[11] There are 5,416 acres designated as TCU in Citrus County, this represents a 1.42 percent of the entire County land area. The majority of the TCU designation is allocated for the Crystal River power complex, the major transmission lines, the Crystal River Airport, and the Inverness Airport.[12]

Environmental Context of CR3

CR3 is located in a lush, natural environment, characterized by unique wildlife and plant species. The power plant complex is located along what is known as the "Nature Coast." This designation, primarily a tourist one, includes the counties stretching from Wakulla to Pasco County, Florida.[13] Covering a total of nine counties, this stretch of coastline is sanctuary to 19 endangered species.[14]

New South Associates found in their study of the PGE site and a 6-mile radius that, "the vegetation in the area is varied in relation to distinct physiographic zones, of which there are three: the estuarine zone, the coastal hammock zone, and the coastal uplands zone."[15] The estuarine zone includes various species of submerged grasses and algae and several salt-tolerant marsh grasses, especially Spartina and Juncus.[16] Coastal hammock vegetation includes those found on small islands and features hardwoods, coontie and palmetto palm and pine. Coastal Lowland areas features pine, hardwoods, and palmetto palm.[17] These environmental zones contain varied food resources and support unique water animals, and terrestrial animals.

New South Associates provide this description of the environment surrounding the power plant complex:

> The area immediately surrounding the plant is a mix of upland (pine) forest, agricultural lands, swamps, and salt marshes. The large tract of land immediately north of the plant is owned by an agribusiness concern with mining interests. Parts of this property are forested, parts are used for cattle ranching and cultivation of citrus trees, and other parts of this property are devoted to limestone/dolomite mining. The area southwest of the plant is salt marsh, which the area south and southeast of the plant is mostly forested wetlands.[18]

The Crystal River Mariculture Center is located at the Progress Energy site and monitors the impact from water released into the Gulf of Mexico. Water is used at the complex to provide cooling and is released back into the Gulf. The water is typically much warmer and has a significant impact on the environment and species. The Mariculture Center, opened in 1991, arose out of the determination that fishing populations were being impacted.[19] The center provides a multi-species hatchery, as well as educational programming.

Outside of the Progress Energy parcel, there are a number of cultural resources that are managed and protected.

Cultural Resources Related to CR3

Homosassa Springs Wildlife State Park lies directly south of the power plant complex, and Chassahowitzka National Wildlife Refuge is located 12 miles from the property boundary to the south.[20] Crystal River Archaeological Park is 4 miles southeast of the power complex and Cedar Keys National Wildlife Refuge is 20 miles north of the site, in Cedar Key, Florida. Three miles to the north, the Marjorie Harris Carr Cross-Florida Greenway occupies land of the former Cross Florida Barge Canal. [21] This canal project was undertaken during the Great Depression to provide jobs and link the Atlantic and Gulf coasts of Florida. The project was characterized by delays and lawsuits and finally halted in 1971 with 30 percent of the project completed and a total cost of 74 million to taxpayers.[22] The project was renamed the Marjorie Harris Carr Cross-Florida Greenway in 1998 in honor of the individual who lead the fight against the barge canal project.

Homosassa Springs Wildlife State Park showcases "native Florida wildlife, including manatees, black bears, bobcats, white-tailed deer, American alligators, American crocodiles, and river otters."[23] The park features habitat exhibits for the animals, as well as demonstrations and educational programs given by park rangers throughout the day. A manatee rehabilitation program protects and cares for manatees that have been injured.[24]

The Chassahowitzka National Wildlife refuge, managed by the National Wildlife Refuge System, was established in 1941 and comprises 31,000 acres of "saltwater bays, estuaries and brackish marshes at the mouth of the Chassahowitzka River."[25] It protects over 250 species of birds, 50 species of reptiles and amphibians, and at least 25 different species of mammals.[26]

The Crystal River Archeological State Park is part of the Florida Park system and is National Historic Landmark. It is a 61-acre, pre-Columbian, Native American site, which features "burial mounds, temple/platform mounds, a plaza area, and a substantial midden."[27] It

was a significant historic site for the Native Americans, who would travel great distances to bury and venerate their dead. Research and study continues at the site to try to better understand earlier cultures and peoples.

The U.S. Fish & Wildlife Service manages the Crystal River National Wildlife Refuge. Established in 1983, the Refuge was designed for the protection of the endangered West Indian Manatee. The "unique refuge preserves the last unspoiled and undeveloped habitat in Kings Bay, which forms the headwaters of the Crystal River. The Refuge preserves the warm water springs haves, which provide critical habitat for the manatee populations that migrate here each winter."[28]

The Crystal River Preserve State Park is also part of the state's park system and protects a varied natural region. It is located along 20-acres of the gulf. This is a transitional area, between temperate and subtropical climate zones and features plants from each. The land and archeology are constantly being studied and the preserve is being actively restored. Interpretative programming and tour guides provide public access and information.

The Yulee Sugar Mill Ruins, also a state park, are a departure from the larger scale parks and cultural attractions. It is a smaller park, located amongst a residential area. It is the ruins, or remains, of a large-scale sugar mill operation. It is an interesting approach to interpretation and does not try to provide a complete presentation to the visitor. This site, along with the other destinations shows the varied history of the City of Crystal River.

According to a December 2006 report completed by New South Associates there are currently 195 archeological sites, 9 structures, and 3 cemeteries within a 6-mile radius of the 4738-acre site owned by Progress Energy.[29] Only two of these sites are listed in the National

Register of Historic Places and both are prehistoric: the Crystal River Indian Mound site complex and Mullet Key.[30]

Proposed Levy County Nuclear Power Plant

The current (2008) generating capacity of CR3 is estimated to be sufficient for Citrus County until 2014.[31] There is a current application submitted to the NRC (2008) for a new nuclear power plant in Levy County, adjacent to Citrus County, FL. This new power plant would supplement the existing power providers and the State believes it necessary to meet the growing power demands in the state. Progress Energy has a 3,000-acre site in Levy County, located 7 miles inland from the Gulf of Mexico and 8 miles north of CR3. The site was chosen "based on an assessment of the major siting criteria: land, access to sufficient quantities of water (from the Gulf) and access to the electric transmission system, as well as an overall evaluation of environmental considerations." [32] Progress Energy has applied for a combined Construction and Operating license from the NRC for two Westinghouse Advanced Passive 1000 Pressurized Water Reactors at the Levy County site. There is still a long way to go before these new reactors will be approved and constructed, and there will still be reviews by the public and other interested parties.

Summary

Crystal River Nuclear Power Plant is an aging commercial nuclear power plant. It is located in an industrialized section of a larger open parcel and features unique flora and fauna. It has, during its operation, shown a care for the natural world and wildlife that is affected by the plant's operation. It is a removed site, one that is accessible to only approved users, but it is still an integral feature of the local landscape. The community relies on this plant for work and economic support and its closure will have a significant effect on the local community.

[1] U.S. Census Bureau, *2005 U.S. Census* (Washington, D.C.: U.S. Census Bureau, last modified 20 June 2006, accessed 20 October 2008); available from http://www.census.gov/popest/cities/tables/SUB-EST2005-04-12.csv; Internet.
[2] City of Crystal River, *City of Crystal River History* (Crystal River, FL: City of Crystal River, last modified 2008; access 20 October 2008); available from http://www.crystalriverfl.org/index.asp?Type=B_BASIC&SEC=%7B04D7A3C3-E282-4C21-91AC-2C0200330D81%7D; Internet.
[3] New South Associates, *Cultural Resources Background Research Supporting License Renewal, Crystal River Nuclear Plant, Citrus and Levy Counties, Florida (*St. Augustine, FL: New South Associates, December 19, 2006, accessed 20 October 2008); available from http://www.dep.state.fl.us/siting/Highlights/Applications/PPSA/Crystal%20River%20Unit%203/Application/Appendices%2010.2_10.3_Citrus%20County.pdf; Internet.
[4] Ibid.
[5] U.S. NRC, *Status of License Renewal Applications and Industry Activities* (Washington, D.C.: U.S. NRC, 03 November 2008, accessed 20 October 2008); available from http://www.nrc.gov/reactors/operating/licensing/renewal/applications.html; Internet.
[6] Energy Information Administration, *100 Largest Electric Plants* (Washington, D.C.: Energy Information Administration, 2005, last reviewed January 2008, accessed 22 October 2008); available from http://www.eia.doe.gov/neic/rankings/plantsbycapacity.htm; Internet.
[7] Citrus County Chamber of Commerce, *Demographics* (Inverness, FL: Citrus County Chamber of Commerce, 2005-2007, accessed 20 October 2008); available from http://www.citruscountychamber.com/index.php?option=com_content&task=view&id=37&Itemid=39; Internet.
[8] Catherine E. Shoichet, "Nuclear Plant Idea Has Support" (St. Petersburg, FL: St. Petersburg Times, 9 October 2005, accessed 12 November 2008); available from http://www.sptimes.com/2005/10/09/Citrus/Nuclear_plant_idea_ha.shtml; Internet.
[9] City of Crystal River, *The City of Crystal River Community Redevelopment Agency: Background* (Crystal River, FL: City of Crystal River, last modified 2008, accessed 12 November 2008); available from http://www.crystalriverfl.org/index.asp?Type=B_BASIC&SEC=%7B75E8AE31-46C9-4E44-912D-7E76D787C2A3%7D; Internet.
[10] Ibid.
[11] New South Associates, Ibid.
[12] Ibid.
[13] Nature Coast Coalition, *Discover Florida's Nature Coast* (Brooksville, FL: Nature Coast Coalition, last modified 4 September 2008, accessed 24 October 2008); available from http://www.naturecoastcoalition.com/; Internet.
[14] Ibid.
[15] New South Associates, Ibid.
[16] Ibid.
[17] Ibid.
[18] Ibid.
[19] Florida Fish and Wildlife Conservation Commission, *Crystal River Mariculture Center* (St. Petersburg, FL: Florida Fish and Wildlife Conservation Commission, last modified 2008,

accessed 22 October 2008); available from http://research.myfwc.com/features/view_article.asp?id=10469; Internet.

[20] New South Associates, Ibid.

[21] Ibid.

[22] Ibid.

[23] Florida Division of Parks and Recreation, *Homosassa Springs Wildlife State Park* (Tallahassee, FL: Florida Division of Parks and Recreation, last modified 2008, accessed 22 October 2008); available from http://www.floridastateparks.org/homosassasprings/ParkSummary.cfm; Internet.

[24] Ibid.

[25] U.S. Fish & Wildlife Service, *Chassahowitzka National Wildlife Refuge* (Crystal River, FL: U.S. Fish & Wildlife Service, last updated 7 August, 2008, accessed 24 October 2008); available from http://www.fws.gov/chassahowitzka/; Internet.

[26] Ibid.

[27] Florida Division of Parks and Recreation, *Crystal River Archaeological State Park* (Tallahasse, FL: Florida Division of Parks and Recreastion, last modified 2008, accessed 24 October 2008); available from "http://www.floridastateparks.org/crystalriver/ParkSummary.cfm; Internet.

[28] U.S. Fish & Wildlife Service, *Crystal River National Wildlife Refuge* (Tallahasse, FL: U.S. Fish & Wildlife Service, last updated 14 august 2008, accessed 24 October 2008); available from http://www.fws.gov/crystalriver/; Internet.

[29] New South Associates, Ibid.

[30] Ibid.

[31] Ibid.

[32] Progress Energy, *Progress Energy Florida names potential nuclear plant site in Levy County* (St. Petersburg, FL: Progress Energy, last modified 2008, accessed 24 October 2008); available from http://www.progress-energy.com/aboutenergy/poweringthefuture_florida/levy/index.asp; Internet.

Figure 6-1. Aerial view of Crystal River Power Complex. (Adapted by Elizabeth Farrow from: www.mapquest.com).

Figure 6-2. View of Crystal River Power Complex from the bay. (Reprinted with permission from: Elizabeth C. Farrow).

Figure 6-3. Entrance to W. Powerline Road and the Crystal River Power Complex. (Reprinted with permission from: Elizabeth C. Farrow).

CHAPTER 7
PROPOSED PRESERVATION AND ADAPTIVE REUSE MODEL FOR CRYSTAL RIVER NUCLEAR POWER PLANT

Overview

The proposed model for Crystal River Nuclear Power Plant is based on the previous investigations and current concerns of preservation and land use planning. This research has shown that:

- The commercial nuclear heritage is one that should be preserved and celebrated. This heritage is of national significance and should be appreciated. Commercial nuclear power sites play an integral part in the advancement and heritage of nuclear power.

- These sites are integral to the economic and daily life of the cities they are found in. Their closure will have a significant effect on the community. Understanding this connection to the community can allow for sensitive planning that provides a gradual transition for the site.

- There is public interest in these sites. This interest suggests that there is an interest to preserve and reuse features of these sites and increase access to them.

- Decommissioning methods do not include preservation approaches or provide for flexibility. Current regulations are difficult to customization or alter, and new thinking needs to be applied to them to incorporate preservation and adaptive reuse approaches.

- There is the need for proactive planning for the reuse of sites. Planning typically occurs after decommissioning has been finalized, and the sites released for unrestricted use. Proactive planning allows an accepted plan to be in place prior to decommissioning and closure.

- There is a lack of an established framework for decommissioned sites. Following release, sites are left without any established guidelines or plans. The following model suggests key issues that can serve as a starting point for the development of guidelines or planning.

- There is a lack of a regulatory body to oversee released sites. Once a site has been released, the NRC and DOE are not responsible for regulating the sites. A regulatory body, either state or federal, would provide assistance for released sites.

- Benefits to preserving and reusing these sites do exist. These benefits are significant and include the retention of memory and the appreciation of history. Economic benefits are found at sites that can adapt and provide diversified land uses and jobs for the community.

The following model is an appropriate model that can be applied at other sites faced with decommissioning, and Crystal River Nuclear Power Plant serves as an illustration of this model.

Key Issues of the Model

Several key issues are the focus of this model:

- Memory
- Preservation and Reuse
- Interpretation
- Site-specific opportunities and constraints
- Access
- Sustainability
- Phasing
- Transparency
- Stakeholders

Each individual site should evaluate these key issues and determine the best approach for their site. The concept of *memory* is the memory of the former use of the site, as an industrial complex, as well as the memory of the achievements of the site. This is a significant history and memory for the workers, community and nation. This memory should be preserved and celebrated.

Next there is the concept of *preservation and reuse* of structures and key elements of the site. At each site, it is important to evaluate the significant structures and stories that should be preserved. Assessing the best preservation approach will develop a guideline for these structures to be saved and retained. Determining which structures or features can be safely reused can help assist in the retention of the memory of the site. The presence of older structures on the reused site can tell the story of the power plant era and maintain the connection to the past.

Thought and planning needs to be given for *interpretation* and the increased public awareness of the history of each site. Interpretation allows for the retention of memory, and illustrates the history of a site in a different way than structures might. Sites may chose to use

interpretative approaches such as signage, museums exhibits, and tours. Interpretation should be an importance consideration at each site.

Fourth, there is the concept of *site-specific opportunities and constraints*. Each individual site must be evaluated for issues of space, scale, existing views, and the opportunities for new land use. Issues of space and scale should be evaluated for the desired retention of existing features. This relates to the idea of preservation and reuse, and is important for maintaining the physical presence of a site. There may be existing views that are important to the site and planning should allow for the retention of these. Existing conditions at the site should be evaluated to determine how best to achieve a diversified and thriving new land use for the site.

Next, there is the issue of *access* to the site, and the importance of incorporating this into new planning for the reuse of the site. This access to the site can be achieved in the form of roads, paths and entrances, as well as access to information and history. Access to the site should be evaluated based on the proposed use for the site, and access allowed or controlled where needed. Allowing for new land use and the opening of former restricted areas will allow for greater access to interpretation and understanding of nuclear power.

Next, there is the concept of *sustainability*. This is both environmental sustainability and economic. Recognizing each site's individual ecological and environmental characteristics will highlight unique planning that needs to be undertaken at each site. Sustaining these animal and plant populations should be a key consideration for planning. Creating a thriving and diversified new land use will allow for economic stability and sustainability.

Each site should evaluate the feasibility of *phasing* planning. Transitioning from a power plant to an unrestricted site is a significant transformation and should be completed over a period

of time. The creation of a master plan and the development of phases of implementation allows for access to select areas of the site, and a more gradual transition.

Transparency should be a key issue in any evaluation of an individual site. Future planning should incorporate public involvement at all points throughout the planning process and makes the aforementioned concepts and goals clear. The application of this model at Crystal River identifies key issues and highlights methods that can achieve and support these concepts.

Each site should consider and evaluate the *stakeholders* that are involved in the decommissioning and redevelopment of a former power plant site. These stakeholders may have varied and disparate needs and it is important that planning should involve all parties and their respective needs.

Planning for These Issues at Crystal River

The idea of memory is part of the plan for CR3. This memory is a link to the site's former use as a power-generating site. This memory can be made tangible in numerous ways. It may be through the retention of buildings and structures that were used during the power plant era, providing a physical representation of this memory. It might also be through the use of signage or other materials that tell the story of the site in narrative form. It may be achieved in the creation of memorial or monument to the past life of the site. As seen at the Big Rock Point case study, a monument is a way for visitors to experience and recognize the history of the site.

Preservation of structures and features of the site can support this illustration of memory and legacy. At CR3, this could be the retention of the two coal plant cooling towers. Although these are not part of the nuclear plant, they are closely associated with the site and serve as recognizable landmarks when viewing the site from a distance. They have become constants in the landscape and their continued presence would make clear the heritage of the site. There may

also be the preservation of elements of the coal plants, as relics, that exist in the new landscape. Other preserved features could include the entry signage, walkways and pathways.

Reuse is closely related to preservation and suggests reusing parts that are to be saved. At CR3, the retention and reuse of other structures, such as office buildings and administrative buildings would allow new uses for these buildings. Using one for a visitor center or museum could provide a location for tourists and visitors to learn the history of the site in a building that continues the legacy. The retention and reuse of infrastructure, such as the main access road, W. Powerline, would reinforce the original approach to the site, while parking lots and other service areas could still be useful. Reusing existing railroad lines could provide new industry with needed support. This would limit the need for new infrastructure and maintain sensitivity to the site.

The goal of interpretation supports the concept of memory and continuing the link to the past. Interpretation can be achieved in a number of ways including signage, personnel, and exhibitry. Signage can be used throughout the site at CR3 and illustrate the story of the site. This signage may be simple and discreet in some places, and larger and more didactic in others. Staff and guides can provide information in another way, providing tours of the site and leading discussions about specific areas of interest. Exhibits in a new museum center or visitor center can provide permanent and changing exhibits related to the history and context of the site, as well as the City of Crystal River. Currently, the City of Inverness is home to the county's historical society, but Crystal River lacks a town museum or historical center. Creating this on the former CR3 site would bring in new visitors and provide a new asset for the city.

Currently, the space at the power complex is vast and open, marked only by the concentrated presence of the industrial complex. The scale of these structures is large, in relation

to the structures located around the property, and the power complex is visible from numerous points throughout the city. This sense of size and scale should be retained in the reuse of the site and can be achieved in different ways. By preserving the cooling towers or larger elements of the structures, the sense of scale and the visibility of the site are still maintained. Creating smaller scaled structures around the site would not detract from these landmarks. The sense of open space should be retained, through the preservation of land areas and the thoughtful placement of new structures. The site is large enough that different zones can be laid out and still they would be far enough away from each other to maintain this sense of openness and space.

This redevelopment should be diversified and include things that have been mentioned such as preserved areas, reused buildings, open space, educational facilities, new residential, commercial and industrial areas. It is through this diversity of design that the site will meet the needs of varied new users and populations. By providing services that are not available in the other parts of the city or supporting existing ones, the site will continue to be an integral part of the community. The reuse of the site should strive to integrate with the existing growth found in the rest of the city.

Providing access and increasing access to the site in the future is key. During its operation as a power complex, the site is often restricted and off-limits to everyone accept approved users. This creates a lack of knowledge about the site and how it was used. Providing access, either for vehicular or pedestrians, opens up areas that were previously inaccessible. This brings the public in and includes them in the knowledge of this site. Using a diversified approach, where there are numerous attractions for visitors, will increase the number of people accessing the site. Through the opening of a former restricted site, this allows for access to information and interpretation.

This encourages the appreciation of these sites and furthers the cause of preserving and recognizing their importance to the nation's heritage.

Sustainability is an important consideration and continues a legacy left by the power plant complex. While it operated, the complex provided sustainability in the form of jobs and economic support for the community. Even nuclear power can be argued to be sustainable, if reprocessing is allowed. The plan for the site should include this idea of sustainability. New environmental methods such as solar or geothermal technology should be looked at. This would continue the legacy of power generation, but provide new "green" methods of generating that power. Additionally, ensuring that existing animal and plant populations are managed and protected with provide for a sustainable wildlife and plant population. Measures should be taken, as they were during the power plant era, to continue protecting the unique flora and fauna at the site. Creating a thriving redevelopment area will provide continued funds and economic support, continuing the sustainability started by the power plant complex.

Using a phased approach at the site will allow for an easier transition, and prevent a period of time when the site is completely closed and not supporting the community. At CR3, this can be the redevelopment and construction of areas that are on the periphery of the site, leaving the industrial complex unavailable and inaccessible. As decommissioning and cleanup opens more areas, these portions can be incorporated. Future designs for the site should develop a master plan and determine a timeline for implementation. Cooperative planning for the coal plants and the nuclear plants should be devised to allow for an overall approach for the site. Planning for the future of the site should be taking place now, rather than in the future when the site is closed or nearly closed.

Making these future designs and plans as transparent as possible will involve and excite the public about the site's new use. The closure of the plant complex will greatly affect the community and it is important to include them in new thinking for the site and develop areas for new jobs and continued community support. Transparency will combat any negative perceptions of the site and further the understanding and appreciation of nuclear power.

There are a number of key stakeholders in the future of the Crystal River site and it is important that planning for CR3 include the participation of all interested parties. First, the owners, Progress Energy Florida, currently have direct ownership of the land and can continue to use it how they see fit. They have a commitment to the public though and should work with others to see that this site is used in new ways. If their involvement ends with the closure and sale of the property then it is hoped that they do so in a way that is beneficial to the city, rather than for purely economic reasons. The City of Crystal River has a direct stake in this parcel. It is situated in a prime location along the gulf coast and represents a large piece of undeveloped land. It is crucial that the city make wise decisions when utilizing the site in the future. The State of Florida manages lands surrounding the site and their involvement in the future would allow for management of parks and wetlands. The local community and public are stakeholders and should be consulted throughout the planning process. Their involvement in the planning process and implementation will ensure that the end result is an area that they would want to frequent and support.

Ideally, this plan would be refined and finalized prior to any decommissioning activities. As seen in the case studies, a lack of plan can mean that a site sits in limbo until all parties can come together. As evidenced in Maine, it took an outside firm to come in to achieve a development plan. The use of a consulting firm and outside specialists will be necessary in

Crystal River, but it is hoped that the City and local stakeholders can retain the majority and see their vision for the site realized. Early planning and the involvement of all parties will ensure this.

Understanding the Framework

This model is based on the assumption of a few details that are still unknown about decommissioning at the Crystal River Power Complex:

First, this model assumes that decommissioning will happen in the future, with a target date of 2040. This is based on the case study examples, as well as the closure of other plants at a certain time. At Crystal River, this date is assumed based on an extension to the current license.

Second, this model assumes that the four coal plants within the complex will also be closed prior to or in conjunction with the closure of CR3. This is based on the age of the facilities as well an increased environmental awareness in the State of Florida. This model uses the unique features and requirements of the decommissioning of the nuclear plant at Crystal River, but cooperative planning for the entire site should take place.

Third, this model assumes that there will be greater flexibility in regulated decommissioning plans in the future. This is suggested in the thesis and modeled in this plan. A level of adherence to current NRC standards is assumed, but new thinking is applied to these.

Fourth, this model assumes that there will be some continual storage or restricted areas on site, even if a federal depository opens. This is based on the understanding that this repository has and continues to be delayed in its opening and an adaptive reuse plan should take this into consideration.

Finally, this model assumes that Progress Energy Florida, like the other energy owners seen in the case studies, will release all or most of the decommissioned land for new use.

Summary

This model at Crystal River incorporates key issues that will create a direct link to the site's previous use, as well as allow for new associations. This model encourages the retention of key features of the site through preservation and the reuse of structures and elements. The inclusion of these older features creates a visual link to the past and provides a tangible connection to an earlier time. The importance of memory and history are key issues for any future plans and will make sure that the story of commercial nuclear power is preserved. Using the site in new ways will bring vibrancy to the city and illustrates how a former power site can still be a thriving part of a city. Understanding the need for new sources of employment and economic support is identified in the model. This model highlights the need for proactive planning and a gradual, phased implementation that includes all interested stakeholders.

CHAPTER 8
OBSERVATIONS

Findings, Concerns and Problems

This thesis has shown that the commercial nuclear heritage is a nationally significant part of the nation's history and advancement and deserving of appreciation and preservation. There is interest, as highlighted in the preservation precedents, on the part of the public to preserve and reuse these sites, as well as experience and tour them. These sites are integral to the economic and daily life of the communities that they are found in and planning should consider this importance.

Current decommissioning regulations are inflexible and do not allow for new thinking and approaches. The current regulations require the removal and demolition of structures and the return of the site to a pre-plant appearance. This does not allow for the preservation or reuse of buildings that are otherwise safe and could still be used. Regulations need to be changed, but this will require the public and preservationist's influence.

There has been inadequate planning for post-decommissioned commercial nuclear power plants. This is due to a lack of foresight, leadership and funding. It is not due to a lack of interest, however, and the public and local stakeholders have demonstrated interest in seeing these sites thrive. Planning typically appears to take place after the site has been fully decommissioned and released for new use. This is not the most efficient or advantageous time for this planning to take place and this thesis has found that waiting until after decommissioning prolongs the time that a site sits idle, when it could be put to another use.

There is a concern that there is no regulatory or federal agency that continues to assist these sites, following closure. Once the land has been deemed safe and released, all government agencies seem to walk away, feeling that their job has been done. This is the time when

assistance is needed, and a framework for new use developed. A post-decommissioning plan is being reinvented at each new site, but this does not have to be the case. A regulatory body could assist in the process and help each site tailor a plan that is specific to their needs.

Another concern is that post-decommissioned sites could be acquired by private developers, creating unharmonious developments, because of the lack of planning on the part of the cities in which they are sited. These former sites are often located on prime real estate and it is important to try to balance development with community interests.

There are still a number of problems to be encountered, and public resistance is the most damaging. As evidenced in Chapter 3, this resistance and anxiety is real and needs to be addressed. The power industry, as well as local agencies, needs to work to alleviate this perception of fear, before any real planning can be implemented. The proposed model at Crystal River suggests ways to counter this public perception and allow for increased access.

What Was Accomplished

There is no road map for life after decommissioning and no government agency to monitor these sites once they are released. Of the ten or so plants that have been decommissioned, it is clear that it is a rocky road that is often fraught with conflict and unforeseen issues. There are positive opportunities though, as seen in the preservation precedents of the USS Nautilus, Hanford B Reactor, Gas Works Park, and Duisburg Nord. The case studies of Maine Yankee, Big Rock Point, and Trojan Nuclear Power plant illustrate the current conundrum that sites find themselves in. A site can and should have a new life and continue to serve the community and economic base.

The Crystal River of 2008 is vastly different than it was in 1977, when CR3 first came online. Population and industry have increased and the surrounding areas in Citrus County are heavily residential and continuing to grow. It is no longer a remote location, but rather becoming

more urbanized. CR3 continues to play a major role in the city and county's economy, providing jobs and community support. The plant is ingrained in the community and a common sight to see when boating or driving throughout the city.

This plant's lifespan is finite and will end in the next decade, or a little longer if an extension is granted. It is a relatively short time and warrants attention now. Its closure will have an impact on energy production and availability, but also jobs and the way of life in the City of Crystal River. The preceding model has suggested a framework for thinking about issues that will arise at the power site, during and following decommissioning. This model raises a number of issues that can serve as a starting point for considering a new life for this site.

Our study focused on small portion of the nuclear power industry, but there are other areas where professional research should focus on. The preservation and interpretation of the Manhattan Project sites and other wartime efforts should be a key focus for the preservation field. The importance of these sites has already been acknowledged, but management is still unclear. Using interpretation and new thinking at these sites will tell a vital story of the nation's history. Research should continue to focus on these sites, and other difficult sites, and look at the opportunities and challenges that they afford.

Research and study into Nuclear Heritage Tourism and the opportunities that this affords should be considered and assessed. Tourism has already shown to be popular at wartime sites, and this may be applicable in the future at commercial nuclear sites. Looking at heritage tourism in general and how it relates to the nuclear era may find ways of bringing new visitors to sites.

Research into other areas of adaptive reuse of Brownfields and former industrial complexes can provide insight into the processes and plans needed for post-industrial sites. This

research and study will in turn inform the practices and approaches taken at nuclear power plants.

Continued research into the effects that are felt by the closure of nuclear power plants will highlight the need for planning. These effects are felt at the site as well as throughout the local community. It is important to understand how the plant's closure will affect the way of life.

LIST OF REFERENCES

Advisory Council on Historic Preservation. *National Historic Preservation Act of 1966*. Washington, D.C.: Advisory Council on Historic Preservation, 15 October 1966, as amended through 2006, accessed 22 October 2008; available from http://www.achp.gov/docs/nhpa%202008.pdf; Internet.

The American Nuclear Society. *Honors and Awards: Nuclear Historic Landmark Award*. La Grange Park, IL: The American Nuclear Society, last modified 2008, accessed 12 November 2008; available from http://www.ans.org/honors/va-nuclandmark; Internet.

The American Society of Mechanical Engineers. *Historic Achievement Recognized: Shippingport Atomic Power Station.* Shippingport, PA, 20 May 1980, accessed 20 October 2008; available from http://files.asme.org/ASMEORG/Communities/History/Landmarks/5643.pdf; Internet.

Andrews, Anthony. Congressional Research Services Report for Congress: *Nuclear Fuel Reprocessing: U.S. Policy Development*. Washington, D.C.: Congressional Research Services, updated March 27, 2008; accessed 24 October 2008, available from www.fas.org/sgp/crs/nuke/RS22542.pdf; Internet.

Associated Press. *Washington: Reactor Now a Landmark*. New York, NY: The New York Times, 26 August 2008, accessed 12 November 2008, available from http://www.nytimes.com/2008/08/26/us/26brfs-REACTORNOWAL_BRF.html?_r=3&emc=tnt&tntemail1=y&oref=slogin&oref=slogin&oref=slogin; Internet.

Blackett, P.M.S. *Fear, War, and the Bomb: Military and Political Consequences of Atomic Energy*. New York, NY: Whittlesey House, 1949.

Boing, L.E. *Beneficial Re-Use of Decommissioned Former Nuclear Facilities*. Argonne, IL: Argonne National Laboratory, June 1997, accessed 28 September 2008; available from http://www.osti.gov/bridge/servlets/purl/16141-3Q9VcA/native/16141.pdf; Internet.

Brehmer, Berndt and Nils-Eric Sahlin, ed. Future Risks and Risk Management. Boston, MA: Kluwer Academic, 1994.

Brown, Martin John. "From Nuclear Fuel to Nature Trails." Paonia, CO: High Country News, Vol. 32, Issue 22, 20 November 2000, accessed 12 November 2008; available from http://martinjohnbrown.net/trojan-st-park.pdf; Internet.

Bureau of Remediation & Waste Management, State of Maine. *Maine Yankee Chronology*. Augusta, ME: Bureau of Remediation & Waste Management, 2005, accessed 24 October 2008; available from http://maine.gov/dep/rwm/myankee/chronology.htm; Internet.

Burger, Edward J., ed. Risk. Ann Arbor, MI: University of Michigan, 1990.

Bush, President George W. *Report of the National Energy Policy Development Group*, Report # A171293, May 2001.

The Chewonki Foundation, *Nature Preserves & Trails*. Wiscasset, ME: The Chewonki Foundation, last modified 2008, accessed 24 October 2008; available from http://www.chewonki.org/about/nature_trails.asp; Internet.

CH2MHill. *Maine Yankee Atomic Power Plant Decommissioning.* Englewood, CO: CH2MHill, last modified 2008, accessed 24 October 2008; available from http://www.ch2m.com/corporate/services/decontamination_and_decommissioning/assets/ProjectPortfolio/MaineYankee.pdf; Internet.

Citrus Country Chamber of Commerce. *Demographics.* Inverness, FL: Citrus County Chamber of Commerce, 2005-2007, accessed 20 October 2008; available from http://www.citruscountychamber.com/index.php?option=com_content&task=view&id=37&Itemid=39; Internet.

City of Crystal River. *City of Crystal River History*. Crystal River, FL: City of Crystal River, Florida, last modified 2008, accessed 20 October 2008; available from http://www.crystalriverfl.org/index.asp?Type=B_BASIC&SEC=%7B04D7A3C3-E282-4C21-91AC-2C0200330D81%7D; Internet.

City of Crystal River. *The City of Crystal River Community Redevelopment Agency: Background.* Crystal River, FL: City of Crystal River, Florida, last modified 2008, accessed 12 November 2008; available from http://www.crystalriverfl.org/index.asp?Type=B_BASIC&SEC=%7B75E8AE31-46C9-4E44-912D-7E76D787C2A3%7D; Internet.

City of Seattle, Washington, Seattle Parks and Recreation. *Gas Works Park*. Seattle, WA: City of Seattle, Washington, 2005-2008, accessed 22 October 2008; available from http://www.seattle.gov/parks/park_detail.asp?id=293; Internet.

Cumo, Maurizio. *Experiences and Techniques in the Decommissioning of Old Nuclear Power Plants*. Rome, Italy: University of Rome, 2002, accessed 24 October 2008; available from http://users.ictp.trieste.it/~pub_off/lectures/lns020/Cumo/Cumo.pdf; Internet.

Duderstadt, James J. *Nuclear Power*. NewYork, NY: Marcel Dekker, 1979.

Energy Information Administration. *100 Largest Electric Plants*. Washington, D.C.: Energy Information Administration, 2005, last reviewed January 2008, accessed 22 October 2008; available from http://www.eia.doe.gov/neic/rankings/plantsbycapacity.htm; Internet.

Fitch, James Marston. *Historic Preservation: Curatorial Management of the Built World*, 4th ed. Charlottesville, VA: University Press of Virginia, 1998.

Florida Division of Parks and Recreation. *Crystal River Archaeological State Park*. Tallahassee, FL: Florida Division of Parks and Recreation, last modified 2008, accessed 24 October 2008; available from "http://www.floridastateparks.org/crystalriver/ParkSummary.cfm; Internet.

Florida Division of Parks and Recreation. *Homosassa Springs Wildlife State Park*. Tallahassee, FL: Florida Division of Parks and Recreation, last modified 2008, accessed 22 October 2008; available from http://www.floridastateparks.org/homosassasprings/ParkSummary.cfm; Internet.

Florida Fish and Wildlife Conservation Commission. *Crystal River Mariculture Center*. St. Petersburg, FL: Florida Fish and Wildlife Conservation Commission, last modified 2008, accessed 22 October 2008; available from http://research.myfwc.com/features/view_article.asp?id=10469; Internet.

Gibbs, Paula. "Dome to Disappear Friday, Sept. 17." Boothbay Harbor, ME: Boothbay Register, 09 September 2004, Vol. 127, Number 37, accessed 12 November 2008; available from http://boothbayregister.maine.com/2004-09-09/dome_to_disappear.html; Internet

Hales, Peter Bacon. *Atomic Spaces: Living on the Manhattan Project.* Chicago, IL: University of Illinois, 1997.

Historic Ship Nautilus and Submarine Force Museum. *History of USS Nautilus SSN571*. Groton, CT: Historic Ship Nautilus and Submarine Force Museum, 2004, accessed 22 October 2008; available from http://www.ussnautilus.org/history.html; Internet.

Hoey, Dennis. "Wiscasset Starts Something Big." Portland, ME: Portland Press Herald, 27 July 2006, accessed 12 November 2008; available from http://www.pointeastmaine.com/news_WiscassetStartsBig.html; Internet.

International Atomic Energy Agency. *The "Atoms for Peace" Agency*. Vienna, Austria: International Atomic Energy Agency, last modified 2008, accessed 28 September 2008; available from http://www.iaea.org/About/index.html; Internet.

International Atomic Energy Agency. "Nuclear Power Worldwide: Status and Outlook." Chevy Chase, MD: Science Daily, 24 October 2007, accessed 28 September 2008; available from http://www.sciencedaily.com/releases/2007/10/071023103052.htm; Internet.

The Internet Movie Database. *The China Syndrome*. Seattle, WA: The Internet Movie Database, 1990-2008, accessed October 30 2008; available from http://www.imdb.com/title/tt0078966/business; Internet.

Jimmy Carter Library, Records of the Speech Writer's Office, *Statement on Nuclear Power Policy*, April 7, 1977.

Johnson, Charles W. and Charles O. Jackson. *City Behind A Fence: Oak Ridge, Tennessee, 1942-1946.* Knoxville, TN: University of Tennessee, 1981.

Jones, Cynthia G, U.S. NRC. *NUREG/BR-0256: The U.S. Nuclear Regulatory Commission and How It Works*. Washington, D.C.: United States Nuclear Regulatory Commission, August 2000, accessed 12 November 2008; available from http://www.nrc.gov/reading-rm/doc-collections/nuregs/brochures/br0256/; Internet.

Landschaftspark. *Duisburg-Nord Country Park- The Park- Evolution*. Duisburg, Germany: Landschaftspark, 23 May 2005, accessed 22 October 2008; available from http://www.landschaftspark.de/en/derpark/entstehung/index.html; Internet.

Lillington, John. *The Future of Nuclear Power*. New York, NY: Elsevier, 2004.

MacIntosh, Heather. Preservation Seattle. *Gas Works Park*. Seattle, WA: Preservation Seattle, 26 November 2005, accessed 22 October 2008; available from http://www.historicseattle.org/preservationseattle/preservationenv/defaultnovember.htm; Internet.

Maine Yankee. *Maine Yankee*. Wiscasset, ME: Maine Yankee, last modified 16 September 2008, accessed 22 October 2008; available from http://www.maineyankee.com/; Internet.

Martin, Jonathan. "Vestige of Region's Nuclear Designs to be Imploded Sunday Morning." Seattle, WA: The Seattle Times, 19 May 2006, accessed 12 November 2008; available from http://community.seattletimes.nwsource.com/archive/?date=20060519&slug=trojan19m. Internet.

Murtagh, William J. *Keeping Time: The History and Theory of Preservation in America*, 3rd ed. Hoboken, NJ: John Wiley & Sons, 2006.

National Park Service. *Standards for Preservation and Guidelines for Preserving Historic Buildings*. Washington, D.C.: National Park Service, 31 July 2006, accessed 7 October 2008; available from http://www.nps.gov/hps/tps/standguide/preserve/preserve_index.htm; Internet.

National Park Service. *Standards for Restoration*. Washington, D.C.: National Park Service, 31 July 2006, accessed 7 October 2008; available from http://www.nps.gov/hps/tps/standguide/restore/restore_standards.htm; Internet.

National Park Service. *Rehabilitating*. Washington, D.C.: National Park Service, 31 July 2006, accessed 7 October 2008; available from http://www.nps.gov/hps/tps/standguide/rehab/rehab_index.htm; Internet.

National Park Service. *National Historic Landmarks Program.* Washington, D.C.: National Park Service, last updated 03 November 2008, accessed 12 November 2008; available from http://www.nps.gov/history/nhl/; Internet.

National Park Service. *National Register of Historic Places.* Washington, D.C.: National Park Service, last modified 28 October 2008, accessed 12 November 2008; available from http://www.nps.gov/nr/about.htm; Internet.

National Park Service. *Questions and Answers.* Washington, D.C.: National Park Service, last updated 22 October 2008, accessed 12 November 2008; available from http://www.nps.gov/nhl/QA.htm; Internet.

Nature Coast Coalition. *Discover Florida's Nature Coast*. Brooksville, FL: Nature Coast Coalition, last modified 4 September 2008, accessed 24 October 2008; available from http://www.naturecoastcoalition.com/; Internet.

Nealey, Stanley M., Barbara D. Melber and William L. Rankin. *Public Opinion and Nuclear Energy.* Lanham, MD: Lexington Books, 1983.

New South Associates. *Cultural Resources Background Research Supporting License Renewal, Crystal River Nuclear Plant, Citrus and Levy Counties, Florida.* St. Augustine, FL: New South Associates, December 19, 2006, accessed 20 October 2008; available from http://www.dep.state.fl.us/siting/Highlights/Applications/PPSA/Crystal%20River%20Unit%203/Application/Appendices%2010.2_10.3_Citrus%20County.pdf; Internet.

Nuclear Energy Agency, *Nuclear Energy: Communicating with the Public.* Paris, France: OECD, 1991.

Nuclear Energy Agency, *Nuclear Power and Public Opinion.* Paris, France: OECD, 1984.

Nuclear Energy Institute. *Nuclear Power Plant License Renewal*. Washington, D.C.: Nuclear Energy Institute, February 2008, accessed 20 October 2008; available from: http://www.nei.org/keyissues/reliableandaffordableenergy/factsheets/plantlicenserenewalpage2; Internet.

Nuclear Information and Resource Service. *Press Statement, November 30, 2006*. Takoma Park, MD: Nuclear Information and Resource Service, 30 November 2006, accessed 22 October 2008; available from http://www.nirs.org/press/11-30-2006/2; Internet.

Oregon Department of Energy. *Review of PGE's Decommissioning Plan for the Trojan Nuclear Plant*. Salem, OR: Oregon Department of Energy, 22 January 1996, accessed 23 September 2008; available from http://www.oregon.gov/ENERGY/SITING/docs/decom.pdf; Internet.

Pasqualetti, Martin J. ed. Nuclear Decommissioning and Society: Public Links to a New Technology. New York, NY: Routledge, 1990.

Portland General Electric. *Trojan Demolition*. Portland, OR: Portland General Electric, last modified 2008, accessed 22 October 2008; available from http://www.portlandgeneral.com/about_pge/corporate_info/trojan/; Internet.

President Dwight D. Eisenhower. "Atoms For Peace" speech delivered to the United Nations General Assembly, New York City, NY, December 8, 1953, accessed 28 September 2008; available from http://www.eisenhower.archives.gov/atoms.htm; Internet.

Progress Energy. *Progress Energy Florida names potential nuclear plant site in Levy County*. St. Petersburg, FL: Progress Energy, last modified 2008, accessed 24 October 2008; available from http://www.progress-energy.com/aboutenergy/poweringthefuture_florida/levy/index.asp; Internet.

Sanger, S.L. *Hanford and the Bomb*. Seattle, WA: Living History, 1989.

Shoichet, Catherine E. "Nuclear Plant Idea Has Support." St. Petersburg, Florida: St. Petersburg Times, 9 October 2005, accessed 12 November 2008; available from http://www.sptimes.com/2005/10/09/Citrus/Nuclear_plant_idea_ha.shtml; Internet.

Sotheby's International Realty Affiliates, Inc, Point East. *I.Park*. Wisscasset, ME: Sotheby's International Realty Affiliates, Inc, 2007, accessed on 22 October 2008; available from http://www.pointeastmaine.com/ipark.html; Internet.

State of Oregon. *Energy Facility Siting: Trojan Nuclear Plant*. Rainer, OR: State of Oregon, last updated 01 August 2007, accessed 23 September 2008; available from http://www.oregon.gov/ENERGY/SITING/TRO.shtml; Internet.

Stipe, Robert E., ed. A Richer History: Historic Preservation in the Twenty-First Century. Chapel Hill, NC: The University of North Carolina, 2003.

Suppes, Galen and Truman Storvick. *Sustainable Nuclear Power*. Boston, MA: Elsevier/Academic Press, 2006.

Thayer Jr., Robert L. *Gray World, Green Heart*. New York, N.Y: John Wiley & Sons, 1994.

Time Magazine. "Yankee, Yes." New York, NY: Time Magazine, 6 October 1980, last modified 2008, accessed 24 October 2008; available from http://www.time.com/time/magazine/article/0,9171,954555,00.html; Internet.

Tri-City Industrial Development Council. *Hanford's Historic Reactor*. Kennewick, WA: Tric-City Industrial Development Council, last modified 23 October 2007, accessed 22 October 2008; available from http://www.tridec.org/ftphome/Hanford%20B%20Reactor.htm; Internet.

Tomkins, Betsy. "Big Rock Point: From Groundbreaking to Greenfield." La Grange Park, IL: Nuclear News, November 2006, accessed 22 October 2008; available from http://www.ans.org/pubs/magazines/nn/docs/2006-11-3.pdf; Internet.

Tulloch, John and Deborah Lupton. *Risk and Everyday Life*. Thousand Oaks, C.A.: Sage Publications, 2003.

Tyler, Norman. *Historic Preservation: An Introduction to Its History, Principles, and Practice*, 2nd ed. New York, N.Y.: W.W. Norton & Company, 2000.

U.S. Census Bureau. *2005 U.S. Census*. Washington, D.C.: United States Census Bureau, last modified 20 June 2006, accessed 20 October 2008; available from http://www.census.gov/popest/cities/tables/SUB-EST2005-04-12.csv; Internet.

U.S. Department of Energy. *Civilian Control of Atomic Energy, 1945-1946.* Washington, D.C.: United States Department of Energy, last modified 2 April 2007, accessed 20 October 2008; available from http://www.cfo.doe.gov/me70/manhattan/civilian_control.htm; Internet.

U.S. Department of Energy. *Origins & Evolution of the Department of Energy*. Washington, D.C.: United States Department of Energy, last modified 19 June 2008, accessed 28 September 2008; available from http://www.energy.gov/about/origins.htm; Internet.

U.S. Department of Energy. *About Doe*. Washington, D.C.: United States Department of Energy, last modified 23 October 2008, accessed 28 September 2008; available from http://www.energy.gov/about/index.htm; Internet.

U.S. Department of Energy. *The National Repository at Yucca Mountain*. Washington, D.C.: United States Department of Energy, last modified 06 October 2008, accessed 24 October 2008; available from http://www.ocrwm.doe.gov/; Internet.

U.S. Department of Energy. *France's Radioactive Waste Management Plan*. Washington, D.C.: United States Department of Energy, June 2001; accessed 23 October 2008; available from http://www.ocrwm.doe.gov/factsheets/doeymp0411.shtml; Internet.

U.S. Fish & Wildlife Service. *Chassahowitzka National Wildlife Refuge*. Crystal River, FL: United States Fish and Wildlife Service, last updated 7 August, 2008, accessed 24 October 2008; available from http://www.fws.gov/chassahowitzka/; Internet.

U.S. Fish & Wildlife Service. *Crystal River National Wildlife Refuge*. Crystal River, FL: United States Fish and Wildlife Service, last updated 14 august 2008, accessed 24 October 2008; available from http://www.fws.gov/crystalriver/; Internet.

U.S. Maritime Administration. *NS Savannah*. Washington, D.C.: United States Maritime Administration, last modified 2008, accessed 20 October 2008; available from https://voa.marad.dot.gov/programs/ns_savannah/index.asp; Internet.

United States Navy. *The Submarine*. Washington, D.C.: United States Navy, last updated 30 July 2008, accessed 20 October 2008; available from http://www.navy.mil/navydata/ships/subs/subs.asp; Internet.

U.S. NRC. *Licensing Process for the Yucca Mountain Geologic Repository*. Washington, D.C.: United States Nuclear Regulatory Commission, 24 June 2008, accessed 28 September 2008; available from http://www.nrc.gov/waste/hlw-disposal/licensing/licensing-process.html; Internet.

U.S. NRC. *Regulatory Guide 4.7: General Site Suitability Criteria for Nuclear Power Stations, April 1998*. Washington, D.C.: United States Nuclear Regulatory Commission, 15 February 2007, accessed 28 September 2008; available from http://www.nrc.gov/reading-rm/doc-collections/reg-guides/environmental-siting/active/04-007/#_1_1; Internet.

U.S. NRC. *Decommissioning of Nuclear Facilities: What We Regulate.* Washington, D.C.: United States Nuclear Regulatory Commission, 26 September 2008, accessed 22 October 2008; available from http://www.nrc.gov/about-nrc/regulatory/decommissioning.html; Internet.

U.S. NRC. *Decommissioning Process*. Washington, D.C.: United States Nuclear Regulatory Commission, 17 April 2007, accessed 22 October 2008; available from http://www.nrc.gov/about-nrc/regulatory/decommissioning/process.html; Internet.

U.S. NRC. *Glossary*. Washington, D.C.: United States Nuclear Regulatory Commission, 05 June 2007, accessed 22 October 2008; available from http://www.nrc.gov/reading-rm/basic-ref/glossary.html; Internet.

U.S. NRC. *Financial Assurance for Decommissioning*. Washington, D.C.: United States Nuclear Regulatory Commission, 17 April 2007, accessed 22 October 2008; available from http://www.nrc.gov/about-nrc/regulatory/decommissioning/finan-assur.html; Internet.

U.S. NRC. *Fact Sheet on the Three Mile Island Accident*. Washington, D.C.: United States Nuclear Regulatory Commission, 20 February 2007, accessed 1 October 2008; available from http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/3mile-isle.html; Internet.

U.S. NRC. *Big Rock Point*. Washington, D.C.: United States Nuclear Regulatory Commission, 21 February 2007, accessed 23 October 2008; available from http://www.nrc.gov/info-finder/decommissioning/power-reactor/big-rock-point.html, Internet.

U.S. NRC. *Status of License Renewal Applications and Industry Activities*. Washington, D.C.: United States Nuclear Regulatory Commission, 03 November 2008; accessed 20 October 2008; available from http://www.nrc.gov/reactors/operating/licensing/renewal/applications.html; Internet.

U.S. NRC. *Backgrounder on New Nuclear Plant Designs*. Washington, D.C.: United States Nuclear Regulatory Commission, 10 June 2008, accessed 12 November 2008; available from http://www.nrc.gov/reading-rm/doc-collections/fact-sheets/new-nuc-plant-des-bg.html; Internet.

Wildavsky, Aaron and Karl Drake. *Theories of Risk Perception: Who Fears What and Why?* Ann Arbor: University of Michigan Press, 1993.

World Nuclear Association. *Nuclear Power Reactors*. London, England: World Nuclear Association, June 2008, accessed 28 September 2008; available from http://www.world-nuclear.org/info/inf32.html, Internet.

World Nuclear Association. *Outline History of Nuclear Energy*. London, England: World Nuclear Association, September 2005, accessed 28 September 2008; available from http://www.world-nuclear.org/info/inf54.htm; Internet.

World Nuclear Association. *Processing of Used Nuclear Fuel for Recycle*. London, England: World Nuclear Association, October 2008, accessed 20 October 2008; available from http://www.world-nuclear.org/info/inf69.html; Internet.

.

BIOGRAPHICAL SKETCH

Elizabeth Farrow graduated cum laude with a Bachelor of Arts in art history and museum studies from Connecticut College, New London, Connecticut. After graduation she worked at the Florence Griswold Museum in Old Lyme, Connecticut, overseeing the refurnishing of the Griswold House, a National Historic Landmark. While at the University of Florida, Elizabeth attended Preservation Institute: Nantucket and graduates with a Master of Science in architectural studies and a concentration in historic preservation. She hopes to assist small towns with their preservation and history efforts.