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Entergy's Legacy of Contamination at Pilgrim Nuclear Power Station

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July 2017

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ACRONYMS

µGy	Microgray
ALARA	As Low As Reasonably Achievable
BEIR VII	Seventh Biological Effects of Ionizing Radiation (National Academies of Science 2005 report)
Cr(VI)	Hexavalent chromium
DOE	U.S. Department of Energy
EPA	U.S. Environmental Protection Agency
FEMA	Federal Emergency Management Agency
Gpd	gallons per day
H-3	Tritium
IARC	International Agency for Research on Cancer
ISFSI	Independent Spent Fuel Storage Installation
JRWA	Jones River Watershed Association
LLRW	low-level radioactive waste
LTR	License Termination Rule
MassDEP	Massachusetts Department of Environmental Protection
MassDPH	Massachusetts Department of Public Health
MCL	Maximum Contaminant Level
MCLG	Maximum Contaminant Level Goal
MEMA	Massachusetts Emergency Management Agency
MERL	Massachusetts Environmental Radiation Lab
mg/L	Milligram/Liter
mGy	Milligray
MOU	Memorandum of Understanding
Mrem	Millirem
NEI	Nuclear Energy Institute
NOAA	National Oceanic and Atmospheric Administration
NOAA Fisheries	National Oceanic and Atmospheric Administration's National Marine Fisheries Service
NRC	Nuclear Regulatory Commission
PCA	Plymouth-Carver Aquifer
pCi/L	picocuries per liter
PSDAR	Post Shutdown Decommissioning Activities Report
Rd	Rad
REMP	Radiological Environmental Monitoring Report

EXECUTIVE SUMMARY

Entergy's Pilgrim Nuclear Power Station is sited on the shore of Cape Cod Bay and above the Plymouth-Carver Sole Source Aquifer. Pilgrim has been releasing radioactive materials and other contaminants deliberately and accidentally into groundwater, surface water, and soils since it began generating electricity in 1972. Leaks of tritium have been documented since voluntary monitoring began in 2007 and leaks are still ongoing today. This report summarizes radiological contamination at Pilgrim, from both routine releases and accidental leaks.

Entergy announced that Pilgrim will shut down no later than May 31 2019, and is planning to refuel one last time in spring 2017. The Nuclear Regulatory Commission will allow Entergy to choose from a variety of strategies for decommissioning. The most common strategy is long-term "SAFSTOR," a process that would allow Entergy defer full decommissioning and cleanup of Pilgrim for up to 60-years. Under SAFSTOR, ongoing leaks and environmental contamination may not be fully addressed for 60 years. Contamination is currently migrating toward Cape Cod Bay and it will continue to do so. Pilgrim's location directly on the shoreline makes it increasingly vulnerable to climate change and sea level rise impacts, meaning more challenges for site cleanup and flushing of contaminants into the surrounding environment. With closure imminent, it is more important than ever to understand the extent of Pilgrim's environmental contamination. An independent site assessment and decontamination plan that goes beyond the inadequate NRC standards is needed. Along with radioactive contamination, cleanup plans should include Pilgrim's wastewater treatment plant leaching field and the reported chemical waste dumping site on the property. Regulators and elected officials need to step up oversight and ensure that the cleanup schedule is accelerated and decontamination is not postponed for 60 years. Pilgrim's buildings and structures are expected to be rubblized, but these should not be allowed to be buried on site where coastal impacts could continue to leach contaminants into Cape Cod Bay. Concrete remains should be tested for a wide range of pollutants and disposed of in an appropriate and safe manner that protects people and the environment.

Additionally, Entergy has built a dry cask storage facility very close to the shoreline and sea level, where large concrete "dry casks" will house highly toxic nuclear waste indefinitely on site. This precariously located storage area is currently within reach of rising tides, coastal storms, and saltwater degradation – creating a potential source of further radioactive waste contamination, long after Pilgrim shuts down. It is essential that this nuclear waste dry cask storage facility be made more robust, moved to a higher elevation farther away from Cape Cod Bay and securely protected from natural and man-made hazards, including acts of terror, until it can be shipped offsite. Although the Department of Energy is working to develop "interim and long-term

storage" for radioactive waste, none exist today. This hazardous material may remain in Plymouth for decades to thousands of years.

The legacy that Pilgrim leaves behind is one of stranded nuclear waste and radioactive contamination that will, at best, be managed but likely never completely cleaned up. In order to achieve the best result, it is critical that regulators and our elected officials ensure transparency and public participation in all phases of environmental cleanup at Pilgrim.

I. INTRODUCTION

> ***Radioactive discharges from Pilgrim pose a regional threat to environmental quality, human health and the health of Cape Cod Bay's ecosystem. Discharges of radioactive tritium into groundwater pose a threat to Plymouth's sole-source aquifer and Cape Cod Bay's water quality and ecosystems." – Association to Preserve Cape Cod Position Statement, 2014.***

This report documents ongoing radiological contamination of the environment by Entergy Nuclear Generation Company's[1] (Entergy) Pilgrim Nuclear Power Station (Pilgrim) in Plymouth, Massachusetts. It also identifies issues to be addressed during the facility's decommissioning, set to begin in May 2019. While Pilgrim discharges a variety of pollutants into the surface waters of Cape Cod Bay, groundwater, soil and air, this report focuses on Entergy's radioactive discharges. These discharges are part of routine operations and from unlicensed spills, leaks, and accidents, which have contaminated groundwater and soils at the site and are flowing into Cape Cod Bay.

Pilgrim has operated for 44 years, affecting the health of people and the environment of the region. Pilgrim's discharge of radioactive materials should cease and permits allowing for such discharges should be terminated. During decommissioning, heightened monitoring of potential radiological contamination from demolishing structures and rubblization or burying of contaminated concrete is needed. This is especially true as stormwater runoff is likely to increase as flooding increases and sea levels and groundwater levels rise as a result of global warming. Existing yard drains could increasingly become conduits for pollution into Cape Cod Bay. An accelerated time schedule should be set for the decommissioning process and a robust monitoring program will be a critical to direct a thorough cleanup of the site.

There are two kinds of radioactive materials: naturally-existing background radiation and man-made radiation not found in nature, such as iodine-131, cesium-137, cesium-134, colbalt-60, and manganese-54. Tritium, a radioactive isotope of hydrogen, is generated both naturally in the

atmosphere and by nuclear reactions that are brought about through man-made processes. Exposure to man-made radiation, like Pilgrim's, can cause damage to the human body, including harmful genetic mutations, cancers, benign tumors, cataracts, birth defects, and reproductive, immune and endocrine system disorders. These impacts can affect humans as well as plants and wildlife.

Known lethal radionuclides being discharged to the environment intentionally and accidentally by Pilgrim include tritium, manganese-54, cesium-137, and cobalt-60. There are several reports showing "footprints" of radiation-linked diseases in communities near Pilgrim.[2]

The National Academies of Science published a report in 2005 about health effects of low levels of ionizing radiation.[3] The report, called BEIR VII (seventh Biological Effects of Ionizing Radiation), found that there is no safe level of radiation and even very low doses can cause cancer and other, non-cancer effects such as heart disease. Exposure to radioactivity over time, no matter how little, increases cancer risk, according to the World Health Organization's International Agency for Research on Cancer (IARC).[4] The conclusion is simple: no amount of radiation is safe.

Furthermore, the ecological health of flora and fauna has been completely ignored. While Entergy is required to conduct some sampling of radioactive materials in certain plants and fish around Pilgrim, this is only done to determine whether concentrations are safe for people who might be exposed by consuming contaminated food or water. There is no evaluation of harm to plant and animals themselves. There have been no assessments of the cumulative impacts from more than forty years of radiological emissions on local flora and fauna, including reproductive impacts or genetic changes.

This report also covers:

- Plans for long-term storage of high-level radioactive waste (spent nuclear fuel) at Pilgrim;
- current unsafe storage of so-called "low level radioactive waste" on site;
- issues with Pilgrim's industrial wastewater treatment facility;
- and reported "midnight dumping" of pollutants on the Pilgrim property.

State and federal governments have failed to provide a comprehensive overview of the issues that need to be addressed, and so the job has been largely left to citizen activists. We have made every effort to ensure that the information in this draft report is accurate and up-to-date, and welcome any comments and feedback at info@capecodbaywatch.org.

II. Pilgrim: Background and History

Entergy's Pilgrim plant is a Mark I "boiling water reactor" made by General Electric. This is the same design as the nuclear reactors that melted down during Japan's Fukushima Dai-ichi nuclear disaster in 2011.

Pilgrim is a merchant plant that has the capacity to produce up to 690 megawatts of electricity, which it sells to the New England electric grid, or ISO-New England. Boston Edison began construction of Pilgrim in 1967 and operations began in 1972 after the predecessor to the U.S. Nuclear Regulatory Commission (NRC), the Atomic Energy Commission, issued Boston Edison an operating license. The license was transferred to Entergy when it purchased Pilgrim in 1999.

Pilgrim has operated continuously since 1972, except for a long-term shutdown from April 1986 to January 1989 caused by a series of mechanical failures and a multitude of short-term emergency shutdowns, or SCRAMS, over the decades.[5]

Pilgrim is one of the worst performing commercial nuclear reactors in the U.S. In 1982, the NRC penalized Boston Edison $550,000 for violating regulations. In 1986, Pilgrim was ranked as one of the most unsafe reactors in the U.S., out of approximately 100 plants. Despite Pilgrim's deteriorated condition and poor safety record, in 2012 the NRC extended Pilgrim's operating license until 2032. The next year, in 2013, the NRC downgraded Pilgrim again due to operating failures and ranked it among one of the 22 worst performing reactors. Pilgrim was then placed under heightened federal oversight, which still continues today. In 2014, the NRC again downgraded Pilgrim's status to one of the 10 worst performing reactors. By 2015, Pilgrim was degraded yet again to a "Category IV" plant by the NRC – placing it in the bottom two performing plants in the nation. This most recent downgrade was based on numerous forced shutdowns and equipment failures, and is just one step away from mandatory shutdown by federal regulators. Only one other plant is currently in Category IV: Arkansas Nuclear. Like Pilgrim, this is an Entergy-owned facility.

In October 2015, Entergy announced that Pilgrim will close no later than May 31, 2019. Entergy could choose the "SAFSTOR" method of decommissioning, which will be a critical time when motoring environmental impacts and risks should be diligently pursued (see Section VII for more about decommissioning).

Since the closure announcement, Pilgrim has continued to be plagued by numerous equipment malfunctions and shutdowns. In 2016 alone, Pilgrim has experienced problems including ocean water too warm to provide required cooling, valve malfunctions in the condenser, a hydrogen leak in the turbine building, and falsified fire-watch reporting. The plant was shut down for nearly two weeks in September 2016 for a series of mishaps.

To top it off, Entergy recently requested to delay implementation of critical safety upgrades at Pilgrim until December 2019 – more than two years after the NRC's deadline for compliance, and about six months after Pilgrim's scheduled closure. After the Fukushima nuclear disaster in 2011, and because Pilgrim is the same design as the Fukushima reactors, the NRC recommended a series of safety upgrades, including installation of "hardened containment vents." These vents would help prevent radioactive release to the local environment if an accident were to occur. It was known before Pilgrim started operations in 1972 that its Mark I design was flawed and the containment structure was too small. The hardened vents are intended to overcome this design flaw. In late September, a Massachusetts Delegation, including Senators Markey and Warren and a long list of congressional representatives called on the NRC to reject Entergy's extension request. The issue is still pending.

Despite heightened NRC oversight triggered by the 2015 Category IV ranking, delayed safety upgrades, and continued mechanical problems and unplanned shutdowns, Pilgrim continues to operate. The NRC is currently carrying out the first of two intensive site inspections (Dec. 2016 and Jan. 2017) to review Pilgrim's status relative to these past problems. The twenty-person inspection team will be reviewing the plant's physical state and staff performance.

It is time for the NRC to shut Pilgrim down and begin decommissioning now, rather than allow it to shut down on its own accord in 2019.

1. Location and Coastal Impacts

Pilgrim is located on the shore of Cape Cod Bay in Plymouth, Massachusetts, close to sea level. The coastal zone in which Pilgrim sits is subject to many coastal hazards, specifically those associated with sea level rise, flooding, storm surge and nor'easters (Figure 1).[6]

Entergy's property in Plymouth consists of approximately 1,700 acres of land,[7] ranging from sea level to nearly 300 feet above mean sea level.[8] It consists of about one mile of ocean frontage on Cape Cod Bay. Since 1970, Cape Cod Bay has been designated as an Ocean Sanctuary by the State of Massachusetts and is supposed to be protected from any activity that alters or endangers its ecology.[9]

Some of Pilgrim's critical infrastructure is located in Cape Cod Bay itself, including its cooling water intake structure, discharge channel, and jetties (Figure 2). The reactor building structure and foundation reach more than 30-40 feet below ground.[10]

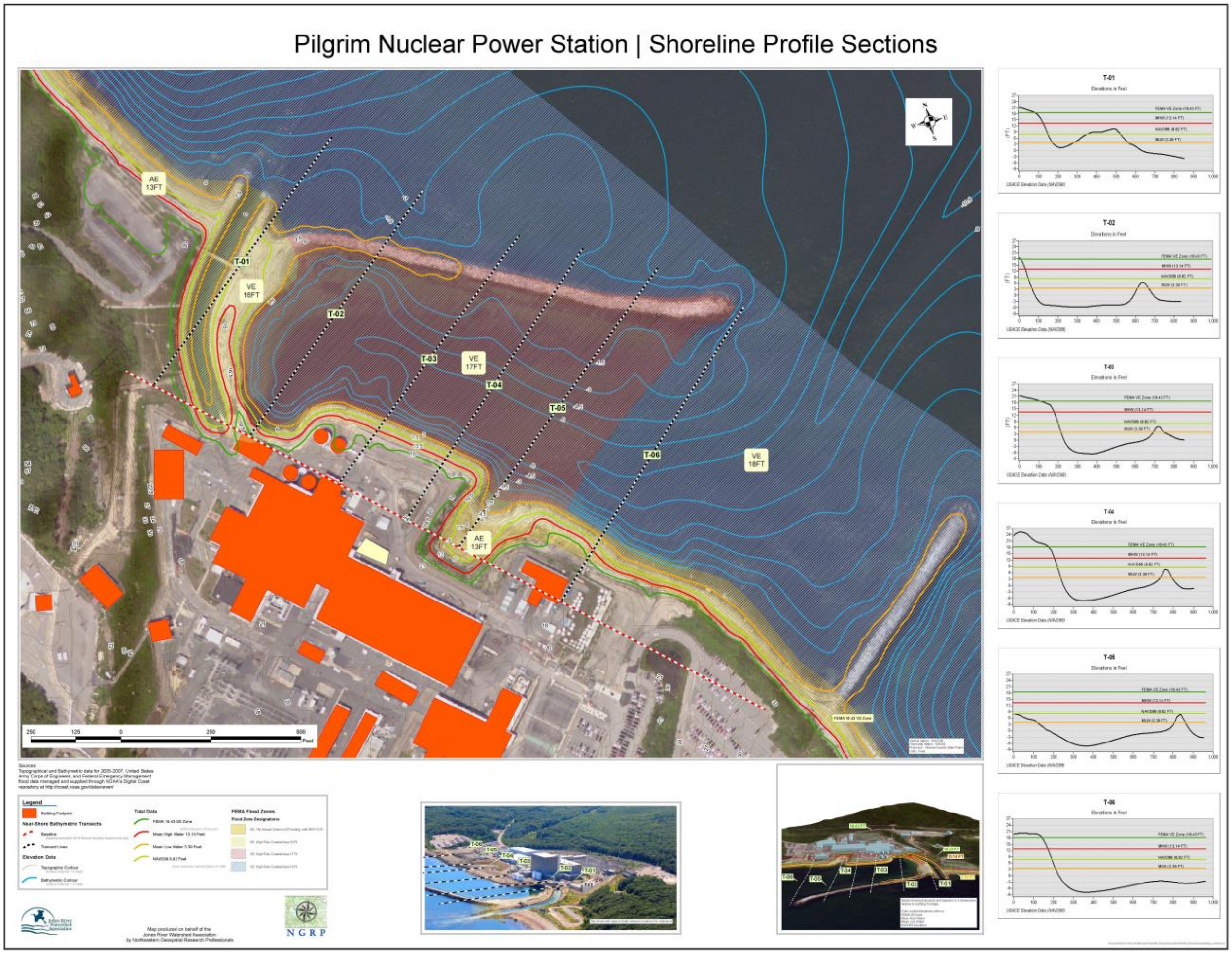

Figure 1. One of several maps developed by NGRP and JRWA as part of an elevation analysis of the Pilgrim Site. This map in particular shows that several surveyed locations reported by Entergy do not match current modeled elevation data, and that the protective jetty at the top of the map could be over-washed in several locations.

In order to maintain these structures, Pilgrim performs periodic maintenance and dredging in the waters of Cape Cod Bay – a public trust resource. After the 9/11 terrorist attacks in New York and Washington, Pilgrim was permitted to exclude public access to an area around its boundary, eventually set at 500 yards.[11] These activities impact the Ocean Sanctuary as well as the use of public "tidelands" under Massachusetts law.

Pilgrim is sited above the Plymouth-Carver Sole Source Aquifer (PCA).[12] The PCA is the second largest aquifer in Massachusetts and provides drinking water to seven towns.[13] The PCA was designated as a "sole source" drinking water aquifer by the U.S. Environmental Protection Agency (EPA) in 1990 at the request of the Massachusetts Department of Environmental Protection (MassDEP) under the Federal Safe Drinking Water Act. The coarse-grained soil, sand and gravel glacial outwash deposits that comprise the PCA are highly permeable and more susceptible to infiltration and migration of contaminates than less permeable soils. A number of private wells

are located near Pilgrim, as are agricultural lands. Although some limited radiation monitoring has been performed in years past, these efforts have been reduced.

Given that Pilgrim will shut down by May 31, 2019, it is more important than ever to fully understand the risks associated with coastal hazards. Pilgrim's nuclear waste storage areas are currently located close to the shoreline. These areas are vulnerable to storm surge, rising sea levels, flooding, salt water degradation, and other coastal risks – raising concerns about potential accidents, leaks, and impacts to the health of Cape Cod Bay (see Section VI for more about waste storage).

Figure 2. Pilgrim Nuclear Power Station, showing jetties, cooling water intake canal (center), and discharge channel (right). (Photo: Marc Costa/CCS/Light Hawk)

Coastal impacts could also undermine successful remediation of contaminants on the site. Pilgrim has been releasing radioactive materials and other contaminants deliberately and accidentally into groundwater, surface water, and soils since it began operating in 1972. As sea levels increase, so do adjacent groundwater elevations. Contamination present on Pilgrim's site will, no doubt, continue to migrate toward Cape Cod Bay even after Pilgrim stops generating power (see Section VII for more about decommissioning).

III. Radiological Standards and Limits

The harmful impacts of extremely hazardous, radiation-releasing isotopes to the public and environment have not been adequately addressed by federal, state or local officials. Federal and

state agencies are responsible for protecting public health and the environment from Pilgrim's radioactive emissions, yet risk and dose limits of the wide array of contaminants leave doubt that the limits are actually protective, given the high incidence of cancers and blood disease in the local region.

Various terms like "risk standards" and "dose limits" are used in order to deflect public concern about the toxic effects of Pilgrim's man-made radioactive emissions that have been released into the environment on an ongoing basis since 1972. These so-called limits are just measures of how much lethal radioactive material Entergy is allowed to discharge into our air, water and soils. If Pilgrim had never started operating, we would have only background levels[14] - or what would be expected to be found in the area if there were no additional man-made sources of contamination.

Various terms like "risk standards" and "dose limits" are used in order to deflect public concern about the toxic effects of Pilgrim's man-made radioactive emissions that have been released into the environment on an ongoing basis since 1972.

There is no "safe dose" of manmade radiation.

Radionuclide emissions are assessed in terms of dose limits (for drinking water and generic overall dose), concentration risk standards depending on the radionuclide (for drinking water), and reporting standards that vary depending on the radionuclide (for non-drinking water).

For the dose limit approach, the unit rem is used. Rem measures the damage done to living tissue. One rem equals 1,000 millirem (mrem). According to the NRC, the radiation dose received in one year by the average American from natural and man-made sources is about 620 mrem.[15] Others – including the U.S. Department of Energy and the Health Physics Society – report the average person receives about 300-369 mrem per year.[16]

The unit curie is different than the unit rem in that it describes the radioactivity of a substance. A picocurie is one trillionth of a curie. This unit can be used when measuring radioactive concentration if expressed as the total amount of radioactivity per unit volume (for example, picocurie per liter (pCi/L). To put the units rem and curie in perspective, an estimated 200 pCi/L of cesium-137 yields a dose of about 4 mrem per year. This relationship will change depending on the radionuclide in question (Table 4).

The NRC has adopted ALARA (as low as reasonably achievable) as a radiation safety principle for minimizing doses and releases of radioactive gas and liquid effluents.[17] For liquid effluents, such as tritiated water, the ALARA annual objective requires that a release must not result in a dose greater than 3 mrem to the whole body or 10 mrem to any organ for members of the public. The

NRC has established a generic dose limit of 100 mrem in one year to members of the public based on the impact from all sources of radioactive effluents combined (gas and liquid).

The NRC also has reporting levels for various radioactivity concentrations in environmental samples at Pilgrim (Figure 4). For instance, the non-drinking water reporting standard for tritium (H-3) is 30,000 picocuries per liter (pCi/L). The NRC also requires Entergy to report results of their Radiological Environmental Monitoring Program (REMP) reports on an annual basis, which summarizes Pilgrim's radioactive releases.

Nuclear facilities are also supposed to comply with EPA's 1979 radiation standard[18] that limits the annual dose to a member of the public to less than or equal to 25 mrem to the total body or organs.[19] The NRC incorporated these EPA standards into its regulations in 1981.

Table 1. Reporting levels for various radionuclides at Pilgrim. (Source: Table 3.5-4, Pilgrim Nuclear Offsite Dose Calculation Manual)

REPORTING LEVELS FOR RADIOACTIVITY CONCENTRATIONS IN ENVIRONMENTAL SAMPLES

Analysis	Water pCi/L	Airborne Particulate or Gases pCi/m^3	Fish pCi/kg, wet	Milk pCi/L	Food Products pCi/kg, wet
H-3	30,000 (1)	--	--	--	--
Mn-54	1,000	--	30,000	--	--
Fe-59	400	--	10,000	--	--
Co-58	1,000	--	30,000	--	--
Co-60	300	--	10,000	--	--
Zn-65	300	--	20,000	--	--
Zr-95	400	--	--	--	--
Nb-95	400	--	--	--	--
I-131	20 (1)	0.9	--	3	100
Cs-134	30	10	1,000	60	1,000
Cs-137	50	20	2,000	70	2,000
Ba-140	200	--	--	300	--
La-140	200	--	--	300	--

(1) Value adjusted for fact that no drinking water pathway exists at Pilgrim Station.

The National Academies of Science published the BEIR VII report in 2005 about health effects of low levels of ionizing radiation.[20] The report found that there is no safe level of radiation and even very low doses can cause cancer and other, non-cancer effects such as heart disease. The

NRC's allowable dose limit for the public is 100 mrem per year. The BEIR VII report estimates that this level, over a 70-year timeframe, will result in approximately one in 100 people developing cancer and one fatal case occurring.[21]

… there is no safe level of radiation and even very low doses can cause cancer and other, non-cancer effects such as heart disease.

To address the BEIR VII findings, EPA identified levels of radionuclides, such as tritium, in drinking water that would cause no adverse health effects, called Maximum Contaminant Level Goals (MCLG). These goals, focused solely on public health, are zero. Unfortunately, these goals are not enforceable. EPA has also set enforceable regulations for drinking water, called Maximum Contaminant Levels (MCL). These levels increased when costs and benefits of the goals were considered (as opposed to public health only). For beta particles (e.g., tritium, idodine-129, strontium-90, cesium-237), EPA's MCL is 4 mrem per year. For tritium, EPA estimates that the average concentration assumed to yield 4 mrem per year is 20,000 pCi/L (Table 4).

As for the state, the Massachusetts Department of Public Health (MassDPH) has established a screening level of 3,000 pCi/L for tritium in groundwater, meaning further investigation is undertaken if tritium levels are detected in excess of this level at Pilgrim.[22]

Regulators like the NRC, EPA and MassDPH often downplay the presence of tritium in groundwater at Pilgrim. In particular, MassDPH asserts that since no one is drinking water from Pilgrim's wells, everything is fine. MassDPH uses EPA's drinking water limit of 20,000 pCi/L to justify Pilgrim's unlawful, unpermitted leaks and discharges of radionuclides into the PCA as "safe."[23] This is not an adequate defense for allowing Entergy to continue to contaminate the groundwater with radionuclides as it has been doing on an ongoing basis since at least 2007. No level of groundwater contamination is acceptable, regardless of whether or not anyone is directly drinking the water from Pilgrim's wells. The PCA is a resource that belongs to everyone; it is not Entergy's to contaminate. In addition, Entergy has failed to adequately assess the groundwater flow direction and residents with wells in the area could indeed be drinking contaminated water. There has been no offsite testing of private drinking water wells for the type of radionuclides Pilgrim discharges into the groundwater.

1. Human Impacts

Radionuclides are a serious concern for public health. Exposure to radiation is known to increase the risk of damage to tissues, cells, and DNA and can cause genetic mutations, cancers, birth

defects, and reproductive, immune and endocrine system disorders. There is no safe threshold to exposure to radiation.

Just because the standards and limits exist, it does not mean they are valid or safe.[24] According to a U.S. General Accounting Office Report in 2000, U.S. radiation standards for public protection, especially for low-level radiation, lack a conclusively verified scientific basis.[25] Many effects of radiation, especially from low-level doses, are largely unknown.

A study published in 1987 found five towns near Pilgrim with a 60% increase in leukemia rate, excluding leukemia not caused by radiation exposure.[26] The rate of myelogenous leukemia (the type most likely to be triggered by exposure to radiation) among males in the five towns was found to be 2.5 times greater than the statewide average.

In another study published in 1990, MassDPH investigated whether communities near Pilgrim had elevated leukemia rates associated with radioactive plant discharges. The report found a two to four-fold increase in risk of leukemia among residents of certain towns within a 20-mile radius from Pilgrim.[27] Pilgrim did not like the results and cut a political deal allowing it to appoint a second peer review panel to re-review the study and write a report. Even Pilgrim's hand-picked panel concluded that, "The original study team adhered to generally accepted epidemiological principles… [And] …the findings of the study cannot be readily dismissed on the basis of methodological errors or proven biases… [and last]…the association found link between leukemia and proximity to the Pilgrim nuclear facility was unexpectedly strong."

According to Dr. Richard Clapp, an epidemiologist and Professor Emeritus of Environmental Health at Boston University School of Public Health, "The effects of radiation exposure are cumulative. The radionuclides released from Pilgrim include substances that will remain active in the local environment for the foreseeable future and should be taken into account when actual on-going doses to the public and the environment are evaluated."[28]

> ***"…radionuclides released from Pilgrim include substances that will remain active in the local environment for the foreseeable future and should be taken into account when actual on-going doses to the public and the environment are evaluated." – Dr. Richard Clapp, MPH, DSc.***

2. *Ecological Risk and Screening Levels*

Radiation protection has historically focused on human health and safety. If plants and animals are tested for radionuclides, it has typically been for tracking potential threats to people as opposed to concern for the environment itself. However, more recently it has become evident that environmental health is strongly tied to economic, social, and health issues. As a result, there

has been a higher priority to the protecting the environment directly (i.e., biological diversity, conservation of species, and the health of natural habitats and ecosystems).[29]

Radioecology, the study of radioactive materials in the environment (e.g., movement and accumulation within ecological systems, and effects on species, populations, communities, and ecosystems) is a growing field but many gaps still exist. The relationships between radiation dose levels and effects on animals and plants are still not well understood. Much of the existing data focus only on effects to individuals and acute exposure, and not so much on populations or communities and chronic lower dose exposures.

With humans we know that health risks increase with increased radiation exposure. However, with wildlife, some studies have found chromosomal abnormalities stay constant and there is an increase in embryonic mortality, even when radiation doses decrease over time – suggesting that chronic low doses of radiation may be more detrimental to non-human biota than previously assumed.[30] Some potential population-level effects have also been found at doses below what was previously assumed to be safe.[31]

…chronic low doses of radiation may be more detrimental to non-human biota than previously assumed.

Concerns for plants and animals include increased mortality, decreased fecundity, and a variety of other sub-lethal effects, and mammals, birds, fish, amphibians, reptiles, crustaceans, insects, and mollusks are among the most sensitive organisms.[32] In terms of reproductive impacts, fish may be the most sensitive in the marine environment.[33]

It is interesting to note that dose limits for plants and wildlife exist in some contexts; however, these limits do not apply to commercial nuclear power reactors in the U.S. At no point does the NRC, EPA, or state directly consider or limit the impacts of radionuclides on plants or wildlife.

The U.S. Department of Energy (DOE) has developed non-human biota dose limits for the protection of populations from effects of ionizing radiation at DOE facilities.[34] Below these limits, populations of wildlife and plants are unlikely to be harmed by ionizing radiation, however individual organisms within populations could still be harmed (Figure 3).

The European Union has also developed dose limits for the protection of ecological resources. However, again these limits would not apply to Pilgrim. The European Union determined that a rate of 10 µGy/hr (0.024 rd/d) to be the “no effect dose rate” for chronic radiological exposure to terrestrial, freshwater, and marine/estuarine ecosystems, meaning 95% of the species in these systems are protected from chronic exposure if the rate does not exceed this limit (Figure 3).

It has been suggested by officials at the New York State Department of Environmental Conservation that these limits are not appropriate when rare, threatened, or endangered species are present.[35] In those circumstances, site-specific values must be developed for the protection of individual organisms.

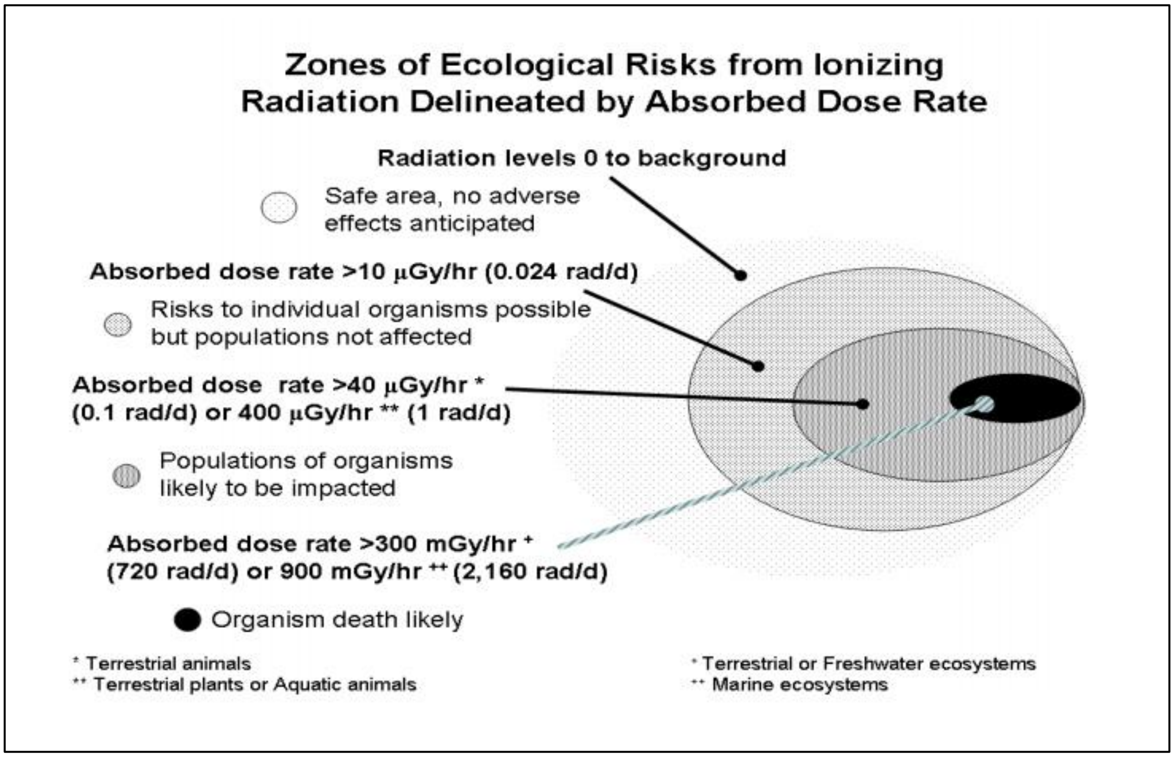

Figure 3. Levels of ecological risk for individuals and populations that can be associated with increasing levels of ionizing radiation. (Source: NY Dpt. of Environmental Conservation, 2014.)

In the case of Pilgrim, not only are there no limits to directly protect ecological resources, but Cape Cod Bay and its coastline are also home to an array of rare and protected species. There are approximately 140 species protected by the Massachusetts Endangered Species Act in Cape Cod Bay or in the coastal areas adjacent to the Bay. There are eight marine species under the National Oceanic and Atmospheric Administration's National Marine Fisheries Service (NOAA Fisheries) jurisdiction that have the potential to be in the immediate vicinity of Pilgrim and are protected under the Federal Endangered Species Act. This includes the North Atlantic right whale, which is one of the rarest large whales in the world that has critical habitat just offshore from Pilgrim.

Under state law Cape Cod Bay has been a protected "Ocean Sanctuary" since 1970[36] and is ranked as a "SA" water body, meaning it is an "excellent habitat for fish, other aquatic life and wildlife." Pilgrim's operations cause impingement and entrainment of billions of marine organisms each year, including species of special concern. Furthermore, the plant's impact to flounder have required hatchery releases to attempt species restoration. This calls into question whether the

"excellent habitat" standard is being upheld near Pilgrim. Under federal law, Cape Cod Bay is also designated as critical habitat for right whales – an area critical to the species' survival.[37]

Pilgrim's operations could negatively impact the primary food source for right whales, copepods, or even the whales directly by the discharge of radioactive waste. Pilgrim regularly discharges thousands of gallons of radioactive water through surface water outfalls directly into Cape Cod Bay. Entergy believes that dilution by sea water solves the problem of radioactive waste pollution; however, the potential negative impacts to right whales and important features of their critical habitat area should be considered by regulators.

There will continue to be implications for plants and wildlife after Pilgrim shuts down if uncontrolled radioactive leaks occur from nuclear waste storage areas or if the groundwater and soils are not promptly cleaned up. Human protection limits should not be assumed to automatically protect plants and wildlife in the vicinity of Pilgrim, especially threatened and endangered species. Some non-human biota may be in high-dose locations that humans are not (i.e., in the soil), or could be susceptible to low doses of radiation over an extended time frame.

3. Limits to Voluntary Groundwater Testing

Tritium is a radioactive isotope of hydrogen with a 12.5 year half-life.[38](Read more about tritium in Section V). Exposure to radioactivity over time, no matter how little, increases cancer risk, according to the World Health Organization's IARC.[39] The NRC adopted the Nuclear Entergy Institute's (NEI)[40] Voluntary Groundwater Protection Initiative in 2007 to test for tritium in groundwater. NEI proposed the monitoring initiative in 2006 after tritium was being found at high levels at several nuclear facilities throughout the U.S. This initiative is nothing more than an unenforceable set of "guidelines" established by the industry to police itself.

Entergy began with six monitoring wells at Pilgrim in 2007 as recommended by industry and as a result of a nation-wide initiative. Tritium was detected in groundwater at Pilgrim as soon as the testing began in 2007. Leaks likely occurred before this time but no monitoring was in place.

Normal background levels for tritium, while variable depending on soils, rock type, wind, and drainage, are typically 5-25 picocuries per liter (pCi/L) in surface water and about 6-13 piC/L in groundwater. MassDPH's established screening level is 3,000 pCi/L for tritium in groundwater, meaning further investigation is undertaken if tritium levels are detected in excess of this level at Pilgrim. When testing began in 2007, levels as high as 3,300 piC/L were recorded. Over the past seven years, tritium levels have consistently been much higher than background levels ranging from annual highs of 70,599 piC/L in 2013 to 1,726 piC/L in 2009 (see Section V for a full history of tritium leaks at Pilgrim).

In July 2010, 25,000 picocuries per liter (pCi/L) of tritium was found in one of Pilgrim's wells. MassDPH's Bureau of Environmental Health – charged with the broad mission of protecting public health from a variety of environmental exposures -- recommended that Entergy install additional wells and start testing surface water in Cape Cod Bay. By August 2010, Entergy installed 6 additional wells. Over time, and due to additional detections of tritium, Entergy has installed even more monitoring wells. Today, Entergy collects samples from 23 groundwater monitoring wells and two surface water locations (Figure 4).[41] The samples are split between two labs – one lab contracted by Entergy and the other is the Massachusetts Environmental Radiation Lab (MERL). MassDPH officials, as well as the Massachusetts Emergency Management Agency (MEMA) and the NRC are provided with the results.

Figure 4. Approximate locations of groundwater monitoring wells around the Pilgrim facility. (Source: MassDPH)

Tritium contamination has been found every month since testing began in 2007. Instead of requiring a cleanup, the NRC and MassDPH simply allowed Entergy to install more wells, while continuing to operate and continuing to leak and discharge radioactive contamination into the environment. MassDPH merely requires Entergy to collect more samples, rather than halt contamination that threatens the health of important environmental resources.

In addition to being unenforceable, another problem with the volunteer program is that Pilgrim's groundwater wells are sampled only for gamma-emitting nuclides and tritium. Minimal requirements exist for analyzing beta- and alpha-emitting radionuclides. Today's radiological monitoring requirements were applicable to nuclear operations in the 1970s (i.e., higher gamma-emitting radionuclides), but today new technologies exist that have created new waste streams (i.e., lower fraction of gamma-emitting radionuclides and a higher fraction of weak beta-emitters). In other words, outdated testing that is used today could be missing radionuclides significant to public and environmental health.

…outdated testing that is used today could be missing radionuclides significant to public and environmental health.

More information is also needed about the groundwater flow direction and hydrology at the Pilgrim site to understand the true extent of the contamination. Some sources estimate that groundwater on the site flows north and east toward Cape Cod Bay at an average rate of 0.4 feet (0.1 meter) per day.[42] On the other hand, MassDPH states that groundwater could flow in the southeast direction on some areas of the site. Both are possible. Pilgrim's reactor building and foundation reach forty feet below ground, cutting through many soil layers, and it is unknown how this vertical connection between layers affects groundwater flow.[43]

Six years ago, MassDPH admitted that additional data are needed since variations of flow on the site have not been well characterized and it is unknown how subsurface conditions may have changed since the plant was first constructed. Yet, no action has been taken to further characterize the groundwater flow direction despite documented tritium leaks on the site since at least 2007.

Relatively few datasets exist for groundwater elevations on the Pilgrim site. Some sources show that elevations on the site vary by location and tide cycle and are estimated to be 0-14 feet below ground.[44] It is important to note that groundwater elevations on site and locally in the PCA will change with tidal fluctuations, and will also increase over time with sea level rise. Rising groundwater levels also impact the capacity of the ground to absorb rain or flood water, potentially contributing to more site-wide flooding at Pilgrim, as suggested in Pilgrim's own reporting.[45] How this influences the distribution and flow of contamination on site is unknown, but must be understood to effect proper safeguards and ultimately decontaminate the site.

IV. ROUTINE RELEASES

Pilgrim routinely releases radioactive materials to the environment as part of its operations in the form of liquids and gases.[46] These releases are allowed by the NRC, as long as they meet certain limits. Planned releases at Pilgrim include both continuous radioactive emissions and routine batch-releases to the surface water of Cape Cod Bay. The NRC requires Entergy to summarize and report Pilgrim's radioactive releases in REMP reports on an annual basis. As discussed in Section III, there are concerns associated with radiological standards and limits approved by regulatory agencies. For example, cumulative impacts nor impacts to flora and fauna are considered when agencies set these purportedly "safe" limits.

REMP reports are intended to monitor levels of radioactivity in the environment and ensure that potential impacts of radiation are detected. However, REMP reports prepared by Entergy at the end of the year summarize what it has discharged the prior year, which does nothing to prevent excessive amounts of radiation from being discharged.

In addition to the REMP reports, Entergy is required by the NRC to conduct some radiation monitoring at locations outside the Pilgrim site. As part of the state's Emergency Planning Zone radiation sampling program, MassDPH also collects samples, but funding constraints prevent a full assessment of the extent of Pilgrim's contamination. Groundwater testing performed by Entergy and the State is only carried out in monitoring wells located on the Pilgrim site; no offsite groundwater testing is done.

1. DISCHARGES TO CAPE COD BAY

The Federal Clean Water Act does not regulate radioactivity from the nuclear power industry; therefore, the EPA does not monitor Entergy's routine discharge of radioactive materials into Cape Cod Bay, even though they are a part of routine operations. Pilgrim routinely discharges thousands of gallons of radioactive effluent by eleven surface water outfalls directly into the surface waters of Cape Cod Bay.[47] From 2010 to 2012, Pilgrim discharged more than 478 billion gallons of diluted radioactive effluent (more than 465,000 gallons undiluted) into Cape Cod Bay through its surface water outfalls. Forty different discharges contained a total of over 7 curies of radioactive products, including tritium. This is an excessive level when compared to EPA's MCL for tritium in drinking water which is 4 mrem per year (an average concentration of 20,000 pCi/L is estimated to result in 4 mrem per year).

From 2010 to 2012, Pilgrim discharged more than 478 billion gallons of diluted radioactive effluent (more than 465,000 gallons undiluted) into Cape Cod Bay through its surface water outfalls.

The NRC simply requires Entergy to self-report discharges of lethal radionuclides into Cape Cod Bay via its REMP reports. The NRC never tests Pilgrim's radioactive discharges to see if Entergy's reports are accurate, nor does any other government agency.

In order to reduce the contamination levels to the NRC allowable limits, Entergy just dilutes the highly contaminated wastewater. The 478 billion gallons it discharged from 2010 to 2012 started out as more than 465,000 gallons of undiluted, highly-contaminated radioactive water. Entergy had to add about 472 billion gallons of non-contaminated water in order to achieve levels acceptable to the NRC.

Pilgrim's liquid radioactive waste system collects waste in sumps and drain tanks at various locations. The waste is then sent to a receiving tank for processing or disposal. The "liquid waste effluent discharge header" has a shielded radioactivity monitor. The radiation monitor is designed to set off an alarm before radioactivity levels exceed release limits. However, some liquid waste sources said to contain "very low levels of contamination," may be discharged directly to the discharge canal that dumps directly into Cape Cod Bay without passing through the liquid radioactive waste discharge header.

One source of the liquid waste that bypasses the radioactive waste discharge header is the neutralizing sump. Prior to discharging such liquid wastes, the tank is mixed and a representative sample is collected for analysis of radioactivity prior to discharge. One means of adjusting liquid radioactive waste concentrations to below federal limits is by simply mixing plant cooling water from the condenser with the liquid effluents in the discharge canal. This larger volume of cooling water dilutes the radioactivity levels to below the release limits. Entergy regularly practices dilution as a solution to deal with water contaminated with radioactive waste.

2. Discharges to Groundwater

In 1991, Pilgrim's wastewater treatment plant was built and began treating its regular discharge of pollutants into groundwater and soils (prior to 1991, Pilgrim only used an on-site septic system for wastewater). At that time, Pilgrim's owner was required by the state Clean Waters Act to treat wastewater flows over 15,000 gallons per day (gpd) to a higher level than could be accomplished using Title 5 technology. Since Pilgrim's groundwater discharge permit was approved in 1988 for a maximum flow of 37,500 gpd, state regulations required a wastewater treatment plant be installed.[48] Wastewater from industrial operations is sent to the wastewater treatment building and then is discharged to a leaching field (Figure 5). These discharges enter the groundwater and soils, which are part of the PCA (see Section II for more about the PCA).

MassDEP's permit for Pilgrim's wastewater treatment plant, which was originally issued in 1989, is inadequate and allows Entergy to discharge pollutants at levels that would be prohibited if it were a municipal wastewater treatment plant. MassDEP has rolled back pollution limits for Entergy and completely eliminated limits for chloride and total dissolved solids in Pilgrim's newest 2007 permit – both of which are unlawful since, when renewing water pollution permits, MassDEP is supposed to apply limits "at least as stringent" as prior permits.

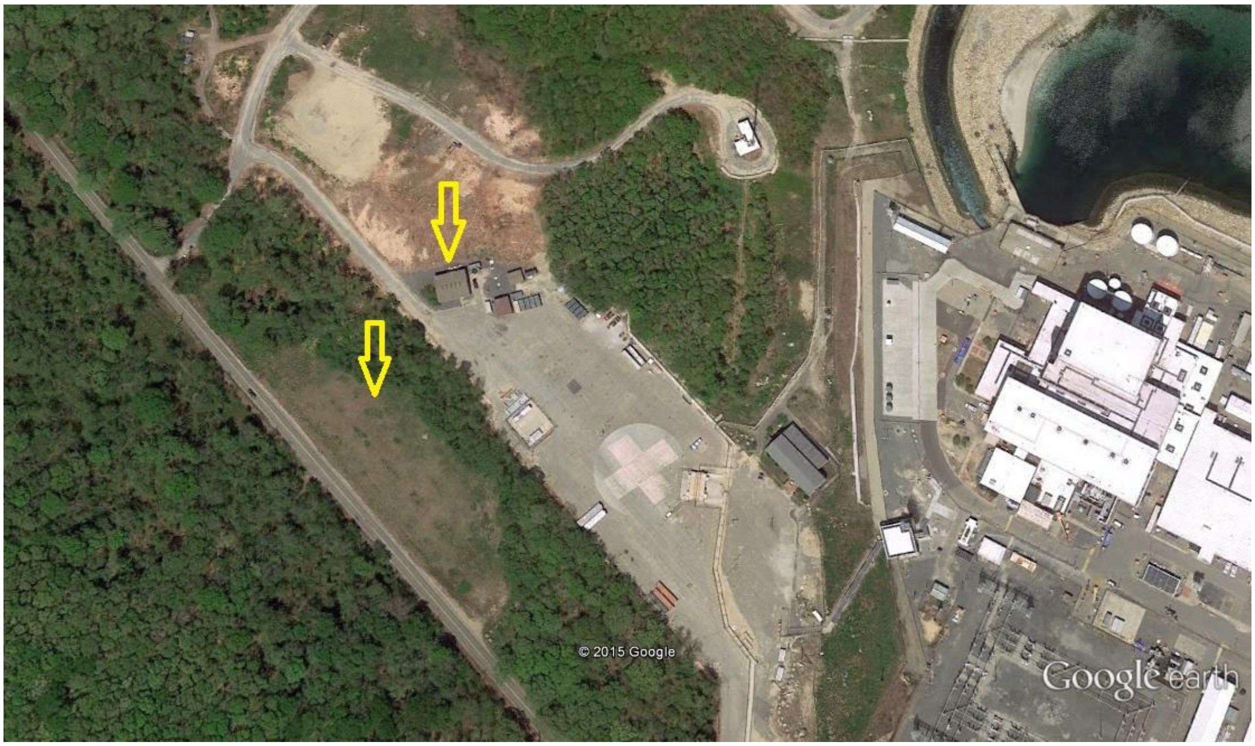

Figure 5. Northern side of the Pilgrim site. Yellow arrows point to the wastewater treatment building and the leaching field just off Rocky Hill Rd., Plymouth.

Entergy has repeatedly and chronically violated the nitrogen pollution limit set by MassDEP in Pilgrim's permit. MassDEP standards require municipal wastewater treatment facilities (including the Town of Plymouth) to discharge a maximum nitrogen limit of 10 mg/L. However, Pilgrim's nitrogen discharges to the ground regularly exceeded that limit by up to twelve times in 2012. Nevertheless, MassDEP has allowed Entergy to delay compliance with this limit from 2007.

Although not a radioactive form of pollution, Nitrogen is still a major concern for Cape Cod Bay and worth outlining in this report. Once excess nitrogen passes though soils and groundwater, it ends up in surface waters where it promotes algal growth and decay. This condition depletes the oxygen supply in the water, making it difficult for fish, sea grass, and other marine life to thrive.

Excess nutrient loading is one of the greatest threats facing water quality in Massachusetts' coastal estuaries and bays. Government and private groups dedicate extensive resources to mitigate and clean up nitrogen pollution in Cape Cod Bay; however, Entergy has been allowed to exceed pollution limits without any ramifications. State officials have failed to take any action to stop this pollution.

MassDEP has also improperly classified Pilgrim's wastewater as "domestic" instead of "industrial," and applies lower standards that accompany a domestic permit. If Pilgrim were properly classified as industrial user, which it clearly is, Entergy would be required to comply with stricter regulations.

Another concern and possible source of pollution is Entergy's "sludge press" at Pilgrim. In 2008, Entergy added an industrial sludge press in the wastewater treatment building. The press is used to extract radionuclides from the facility's process water. It is unclear where Entergy is disposing of sludge from this industrial press. There is also concern that radioactive materials passing through the sludge press or the wastewater treatment plant are being discharged to the leaching field. Based on current knowledge, there has been no regular testing of these discharges for radioactive materials.

V. Unpermitted Releases

Over the years, Pilgrim has had a number of unpermitted leaks into the groundwater and soils on the site. Due to these leaks, a number of lethal radionuclides, including tritium, manganese-54, cesium-137, and cobalt-60, have been found in the surface water, groundwater, and soils at Pilgrim at levels exceeding "background" levels - or what would be expected to be found there if there were no man-made source of contamination.

As discussed in Section II, Pilgrim is sited above the PCA, which makes these unpermitted leaks even more concerning. The PCA is the second largest aquifer in the state that provides drinking water to seven towns and supports a variety of natural resources (Figure 6).

1. Buried pipes and tanks

Beneath Pilgrim is a network of underground[49] pipes and tanks. These components are made from a variety of materials, including concrete, carbon steel, stainless steel, titanium and have external coatings and wrappings – much of which is susceptible to age-related and environmental degradation.

Underground piping at nuclear facilities is designed to support safety and non-safety related systems including fire protection, emergency diesel generator fuel oil, cooling, gas treatments, salt service water, and more.[50] Some of these pipes and tanks contain industrial process and wastewater contaminated with radionuclides, and degradation of these components can lead to leaks of toxic materials into groundwater and soils.[51]

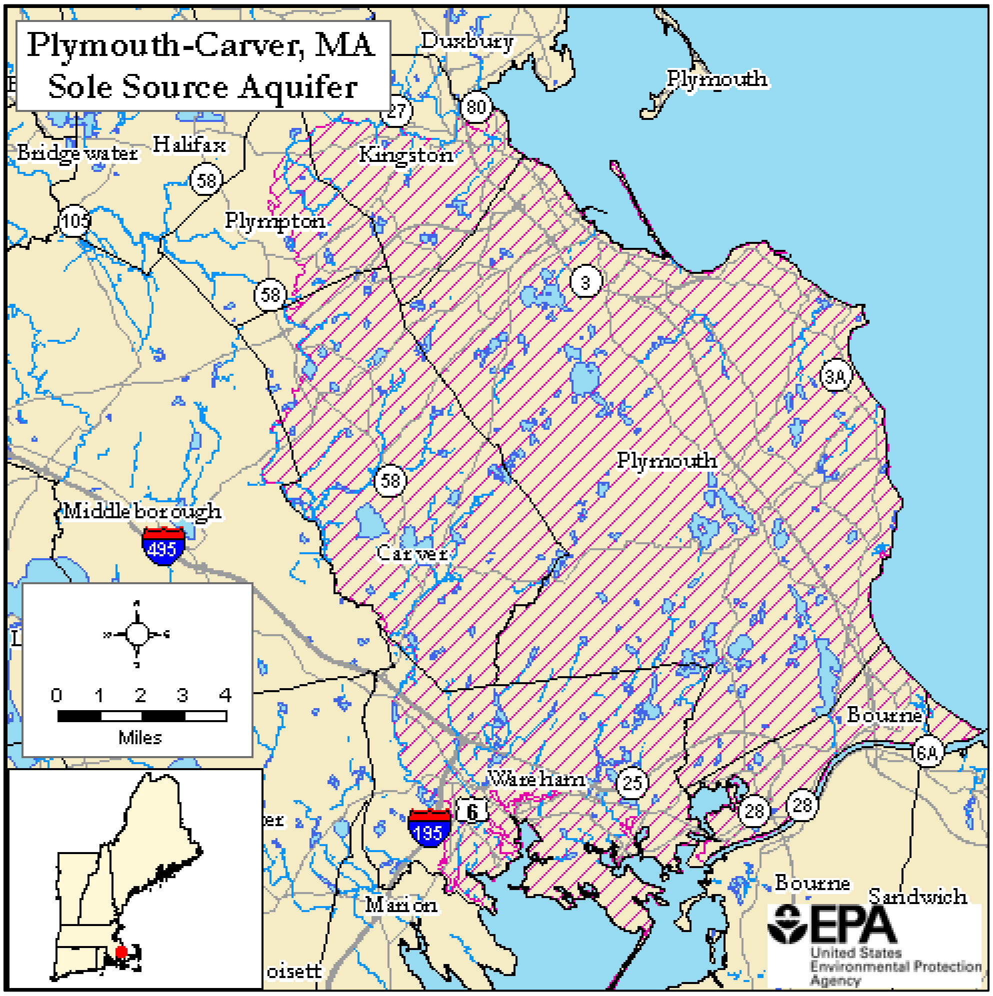

Figure 6. Plymouth-Carver Sole Source Aquifer. (Source: EPA, www3.EPA.GOV)

NRC's program for inspecting buried pipes and tanks is inadequate and allows leaks and spills to go unnoticed.[52] For decades Pilgrim's subsurface components have been (and will increasingly be) exposed to inundation with salt water, rising groundwater tables, and flooding,[53] which could provide conduits for radioactive materials to leak into the environment. According to Entergy, all of Pilgrim's underground pipes are within 10 feet of the surface,[54] which is well within reach of groundwater and salt water flooding.

A nuclear industry initiative, called the Buried Piping/Underground Piping and Tanks Integrity Initiative, began in 2009 to inspect underground pipes and tanks at nuclear power plants like Pilgrim for leaks. Like groundwater monitoring, this initiative is voluntary only. In 2010, the NRC also revised its Aging Management Program to manage the effects of aging on structures or components, including underground piping.[55]

The NRC's monitoring programs are inadequate. They are based on inaccurate assumptions about corrosion and an insufficient inspection regime (i.e., physical inspections conducted only in those rare instances when pipes are dug out for other purposes). Rather than a comprehensive approach to dealing with leaks of radioactive materials from buried pipes and tanks, the NRC allows the industry take piecemeal approach by only fixing sections of pipe.[56] These processes are incapable of ensuring the integrity of decades-old piping systems.[57]

2. Tritium and other Radionuclides in Groundwater

Tritium (H-3) is a radioactive isotope of hydrogen that is produced during routine nuclear facility operations, and has a half-life of 12.5 years.[58] A half-life is essentially the time it takes for a radioactive substance to lose half its radioactivity. Tritium is a carcinogen and a significant hazard when inhaled, ingested via food or water, or absorbed through the skin.[59] The most common form of tritium is in water. Tritiated water is colorless and odorless, and is commonly leaked at nuclear plants.[60]

Tritium is overwhelmingly the most common radionuclide released from nuclear facilities; however, it is not the only radionuclide. Tritium is an indicator contaminant. It is highly soluble in water and easily and rapidly flows with groundwater, whereas other radionuclides adsorb strongly to some soils. Tritium may be detected sooner than other contaminants and can be a good indication that other radionuclides are also leaking.[61]

Since 2007, Entergy's own groundwater well tests have confirmed what many had long suspected: Pilgrim is leaking radionuclides and contaminating the soil and groundwater. Entergy's tests have shown levels ranging from non-detect levels to as high as 70,000 piC/L.[62] Every year since 2007 there has been at least one well with levels well above the upper limit of normal background levels. Background levels for tritium, while variable depending on the substrate, drainage, and other factors, are typically 5-25 piC/L in surface water and about 6-13 piC/L in groundwater.

In all but 2 years, there was at least one well above MassDPH's screening level of 3,000 piC/L and 3 years with at least one well above EPA's safe drinking water standard of 20,000 piC/L (Table 2; see Section III for more about "safe" standards). By 2016, nine years after Entergy itself confirmed that Pilgrim is leaking tritium into the groundwater and soil, nothing has been done to clean it up or stop the illegal discharges that are inevitably moving toward and into Cape Cod Bay.

By 2016, nine years after Entergy itself confirmed that Pilgrim is leaking tritium into the groundwater and soil, nothing has been done to clean it up or stop these illegal discharges.

One of the more publicized tritium leaks at Pilgrim began in April 2013, when an underground line leading to the discharge canal was suspected to have separated. The leak was accidently discovered when tritiated water was found coming out of an electrical junction box inside the facility.[63] Five months later, groundwater tests results showed tritium levels trending high in one of the wells (4,882-5,307 pCi/L), and this was suspected to be related to the separated underground line.[64] Soil sampling was done soon after, and preliminary results showed the presence of radioactive contaminants: tritium, cobalt-60, and cesium-137 at levels above normal (1,150 picocuries per kilogram (pCi/kg) of cobalt-60 and 2,490 pCi/kg of cesium-137). [65]

Table 2. Range of tritium levels detected in Pilgrim's groundwater monitoring wells each year since monitoring began in 2007. (ND = non-detect levels)

YEAR	Range of Tritium Levels (piC/L)
2007	371 - 3,300
2008	ND - 2,409
2009	ND - 1,726-
2010	ND - 27,142
2011	ND - 16,013
2012	ND - 8,671
2013	ND - 70,599
2014	ND - 21,012
2015	ND - 3,572
2016	<265 - 6,481

Three new wells were eventually installed; two of which were part of a broader tritium leak investigation. By January 2014 – nine months after the leak was originally discovered – excessive levels of tritium (69,000-70,000 pCi/L; the highest in Pilgrim's recorded history) were detected near a basin that collects radiologically contaminated water and ultimately sends it to Cape Cod Bay. Despite these alarming levels of tritium at this time, Entergy and MassDPH only continued

their investigation, all the while, high levels of hazardous pollutants continued to enter the groundwater and soils.[66]

More than a year later, Pilgrim's newest groundwater wells continued to show elevated levels of tritium and final soil testing results show levels of tritium, manganese-54, cesium-137, and cobalt-60 at various depths near the separated underground line above typical background levels.[67]

According to MassDPH in its August 2014,[68] November 2014, and May 2015 Groundwater Monitoring Reports, tritium levels continued to trend higher in some of Pilgrim's wells and radionuclides (e.g., Cobalt-60 and Cesium-137) were still being found in soils on the site. The November report even describes new samples showing high levels of tritium in air conditioning condensate at the facility (3,500-4,000 piC/L).

Despite all the "investigations" and explanations that Entergy and the state has provided in the nearly three years since this leak was originally discovered, at no point does age-related degradation ever come up. Extreme temperatures and storms, salt water and air, corrosive chemicals, and intense radiation most likely have caused components to thin and crack, compromising the structural integrity of the facility and underground/buried pipes. However, state and federal agencies responsible for regulating Pilgrim have not indicated that Entergy will suffer any consequences whatsoever for the groundwater and soil pollution related to the leaks discussed above.

In addition to the most recent spill described in detail above, there have been five other historic spill events that have been reported on the Pilgrim site since 1976.[69] For instance, in 1988 there was a spill of low-level radioactive waste water. The radioactively contaminated liquid waste was discovered inside a process building and had leaked outside the building. An estimated 2,300 gallons of contaminated water were spilled and 200 gallons leaked outside the building from under a door. About 2,500 square feet of asphalt and 600 cubic feet of sand and gravel were contaminated.[70]

These leaks and spills are only the ones known about and reported. As discussed in Section II.3, leaky underground piping and tanks are difficult to monitor for leaks. Even when leaks are known, it is hard to predict the movement of contaminants.

Regulators like the NRC, EPA and MassDPH often downplay the presence of tritium in groundwater at Pilgrim. In particular, MassDPH asserts that since no one is drinking water from Pilgrim's wells, everything is fine. MassDPH uses EPA's drinking water limit of 20,000 pCi/L to justify Pilgrim's unlawful, unpermitted leaks and discharges of radionuclides into the PCA as

"safe." This is not an adequate defense for allowing Entergy to continue to contaminate the groundwater with radionuclides-as it has been doing on an ongoing basis since at least 2007.

No level of groundwater contamination is acceptable, regardless of whether or not anyone is directly drinking the water from Pilgrim's wells. The PCA is a resource that belongs to everyone: it is not Entergy's to contaminate. In addition, as described above, Entergy has failed to adequately assess the groundwater flow direction and indeed, residents with wells in the area may indeed be drinking contaminated water. There has been no offsite testing of private drinking water wells for radionuclides of the type Entergy discharges into the groundwater. No one knows where the groundwater is going in the future or what will be contaminated.

Soil samples obtained in 2014 as part of a larger tritium leak investigation showed high levels of manganese-54, cesium-137, and cobalt-60 at various depths near a separated underground line above typical background levels (Table 3).[71]

Table 3. Final results from soil samples near the line separation area tested by Entergy in July 2013.

Depth	Tritium (pCi/kg)	Manganese-54 (pCi/kg)	Cesium-137 (pCi/kg)	Cobalt-60 (pCi/kg)
3 ft	1,300	138	604	304
5 ft	5,760	146	997	350
5.5-6 ft	26,100	148	1,600	2,530
6-7 ft	34,300	295	1,910	832

For the non-drinking water reporting standards for cobalt-60 (5.27 years half-life), cesium-137 (30.17 years half-life), and manganese-54 (312 days half-life), see Table 4. For drinking water, EPA's MCL for these radionuclides is 4 mrem per year. For cesium-137, the level found in Pilgrim's soil was 38x more than the reporting standard. For cobalt-60, the level found in Pilgrim's soil was more than 8x the reporting standard.

Table 4. EPA's maximum contaminant level (MCL), non-drinking water reporting standards, and the average concentration assumed to yield 4 mrem per year for select radionuclides.[72]

Radionuclide	EPA's MCL for Drinking Water	Non-Drinking Water Reporting Standards (Entergy/NRC)[73]	Average Concentration assumed to yield 4 mrem/year
Tritium	4 mrem/year	30,000 piC/L	20,000 piC/L
Manganese-54	4 mrem/year	1,000 piC/L	300 piC/L
Cesium-137	4 mrem/year	50 piC/L	200 piC/L
Cobalt-60	4 mrem/year	300 piC/L	100 piC/L

3. Stormwater Drains and Electrical Vaults

Pilgrim has twenty-five electrical vaults on site that are a source of stormwater. The vaults and other sources of untreated water are pumped out to four stormwater drains and directly into Cape Cod Bay. Over the past twenty-five years, Pilgrim's storm drains were supposed to be tested twice per year for pollutants,[74] as required by EPA. Despite this, Entergy failed to conduct sampling over roughly the past 10 years, according to EPA.[75] Sampling has only occurred three times since January 2009, and only three of the four storm drains were tested.

While it is known that radioactive tritium has been leaking into the groundwater and soils on the site since at least 2007, whether this contamination has been discharged to Cape Cod Bay via these storm drains is unknown since testing for radionuclides is not required for the drains.

There is also a fifth "miscellaneous" storm drain has never been covered under any permit, and therefore has never been tested. As of 2016, EPA acknowledges the drain and authorizes its discharges, but no monitoring requirements apply since it is inaccessible, according to Entergy. Entergy reports that it is not often used and it is not expected to drain to Cape Cod Bay except during extreme storm events; however, testing should still be required. Testing will be particularly important after decommissioning begins, when structures are demolished and soils disturbed, as this outfall could become a channel for contaminates entering Cape Cod Bay. Furthermore, the consequences of climate change are being experienced along the Northeast coastline, including more intense storm events, precipitation and storm surge. If this storm drain only drains to Cape Cod Bay during extreme storm events, there is no better time than now to apply monitoring and pollution limits for this outfall location.

Even more concerning is that when storm drain sampling was done more frequently (from 1998-2007), certain parameters were exceeded on many occasions.[76] Not only has testing rarely been done, but exceedances were likely regularly occurring and went unreported to state and federal regulatory agencies. No penalties for the lack of testing, or for the known exceedances, have been imposed.

Only in 2016, and after going unmonitored for years, EPA and MassDEP established draft testing requirements for the twenty-five electrical vaults. Regulatory agencies potentially knew about these discharge locations for more than two decades but failed to make them subject to monitoring requirements until now. Furthermore, the draft testing requirements seem insufficient. While a one-time test of all twenty-five vaults is required, quarterly monitoring for only five vaults is considered sufficient by regulatory agencies.

Initial sampling by EPA from only seven vaults found total suspended solids, cyanide, phenols, phthalates, PCBs, antimony, iron, copper, zinc, lead, nickel, cadmium, hexavalent chromium. Lead, copper, and zinc exceeded marine water quality criteria.

In the new testing requirements developed by EPA, not all of these pollutants are included. Cyanide, antimony, nickel, and hexavalent chromium are apparently omitted. Shockingly, EPA is only requiring Entergy to monitor these toxic pollutants in order to assess the need for limitations. The fact that these pollutants were found in the vaults should be enough evidence to establish limitations immediately. Further, if stormwater from these 25 vaults is being discharged to stormwater drains, the drains themselves should also tested for the full list of pollutants.

Hexavalent chromium (Cr(VI)) – found in Pilgrim's electrical vaults but omitted from future testing requirements -- is particularly harmful to aquatic life. One study[77] conducted research on eels, trout, and winter flounder (species found near Pilgrim) and found that chromium is highly toxic to fish and can cause physiologic, histologic, bio-chemical, enzymatic, and genetic problems, even upon short-term exposure. Cr(VI) induced "alterations in the morphology of gills and liver in fish in a dose- and time-dependent manner." Despite the toxic effects of Cr(VI), no limits have been established by regulatory agencies to ensure this pollutant is not causing harm in Cape Cod Bay.

The fact that EPA and MassDEP have allowed these discharges to occur for an unknown length of time and are only now subjecting Pilgrim's electrical vaults to the limited monitoring requirements is an egregious failure of regulatory oversight.

As climate change impacts get worse and decommissioning commences in 2019 storm drains and stormwater testing will become even more critical, as these outlets could become further conduits for pollution into Cape Cod Bay. Increased flooding and storm intensity, sea level rise, and rising groundwater tables could increasingly flush contaminates present in groundwater and soil into Cape Cod Bay. As Pilgrim commences decommissioning in 2019 (site cleanup could be deferred for up to 60 years), understanding how coastal impacts will influence contamination of Cape Cod Bay via storm drains and stormwater runoff will become more critical. Additional sources of contamination could result from disturbed soils or demolished structures on the site; however, decommissioning does not include cleanup or management of non-radiological contaminants. It is up to our regulatory agencies to ensure that non-radiological and radiological contamination present on site does not flush into water sources over time.

Regulators have also directed Entergy to monitor standing water in storm water manholes, junction boxes, and electrical duct banks. Monitoring results show radioactive materials at generally less than the minimum detectable limit for tritium (400 piC/L), but as high as 1,500 pCi/L in some storm water manholes and up to 4,500 pCi/L in some electrical duct bank manholes.[78] Even though these levels may be low in relation to the excessive levels in the groundwater, they still exceed the background level of 5-25 piC/L for surface water and 6-13 piC/L for groundwater. Moreover, they are ongoing and cumulative.

VI. Long-Term Nuclear Waste Storage at Pilgrim

Nuclear waste will be stored at Pilgrim indefinitely. There is no long-term, geological repository in the U.S., nor is there an interim storage site in place. Plans for the Yucca Mountain nuclear waste storage site in Nevada are on hold. Even if Yucca Mountain were completed in the future, it is likely incapable of holding all nuclear waste present in the U.S. today. Right now DOE is in process of developing “consent-based siting” plans for more permanent storage solutions in collaboration with communities across the country. However, solutions are a long way away and no saying the process will even be successful.

All of the high-level nuclear waste generated at Pilgrim since it started generating power in 1972 is now stored on site. This high-level nuclear waste is also called “spent nuclear fuel.” This waste is so lethal that, upon removal from the reactor it could deliver a fatal dose within minutes to someone in the immediate vicinity who is inadequately shielded.[79]

Most of Pilgrim’s spent nuclear fuel is currently stored inside the reactor building in its spent fuel pool. Since Pilgrim’s pool is near capacity, Entergy has started moving the waste to a dry cask nuclear waste storage facility, also known as an Independent Spent Fuel Storage Installation

(ISFSI; Figure 7). Entergy plans to expand the ISFSI so that it can eventually store all 40+ years' worth of Pilgrim's spent nuclear fuel in dry casks on site.

As seen in Figure 7, Pilgrim's ISFSI is located too close to the shoreline and is only about four feet above the Federal Emergency Management Agency's (FEMA) flood level. Pilgrim's nuclear waste will remain in Plymouth indefinitely and the ISFSI is currently sited within reach of rising sea levels, coastal storms, and saltwater degradation -- creating a potential source of contamination, long after Pilgrim shuts down in 2019.

…the ISFSI is currently sited within reach of rising sea levels, coastal storms, and saltwater degradation, creating a potential source of further contamination, long after Pilgrim shuts down.

Entergy built the ISFSI without proper zoning approval from the Town of Plymouth. In August 2016, a legal trial concluded related to Entergy's non-compliance with Plymouth's zoning by-laws and failure to obtain a special permit for Pilgrim's ISFSI. If Entergy were to be required to obtain a special permit, the Town of Plymouth would have authority to impose conditions on the ISFSI in order to ensure that it is properly sited, operated, and maintained.[80] The court's decision is due before the end of 2016.

Entergy also stores so called "low-level" radioactive waste (LLRW) at Pilgrim, some of which is located in containers along the shoreline – another potential source of contamination to Cape Cod Bay.

The "low-level" category has nothing to do with the actual radioactivity level or how long the waste will remain radioactive. Instead, radioactive waste is defined solely by the process which produced it. High-level waste is defined as spent reactor fuel, or wastes resulting from the reprocessing of spent nuclear fuel. LLRW is a catch-all, and includes all radioactive waste that is not high-level waste, and includes transuranic wastes (material contaminated with radioactive elements heavier than uranium, such as plutonium, neptunium, americium and curium that have extremely long hazardous lives) or uranium mill tailings. A typical nuclear reactor's LLRW is significantly more radioactive that some of the military's high-level waste. Pilgrim's LLRW, for example, includes the control rods, resins, sludge, filters, and will include the entire nuclear power reactor when it is eventually dismantled.[81]

Figure 7. Pilgrim's ISFSI project (circled) begins approximately 106 ft. from the shoreline. The first casks (pictured) were filled and placed on the concrete pad in early 2015.

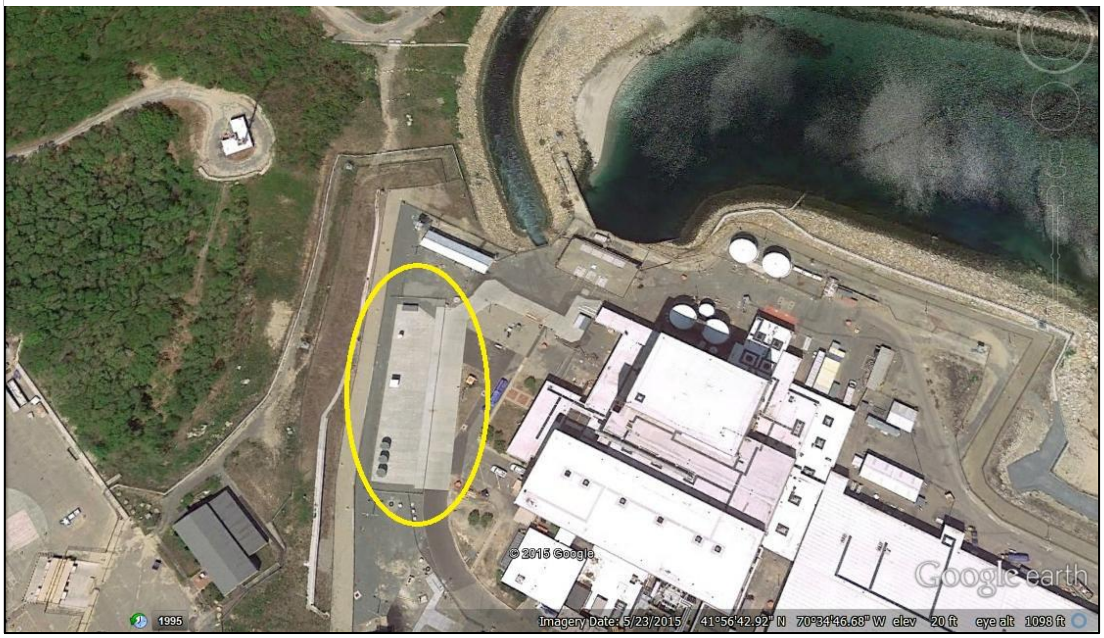

Figure 8 shows the shoreline location of Entergy's storage of LLWR. It shows that Pilgrim has about 20-30 white storage containers located approximately 30 feet away from the coastal bank. According to the NRC, only one of these containers currently contains Greater-than-Class-C waste, the most toxic type of LLRW, and that all of the others are now empty.

Figure 8. The white containers pictured here are LLRW containers, located about 30 ft. away from Cape Cod Bay. At least one of these holds radioactive waste and many more will likely be filled during decommissioning. Also shown to the right of the storage area is the LLRW building containing equipment that compresses materials to be stored for shipment.

The Greater-than-Class-C waste will remain on the Pilgrim site, like the high-level radioactive waste, until an offsite repository is developed. Huge amounts of LLRW will result during the decommissioning process, and likely more of these storage containers will be used.

All of Pilgrim's low- and high-level radioactive wastes need to be moved to higher-elevation areas, farther away from Cape Cod Bay and securely protected from natural and man-made hazards to prevent future leaks from happening.

VII. Decommissioning and Site Cleanup

Entergy has announced it will stop generating electricity at Pilgrim by May 31, 2019. Once it closes, the NRC allows Entergy to choose a scenario for decommissioning and site cleanup. One scenario is long-term SAFSTOR, a process that allows Entergy set aside Pilgrim for up to 60 years before decommissioning is completed. Under NRC rules, decommissioning a nuclear power plant includes dismantling buildings and cleaning up radioactive contamination.

The 60-year time frame is chosen since it corresponds to 10 half-lives for cobalt-60, one of the more common radioactive isotopes left behind at a nuclear facility. Over the decades, the radioactivity is thought to decay. At 60 years, cobalt-60 reportedly decays to background levels. Entergy may take down some non-essential buildings, etc. before buttoning it up for the 60 years.

If the NRC allows Entergy to choose SAFSTOR, the ongoing leaks and environmental contamination do not have to be addressed for 60 years. Contamination is currently migrating toward Cape Cod Bay and it will continue to do so. Pilgrim's location directly on the Cape Cod Bay shoreline makes it vulnerable to rising sea levels and groundwater levels, intense storms, precipitation and flooding. These coastal impacts will increasingly create challenges for site cleanup and potentially cause more flushing of contaminants into Cape Cod Bay. Allowing decades to pass may decrease the radioactivity at Pilgrim, but more likely due to dilution into the environment faster than decay.

Aside from establishing some technical and financial criteria, the NRC has very little say in the decommissioning process itself. For example, Entergy will need to submit a PSDAR (Post Shutdown Decommissioning Activities Report) to the NRC, which is due within two years of shutdown. The PSDAR will provide a description and schedule for planned decommissioning activities, an estimate of expected costs, and a discussion concluding that the environmental impacts will be bounded by already issued Environmental Impact Statements. The NRC only reviews this PDSAR, but does not have to approve it. While public comments on the PSDAR will be solicited by the NRC, the agency will not be required to incorporate any concerns and comments into the final PSDAR document. The NRC also does not require Entergy to restore the

Pilgrim site to the conditions that existed before the construction of the plant, nor does it ensure that there are sufficient funds in the decommissioning trust fund to achieve this.

With Pilgrim slated to close, it is more important than ever to understand the extent of the environmental contamination at the site. There should be an independent site assessment and decontamination plan that goes beyond inadequate NRC standards. Regulators and elected officials need to step up to ensure that this contamination is addressed immediately. This report is a call for a process that provides full transparency and public participation in all phases of cleanup and improvements to Entergy's current plan for long-term storage of high-level nuclear waste on the shore of Cape Cod Bay. Pilgrim's high-level nuclear waste dry cask storage facility should be made more robust, moved to a higher elevation farther away from Cape Cod Bay and securely protected from natural hazards.

1. NRC and EPA Clean Up Rules

When Entergy remediates contaminated soil and groundwater, the "clean" standards that will be used differ from the "safe" standards discussed in Section III.

The NRC's ultimate goal for a closed nuclear reactor site is for "unrestricted use," meaning the radioactive materials left after the facility closes are not to exceed 25 mrem per year. According to the NRC, if this standard is met then the site can be reused for any purpose.[82] On the other hand, if a site cannot meet these criteria it may instead be reused for limited purposes, with a formal legal restriction recorded on the deed. The NRC does not require that the site be returned to the uncontaminated state it was in before Pilgrim was built. Even if this were possible, the NRC does not require Entergy to have sufficient funds in its decommissioning trust fund to achieve it.[83] The NRC only requires radioactive remediation, or "meaning it is safe for use by the public from a nuclear perspective," said one NRC staff member.[84] In addition to the legacy of contaminated soil and water, the lethal spent nuclear fuel at Pilgrim is likely to remain there for hundreds of years or more.

In 1997 the NRC adopted the License Termination Rule (LTR), which established cleanup standards for nuclear sites.[85] The LTR sets a total dose limit of 25 mrem per year from all radiological sources (i.e., air, groundwater, surface water, soil), as the cleanup standard to be achieved before a facility's license can be terminated. This rule applies to Pilgrim. Entergy must also demonstrate that it has reduced the residual dose at Pilgrim following decommissioning to ALARA, considering economic and other factors.[86] The NRC does not, however, set specific groundwater protections.

In 2012 the LTR regulations were amended when the NRC's "Legacy" Final Rule went into effect.[87] Now nuclear facilities are required to minimize the introduction of radioactivity into groundwater and soils during operations and to provide additional reporting concerning costs of cleanup and contamination. But the new rule still does not provide specific groundwater cleanup standards.

EPA established its own cleanup standards for decommissioned nuclear sites in 1997, in the form of non-binding Superfund law guidance. [88] This sets a maximum dose of 15 mrem per year from all sources, and MCLs for ground and surface waters used for drinking. This is the same year that the NRC finalized its own standards of 25 mrem per year.

For the next five years, the NRC and EPA were at odds about their differing policies and regulatory approaches, mainly over EPA's specific groundwater protections.[89] EPA favors more restrictive protections and views groundwater as an important national resource. The NRC, on the other hand, has no specific groundwater restrictions and views groundwater as one of many pathways included under its 25 mrem per year umbrella. One reason the NRC may favor this less restrictive approach is that it is costlier for licensees (plant operators like Entergy) to implement. For instance, according to an EPA analysis it would cost $1 billion to achieve 25 mrem per year, but $1.5 billion to achieve 15 mrem per year.[90]

To bridge the disagreement and better define regulatory roles, in 2002, NRC and EPA entered into a Memorandum of Understanding (MOU) regarding the coordination of decommissioning.[91] Essentially EPA will only get involved if it determines a site is not being properly responded to by the NRC. These federal agencies are required to consult with each other if the following circumstances occur:

1. NRC determines that residual levels in groundwater will exceed radionuclide MCLs established under the Safe Drinking Water Act,
2. residual levels in soil will exceed the soil concentrations in "MOU Table 1: Consultation Triggers for Residential and Commercial/Industrial Soil Contamination,"
3. NRC contemplates that future use of the site will be restricted by conditions contained in the license termination,[92] or
4. NRC contemplates the use of alternative criteria for license termination (i.e., a site-specific dose greater than NRC's primary dose limit of 25 mrem per year may be allowed).

If radioactive groundwater contamination is above either EPA's MCLs for drinking water or if soil contamination exceeds specific concentrations (Table 5), EPA can list a nuclear reactor site as a Superfund site and have more oversight in the cleanup. Only in these cases would EPA's more

restrictive protections apply. Otherwise, EPA's cleanup standards are not applicable to commercial nuclear reactor sites.

MassDEP does set some cleanup standards on a case-by-case basis, under the Massachusetts Contingency Plan (Chapter 21E) but it are largely the federal standards that apply.

Table 5. EPA/NRC consultation triggers (concentration, piC/g) for industrial soil contamination

Radionuclide	Soil Concentration
Tritium (H-3)	423 piC/g
Manganese (Mn-54)	112 piC/g
Cobalt 60 (Co-60)	6 piC/g
Cesium 137 (Cs-137)	11 piC/g

2. Historic Midnight Dumping at Pilgrim

Sources have reported that drums of hazardous waste were buried on the Pilgrim site in the 1980s and/or 1990s.[93] Barrels of chemical waste were reportedly shipped from New Jersey were buried along Power House Road (Pilgrim's access road) and then over-planted with evergreen trees (Figure 9).

This contamination was the subject of public comments to the NRC in 2007.[94] These comments are reported in Pilgrim's "Generic Environmental Impact Statement for License Renewal," which as follows: "The public, NRC officials and Entergy staff also are well aware of burials off the Access Road." The NRC responded to this comment by saying that the comment was noted and would be kept on file to "ensure that these types of areas will be identified during plant decommissioning. In addition, these regulations provide assurance that any contamination will be appropriately remediated during site decommissioning. Specifically, at the time of decommissioning, the licensee is required to submit a License Termination Plan which contains information on the types and quantities of radioactive materials on the site."

Figure 9. Location of suspected chemical waste dumping site on the Pilgrim property.

In October 2015, community members filed a formal "Chapter 21E"[95] report to MassDEP about these hazardous materials. The Chapter 21E report triggers regulations that requires the agency to investigate and report its findings to the public. MassDEP followed up a year saying that without more evidence, such as samples showing contamination, or pictures of stuff being buried, there is nothing more the agency could do.

VIII. Emergency Backup Cooling

In 2012, one year after the Fukushima nuclear disaster in Japan, the NRC ordered Entergy to install upgrades at Pilgrim to prevent a similar disaster at Pilgrim.

One of the fixes that the NRC ordered is a backup emergency water system. Even when it is not operating, Pilgrim needs water to cool the nuclear reactor and spent fuel pool where the nuclear waste is stored. Pilgrim also needs offsite power in order to run pumps that cool the pool and reactor. Since 1974, Pilgrim has regularly lost power during storms, requiring it to use its emergency backup generators. The NRC found that if there was a severe natural event like a

nor'easter, blizzard, hurricane, earthquake or tsunami that knocked out the generator and offsite power, it could lead to Pilgrim having a meltdown or spent fuel fire. Hence, the need for a backup cooling system.

Part of Entergy's proposal to the NRC, dubbed the "Fukushima Fix" and 'Recipe for Disaster" by critics (Figure 10), was to install moorings in Cape Cod Bay so that during an event like a hurricane, it could send workers to the mean high water line where they would attach strainers to the moorings and then connect a hose that would pump cooling water from Cape Cod Bay directly into the reactor.

Entergy needed a state Waterways License to put the moorings in the public tidelands of Cape Cod Bay. Under state law, the shoreline of Massachusetts (i.e., tidelands) belongs to the public and is held in trust for the people; therefore, Entergy needed get permission and a Waterways License from the state to install the moorings in this area. When Entergy applied to MassDEP for the license, it claimed that the moorings would be in "private tidelands" and not harm public rights in the intertidal area.

In the summer of 2014, local residents and the Jones River Watershed Association (JRWA) submitted comments to MassDEP challenging Entergy's license application. MassDEP held a public hearing in Plymouth in November 2014, where many of the 80 attendees raised concerns about the backup cooling system. A few months later, MassDEP issued the Waterways License despite the objections raised by the public. Twelve local residents and JRWA filed a legal appeal in March 2015.

MassDEP's judge held a hearing in September 2016 and heard evidence from JRWA, the residents, Entergy and MassDEP staff. The judge's February 5, 2016 decision upheld the License granted to Entergy.[96] The judge's decision has two parts: first, JRWA and the residents had legal standing to challenge the Waterways License. This is a significant victory for the rights of citizens to challenge actions by the state that may harm the environment. Entergy argued that the appeal should be thrown out since JRWA did not meet the legal standing and it could not show that it would suffer "harm" from the project. The judge disagreed.

The judge wrote that if the proposed mooring system fails to work in an emergency at Pilgrim, "this may result in inadequate cooling of the radioactive [spent fuel pool] at Pilgrim and lead to a [spent fuel pool] fire, and if that occurs, dire environmental consequences would likely befall the Jones River and Cape Cod Bay." The judge went on to describe the various ways that this harm would occur: "the quality, habitat and ecosystem of that area would be harmed by radioactive contamination resulting from the spent fuel fire, and as a result, JRWA and its members would suffer harm to their conservational, recreational, and aesthetic interests in the area because their ability to use and enjoy the Jones River, its estuary, and the functioning of

Cape Cod Bay as a habitat, nursery, and migratory route for fish and marine species connected with the Jones River would be impaired."

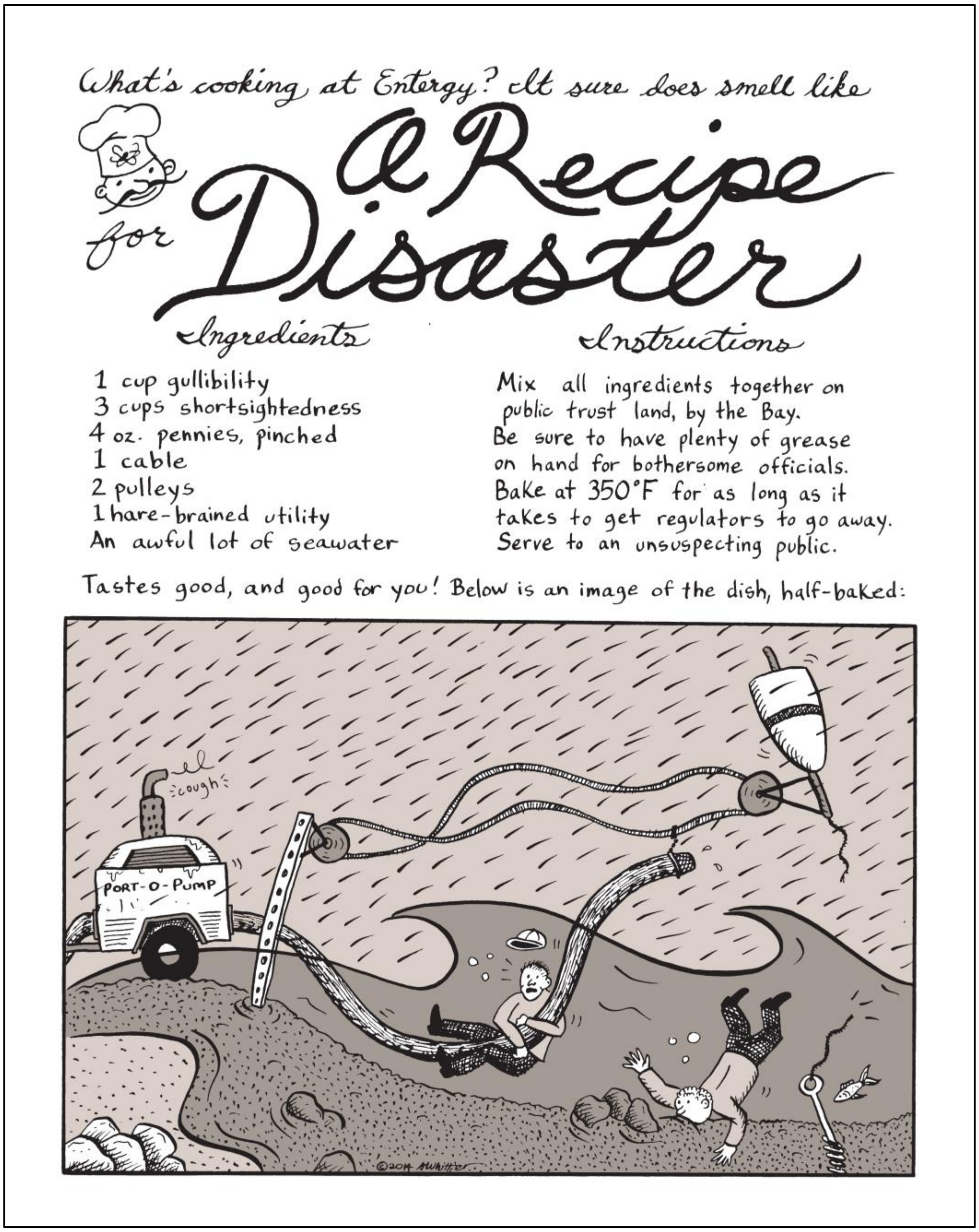

Figure 10. Critics dubbed Entergy's backup cooling plan a "Recipe for Disaster" (Source/Artwork: Adam Whittier)

The judge based this finding on testimony from JRWA and a chronology of "loss of offsite power" events that have occurred at Pilgrim since 1975. This showed that from September 1975 to February 2015 Pilgrim had 21 losses of offsite power events which forced Pilgrim into emergency

shutdown situations. The judge ruled "…weather related events demonstrate that Pilgrim is vulnerable to adverse weather conditions such as a nor'easter or blizzard."

Even though JRWA and the group of citizens were found to have legal standing to bring the appeal, it was ruled that MassDEP properly applied the Chapter 91 law to grant the Tidelands License to Entergy. This law includes a complex set of legal regulations that, in part, require MassDEP to locate the proper boundaries of the high and low water lines on the shoreline.

At the crux of the legal appeal was the method MassDEP used to determine where the high and low water marks are at Pilgrim. The citizen groups said the moorings were below the low water mark, meaning a stricter standard of regulation applied. Entergy and MassDEP said they were above the low water mark, in the intertidal zone or "private tidelands" and subject to looser regulations. The judge agreed with Entergy and MassDEP, and based the decision on maps from 1866. The judge did not agree with the testimony of the citizens' expert who said the 1866 map was outdated and the mooring system was in public tidelands.

MassDEP issued the final Chapter 91 license on March 2, 2016. Even though the citizens ultimately lost the appeal, the Decision is a major victory for advocates and local residents who want to use the law to protect their rights to the environment. By granting standing to JRWA and the twelve residents, the judge set a legal precedent that can be relied on in many types of lawsuits seeking to enforce environmental laws.

It's also important to note that, as part of Entergy's emergency backup plan for Pilgrim, three deep groundwater wells were installed as an emergency source of cooling water. The wells are located south of the reactor building at depths of approximately 80 feet, reaching the underlying bedrock. The influence of these deep wells on the movement of groundwater and contaminants is unknown.

IX. CONCLUSION

Regulatory agencies, including the NRC, have repeatedly tolerated accidental and uncontrolled radioactive leaks at Pilgrim, and Entergy has never faced any consequences. The NRC selectively enforces regulations, and enforcement appears to have nothing to do with the quantity, duration or severity of a leak.[97] Typically, when leaks are discovered and reported, industry only monitors and investigates them but is not required to stop them. The NRC has largely replaced its regulatory oversight of radioactive leaks with voluntary initiatives. Other regulatory inadequacies over the past four decades include:

- Agencies use various "safe" standards and limits for radiation exposure, even though in reality there are no safe levels, as a way to deflect public concern about contamination.
- EPA's MCLGs are focused solely on public health and set acceptable levels of tritium and other radionuclides as zero; however, these goals are not enforceable.
- Due to regulatory conflict with the NRC, EPA's more restrictive cleanup standards are not applicable to commercial nuclear reactor sites.
- Agencies absurdly downplay the risk of tritium by stating that Pilgrim's monitoring wells are not used for drinking water, thus allowing ongoing contamination of the PCA and the bay.
- The impact of radionuclides on ecological health is not properly evaluated; even human tolerances, if fully understood, could not be assumed to automatically protect plants and wildlife, especially threatened and endangered species.
- Pilgrim's groundwater wells are only sampled only for gamma-emitting nuclides and tritium; outdated testing that is used today could be missing other radionuclides significant to public and environmental health.
- The Federal Clean Water Act does not regulate radioactive waste even though Pilgrim regularly discharges radioactive water directly into the surface waters of Cape Cod Bay.
- State agencies have failed to enforce water quality standards for radioactive materials even though Entergy routinely dumps these materials into Cape Cod Bay, a "Class A" water body under the state's Clean Waters Act.
- Pilgrim's wastewater treatment facility has polluted groundwater since it began operating; the state has allowed delayed compliance with nitrogen limits and eliminated some pollution limits altogether from Pilgrim's newest groundwater discharge permit.

The role for regulators and elected officials is obvious: a push for transparency in the decommissioning and cleanup process and ensure that the highest standards are applied. There needs to be a complete, thorough site assessment that looks at all areas of potential contamination. It will be critical to fully understand the extent of the contamination in order for proper clean up to be accomplished. An independent site assessment and decontamination plan that addresses radioactive and non-radiological contamination on the property is needed.

It is also important to consider sea level rise, rising groundwater tables, and other coastal hazards that could potentially influence contaminants present on the site and the success of decommissioning. Cleanup activities should not be delayed, but rather accelerated. This also holds true for Pilgrim's nuclear waste – currently in reach of coastal hazards – that will likely remain a potential source of leaks and contamination for hundreds of years or longer. Pilgrim's nuclear waste storage area needs to be moved away from Cape Cod Bay and secure from coastal and man-made hazards.

The public should be reimbursed for natural resource damages to the PCA and Cape Cod Bay. Pilgrim's leaks and releases have negatively impacted Cape Cod Bay and the regional environment. Natural resources belong to the public, and are not Entergy's to pollute at will, without consequences. Entergy has essentially created a sacrifice zone: in all likelihood the site will be off limits for generations due to the scale and scope of contamination.

The harm caused by Pilgrim's long history of regulated and accidental discharges of radioactive materials to the environment, plus the inadequacy of regulatory oversight and enforcement are major concerns and must be addressed post operations. It is imperative Pilgrim' toxic legacy is dealt with quickly and fully to best protect public health and safety and our environmental resources.

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Addendum to Entergy's Legacy of Contamination at Pilgrim Nuclear Power Station (Draft 2, February 2017)

2017 Update: Massachusetts Department of Public Health (MassDPH) May 2017 Groundwater Investigation Update for Entergy's Pilgrim Nuclear Power Station

In May 2017, the Mass. Department of Public Health (MassDPH) published its latest Groundwater Investigation Update for Entergy's Pilgrim Nuclear Power Station. The reports covers testing that occurred in the the last six months of 2016.

Even though Pilgrim is scheduled to shut down in 2019, it is important to remember that there are two more years of operations. This means there will also be two more years of tritium entering the groundwater and soils on the site. It is important to understand the contamination on the site considering decommissioning is right around the corner. If Pilgrim is allowed to postpone full cleanup of the site for decades (up to 60 years is possible!), then contamination will undoubtedly migrate and flush into Cape Cod Bay over time. This is especially true given rising sea levels and storms affecting the site.

Background:

Energy collects water samples from 23 groundwater monitoring wells and two surface water locations on the Pilgrim site. The samples are split between two labs – one lab contracted by Entergy (Teledyne) and the other is the Massachusetts Environmental Radiation Lab (MERL).

Some important numbers to keep in mind are:

- 3,000 picocuries per liter (piC/L) = screening level; based on 1/10th the NRC approved level of tritium in non-drinking water (30,000 piC/L). Anything above 3,000 piC/L is of concern.
- 20,000 piC/L = U.S. Environmental Protection Agency's (EPA) "safe" drinking water standard for tritium.
- 0 piC/L = The level of safe exposure identified by the National Academies of Science's 2005 report called "Health Risks from Exposure to Low Levels of Ionizing Radiation." There is no safe level of exposure to radiation and even low doses can cause cancer. To address this, EPA set a Maximum Contaminant Level Goal (MCLG) for all radionuclides (including tritium) as ZERO. EPA defines MCLG as the "level of a contaminant in drinking water below which there is no known or expected risk to health."
- 5-25 piC/L = Normal background levels for tritium. While this can be variable depending on soils, rock type, wind, and drainage, typically 5-25 pCi/L are found in surface water and about 6-13 piC/L in groundwater.

Overview of May 2017 Report:

According to MassDPH, seven of Pilgrim's wells had no detectable levels above background. Fourteen wells had stable levels of tritium (above background but similar to historical records). Two of the wells (#216 & 210) saw increases in tritium levels. Two wells (#216 and #218) had levels above the 3,000 piC/L threshold.

<u>Monitoring Well 210</u> – Monitoring of well #210 will increase from quarterly to every 3 weeks until the tritium levels stabilize. This is due to levels increasing from 597 pCi/L in August to 1,180 pCi/L in November.

<u>Monitoring Well 216</u> – Well #216 is historically a "problem" well. It is located on the northeast corner of the turbine/reactor building. Historically, there have been increases in tritium in well #216 during the months of September and November. Last year was no different, and the "peak" was higher in 2016 (5,756 piC/L) than it was the previous year (4,300 piC/L). Entergy and MassDPH have been trying to figure out why these spikes occur since 2013. The 2017 MassDPH report states that Entergy is still working with a consultant (ERM) to figure out the cause. It is suspected to be due to residual tritium in a seismic gap (seismic gaps are man-made spaces between building foundations that allow them to move during an earthquake). According to a 2015 MassDPH report, the gap was re-sealed that year. However, spikes in tritium are still occurring during the fall months.

<u>Monitoring Well 218</u> – Monitoring well #218 has also been a "problem" well. It was installed as part of the Neutralization Sump Discharge Line Investigation in late 2013 (due to excessive levels of tritium (69,000-70,000 pCi/L) detected in monitoring well #219).

Tritium has fluctuated from about 960 pCi/L to 6,481 pCi/L since this well was installed 2013 — with the highest tritium levels occurring in 2016 (a peak of 6,481 piC/L in March). Despite this, MassDPH reports that the levels in #218 (as well as well #211) have "stabilized" after a leak in the Condenser Bay area. This leak reportedly contributed to elevated levels in both wells. The leak was detected and repaired in early 2016. MassDPH states, "Recent results are near previous levels and Entergy continues to monitor the Condenser Bay area for leaks." It is unclear if MassDPH is referring to results from testing done in 2017 (around the time the report was published), or results from late 2016 (July-Dec 2016 results ranged from 2,230 to 4,086 piC/L).