


Models of Neighborhood-Scale Wastewater Treatment on Buzzards Bay: Successes from West Island, Fairhaven and New Silver Beach, Falmouth

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Introduction

West Island in Fairhaven and New Silver Beach in Falmouth are prime examples of dense, coastal, residential neighborhoods on Buzzards Bay. They were originally developed for seasonal use, consisting of small, clustered cottages. Due to a variety of factors, such as small lots, overuse, and high groundwater, the homes' septic systems started to fail. Lawns were consistently flooding with wastewater and drinking wells were being contaminated with bacteria. It became so severe that at one point each of the towns had to issue public health warnings for these neighborhoods.

The Massachusetts Department of Environmental Protection (DEP) revised the Massachusetts Title V Environmental Code in 1995, which regulates on-site sewage treatment and disposal systems, namely, septic tanks and cesspools. The revised code requires at least four feet of soil between the leach field and water table, to allow for sufficient die off of pathogens coming from septic tanks. The 1995 code has required thousands of Massachusetts homeowners to upgrade their systems, especially those living on the coast where the water table is relatively high.

Both towns resolved their septic system issues on West Island and in New Silver Beach by developing small neighborhood-scale wastewater treatment facilities. The West Island wastewater treatment facility has been in operation for twenty years, and the New Silver Beach wastewater treatment facility for ten years. These treatment facilities have succeeded in diminishing public health concerns, relieving homeowner stress, enhancing property values, and helping improve the water quality of surrounding water bodies.

West Island

Background

West Island is a small island within the town of Fairhaven that is approximately 535 acres and separated from the mainland by a 0.4 mile causeway (Figure 1). It is surrounded by both Buzzards Bay to the south and Nasketucket Bay to its north. Prior to World War II, most homes on the island were used as summer homes. They were developed on small lots, between 6,000 and 8,000 square feet, with primitive septic systems that often consisted of a 55-gallon drum with perforated holes. There was a restriction on the number of bedrooms each home could have and none had washing machines or dishwashers. Residents also relied on well water for drinking, while the rest of Fairhaven utilized town water. After World War II, these summer homes started transitioning into year-round homes where the usage of water increased.

Figure 1: Aerial view of West Island, Fairhaven (Google Earth, 2017).

Problem

Since 1983, the Town of Fairhaven recognized the need to provide a sewer system for the homes on West Island (Figure 2). It didn't become urgent though until Hurricane Bob made landfall in late August of 1991. This was the worst storm to hit the area in 30 years, and Fairhaven alone accumulated $8 -12 million in property damage. Wind speeds reached 100 miles per hour and the tidal surge was between 7 and 9 feet, nearly washing away the causeway to West Island and causing it to be closed for two weeks for repair. Many low lying areas flooded on West Island, where both wells and septic systems were inundated with water.

The Board of Health (BOH) was concerned about the safety of drinking water after this devastating hurricane, so Pat Fowle, BOH agent at the time, operated a certified drinking water lab to test the drinking water. Homeowners were able to test their well water for bacteria free of charge. Within a month, Pat Fowle processed a total of 800 water samples. It was assumed that the hurricane contaminated the wells due to the severe flooding, but well water was still failing Massachusetts drinking water standards after flooding had subsided. Homeowners were advised to chlorinate their drinking water, but samples were still failing. At this point, town officials agreed that it was the septic tanks and cesspools contaminating the drinking water wells. Because

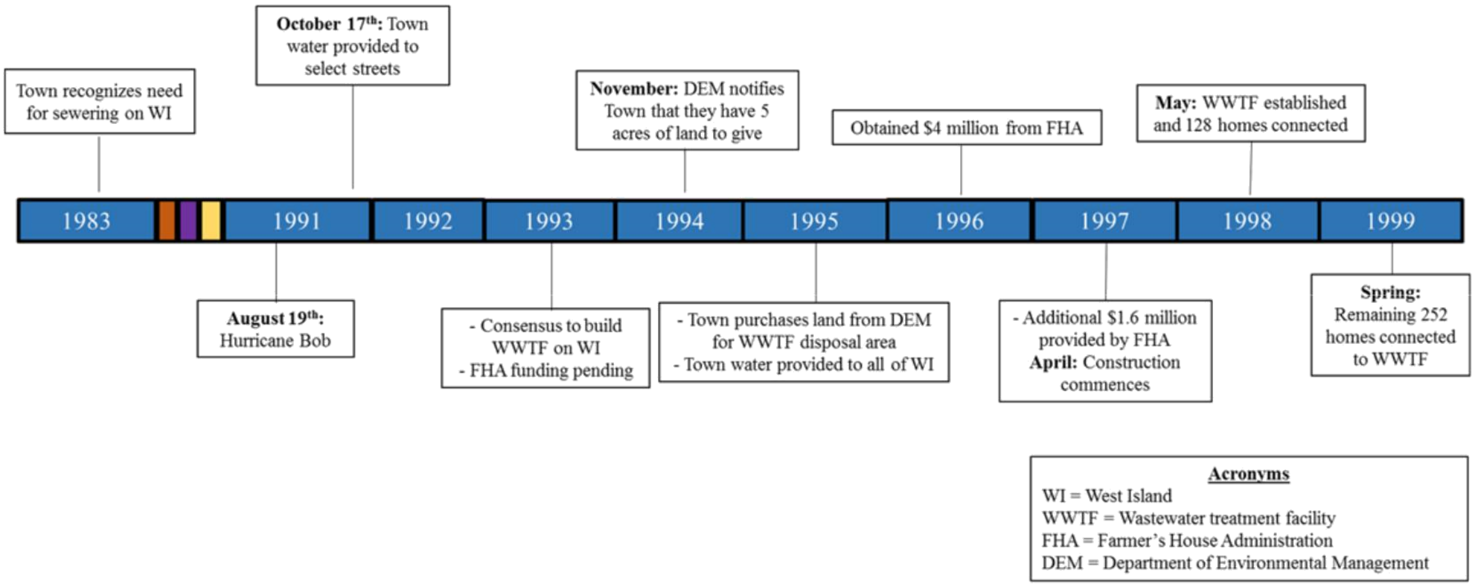

Figure 2: Timeline for West Island wastewater treatment facility project.

drinking water for homes on Alder and Balsam Street had high bacteria concentrations, the Town had to extend town water to those 100 homes immediately. Eventually, the rest of the island connected to town water, which led to an increase in water consumption, causing more septic tank failures. These consistent septic tank failures posed a health hazard due to the frequent flooding of wastewater onto lawns.

Solution

The BOH approached the West Island Improvement Association, a volunteer community organization, to discuss solutions for the wastewater issue. One proposed solution was to run a pipe from Fairhaven's main wastewater treatment facility to all of the homes on West Island. This would require approximately 7 miles of piping though, which was determined to be cost prohibitive. Another proposed solution was to establish a wastewater treatment facility on West Island and use an existing parking lot as its leach field, but the soil conditions on West Island were not sufficient for a traditional wastewater treatment facility.

The Fairhaven Town Administrator at the time, Jeff Osuch, came across a technique used by some towns in Florida where treated wastewater effluent is pumped into the ground. He presented the idea of building a wastewater treatment facility on West Island where a pump station would bring the wastewater to the facility for treatment, and then direct it to wells where the treated effluent drains into the ground.

Regulatory Hurdles

Treated effluent had not been discharged into wells in Massachusetts before, and there was concern that over time the effluent would rise to the surface. To test the feasibility of the practice, the Town and its advising hydrogeological firm, Caswell, Eichler and Hill, placed a fire hose into one of the wells and pumped 100,000 gallons per day of water for 30 days and monitored the groundwater level. Over the course of the 30 days, groundwater was never close to surfacing and flowed to the bay. Given this, the DEP wanted to know where in the bay the wastewater effluent was discharging. To try to pinpoint a location, the Town and engineering firm performed a biodegradable dye test. They pumped water mixed with dye into one of the wells and stationed themselves in boats on the bay to see where the dye would appear. The dye was not observed in the bay possibly because the dye degraded while underground or because the water containing the dye took longer than a couple of days to discharge into the bay. After working closely with the Town on these trials, the DEP approved the project.

The next obstacle was obtaining a piece of land large enough to implement this technology. With help from State Representative William Straus and State Senator William MacLean, the Town purchased five acres of land from the West Island State Reservation as well as a 20 acre easement around its perimeter. This purchase came with specific conditions from the State. For instance, under Massachusetts General Law, the BOH had to adopt a regulation to prevent overuse of the facility. The regulation stated that the facility cannot be used for any new developments on West Island and current residences could not add any new dwellings. The town's building department and BOH work closely together to enforce this regulation. The building department refers any floor plans for additions or modifications to a current residence to the BOH to ensure that no bedrooms are added.

Financing

Financing was the last major obstacle for the project. The Town wanted to decrease the cost for homeowners as much as possible. The Farmers Home Administration, now referred to as the United States Department of Agricultural Rural Development, is a federal agency that provides funding to towns with populations less than 10,000 people. At the time, the town of Fairhaven had a population of roughly 16,000 people. However, with support from U.S. Congressman Barney Frank, the Town argued that West Island's remoteness and unique position as an island earned a special consideration and secured a grant totaling $5.2 million. Securing these funds significantly lowered the betterment fee for homeowners. Because the Farmers Home Administration funded approximately 75% of the wastewater treatment facility project, the betterment fee was only $26 per linear foot of property frontage. The average property frontage on West Island is 60 feet, so the approximate betterment fee was $1,560 per home.

Wastewater Treatment Facility

The West Island wastewater treatment facility project cost approximately $7 million and services 375 homes, 89 of which are seasonal. Since the establishment of the facility, six new homes have been built on West Island and are on their own Title V septic systems. The sewer user fee is currently $0.94 per 100 gallons of water with a $50 annual charge. Since the facility's development, the only major changes have been refurbishing the tertiary filter and modifying some piping in the pretreatment tank, which cost approximately $70,000. The facility will be undergoing major upgrades within the next couple of years that will amount to approximately $627,000.

Figure 3: West Island wastewater treatment facility.

The facility and sewer system on West Island consist of two pump stations, a treatment facility that provides tertiary treatment, holding tanks, and a dispersal field (Figure 4). It was important to blend the facility with the rest of the community, so an old clubhouse on the East side of the Island was refurbished to look like a compact house (Figure 3). All equipment is indoors, besides the holding tanks, which prevents odor issues. The facility was built to handle 100,000 gallons per day (gpd) of wastewater but usually averages 16,000gpd (Figure 5). During summer holidays and intense rainstorms, the facility has managed flow rates up to 98,000gpd. The facility has one full time employee with 12 on-call employees in case of emergency.

Figure 4: Wastewater collection system schematic for West Island wastewater treatment facility (courtesy of Town of Fairhaven).

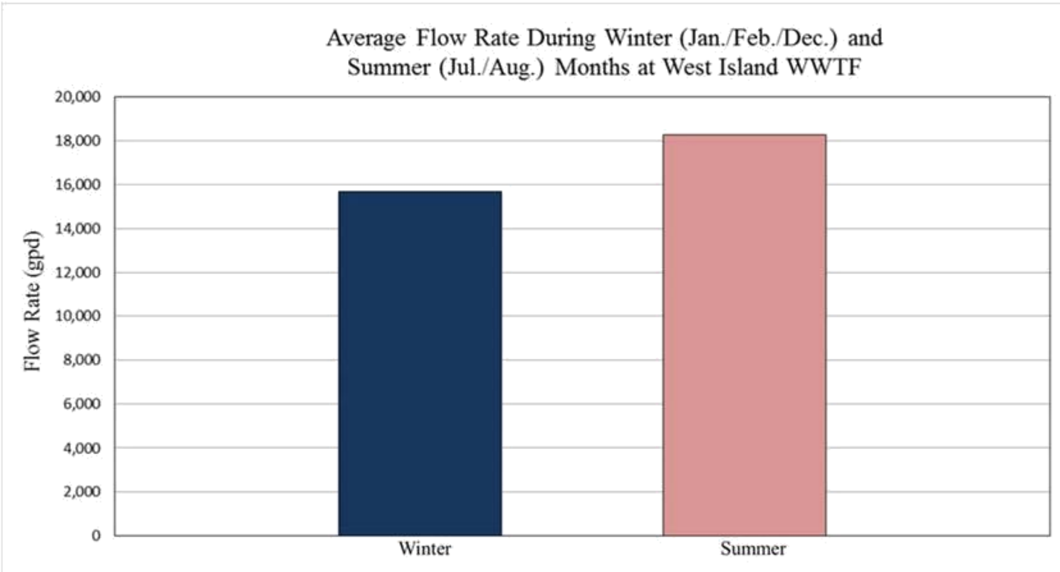

Figure 5: Average flow rates during winter (15,712gpd) and summer (18,247gpd) months at West Island wastewater treatment facility.

The wastewater treatment process is described in Figure 6. The pump stations deliver the collected wastewater to the facility, and then once treated, it is transported to the wells using a copper pipe. The four wells in the dispersal field are approximately 30-40 feet deep and 12 inches in diameter with five feet of well screen at the bottom to ensure even dispersal. The wells are designed to be free-flowing with gravity used as the ultimate mechanism dispersing the effluent through the soil.

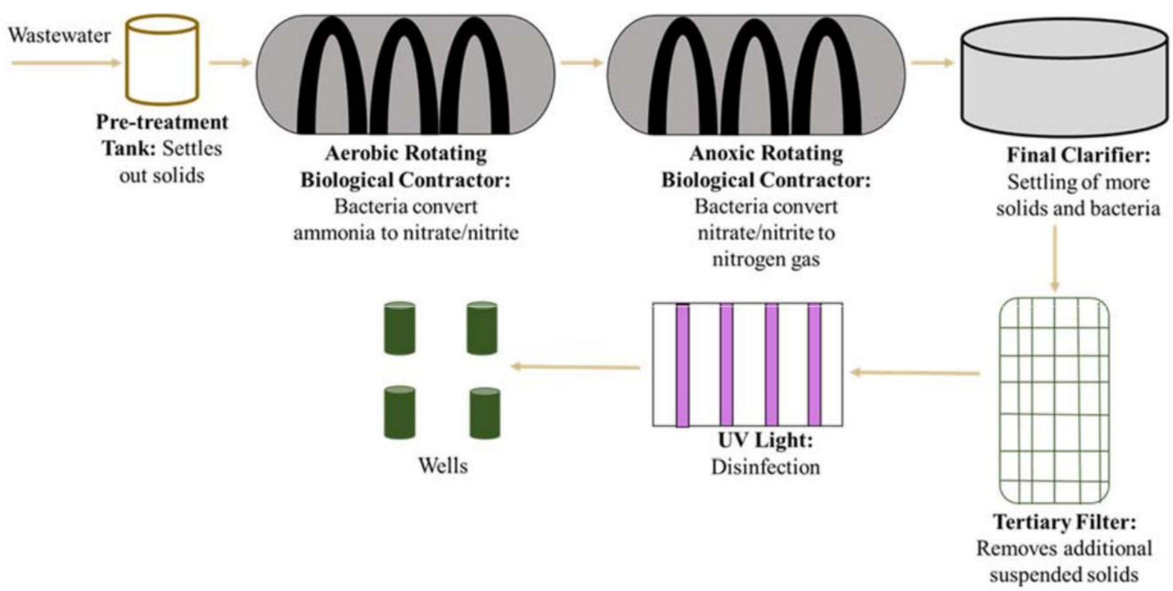

Figure 6: Wastewater flow diagram for West Island wastewater treatment facility.

Benefits of the Wastewater Treatment Facility

The West Island wastewater treatment facility solved the public health threat. Wastewater was no longer surfacing on homeowner lawns, public health emergencies weren't being issued due to failing septic systems, and the facility was removing a significant amount of bacteria and nitrogen that would have entered the nearby bay.

Wastewater Treatment Facility Performance: Septic tanks and cesspools perform very little nitrogen removal and the ones on West Island were also failing to remove bacteria. The West Island wastewater treatment facility successfully removes both nitrogen and bacteria from wastewater before it is discharged. For example, the facility reduces ammonia concentrations, a form of nitrogen, by approximately 97%. A similar trend can be seen with biological oxygen demand (BOD). BOD is commonly measured at wastewater treatment facilities to assess the level of organic substances that can deplete oxygen in receiving waters. High BOD can be an indicator of high levels of fecal bacteria. The facility removes approximately 96% of BOD from the wastewater before it is discharged.

Not all wastewater treatment facilities are specifically equipped with a nitrogen removal process, commonly referred to as a tertiary treatment system. Fortunately, the West Island wastewater treatment facility is and it significantly lowers total nitrogen effluent concentrations compared to facilities that do not have this treatment process, such as Fairhaven's main wastewater treatment facility. For example, between January 2015 and December 2017, Fairhaven's main wastewater treatment facility's total nitrogen effluent concentrations ranged from 11 mg/L to 29 mg/L with an average concentration of 19.25 mg/L (Figure 7). However, the West Island wastewater treatment facility's total nitrogen effluent concentrations ranged from 3 mg/L to 10 mg/L with an average concentration of 6.88 mg/L. Because of the additive tertiary treatment process, the West Island wastewater treatment facility is removing almost three times more total nitrogen compared to Fairhaven's main wastewater treatment facility. A recent permit renewal by the Environmental Protection Agency is now requiring major upgrades to Fairhaven's main wastewater treatment facility before 2026.

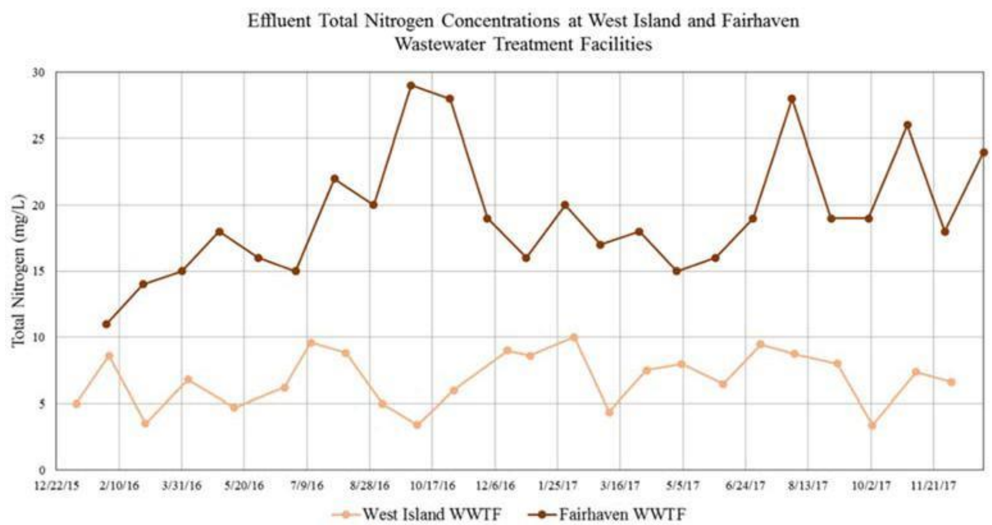

Figure 7: Effluent total nitrogen concentrations at West Island wastewater treatment facility and Fairhaven's main wastewater treatment facility.

Water Quality: The Buzzards Bay Coalition began monitoring water quality at station WI1 in 1993 to track changes in Nasketucket Bay. Station WI1 is located north of the causeway to West Island, where water exchanges between Nasketucket Bay and Buzzards Bay (Figure 8). Historically, the water quality at WI1 has been very good because the area is well flushed, so clearly identifying water quality improvements due to the wastewater treatment facility is difficult. However, there is a slight, but noticeable, decrease in average nitrate/nitrite (Figure 9) and dissolved inorganic nitrogen concentrations (Figure 10) since the wastewater treatment facility has been established.

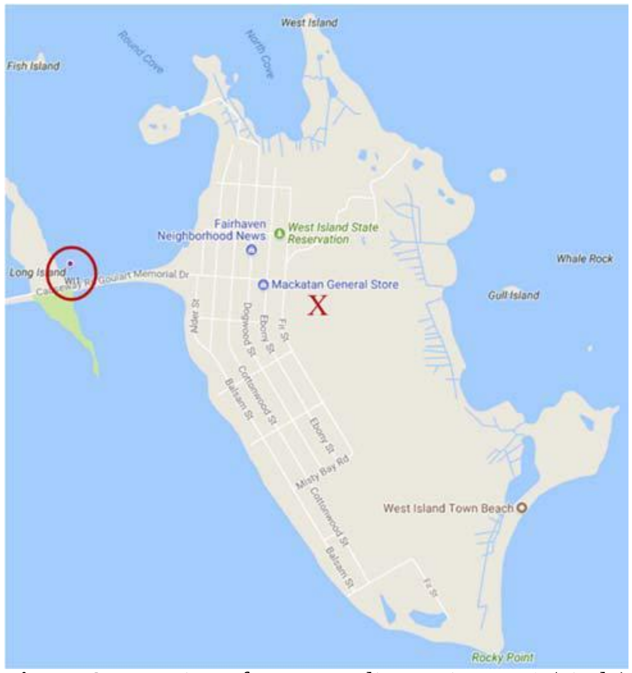

Figure 8: Location of water quality station WI1 (circle) and treatment facility (X).

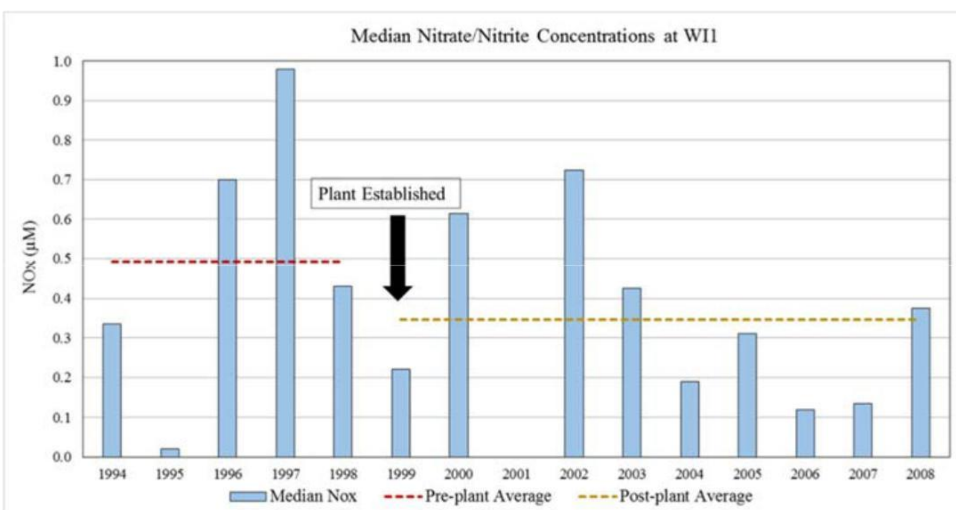

Figure 9: Annual median nitrate/nitrite concentrations at water quality station WI1. Pre-plant average nitrate/nitrite concentration was 0.49 µM and post-plant average nitrate/nitrite concentration was 0.35 µM. This suggests that 29% less nitrate/nitrite is present in Nasketucket Bay since the construction of the wastewater treatment facility.

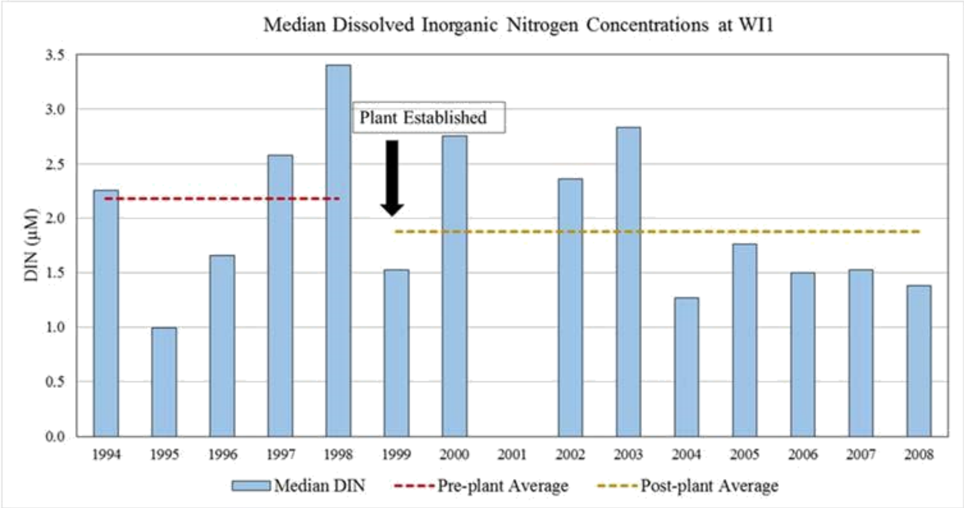

Figure 10: Annual median dissolved inorganic nitrogen concentrations at water quality station WI1. Pre -plant average dissolved inorganic nitrogen concentration was 2.18 µM and post-plant average dissolved inorganic nitrogen concentration was 1.88 µM. This suggests that 14% less dissolved inorganic nitrogen is present in Nasketucket Bay since the construction of the wastewater treatment facility.

Property Values: Between the early and mid-1990's, the average value for a single family home on West Island was less, by approximately 15%, than the average value for a single family home in Fairhaven as a whole (Figure 11). The wastewater treatment facility was established in 1999, and soon after the average value for a single family home on West Island rose to become higher, by approximately 17%, than that in the rest of Fairhaven. This change remains, even after the financial crisis, with the average home value on West Island still approximately 16% higher than the rest of the Town. While home values depend on many factors, it is likely that the development of the wastewater treatment facility contributed to the increase in value for single family homes on West Island.

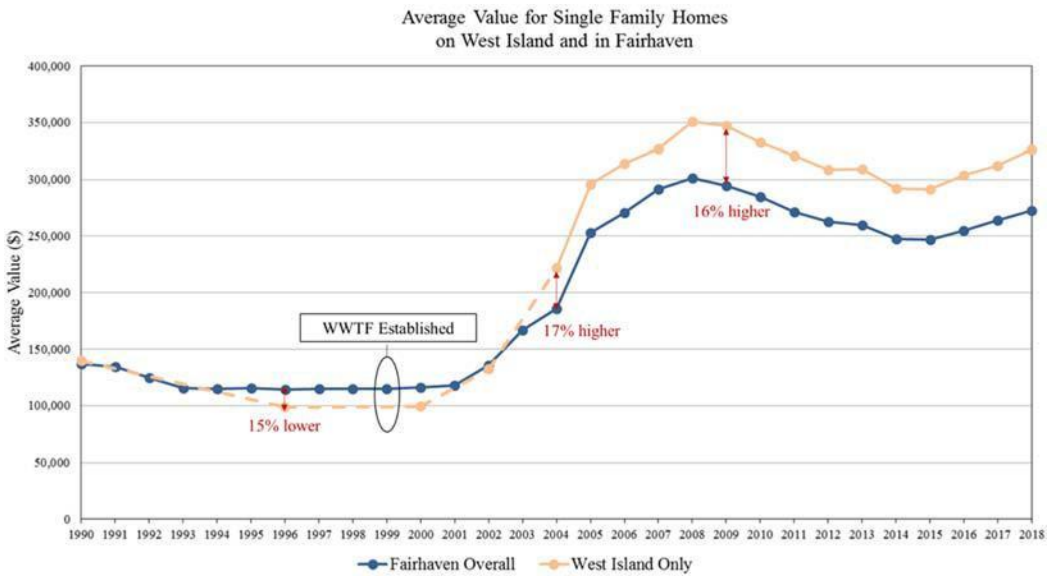

Figure 11: Average values for single family homes on West Island and in all of Fairhaven.

New Silver Beach

Background

New Silver Beach is an area within North Falmouth that primarily consists of summer homes, where less than 20% are occupied year-round (Figure 12). The village sits on a sandy floodplain adjacent to Wild Harbor, and similar to West Island, the homes are on small, clustered lots.

Figure 12: Aerial view of New Silver Beach, Falmouth (Google Earth, 2017).

Problem

Dating back to the 1980's, the BOH noted New Silver Beach as a problem area. The area sits on a low wetland area, where the groundwater table is only about six inches below the ground. This, in conjunction with numerous small lots with antiquated cesspools and septic tanks posed a health concern. Septic system backups and flooding were occurring on a consistent basis. At times there were even accounts of homeowners flushing toilets and wastewater instantaneously surfacing in the neighbor's yard. After Hurricane Bob made landfall in August 1991, conditions were at their worst and a public health emergency was declared for the area.

Solution

The first solution considered was creating raised septic systems so more clearance was given between the septic system and groundwater. The BOH tested this solution with a few homes but it was realized soon after that this approach would be too expensive to complete for all of the homes, and it did not necessarily resolve the issue. The next approach considered was to sewer the entire area, but it would have been very costly to connect the homes in New Silver Beach to the already existing Falmouth wastewater treatment facility. Therefore, the Town decided to build a compact wastewater treatment facility near New Silver Beach where only the homes that experienced the highest groundwater table would be connected.

Regulatory and Public Hurdles

While the septic system problems on both West Island and New Silver Beach became urgent when Hurricane Bob made landfall in 1991, the New Silver Beach wastewater treatment facility took much longer to construct than the West Island wastewater treatment facility (Figure 13). This was primarily due to citizen concern and legal delays regarding the location of the treatment plant and leach field and the financing of the project.

The Town selected the North Falmouth Elementary School as the optimal location for the wastewater treatment facility because the school owned 35 acres of land that was available for installing the leach field. However, property owners abutting the proposed location feared the wastewater facilities would negatively impact their properties, and for many years this group appealed permits the Town was trying to obtain. In 2003, these property owners petitioned the Annual Fall Town Meeting to require the wastewater collected from the New Silver Beach area be pumped to the Falmouth wastewater treatment plant. By a counted vote of 87 in favor and 128 opposed, this motion did not pass but demonstrated a divided opinion amongst residents.

Financing

Those who lived in the New Silver Beach area wanted to have their homes connected to a sewer line, but the rest of Falmouth was more hesitant about the development of the facility. The Town of Falmouth did not receive any state or federal grants, so the construction of the facility was completely funded through homeowner betterment fees and taxpayer dollars. However, the Town did benefit significantly from a 0% interest loan from the State Revolving Loan Program. The homeowner betterment fee was disputed numerous times, as well as whether the Town should file for exemption from the provisions of Proposition 2 ½ in order to cover the Town's portion of the cost (Table 1). The cost distribution was finalized in May 2007 with 70% of the cost paid by homeowner betterment fees and 30% paid by the Town through debt exclusion. Unlike West Island where each property owner paid a betterment fee based on property frontage, all property owners within the New Silver Beach wastewater treatment facility service area paid the same betterment fee, approximately $27,585.

Proposition 2 ½ is a Massachusetts statue where all municipalities are subject to two property tax limits:

1) Ceiling: the total annual property tax revenue raised by a municipality shall not exceed 2.5% of the assessed value of all taxable property contained in it.

2) Increase Limit: The annual increase of property tax cannot exceed 2.5%, plus the amount attributable to taxes that are from new real property.

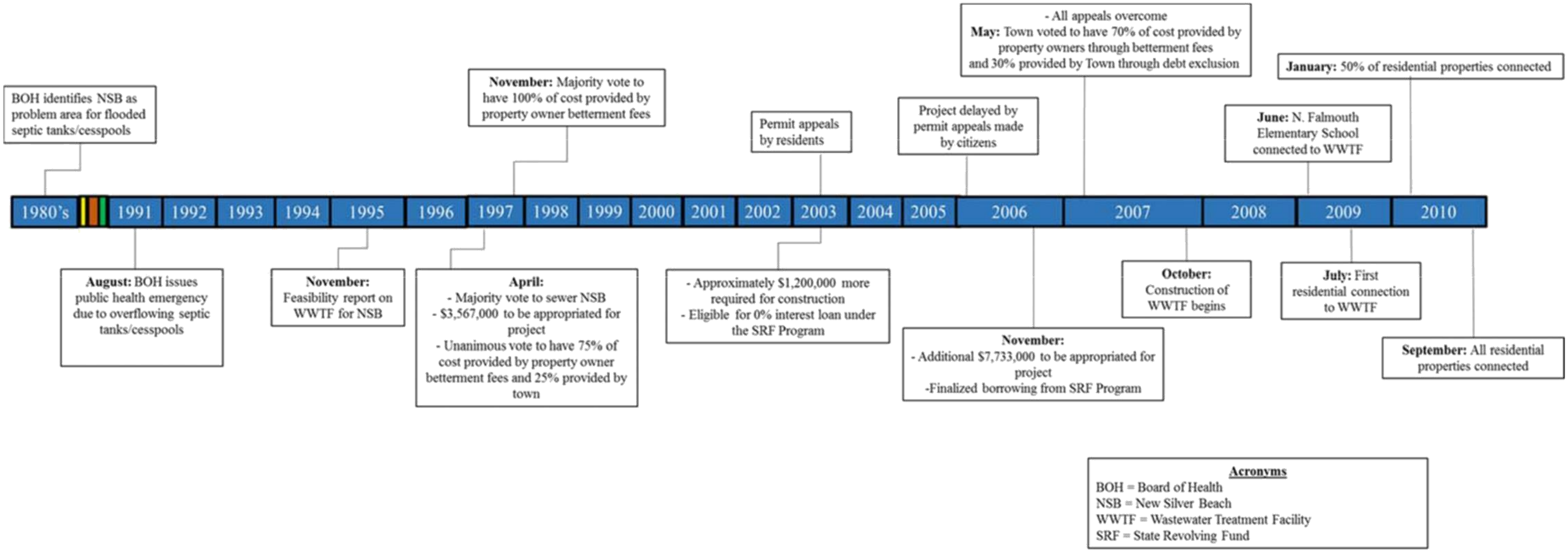

Figure 13: Timeline for New Silver Beach wastewater treatment facility project.

Table 1: Votes regarding whether Town should file for exemption from Proposition 2 ½.

Year	Yes	No
1997	3,221	3,939
2007	3,552	3,295

Wastewater Treatment Facility

After twelve years of numerous Town meetings, deliberations, and compromises, the New Silver Beach wastewater treatment facility was constructed. The project cost approximately $9.1 million and serves 231 residential properties as well as the North Falmouth Elementary School. Because the leach field is on school property, the Town constructed a two acre athletic field above it. Currently, the sewer user fee is $0.90 per 100 gallons of water in addition to a $268 annual charge.

Figure 14: New Silver Wastewater Treatment Facility

The New Silver Beach wastewater treatment facility is designed to handle 60,000gpd. Because most of the homes are seasonal, the flow to the plant drastically fluctuates by season. During winter months it experiences 3,000- 12,000gpd, while during summer months it experiences 15,000 -30,000gpd (Figure 15). The dramatic swings in flow volume can present operational challenges. The facility does not have dedicated full time staff, but a plant operator checks the facility daily.

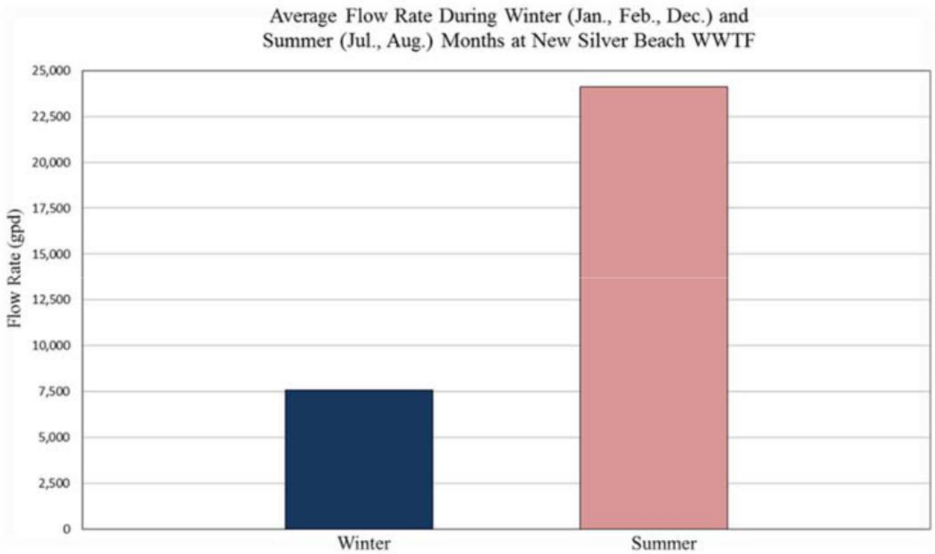

Figure 15: Average flow rates during winter (7,593gpd) and summer (24,119gpd) months at New Silver Beach wastewater treatment facility.

The wastewater collection system conveys wastewater, primarily by gravity, to a lift station on Silver Beach Avenue. The wastewater is then pumped from the lift station to the wastewater facility via a force main (Figure 16). At the facility, treatment involving Sequencing Batch Reactors reduces the amount of nitrogen, solids, and other pollutants in the wastewater (Figure 17). Ultraviolet light disinfects the wastewater. Solids are removed as required and transported to the Falmouth wastewater treatment facility where they are properly treated.

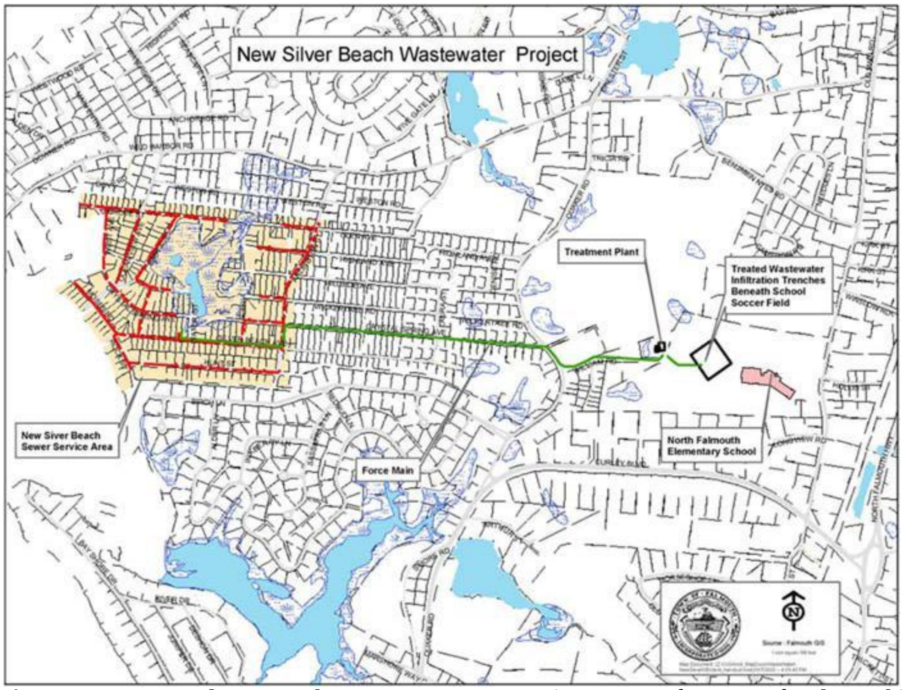

Figure 16: New Silver Beach sewer service area (courtesy of Town of Falmouth).

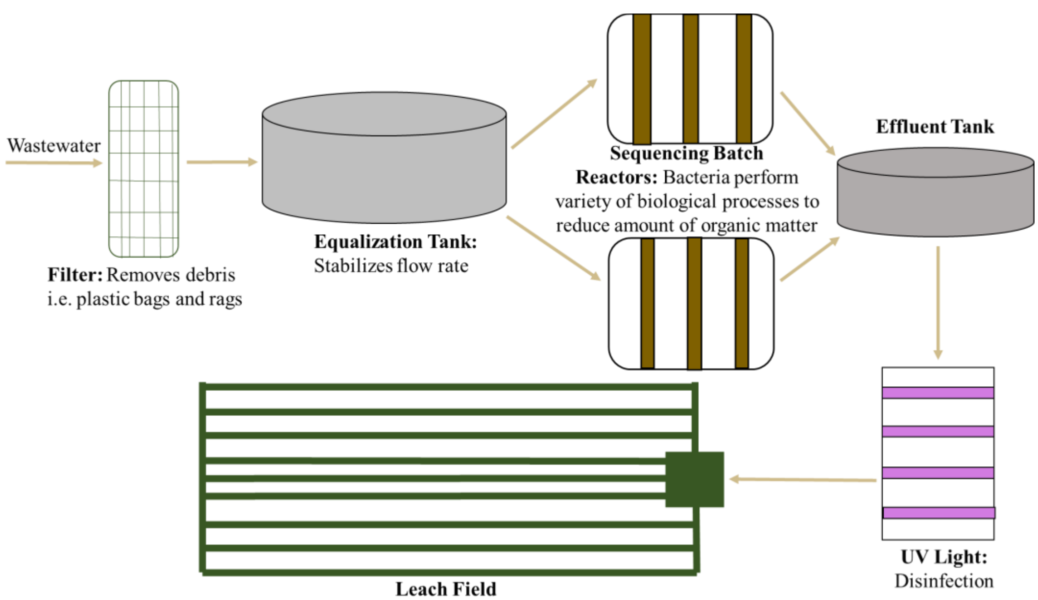

Figure 17: Wastewater flow diagram for New Silver Beach wastewater treatment facility.

Benefits of the Wastewater Treatment Facility

The establishment of the New Silver wastewater treatment facility resolved the public health threat. In addition, homes were allowed to have more bedrooms and the water quality in Wild Harbor significantly improved.

<u>Wastewater Treatment Facility Performance:</u> The New Silver Beach wastewater treatment facility is designed to remove both nitrogen and bacteria from wastewater before it is discharged. For example, the facility reduces ammonia concentrations, a form of nitrogen, by approximately 94%. Similarly, the facility reduces BOD concentrations, which can be an indicator of fecal bacteria, by approximately 96%. The facility is significantly reducing the amount of nitrogen and bacterial pollution entering Wild Harbor and inner Wild Harbor.

<u>Water Quality:</u> The Buzzards Bay Coalition began monitoring water quality at stations WH2 and WH1N in 1999 to track changes in the health of the aquatic environments. WH1N is located in inner Wild Harbor while WH2 is located in Wild Harbor River, a salt marsh tributary connected to Wild Harbor (Figure 18). Prior to the startup of the wastewater treatment facility, wastewater coming from septic tanks and cesspools would flow westward and discharge into both of these waterbodies. Now that the facility has been constructed, wastewater is treated before discharged. There have been significant decreases in median ammonium (Figure 19a and 19b), dissolved inorganic nitrogen (Figure 20a and 20b), and phosphate concentrations (Figure 21a and 21b) at both water quality stations.

Figure 18: Location of two water quality monitoring stations (WH1N and WH2) in Wild Harbor and inner Wild Harbor.

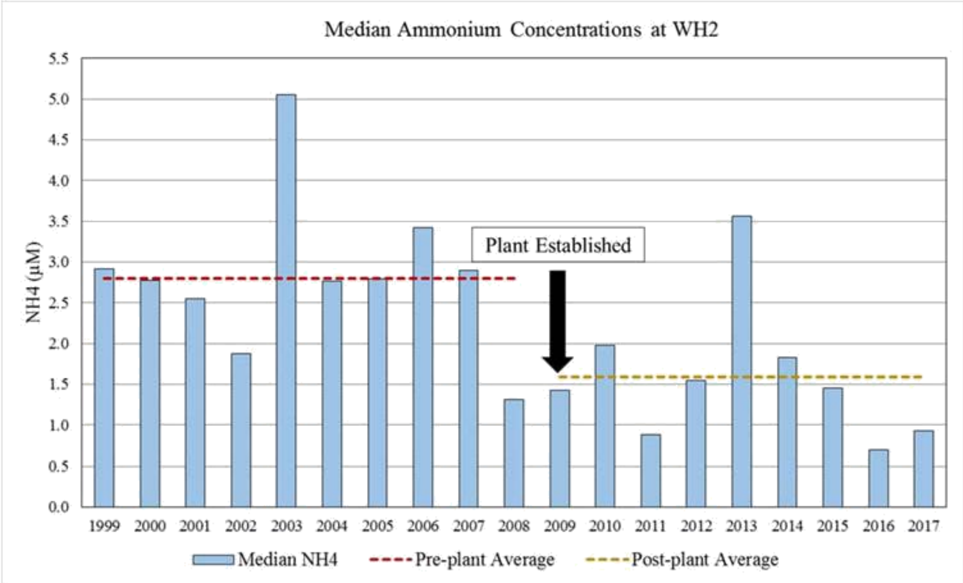

Figure 19a: Annual median ammonium concentrations at station WH2. Pre-plant average ammonium concentration was 2.80 µM and post-plant average ammonium concentration is 1.59 µM. This suggests that 43% less ammonium is present in Wild Harbor since the construction of the wastewater treatment facility.

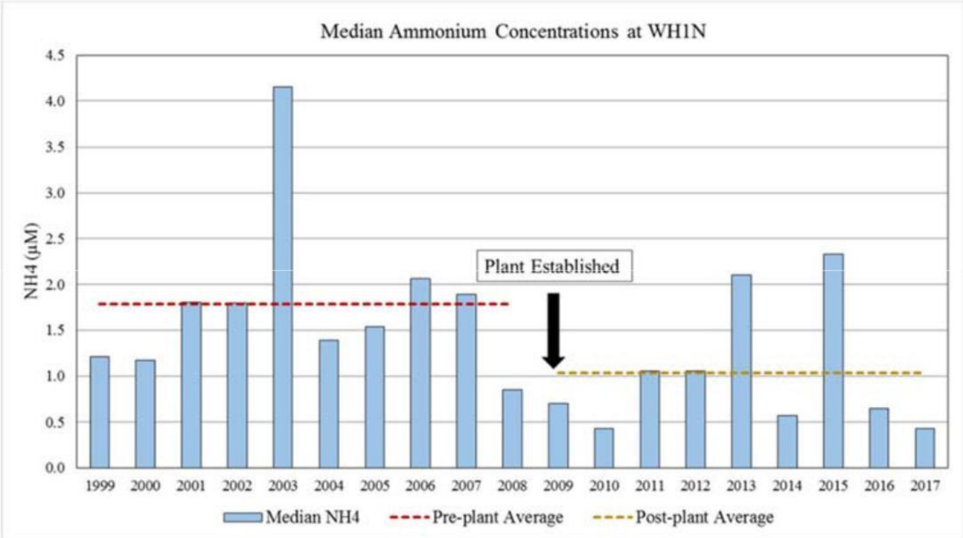

Figure 19b: Annual median ammonium concentrations at station WH1N. Pre-plant average ammonium concentration was 1.89 µM and post-plant average ammonium concentration is 1.04 µM. This suggests that 45% less ammonium is present in inner Wild Harbor since the construction of the wastewater treatment facility.

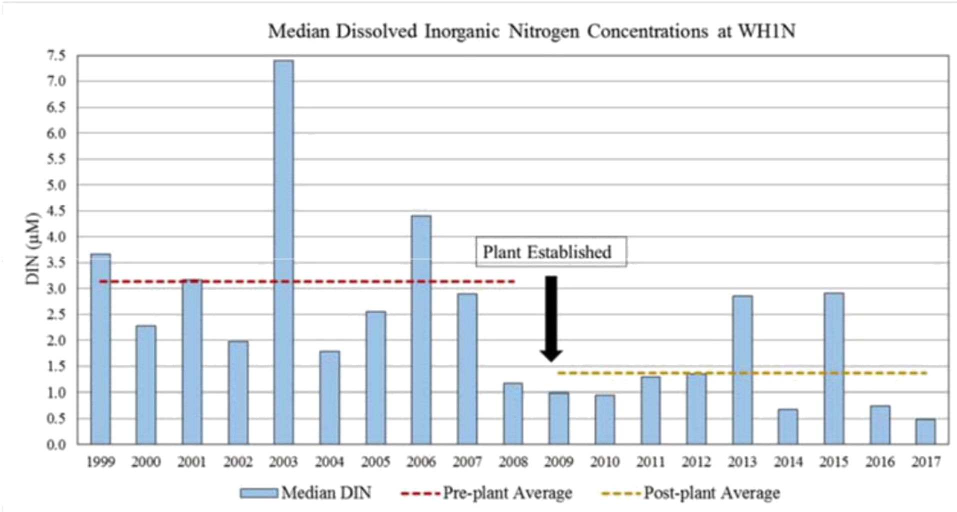

Figure 20a: Annual median dissolved inorganic nitrogen concentrations at station WH2. Pre -plant average dissolved inorganic nitrogen concentration was 5.17 µM and post-plant average dissolved inorganic nitrogen concentration is 2.97 µM. This suggests that 43% less dissolved inorganic nitrogen is present in Wild Harbor since the construction of the wastewater treatment facility.

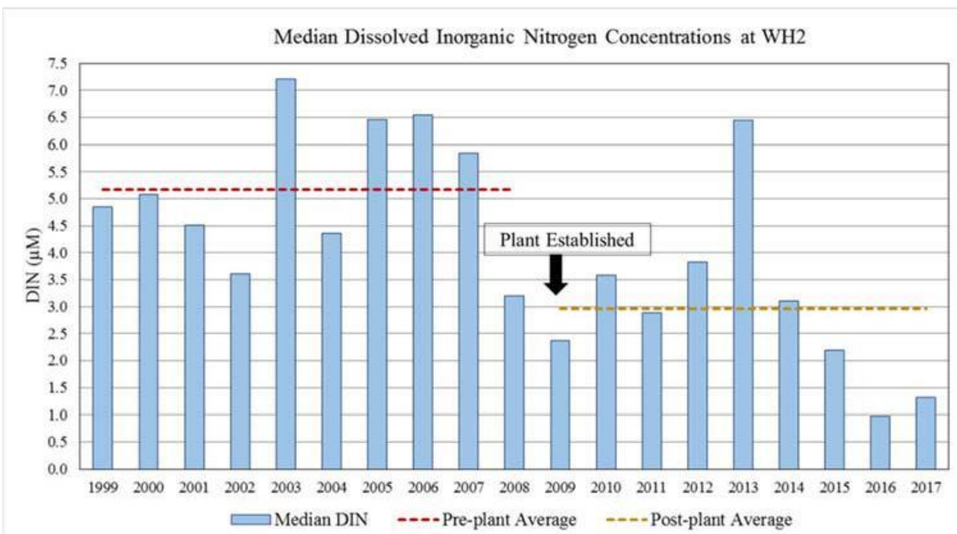

Figure 20b: Annual median dissolved inorganic nitrogen concentrations at station WH1N. Pre-plant average dissolved inorganic nitrogen concentration was 3.13 µM and post-plant average dissolved inorganic nitrogen concentration is 1.36 µM. This suggests that 57% less dissolved inorganic nitrogen is present in inner Wild Harbor since the construction of the wastewater treatment facility.

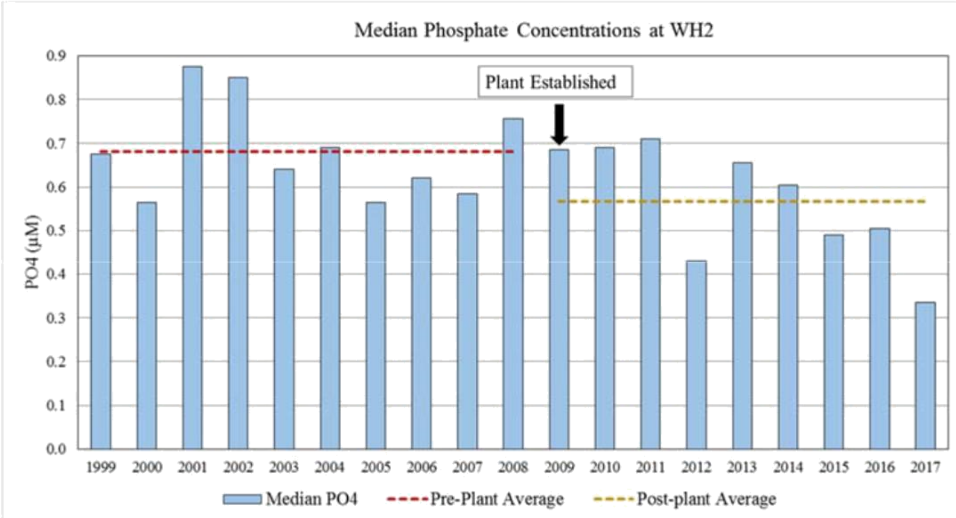

Figure 21a: Median phosphate concentrations at station WH2. Pre-plant average phosphate concentration was 0.68 µM and post-plant average phosphate concentration is 0.57 µM. This suggests that 16% less phosphate is present Wild Harbor since the construction of the wastewater treatment facility.

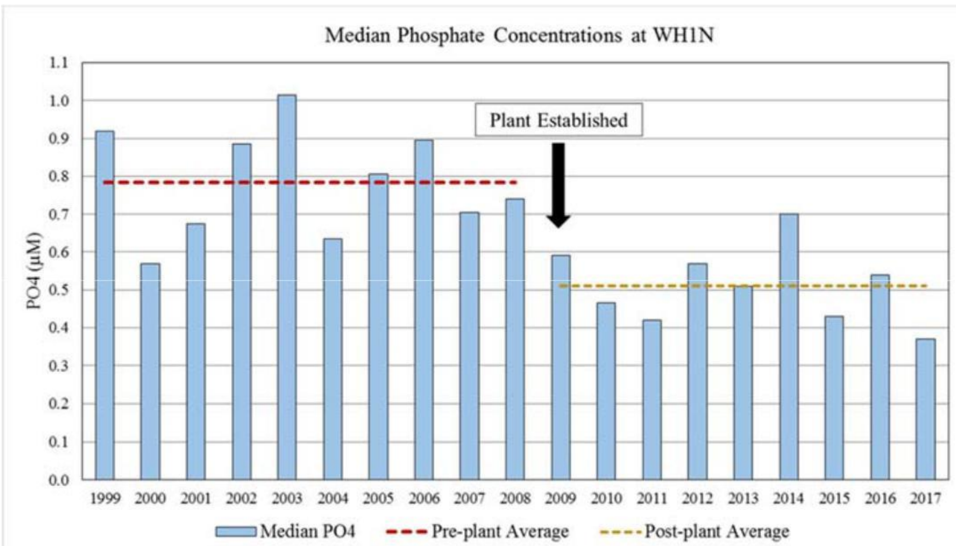

Figure 21b: Median phosphate concentrations at station WH1N. Pre-plant average phosphate concentration was 0.79 µM and post-plant average phosphate concentration is 0.51 µM. This suggests that 35% less phosphate is present in inner Wild Harbor since the construction of the wastewater treatment facility.

Property Values and Home Improvements: New Silver Beach was established as a seasonal community where homes sit on small, clustered lots and has remained highly seasonal. Because the majority of these homes are used only during summer months, most are not winterized so their value tends to be lower than that of homes in the rest of Falmouth. Between 2007 and 2010, the average value for a single family home in the New Silver Beach area was 20% lower than a single family home in Falmouth (Figure 22). Since the wastewater treatment facility began serving homes in the New Silver Beach area in 2010, the disparity in price between single family homes in New Silver Beach and single family homes in Falmouth has narrowed. Between 2012 and 2018, the average value for a single family home in the New Silver Beach area is only 13% lower than the average value for a single family home in Falmouth.

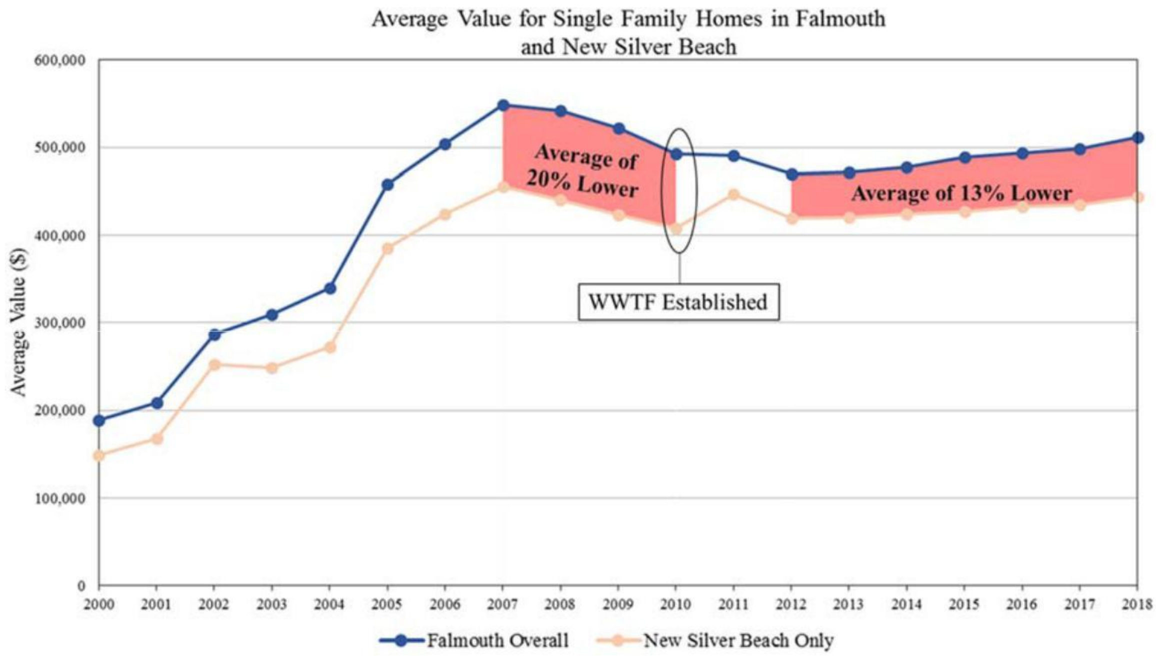

Figure 22: Average value for single family homes in New Silver Beach and Falmouth town-wide.

Similar to the condition for West Island, only the original 231 properties are connected to the New Silver Beach wastewater treatment facility, but these properties include a number of buildable lots. Unlike West Island though, residences within the sewered area have the option to expand the number of bedrooms in their home to three if the property has two or less bedrooms. Homes that have three or more bedrooms are grandfathered with that number but may not add additional bedrooms. Thus, the establishment of the facility allows some homes to expand, enabling their home value to increase as well.

Conclusion

The West Island wastewater treatment facility and the New Silver Beach wastewater treatment facility both resolved significant wastewater problems for dense coastal communities originally developed for seasonal use. They serve as examples for how towns around Buzzards Bay can create small wastewater treatment facilities that are capable of treating wastewater from several hundred homes.

The construction of the West Island and New Silver Beach wastewater treatment facilities alleviated public health threats and helped to improve water quality and home values. Developing compact wastewater treatment facilities like these is a sound option for effectively treating wastewater, particularly in dense, coastal neighborhoods.

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