

Mitigation Engineering for Water Pollution Control Facilities

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Abstract: *Water pollution control facilities (aka wastewater treatment plants) play an extremely important role in protecting waterways. On the other hand, they can have a negative effect on their immediate environment. The purpose is to exemplify impacts and mitigation measures, and add some perspective commentary. Mitigation of noise at water pollution control facilities is discussed separately by Graber [1]. The discussion here focuses on the Deer Island Water Pollution Control Facility (WPCF) in Massachusetts USA, although the title reflects its broader applicability. Mitigation measures discussed include a Memorandum of Understanding, water infrastructure, wastewater residuals, electric and gas infrastructure, outfall location, financial mitigation and plan reviews, transport through the town adjoining the facility, street openings in the town, odor control and air quality, and economic impacts more generally.*

Keywords: *Boston Harbor, Deer Island, Mitigation, Wastewater management; Wastewater treatment; Water pollution*

Date of Submission: 01-07-2024

Date of Acceptance: 12-07-2024

I. Introduction

Water pollution control facilities (aka wastewater treatment plants) play an extremely important role in protecting waterways. On the other hand, they can have a negative effect on their immediate environment. The purpose is to exemplify impacts and mitigation measures, and add some perspective commentary. Mitigation of noise at water pollution control facilities is discussed separately by Graber [1]. The discussion here focuses on the Deer Island Water Pollution Control Facility (WPCF) in Massachusetts USA, although the title reflects its broader applicability.

Some background regarding the Deer Island WPCF will help set the stage. In 1984, Deer Island was host to two major facilities: the Deer Island Correctional Institution aka Prison and the Deer Island Wastewater Treatment Plant (WWTP). The part of Winthrop abutting Deer Island is known as Point Shirley. The prison was originally a low to medium security facility. But as prisons elsewhere became more crowded, it became necessary to place inmates there who would otherwise have been medium to high security facilities. Consequently there were on the order of 25 escapes per year, which added to the anxiety of living in the adjacent portion of Winthrop. Escaped prisoners were found making breakfast in peoples' homes, the sirens which sounded when a prisoner escaped could be heard throughout the Point Shirley area, prison dogs and barking police dogs would go running through the streets of Point Shirley following a break. Some of the escapes involved gate crashing with a commandeered vehicle which would then go racing through the streets of Point Shirley

The author was on Deer Island with one of his sons who was doing a science project on wastewater residuals one afternoon when the sirens went off. Two prisoners had escaped and could not be found. It turns out that they were able to hide on Deer Island for two days. Early on the morning of the third day, they went to the southern end of the island and waved at a man fishing in a boat just off the Island. The fisherman motored over, and they asked him if he would give them a ride to East Boston. It came out subsequently that the fisherman asked them where they were from and they told him they had escaped from the prison. He laughed, thought they were joking, and said "welcome aboard." He took them to East Boston, where they were captured a few days later. When they were questioned about their escape they told about the friendly fisherman. The police questioned the fisherman and concluded that he was just being friendly. The prison was subsequently decommissioned to make room for the enlarged WWTP on January 3, 1992.

Topics discussed below are under the headings of Background Memorandum of Understanding (MOU), Water Infrastructure, Wastewater Residuals, Electric and Gas Infrastructure, Outfall Location, Financial Mitigation and Plan Reviews, Transport Through the Town, Street Openings, Odor Control and Air Quality More Generally, Other Economic Impacts, and Conclusions.

II. Background Memorandum of Understanding (MOU)

This project entailed extensive consulting services over a 16-year period regarding Boston Harbor wastewater treatment facilities and related assessments, and Fast-Track construction plans. In connection with the Deer Island Wastewater Treatment Plant, the author successfully negotiated, with the Massachusetts Water Resources Authority, a \$1.25 M Fast-Track construction mitigation plan for the Town of Winthrop, Massachusetts USA and a \$30 M long-term mitigation agreement. Services included assessment and mitigation of environmental impacts, including construction and operating noises, air quality, odors, traffic, etc.

Curiously, the precipitant cause of the lawsuit, brought by the City of Quincy, Massachusetts USA, was fouling of the beaches of that City; which was subsequently found to be caused by sewage overflows from the City's own sewers. In 1982, Quincy filed a lawsuit in state court against the Metropolitan District Commission (MDC, then the operator of the Deer Island facility) and the U.S. Environmental Protection Agency. The Conservation Law Foundation, learning of the complaint, filed in 1983 a suit in federal court against the MDC. The lawsuit resulted in the creation of the Massachusetts Water Resources Authority (MWRA) created by the legislature in 1984 as an autonomous, self-supporting agency. MWRA inherited from the MDC operations and facilities (water and wastewater) in 1985. The wastewater treatment facilities were at Deer Island in Boston and Nut Island in Quincy. The U.S. EPA joined that suit in 1985. The Town of Winthrop (the author's client), City of Quincy, Commonwealth of Massachusetts, and the Boston Water and Sewer Commission also became parties to that suit. The facilities were thus designed and constructed under the oversight of a federal judge. The legal aspects of this case are addressed in Dolin [2]. One important legal aspect not mentioned by Dolin is discussed below in connection with the rescinding of a federal court order.

Despite the false attribution by Quincy mentioned above, the Deer Island facility was in fact causing serious pollution in Boston Harbor. Under the 1972 Water Pollution Control Act, coastal communities were allowed to seek a waiver from requirements for secondary treatment. This made sense for west coast facilities because the western continental shelf is short and very deep waters occur within a distance that can be reasonably breached by outfalls. However, that is not the case for the eastern continental shelf. Massachusetts attempted to obtain a secondary-treatment waiver for the Deer Island facility, which ultimately proved unsuccessful but resulted in delays beyond the period of generous federal and state funding of such facilities. This resulted in a substantial local financial burden. Not only was the facility only providing primary wastewater treatment and discharging to the Harbor via a short outfall, but the sludge was also permitted to be discharged on the outgoing tide in nearshore waters. Most of that sludge returned on the incoming tide, adding to the pollution of Boston Harbor.

The Massachusetts Water Resources Authority (MWRA) had made major commitments to environmental mitigation measures through the federal and state environmental review processes. Why then a Memorandum of Understanding (MOU)? That was partly because of additional issues and greater specificity desired. And also because the Massachusetts Environmental Policy Act produces non-binding policy documents in which the mitigation is often implemented to the extent the impacted parties are vigilant, and even then not necessarily. Furthermore, the National Environmental Policy Act is only as effective as the U.S. Environmental Protection Agency chooses to enforce their Record of Determination and has the leverage to do so via federal grants.

In addition to the MOU, the Town took advantage of certain other means available to it in order to provide environmental protection or protect its infrastructure. These were not done only because of Deer Island-related impacts, but they provided impetus. Those measures are discussed below under the headings of Transport Through the Town, and Street Openings.

There is a legal time limit to the term of a contract involving a municipality. The term of the initial MOU ran from the time the MOU was signed in February 1988 to July of the year 2000. Certain things can be contractually agreed upon for longer periods of time. One is Paragraph I.E., which agrees that a separation area or buffer zone between Winthrop and the Deer Island Treatment Plant will be maintained in perpetuity. That separation area of berms and open space was to "mitigate both noise and odor impacts on the Town." From Winthrop's standpoint its most important benefit was mitigation of visual impact. Noise and odor impacts were otherwise mitigated, as discussed in Reference [1] and Section IX below.

There is an important concept involved here. If something is more economical on a regional scale, then it should be possible, in most cases, to come up with a financial arrangement that will make it politically acceptable, using here the term political in the better sense related to public opinion. The financial arrangement can include both environmental and non-environmental mitigation. An example of environmental mitigation is the reduction of odors impacting Winthrop, as discussed in Section IX below. For non-environmental, examples are unfettered payments to the Town and preferentially having job fairs in Winthrop for employment opportunities. The notion that the recipient of a facility in a siting decision should be simply regarded as having lost the battle and forgotten about is a notion that is wrong, not only from a moral standpoint but also from

pragmatic standpoints. Pragmatically it reduces the opposition of the host community. Mitigation obviously benefits the host community, but it benefits the proponent as well.

In September 1987 Paul Levy assumed the position of Executive Director of MWRA. Recognition of the above-mentioned benefits was one of his major policy contributions. Relations between Winthrop and MWRA changed dramatically once Levy started attending to this issue. The two parties worked intensely over the next few months, and by February 1988 there was a signed MOU. The author and Virginia Wilder, Winthrop's very capable Director of Community Development, negotiated on behalf of Winthrop. Winthrop's attorney was consulted as needed, but did not participate directly in the negotiations, which the author believes allowed the negotiations to proceed more quickly. It also took a great deal of work for Levy and Winthrop's Board member Margaret A. Riley to sell the ideas to the MWRA Board of Directors. The MWRA Board of Directors was a tough sell, particularly because one of the influential Board members had little concern for environmental issues.

Time has enabled demonstration of the success of the long-term mitigation efforts.

III. Water Infrastructure

Winthrop provided water to Deer Island through its distribution system. The Town purchased water from MWRA wholesale at one end of the Town, added value to the water (i.e., the costs of planning, designing, operating, and maintaining that distribution system), and then sold water to the treatment plant at the retail rate. Winthrop was charged for all the water that was used in Winthrop and continued on to Deer Island. The quantity of water that Winthrop sold was based on water meters located on Deer Island. However, there were major leaks on Deer Island into Shirley Gut, which is the narrow peninsular connection between Winthrop and Deer Island. The Town paid for that water, but lost it upstream of the revenue meters. It was estimated that the Town lost about \$100,000 per year because of that. That line was replaced as part of the construction of the new water line discussed next.

The expanded Deer Island WWTP required an upgraded water supply. MWRA proposed to construct a new water line from their distribution system at the Revere/Winthrop line to Deer Island. Computer modeling was performed by MWRA to assure that the proposed construction would not result in a reduction or excessive increase in the water pressure and not result in a decrease in water quantity to the Town. MWRA initially planned to rely solely on water storage provided by the 750,000 gallon Winthrop standpipe. There is no water storage tank or standpipe in East Boston from which water enters Winthrop enroute to Deer Island. The author, on behalf of Winthrop, argued that the existing storage was inadequate for the expanded WWTP. The Boston and Winthrop fire chiefs expressed similar concerns. Then MWRA proposed to construct a new 2 million gallon water storage tank on Deer Island and demolish the Winthrop standpipe. The author noted the need for redundancy and argued that both were needed for safe redundancy, again supported by the fire chiefs. As part of its mitigation agreement with Winthrop, MWRA then undertook to sandblast and repaint the interior and exterior of the Winthrop standpipe. Interestingly, the Winthrop standpipe was constructed in 1909 and is still in excellent condition; without modern understanding of structural design of such standpipes, they were conservatively overdesigned.

An issue arose concerning the draining of the Winthrop standpipe. MWRA planned to allow the drain water to flow down the hill and into the ocean. The primary concern from the author's perspective was the impact of residual chlorine on the nearshore waters. Chlorine residuals in drinking water are commonly higher than concentrations toxic to marine aquatic life. The applicable EPA water quality criterion is $13 \mu\text{g} / \text{L}$ ($0.013 \text{ mg} / \text{L}$), much less than the typical $1 \text{ mg} / \text{L}$ total chlorine level in drinking water. MWRA then modified their plan to drain the tank into the storm drains, and that if residual chlorine levels exceed the EPA water quality criterion (which they certainly would) discharge will go into the sanitary sewer for treatment at the Deer Island WWTP. The author found that acceptable, provided that the tank contents first be consumptively drained to the distribution system.

In some cases it was necessary to replace water service connections to homes or businesses during water main construction. In those cases the opportunity was taken to replace lead services with copper. Subsequently Winthrop proceeded with a program to replace additional lead services. Another issue concerned the connection of house sewers to new sewer mains constructed by MWRA. The issue centered on whether to use wye or tee connections. The author concluded that the connections should be made by means of wyes which are either ductile iron or special-ordered PVC wyes made to match the ductile-iron O.D. Such fittings can be pressure tested and seem to be the only way to assure the degree of tightness that is desired. Tees were rejected as an alternative because: (1) wyes are hydraulically better than tees; (2) wyes better facilitate cleaning; and (3) in those relatively few cases where there are tee connections, roto-rooters have sometimes bored through the opposite wall of the sewer main.

As the ultimate purveyor of water to Deer Island, the Winthrop Water Superintendent was responsible for water supply to Deer Island and regulatory authority over the Deer Island water system. MWRA needed to augment the water supply to Deer Island by constructing new water lines in Winthrop. There being no suitable standards at that time for separation between water and sewer lines within Winthrop and on Deer Island, the Town adopted such standards. These were required to be on all plans for work in Winthrop and on Deer Island. Those standards are given below.

1. A "sewer line" shall be defined as a utility line containing sewage in any form, such as Sanitary Sewage, Effluent, Raw Wastewater (RWW), High Pressure Effluent Flushing Water (W3H), Low Pressure Effluent Flushing Water (W3L), Sludge (TDS, WSL, PSL, etc.), and Dewatering, and includes the manholes. Chilled Water, Hot Water Supply and Return, Chemical, Fuel, and Storm Drainage are not applicable.

2. HORIZONTAL SEPARATION

A. Potable water mains shall be laid at least 10 feet horizontally from any existing or proposed sewer line. The distance shall be measured edge to edge. In cases where it is not practical to maintain a 10-foot separation, it is permissible to install a potable water main closer to a sewer line, provided that the potable water main is laid in a separate trench or on an undisturbed earth shelf located on one side of the sewer line at such an elevation that the bottom of the potable water main is at least 18 inches above the top of the sewer line.

3. VERTICAL SEPARATION

A. Potable water mains crossing sewer lines shall be laid to provide a minimum vertical distance of 18 inches between the outside of the potable water main and the outside of the sewer line. The potable water main shall cross above the sewer line. At crossings, one full length of potable water pipe shall be located so that both joints will be as far from the sewer line as possible.

4. EXCEPTIONS

A. When it is impossible to construct the potable water main above the sewer line or to obtain the horizontal and vertical separation specified in 2 and 3 above, both the potable water main and sewer line shall be constructed or reconstructed (in the event of an existing line) of cement-lined ductile-iron pipe with restrained push-on joints or other equivalent (as approved in writing by the CM, based on water tightness and structural soundness) for a distance at least 10 feet beyond the point, measured perpendicular to the water line, where horizontal or vertical separation is less than specified above. At crossings, one full length of potable water pipe shall be located so that both joints will be as far from the sewer line as possible. Copper pipe with soldered joints shall be used for pipes 3-inch diameter and less. If the existing sewer is constructed of a system that is equivalent to mechanical joints based on water tightness and structural soundness and has not been disturbed, it does not have to be reconstructed or encased.

B. As an alternative to reconstruction in 4.A, if shown on the drawings or permitted in writing by the CM, the water pipe or sewer line may be encased in a watertight carrier pipe which extends at least 10 feet beyond the point, measured perpendicular to the water line, where horizontal or vertical separation is less than specified above. The carrier pipe shall be welded joint steel pipe or cement lined ductile iron restrained joint pipe, and shall be as shown on the drawings and/or as specified. The annular space shall be filled with fine aggregate.

5. All new pipes shall be pressure tested in accordance with Specification Section 02615 (or other applicable Section) and test requirements in the Piping Schedule. However, in no case shall the test requirements be less than 150 psi for 360 minutes with zero leakage.

6. Under no conditions shall pipes be installed such that they are in direct physical contact.

In accordance with the above, the author, as Winthrop's consultant, reviewed many MWRA plans for water infrastructure in Winthrop to supply Deer Island and on Deer Island itself. Unfortunately, MWRA was exceedingly lax in reviewing plans for water/sewer separation. Literally dozens of comment letters were prepared by the author criticizing plans for inadequate separation. The author did so successfully, but only after many iterations. In cases where obstructions prevented adequate separation, pipelines were installed in accordance with 4. EXCEPTIONS above. An alternative method was proposed by MWRA's consultants in a number of cases, namely encasing the sewer pipe in concrete in Winthrop and on Deer Island. That was not one

of the approved methods discussed above. Furthermore it makes any future replacement of pipes particularly difficult. And in some cases plans called for no protection on crossings of sewers above or close below water pipes. This was in spite of the fact that Field Transmittal Memos (FTMs) had been issued by MWRA that covered these matters, and required the replacement of the sewer by ductile iron or C-900 PVC pipe. In these cases Winthrop had the authority to require corrections by virtue of having authority to authorize pressurizing of the water mains, and informed MWRA that it would not do so until these replacements were made. Similar issues arose and were rectified for horizontal separation. Another situation involving water-sewer separation in the Town is discussed below under **IX. Street Openings**.

Another issue concerned the direction of opening of hydrants on Deer Island. The Boston/Winthrop/Deer Island standard required that hydrants open clockwise. That had to be, and was, corrected based on Winthrop comments for, e.g., a project that included construction of a water tank on Deer Island.

An interesting legal matter was the unusual rescinding by the federal court judge of his order against the Town of Winthrop. MWRA constructed water, sewer, and gas lines in Winthrop to service Deer Island or replace aged lines in close proximity to their water and sewer lines. Permits of various types were required from Winthrop to do that work. One of MWRA's engineering contractors was particularly incompetent, and based on the author's review Winthrop disapproved several of their sets of plans and specifications. At a certain point, under a new executive director who professed to not respect the MOU, MWRA surreptitiously filed a motion with the federal court to compel Winthrop to provide the necessary permits. The judge endorsed that order. Under the author's guidance, Winthrop refused to comply with the order in a filing which explained, among other things, that cellars in one part of Town would have basements flooded by sewage under the plans as proposed. Upon learning that, the judge rescinded his order, and ordered Winthrop and MWRA to work things out. That was accomplished by MWRA correcting the design by suitably relocating the sewage lines.

IV. Wastewater Residuals

Another issue in which the author became very involved concerned ultimate disposal of the wastewater sludge. MWRA's residuals management design consultant had proposed on-site incineration of the sludge. A debate was held in Boston with the author on one side of the issue and MWRA's consultant and quantitative risk analysts on the other. The author argued against the risk analysts' methodologies and in favor of anaerobic digestion and beneficial use of the digester gas and digested residuals. Paul Levy, Executive Director of the MWRA, was in the audience and said he found the authors arguments very informative. MWRA decided in favor of anaerobic digestion using efficient egg-shaped digesters. The methane generated by the digestion process is used on site for heating of the digesters and power generation. The digested solids are conveyed in pressure pipes, constructed within the conduit that conveys wastewater from the south service area to Deer Island, to the Fore River Shipyard in Quincy where they are dewatered and heat dried into commercial pelletized fertilizer by a private company. That company produces more than 100 tons of fertilizer per day, which it markets as Bay State Organic. About 10% of the product is distributed for free in Massachusetts where it is used for turf application on golf courses, parks, and cemeteries. To a lesser extent it is sold through gardening stores in Massachusetts in 40-lb bags. The majority of the pellets are purchased by a fertilizer blender in Ohio. Some pellets are also sold to farmers in Colorado and Arizona for use as a soil conditioner in clear-cut forest replanting and strip mine revegetation [3].

V. Electric and Gas Infrastructure

MWRA proposed to install a high-voltage 115 kV (kilovolt) electric line through Winthrop to Deer Island. To facilitate the least expensive construction, MWRA proposed that the line be buried in Winthrop bathing beaches along the Atlantic Ocean side. The author cited evidence that the radiation could be harmful to people on the beach. The author prevailed, and MWRA instead arranged with the Harbor Electric Energy Company to bring an underwater electric line across harbor from the South Boston K Street substation to Deer Island.

Winthrop had a dense network of gas lines, most of which were quite old. The oldest, in several of the streets planned for water main construction, were installed in the year 1901. Gas leaks occurred frequently in Revere Street where the lines entered from the City of Revere. Certain gas lines had to be replaced to accommodate construction of water mains through Winthrop to Deer Island. The author assisted Winthrop in arranging the replacement of other gas lines proximate to the water main construction. That was accomplished by invoking regulations to compel the gas company (Boston Gas Company) to replace lines while construction was being done in those streets. The pertinent regulations are 220 CMR 113.00: Operation, maintenance, replacement, and abandonment of cast-iron pipelines. Section 113.04(1) stipulates that cast-iron pipe shall not be installed for the distribution of gas after April 12, 1991. Section 113.07(3) requires that a low-pressure cast-iron pipe that is parallel to a deep trench excavation and lies within the angle of influence shall be replaced if (a) the pipe is exposed and undermined; (b) the pipe is totally, or in part, within three feet of the edge of the trench

and sheeting that may have been used is not left in place. Replacement pipe is to be thermoplastic pipe of specified thicknesses pursuant to 220 CMR 101.00: Massachusetts Natural Gas Pipeline Safety Code.

VI. Outfall Location

As a member of a technical advisory committee, the writer proposed criteria which were used to determine the location of the new outfall, in deeper ocean water 10 miles out to sea. The outfall was bored through rock under the bay, and is one of the longest underwater tunnels in the world. In the last mile of the tunnel, the outfall was fitted with 52 large mushroom-capped risers that carry the treated wastewater up to the floor of the diffusers to disperse the treated wastewater.

Prior to construction of the new treatment plant and outfall, Boston Harbor was disgusting. One of the author's memories in that regard was taking in submerged lines while securing boats on which he sailed, those lines being grossly fouled. Following construction of the new treatment plant and outfall, the restoration of Boston Harbor occurred quicker than scientists had expected. Tube worms (*Spirorbis borealis*) proliferated and cleaned the polluted sediment at a remarkable rate. Porpoises began to appear in the Harbor for the first time in many years, attracted by prey fish returning to the Harbor.

VII. Financial Mitigation and Plan Reviews

The MOU provided for a dispute resolution procedure consisting of the following successive steps: Stage One - Disputes will be submitted to Official Mitigation Representatives, one Official Mitigation Representative (OMR) designated by the Town and the other designated by MWRA, who will meet and attempt to reach an informal resolution, with various stages and time periods specified; Stage Two - A four member panel will be designated, consisting of a four member panel with two panel members appointed by each party who will proceed generally as stated in Stage One; Stage Three - The Chairman of the Town's Board of Selectmen and the Executive Director of the MWRA who will proceed generally as stated in Stage One. After exhaustion of remedies under the three stages, a party may seek determination of its rights by a court of competent jurisdiction. Only two issues went to this final stage. The first had to do with an order of the federal court as discussed under Section III above. The second was related to a payment inflation provision of the MOU under Section XI. That section states: "All dollar amounts set forth in this MOU are based on 1987 dollars, to be increased at the time of disbursement by an amount equal to the annual or cumulative increase in the Engineering News Record Construction cost index....when said increase exceeds 10 percent." The author notified MWRA when that exceedance occurred, only to have their Executive Director resort to a ridiculous misinterpretation of that provision. Winthrop filed a law suit against MWRA on that one, which was settled before it came to trial with the intent of the MOU successfully implemented.

Part of the agreement negotiated between Winthrop and the MWRA called for the author to be given the opportunity to review and comment on each of the construction packages that made up the Deer Island project. Many improvements and corrections were made in response to the author's comments.

VIII. Transport Through the Town

Local control of transport is difficult because of federal supremacy/preemption. The basic federal authority in this regard derives from Article I, Section 8 of the U.S. Constitution (the "Commerce Clause"), pursuant to which "statutes or regulations which impermissibly burden interstate commerce...are unconstitutional and unenforceable" [4, §6.1.2]. Communities are required to provide thoroughways for trucking, and a community cannot selectively disallow certain trucking on roads on which other trucks of similar weight classes are allowed. Local health departments or boards can enact regulations that add certain controls over transport if related to public health. Winthrop's Board of Health, with the author's input, thus enacted a regulation for vehicles transporting hazardous wastes and sewage byproducts. That regulation requires that such vehicles be watertight and, if applicable, airtight, and that an agent of the Board of Health has authority to inspect and approve vehicles used for such transport. However, it has been recognized that the Winthrop regulation might not be able to withstand challenge because of federal preemption. That regulation may derive more force from the awareness that it would be damaging from a public-relations standpoint for someone to challenge that regulation (which was adopted primarily because of activities associated with the Deer Island Wastewater Treatment Plant).

One use of Winthrop's transport regulation was its application to the trucking of sewage solids (grit and screenings) through Winthrop. An incentive for creating these regulations was the frequent spilling of those solids on Winthrop streets. An area on Deer Island was used to landfill solids from several of MWRA's sewage pumping station in Boston, so called "grit and screenings." These materials would be brought through Winthrop in open dump trucks with banging tail gates, which would drop the materials every time the tailgate banged or they took a fast turn. The Winthrop Public Works Department and Fire Department had to go out and clean up these odorous messes. This was a main factor prompting the regulations mentioned in the previous paragraph.

Those regulations were used to establish an inspection and approval program with which Winthrop required the use of trucks with secure tailgates, That put an end to the problem.

Gaseous chlorine was used for wastewater disinfection on Deer Island. Trucks carrying liquefied gaseous chlorine traveled through the Town to Deer Island, and an accident with such a truck in a highly urbanized area could be catastrophic [5]. There were leaks of the gaseous chlorine on Deer Island. On one occasion, the prison guards on Deer Island (when there was a correctional facility there) were observed by Winthrop police to be wearing gas masks. The Winthrop Fire Chief investigated and found after making numerous inquiries that chlorine gas had leaked from piping on the Island. There were dead birds, and if the wind had not been carrying the gas away from Winthrop it could have been a real problem. No one bothered to inform the Town officials when the leak was discovered.

The author convinced MWRA of the importance of converting to a safer means of wastewater disinfection on Deer Island. Based on cost-effectiveness determinations among different safe disinfectants, liquid sodium hypochlorite was selected. Since the volume of liquid chlorine is much greater than gaseous chlorine and limitations on trucking discussed below,, MWRA decided that the liquid chlorine would be barged to Deer Island rather than transported through the Town.

The MOU provided that, following completion of pier construction, construction truck traffic to Deer Island would be limited to no more than 6, two-axle truck, round trips per day. Following completion of pier construction, such truck traffic would be limited to no more than 8, two-axle truck, round trips per day. Public safety emergency vehicles could enter the facility without limitation.

The MOU further provided that for all facilities construction, except piers and early site preparation, the MWRA shall provide the capacity to ferry a minimum of 50 percent of the daily construction work force. The workers were ferried to and from Long Wharf in Boston and Hingham Terminal to the Deer Island pier. The MWRA will attempt during most construction to ferry more than 50 percent of the daily workers (more than 1,400 daily) [6] and also for operational personnel. For all facilities construction, except piers and early site preparation, personnel not ferried and who live outside of Winthrop and East Boston, shall be bused to Deer Island (about 1,200 daily) [6]. Parking facilities were provided for workers at Suffolk Downs race track in East Boston, where the bus trips originated. These were logistical necessities to accomplish the construction in light of Winthrop's narrow, congested streets., The MOU limits do go beyond logistical necessity and in that sense provide mitigation.

One of the early problems after signing of the MOU was with implementation of its limitation on traffic. Some of the inventiveness of the construction contractors on Deer Island was hard to deal with. For example, cement trucks were not supposed to travel through the Town to supply MWRA construction on Deer Island. The prison would have small construction projects going on, and the contractors would get together. Concrete trucks would come onto Deer Island and drop off 3 yards of concrete at the prison, and then surreptitiously continue on to drop 9 yards off to an MWRA contractor. MWRA was rather slow to enforce the traffic limits of the MOU. It was found necessary to document the actual number of trucks, and become somewhat assertive before MWRA finally hired a former state police officer to implement serious controls over traffic in and out of Deer Island.

Shortly thereafter there was had the incident of the pregnant pizza lady. It seems that one of the Deer Island contractors completed a construction milestone one evening, and decided to have a pizza party for the workers. So they ordered pizza from a place in Winthrop, and asked that it be delivered right onto the Island. The pizza lady deceived MWRA's guard at the gate, by saying the delivery was to the prison. However, the guard observed her continue past the prison and up to the site of MWRA's contractor. The guard said nothing to her as she exited the Island, but he remembered. The contractor thought that went so well that a week later he placed another pizza order. This time, to hear the newspaper tell it, as the very-pregnant pizza lady approached the gate she was surrounded by a swat team of MWRA guards who ordered her off the Island, pizza and all. The Winthrop Selectmen voiced their obligatory expressions of outrage that this would be done to a Winthrop business and pregnant citizen. But they know full well that the guard had done what was supposed to be done, and that the circumstances had been greatly exaggerated.

Construction of a new water main and new gas main through Winthrop were required to service Deer Island The MOU (Section II.C) specified for paved streets disturbed by construction of the mains, MWRA would repave the streets curb to curb including restoration of the road base as necessary. Design was to be provided by an independent public works consultant. The same was to be done for the designated truck route through Winthrop to Deer Island, which was in serious disrepair. Against the author's advice based on experience elsewhere (discussed below), Winthrop's Public Works Director approved a Value Engineering Proposal by the Contractor to use less-costly water jetting rather than the specified road-roller compaction. The contractor benefited by the practice of splitting the savings 50/50 between the Owner and the Contractor. A geotechnical engineer approved the proposal; unfortunately contractors can too readily find such an engineer who will provide such approval. Within a few months, the roadway was severely rutted. The author

recommended selection of a road design firm that designed and oversaw construction of a new road surface that has held up well.

The experience elsewhere mentioned above was reconstruction of a roadway between the Towns of Canton and Stoughton, Massachusetts USA. The reconstruction followed trenching to place a large water main connecting the two towns. Construction with piles over peat, again based on the recommendation of a geotechnical engineer resulted in severe rutting and damage to the water main. It was necessary to reconstruct the road, and the water main was placed above ground on supports with insulation and heat tracing.

An interesting occurrence was during the transport of concrete by truck through Winthrop for construction of on-island piers. The time it took for such transport through the Town resulted in the concrete almost setting up and being barely usable. So MWRA decided to construct a concrete batch plant on Deer Island. Then it was decided to convey concrete ingredients (cement, sand, gravel) by barge to the on-island piers. Although MWRA referred to these as mitigation measures, they were actually logistical necessities.

Control of truck traffic through Winthrop to Deer Island was accomplished by means of a Heavy Vehicle Permit process, whereby trucks going through Winthrop to Deer Island had to have a Town permit issued in advance. That enabled the Town to regulate and keep track of truck traffic through the Town. Its effectiveness relied on the fact that Town police would cite trucks found traveling in the Town without a permit posted on their windshield. In addition to the truck permit, an additional requirement applied to vehicles transporting explosives. Winthrop implemented an additional procedure relative to blasting. For vehicles transporting explosives to Deer Island and any unused explosives being transported off the island explosives, a Winthrop police escort was required.

IX. Street Openings

Winthrop has a street-opening bylaw and permit, which applied to MWRA work within Winthrop such as construction of a water line through the Town to Deer Island. One of the advantages of that mechanism is that special conditions can be attached to the permit that extend beyond the street opening bylaw *per se*. Early in the construction of the water line through Winthrop, the Town's Public Works Director, at the writer's recommendation, ordered work halted because the required water-sewer line separation was not being provided. After work resumed, that problem did not reoccur.

X. Odor Control and Air Quality More Generally

Logan Airport is a short distance across Boston Harbor from Winthrop, and flight paths have aircraft crossing over Point Shirley at altitudes of a few hundred feet. The jet fuel odors are very noticeable, and people in Winthrop cannot hang their clothes to dry outdoors because they will come in smelling of jet exhaust.

The worst environmental impact in the author's opinion was the WWTP odors, which permeated for a considerable distance into Winthrop. People in Point Shirley would complain bitterly about not being able to enjoy the outdoors and having to keep windows closed. One woman spoke at a public hearing about the embarrassment of having to ask bar-b-cue guests to run indoors when the wind shifted in their direction. From sailing in Boston Harbor, the author knows that you could tell from miles away when you reached a point downwind of the treatment plant. It did not help matters to have the treatment plant's consultants initially suggest that the odors were not due to the treatment plant at all, but rather due to the tidal mud flats. That was subsequently proven ridiculous when a company specializing exclusively in odor monitoring came in and completed a thorough study documenting the serious impact of treatment plant odors in Winthrop.

There was one public meeting at the Point Shirley Neighborhood Association Building at which MWRA's consultant was getting frustrated at having to stop talking every time an airplane went over. Then, as he was about to talk again, he sniffed, a look of surprise came over his face, and he asked "That's the treatment plant?: It was.

For odors, there is no instrument that can mimic the human nose. That is something that scientists and engineers who are accustomed to dealing with chemical air-quality limits are often slow to accept. There are techniques with good repeatability which rely on odor panels made up of groups of people who are screened and briefly trained. The techniques and associated equipment have been standardized by the American Society of Testing and Materials [7].

The primary means of mitigating odors and other air quality impacts (volatile organic compounds) was by the design of five facilities on Deer Island by a well-qualified consultant with the company Odor Science & Engineering. The author played a major role in bringing that consultant on board and coordinating with the consultant. Five air scrubbers and carbon adsorbers were planned and constructed to receive all significant off-gases from covered primary and secondary treatment tanks, sludge processing, plant pumping, and grit removal facilities.

Some measurements were initially combined with calculations and assumptions to predict odors that would be emitted from each of the five odor-control facility stacks. Those emissions were then modeled using

sophisticated “puff” modeling techniques to determine the level of control required to meet the criterion at the receptor location. Odor-control equipment was then designed to achieve the required levels of control. That was followed by measuring odor D/Ts (dilution:threshold values) at each stack as it came on line, and adjusting the equipment to achieve the required control level. The final step consisted of confirming that the treatment plant is odor-free at the property line. That was successfully achieved.

A good review of odor-control laws is provided by McGinley, Mahin, and Pope [8].

XI. Other Economic Impacts

By a geopolitical quirk, Deer Island is part of Boston but is geographically not contiguous with Boston. Traffic to Deer Island has to pass from Boston through Winthrop to Boston. The Winthrop Fire Department, being closest, provided first response to Deer Island. When the writer analyzed the cost of that, it was found that approximately \$300,000 per year, one-third of the Winthrop Fire Department’s expense budget went to answering calls on Deer Island. That was a fair amount of money for a Town of around 19,000 people.

The MOU negotiated by the writer called for MWRA to initially pay the Town \$300,000 per year for fire department services. The MOU limited the term of those payment to a period of five years with an option to renew. One reason for that was to allow a determination of whether the first five-years history justified the annual payment given that certain improvements were planned to reduce the number of fires on Deer Island. That including replacing diesel engines that spewed oil onto the roof on the building that contained those engines, which was then often ignited by sparks. The fire hoses used to combat the fires became oily and had to be replaced at significant cost. The option to renew was exercised, and Winthrop Fire still provides services to Deer Island. Although the number of fires decreased, with the massive construction the number of calls due to worker injuries increased. An excellent relationship continues to exist between the Deer Island staff and the Winthrop Fire Department.

XII. Conclusions

Water pollution control facilities (aka wastewater treatment plants) play an extremely important role in protecting waterways. On the other hand, they can have a negative effect on their immediate environment. The purpose is to exemplify impacts and mitigation measures, and add some perspective commentary. Mitigation of noise at water pollution control facilities is discussed separately by Graber [1]. The discussion here focuses on the Deer Island Water Pollution Control Facility (WPCF) in Massachusetts USA, although the title reflects its broader applicability. Mitigation measures discussed include a Memorandum of Understanding, water infrastructure, wastewater residuals, electric and gas infrastructure, outfall location, financial mitigation and plan reviews, transport through the town adjoining the facility, street openings in the town, odor control and air quality, and economic impacts more generally.

Acknowledgment(s)

The author acknowledges Paul F. Levy, former Executive Director of the Massachusetts Water Resources Authority, whose enlightened leadership led to successful mitigation of impacts of the Deer Island Water Pollution Control Federation.

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