how will the new **outfall** benefit water quality?

Rapid mixing with a large volume of seawater will quickly dilute the constituents of the effluent to background levels.

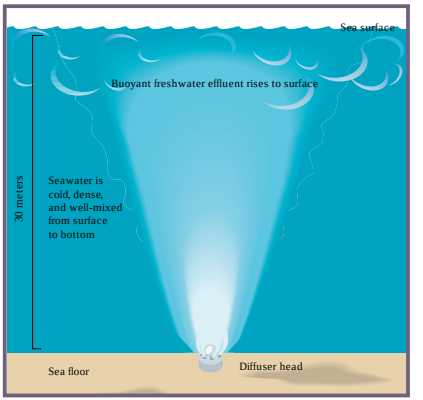
The new outfall is designed to maximize mixing and dilution of effluent. At the present time, treated wastewater effluents from the Deer Island and Nut Island treatment plants are discharged near shore within Boston Harbor. Strong tidal currents eventually carry the effluent into Massachusetts Bay, but each incoming tide brings some of the effluent back into the Harbor. Because the Harbor is shallow (on average only 30 feet deep), the effluent plumes receive little dilution and reach the surface, where they are visible. With onshore winds, the effluent can reach the shoreline. By contrast, the new offshore location is in an area where circulation is greater and more variable, providing better mixing.

The new outfall (illustrated on the previous page in Figure 10a-d) will carry effluent 9.5 miles (15 kilometers) off shore to a location where Massachusetts Bay is 100 feet (30 meters) deep. The effluent will be discharged through 55 diffuser heads each with eight outlets (ports), creating a diffuser that altogether will be 1.25 miles (2000 meters) long. The long diffuser area and multiple ports will effectively disperse the effluent to maximize dilution. The initial dilution of the effluent at the new location will be about 150 to 1, compared to the present dilution near Deer Island of 14 to 1.

Because effluent is mostly fresh water, it is lighter than seawater. Buoyancy causes the effluent to rise toward the ocean surface, rapidly mixing with the surrounding water. This vertical mixing causes the density of the effluent plume to increase, and the mixed effluent becomes about as dense as seawater. This mixing happens within a few minutes, and within a distance of tens of meters from the diffuser.

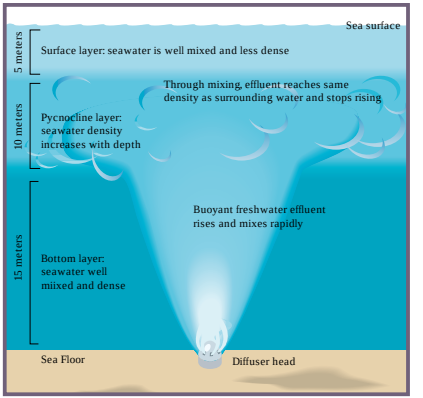
In the winter, the effluent plume, after mixing, will reach the surface. In the summer, effluent will be trapped below the surface because it quickly takes on the same (denser) characteristics as the bottom water (Figures 11a and 11b).

After initial mixing, whether the plume surfaces or not, it will be mixed horizontally by currents at the new outfall site. These currents vary in direction, helping to further disperse the effluent. The outfall is distant enough from shore so that even shoreward currents will not carry the effluent close to beaches or shellfish beds.



Diluted effluent rises to surface in winter

Figure 11a. What ultimately happens to the effluent plume depends upon seasonal effects on the density of ocean water in Massachusetts Bay. Seawater density is controlled by temperature and salinity. Warmer temperatures and lower salinity make seawater lighter, while cooler temperatures and higher salinity make seawater heavier. In the winter, the waters of the Bay are about the same density top to bottom and are well mixed. When the seawater has a relatively uniform density top to bottom, the effluent plume will rise to the surface as it mixes.



Diluted effluent trapped beneath surface in summer

Figure 11b. In the summer, the surface water is warmed and becomes increasingly lighter, setting up a layering effect. The level where the density change is most abrupt is called the pycnocline.

Effluent becomes increasingly dense as it mixes with seawater, and will rise up only to the depth where it is no longer lighter than the surrounding water—at the pycnocline. Thus the effluent plume will be trapped below the pycnocline. At the outfall site, this is about 50 feet (15 meters) below the surface.

Dilution contours, Harbor outfall location

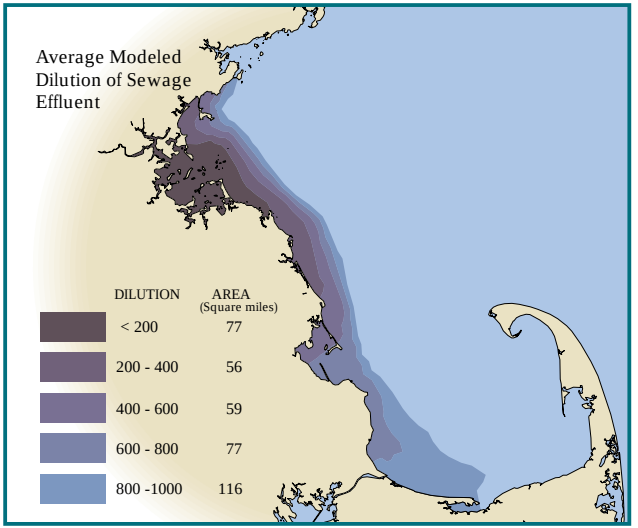


Figure 12a.

Dilution contours, new Bay outfall location

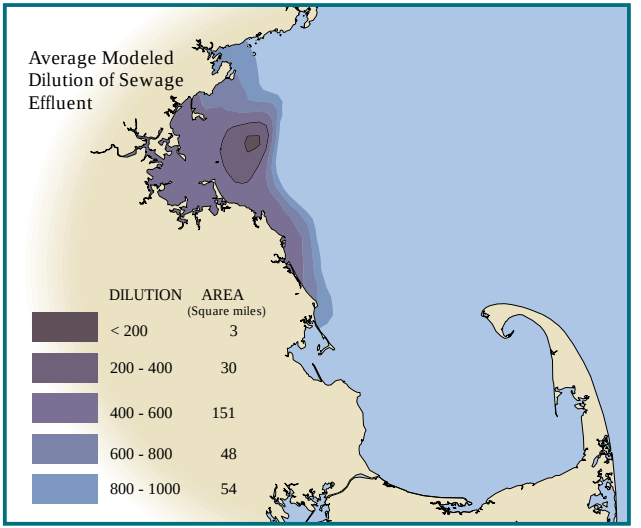


Figure 12b.

Moving the outfall offshore greatly reduces the area most affected by effluent. These two figures show the results of computer model predictions of effluent dilution during winter conditions at the present and future outfall locations. At present (12a), 77 square miles all of Boston Harbor and the South Shore to Cohasset Harbor, now have a dilution factor of less than 200-fold. At the future outfall location (12b), only 3 square miles, immediately above the diffusers will have a dilution of less than 200-fold. The dilution model assumes concentrations in effluent are the same for both Harbor and Bay outfalls: this is true for nutrients. The illustration does not take into account the effect of improved treatment in lowering the concentrations of contaminants in effluent. Model predictions based on winds and currents, winter 1990-1991. (Model created by R. Signell and H. L. Jenter of the U. S. Geological Survey and A. Blumberg of HydroQual, Inc.)