# CHAPTER 4

# WASTEWATER TREATMENT AND WATERSHED NITROGEN BALANCE EVALUATIONS

## 4.1 INTRODUCTION AND OVERVIEW

As discussed in Chapters 1 and 2, a group of 3 alternative scenarios were developed for detailed evaluation. They all utilized the following wastewater management components:

- Enhanced nitrogen removal (ENR) processes using sequencing batch reactors (SBR) followed by denitrification filters and disinfection to treat the nitrogen down to 3 mg/L which is a 93% removal. (This treatment type is referred to as Treatment Type A and is the same type of treatment currently used at the existing Blacksmith Shop Road WWTF.)
- Treated water recharge at the Falmouth Country Club site through sand infiltration beds and subsurface leaching facilities with the ability for spray irrigation from the groundwater.
- Wastewater collection from the Phase 1, 2, and 3 areas as well as from portions of Mashpee and Sandwich with the goal of meeting the nitrogen TMDLs.

The main difference between the alternatives was the location of the treatment facilities and the necessary infrastructure to convey the wastewater from the service area to the treatment facility, and convey the treated water to the Falmouth Country Club site. The three sites evaluated for this type of treatment were:

- Site 1: The existing Blacksmith Shop Road WWTF
- Site 2: The Falmouth Country Club site
- Site 3: The MMR Otis AFB WWTF site

These three sites in combination with the ENR wastewater treatment process comprise the three alternative wastewater management scenarios:

- Scenario 1A
- Scenario 2A
- Scenario 3A

The three scenarios were evaluated in the following progression:

1. The sewer service area was identified and costs were developed to convey the wastewater to the three sites.
2. Treatment plant components and sizing were identified and costs for the three (Type A treatment) plants were developed.
3. The infiltration facilities at the Falmouth Country Club site were identified and groundwater modeling was completed to learn the feasibility of this site for the treated water recharge. Costs were also developed for these facilities and the infrastructure to convey the treated water to this site.
4. All of the costs were compared and the feasibility of the treatment and recharge sites was evaluated with the following findings:
    a. The costs for the three scenarios were similar (within 8 percent of each other) due to the large wastewater collection component (sewers and pump stations) that is common to all. This 8% difference is within the 25% contingency factor used in the development of these costs; therefore there is no significant difference between the costs.
    b. The MMR/Otis AFB WWTF site was identified as the best site for the following reasons:
        - It has the most space for a modern expandable treatment facility.
        - It is located in the Planning Area.
        - It does not have any abutting residential neighborhoods; therefore, "Not in my Back Yard" (NIMBY) opposition to this site would be the least of the three sites.
        - It lends itself to becoming a regional facility also serving the towns of Mashpee, Sandwich, and Bourne as well as the MMR; and is consistent with Cape Cod Commission and MassDEP efforts to encourage regionalization where feasible.

c. The Falmouth Country Club site has good infiltration capacity and could recharge a large flow of treated water. These alternatives involving ENR treatment and recharge at the Falmouth Country Club Site (1A, 2A, and 3A) would meet the TMDLs for Little, Great, and Green Ponds. However, these alternatives would not meet the TMDL for Bournes Pond or Waquoit West, even with 100% sewering of those watersheds, and even with a Bournes Pond inlet widening (though there is not yet a TMDL for Waquoit West, the Waquoit West TMDL has been estimated for this report based on the limit set for adjacent Bournes Pond). Even with nitrogen removal to 3 mg/L, and sewering up to 100% of the watersheds, the return of a large volume of treated water to the watersheds through recharge means that not all of the TMDLs can be met under these alternatives.

d. Infiltration at the Falmouth Country Club site would require a large portion of forested area to be cleared to locate the infiltration facilities; and less intrusive technologies are desired.

e. The vast majority of each watershed (100% of some watersheds) needs to be sewered and the wastewater needs to be treated to levels below 3 mg/L total nitrogen and the treated wastewater needs to be recharged fairly evenly across the Planning Area in order to meet TMDLs for all ponds in the planning area.

Based on these findings, there was a need to develop additional treatment and recharge scenarios that would provide a greater level of treatment (for nitrogen as well as other contaminants such as pharmaceuticals and personal care products that are not yet regulated) and recharge the treated water in such a way that it could be reused to recharge ponds, streams, wetlands, and drinking water supplies in a more comprehensive and holistic manner.

5. A group of water reuse scenarios (Treatment Types B and C) using further advanced nitrogen and total organic carbon (TOC) removal processes and well recharge across the Planning Area were identified and costs developed.
6. Costs were then compared and the preferred alternative was selected.
7. Due to continuing interest by members of the Nutrient Management Working Group to look more closely at an ocean outfall alternative (previously screened out in the November 2007 Alternatives Screening Analysis Report), an ocean outfall scenario (Scenario 1D) was developed with costs and non-monetary considerations.

The purpose of this chapter is to describe the details of these wastewater management evaluations. Similar evaluations for the non-wastewater nitrogen management alternatives are summarized in Chapter 5.

## 4.2 COLLECTION SYSTEM EVALUATIONS

After review of the Environmental Notification Form, there was general agreement that a centralized sewer system was needed for the southern portions of the Planning Areas. These portions of the watershed (as illustrated in Figure 1-3) have a groundwater system that drains the septic system nitrogen loads directly to the marine water bodies and have little natural nitrogen attenuation as estimated for the northern portions of the watershed that drain through fresh water systems before reaching the marine water bodies. This north-south demarcation of the watersheds is very close to Route 28.

A conceptual design of a collection system along Route 28 south to Nantucket Sound was developed utilizing SewerCAD® modeling procedures based on topography, road layouts, and available sites for wastewater pumping stations. (This modeling procedure is summarized in a Guidance Document and Case Study Report prepared for the Town of Mashpee and Barnstable County entitled "Sewer Modeling and Preliminary Design Evaluations to Address Nitrogen TMDLs at Popponessett Bay and Mashpee, MA", Stearns & Wheler GHD, November 2005; available at:
www.capecodwaterprotectioncollaborative.org/index.php/regionalwastewatermanagement/regionalreports/ ).

Sewer service areas were developed for each of the peninsular areas A through F in Falmouth as illustrated in Figure 4-1. The collection system layout and conceptual design utilized the following approaches that were the basis of the cost development:

- Mixture of gravity sewers and low pressure systems that would lead to one main lift station per area that would pump to the treatment facility.
- The use of gravity sewers was maximized as allowed by the topography and road layouts to minimize the need for low pressure systems. When properties were too low in the service area to be served by gravity sewers, they would have their own grinder pump unit (located in their yard) that would feed a low pressure sewer in the road layout and discharge to the nearest gravity pipe.

- Infrastructure sizing design for Areas A – F to allow expected future sewer extension north of Route 28 (Phase 3 Area) and into Mashpee and Sandwich.

This sewer modeling procedure is a detailed way to develop cost estimates and develop a computer model that can be used in the future as planning becomes more refined.

The following table summarizes the pipe lengths and other characteristics of Sewer Areas A – F.

**TABLE 4-1**

**SEWER AREAS A – F CHARACTERISTICS**

| SEWER SERVICE AREA | GRAVITY SEWER LENGTH (MILES) | LOW PRESSURE SEWER LENGTH (MILES) | NUMBER OF LIFT STATIONS | NUMBER OF GRINDER PUMPS |
|---|---|---|---|---|
| A | 8.6 | 2.2 | 4 | 220 |
| B | 15 | 5.2 | 10 | 490 |
| C | 15 | 1.0 | 14 | 60 |
| D | 18 | 2.8 | 27 | 170 |
| E | 14 | 0.74 | 19 | 40 |
| F | 7.7 | 2.2 | 18 | 120 |

These characteristics are expected to change as the project proceeds through planning and design, but they are a reasonable basis for cost development based on actual conditions in this area.

Capital costs for the collection system in Areas A – F are summarized below for the three alternative scenarios.

**TABLE 4-2**

**COLLECTION SYSTEM CHARACTERISITCS AND CAPITAL COSTS FOR SCENARIOS 1, 2, AND 3**

| ITEM | SCENARIO 1 | SCENARIO 2 | SCENARIO 3 |
|---|---|---|---|
| **System Characteristics** | | | |
| Gravity Sewer Length (miles) | 79 | 79 | 79 |
| Low Pressure Sewer Length (miles) | 14 | 14 | 14 |
| Number of Lift Stations | 89 | 92 | 92 |
| Number of Grinder Pumps | 1100 | 1100 | 1100 |
| Force Main Length (miles) | 52 | 39 | 52 |
| **Capital Costs** | | | |
| Construction Costs ($M) | 210 | 200 | 210 |
| Contingency Costs ($M) | 53 | 50 | 53 |
| Fiscal, Legal, and Engineering Costs | 53 | 50 | 53 |
| **Total Capital Costs ($M)** | **320** | **300** | **320** |

Notes:

(1) All costs are referenced to the benchmark date of July 2009 and are rounded to 2 significant digits.

(2) Contingency costs and Fiscal, Legal, and Engineering costs are each estimated at 25% of the construction cost.

This table illustrates that the costs for all three scenarios are approximately the same. Scenario 2 costs are slightly less due (mainly) to reduced force main length.

The estimated wastewater flows from Sewer Service Areas A – F as well as projected "Future Sewer Limits" are summarized below.

**TABLE 4-3**

**SEWER SERVICE AREAS A – F FLOW AND FUTURE SEWER UNITS**

| SEWER SERVICE AREA | FUTURE WASTEWATER FLOW[1] (MGD[2]) | FUTURE SEWER[(3)] UNITS |
|---|---|---|
| A | 0.04 | 240 |
| B | 0.51 | 3,000 |
| C | 0.22 | 1,300 |
| D | 0.30 | 1,700 |
| E | 0.24 | 1,400 |
| F | 0.08 | 470 |
| Allowance for I/I[(4)] | 0.4 | N/A |
| **Total** | **1.8** | **8,100** |

Notes:

(1) Based on buildout projection developed in the Needs Assessment Report and projected average water consumption of 170 gpd for residential properties, existing water consumption for existing commercial properties, and average consumption values for future commercial land use.

(2) Million gallons per day.

(3) Based on "Future Wastewater Flow" divided by 170 gpd/residential property.

(4) Estimated at 30% as discussed in the Needs Assessment Report.

The "Future Sewer Unit" values were compared with the number of existing properties (sum of residential and commercial buildings as identified from the Town Assessor's database) and the comparison indicates an approximate 3 to 13 percent growth in Areas B – F. Area A has several commercial establishments (the Falmouth Mall, Admiralty Inn, etc.) that indicate that the number of "Future Sewer Units" is significantly higher than existing properties. This area will require specific consideration when betterments are being assessed.

Costs for the collection system north of Route 28 were estimated in a more general way. This area is not as densely developed as most areas south of Route 28 except for Area F (illustrated on Figure 4-1). Due to the greater distance between properties, extending sewers north of Route 28 will tend to be more expensive than for the other more densely developed areas. Due to these similarities, unit costs from Area F were used to estimate costs north of Route 28 (Phase 3 Area).

The number of properties that need to be sewered in the Phase 3 area will depend on where the treated water is recharged and the nitrogen balance that meets the nitrogen TMDLs in each watershed. This nitrogen balance is considered later in this chapter and ultimately will occur as part of adaptive management implementation.

## 4.3 EVALUATIONS OF ENHANCED NITROGEN REMOVAL (ENR) TREATMENT AND TREATED WATER RECHARGE

A. **Introduction.** Evaluations were completed to compare costs and non-monetary factors for constructing enhanced nitrogen removal (ENR) treatment facilities at the three alternative sites (illustrated on Figure 2-1) and the infiltration facilities to recharge the treated water. The alternative scenario and treatment sites are listed below:

- Scenario 1A: Expansion at the Existing Blacksmith Shop Road WWTF
- Scenario 1B: Development of a new WWTF at the Falmouth Country Club site.
- Scenario 1C: Development of a new WWTF at the Otis AFB WWTF site.

The treated water recharge site is the same for all the scenarios and is the Falmouth Country Club site.

The ENR facilities recommended in the November Alternatives Screen Analysis Report and the Environmental Notification Form were sequencing batch reactors (SBR) followed by denitrification filters and ultraviolet (UV) disinfection. This is the combination of technologies used at the existing Blacksmith Shop Road WWTF, and it has performed well.

B. **Wastewater Treatment and Recharge Capacities.** Future wastewater flows from Areas A-F are estimated at 1.8 mgd as listed in Table 4-3. Preliminary estimates (for cost estimating purposes) of future wastewater flows for the Phase 3 Area and Mashpee / Sandwich Areas were 0.9 mgd each based on future septic systems removals.

The wastewater flows identified above are average annual flows based on projected water consumption as discussed in the Needs Assessment Report. Wastewater treatment facilities need to be sized to treat the peak flows that occur in the summer months (maximum month conditions); and review of Falmouth Water Department well pumping records indicates a 80 percent increase in water pumping during July and August as compared to the average annual rates. This peaking factor was used to develop the maximum month flows listed below.

**TABLE 4-4**

**SUMMARY OF PROJECTED FUTURE WASTEWATER FLOWS, AND TREATMENTS AND RECHARGE CAPACITIES**

| SEWER AREA | AVERAGE ANNUAL (MGD[1]) | MAXIMUM MONTH FLOW[2] (MGD) |
|---|---|---|
| Phase 1 & 2 Area | 1.8 | 3.3 |
| Phase 3 Area | 0.9 | 1.6 |
| Mashpee/Sandwich Area | 0.9 | 1.6 |
| TOTAL | 3.6 | 6.5 |

Notes:

(1) Million gallons per day (mgd)

(2) Based on observed pumping factors from Falmouth Water Department.

These flows were utilized to size, consider phasing, and develop cost estimates of the treatment and recharge facilities.

C. **Recharge Facilities at the Falmouth Country Club Site.** The treated water was evaluated for recharge at the Falmouth Country Club site at the proposed sand infiltration beds (Area A and B) and the subsurface infiltration facilities (Areas C1-3) as illustrated on Figure 2-2. Additional recharge facilities were considered at other locations at (and under) the golf course but conservation restrictions did not allow use of other areas.

These areas were estimated to have sufficient hydraulic recharge capacity to recharge the flow from the Phase 1 and 2 areas as well as flow from the Phase 3 Area. The ability of the site to infiltrate the additional 0.9 mgd from Mashpee/Sandwich areas will need additional performance testing once treated water from the other areas has begun flowing to the site. The need for performance testing is required by MassDEP to allow a higher application rate (11 gpd/sf as opposed to 7 gpd/sf) and to more accurately calibrate the sub-regional groundwater model.

There would be significant land clearing needed for the sand infiltration beds (Areas A and B on Figure 2-2) and disruption to the two driving ranges (during construction) for the subsurface leaching facilities (Areas C1-3 on Figure 2-2). The use of spray irrigation at the golf course was also considered and it was observed that the additional treatment needed for spray irrigation as well as storage needed for spray irrigation would add significant cost. Also, these facilities could only be used during the summer growing months and not at times when people were out playing golf. Due to these considerations, it was decided that groundwater recharge and withdrawal with irrigation wells would be the best way to obtain an irrigation benefit from the treated water recharge and the recharge could be used year round.

Construction costs for these recharge facilities are estimated at $5.1 million for the Phase 1 and 2 flows. These costs are summarized with treatment costs later in this Chapter.

D. **Enhanced Nitrogen Removal (ENR) Treatment System Costs and Site Selection.** As identified previously, the ENR facilities evaluated for the three alternative sites include the following components:

- Headworks (for wastewater screening and grit removal) and odor control facilities
- Sequencing Batch Reactors (SBR)
- Denitrification filters
- Ultraviolet (UV) disinfection
- Sludge management facilities
- Effluent pump station

Components would be modular to allow construction in phases and would have multiple process trains and equipment to allow individual components to be taken off line without affecting treatment performance.

Figures 4-2 through 4-4 illustrate the conceptual site plans for the SBR/ENR facilities at the three sites. Figure 4-5 illustrates the (now abandoned) trickling filter WWTF that previously existed at the Otis / MMR site. Portions of the abandoned original Otis/MMR WWTF as well as the WWTF that currently serves Otis/MMR can be seen east of the proposed Falmouth/joint WWTF site on Figure 4-4

The following items are noted about the potential site layouts and sites:

1. Construction of additional SBR facilities at the existing Blacksmith Shop Road site would be integrated into the existing facilities with the following items noted:

- This site has sufficient space for the facilities
- All treatment components would need to be expanded but savings could be realized by reductions in needed redundancy (Two SBR reactors would be needed as compared to three reactors at the other sites because this site already has two reactors).
- The site already has an operations building, an access road, and utilities.

2. Construction of SBR facilities at the Falmouth Country Club site is feasible but the site is very small with the following items noted:

- The majority of the available site is needed for infiltration facilities and the ability to expand is limited.
- There are residential neighbors that would not want the WWTF in their backyard.
- Access to the site is very limited.
- This site is currently forested and undeveloped, and currently has no access road or utilities.
- This treatment site is closest to the Phase 1 and 2 sewer service areas and to the recharge site; therefore, wastewater and treated water transmission costs will be lower.

3. Siting of new wastewater facilities at the Otis / MMR site fits in well with the other wastewater and regional solid waste facilities that occupy this corner of the MMR. The following items are noted:

- The site is large and there is sufficient room for a regional facility to address wastewater needs in Mashpee, Bourne, and Sandwich.
- The site is located at the old Otis Trickling Filter WWTF site that was abandoned in 1995. It is a disturbed site that has been previously used for wastewater treatment.
- The facility could pick up wastewater flows from the existing Otis WWTF that began operation in 1995 and additional flows from expected increased land use at the MMR.
- This site has an access road and utilities.

Costs for the treatment and recharge facilities are summarized on Table 4-5 with the costs for the collection system in Phase 1, 2, and 3.

## Table 4-5
## Summary of Cost Comparison for
## SBR and Denite-Filter Treatment (Treatment Scenario A), and Infiltration Bed Recharge at FCC[5] Site

| Cost Component | Scenario 1A (Existing BSR[4] WWTF Site) Phase 1 and 2 | Scenario 1A Addl. Costs for Phase 3 | Scenario 2A (FCC[5] Site) Phase 1 and 2 | Scenario 2A Addl. Costs for Phase 3 | Scenario 3A (MMR[6] Site) Phase 1 and 2 | Scenario 3A Addl. Costs for Phase 3 |
|---|---|---|---|---|---|---|
| **Capital Costs** | | | | | | |
| *Collection System* | *$220,000,000* | *$130,000,000* | *$200,000,000* | *$130,000,000* | *$210,000,000* | *$130,000,000* |
| Collection and Minor PS & FM | $170,000,000 | $120,000,000 | $170,000,000 | $120,000,000 | $170,000,000 | $120,000,000 |
| Major PS and FM | $45,000,000 | $5,300,000 | $32,000,000 | $5,300,000 | $41,000,000 | $5,300,000 |
| *Treatment Site and Systems* | *$17,000,000* | *$9,000,000* | *$26,000,000* | *$9,000,000* | *$26,000,000* | *$9,000,000* |
| Site Development | $6,100,000 | $3,300,000 | $8,900,000 | $3,300,000 | $8,900,000 | $3,300,000 |
| WW Treatment Systems | $9,100,000 | $3,600,000 | $13,000,000 | $3,600,000 | $13,000,000 | $3,600,000 |
| Sludge Management System | $1,900,000 | $1,700,000 | $3,600,000 | $1,700,000 | $3,600,000 | $1,700,000 |
| *Recharge System* | *$14,000,000* | *$1,900,000* | *$5,100,000* | *$1,600,000* | *$13,000,000* | *$1,900,000* |
| Pump Station and Infiltration Facility | $7,200,000 | $1,900,000 | $5,100,000 | $1,600,000 | $7,200,000 | $1,900,000 |
| Treated Water Force Main | $6,500,000 | | | | $5,500,000 | |
| **Total Construction Costs** | **$251,000,000** | **$141,000,000** | **$231,000,000** | **$141,000,000** | **$249,000,000** | **$141,000,000** |
| Contingency (25%) | $63,000,000 | $35,000,000 | $58,000,000 | $35,000,000 | $62,000,000 | $35,000,000 |
| Fiscal, Legal and Engineering (25%) | $63,000,000 | $35,000,000 | $58,000,000 | $35,000,000 | $62,000,000 | $35,000,000 |
| **Total Capital Costs** | **$380,000,000** | **$210,000,000** | **$350,000,000** | **$210,000,000** | **$370,000,000** | **$210,000,000** |
| Cost Component | Scenario 1A (Existing BSR[4] WWTF Site) Phase 1 and 2 | Addl. Costs for Phase 3 | Scenario 2A (FCC[5] Site) Phase 1 and 2 | Addl. Costs for Phase 3 | Scenario 3A (MMR[6] Site) Phase 1 and 2 | Addl. Costs for Phase 3 |
| **O&M Costs** | | | | | | |
| Electrical Costs | | | | | | |
| Collection System Lift Stations | $290,000 | $180,000 | $160,000 | $100,000 | $210,000 | $130,000 |
| Treatment Site | $270,000 | $140,000 | $270,000 | $140,000 | $270,000 | $140,000 |
| WWTF operations & repairs | $380,000 | $200,000 | $760,000 | $200,000 | $760,000 | $200,000 |
| Collection system operations & repairs | $1,500,000 | $700,000 | $1,300,000 | $700,000 | $1,500,000 | $700,000 |
| Sludge Disposal | $300,000 | $200,000 | $300,000 | $200,000 | $300,000 | $200,000 |
| Treated Water Recharge System | $11,000 | $7,000 | $11,000 | $7,000 | $11,000 | $7,000 |
| Marine Water Quality Monitoring Allowance | $100,000 | $0 | $100,000 | $0 | $100,000 | $0 |
| Total O&M Costs per year | $2,900,000 | $1,400,000 | $2,900,000 | $1,300,000 | $3,200,000 | $1,400,000 |
| Discount Rate of 5% (P/A for 5% and 20 yr = 12.4622) | | | | | | |
| **Present Worth of O&M Costs** | $36,000,000 | $17,000,000 | $36,000,000 | $16,000,000 | $40,000,000 | $17,000,000 |
| **Total Present Worth Costs** | $420,000,000 | $230,000,000 | $390,000,000 | $230,000,000 | $410,000,000 | $230,000,000 |

Notes:
1. All costs are rounded to two significant digits except total construction costs which are rounded to three to reduce rounding error
2. All cost are referenced to July 2009 costs
3. Costs do not include potential costs for property purchase or easements
4. Blacksmith Shop Road
5. Falmouth Country Club
6. Massachusetts Military Reserve

Review of the cost summary indicates that the capital costs for the three scenarios differ by only 8% due to the higher collection system costs that are common to all scenarios. This 8% is significantly less than the 25% contingency that was used for these estimates. This difference is considered insignificant and the costs are essentially the same.

Based on the similar costs, the main focus of choosing the best site centered on the following criteria:

- Site should not be objectionable to neighbors; and (preferably) should not be adjacent to residential land use.
- Site should be large and should be able to accommodate facility expansion due to additional flows from other areas of Falmouth or from other towns. It should be able to expand to address future treatment requirements.
- A site that was previously developed/disturbed is preferable, though not required.
- It should have good access for deliveries and sludge removal from the site.
- It should be located in the Planning Area.

These siting considerations indicate that the Otis WWTF/MMR site is the best location to site a new WWTF for the Planning Area. Once this finding was understood, steps were taken to begin the dialog with MMR staff to gain use of the site. This dialog (documented in Appendix 3-6 and summarized in Chapter 3) is continuing.

E. **Groundwater Modeling and Watershed Nitrogen Balance.** As discussed in Chapter 2, the Town was awarded a grant from the Cape Cod Water Protection Collaborative to complete groundwater modeling for the proposed recharge at the Falmouth Country Club Site. The modeling developed a calibrated sub-regional model based on the USGS regional model of the Sagamore Lens. Several model runs evaluated groundwater mounding to determine if the site had the hydraulic capacity to infiltrate the estimated flows. The model runs also evaluated flow particle tracking to determine which surface water bodies would ultimately "receive" the recharged water. That evaluation and the Guidance Document and Case Study Report that resulted is described in Chapter 2 and attached in Appendix 2-2. The main findings are summarized below.

- Based on the model calibration criteria, the groundwater flow model simulated existing and potential groundwater conditions at the site reasonably well.

- The groundwater mounding analysis conducted under high groundwater conditions for the Phase 1 and 2 flows indicates no flooding impacts. This same analysis for the Phase 3 and Mashpee/Sandwich flows indicates that the low elevation portions of Site A would need to be raised in order to meet the 4-foot separation criteria, and this change could be made when the beds were constructed. There may also be some intermittent groundwater recharges (seeps) to the low swale south of Site A for this model run.
- The results of the particle tracking analysis indicate that the ultimate fate of the treated water/groundwater will be primarily to the Bournes Pond watershed with significant flows to the Green Pond and Eel Pond watersheds. A small percentage of flow (10% or less) will be directed to the Waquoit Bay main watershed.

Hydraulic modeling results indicate that the recharge sites at the Falmouth Country Club property are feasible to recharge the flows from the Phase 1 and 2 areas. The findings also indicate that the recharge sites at the Falmouth Country Club property may be feasible to recharge the flows from the Phase 3 and Mashpee/Sandwich areas. Additional evaluation will be needed once actual infiltration data is obtained (from the Phase 1 and 2 recharge) to determine the feasibility for the Phase 3 flows and any planned flows from Mashpee/Sandwich.

From a nitrogen loading perspective, the TMDLs for Little, Great, and Green Ponds could be met with ENR treatment and recharge as modeled at the FCC site. The residual nitrogen concentration in the treated water (estimated at 3 mg/L total nitrogen) would cause the TMDLs for both Bournes Pond and Waquoit West to be exceeded even at 100% sewering of these watersheds (as described earlier, there is not yet a TMDL for Waquoit West; the Waquoit West TMDL has been estimated for this report based on the limit set for adjacent Bournes Pond).. This is due to the large flow (even at the low nitrogen concentration) that would be recharged.

The flow going to Bournes Pond and Waquoit West is illustrated in Figure 4-6 for the recharge flow of 1.8 mgd. This model run indicated that 45% of the flow (0.8 mgd) will recharge through Bournes Pond. When this recharge flow is evaluated in a worksheet developed from the MEP land use model, (see Figure 4-7) the resultant nitrogen loading greatly exceeds the nitrogen TMDL. The estimated TMDL for Waquoit West is also exceeded. This finding does not change if a portion of the 1.8 mgd flow is diverted to the C1-3 facilities due to the low recharge capacity of these facilities.

The Figure 4-7 worksheet utilizes the nitrogen attenuation factors developed by the MEP to account for nitrogen attenuation in the upper watershed. The resultant nitrogen load from the recharge is then added to the other controllable nitrogen loads (projected for buildout conditions and 100% sewering in the Bournes Pond Watershed) and compared to the TMDL. Figure 4-7 indicates the nitrogen loading from this scenario is over 3 times the value of the TMDL.

This finding indicates that the recharge of a successful wastewater plan needs to be distributed over a larger area and the treated water needs to be treated to lower nitrogen concentrations. This finding led to the next set of evaluations to investigate water reuse and well infiltration along the Route 151 right-of-way described below.

## 4.4 EVALUATION OF TOC TREATMENT AND WATER REUSE ALTERNATIVES

A. **Introduction.** Based on the finding that the TMDLs could not all be met when the recharge was distributed as originally planned across the FCC site, and due as well to concern about the amount of land area required for surface infiltration; the project team investigated additional recharge sites and technologies. The plan needs to efficiently and cost-effectively spread the recharge over a larger area similar to the recharge approaches utilized by the Air Force Center for Engineering and the Environment (AFCEE) with their groundwater remediation program on the MMR. AFCEE produces a highly-treated water and then recharges the water through infiltration wells located for proper management of the groundwater and surface-water resources. The best location to apply this approach in the Planning Area is in the Route 151 right-of-way (ROW) located in the northern portion of Falmouth.

B. **Well Infiltration Technology.** This technology was identified and screened in the November 2007 Alternatives Screening Analysis Report. Water is recharged to the groundwater by pumping it through the wells into permeable, saturated and unsaturated geologic strata. When recharged into saturated strata, this type of recharge can be compared to the reverse of extracting water from a well. Extensive treatment to remove the organic carbon from the water is needed to avoid plugging of the strata.

This technology has the advantage that it does not require the large land areas (cleared of trees and animal habitat) typically required for other infiltration technologies. As a result, it can be less expensive to implement and have significantly less environmental impact with respect to surface disruption and habitat damage.

It is noted that this technology was screened from further evaluation in the November 2007 Alternatives Screening Analysis Report and it was not in the project scope forwarded by the December 2007 Environmental Notification Form and the Secretary's Certificate. The addition of this technology and the potential use of recharge sites along Route 151 indicates that a Notice of Project Change (NPC) be filed with this DCWMP/DEIR to alert the MEPA review process that this alternative will receive additional detailed evaluation. The NPC is attached in Chapter 9.

The following conceptual design items were used for sizing and cost development of infiltration wells proposed for the Route 151 ROW:

- 0.5 mgd (350 gpd) capacity per well that could be increased to 0.75 to 1.0 mgd for short periods to meet operational requirements. This capacity assessment is based on the design and operating experience of the AFCEE infiltration well that recharges the treated water from their LF-1 treatment system.
- 10-inch diameter well riser and stainless steel screen.
- Approximate well depth of 200' with approximately 70' of screened opening. (These factors are similar to the ones encountered at LF-1 and would need to be tailored for each well installation.)
- Estimated installation cost of $300,000/well and annual redevelopment cost of $15,000 per year per well.
- Well-system flow capacities needed:

| RECHARGE FLOW | PHASE 1 & 2 | PHASE 1, 2 & 3* |
|---|---|---|
| Average Annual (mgd) | 1.8 | 2.7 |
| Maximum Month (mgd) | 3.3 | 5.0 |
| Maximum Daily (mgd) | 3.7 | 5.6 |
| * Mashpee/Sandwich flows will be recharged in Mashpee and/or in Sandwich. | | |

- Eight wells (at 0.5 mgd each) needed to meet Phase 1 & 2 flows. This allows one well out of service at maximum daily flow.
- Twelve wells needed to meet Phase 1, 2 & 3 flows. This allows one well out of service at maximum daily flow.

- Additional infrastructure needed for well injection:
  - Wet well and PS with chemical feed to recondition the water.
  - Treated water force main and valve vaults.
  - Backup sand infiltration bed facility.

This layout is illustrated in Figure 4-8 in a conceptual manner. The placement of the wells has not yet been determined. Final placement would be made to place the recharge in the watersheds that can best assimulate it as part of implementation and adaptive management. Costs for these components are summarized later in this Chapter.

This approach allows flexible recharge of the treated water and redundancy of wells so that wells can be taken off line for annual maintenance.

It is noted that MassDEP has been hesitant to approve well recharge technologies for municipal applications in the past. This hesitancy was a primary reason the technology was previously screened from detailed evaluation. Recently, MassDEP appears more open to the technology if implemented with adequate safeguards.

The characteristics of the treated water from a municipal treatment plant will be different from the water characteristics from the LF-1 treatment plant at MMR; therefore, performance testing is needed in an adaptive management mode. The implementation and adaptive management of these infiltration wells would be as follows:

- Construction of the new WWTF and the first two injection wells in the Route 151 ROW.
- Startup and operation of the WWTF for sufficient time to meet the treatment and performance requirements needed for well recharge. Treated-water recharge at this time would be in conventional sand beds utilized for backup recharge purposes.
- Startup of the injection wells with the treated water once the WWTF meets its performance requirements.
- Modification to the WWTF treatment process as needed for infiltration well performance. Modifications may include additional treatment processes.

This performance testing procedure is a type of pilot testing that uses the first two wells as the pilot project. It allows testing with the actual water being produced.

A conceptual layout for the infiltration wells is illustrated on Figure 4-8. This area is up gradient of several public water supply wells with expected travel time of greater than two years. This type of recharge will require total organic carbon (TOC) removal as required by the new MassDEP discharge regulations, as discussed below. This area is also up gradient of fresh water ponds; therefore, phosphorus removal will be needed at the WWTF.

This recharge and reuse approach is proposed as a comprehensive way to reuse the water and put it back into the hydrologic cycle to recharge ponds, streams, and drinking water supplies.

C. **Total Organic Carbon (TOC) Treatment and Water Reuse.** In early 2009, MassDEP revised their groundwater discharge regulations (314 CMR 5) to require removal of TOC to less than 3 mg/L for treated water recharge into Zone II areas with travel times that are greater than two years. This treatment limit is reduced to less than 1 mg/L TOC for travel of two years or less, and for treated waters that are recharged directly to the groundwater without the benefit of treatment in the unsaturated soil zone. They implemented this limit to protect drinking waters from a new class of contaminants called endocrine disruptors (discussed in the November 2007 Alternatives Screening Analysis Report starting on page 3-29). Endocrine disruptors, pharmaceuticals, and personal care products are included in a more general category of contaminants called "contaminants of emerging concern" or "CEC". These CEC are being measured in water and wastewater at small concentrations because analytical methods have improved and use of pharmaceuticals and personal care products is becoming more widespread. They are considered "emerging" because there are no limits or standards on the amounts that might cause human or environmental health risk. These emerging contaminants are typically made of organic carbon compounds; therefore, if the TOC content is reduced to low values, the emerging contaminants are typically removed.

TOC is removed in biological treatment processes with long solids retention time and high mixed liquor suspended solids (MLSS). Biological processes with these characteristics consume the organic carbon as food. The membrane biological reactor (MBR) process (identified as the Zenon treatment system on page 3-20 of the Alternatives Screening Analysis Report) provides controls to maximize these two operational parameters.

Some organic carbon compounds are very refractory and are resistant to biological degradation. Advanced oxidation processes utilize oxidants such as peroxide and ozone in combination with ultraviolet (UV) light to break apart refractory compounds. These processes are often used as a polishing process in combination with disinfection or are used for side stream treatment on a reject water stream from a membrane process.

When TOC is in small concentrations in water it is typically removed through adsorption onto granular activated carbon (GAC). This process is used extensively by AFCEE in their groundwater cleanup processes at MMR.

Finally, fine membranes such as reverse osmosis (RO) can be used as an additional polishing step to remove TOC to low levels.

These four processes (MBRs, advanced oxidation, GAC adsorption, and RO) are the main approaches to treat the emerging contaminants and produce a highly treated water that is suitable for well injection into Zone II areas.

Conceptual design of two treatment systems utilizing combinations of these flow processes were completed for costing and feasibility evaluations as identified below.

1. Treatment Type B including the following components:

   - Wastewater pretreatment for screenings and grit removal.
   - Membrane biological reactors (MBR) treatment configured in a Bardenpho configuration for organic carbon, nitrogen, and phosphorus removals.
   - Granular activated carbon adsorption (GAC) for final TOC removal.
   - Final disinfection.

2. Treatment Type C including the following components:

   - Wastewater pretreatment for screenings and grit removal.
   - Membrane biological reactors (MBR) treatment configured in a Bardenpho configuration for organic carbon, nitrogen, and phosphorus removals.
   - Reverse osmosis treatment of a portion of the flow to produce purified “product water” of approximately 67% of the total flow. This process also produces a reject

water stream where all the organic carbon and inorganics are concentrated at approximately 22% of the flow.

- Advanced oxidation of the reverse osmosis reject water to break apart the refractory organic carbon compounds that were not removed by the MBR and were concentrated in the reject water stream by reverse osmosis. Once the refractory carbon compounds are broken into biodegradable compounds, the reject water is returned to the MBR for further biological treatment.
- GAC adsorption for approximately 33% of the total flow to produce a Type B product water. This Type B "bleed" stream is needed to avoid concentration of inorganic solids such as salts that would affect the biological process in the MBR.
- Combination of the Type B and reverse osmosis product waters for disinfection, reconditioning, and recharge.
- Possible segregation of the Type B and reverse osmosis product waters for separate infiltration: well infiltration for the reverse osmosis product water, and conventional sand bed or subsurface infiltration for the Type B product water.

Flow schematics of these two treatment types are illustrated on Figure 4-9 with the schematic for Treatment Type A.

Treatment performance of the treatment types is summarized below.

**TABLE 4-6**

**EXPECTED TREATMENT PERFORMANCE FROM ALERNATIVE TREATMENT TYPES**

| TREATMENT TYPE | TOTAL NITROGEN (MG/L) | TOTAL ORGANIC CARBON (MG/L) |
|---|---|---|
| Type A: SBR followed by Denitrification Filters | 3 | 10 to 20 |
| Type B: MBR followed by GAC Adsorption | 2 | <3 |
| Type C: MBR followed by Reverse Osmosis and GAC Adsorption | 1 | <1 |

It is noted that the water purification industry is changing with the introduction and proven performance of new membrane types. Reverse osmosis membranes have been used for years for water purification and disinfection. Microfiltration and ultra filtration membranes are two newer types that are used in MBRs. Nanofiltration membranes are also a newer type of membrane technology that is closer to reverse osmosis. The following table summarizes pore sizes of these membranes.

**TABLE 4-7**

**MEMBRANE PORE SIZES**

| MEMBRANE TYPE | TYPICAL PORE SIZE (MICRON) |
|---|---|
| Microfiltration | 1.0 |
| Ultrafiltration | 0.05 |
| Nanofiltration | 0.005 |
| Reverse Osmosis | <0.001 |

Selection of the membrane types for MBR and final polishing processes should remain flexible and would change over time as new membranes enter the market place. The membrane canisters should be selected during design with a perspective on future flexibility.

The layout for both the Type B and Type C treatment types would be similar. Membrane units (for the MBR process as well as final polishing membranes or reverse osmosis) and GAC adsorption units would be enclosed in a building. Figure 4-10 illustrates a layout for the Type B and C treatment systems.

Costs for these two treatment types at MMR site are illustrated in Tables 4-8 and 4-9. These costs are summarized with the costs of the Type A treatment and recharge system at the end of this chapter.

The high costs and complex operations of the Type B and C treatment types renewed an interest to consider an ocean outfall alternative in more detail. This evaluation is summarized in the following section.

## 4.5 FURTHER EVALUATIONS OF AN OCEAN OUTFALL ALTERNATIVE

A. **Nobska Point Outfall Evaluations.** Previous wastewater planning efforts in the 1970s evaluated the possible use of an ocean outfall from Nobska Point in Woods Hole extending approximately 2,000 feet into Vineyard Sound. A series of 3 articles were published in the Journal of Boston Society of Civil Engineers and describe those evaluations. These articles are

## Table 4-8
## Summary of Cost Comparison for MBR and GAC Treatment, and Well Injection Recharge at Rt 151 Corridor

| | Scenario 3B (MMR[4] Site) | |
|---|---|---|
| Cost Component | Phase 1 and 2 | Addl. Costs for Phase 3 |
| **Capital Costs** | | |
| *Collection System* | *$210,000,000* | *$115,000,000* |
| Collection and Minor PS & FM | $170,000,000 | $110,000,000 |
| Major PS and FM | $42,000,000 | $4,800,000 |
| *Treatment Site and Systems* | *$51,000,000* | *$16,000,000* |
| Site Development | $8,900,000 | $3,000,000 |
| WW Treatment Systems | $38,000,000 | $13,000,000 |
| Sludge Management System | $3,600,000 | $250,000 |
| *Recharge System* | *$8,000,000* | *$1,500,000* |
| Pump Station and Injection Well System | $2,900,000 | $910,000 |
| Treated Water Force Main to Injection Wells | $4,600,000 | $540,000 |
| Backup 0.5 mgd Infiltaration Bed System at MMR or FCC Site & FM | $530,000 | $0 |
| **Total Construction Costs** | **$269,000,000** | **$133,000,000** |
| Contingency (25%) | $67,000,000 | $33,000,000 |
| Fiscal, Legal and Engineering (25%) | $67,000,000 | $33,000,000 |
| **Total Capital Costs** | **$400,000,000** | **$200,000,000** |

| | Scenario 3B (MMR[4] Site) | |
|---|---|---|
| Cost Component | Phase 1 and 2 | Addl. Costs for Phase 3 |
| **O&M Costs** | | |
| Electrical Costs | | |
| Collection System Lift Stations | $210,000 | $100,000 |
| Treatment Site | $310,000 | $160,000 |
| WWTF operations & repairs | $2,700,000 | $1,200,000 |
| Collection system operations & repairs | $1,500,000 | $560,000 |
| Sludge Disposal | $300,000 | $160,000 |
| Treated Water Recharge System | $130,000 | $34,000 |
| Marine Water Quality Monitoring Allowance | $100,000 | $100,000 |
| Total O&M Costs per year | $5,300,000 | $2,300,000 |
| Discount Rate of 5% (P/A for 5% and 20 yr = 12.4622) | | |
| **Present Worth of O&M Costs** | **$66,000,000** | **$29,000,000** |
| **Total Present Worth Costs** | **$470,000,000** | **$230,000,000** |

Notes:
1. All costs are rounded to two significant digits except total construction costs which are rounded to three to reduce rounding error
2. All cost are referenced to July 2009 costs
3. Costs do not include potential costs for property purchase or easements
4. Massachusetts Military Reservation

## Table 4-9
## Summary of Cost Comparison for
## MBR, RO and GAC Treatment, and Well Injection Recharge at Rt 151 Corridor

| Cost Component | Scenario 3C (MMR[4] Site) Phase 1 and 2 | | Scenario 3C (MMR[4] Site) Addl. Costs for Phase 3 | |
|---|---|---|---|---|
| **Capital Costs** | | | | |
| *Collection System* | *$210,000,000* | | *$120,000,000* | |
| Collection and Minor PS & FM | | $170,000,000 | | $107,000,000 |
| Major PS and FM | | $37,000,000 | | $4,800,000 |
| *Treatment Site and Systems* | *$54,000,000* | | *$17,000,000* | |
| Site Development | | $8,900,000 | | $3,100,000 |
| WW Treatment Systems | | $41,000,000 | | $13,000,000 |
| Sludge Management System | | $3,600,000 | | $600,000 |
| *Recharge System* | *$8,000,000* | | *$1,500,000* | |
| Pump Station and Injection Well System | | $2,900,000 | | $910,000 |
| Treated Water Force Main to Injection Wells | | $4,600,000 | | $540,000 |
| Backup 0.5 mgd Infiltaration Bed System at FCC or MMR Site & FM | | $530,000 | | $0 |
| **Total Construction Costs** | **$272,000,000** | | **$131,000,000** | |
| Contingency (25%) | $68,000,000 | | $33,000,000 | |
| Fiscal, Legal and Engineering (25%) | $68,000,000 | | $33,000,000 | |
| **Total Capital Costs** | **$410,000,000** | | **$200,000,000** | |

| Cost Component | Scenario 3C (MMR[4] Site) Phase 1 and 2 | Scenario 3C (MMR[4] Site) Addl. Costs for Phase 3 |
|---|---|---|
| **O&M Costs** | | |
| Electrical Costs | | |
| Collection System Lift Stations | $210,000 | $100,000 |
| Treatment Site | $1,600,000 | $900,000 |
| WWTF operations & repairs | $2,500,000 | $1,200,000 |
| Collection system operations & repairs | $1,500,000 | $620,000 |
| Sludge Disposal | $300,000 | $160,000 |
| Treated Water Recharge System | $130,000 | $36,000 |
| Marine Water Quality Monitoring Allowance | $100,000 | $100,000 |
| Total O&M Costs per year | $6,300,000 | $3,100,000 |
| Discount Rate of 5% (P/A for 5% and 20 yr = 12.4622) | | |
| **Present Worth of O&M Costs** | **$79,000,000** | **$39,000,000** |
| **Total Present Worth Costs** | **$490,000,000** | **$240,000,000** |

General Notes:
1. All costs are rounded to two significant digits except total construction costs which are rounded to three to reduce rounding error
2. All cost are referenced to June 2007 costs
3. Costs do not include potential costs for property purchase or easements
4. Massachusetts Military Reservation

attached in Appendix 4-1. Town meeting decisions at that time approved this approach, but a subsequent ballot vote did not move it forward, and its use did not proceed. Since then, the Massachusetts Ocean Sanctuaries Act was passed which prohibits the discharge of any municipal treated waste water into this portion of Vineyard Sound (as well as all of the marine waters around Falmouth). The legislation is strictly imposed and a variance would require action by several State agencies. It is believed that a variance would only be given if it was shown that ocean disposal was the only feasible way to protect public health and the environment.

Similar to recharge wells discussed in the previous section, the ocean outfall technology was screened from further evaluation in the November 2007 Alternatives Screening Analysis Report and it was not in the project scope forwarded by the December 2007 Environmental Notification Form or in the subsequent Secretary's Certificate. Because of the additional evaluation of these technologies (well recharge and ocean outfall), a Notice of Project Change (NPC) is being filed with this DCWMP/DEIR to alert the MEPA review process. The NPC is attached in Chapter 9.

This ocean outfall treatment and discharge alternative (Scenario 1D) would have the following components:

- Wastewater collection from the Planning Area to meet the nitrogen TMDL as indicated in Figure 1-3.
- Conveyance to the existing Blacksmith Shop Road WWTF and treatment to the current standards (advanced nitrogen and solids removal) followed by filtration and disinfection.
- Possible discontinuance of the current groundwater recharge at the existing WWTF site and conveyance of the total flow (from existing sewered area and needed sewered area in the Planning Area) to an additional disinfection facility in Woods Hole.
- Final disinfection and discharge through the outfall.

The proposed outfall location is illustrated on Figure 4-11 which is the same location as discussed in the Boston Society of Civil Engineers Journal articles.

Costs for this scenario are summarized in Table 4-10.

The costs are based on the following factors:

## TABLE 4-10

## Summary of Cost Comparison for SBR and Denite-Filter Treatment at Blacksmith Shop Road WWTF and Discharge Through an Ocean Outfall at Nobska Point

| Cost Component | Scenario 1D Phase 1 and 2 | | Scenario 1D Addl. Costs for Phase 3 | |
|---|---|---|---|---|
| **Capital Costs** | | | | |
| *Collection System* | *$220,000,000* | | *$112,000,000* | |
| Collection and Minor PS & FM | | $170,000,000 | | $107,000,000 |
| Major PS and FM | | $45,000,000 | | $4,800,000 |
| *Treatment Site and Systems* | *$17,000,000* | | *$9,000,000* | |
| Site Development | | $6,200,000 | | $3,300,000 |
| WW Treatment Systems | | $9,100,000 | | $3,600,000 |
| Sludge Management System | | $1,900,000 | | $1,700,000 |
| *Ocean Outfall* | *$38,000,000* | | *$0* | |
| Pump Station and Treated Water Force Main | | $14,000,000 | | $0 |
| Final Disinfection and Pump Station | | $1,700,000 | | |
| Ocean Outfall | | $24,000,000 | | |
| **Total Construction Costs** | **$275,000,000** | | **$121,000,000** | |
| Contingency (25%) | $69,000,000 | | $30,000,000 | |
| Fiscal, Legal and Engineering (25%) | $69,000,000 | | $30,000,000 | |
| **Total Capital Costs** | **$410,000,000** | | **$180,000,000** | |
| Cost Component | Scenario 1D Phase 1 and 2 | | Scenario 1D Addl. Costs for Phase 3 | |
| **O&M Costs** | | | | |
| Electrical Costs | | | | |
| Collection System Lift Stations | $290,000 | | $190,000 | |
| Treatment Site | $270,000 | | $140,000 | |
| WWTF operations & repairs | $380,000 | | $200,000 | |
| Collection system operations & repairs | $1,500,000 | | $740,000 | |
| Sludge Disposal | $300,000 | | $200,000 | |
| Treated Water Discharge System (4) | $100,000 | | $67,000 | |
| Marine Water Quality Monitoring Allowance | $100,000 | | $0 | |
| Total O&M Costs per year | $2,900,000 | | $1,500,000 | |
| Discount Rate of 5% (P/A for 5% and 20 yr = 12.4622) | | | | |
| **Present Worth of O&M Costs** | $36,000,000 | | $19,000,000 | |
| **Total Present Worth Costs** | $450,000,000 | | $200,000,000 | |

General Notes:

1. All costs are rounded to two significant digits except total construction costs which are rounded to three to reduce rounding error
2. All cost are referenced to July 2009 costs
3. Costs do not include potential costs for property purchase or easements
4. Treated water discharge costs includes allowance for pump station O&M, chlorination/dechlorination system O&M, and outfall monitoring

- Collection and treatment as previously discussed for Scenario1A.
- Force Main (3-foot diameter) to be placed next to the existing wastewater force mains that extend from Woods Hole to the Blacksmith Shop Road WWTF (approximately 7.3 miles).
- Final disinfection facility to include chlorination and dechlorination facilities and (possible) pump station.
- Three foot diameter high density polyethylene (HDPE) ocean outfall extending 2,000 feet from Nobska Point into Vineyard Sound.
- Outfall would be buried and armored as needed.
- The outfall would extend directly into the sound from Nobska Point to a tee and the outfall diffusers would be placed parallel to the currents to maximize mixing.
- Costs are based on actual unit costs for the 1,300-foot long outfall constructed at the Seabrook WWTF in 1994. This is believed to be the last new ocean outfall (of this size) constructed in New England. Costs were adjusted based on differences in diameter, length, depth, and date of construction.

Evaluation of the non-monetary factors indicates the following findings:

- An outfall at this location with water treated to ENR standards would most likely not have an adverse environmental impact on the marine environment, but additional scientific studies would be needed to address questions and concerns of the local, regional, state, and federal stakeholders that would need to approve it.
- An outfall at this location could have an environmental benefit because it would move the treated water (with its low nitrogen concentration of less than 3 mg/L total nitrogen) beyond the near-shore environment into a well mixed zone of Vineyard Sound. It is noted that groundwater recharge of treated water eventually reaches the same off-shore environment; but in doing so, it moves through the near-shore environment where it causes eutrophication in the estuaries.
- By eliminating recharge of treated water to the watersheds, the outfall option would reduce the amount of upper watershed sewering required to meet the TMDLs.
- The outfall would lower groundwater elevations of the Sagamore flow lens in certain areas of Town due to the relocation of the current water recharges (at the existing WWTF and at existing septic systems) to the outfall discharge. This effect would need to be evaluated in detail using a groundwater model for the whole Sagamore flow lens.

- These scientific studies would take at least 1 year to complete, and the public and regulatory decision process on a CWMP and a variance request for an ocean outfall in an ocean sanctuary could add five more years.
- Legal challenges could add additional delays.

If the Town wanted to proceed with this alternative as the recommended plan, the following next steps would be indicated:

1. Prepare a Notice of Project Change (NOPC).
2. Obtain the revised EOEEA scope and complete the groundwater modeling and other evaluations needed to submit a DCWMP/DEIR that recommends an ocean outfall as the recommended plan.
3. Obtain Town support for the ocean outfall and recommended plan. (Town Meeting vote in the form of a non-binding resolution may be advisable.)
4. Submit the DCWMP/DEIR (with the ocean outfall as the recommended plan) for EOEEA and MEPA review.
5. If the DCWMP/DEIR is approved, the Town would proceed with the preparation and filing of the Final Comprehensive Wastewater Management Plan and Final Environmental Impact Report (FCWMP/FEIR).
6. If the FCWMP/FEIR is approved, the Town would proceed with the filing of a variance request to the Ocean Sanctuaries Act in accordance with MGL Chapter 132A Sections 16b and 16d. This variance is filed once a final certificate is received for the FCWMP/FEIR and needs to demonstrate that it is the only feasible alternative. Massachusetts General Law is clear on how the variance would be filed and how notice is given to all towns abutting the ocean sanctuary.
7. If the variance is approved, there may be legal challenges to MassDEP's review and approval. A Notice of Claim and an adjudicatory hearing would initiate a possible claim and it could require 2 to 5 years to settle.
8. Additional claims could challenge the variance to higher courts. Also, MGL Chapter 214 Section 7a allows additional citizen claims.
9. The expected time period to obtain a variance to the Ocean Sanctuaries Act is 5 to 10 years.

10. Once the variance is approved the following permit application and review would proceed:
    - Federal permitting under Section 404 of the Clean Water Act and the Rivers and Harbors Act of 1899.
        - Corps of Engineers would be the lead agency
        - A Federal Environmental Impact Statement (EIS) and review would accompany this permitting process
        - This review process would require approximately 2 years and would need to show that the ocean outfall alternative is the Least Environmentally Damaging Practical Alternative (LEDPA)
    - State permitting for Water Quality Certification, Coastal Zone Management (CZM) consistency review, CZM administration of the Ocean Sanctuaries Act, and Chapter 91 licensing.
        - MassDEP would be the lead reviewing agency
        - This review process would proceed in coordination with the federal reviews
    - Local permitting and approvals would be needed by the Falmouth Board of Health and the Falmouth Conservation Commission.

These "next steps" to obtain all of the approvals to construct an ocean outfall would require 5 to 10 years and may not be successful.

B. **Cape Cod Canal Outfall Considerations.** This outfall concept was not evaluated in detail but previous Environmental Impact evaluations were reviewed.

In October 1981, a Draft EPA Environmental Impact Statement (EIS) was prepared for environmental review of several wastewater management alternatives that involved sewering and treatment of a portion of Sandwich Village Center and surrounding area. The alternatives included consideration of three alternative ocean outfalls into the canal. All three were located at the east end of the canal near the power station. . The evaluation concluded that there would be no environmental impact due to the large volume of water that moves through the canal:

- Westward flow is 22 billion gallons per tide cycle.
- Eastward flow is 19 billion gallons per tide cycle.

Excerpts of the evaluation are attached in Appendix 4-2. The Draft EIS was never finalized and the wastewater planning project never proceeded.

In June 1990 a Final Environmental Impact Statement was reviewed and subsequently approved for an upgrade of the Otis ANG WWTF and recharge of the treated water at sand infiltration beds at a location on the south side of the canal and Sandwich Road (the current site of the recharge beds). An outfall to the canal near this site of the recharge beds was also considered and environmental impacts were determined to be negligible. The outfall was not considered in detail due to public opinion that wanted discharge at the recharge beds and further upgrade of the WWTF for nitrogen removal. Excerpts of this EIS are attached in Appendix 4-3.

The two case studies are provided to give additional background on previous evaluations of an ocean outfall at the canal. They should be considered further if the Town wants to proceed with an outfall. An outfall to the Cape Cod Canal from an MMR treatment plant site could be less costly and have less environmental impact than an outfall at Nobska Point. In addition, an outfall to the canal from an MMR treatment plant site would preserve the advantages of the regional treatment option.

## 4.6 SLUDGE MANAGEMENT EVALUATIONS

The purpose of this section is to summarize sludge management evaluations completed in the November 2007 Alternatives Screening Analysis Report and provide additional analysis. Sludge management represents a large cost of operating a modern WWTF as well as a potential source of odors; therefore understanding the various options to manage sludge is critical.

Sludge (also called biosolids) is a combination of microorganisms, and organic and inorganic material generated in advanced treatment processes. Sludge is produced from the treatment process as a liquid and typically has a solids concentration of 5,000 to 20,000 mg/L (0.5 to 2 percent total solids). It is typically thickened and disposed (or reused) at regional facilities at a concentration of 4-6 percent total solids. Also, it can be dewatered and disposed (or reused) at regional facilities as a sludge cake at a concentration of 15 to 25 percent total solids. It can also be dewatered and composted on site to produce a soil conditioner material of approximately 35 to 50 percent total solids.

The following text identifies the main methods to process sludge and the sludge management alternatives (comprised of the processing methods) evaluated.

A. **Sludge Processing Methods**. Sludge processing methods are divided into the four main categories as detailed below:

1. **Sludge Thickening.** Sludge thickening is a process to concentrate sludge, generally to 4-6 percent solids, by removing a portion of the liquid fraction. Sludge thickening reduces transportation and disposal costs and facilitates additional sludge treatment processes, including dewatering and stabilization. Sludge thickening can be accomplished by several processes. The simplest thickening process involves storing sludge in an aerated tank and periodically stopping aeration to allow sludge to settle and excess liquid to be decanted to the main wastewater treatment process. Other thickening processes are more complicated and utilize equipment such as filters, centrifuges, and rotating drums. Thickening with these types of mechanical equipment (mechanical thickening) often requires a covered process building, odor control facilities, and additional process equipment such as feed pumps and piping. Mechanical thickening also typically requires the addition of chemicals, such as polymer, to condition the sludge and facilitate the thickening process. The existing Blacksmith Shop Road WWTF utilizes a mechanical sludge thickening process, and the thickened sludge is transported to a regional facility for disposal or reuse as allowed by the transportation contract.

2. **Sludge Dewatering.** Sludge dewatering is a physical process, using equipment such as a belt filter press or centrifuge to reduce the water content of thickened sludge to 15-25 percent solids. Dewatered sludge, also known as sludge cake, has the consistency of moist sawdust and requires less volume for storage or transportation to a disposal (or reuse) site.

3. **Sludge Stabilization – Composting, Digestion, Alkaline Stabilzation or Heat Treatment/Drying.** Sludge is often stabilized to reduce pathogens, odors, and the potential for the sludge to biologically decay. Sludge stabilization processes can be used prior to or following sludge dewatering. Common sludge stabilization technologies include composting, digestion, alkaline stabilization, and heat treatment and drying.

a. **Composting.** Composting is a biological sludge stabilization process that destroys pathogens, reduces the water and organic solids content of dewatered sludge, and produces a granular, soil-like material of 35-50 percent solids. Sludge composting processes typically include the following three steps:

1) Dewatered sludge is mixed with a bulking agent such as wood chips, yard waste, or sawdust.

2) The mixture is aerated or regularly mixed, which increases the temperature of the mixture, killing pathogens and degrading the highly volatile solids of the sludge.

3) The composted material is cured and stored for distribution.

Finished compost can be distributed to the public if it meets numerous rigorous criteria established by MassDEP regulations. Composting is typically most successful if the sludge to be composted has already been digested because the material is partially stabilized, there is less potential for generation of odors, and the sludge is easier to handle. Although composting can provide a beneficial reuse of sludge, it is usually not cost effective for low sludge flows (WWTF less than 3 mgd in size). Sludge composting facilities often consist of large covered structures to shelter the compost machinery and odor control facilities. The facility would need to include a liner / containment to prevent runoff offsite and/or leaching to groundwater, particularly given the nutrient management concerns in the Town of Falmouth. Land areas and capital costs are usually relatively high for composting facilities.

There have been 3 failed attempts of sludge composting on Cape Cod since the 1980s. They were at the Otis WWTF, the Tri-Town Septage Treatment Facility, and the Yarmouth Dennis Septage Treatment Facility. They have failed due to a combination of odor generation, inability to consistently meet MassDEP requirements to allow distribution of the compost material, complex operational and mechanical problems and economics. All of the sludge produced at Cape Cod WWTFs is currently transported off Cape for disposal or reuse at regional facilities. It is believed that any future composting facility would need to be an enclosed system with excellent process control to eliminate odors, operational problems, and fully meet the MassDEP requirements.

b. **Digestion.** Digestion is a biological stabilization process that reduces the number of pathogens and the overall solids content of sludge through the use of microorganisms. The microorganisms feed on the organic material in the sludge and are utilized in two types of sludge digestion processes: anaerobic digestion and aerobic digestion. Digested sludge can be dewatered, composted, or disposed of at a regional facility. Anaerobic digestion produces methane gas that can be used as a fuel source.

Anaerobic and aerobic sludge digestion processes typically include two or more large covered tanks. Thickened sludge is fed into the tanks where anaerobic or aerobic microorganisms decompose the sludge. Mixing and/or aeration equipment is required to improve the digestion process and maintain either an anaerobic or aerobic environment. The digestion process also requires covered buildings to protect process equipment and odor control facilities. Anaerobic digestion produces methane gas which, if produced in large enough volumes, can be used as a supplementary energy source. Sludge digestion is typically not cost effective for small WWTF (WWTF less than 3 mgd in size.

c. **Alkaline Stabilization.** Alkaline stabilization is a process in which dewatered sludge is combined with an alkaline material, such as cement kiln dust or lime to raise the pH, raise the temperature, and reduce the water content of the sludge. Raising the pH and temperature of the sludge creates an environment which is hostile for pathogen growth and reproduction. Alkaline stabilization, like composting, can produce a material that meets MassDEP’s requirements for distribution to the public.

The primary market for an alkaline stabilized sludge is the agricultural industry. The alkaline stabilized sludge has alkalinity and nutrients that are useful for growing field crops; however, this type of agricultural market does not exist on a sufficient scale on Cape Cod or in southeastern Massachusetts to justify alkaline stabilization of sludge on Cape Cod. The facilities required for alkaline stabilization include enclosed areas for storing alkaline materials, processing the sludge-alkaline material mixture, and storing the final product. Equipment requirements include screw conveyors for transferring the alkaline materials, a mixing unit that combines dewatered sludge and alkaline material, and a drying process for the blended material. Land area requirements and capital and operations costs are comparable to those of a composting facility. Alkaline stabilization is typically not cost effective for small WWTF or in places where there is not a market for the final product.

d. **Heat Treatment and Drying.** Heat treatment and drying are thermal stabilization processes that involve heating sludge under pressure to disinfect and dry the sludge. The resulting material is easier to dewater and may be dried to produce a powdered or pelletized product, which can be used as a fertilizer or soil conditioner.

These processes generally have high capital costs, high level of complexity, high energy usage and operation costs. In addition, thermal processes require a continuous flow of sludge to keep the process running and are therefore usually not cost effective for low sludge flows at small WWTFs.

B. **Sludge Management Alternatives.** The sludge processing methods described in the section above have been paired with reuse/disposal options to form several overall Sludge Management Alternatives for further evaluation: sludge thickening and transport to a regional facility for disposal or reuse; sludge dewatering and transport to a regional facility for disposal or reuse; sludge dewatering, composting (and/or other stabilization processes), and distribution to the public; sludge thickening and/or dewatering and land application.

Under each of these alternatives, the new sludge processing facilities could be constructed at a new WWTF site or at the Town's existing main WWTF site on Blacksmith Shop Road (BSR). The existing sludge processing facilities at the Town's main WWTF would need to be substantially modified and expanded to accommodate the wastewater sludge from the current Planning Area under any of the alternatives. Also, if sludge management is centralized at one site, but wastewater treatment continues at more than one site (existing BSR site and at a new WWTF site), unthickened sludge would need to be hauled from one site to the other for processing.

The recently constructed (2005) sludge management facilities at the existing main Falmouth WWTF include the following processes:

1. Sludge storage

2. Sludge and septage thickening

3. Thickened sludge disposal by a contracted sludge trucking company at a MassDEP-approved sludge disposal and/or reuse facility

This disposal option was determined to be the most cost effective in the 2001 Wastewater Facilities Plan after evaluation of several sludge processing and disposal alternatives.

The sludge management alternatives evaluation is summarized on the following pages. A diagram identifying potential sludge management alternatives is included as Figure 4-12.

1. **Sludge Thickening and Transport to a Regional Facility for Disposal or Reuse.** This alternative would involve the transportation and disposal (or reuse) of thickened sludge at a regional facility. This would require the construction of sludge storage and thickening facilities. The thickened sludge would be transported to a regional facility for disposal or reuse (typically to Cranston RI or Fitchburg MA for incineration).

This alternative has the following advantages:

a. Minimizes capital costs and equipment operational costs.

b. Reduces risk of odor generation.

This alternative has the following disadvantages:

a. It may not meet some public desires to reuse the material locally.

b. Thickening results in a larger volume of "thinner" sludge for hauling/disposal than dewatering or stabilization/composting.

2. **Sludge Dewatering and Transport to a Regional Facility for Disposal or Reuse.** Using this alternative, facilities would be constructed to store and dewater the sludge, and sludge cake would be transported to a regional facility for disposal/reuse.

This alternative has the following advantages:

a. Disposal costs for sludge cake are less than those for thickened liquid sludge.

This alternative has the following disadvantages:

a. Dewatering equipment is generally more expensive to purchase/install than simple thickening equipment.

b. There are few regional disposal facilities that accept sludge cake and the cost savings with sludge cake disposal do not offset the higher cost to produce it.

c. The sludge dewatering process provides a greater potential for release of odors than thickening.

3. **Sludge Dewatering, Composting (or other stabilization process), and Distribution to the Public.** This alternative involves the construction of sludge storage, dewatering and composting facilities, with the primary goal to produce a material that could be distributed to the public or to the agricultural market. Experience indicates that the public will pick up and use composted material if it is free and of good quality; however it is unknown whether the demand would be sufficient in Falmouth such that all material would be picked up by local end users, or whether some material would have to be transported offsite to other regional users.

Composting (or other stabilization process) and distribution of compost would have the following advantages:

a. The Town would not have to pay for sludge disposal (if sufficient demand was found for free pick up of the composted product).

b. Beneficial reuse is provided.

c. The Town has more control over sludge management and is not dependent on a regional sludge facility.

d. Sludge generated and thickened at multiple facilities could be dewatered and composted at one centralized location.

This alternative would have the following disadvantages:

a. The demand for a composted product is low due to the relatively low number/size of agricultural areas in Cape Cod and Eastern Massachusetts. Also, the large volumes of free yard waste compost produced by municipalities on Cape Cod have reduced the local demand for soil conditioners.

b. Construction and O&M costs are typically highest for this alternative.

c. Extensive permitting and monitoring is required by MassDEP and USEPA prior to distribution of the finished material.

d. The potential for odors is increased and adjacent property owners may not welcome this type of process.

e. Large land area is required.

f. It would be necessary to transport sludge to this facility from either the existing WWTF or a new WWTF or both.

g. These processes require high skill levels for operation and maintenance of the complex machinery and process.

4. **Sludge Thickening and/or Dewatering and Land Application.** This alternative involves the thickening and/or dewatering of sludge and subsequent spreading of sludge (in very controlled application rates) onto and into the land. The land is then seeded with an agricultural crop to utilize the sludge's nutrients and turn it into soil material. This type of sludge disposal is common in the Midwestern United States, where there are large farms that welcome the nutrients. It has also been used in other places to produce inexpensive topsoil for the construction of landfill caps. This method of sludge disposal is not recommended for Falmouth because there are no large agricultural lands nearby that could use (or want) the sludge. Also, sludge contains significant amounts of nitrogen, which typically does not lend itself to application in Falmouth and the many watersheds to sensitive coastal embayments.

C. **Comparison of Sludge Management Alternatives and Recommendation.** The comparison of sludge management alternatives is based on the description provided for each alternative and its advantages and disadvantages. A summary of sludge management alternatives and a side-by-side comparison of standard criteria are included in Table 4-11.

Sludge thickening is a relatively simple process with lower capital costs and lower operation, maintenance, and energy requirements than any of the other alternatives. Thickened sludge can be disposed of at a number of regional facilities. Sludge thickening is the first step required for the more complicated sludge management processes of sludge dewatering and composting and other stabilization processes; therefore these additional processes could be added in the future if desired as sludge flows increase.

Thickened sludge is believed to be the most practical sludge disposal/reuse alternative and is the recommended sludge management alternative. As the wastewater flows increase after the first 10 to 15 years of sewer expansion, and if energy costs and disposal costs increase significantly, this strategy could be re-evaluated for the higher flows.

Costs for the sludge management facilities are included in the cost summaries for the alternative wastewater management scenarios.

## 4.7 SUMMARY OF EVALUATIONS AND SELECTED ALTERNATIVE

The costs for the six wastewater management alternatives identified for sewering and advanced treatment of the Plan 1 and 2 areas in the 20-year planning period are summarized in Table 4-12.

## TABLE 4-11

## SUMMARY OF SLUDGE MANAGEMENT ALTERNATIVES
Comprehensive Wastewater Management Planning Project
Town of Falmouth, MA

| ALTERNATIVE | REGULATORY REQUIREMENTS | EFFLUENT QUALITY | MAINTENANCE REQUIREMENTS AND COMPLEXITY OF OPERATION | FLEXIBILITY | ENERGY USE | LAND REQUIRE-MENTS | POTENTIAL FOR AIR EMISSIONS | PUBLIC ACCEPTANCE | EASE OF IMPLEMENTATION | RELATIVE CAPITAL COSTS | RELATIVE O&M COSTS | RECOMMEND |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sludge thickening and disposal or reuse at a regional facility | Siting, design, and permitting requirements for new facilities. | Responsibility of regional facility and not applicable to disposal evaluation. | Town depends on outside source for reliable disposal. Thickening equipment is typically reliable. | Variety of disposal facilities accept thickened sludge both on and off-Cape. | Low. | Low. | Odor control facilities are often required. | Thickening facilities would be part of a new large facility, or use/expansion of the existing Falmouth facility. | Easiest. Many regional facilities accept liquid sludge. | Relatively low compared to other management alternatives. | Relatively low compared to other management alternatives. | Yes, due to the desire for flexible operations, and lower costs. |
| Sludge dewatering and disposal or reuse at a regional facility | Siting, design, and permitting requirements for new facilities. | Responsibility of regional facility and not applicable to disposal evaluation. | Town depends on outside source for reliable disposal. Dewatering equipment is typically reliable. | Limited number of facilities receiving dewatered sludge. | Moderate due to operation of dewatering equipment. | Low. | Odor control facilities are often required. | Dewatering facilities would be part of a large centralized facility. | Relatively easy due to the existence of few facilities that except sludge cake | High due to dewatering equipment and building. | Disposal costs can be reduced because solids are consolidated. Equipment maintenance costs are higher. | No, due to higher costs and fewer disposal and/or reuse locations |
| Sludge thickening, dewatering, and composting (or alkaline stabilization, digestion, and/or heat treatment) | Siting, design, and permitting requirements for new facilities. Regular sampling, analysis, and reporting to MassDEP. | Capable of producing a material that can be distributed to the public. Must be closely monitored | Previous installations on Cape Cod were shut down due to odors and poor economics. | Limited options for disposal if public interest in taking material is low. | High due to extensive equipment and odor control facilities. | High for covered structures, storing, and loading areas. | High potential for odors. Previous facilities on Cape Cod shut down due to odors. | Adjacent property owners may challenge this process due to potential for odors, large land requirements, and visual impacts. | Difficult due to construction of new facilities and extensive permitting. | High compared to thickening. | High due to purchase of materials, operation and maintenance of equipment, and operator requirements. | No at this time due to higher costs, greater potential for odors, and the low sludge flows that are expected in the next 10 to 15 years. This evaluation should be reconsidered as WW and sludge flows increase |
| Sludge thickening and/or dewatering and land application | Siting, design, and permitting requirements for new facilities. Regular sampling, analysis, and reporting to MassDEP. | There is a risk that nitrogen will leach from the sludge and enter the groundwater system. | Relatively simple in agricultural areas, but expected to have difficult permit requirements in Falmouth. | Can be flexible if there is sufficient land area. | Low. | High. | High. | Low. | Extremely difficult due to extensive permitting requirements and minimal locations for the land application. | Low if there is a nearby agricultural economy. | Low if there is a nearby agricultural economy. | No, this method is not appropriate for Falmouth because there are few expansive agricultural areas. |

# TABLE 4-12

## SUMMARY OF COSTS[1] FOR ALTERNATIVE WASTEWATER MANAGEMENT SCENARIOS FOR 20-YEAR PLANNING PERIOD FROM 2015 TO 2035 FOR SEWER EXTENSION AND WASTEWATER MANAGEMENT FOR PHASE 1 AND 2 AREAS

| SCENARIO NUMBER AND DESCRIPTION | | TOTAL CAPITAL COSTS[1] ($ MILLION) | ANNUAL O&M COSTS[1] ($ MILLION) |
|---|---|---|---|
| 1A | Wastewater Collection, ENR[2] treatment at Blacksmith Shop Road (BSR[3]) site, and recharge at Falmouth Country Club (FCC) site. | 380 | 2.9 |
| 2A | Wastewater collection, ENR[2] treatment at FCC site, and recharge at FCC[4] site. | 350 | 2.9 |
| 3A | Wastewater collection, ENR[2] treatment at MMR[5] site, and recharge at FCC[4] site. | 370 | 3.2 |
| 3B | Wastewater collection, MBR[6] and GAC[7] treatment at the MMR site and well recharge at Route 151 ROW[8]. | 400 | 5.3 |
| 3C | Wastewater collection, MBR[6] and RO[9] and GAC[7] treatment at the MMR site and well recharge at Route 151 ROW[8]. | 410 | 6.3 |
| 1D | Wastewater collection, ENR[2] treatment at BSR[3] site and ocean outfall disposal at Nobska Point. | 410 | 2.9 |

Notes:

(1) All costs are in millions of dollars rounded to two significant digits with the following definitions:

- Costs are referred to July 2009; therefore, these costs will need to be scaled to account for inflation in the future.
- Total capital costs include estimated construction costs, 25 percent contingency allowance, and 25 percent allowance for fiscal, legal, and engineering costs of implementation.
- Annual operation and maintenance (O&M) cost includes annual costs for electricity, chemicals, solids disposal/reuse, operating labor, repairs when the facilities reach their design flow, and environmental monitoring.

(2) Enhanced Nitrogen Removal (ENR).

(3) Blacksmith Shop Road (BSR).

(4) Falmouth Country Club (FCC).

(5) Massachusetts Military Reservation (MMR).

(6) Membrane Bioreactor (MBR).

(7) Granular Activated Carbon (GAC).

(8) Right-of-Way (ROW).

(9) Reverse Osmosis (RO).

The cost for these same alternatives to extend sewers for the Phase 3 area in the 40-year planning period and meet the nitrogen TMDLs are summarized in Table 4-13.

**TABLE 4-13**

**SUMMARY OF COSTS(1) FOR ALTERNATIVE WASTEWATER MANAGEMENT SCENARIOS FOR 40-YEAR TIME PERIOD FROM 2015 TO 2055 FOR SEWER EXTENSION AND WASTEWATER MANAGEMENT FOR PHASE 1, 2, AND 3 AREAS**

| SCENARIO NUMBER AND DESCRIPTION | | TOTAL CAPITAL COSTS(1) ($ MILLION) | ANNUAL O&M COSTS(1) ($ MILLION) |
|---|---|---|---|
| 1A | Wastewater Collection, ENR(2) treatment at Blacksmith Shop Road (BSR(3)) site, and recharge at Falmouth Country Club (FCC) site. | NA(10) | NA(10) |
| 2A | Wastewater collection, ENR(2) treatment at FCC site, and recharge at FCC(4) site. | NA(10) | NA(10) |
| 3A | Wastewater collection, ENR(2) treatment at MMR(5) site, and recharge at FCC(4) site. | NA(10) | NA(10) |
| 3B | Wastewater collection, MBR(6) and GAC(7) treatment at the MMR site and well recharge at Route 151 ROW(8). | 600 | 7.6 |
| 3C | Wastewater collection, MBR(6) and RO(9) and GAC(7) treatment at the MMR site and well recharge at Route 151 ROW(8). | 610 | 9.4 |
| 1D | Wastewater collection, ENR(2) treatment at BSR(3) site and ocean outfall disposal at Nobska Point. | 590 | 4.4 |

Notes:

(1) through (9) are the same as listed on Table 4-12.

(10) These costs are Not Applicable because this scenario cannot meet the TMDL in Bournes Pond.

Alternatives 1A, 1B, and 1C were determined to be not feasible because they did not meet the TMDLs for Bournes Pond and Waquoit West.

Alternative 1D which utilizes an ocean outfall has the lowest capital costs for the 40-year time period planned to meet the nitrogen TMDL; and it has the lowest operation and maintenance (O&M) costs. In the 20-year period, this alternative has capital costs that are similar to the Alternatives 3B and 3C which both utilize groundwater recharge, but Alternative 1D still has lower O&M costs.

Alternative 3B and 3C, the alternatives that produce reuse quality water for groundwater recharge, are similar in cost.

The non-monetary evaluations determined that the Otis WWTF/MMR Site (Site 3) is the most feasible for long-term treatment and groundwater recharge. If an ocean outfall is utilized, the existing Blacksmith Shop Road WWTF would be the most feasible site.

It is unknown if Alternative 1D could be approved by the federal, state, regional, and local approval agencies. If the Town chose to proceed with Alternative 1D, the approval process is projected to require an additional 5 to 10 years of state and regulatory reviews.

Based on the Towns desire to proceed with this project in the near future, and provide improved estuarine water quality as quickly as possible; it is believed that the reuse alternatives of 3B and 3C are the most feasible. Both are similar in capital costs, but Alternative 3B has less O&M costs and is the preferred wastewater alternative for environmental impact analysis and implementation. Approval of this alternative will require discussions with MassDEP due to their groundwater discharge regulations which requires TOC removal to 1 mg/L for recharge directly to groundwater systems. The regulations may provide some flexibility after discussion with MassDEP.

Both Alternatives 3B and 3C could meet the TMDLs in all the watersheds. The areas to be sewered (in the period of 2035 to 2055) and the exact location of the infiltration wells has not been determined yet and will be part of the Adaptive Management implementation. Verification of TMDL compliance for Alternative 3B was made by evaluating the performance of the following sewer extension (wastewater nitrogen removal) percentages and recharge areas.

- 100% and 84% sewering and wastewater nitrogen removal for the lower and upper portions (respectively) of Little Pond Watershed. These are the removals needed for the future (buildout) conditions as illustrated in Figure 1-3.
- 100% and 72% sewering and wastewater nitrogen removal for the lower and upper portions (respectively) of Great Pond Watershed. Again, these are the removals needed for the future (buildout) conditions as illustrated in Figure 1-3.
- Treated water recharge in the upper Green and Bournes Pond Watersheds along Route 151.

- 100% sewering and wastewater nitrogen removal for the lower and upper portions of Green and Bournes Pond Watersheds. This 100% sewering in the lower watersheds is already attained when sewers are provided along and south of Route 28 for Phases 1 and 2. The additional 100% sewering of the upper watersheds would allow TMDL compliance with the recharge at these locations.
- 100% and 84% sewering and wastewater nitrogen removal for the lower and upper portions (respectively) of Waquoit West Watershed, similar to Little and Great Ponds. These are the removals needed for future (buildout) conditions as illustrated in Figure 1-3.
- 100% sewering and wastewater nitrogen removals in the Moonakiss/Quashnet River subwatershed of the Waquoit-East Watershed. It is noted that complete sewering of Falmouth's portion of the Hamblin Pond/Red Brook Subwatershed (of the Waquoit-East Watershed) is provided after Phase 1 and 2 sewering along and south of Route 28.

A watershed nitrogen balance was developed for this scenario and is illustrated in Appendix 4-4. As discussed for Figure 4-7, this worksheet is developed based on the "Rainbow Spreadsheets" developed as part of the MEP land use assessments for these watersheds. The worksheet has maintained the nitrogen alteration factors, buildout assumption, and spreadsheet color codes for consistent evaluation of the watersheds.

It is noted that this is one well recharge alignment that meets the TMDLs, taking advantage of the assimilative capacity of Green Pond in order to reduce the total area of upper watershed sewering. However, there are other well alignments that would also meet the TMDLs. Once the Recommended Plan has been reviewed, one or more well alignment alternatives can be run in the MEP model to verify TMDL compliance/theoretical threshold achievement.

Based on this verification of long-term TMDL compliance in the Phase 3 time period and understanding that Adaptive Management Implemention of the non-wastewater nitrogen removal strategies (discussed in Chapter 5) could reduce the needed sewering north of Route 28, the Town wants to proceed with implementation of Alternative Scenario 3B and sewer extension along and south of Route 28. These wastewater facilities are illustrated in Figure 4-14.