

## **Appendix 5-1**

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# **Summary of Evaluations for Treated Water Recharge/Reuse Sites Evaluated in the 2007 WWFP**

## **APPENDIX 5-1**

### **SUMMARY OF EVALUATIONS FOR TREATED WATER RECHARGE/REUSE SITES EVALUATED IN THE 2007 WWFP**

**This Appendix is Chapter 6 from the 2007 Final Wastewater Facilities Plan (WWFP) and Final Environmental Impact Report (FEIR). Figures, tables, and appendices referenced in the text are located at the end of the appendix.**

#### **6.1 INTRODUCTION**

Many detailed evaluations have been completed to identify potential sites suitable for effluent recharge and reuse. These evaluations were presented in detail in the November 2005 NPC, and a brief chronology is presented below.

A. In 1993, Geraghty & Miller, Inc. assessed the contributing areas to public water wells (Zone II areas) and the groundwater conditions in Barnstable.

B. In 1995, effluent recharge/reuse technologies were evaluated and potential sites were identified and screened.

C. In 1996, costs were developed for the technologies and potential sites were identified and screened again. The project team selected effluent recharge through well injection, which required pilot testing at the Hyannis WPCF.

D. The pilot testing was conducted in 2000 and found that this technology was not feasible without chlorination of the effluent. MADEP did not support proceeding with chlorination.

E. The February 18, 2005 Benchmark Evaluation Report reviewed the accuracy of the previous Geraghty & Miller modeling based on real-world monitoring data from 1993 to the early 2000s and found it was overly conservative and did not accurately predict groundwater elevation rise due to effluent recharge at the WPCF site.

F. The November 15, 2005 Notice of Project Change summarized the evaluations done to date, including:

1. Detailed evaluation of technologies for effluent recharge, including:
  - rapid infiltration beds (also known as sand filter beds)
  - subsurface infiltration
  - spray irrigation
  - drip irrigation
  - well injection
  - wick well leaching
  - wetland restoration concepts to restore hydraulic flow to disturbed watersheds
2. Town-wide site screening evaluations which focused attention on an area of Town around the Mid-Cape Highway (Route 6) from the Route 132 interchange extending east to Phinney's Lane.
3. Detailed screening evaluations of the following sites to determine their suitability for effluent recharge:
  - the Hyannis WPCF site
  - the McManus site
  - the airport site
  - the CCCC site
  - the Lorusso property, a power line ROW site near Route 6
  - Cape Cod Aggregate Company property
  - Route 6 ROW (median strip and ROW edges along the road)
  - Route 132 ROW (planned median strip and ROW edges along the road)
4. Detailed site investigations of the following four sites that were determined to be the most feasible:
  - the McManus site (Site B)
  - the airport site (Site C)
  - the CCCC site (Site D)
  - the Lorusso site (Site E)

These investigations included soil borings, test pits, percolation tests, and localized hydrogeologic modeling.

5. USGS groundwater modeling of these four sites plus two additional sites (the County Farm sites and the Hospital abandoned bog site [Site W2], and discussed later in this chapter).
6. Hydraulic load testing of the McManus site and determination that it was suitable for effluent recharge.
7. Additional environmental and institutional feasibility evaluations of the McManus site, including:
  - More detailed USGS groundwater modeling
  - Preparation of a Natural Resources Inventory for the site
  - Evaluation of the site's suitability based on portions of the property being purchased by Land Bank monies.
  - Evaluation of potential benefits and/or impacts to public and private water supply wells in the area.
  - Water quality modeling (by SMAST) of potential impacts to Barnstable Harbor.
  - Consideration of potential impacts to Wequaquet Lake and Hinckley Pond.
  - Potential impacts to historic or archaeological artifacts on the site.

The entire McManus site is comprised of 44 acres of land; 37.1 acres of this site were acquired in March 2002 as Article 97 land and will be upheld with the use conditions and restrictions established by the Cape Cod Open Space Land Acquisition Program (Cape Cod Land Bank) pursuant to Chapter 293 of the Acts 1998 and Chapter 127 of the Acts of 1999. Prior to the purchase of the land in March 2002, the Town of Barnstable also acquired a use easement associated with 6.9 acres of the McManus site specifically for effluent mitigation use as a groundwater discharge facility. For the purpose of clarity, the 6.9-acre site will be referred to as the "6.9-acre site" purchased with sewer reserve funds.

G. The Secretary's Certificate and Phase I Waiver (dated January 20, 2006 and attached in Appendix 1-3) on the Notice of Project Change provided the following direction on the McManus site:

1. The Town could proceed with effluent recharge at the 6.9-acre site up to 0.5 mgd.
2. The Town could use sand infiltration beds for this 0.5 mgd recharge to minimize costs and land disturbance.
3. The Town could continue to pursue a larger effluent recharge (1.3 mgd) at the full McManus site after the following issues have been resolved (refer to Chapter 11 for additional information):
  - Mitigation of the Article 97 land issues associated with the Land Bank purchase.
  - Evaluation to indicate that the treated water will not negatively impact the public water supply wells and Lake Wequaquet.
4. The Town should continue to pursue other effluent recharge sites and concepts to develop a flexible effluent recharge and reuse plan (refer to Chapter 11 for additional information).

Since receiving this approval, the Town has proceeded with effluent recharge evaluations and decision making. Based on the realization that the groundwater model developed by Geraghty & Miller as discussed in the Benchmark Report is very conservative and has not accurately predicted groundwater elevation rise as compared to long-term groundwater monitoring; the Town wants to proceed with effluent recharge at the Hyannis WPCF up to 4.2 mgd while it proceeds with the following additional steps:

1. Permitting and construction of the 0.5 mgd recharge at the 6.9-acre site.
2. Continued evaluation of additional effluent recharge sites and concepts.
3. Implementation of an Adaptive Use Management Plan to expand the recharge at the existing WPCF site to 4.2 mgd with the following actions planned if the WPCF recharge impacts low elevation properties.
  - Further evaluation of the impacts to verify they are correlated to the WPCF recharge.

- Installation of additional monitoring wells
- Potential additional groundwater modeling.
- Drainage modifications and groundwater pumping to mitigate the impacts.
- Approval requests, permitting, and implementation of additional effluent recharge sites and concepts.
- Discontinuation of sewer extension until the impacts are addressed.
- Possible purchase of affected properties and creation of open space.
- Diversion of flow to the 6.9-acre site.

The purpose of this chapter is to summarize the evaluations that have occurred since the November 2005 NPC and present the effluent recharge plan for the future.

## **6.2 FURTHER EVALUATIONS FOR THE 6.9-ACRE SITE**

After receiving the Secretary's response to the November 2005 NPC, the Town evaluated the costs and design criteria associated with the 0.5 mgd recharge through sand filter beds. The Town plans to proceed with these facilities to include:

1. The effluent force main to convey the treat effluent to the McManus site from the WPCP site (much of it to be constructed as part of the Route 132 road improvements project).
2. Effluent filtration and disinfection facilities and pumping facilities at the Hyannis WPCF site.
3. Two sand infiltration beds on the 6.9-acre site.

These facilities would be designed to be expandable to allow increased effluent recharge at the site. However, this expansion shall be a subsequent filing and will require the proper mitigation of the Article 97 land issues associated with the Land Bank purchase as discussed further in Chapter 11. Estimated capital costs for the recharge facilities at the 6.9-acre site are summarized in Table 6-2.

### **6.3 FURTHER EVALUATIONS OF ADDITIONAL EFFLUENT RECHARGE SITES AND CONCEPTS**

A. **Introduction.** Figure 6-1 illustrates the primary sites that are still under evaluation for potential effluent recharge in the future. This section summarizes the evaluations and/or considerations for those sites.

B. **Existing Hyannis WPCF Site (Site A).** The Town plans to continue recharge at this site up to 4.2 mgd until groundwater monitoring indicates there is a potential threat to downgradient receptors. The following section describes the evaluations completed to develop a groundwater elevation and groundwater quality monitoring program and the development of the Adaptive Use Management Plan for the effluent recharge.

C. **Cape Cod Community College (Site D).** Town staff recently met with the College President and the Board of Directors' Building and Grounds Subcommittee. After discussion on several issues related to wastewater management, the college agreed to further subsurface testing (including hydraulic load testing) to determine suitability of the site for effluent recharge through open sand beds or subsurface infiltration.

D. **6.9 Acre Site.** As discussed above, the Town plans to proceed with implementation of the 6.9-acre site purchased with sewer reserve funds. Evaluations for potentially expanding effluent recharge onto the full McManus site (additional 37.1 acres) will only proceed if the Town plans to expand the flow or site in the future. Either scenario will require a submittal as requested by the Secretary of Environmental (Refer to Appendix 1-3 for additional information).

E. **Airport Site (Site C).** This site is still a viable site, but has several complicating issues, including:

1. Federal Aeronautical and Aviation (FAA) restrictions that would make effluent recharge on this site impractical.
2. A relatively shallow distance to the groundwater.
3. Public water supply wells located downgradient with a relatively short travel time.

4. Reportable releases as defined by the MADEP.

Additional evaluations on this site are currently on hold, refer to Chapter 11 for additional information.

F. **Lorusso Site (Site E).** This site is still a viable site, but has the following limitations: (1) relatively small size; and (2) power line easement that limits the extent of infiltration facilities at the site. Additional evaluations on this site are currently on hold.

G. **County Farm Site.** This site was identified as a possible site by county staff during groundwater modeling evaluations, and potential recharge flows were modeled at the site. Based on preliminary research, this property has conservation restrictions that would make its use as a recharge facility difficult to implement. Additional evaluations on this site are currently on hold.

H. **Hospital Abandoned Cranberry Bog Site (Site W1).** This site would use an innovative wetland restoration concept to re-establish the watershed base flow that is currently being removed by the upgradient water supply wells at approximately 1.3 mgd. The concept would require the following components:

1. Further effluent treatment to remove phosphorus and fine suspended solids.
2. Construction of a pipeline to the site.
3. Subsurface leaching of the treated water adjacent to a constructed wetland that would allow the water to seep into the natural wetland and depleted watershed.

The site is located on Cape Cod Hospital property in the Town of Yarmouth and discussions have been initiated with the following stakeholders:

1. Town of Yarmouth staff.
2. USDA Natural Resources Conservation Service staff, who have been working with the hospital to restore the cranberry bog to a more natural wetland area as required by a USEPA consent order on the discontinued cranberry operation.

3. Cape Cod Commission staff.

The site and effluent recharge concept was reviewed at a recent workshop sponsored by the CCC on nitrogen TMDL implementation strategies, and a project brief from that meeting is attached in Appendix 6-1. Comments by MADEP's Wetlands and Waterways Program Director agreed on the benefits on the use of constructed wetlands and re-establishment of base flow in the watershed.

A recent meeting with MADEP technical staff reviewed the recharge concept and provided the following comments:

1. Effluent treatment requirements are expected to include:
  - a. Groundwater discharge requirements.
  - b. Disinfection to less than 20 colonies/100 ml.
  - c. Phosphorus removal (expected to be less than 0.2 mg/L total P).
2. The constructed wetland and natural wetland/abandoned bog could polish the small residual quantities of nutrients in the water and protect the water quality in Lewis Bay.
3. The site recharges to a portion of Lewis Bay that is open to the tidal exchange from Nantucket Sound.
4. Coordination and agreements would be needed with the Town of Yarmouth.

The evaluation is continuing with the following actions identified for the future:

1. Further discussion with Town of Yarmouth staff.
2. Further discussions with the stakeholders as needed.
3. Ongoing technical evaluations.

I. **Makepeace Abandoned Cranberry Bog Site (Site W2).** This site and recharge concept are similar to the Hospital Bog site and concept except that it is located in the Town of Barnstable and in an area that is planned for significant environmental mitigation. The site is

located at the upper reaches of the Stewart's Creek watershed where the following mitigation actions are planned:

1. Enlargement of the opening of Stewart's Creek to Nantucket Sound to restore tidal exchange.
2. Dredging of portions of Stewart's Creek.
3. Sewering of properties around Stewart's Creek (Area H1 as discussed in Chapters 5 and 7).
4. Conversion of the 725 Main Street property (an abandoned gas station) to an open space and parkland.

Similar to the Hospital Bog site, this site and concept were also presented at the CCC workshop and MADEP progress meeting and are briefly summarized in Appendix 6-1. Evaluations on this site continue as the other environmental mitigation efforts in the watershed proceed.

**J. Groundwater Pumping to a Remote Site Such as the McManus Site or a Wetland Restoration Site.** The concept of pumping groundwater from a location downgradient of the Hyannis WPCF to a remote site (instead of pumping treated effluent) has been considered and reviewed with MADEP staff. The following advantages were noted for this concept over pumping treated effluent:

1. Potential cleaner water because the groundwater would be able to take advantage of filtration and nutrient removal through the sand beds, aquifer, and a pond.
2. Possible lower capital costs due to reduced need to treat the effluent.
3. Possible improved public perception due to the fact that the water being pumped is groundwater, not effluent.

MADEP staff was concerned with a possible precedent being set and indicated they needed to consider the concept and would contact the Town with their observations. Additional evaluations on this concept are currently on hold.

**K. Tree Plantations to Facilitate Evapotranspiration.** The concept of planting poplar or willow trees downgradient of the WPCF recharge has been evaluated. The two species of trees can evapotranspire large volumes of groundwater in the summer (3 to 300 gpd per tree). The evaluation has identified the following factors that indicate this concept would be infeasible as a long-term management solution:

1. There are no large agricultural areas with shallow depth to groundwater near the WPCF site.
2. The depth to groundwater at the WPCF site is greater than the depth of the trees' root system. The ground elevation would need to be reduced to allow the roots to reach the groundwater system.
3. The trees' evapotranspiration rates decline to zero in the winter when the trees are dormant.
4. There is no way to control the evapotranspiration process.

Evaluations on this concept continue and it will be considered with any large modifications at the WPCF site.

## **6.4 EVALUATION OF GROUNDWATER MONITORING AND RECOMMENDATIONS**

**A. Introduction.** The current groundwater monitoring program for the WPCF calls for monthly water quality sampling and water level measurements at the monitoring wells listed in Table 6-1. The locations of these wells are shown in Figure 6-2. Historical data on water quality and water levels were thoroughly reviewed to assess the adequacy of the current monitoring program. As a result of this review, some recommended changes have been made to revise the groundwater monitoring plan. These changes, and the justifications for them, are discussed below.

**B. Groundwater Quality Monitoring.** The monitoring wells listed in Table 6-1 have been sampled on a monthly basis and data since December 2004 has been reviewed. The groundwater samples are analyzed for pH, specific conductance, ammonia, nitrate, chloride, copper, iron,

manganese, sodium and sulfate. Once per year, the samples are also analyzed for potassium, volatile organics and total trihalomethanes. Although there have been fluctuations in the levels of individual constituents during this period of time there have been no dramatic changes in water quality and no alarming trends. Continued sampling on a monthly basis does not seem justified. Therefore, we recommend monthly sampling be reduced to quarterly sampling. The annual sampling should remain unchanged.

During this period of monthly testing, it has also been noted there have been no detections of copper above the detectable limits. Therefore, it seems reasonable to discontinue testing for copper. The other water quality parameters should continue to be analyzed.

C. **Groundwater Elevation Monitoring.** A review of historic groundwater elevation data and topographic mapping was completed to evaluate potential high groundwater impacts to basements and septic systems in the vicinity of the Barnstable WPCF. Seven potentially impacted areas were recognized and the number of properties that would possibly be threatened by high water table conditions was identified. This list is slightly different from previous effluent mitigation evaluations in that it includes Area 4 and eliminates Area 9. The areas and number of potentially impacted properties are described below and summarized in Table 6-3.

TABLE 6-3  
POTENTIALLY IMPACTED AREA

STUDY AREA	DESCRIPTION	NUMBER OF POTENTIALLY IMPACTED PARCELS
2	Dunn's Pond	9 houses
3	Lincoln and Arrowhead	3 houses
4	Alicia Road Circle	3 houses
5	St. Francis Circle	8 houses
7	Vineyard and Hampshire	2 houses
8	Hambden Circle	12 houses
12	Blanchard's Liquors Area	3 houses, 3 commercial Properties, including Blanchard's Liquors

1. **Area 2.** In the area around Dunn's Pond, it appears that nine homes could potentially be impacted by high groundwater water levels. The pond elevation is approximately 30 feet NGVD, and there appear to be nine homes that were constructed on sites that are below the

40-foot contour. Groundwater could rise above basement floors during extremely high groundwater conditions.

2. **Area 3.** An area around the topographic depression between Lincoln Road and Arrowhead Drive has been identified as a problem area. This area is east of Dunn's Pond but groundwater levels are expected to be at approximately the same level as those in Area 2. Three homes constructed below the 40-foot contour may potentially be impacted by extremely high groundwater levels.

3. **Area 4.** The vicinity of Alicia Road Circle near its intersection with Masa's Place has a low topographic area. It appears that three residences here were built below the 40-foot contour elevation. High groundwater levels at the nearby monitoring well W-4 are close to 31 feet.

4. **Area 5.** The homes along Saint Francis Circle were built around a low lying surface water body. Eight of these homes were constructed below or at the 40-foot ground surface elevation. This area is also relatively close to monitoring well W-4.

5. **Area 7.** There are two homes constructed near a marshy area between Vineyard and Hampshire Avenues. Mapping of the area shows that the homes were constructed near the 30-foot ground surface elevation. High groundwater levels at the nearest monitoring well, C-4, approach 25 feet.

6. **Area 8.** Three topographic depressions exist at this site along Hambden Circle. Twelve homes constructed near the 30-foot ground surface elevation may experience high groundwater conditions. High groundwater levels at the nearest monitoring well, C-3, approach 22 feet.

7. **Area 12.** In the area identified at Blanchard's Liquors, there are three residences and three commercial properties, including Blanchard's Liquors, which lie at or near the 40-foot ground surface elevation. High groundwater elevations are expected to be as high as 31 feet. This area may be affected by the runoff from the large paved and building areas in this part of Hyannis (Mall Area)

8. **Area 9 (Removed).** It appears the concerns of high groundwater at the school playing field (Area 9) are likely caused by poor drainage in this area and not a result of any activity associated with high groundwater levels and the Hyannis WPCF. Historical high groundwater levels in the area do not appear to be high enough to contribute to surface flooding.

It is noted that the potential for high groundwater exists at each of these areas irrespective of any recharge at the WPCF. Increased recharges at the WPCF will slightly increase water levels at these locations and slightly increase the number of potential occurrences of these events. However, quantifying that potential or separating out the relative contribution of WPCF discharges to any high groundwater event would require significant study and analysis.

Currently, water levels are obtained on a monthly basis at the monitoring wells listed in Table 6-1. A revised water level monitoring plan was developed to track groundwater levels over time and to determine when water levels have reached heights that may come above potential basement elevations (reductions in the minimum 4-foot separation were not used as criteria because there is no significant impact associated with a short-term reduction in the 4-foot separation). A group of five monitoring well locations were identified to monitor water levels specifically for these seven areas of concern. Existing wells were used where available and one additional monitoring well is proposed for installation. The revised groundwater monitoring plan is described in Section 6.5.

**D. Additional Recommendations.** The proposed water level monitoring program is based primarily on estimated elevations of basements. Basement floors are estimated to be approximately 8 feet below the ground surface. The ground surface elevations were determined primarily from contour maps prepared by the Town of Barnstable GIS Department (with 2-foot contour intervals). However, as the Adaptive Management Plan proceeds, the Town will collect spot ground surface elevations at each identified potential problem area to provide more accurate elevation data and provide a more accurate trigger elevation for each of the sites, as described in the groundwater monitoring plan. The Town will survey the ground level of each potentially impacted residence and commercial area to confirm the elevations of the ground surface and if possible collect basement elevation data.

It is also recommended that a new groundwater monitoring well be installed at one location. A monitoring well should be constructed at the end of Olander Drive, possibly in the road right-of-

way, to provide more accurate groundwater levels at Areas 2 and 3. This well would be used in the long term monitoring plan rather than Well S-7, which was removed in 1999.

In addition, it is suggested that the Town investigate the potential cause of high groundwater levels in the vicinity of Blanchard's Liquors. The large paved parking surface and stormwater drainage system of the commercial area may be significantly contributing to high groundwater levels in the area. A monitoring well in this area would provide data that could identify whether the elevated groundwater conditions occurred during storm events.

The Town should also investigate the flooding issues occurring at Area 9 (school playing field). Groundwater modeling results and drainage patterns suggest that the problem in this area may be a result of poor drainage rather than high groundwater levels.

Finally, it is recommended that the town investigate the stormwater drainage patterns in all of the potentially impacted areas. It appears that road runoff may be directed toward the low topographic areas and surface water bodies, increasing the potential for flooding in the nearby properties. It may be beneficial for the Town to evaluate rerouting stormwater runoff in some areas.

## **6.5 DEVELOPMENT OF THE EFFLUENT RECHARGE ADAPTIVE MANAGEMENT PLAN**

**A. Introduction.** The February 2005 Benchmark Report identified that the groundwater model developed for this project by Geraghty & Miller in 1993 has proven to be too conservative, and it overestimates the rise in groundwater as compared to actual groundwater measurements since 1993. The Benchmark Report recommended using the existing maximum month flow of 2.5 mgd during periods of high groundwater as the threshold capacity for pursuing remote recharge sites or initiating a Risk Management/Adaptive Management Plan. The 2.5 mgd threshold was expected (at that time) to be lower than the actual groundwater system capacity and was the most up-to-date empirical data available. As a result of these evaluations, the WPCF groundwater monitoring evaluations (as discussed above) have recommended a more appropriate (and efficient) groundwater elevation monitoring system to provide understanding and advance notification when the WPCF may cause impacts to properties in low areas. The following section summarizes the plan that the Town will use to monitor and manage the groundwater elevations in the future. Additional scope of the AMP is described in greater detail in Section 11.3.

**B. Groundwater Adaptive Management Plan.** A Groundwater Adaptive Management Plan has been developed to monitor for potential impacts to low elevation properties downgradient of the Hyannis WPCF from high groundwater events typically occurring naturally every 10 to 25 years in combination with an incremental increase to the groundwater elevation due to the groundwater recharge at the WPCF site. It is also developed to identify procedures that will be used if groundwater reaches specific elevations (threshold elevations) in a group of sentinel wells.

1. **Groundwater Monitoring.** Evaluations described earlier in this chapter were used as a basis for recommended changes to the current groundwater monitoring (elevation and water quality) program. The recommendations for the groundwater elevation monitoring are an important component of this Adaptive Management Plan. The revised water level monitoring plan calls for the monitoring of five wells located in the vicinity of the seven identified areas. The five wells and their associated areas are listed in Table 6-4.

Installation of a new monitoring well is proposed at the end of Olander Drive to monitor water levels at Areas 2 and 3. Existing Well W-4 will be used for Areas 4 and 5. Data will be collected at C-4 for Area 7 and C-3 for Area 8. Data collected at C-2 will be used to monitor groundwater conditions at Area 12. Figure 6-2 identifies the locations of wells included as part of the long-term monitoring plan.

TABLE 6-4  
PROPOSED GROUNDWATER LEVEL MONITORING WELLS  
AND THRESHOLDS

AREA NUMBER	MONITORING WELL	ELEVATION THRESHOLD (FEET NGVD)
2	Proposed well	27
3	Proposed well	27
4	W-4	26
5	W-4	26
7	C-4	29
8	C-3	24
12	C-2	33

Groundwater elevations will be collected at each of the monitoring wells on a monthly basis. If water elevations at any of the wells exceed the elevation threshold levels,

monitoring will be conducted on a weekly basis and consideration will be given to one or more actions under the Adaptive Management Plan. These elevation threshold levels are based on the estimated elevation at the monitoring well above which basement flooding might occur. Monitoring will revert to monthly once water levels have returned to levels that are 0.5 below the threshold levels. These elevation thresholds should be revisited if the elevations at individual properties or basements are surveyed.

**2. Adaptive Management Action Plan.** If groundwater elevations reach elevation threshold levels, the following immediate actions will be implemented:

- a. Further evaluations to verify the groundwater rise or potential impact, including:
  - 1) Possible correlation of groundwater rise to the WPCF recharge.
  - 2) Installation of additional monitoring wells
  - 3) Investigation of possible water main or drainage contributions to the elevation rise.
  - 4) Inquiries to adjacent property owners that may be impacted as to whether groundwater is entering any basement living space or if problems have been noted with operation of their septic systems.

If the threshold elevations are exceeded and the exceedances are believed to be due to Hyannis WPCF recharge at the site, the following correction action alternative evaluations will occur:

- a. Evaluate various mitigation alternatives to address the high groundwater that may include the following:
  - 1) Drainage improvements.
  - 2) Wellpoint dewatering and recharge at an appropriate (permitted) location.
  - 3) Relocation of effluent recharge at the Hyannis WPCF to another group of sand beds.

- 4) Relocation of up to 0.5 mgd to the 6.9-acre site.
- 5) Property purchase of the affected property.
- 6) Accelerated evaluation, planning, approval, and implementation of additional remote effluent recharge locations including:
  - CCCC Site
  - Airport Site
  - Hospital Bog Site
  - Makepeace Bog Site

The order that the sites are listed above is the current prioritized order. Evaluations on the feasibility and prioritization of these sites are continuing.

- 7) Discontinuation of sewer connections to properties that want to be served by the sewer (sewer moratorium).

b. Prepare an evaluation report for submittal to MADEP summarizing the evaluations and recommended actions and timetable.

C. **Ongoing Evaluations.** Since the development of the Groundwater Adaptive Management Plan, several additional evaluations were completed, as summarized below:

**1. Comparison of July 2006 Groundwater Elevations With Groundwater Elevations Predicted by the Geraghty & Miller (G&M) Model and Frimpter Adjustment Factor, and Field Evaluations.** As previously discussed, the Town of Barnstable has been collecting data on groundwater levels near the Hyannis WPCF and has recently compared the levels to those predicted by Geraghty & Miller (G&M) in their 1995 groundwater modeling report. In addition, the treatment plant operators have been performing field evaluations by moving the treated effluent recharge locations to various sand beds of the recharge field to observe the effect on groundwater elevations near the plant. These investigations are a follow-up to the February 2005 Benchmark Evaluation Report, which recommended continued groundwater elevation monitoring. These

investigations are extremely timely because the groundwater elevations on Cape Cod are very near all-time high elevations, and the current conditions allow an opportunity to verify the assumptions in previous modeling efforts.

Based on historical records of the nearest long-term groundwater monitoring well maintained by the U.S. Geological Survey (Well AIW-230, located near the airport), water levels in the region are near historical maximum high groundwater levels. Water levels have been monitored at this well since the 1950s. The July 2006 water level at this well was 21.33 feet below ground. This is higher than any previous July water level on record and is in the upper 97 percent of all water levels ever recorded at the well. By comparison, the May 1998 water level referenced in the Benchmark Report was 20.93 feet below ground, a difference of only 0.4 feet. The highest water level ever recorded at the well is only 1 foot higher. This 97 percent maximum high groundwater condition represents a near-maximum groundwater condition and can be used as a reasonable benchmark for comparing projected and actual high groundwater conditions in the area of the WPCF.

The average recharge flow from the WPCF for July 2006 was approximately 2.5 mgd. In 1995, a groundwater simulation by G&M was conducted for high groundwater conditions and a wastewater recharge of 2.5 mgd. This provides a unique opportunity to compare the groundwater simulation to observed conditions under a nearly identical scenario. The table below shows the actual water levels at selected monitoring wells compared to the G& M model-simulated water levels.

MONITORING WELL	BA-1	BC	BE	PT300
Observed July 2006 (el. ft.)	30.8	34.9	21.57	33.55
G&M Simulated (el. ft.) <sup>(1)</sup>	36.8	38.6	27.5	38.5
Difference (ft.)	6.0	3.7	5.93	4.95

(1) Simulated elevations were illustrated on Figure 1 of the February 2005 Benchmark Report.

As shown above, the G&M groundwater flow model with the Frimpter adjustments (to simulate maximum high groundwater conditions) predicted significantly higher water levels than have been observed under the July 2006 real-time scenario. The differences range between approximately 4 and 6 feet. This comparison indicates that the maximum high groundwater conditions predicted by previous modeling may be even more

conservative than previously evaluated in the February 2005 Benchmark Evaluation. Given the fact that previous modeling efforts used reasonable scientific approaches based on the best available data to predict groundwater elevations, it appears that such predictions were conservative. This finding is expected to hold true for other predicted maximum high groundwater conditions at higher effluent recharge rates.

Furthermore, observations by treatment plant personnel indicate that moving the recharge locations within the existing beds has reduced groundwater elevations nearest properties that could be potentially impacted. Initial groundwater simulations completed during the 1995 modeling program did not indicate this positive effect.

Based on these recent findings and observations, the recharge capacity of the existing sand beds at the treatment plant site is believed to be greater than originally simulated. Using the combination of the 1995 modeling work together with current information, the expected capacity of the existing sand beds is 3.7 mgd or greater. These findings, combined with the use of the 6.9-acre site for additional recharge, further support the Town's approach to managing groundwater in the area of the Hyannis WPCF.

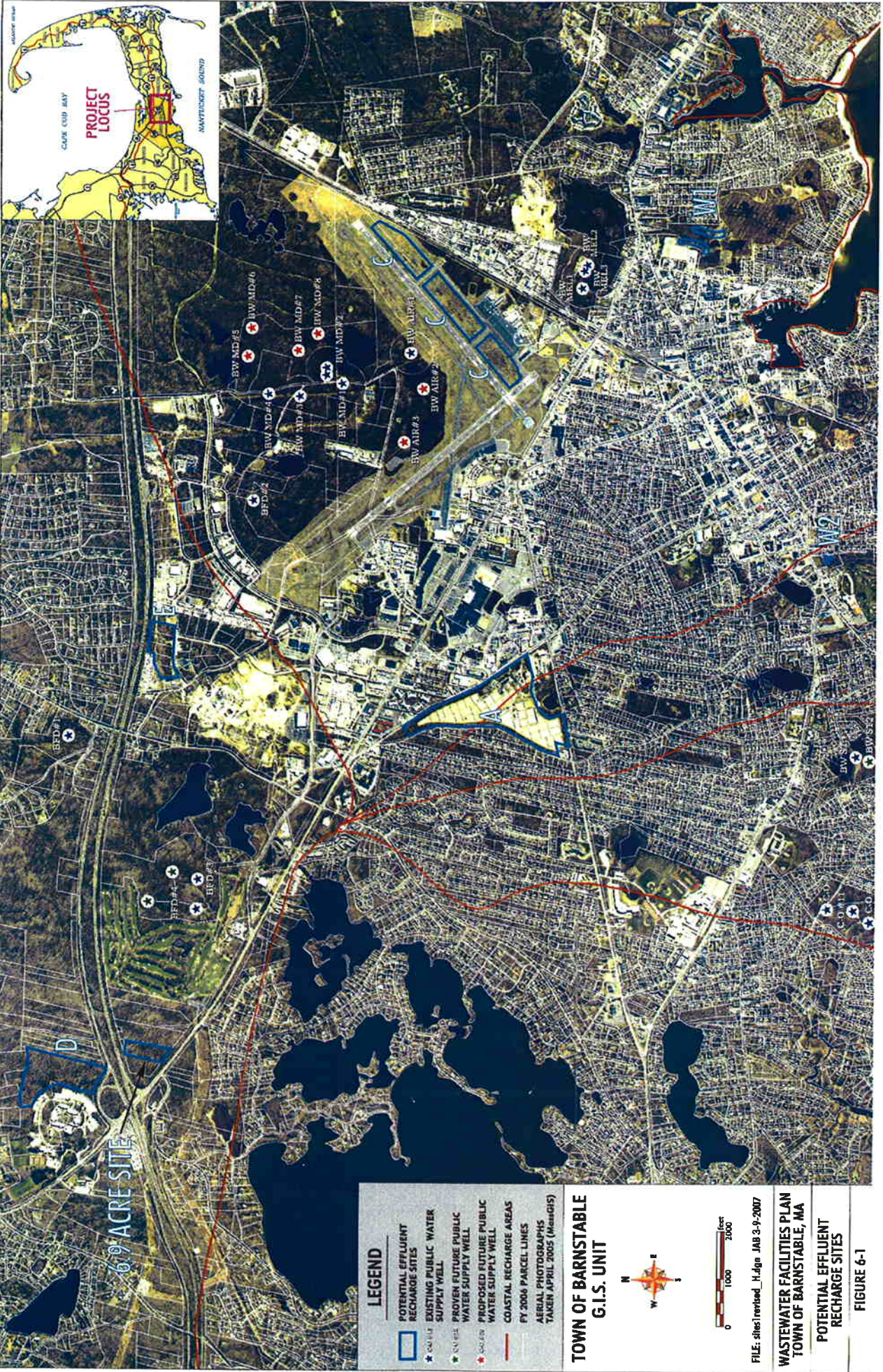
Further evaluations were completed to investigate the possible effect of increasing the effluent recharge from 2.5 to 3.7 mgd at a time of maximum high groundwater as experienced in July 2006. The G&M-predicted elevation increases were investigated for several recharge scenarios to add on top of the elevations observed in July 2006 using the hydrogeologic concept of superposition for the 1.2 mgd increase from 2.5 to 3.7 mgd.

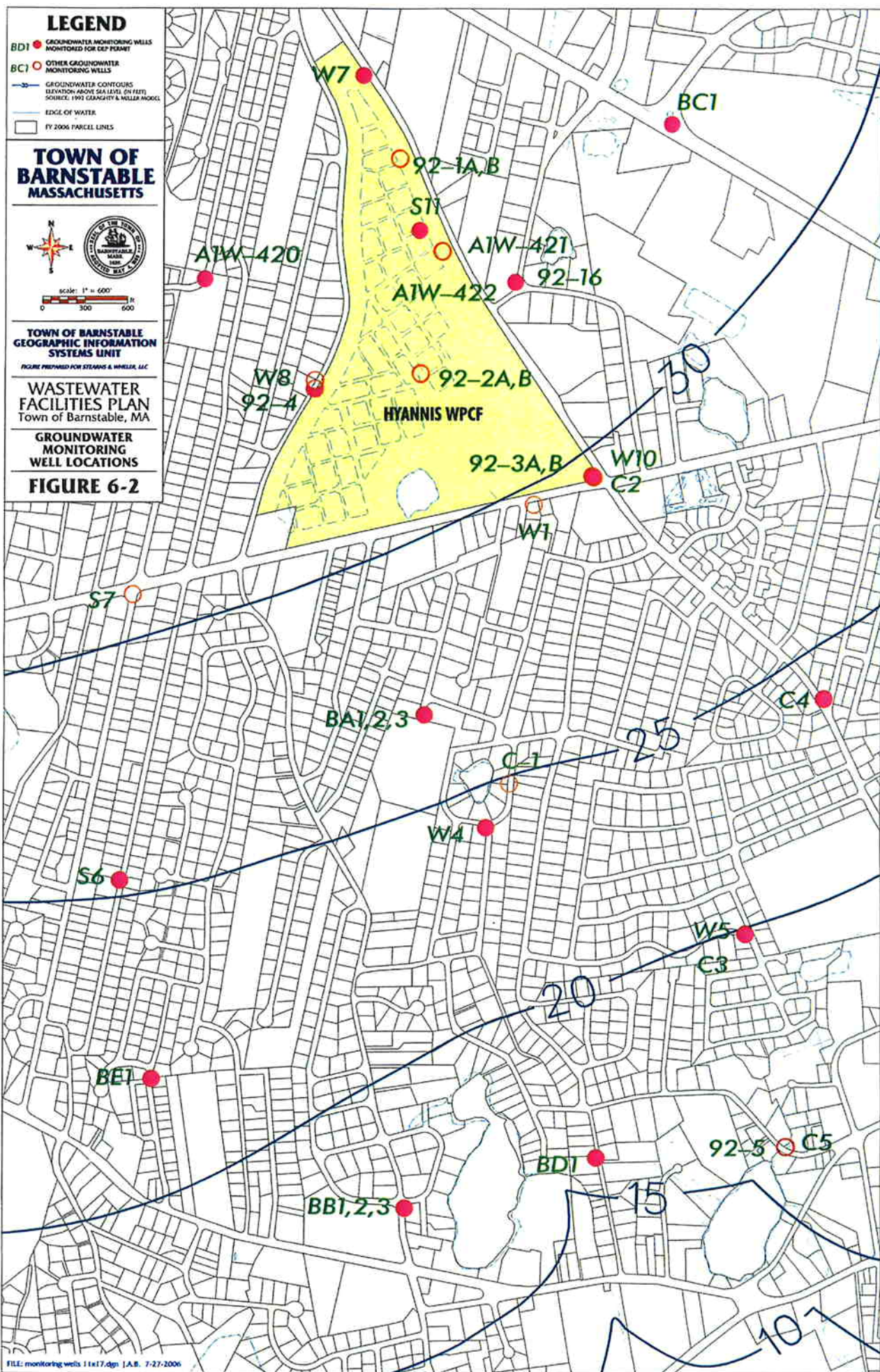
The two Geraghty & Miller-modeled scenarios that represent an increased recharge closest to an increase of 1.2 mgd are the 3.5 and 5.0 mgd scenarios which show groundwater levels under an increased recharge of 1.5 mgd. (Using these 2 simulations should provide a conservative estimate.) The difference in water levels between the 3.5 and 5.0 mgd recharge scenarios is added to water levels obtained in July 2006 to provide an estimate of water levels under high groundwater conditions and a recharge of 3.7 mgd, as summarized below.

MONITORING WELL	BA-1	BC	BE	PT300
Observed July 2006 (el. ft.)	30.8	34.9	21.57	33.55
G&M simulated at 2.5 mgd (el. ft.)	36.8	38.6	27.5	38.5
Revised estimate @ 3.7 mgd	31.6	35.8	22.0	34.8

This analysis indicates that even with an increased recharge of 1.2 mgd to a total of 3.7 mgd, the water levels are still expected to be significantly lower than those previously predicted by Geraghty & Miller for the 2.5 mgd condition.

**2. Ongoing Monitoring results.** Recent monitoring (based on limited data) has indicated that elevation thresholds may be exceeded at Wells W-4 and at Well C-2. No problems have been identified by neighboring property owners, but the Town has initiated a more detailed survey at these locations to verify the GIS based elevations used to date, and has initiated efforts to replace one of the wells that appears to be providing faulty readings, and to add additional monitoring wells. This survey, and monitoring well verification and addition are the first steps of the Adaptive Management Program identified earlier in this chapter.





**Table 6-1**  
**Monitoring Wells and Type of Monitoring**  
**Wastewater Facilities Plan**  
**Town of Barnstable, Massachusetts**

WELL	WATER QUALITY SAMPLING	WATER LEVEL MONITORING
BA-1	X	X
BA-2	X	
BA-3	X	
BB-1	X	X
BB-2	X	
BB-3	X	
BC	X	
BD	X	X
BE	X	X
PT 300 SE	X	
W7		X
BC-1		X
S-15		X
S-11		X
92-16		X
W-1		X
C-2		X
W-4		X
C-4		X
C-3		X
92-4		X
S-4		X
Duck Pond		X

**Table 6-2**  
**Estimated Capital Costs for Effluent**  
**Recharge Facilities at the 6.9-Acre Site <sup>(1)(3)</sup>**  
**Wastewater Facilities Plan**  
**Town of Barnstable, Massachusetts**

Component	Incurred and Estimated as Part of Route 132 Reconstruction Project (2)	Additional Costs	Total
<b>WPCF Pump Room Modifications</b>		\$740,000	\$740,000
<b>Filtration and UV Facilities at the WPCF</b>		\$2,100,000	\$2,100,000
<b>Force Main to the Site</b>	\$1,000,000	\$1,400,000	\$2,400,000
<b>Discharge Site</b>		\$900,000	\$900,000
<b>Mobilization and General Conditions</b>		\$460,000	\$460,000
<b>Subtotal Construction Costs</b>	<b>\$1,000,000</b>	<b>\$5,600,000</b>	<b>\$6,600,000</b>
<b>Contingency (15%)</b>	\$150,000	\$840,000	\$990,000
<b>Fiscal, legal and engineering</b>	\$510,000	\$1,400,000	\$1,910,000
<b>Subtotal Indirect Costs</b>	<b>\$660,000</b>	<b>\$2,200,000</b>	<b>\$2,900,000</b>
<b>Total Capital Costs</b>	<b>\$1,700,000</b>	<b>\$7,800,000</b>	<b>\$9,500,000</b>
<b>Notes:</b>			
1. Costs are rounded to 2 significant digits and are referenced to June 2006 (ENR 7700).			
2. Portions of the project have been completed (Water recharge evaluations and Force main design); and other portions are contracted for construction in 2007 and 2008 (Force main construction along Rt. 132).			
3. This project received Town Council appropriation in 2005 for \$8,800,000.			

Items referenced as  
Appendix 6-1 from Chgs 6  
of the 2007 WWFP FEIR.

### Wetland Modification and Nitrogen Attenuation Project No. 3

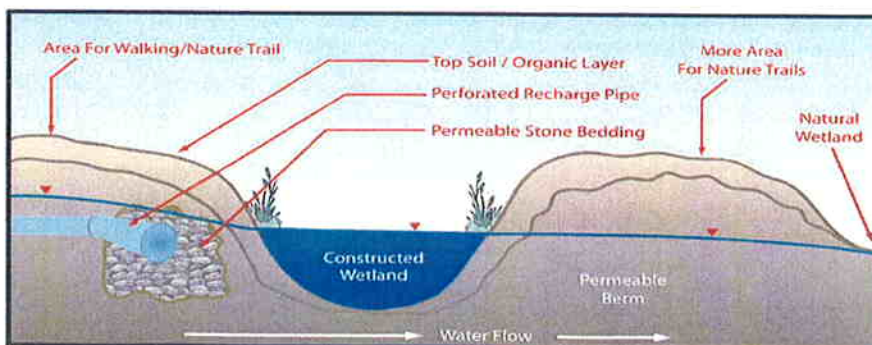
**Title:** Cape Cod Hospital Bog Hydraulic and Wetland Restoration

**Project Location:** Town of Barnstable and Yarmouth as illustrated on Figure 1

**Background:** The Cape Cod Hospital bog area has a history of impacts and regulatory compliance issues:

- The wetland was turned into a cranberry bog over 100 years ago and was in production up to 1997
- The Town of Barnstable has 3 water supply wells directly upgradient of the bog area and withdraws approximately 1.3 mgd from the watershed.
- In 1997 USEPA signed a Compliance Consent Agreement with the Cape Cod Hospital to stop the bog tail-water pond dredging that was occurring and to prepare a Wetland Restoration Plan
- Since 1997, the following events have occurred:
  - The cranberry bog has ceased production
  - The restoration plan has been completed and implemented to control invasive species, control water levels, and encourage the creation of wildlife habitat.
  - Several conservation restrictions have been placed on the bog property
  - Bog water levels have declined due to water supply withdrawals in the watershed
  - The Town of Barnstable is working to develop additional effluent recharge capacity for its Water Pollution Control Facility (WPCF) to allow expansion of its sewer system and to remediate water-supply and surface-water quality problems in Barnstable.
  - The Town of Yarmouth has initiated wastewater planning efforts, and has identified the properties surrounding the bog to be in need of sewers

The Town of Barnstable is evaluating options to recharge treated water from the Hyannis WPCF above the bog to restore the watershed base flow. The recharge will be through constructed wetlands shown as hatched lines on Figure 1, and shown in cross-section below.



**Figure 2. Cross-Section of Constructed Wetland/Pond Recharge Area**

A possible 1.3 mgd groundwater recharge to restore the watershed base flow would be subsurface adjacent to the constructed wetland as illustrated in Figure 2. The groundwater would then flow through the constructed wetland and confining berm to recharge the natural wetland and abandoned bog. The following benefits could be attained with this project:

- Restoration of base flow by recharging the 1.3 mgd that is withdrawn from the water-supply wells back into the watershed
- Additional nitrogen attenuation as the water flows through the wetland
- Additional effluent recharge capacity for the Hyannis WPCF after treatment for nitrogen, phosphorus, tertiary filtration, and UV disinfection

A meeting with Mass DEP and CCC staff on April 27, 2006 indicated that the concept could be feasible with these advanced treatment components. An additional meeting with the CCC USEPA Grant Committee and Mass DEP Wetlands and Waterways staff on May 11, 2006 indicated that this type of recharge fits well with DEP's overall policy of encouraging recharge to replenish drinking water withdrawals.


**The following issues are being reviewed and resolved:**

- Modification of the current wetland system to construct the constructed wetlands as indicated in Figures 1 and 2 would require regulatory permits from Mass DEP, Town of Yarmouth Conservation Commission, USEPA, possibly Corps of Engineers, and possibly Massachusetts CZM.
- There is an active Hyannis Park Civic Association and a Town of Yarmouth Wastewater planning effort that may request that the residential and commercial area around the bog be served by sewers and the Hyannis WPCF to address wastewater problems in the area. The Town plans to coordinate with these groups if the concept is feasible from a permitting perspective



0 250 500 1,000  
Feet

1 inch equals 500 feet

 — Proposed Recharge Area

FILE LOCATION: J:\GIS\PROJECT FOLDERS\081201\BOS\FIGURES\1\_20\_06 FIGURE SC0150F01.MXD



Stearns & Wheeler, LLC  
Environmental Engineers and Scientists

1000 Main Street  
Barnstable, MA 01953  
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Fax: 508/548-1101  
www.stearns-wheeler.com

DATE: 1/26/06  
PROJECT No: 20190

TOWN OF BARNSTABLE, MA

BARNSTABLE TASK  
14 EVALUATION

HOSPITAL BOG SITE

FIGURE 1

Site W2

## Wetland Restoration and Nitrogen Attenuation Project No. 4

**Title:** Stewart's Creek-Makepeace Bog Wetland Restoration

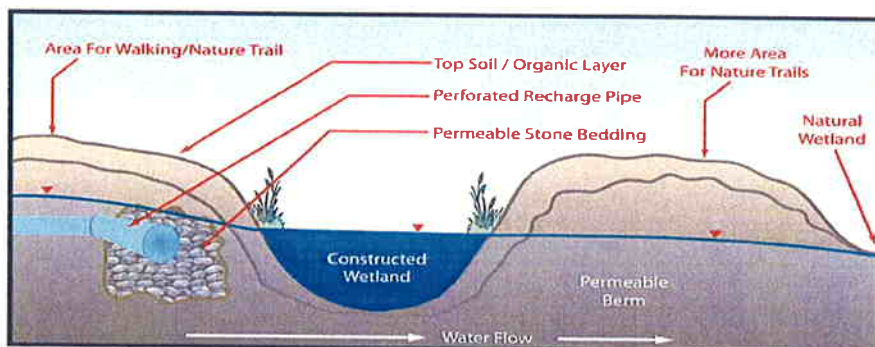
**Project Location:** Town of Barnstable (Town) Stewart's Creek Area as illustrated on Figure 1

**Background:** The Stewart's Creek area is currently receiving much attention to address water-quality, wildlife-habitat and recreational issues including:

- Planned sewerage of the area around the creek as identified in the Town's wastewater facilities plan and Preliminary Sewer Design for this area. This sewerage would remove an average wastewater flow of 0.05 mgd from the watershed and a nitrogen loading of 15 lb/day (based on a nitrogen concentration of 35 mg/l)
- The Town and Army Corps of Engineers are planning a new culvert and dredging at the creek outlet to Nantucket Sound. This project is described on the Town's web site at the following link:  
(<http://www.town.barnstable.ma.us/Conservation/stewartCreek.asp>)
- The Town recently purchased the old Gulf Gas Station Property (shown on Figure 1) on Main Street at the north end of Stewart's Creek. The gas station was demolished and a town park and open space is now on the property

Just south of the Gulf Station Property is the abandoned Makepeace cranberry bog and disturbed wetland. There is an opportunity to restore the old bog area and create a more diverse wildlife habitat of wetland and upland area where nature trails could provide passive recreation.

The Town of Barnstable is evaluating options to recharge treated water from the Hyannis WPCF above the bog to provide greater hydraulic flow and to restore the wetland. The recharge will be through constructed wetlands shown as a shaded area just south of the old gas station site on Figure 1, and shown in cross-section below.



**Figure 2. Cross-Section of Constructed Wetland/Pond Recharge Area**

A potential groundwater recharge being would be subsurface adjacent to the constructed wetland. The groundwater would then flow through the constructed wetland and confining berm to recharge the natural wetland and abandoned bog. The following benefits could be attained with this project:

- Additional nitrogen attenuation as the water flows through the wetland
- Overall reduced nitrogen loading to the creek after sewerage of the Stewarts Creek Area
- Groundwater recharge to the watershed to replace drinking water removed further upgradient
- Additional effluent recharge capacity for the Hyannis WPCF after treatment for nitrogen, phosphorus, tertiary filtration, and UV disinfection

Meeting with Mass DEP and CCC staff on April 27, 2006 indicated that the concept could be feasible with these advanced treatment components. An additional meeting with the CCC USEPA Grant Committee and Mass DEP Wetlands and Waterways staff on May 11, 2006 indicated that this type of recharge fits well with DEP's overall policy of encouraging recharge to replenish drinking water withdrawals.

**The following issues are being reviewed and resolved:**

- Modification of the current wetland system to construct the constructed wetlands as indicated in Figures 1 and 2 would require regulatory permits from Mass DEP, Town of Barnstable Conservation Commission, possibly Corps of Engineers, and possibly Massachusetts CZM. The Town is researching the most efficient regulatory process to attain these permits
- The area proposed for the wetland restoration is currently privately owned. The Town plans to initiate discussions on a purchase if the concept is feasible from a permitting perspective



Figure 1  
STEWART'S CREEK  
AREA

LEGEND

- Town Owned Parcels
- Parcel Lines (TY 2005)
- 10' Topographic Contour
- 2' Topographic Contour

AERIAL PHOTOGRAPHS:  
APRIL 2001



TOWN OF BARNSTABLE  
GEOGRAPHIC INFORMATION  
SYSTEMS UNIT