Effects of Land Development on Water Resources of the Pinelands Region

Prepared for New Jersey Future by

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Contents

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- Hammonton Water & Sewer Department: Anthony DeCicco, Supervisor
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- Little Egg Harbor Township Municipal Utilities Authority: David Johnson, Executive Director
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Executive Summary

The purpose of the report is to assess the extent to which water and water-related resources in the Pinelands region are modified by land development, especially since adoption of the Pinelands Comprehensive Management Plan. Land development includes both urban uses (e.g., housing, commercial and industrial, utilities, public facilities, roads) and agricultural uses (e.g., field, orchard and berry crops). To allow for comprehensive evaluations within available resources, the project focuses on three developed areas and one undeveloped area. The three developed areas are: Medford Lakes Borough, Medford Township and Evesham Township; Town of Hammonton; and Tuckerton Borough and Little Egg Harbor Township. The undeveloped area is the watershed of McDonalds Branch, a tributary of the Rancocas Creek in the Brendan T. Byrne State Forest. (See **Figures ES-1** through **ES-4**).

New Jersey is the most developed state in the nation, with 33 percent of its land developed. An additional 46 percent of its land has been permanently preserved or is considered environmentally constrained and hence undevelopable. This leaves only 21 percent of the state's land area still available for development. Despite this impending build-out, development continues to occur inefficiently, with growth in developed acres outpacing population growth by a factor of 3.7 between 2002 and 2007 (Haase and Lathrop, 2010). These development patterns have taken a toll on New Jersey's water resources. This pattern of growth, combined with dated water management policies and systems, has degraded water quality and quantity throughout the state, even in places to which it is most desirable to direct growth. Future development threatens to exacerbate the problem, further polluting the waters on which citizens rely on for drinking, recreation and ecosystem health.

New Jersey has taken important steps to protect its water resources. Critical among them is the landmark Pinelands program. Established in 1978 by federal law, the Pinelands National Reserve covers 1.1 million acres comprising 22 percent of New Jersey's land area, including portions of seven counties and all or part of 56 municipalities, and enormous ground water resources in the Kirkwood-Cohansey Aquifer. New Jersey's Pinelands Protection Act (1979) established the Pinelands Commission and mandated adoption of a regional Comprehensive Management Plan (CMP) to protect the quality and quantity of water within its borders (the Pinelands Area, which does not include the full National Reserve), in part by guiding the location and intensity of development. Municipal conformance to the plan is mandatory and enforced by the Pinelands Commission. Underlying the Pinelands CMP is the assumption that future growth will be directed to and accommodated in locations that have the necessary infrastructure in place to support development, and away from areas with the highest value environmental resources. The Pinelands CMP is an early example of "smart growth" principles that seek to optimize the benefits of focused development while minimizing harmful impacts.

What this approach may not address adequately are the impacts that such directed development will have on water resources. First, can development, and especially dense development, occur without jeopardizing the quality of the local water resources or the quality of the ecological and man-made systems that rely on adequate supply, and if so, under what conditions? A related issue also must be considered: if less dense development would reduce impacts in the immediate area, would the increased area of development result in greater impacts overall? Second, can a plan focused on future development rectify problems caused by past development? The Pinelands region was not a pristine, undeveloped area when the Pinelands CMP was adopted. Third, to what extent can a plan (the CMP) that includes parts of watersheds along its boundaries protect the overall integrity of those watersheds? The answers to these questions are critical to the long-term ecological health of the Pinelands region.

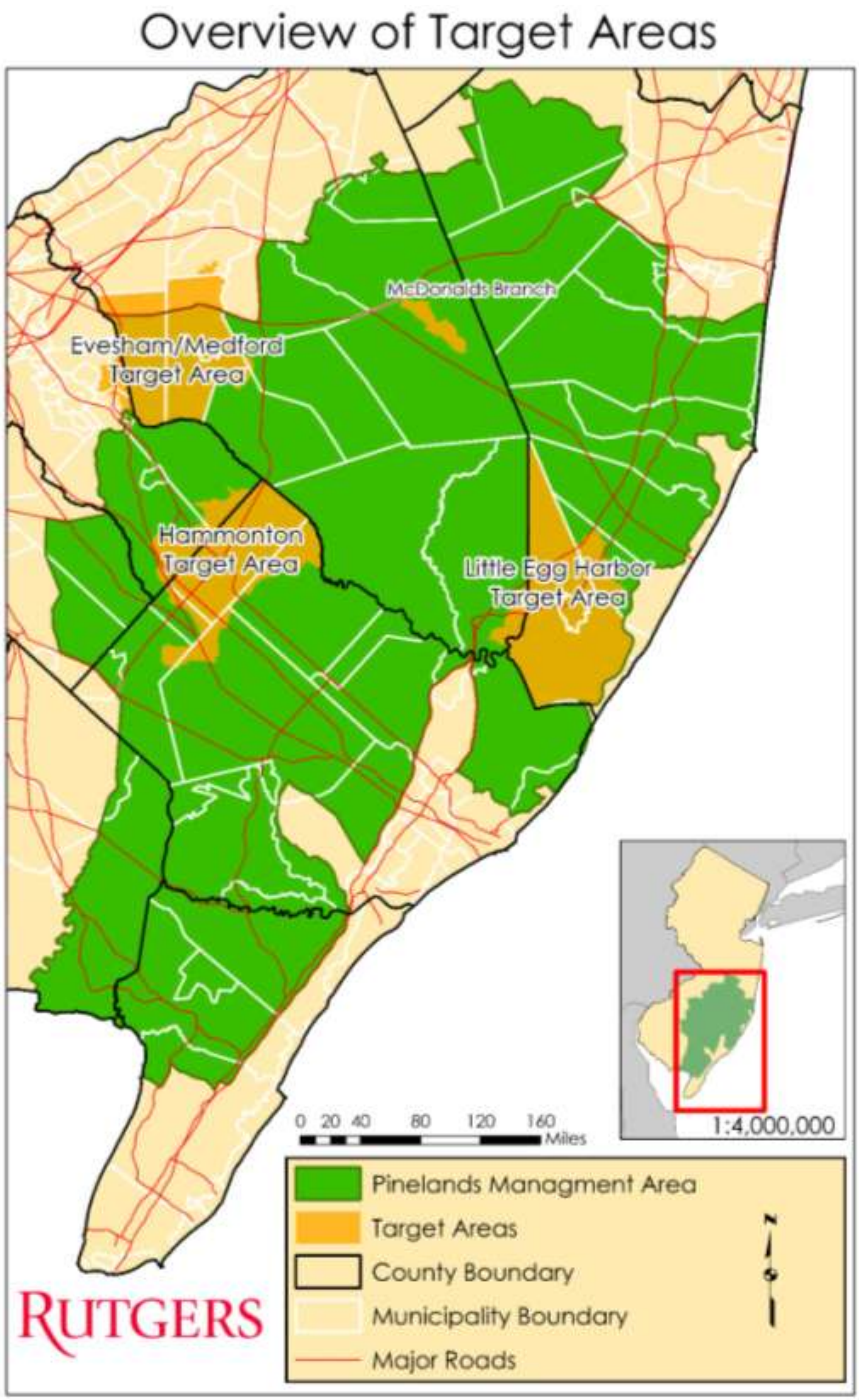


Figure ES-1. Key Map of Project Areas

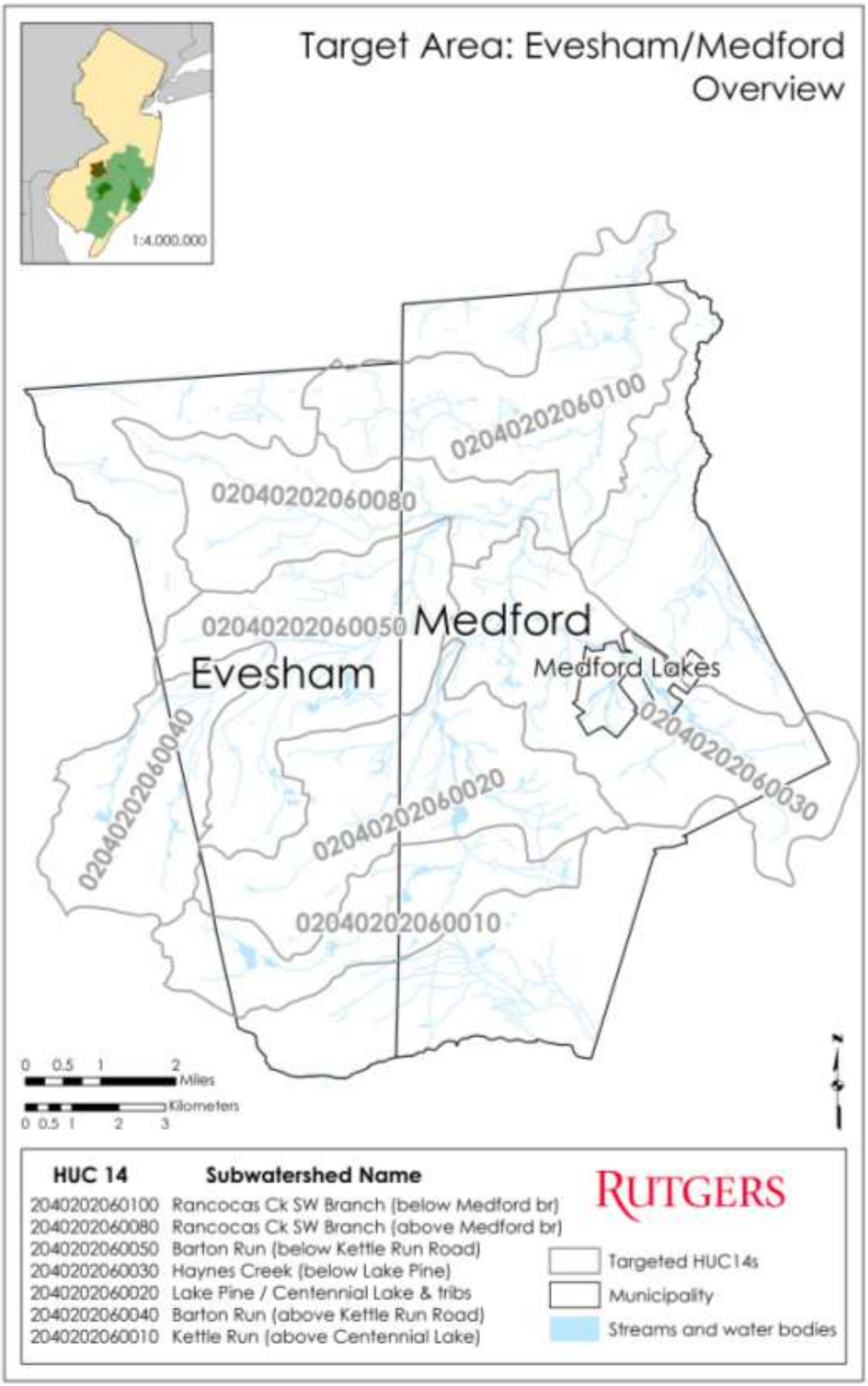


Figure ES-2. Municipalities and Subwatersheds: Evesham/Medford Target Area

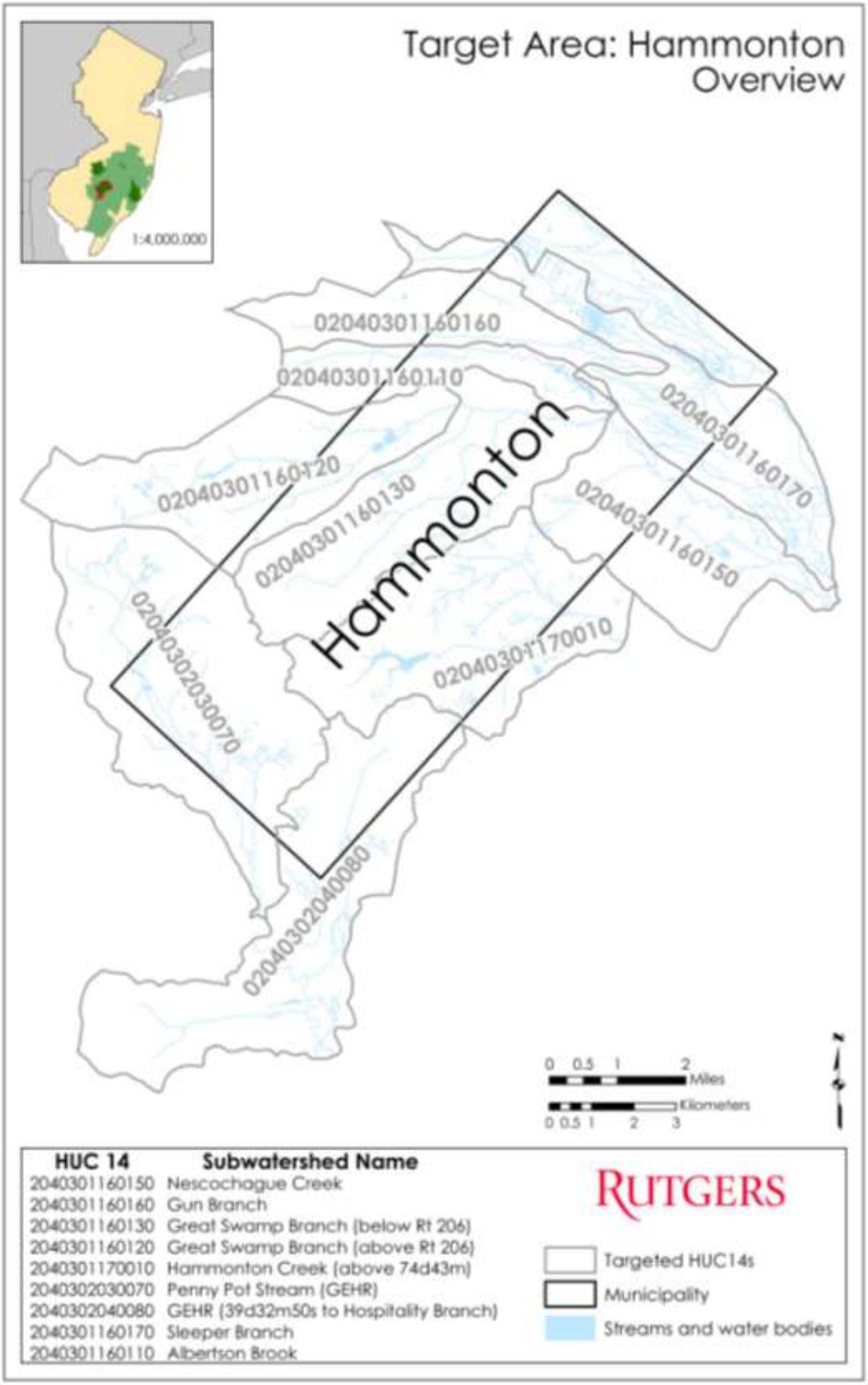


Figure ES-3. Municipalities and Subwatersheds: Hammonton Target Area

Figure ES-4. Municipalities and Subwatersheds: Little Egg Harbor/Tuckerton Target Area

After more than 30 years of operation, the Pinelands program has proven tremendously successful at preserving land – since 1979, nearly 300,000 acres have been permanently preserved, for a total of nearly 600,000 acres in the Pinelands Area, and more land is preserved every year. Land use/land cover data through 2007 show that the CMP has also been successful at directing growth to the designated growth areas, with a substantially higher proportion of development occurring in regional growth areas, towns, villages, and rural development areas, when compared to the more protected preservation, special agricultural and forest areas.

Despite these significant achievements it has become clear that the CMP and regulations of the NJDEP do not fully address various issues of water quality (and related water supply issues) in these more intensely developed watersheds that are planned for future growth, including both past and future impacts. According to the Cromartie and Chirenje (2008), "Water quality is suffering because of development policies in the Regional Growth Areas. This is documented by the Pinelands Commission's own scientific studies (Zampella *et al*. 2001, 2003, 2005)." These water quality impacts affect not only the developed areas but also downstream reaches of Pinelands streams.

While conservation and preservation measures in the less developed and undeveloped portions of the Pinelands are critical, the developed and populated portions of the Pinelands will continue to grow and affect the water resources of the region. In fact, the long-term growth rate in the Pinelands region continues to be more than double the state average, regardless of how the region is defined, while only growth in the core Pinelands municipalities nearly match 2000-2010 statewide growth rates, as noted in **Table ES-1**.

Table ES-1. Growth Rates of Pinelands Area and Other Municipalities

Area	**Growth rates**	
	2000-2010	**1970-2010**
New Jersey total	4.50%	22.60%
Municipalities entirely in Pinelands Area (11)	4.90%	61.80%
Municipalities at least 50% of land area in Pinelands (32)	10.30%	127.80%
Municipalities at least 20% of land area in Pinelands (46)	13.40%	166.60%
Municipalities at least partially in Pinelands (55)	11.30%	135.80%

Source: U.S. Census Bureau

This study examines the major bodies of evidence regarding ecosystem and water resource changes in three developed and developing Pinelands areas (see **Chapter 1**):

- **Evesham/Medford Target Area**: Evesham Township, Medford Lakes Borough, Medford Township. Northern portions of the two townships are outside the Pinelands Area and the Pinelands National Reserve. While all of Medford Lakes is within the Pinelands Area, the borough is almost entirely developed.
- **Hammonton Target Area**: Hammonton Town, which is entirely within the Pinelands Area. The core developed areas of the municipality are designated a Pinelands Town, but much of the land within the target area is in agricultural production. Of the three target areas, Hammonton is the only one with a substantial core "downtown" with mixed commercial/retail/office/residential uses.
- **Little Egg Harbor/Tuckerton Target Area**: Little Egg Harbor Township, Tuckerton Borough. The northern portion of the township is within the Pinelands Area, while the southern township and all of Tuckerton are outside the Pinelands Area but within the Pinelands National Reserve and New Jersey's Coastal Zone Management Area. Tuckerton has a small downtown area.

The McDonalds Branch subwatershed, an undeveloped subwatershed in the Brendan T. Byrne State Forest, was selected as a comparison representing natural conditions. This subwatershed is used primarily as a yardstick against which to measure current conditions in the target subwatersheds, relative to conditions in McDonalds Branch that can be considered as close to "pristine" as is available in the Pinelands region. Conditions in McDonalds Branch are not proposed as a recommended standard, however, as both urban and agricultural development will inevitably change the water resources of the affected subwatersheds. Most of the target area subwatersheds had significant development prior to adoption of the Pinelands Protection Act and then additional development in the years that followed.

The study represents a compilation, evaluation and synthesis of available information regarding a wide array of land use, environmental, water utility and demographic topics, including:

- **Subwatershed Integrity** (Chapter 2): including evaluations by subwatershed of land use/land cover, and status and trends of key environmental features (e.g., wetlands, forests, riparian areas), environmental functions (e.g., flood storage and aquifer recharge capacity), etc. In all cases, land use and land cover are compared to a base year of 1986, which is both the earliest available digitized year and also is close to when land use projects approved under the Pinelands CMP started to be developed in significant numbers.
- **Water Quality** (Chapter 3): including unconfined aquifer quality, and surface water quality and biological integrity.
- **Water Availability** (Chapter 4): including several different approaches to assessing water availability for unconfined aquifers and surface waters by watershed and subwatershed.
- **Water Utilities**: including Public Community Water Supply (PCWS) systems (Chapter 5), public wastewater (sewage) systems (Chapter 6), and public stormwater systems (Chapter 7).

The report results are summarized below. Implicit in all discussions are the complexities posed in tracking and aggregating environmental change over time using a broad variety of parameters. Each analysis posed its particular challenges regarding methodology and data availability. Changing management practices for new development make difficult the overall evaluation of development at a larger scale. Finally, there are inherent difficulties involved with comparing a variety of somewhat or largely unrelated parameters to draw conclusions regarding overall environmental integrity. However, with the understanding that the synthesis is by necessity qualitative, the underlying parameter-specific evaluations generally have a strong quantitative basis that provides a good level of certainty regarding the foundations for the broader analysis.

Overview of Target Area Results

The three target areas have some similarities and some differences in their land use patterns, water resource conditions and water utilities. More details are provided in the report and are summarized in Chapter 9.

Evesham/Medford Target Area

This target area has the broadest expanse of low to moderate density suburban development, which has had widespread effects on stream corridors and moderate to high levels of impervious surface and losses of flood prone areas. The target area subwatersheds also have seen significant losses of recharge areas. However, some of these losses occurred prior to 1986. All but two target area subwatersheds have limited preserved open space.

Every subwatershed violates the Surface Water Quality Standards for pH, an important Pinelands criterion, but two subwatersheds have additional violations that are very typical of areas affected by land development. Available ground water quality data likewise show some impacts from land uses, which in part may relate to the relatively large number of Known Contaminated Sites in several of the target area subwatersheds. Water demands are from confined aquifers and outside sources, resulting in very limited impacts on wetlands, and indeed the overall watershed achieves a net increase in water flows because imported waters are discharged within the watershed – the opposite of the norm.

The three municipalities have very different conditions regarding water utilities. Evesham Township has sufficient capacity to address water demands and sewage generation from both projected 2040 population and the much larger demands of full build-out. Medford Township lacks sufficient water and sewer capacity for full build-out of the municipality but may have sufficient capacity for projected 2040 population. Medford Lakes expects little growth and has sufficient sewer capacity; it has no public water supply utility.

The net result is that this target area shows water stresses from the existing development and can anticipate additional stresses in the two townships at anticipated growth rates, with far greater stresses if build-out levels were attained up to available water utility capacity.

Hammonton Target Area

Hammonton has seen relatively little change in land use and land cover since 1986, with almost no change in its limited losses of riparian area, flood prone areas, wetlands, and forests; only recharge areas have shown significant losses since 1986, mostly likely reflecting their status as well-drained lands that would seem desirable for development. Some of the subwatersheds have significant surface water quality problems, however. Hammonton has a high degree of agricultural lands, which would influence surface water quality regarding nutrients such as nitrates. The only subwatershed with a phosphorus issue is Hammonton Creek, to which the local sewage treatment plant discharges. Available ground water data show considerable evidence of elevated nitrate levels. Fertilizers are the likely source, given that the entire area has been sewered since the 1920s, minimizing septic system impacts.

Water availability is a major issue in Hammonton, both for aquatic ecosystems and for the municipality. Wetlands impacts from water withdrawals are the highest of the three target areas, a result of using the water table aquifer for part of Hammonton's supplies. Six subwatersheds show very high impacts on wetlands from water demands. In addition, existing demands are exceeding both the firm capacity and the water allocation permit for the local water supply system, leaving no capacity for growth unless water conservation is exceptionally successful. The sewage treatment plant also is constrained in its ability to serve increased demands, due to limitations of the new ground water discharge system.

The net result is that the Hammonton target area shows high levels of stress in many subwatersheds due to a combination of existing lands uses and utility constraints, but this situation has not changed a great deal since 1986. Both the demands of build-out and of 2040 population projections cannot be met under existing utility conditions, and if they were, the additional environmental impacts (e.g., drawdown of the water levels in wetlands) could be severe.

Little Egg Harbor/Tuckerton Target Area

While Tuckerton has seen relatively little development since 1986, Little Egg Harbor Township has grown considerably. Tuckerton Creek has had the most changes in land use and land cover, with increases in urbanization and impervious surface, and in urban lands with riparian areas and flood prone areas. Forest and recharge area losses are also significant, though wetlands losses have been minimal. Only one subwatershed (Mill Creek) has a high level of preserved lands.

Surface water quality issues are clearly evident in some subwatersheds, particularly Tuckerton Creek, but not in others. Available ground water quality data show minor water quality impacts, which correlates with the limited number of septic systems and little agriculture in the area.

Three subwatersheds show significant impacts of existing water withdrawals on wetlands, and increased water demands would likely affect the same areas. Both Little Egg Harbor Township and Tuckerton have water allocation and firm capacity constraints relative to their build-out potential, though Tuckerton may have sufficient capacity to meet 2040 population projects. Little Egg Harbor Township, on the other hand, is the only municipality in this report that has a housing demand by 2040 that is greater than its build-out capacity, most likely due to expectations that seasonal housing will convert to year-round housing. However, the result is that water supply availability could be a major issue for the Township. Both municipalities are in the sewer service area of Ocean County Utility Authority's Southern Treatment Plant, which has ample capacity. Both municipalities have significant coastal lagoon development, which raises major issues regarding both recovery from Hurricane Sandy damages and the potential for future flood and storm damages.

The net result is that Tuckerton Creek especially, and other subwatersheds to a lesser extent, are showing stresses from existing development. Future development will be constrained by water supply availability and the environmental impacts of more water withdrawals, and by the impacts of sea level rise and storms on densely developed areas along the bay shore.

Changes in Subwatershed Integrity

The prior section addressed the three target areas holistically. However, for many environmental impacts the most critical area of focus is the subwatershed. Of the subwatersheds in the three target areas, **Table ES-2** shows the most significant impacts of development during the study period of 1986 through 2007, indicating that the stresses are increasing over time. The first three are in the Evesham/Medford target area, while the fourth is in the Little Egg Harbor/Tuckerton target area. None are in the Hammonton target area. In each case, ecological damages and water quality stresses are expected based on the loss of natural vegetation (e.g., forests and wetlands) and hydrological capacity (e.g., flood prone and riparian areas). Stormwater discharge volumes will have increased due to increases in urbanization and impervious surface, even where peak discharges may be mitigated through stormwater basins. While agricultural land uses also have significant effects on water resources, no municipality has had an increase in agricultural acreage since 1986. Therefore, the potential effects of agriculture are addressed in the context of other issues such as water quality.

Table ES-2. Compilation of Target Area Indicators of Watershed Integrity
(Values in bold indicate significant increases during period of analysis)

Indicator	**02040202060020 Lake Pine / Centennial Lake & tribs**	**02040202060080 Rancocas Ck SW Branch (above Medford br)**	**02040202060100 Rancocas Ck SW Branch (below Medford br)**	**02040301140030 Tuckerton Creek (below Mill Branch)**
Urbanization 1986-2007 (Acres)	**825**	**770**	**838**	**817**
Impervious Surfaces (%)	7	**21**	10	**14**
Riparian Area (% Urban)	23.3	**31.3**	**14.9**	**32.5**
Flood Prone Area (% Urban)	21	**26**	9	**39**
Forest % Losses (1986-2007)	**13**	-1	1	**19**
Wetlands % Losses (1986-2007)	1	**6**	**6**	1
PGWRA (% Urban)	**13**	**19**	**12**	**37.1**
Protected Areas (%)	17.6	26.2	0.4	10.7

Other subwatersheds also have extensive development that would cause environmental damages, but experienced far less development since 1986. As such those subwatersheds can be considered stressed but stable. More details are available in **Chapter 2**.

Water Quality

For the Pinelands Area, NJDEP's surface and ground water quality standards have a special Pinelands classification (Class PL and Class I-PL, respectively) with stringent antidegradation policies. In both cases, the antidegradation policies are linked to the Pinelands CMP, so that what is allowed by the CMP is generally allowed by the water quality standards. Only in the areas of northern Evesham and Medford townships and in Tuckerton and southern Little Egg Harbor Township do non-Pinelands standards and antidegradation policies apply.

The three study areas have significant water quality problems from a wide variety of sources. Some are inherent to the land uses. For instance, agriculture for non-native species requires modification of the sandy soils to support fertility, which shifts pH, alkalinity, carbon content and nutrients; each changes water quality. Urban land uses pose some of the same issues (e.g., soil alterations to allow viability of New Jersey's top crop by acres, grass) but also raise threats ranging from industrial contamination to stormwater volumes and discharge rates that can badly damage stream channels. **Table ES-3** provides an overview of the water quality indicators showing either significant differences from McDonalds Branch (the comparison subwatershed used to represent natural conditions) or confirmed water quality violations. Some information is not directly associated with the subwatershed due to data available. For example, some monitoring stations are within the watershed but not necessarily the specific subwatershed, while other statistics are provided only by municipality.

Table ES-3. Water Quality Issues in Target Area Subwatersheds

HUC14	**Subwatershed Name**	**Surface Water Chemistry (high levels of nutrients, pH, chloride, etc.)**	**PMI**	**Existing Non-Native Pond Fish**	**SWQS Violations**	**KCSL Sites/ CEAs/KCEs**
02040202060030	Haynes Creek (below Lake Pine)		Fair	**High**	pH	**High**
02040202060040	Barton Run (above Kettle Run Road)		**Poor**	**High**	**Multiple**	**High**
02040202060050	Barton Run (below Kettle Run Road)				**Multiple**	Low
02040202060080	Rancocas Creek SW Branch (above Medford Br)	**Multiple**	**Poor**		**Multiple**	**High**
02040202060100	Rancocas Creek SW Branch (below Medford Br)				**Multiple**	Low
02040301160120	Great Swamp Branch (above Rt 206)		Fair		**Multiple**	**High**
02040301160130	Great Swamp Branch (below Rt 206)				**Multiple**	
02040301160170	Sleeper Branch				**Multiple**	
02040301170010	Hammonton Creek (above 74d43m)	**Multiple**	Fair	High	**Multiple**	**High**
02040301140020	Mill Branch (below GS Parkway)				**Multiple**	Low
02040301140030	Tuckerton Creek (below Mill Branch)				**Multiple**	Mod

Legend		
Evesham/Medford Target Area	Blank Cells are N/A	KCSL – Known Contaminated Sites List
Hammonton Target Area	SWQS – Surface Water Quality Standards	CEA – Classification Exception Area (GW)
Little Egg Harbor/Tuckerton Target Area	PMI – Pinelands Macroinvertebrate Index	KCE – Known Contaminant Extent (GW)

The aggregate results are discussed in more detail in **Chapter 3**. They clearly show major water quality issues related to land uses in all three target areas, especially:

- Evesham/Medford
  - Barton Run, which receives drainage from the King's Grant area in Evesham Twp.
  - Rancocas Creek SW Branch, which receives drainage from Medford Lakes and the Medford village area
  - Both watersheds have a Poor rating for Pinelands Macroinvertebrate Index (PMI), and they have a high incidence of hazardous contaminated sites (as does Haynes Creek).
- Hammonton:
  - Great Swamp Branch, which has a largely agricultural drainage area
  - Hammonton Creek, which receives drainage from downtown Hammonton (including Hammonton Lake), downstream agricultural areas, and further downstream has been the receiving water for the sewage treatment plant
  - Both of these areas also have a high incidence of hazardous contaminated sites.
  - Sleeper Branch, which has extensive agriculture and some urban areas within its drainage, but is also one-third forested
- Little Egg Harbor/Tuckerton:
  - Westecunk Creek, which has some urban land but is primarily forest and wetlands, as indicated by the Excellent rating for PMI.
  - Tuckerton Creek, which drains from Pohatcong Lake and goes through a developed area east of Route 9 (Main Street) in Tuckerton

More generally, pH violations exist in every subwatershed in the Evesham/Medford target area and nearly every subwatershed in the Hammonton target area, but only one subwatershed (Westecunk Creek) in the Little Egg Harbor/Tuckerton target area. An issue not relevant to most of these areas is the impact of septic systems, as in most cases much of the existing and projected development is or will be served by public sewer systems.

Water Availability

The report assesses ground water availability using analyses by the Pinelands Preservation Alliance using a method from the USGS Kirkwood-Cohansey aquifer study (subwatershed scale), a report from the New Jersey Geological Survey (NJGS) on ground water recharge (subwatershed scale), a new report from NJGS on the Low Flow Method for water availability (watershed scale), and a NJGS report on consumptive and depletive water uses (watershed scale). However, as noted, the available information is not all at the same scale and therefore considerable care must be used in drawing inferences from the combined results. The detailed evaluation is provided in **Chapter 4**. **Table ES-4** shows the subwatersheds with the clearest indication of current problems regarding water availability based on the unconfined aquifers and surface waters. The highlighted subwatersheds are of greatest concern.

Table ES-4. Overview of Ground Water Availability Indicator Results for Target Subwatersheds

HUC14	Subwatershed Name	5% of Drought Recharge (MGD)	5% LFM (MGD)	20% LFM (MGD)	Wetlands Drawdown >=5 cm	Wetlands Drawdown >=15 cm	Wetlands Drawdown >=30 cm	Net Withdrawal (Unconfined and SW) (MGD by HUC11)
2040301130060	Westecunk Creek (below GS Parkway)	0.161	**0.05**	**0.18**	**25.8%**	4.3%	0.8%	1.5
2040301140020	Mill Branch (below GS Parkway)	0.126	0.08	0.32	**47.2%**	8.8%	1.6%	0
2040301140030	Tuckerton Creek (below Mill Branch)	0.119	0.09	0.34	**19.1%**	4.6%	1.3%	
2040301160120	Great Swamp Branch (above Rt 206)	0.134	0.08	0.33	**55.4%**	**21.5%**	9.3%	**4.4**
2040301160130	Great Swamp Branch (below Rt 206)	0.104	0.11	0.43	**73.5%**	**39.3%**	**17.4%**	
2040301160150	Nescochague Creek	**0.071**	0.14	0.56	**83.9%**	**67.4%**	**37.5%**	
2040301160160	Gun Branch	**0.049**	0.13	0.52	**35.8%**	8.4%	2.2%	
2040301170010	Hammonton Creek (above 74d43m)	0.130	0.07	0.28	**73.4%**	**67.2%**	**56.2%**	1.5
2040302030070	Penny Pot Stream (GEHR)	0.148	0.09	0.35	**61.4%**	**24.3%**	9.6%	**5.4**

Water Utilities

The municipalities in the three target areas vary greatly in their capacity to address additional demands from future development, as assessed using a build-out analysis (**Chapters 5 through 7**) and summarized in **Table ES-5** for water supply and sewer utilities. In this case, the project team used land build-out as a basis for estimating the ultimate demands that would occur if all available lands in the municipality were developed at their zoned capacity.

Evesham Township would expect additional demands of less than 0.7 MGD at build-out, and has sufficient current water supplies to meet those demands. Further, the Evesham/Medford target area shows little current or potential impact of water withdrawals on wetlands ecosystems, due to their reliance on the confined aquifers. Evesham Township also is prohibited from increasing its withdrawals from the confined aquifer through NJDEP controls on Water Supply Critical Area #2, but can increase its contract with NJ American Water Company to import Delaware River water supplies. Evesham Township also has ample wastewater capacity between its Woodstream and Elmwood sewage treatment facilities (a third facility, King's Grant, is not included due to its constrained and fully developed service area).

Medford Lakes has no PCWS system. It has almost no build-out demand or available wastewater capacity, though the Borough intends to unlock existing capacity through a major capital project to line their entire collection system, thus reducing infiltration and inflow (I&I) that reduces current capacity.

Medford Township, on the other hand, has an additional demand at build-out of over 2 MGD but almost no net available supply for its PCWS system, though it is also within Water Supply Critical Area #2, and can increase its contract with NJ American Water Company. Likewise, it has some sewer capacity but nowhere near sufficient to meet its build-out demand.

Hammonton is by far the most stressed PCWS system, with an additional demand at build-out of 2.24 MGD and a current deficit in available capacity. Even with the water conservation actions being undertaken by the municipality, capacity is likely to remain well below build-out demands. Further use of the unconfined aquifers would likely increase the already high levels of stress on wetland habitats in the relevant subwatersheds. Hammonton is a special situation for wastewater, as it is shifting to ground water discharge that may limit its capacity regardless of the potential design capacity at its treatment plant. This shift is mandated by the Pinelands CMP. However, even with an increase in total capacity from 1.6 to 2.5 MGD, that capacity would address less than half of the build-out demand, and as noted water supply is also a major constraint.

Finally, Little Egg Harbor Township and Tuckerton both have some net available capacity for their PCWS systems, but not enough to serve all new demands that would result from build-out of the municipalities (3.32 MGD and 0.34 MGD, respectively). They both have essentially no wastewater constraints on their build-out demand (unlike for water supply) due to their connection to Ocean County Utilities Authority, which has a very large net available capacity of 10.4 MGD.

Table ES-5. Water Supply and Wastewater Demands at Build-out for Target Area Municipalities

Municipality	Additional Demand at Build-out (MGD)		Water Supply Net Available Capacity (MGD)	Wastewater Net Available Capacity (MAX3O/Annual Average Methods) (MGD)
	PCWS	Sewer		
Evesham Township	0.69	0.54	4.869 (Firm Capacity) 1.39 (Water Allocation)	0.828/1.090
Medford Lakes Borough	No PCWS system	0.012	No PCWS system	0.037/0.108
Medford Township	2.12	1.64	0.074 (Firm Capacity) 0.0028 (Water Allocation)	0.209/0.368
Hammonton Town	2.24	2.02	35-0.74 (Firm Capacity) 0.0 (Water Allocation)	-0.061/0.420
Little Egg Harbor Township	3.32	3.10	2.002 (Firm Capacity) 0.586 (Water Allocation)	10.4/12.125 (OCUA Southern STP)
Tuckerton Borough	0.34	0.28	0.231 (Firm Capacity) 0.184 (Water Allocation)	

Of the six municipalities, only Little Egg Harbor Township MUA indicated that it has a comprehensive, formal system for asset management. The other municipalities are investing in their assets based on local knowledge but hope to shift to more formal asset management programs or are in the process of doing so. However, all six acknowledge that advancing age of existing water infrastructure will increase necessary capital investment costs, which will in turn strain resources at current rates. Little Egg Harbor Township MUA is in a somewhat more favorable position, as the payoff of existing debt in two years will open up a revenue stream for capital expenditures without a rate increase, but conversely the MUA currently maintains only a small reserve fund for capital costs. The MUA and the neighboring Tuckerton systems experienced major damages and costs from Hurricane Sandy flooding. Evesham Township MUA maintains a somewhat larger reserve account for capital costs that will help, though not solve, the revenue stresses it faces. Medford Township has a relatively modern system, as it developed more recently than many of the other municipalities, and invested in upgrades to water supply systems purchased from three private companies in the 1980s.

Stormwater systems were also assessed in a limited manner, by determining the developed areas in that had sufficient densities to require stormwater systems. The area of stormwater basins was also evaluated. The results show that for the three target areas, developed areas increased by 36% (Hammonton) to 57% (Little Egg Harbor/Tuckerton) from 1986 through 2007. Stormwater basin area increased much more sharply, from 300% (Evesham/Medford) to nearly 2000% (Little Egg Harbor/Tuckerton). In all three target areas, few stormwater basins were identified as of 1995. In each case, responsibility for public stormwater system maintenance remains with the municipal governments, but many systems are owned by private entities. A frequent concern and issue is that stormwater systems (both public and private) are not always maintained and can fail with both public safety and environmental damages as a result.

Development Potential and Impacts

However, a major point must be raised regarding the results posed above. Build-out may not occur for long periods, or even at all, depending on market conditions, land acquisitions for open space and farmland preservation, approvals at less than zoned maximums, etc. **Table ES-6** provides a comparison of the housing units from the build-out assessment and from population projections to the year 2040. In several municipalities the projected housing units through 2040 are far lower than the build-out conditions, with Medford Township showing the most striking difference. Conversely, the population projections for 2040 in Little Egg Harbor Township would require more housing than the build-out demand indicates is feasible under existing zoning. However, the township has a large stock of seasonal housing that has been shifting to year-round use, though Hurricane Sandy impacts may slow that trend.

Table ES-6. Comparison of New Housing: Population Projections (2040) v. Build-out Conditions

	Evesham Township	Medford Lakes Borough	Medford Township	Hammonton Town	Little Egg Harbor Township	Tuckerton Borough
Population						
2010	45,538	4,146	23,033	14,791	20,070	3,350
2040 (projected)	47,720	4,187	26,897	19,490	30,930	4,840
2010-2040	2,182	41	3,864	4,699	10,860	1,490
Housing Units	*774*	*15*	*1,370*	*1,666*	*3,851*	*528*
Build-out						
Build-out Units	*2,281*	*24*	*6,987*	*3,083*	*3,506*	*899*
Difference	**1,507**	**9**	**5,617**	**1,417**	**-345**	**371**
Difference (%)	**66.1%**	**37.5%**	**80.4%**	**46.0%**	**-9.8%**	**41.3%**

Recommendations

Based on these evaluations, it is clear that the three target areas exhibit significant environmental impacts from development (historic and recent), with loss of natural resources (e.g., forest, wetlands, riparian areas), loss of natural resource functions (e.g., recharge capacity, flood storage capacity) and water resources impacts (e.g., water quality degradation, water withdrawal impacts on wetlands). Utility capacity is currently constrained in Medford Lakes (sewer), Medford Township (water supply and sewer), Hammonton (water supply and likely sewer), Little Egg Harbor (water supply) and Tuckerton (water supply). Utility service demands at build-out and for projections through 2040 would exceed capacity in each of these communities except Medford Lakes, which has little development potential. To the extent that water supplies come from unconfined aquifers (Hammonton) or from confined aquifers that have a close linkage with the unconfined aquifer (Little Egg Harbor and Tuckerton), increased demands will exacerbate already high impacts on wetlands water levels.

The question facing policy and planning entities is how to address these issues. The Pinelands CMP and NJDEP rules are compatible or mutually supportive for many issues and resources. However, several areas exist where improved management will require consideration of additional rules and planning by the state agencies and also by counties, municipalities and further research. The following sections are drawn from **Chapter 9**.

Considerations for State Agency Action

The environmental impacts of existing land uses can be mitigated in some cases through regulatory programs, such as those of NJDEP mandating the management of municipal stormwater systems to reduce litter and sediments from entering the systems, and to reduce stream scour from stormwater discharges to streams. Existing impacts may also be mitigated by voluntary programs such as state and federal agricultural assistance programs. However, impacts of future development are addressed primarily through regulatory requirements for planning, site design and construction methods. The Pinelands CMP and NJDEP provide a management matrix regarding development intensity, site design and construction, within which municipal ordinances regulate development type and further site design issues of local concern.

The regulations of the two state agencies are compatible or mutually supportive for many issues and resources. However, some areas exist where improved management will require consideration of additional rules and planning:

- **Water Allocations**: The recently completed USGS study and Pinelands Commission ecological reports provide a basis for major modifications to water allocation policy in the Kirkwood-Cohansey Aquifer area, both in the Pinelands Area and outside of it. The Pinelands Commission and NJDEP now have the opportunity to provide much more detailed environmental objectives and regulatory approaches that can provide subwatershed-specific water availability based on ecologically-derived thresholds. As part of this process, all requests for additional water allocation should require proofs that existing water uses are efficient and that the PCWS systems have minimized water losses prior to granting the allocation. Finally, more consideration can be given to water cycling, where water that is used comes back into the hydrologic system of the Pinelands in an environmentally beneficial manner, rather than being discharged outside of the region or to the ocean.
- **Water Quality Standards**: The Pinelands CMP uses a single parameter (Nitrate-N) as its focus for water quality in both ground and surface waters; NJDEP's water quality standards incorporate that standard while also providing for broader nondegradation policies. However,

NJDEP's nondegradation policies for the Pinelands include specific wording that defers to the Pinelands CMP regarding development activities.[1] While this approach reduces the potential for a Pinelands-approved development to be rejected by NJDEP and vice versa, it raises a substantive issue regarding how firm the nondegradation policy truly is. Individual developments that meet the nitrate standard and perhaps have minimal other impacts may still, in aggregate, diminish water quality in larger ways including pH modifications related to lawn maintenance, salts from winter road maintenance and point-of-use water treatment systems, new chemicals of concern, etc. Consideration should be given to establishing a firmer relationship between growth expectations of the Pinelands CMP and nondegradation policies of the NJDEP water quality standards.

- **Environmental Enhancement through Redevelopment**: The Pinelands CMP primarily addresses the impacts of <u>new</u> development. Somewhat like NJDEP's current stormwater rules for urban redevelopment, the CMP does not effectively seek to increase and harness redevelopment activities to improve watershed integrity. The CMP could establish rules that either are prescriptive or that provide incentives toward improved stormwater management (especially in areas where development predates any of the more modern stormwater requirements of the 1990s and later), naturalized vegetative cover where lawns currently exist, and improved wastewater management.
- **Watershed Plans for Boundary Waters**: A number of subwatersheds in the Evesham/ Medford and Little Egg Harbor/Tuckerton target areas overlap between the Pinelands Area and non-Pinelands areas. In the first area, applicable regulations are those of NJDEP's normal statewide rules, while the Coastal Zone Management rules apply in the second area. Consideration should be given to collaborative watershed management plans, including regional stormwater management plans and TMDLs, where the statewide NJDEP rules would be supplemented by watershed-specific objectives and standards. Such plans are already allowed by NJDEP rules (see NJAC 7:15-3 and -6). The ongoing work for the Barnegat Bay watersheds is an example of such planning efforts, and also is a very good example of why these cross-boundary, multi-governmental watersheds are so difficult to address.
- **Watershed Plans for Pinelands Waters**: Both NJDEP rules and the Pinelands CMP focus on new development. However, watersheds in the Pinelands are showing clear signs of stress, such as high levels of wetlands stress due to water withdrawals. Unlike the Highlands Regional Master Plan, for example, the CMP does not have a specific mechanism for identifying, assessing and remedying these existing problems, or of future problems, through means other than development controls. Mitigation of environmental impacts from existing development could also help offset the inevitable impacts of even well-designed, appropriate development that occurs in the future. These plans can also help focus land preservation priorities, which can be implemented through fee simple acquisition, easement acquisition, contiguous and non-contiguous cluster development and the Pinelands Development Credit program.
- **Prime Ground Water Recharge Areas**: Neither the Pinelands CMP nor NJDEP rules provide for any direct protection of these areas, which by their nature tend to be well-drained lands that will be targeted for development. Protection of net recharge volume is established policy for both agencies, but this objective is much more easily achieved if the best recharge areas are

[1] For example, the Ground Water Quality Standards at NJAC 7:9C state: "The Department shall not approve any discharge or any other activity which would result in the degradation of natural quality, <u>unless in conformance with the Pinelands CMP</u>." (emphasis added)

protected. Consideration can be given to mapping prime recharge areas (however defined) and establishing protective policies. Unlike protection of resources such as wetlands, it may not be appropriate to protect all prime recharge areas, but rather to ensure that a major portion remain in natural vegetation through such techniques as cluster development.

- **Incorporate Existing Development Impacts**: Building on the point of improved watershed plans, each watershed has a unique pattern of land uses, and yet environmental regulations apply the same standards to new development regardless of the ambient conditions – good or bad. A more nuanced approach would have a baseline regulatory process, with more restrictive standards applied where necessary to offset existing damages. For example, a subwatershed with few septic systems would use the baseline rule at 2 mg/L Nitrate-N. Development with septic systems within a subwatershed that already has a large number of existing septic systems would be more constrained. As an incentive for better watershed plans, the more restrictive conditions could then be offset by off-site activities (by the developer or by other entities entirely) that will achieve the same environmental result. As an example, the State of Maine has long had policies to protect its lakes, where a development that seeks to add phosphorus loads (beyond a stringent level) must implement off-site controls that provide a net phosphorus load meeting the policies.
- **Septic System Densities**: NJDEP should consider application of its septic system density thresholds at the subwatershed level, rather than the watershed level, at least for Pinelands region streams, to allow for a finer-grained evaluation of water quality impacts.
- **Sewer Service Areas**: Low density development on sewers results in a low revenue per linear mile for all utilities, driving up the cost of system operations. Policies and regulations can establish clear differentiation between the appropriate densities for septic systems and for sewer areas. Sewer service areas should be at development densities that will be cost-effective both at the development stage and for lifetime operation and maintenance of the water supply, sewer, stormwater and road infrastructure.
- **High Density Septic System Areas**: As with other regions of the state, the Pinelands include older, densely developed areas that have relied on septic systems (or even cesspools) due to the lack of public sewer systems. Development at that density would not be approved now without sewer service, and yet these areas exist and have ongoing impacts on water quality and (if combined with shallow domestic wells) public health. The Pinelands CMP could include a planning component to both identify such areas and address means to provide tailored wastewater solutions that will significantly increase environmental quality, reduce public health threats, and yet ensure that secondary growth is constrained to appropriate areas only.
- **Development Using Septic Systems**: Many jurisdictions including the Pinelands Commission use a nitrate dilution model to estimate the sustainable level of development using septic systems, which discharge pollutants to ground water after limited treatment (primarily for control of pathogens, solids and suspended solids). Nitrates are normally used as the metric, as an indicator for other pollutants that are not as conservative in water, and as a pollutant of concern in and of itself. Water quality thresholds are established as a modeling target. In most cases, mass balance dilution models are used, but in some cases more sophisticated models provide a better sense of pollutant fate and transport. However, three significant issues arise from the use of dilution models, as in the Pinelands CMP. First, nitrate is a useful indicator but there are other pollutants of concern (such as endocrine-like compounds) that may be of greater concern. The relationship of nitrates to these other pollutants is not clear, and so the use of nitrates as

the sole indicator may or may not be sufficient protective. Second, mass dilution models assume that the septic system plumes do, in fact, dilute. Instead, they tend to travel in discrete plumes until encountering a discharge point. In some cases, the assumptions behind dilution models work well, but in others they may not. Third, other sources of nitrates from residential development may not be fully reflected in the modeling assumptions. These issues have not been explored in sufficient detail.

- **Stormwater Management**: Existing stormwater rules are far superior to what existed in 1979, but several major issues exist that need to be addressed. First, the stormwater rules address maintenance of ground water recharge, certain pollutant controls (primarily suspended solids) and stormwater discharge rates. However, they do not address total stormwater volume discharged or other pollutants that can be discharged to or from stormwater systems. Development tends to cause increased volumes, which have effects on streams even if peak stream flows do not increase. Pollutants such as pH modifiers, nitrates, pathogens and oils are of concern in the Pinelands due to potential effects on endemic plants and animals. The Pinelands region could benefit from specialized stormwater requirements that specifically address Pinelands conditions. Additional emphasis can be placed on shifting stormwater systems to methods that mimic the natural hydrograph, including green infrastructure approaches.
- **Riparian Areas Protection:** Many programs that seek to protect wetlands or surface waters do so by establishing a buffer around the resource within which development is prevented or limited. Most of these buffers are fixed distances, such the provisions of N.J.A.C. 7:8 establishing 300 foot buffers on both sides of Category One streams. However, in terms of ecosystem functions wetlands and open waters do not have fixed boundaries, but rather blend with the adjacent ecosystems and land areas. This issue has been explored by some programs, including the Raritan Basin Watershed Management Project and the Highlands Council. The Nature Conservancy (Smith, et al., 2008) concept of “active river areas” may be applicable here. NJDEP, the Pinelands Commission and research ecologists could review the functionality of alternative buffer approaches for protection of wetlands and open waters.
- **Water Utility Asset Creation and Management**: The Pinelands Commission does not have extensive regulatory authority regarding management of existing assets but can play a significant role with NJDEP in ensuring that new utility assets that are created through development (Pinelands Commission and NJDEP) or through utility management (NJDEP) are associated with cost-effective development densities, will have the lowest possible life cycle cost, and minimize the potential for future water losses and I&I. NJDEP can play a significant role by increasing its focus on regulation of utility asset integrity, by establishing metrics, norms, reporting requirements and management requirements for utility assets.
- **Growth Area Plans**: Again based on the project-specific nature of existing rules, there is a benefit to facilitating community and environmental planning for Pinelands Towns, Villages and Regional Growth Areas that explicitly address aggregate environmental metrics, impacts and objectives. The plans would then be used as part of the watershed planning process, but more directly would increase the ability of each area to better design its future. The Pinelands Commission can incorporate an economic improvement mission in a way that actually enhances environmental quality and community viability.

County and Municipal Actions

Counties in the Pinelands region can play important roles in many of the concepts discussed in the prior section, especially regarding targeted land preservation (open space and farmland), wastewater management planning for sewer service areas and septic system densities, and coordination of watershed management plans, especially for those watersheds that overlap the Pinelands Area boundaries. Counties have little regulatory authority, but do have the ability to bring expertise to collaborative planning and policy development.

Municipalities in the Pinelands Area are subject to the requirements of the Pinelands CMP regarding new development and redevelopment. However, they can engage in significant efforts to improve the environmental and economic impacts of existing development, set the stage for redevelopment that will actually improve environmental conditions, emphasize the proper management of water utility assets, and facilitate innovative development approaches that provide greater benefits than currently required by NJDEP or the Pinelands Commission, such as enhanced use of green infrastructure for stormwater management. A critical role for municipalities is to ensure the effective combination of economic improvement with environmental improvement, resulting in more sustainable communities.

Issues for Further Evaluation

A synthesis report of this nature must address a large number of environmental issues, impacts and considerations, but no single rubric exists for evaluating the net impact of these factors. This study is not the first to acknowledge this methodological constraint and will not be the last. Important to the process is recognition that environmental impacts are in part objective (e.g., X change in water quality or Y loss of wetlands acres) and in part subjective (i.e., is a change in water quality more or less important than a loss of wetland acres). Further, a study that relies on existing information may be (and in this case at times was) unable to definitively ascribe certain impacts to specific policies. Much of the existing development in the Pinelands region predates the Pinelands Protection Act of 1979 and also most NJDEP regulations. The available data on environmental impacts do not always line up well with the periods under study. Based on the report findings, several next steps can be proposed in developing a more rigorous assessment of cause and effect, both past and future:

- **Water Availability**: A fundamental question facing the Pinelands region is how much water can be abstracted without damaging the ecosystems that make this area unique. The region now has more technical tools available, but policies must be generated that make sense from an ecological perspective and are feasible to implement. As noted in **Chapter 4**, there are several different metrics that can be used, and it may be that more than one metric should be used given the various environmental impacts that can occur (e.g., wetlands impacts, pond impacts, stream flow impacts, saltwater intrusion). Given the extremely strong relationship of the ecosystems to water resources, further evaluation of effective metrics, thresholds and implementation approaches may be the most critical recommendation for further work.
- **Ground Water Quality**: In the surficial aquifers, the primary difference between ground water and surface water is time, and so attention to ground water quality is critically important to the question of surface water quality. Ground water quality data are available from the monitoring well network over decades of time. Perhaps more importantly, water quality data may be available from public water supply wells. The land areas that affect the water quality of these wells can be defined, and the development intensity of these areas can be tracked using a combination of aerial photography and other data. The relationship between land uses and water quality impacts can then be described in a more rigorous manner than was feasible in this study.

- **Watershed Impact Analysis**: This study focused on three target areas and all of the associated subwatersheds. Another study approach would be to identify a small number of subwatersheds with different land use patterns, each of which has a very high data density that would allow the tracking of water quality, water flow, land cover change and other factors over time and in relationship to varying regulatory approaches during the study period. The result could be used to help predict impacts of future development activities in the target subwatershed (which would be tracked using a continuing monitoring network) and to help set policies that would apply to all subwatersheds.
- **Multi-parameter Management**: Regardless of how important water is to the Pinelands, it is not the only important factor. Management of the various key issues will be neither effective nor cost-effective if each is addressed in isolation. The question is how to meld all the major issues within a multi-parameter approach that allows for the weighing of multiple positive and negative impacts from any specific action, and to plan for the future in a manner that optimizes benefits and minimizes costs and losses. A major problem encountered in any effort of this nature is that benefits and costs may be quantitative or qualitative, antagonistic or synergistic, related or unrelated. Conceptual systems do exist for addressing this methodological mess, but they require extensive involvement of committed parties that are willing to engage in interest-based discussions and negotiations, rather than statement of fixed positions. However, even partial success in the development of a more comprehensive analytical approach would be valuable, as it would help address the question: How do we know what the future will look like if we take specific actions?

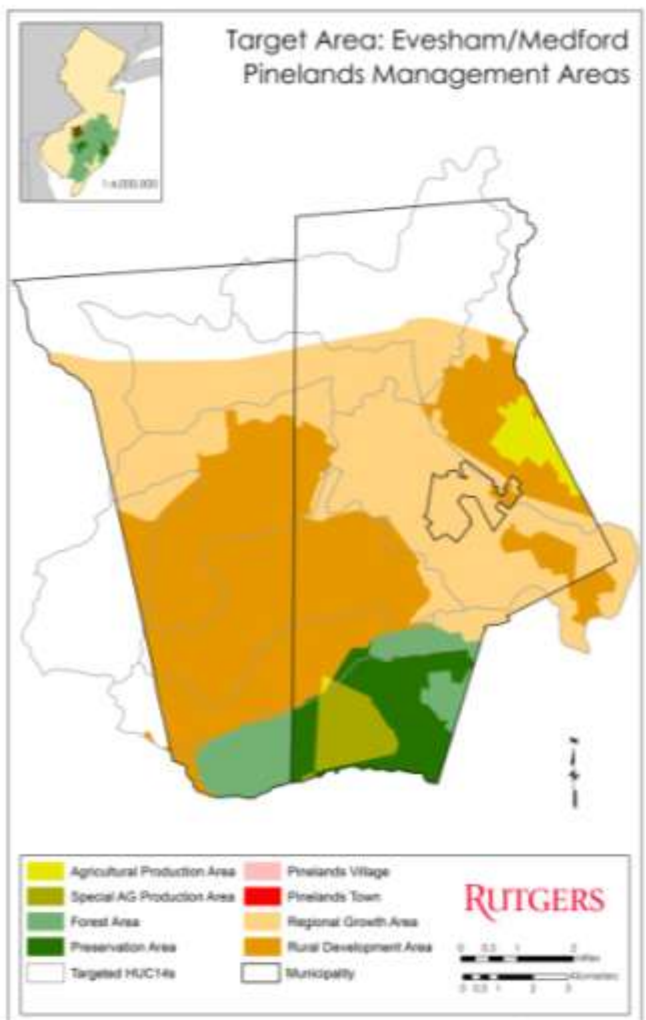
Chapter 1: Overview of Target Areas

Introduction

This report was developed to assess the impacts of historic and potential development on water resources of the Pinelands of New Jersey using three sets of municipalities and a comparison area (see **Figure ES-1**). The three target areas are:

- Evesham Township, Medford Lake and Medford Township, Burlington County
- Hammonton Town, Atlantic County
- Little Egg Harbor Township and Tuckerton Borough, Ocean County

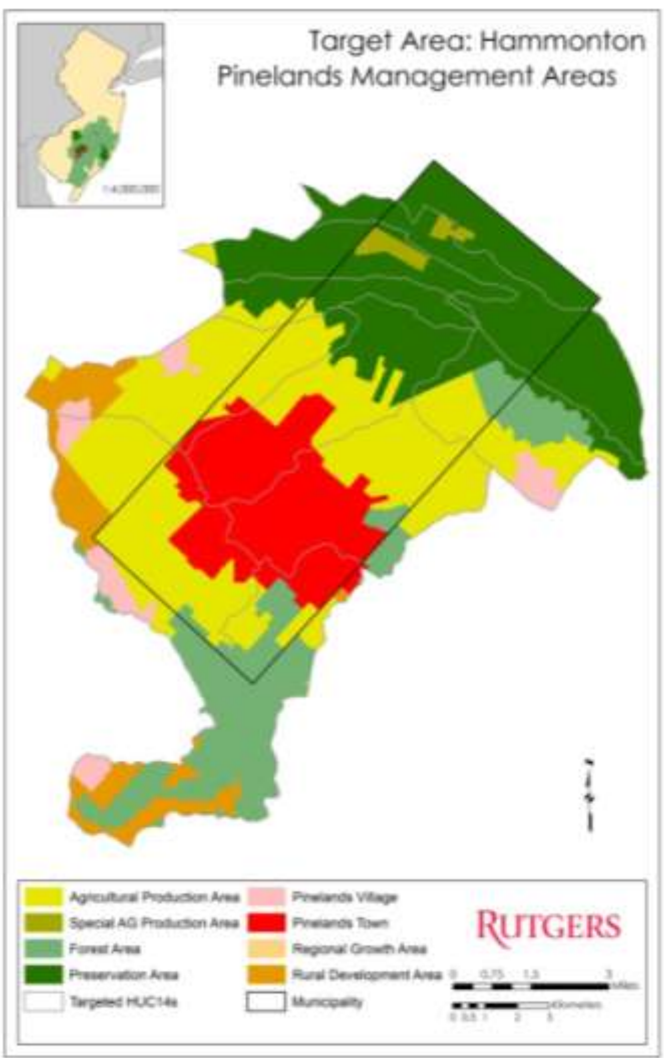
In this report, references to the "Pinelands" are to the ecomosaic described in Forman (1979) as typical of this region, with sandy soils, low pH waters, and a combination of pitch pine, oak and Atlantic white cedar forests. "Pinelands Area" means the area under the direct land use regulatory jurisdiction of the Pinelands Commission as described in the Pinelands Protection Act of 1979. The "Pinelands National Reserve" means the somewhat larger area described in a 1978 federal law; the Pinelands Commission has planning authority for the full National Reserve, but lacks regulatory authority for parts of the Reserve that are outside of the Pinelands Area. Some of these National Reserve lands on the east side are within the regulatory jurisdiction of the New Jersey Department of Environmental Protection (NJDEP) under the Coastal Area Facility Review Act (CAFRA), while lands in other areas are not.



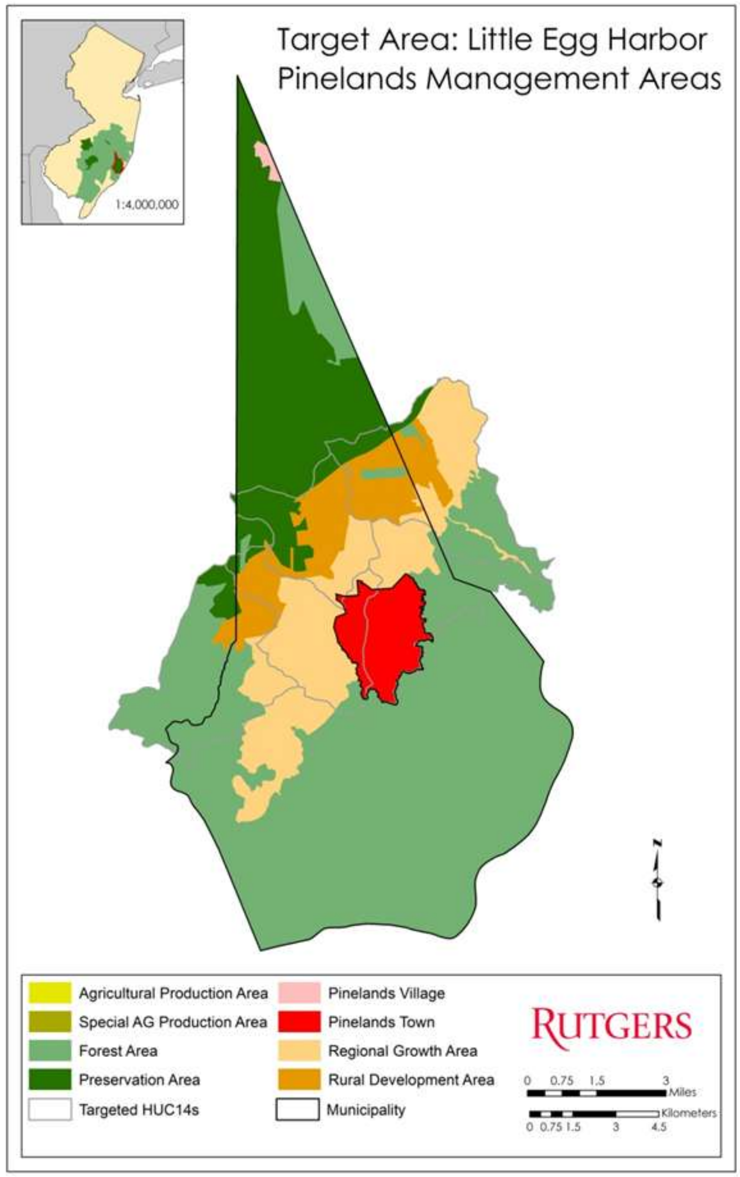
History and Pinelands Management Areas

The area of Medford Lakes Borough, Medford Township and Evesham Township is on the western edge of the Pinelands Area within Burlington County. It is bounded to the north by Mount Laurel and Lumberton Townships, to the east by Southampton, Tabernacle and Shamong Townships, and to the south and west by the Camden County municipalities of Waterford, Berlin and Voorhees Townships. Medford Lakes was developed in the 1930s as a resort community around small lakes that had been created to serve a forge and mills (Medford Lakes, n.d.). The forge relied on bog iron and local charcoal, both of which were commonly-used resources in the Pinelands region before the development of Pennsylvania iron mines and coal. Medford Township surrounds Medford Lakes, with Evesham Township just to the west. Medford Village is the historic village center of Medford Township, supported by forges and mills in a manner similar to Medford Lakes, with later development in the 1800s related to railroad service (Medford Township, n.d.). Evesham Township, which originally included both Medford Township and Medford Lakes Borough (along with Mount Laurel, Lumberton, Hainesport, Shamong and Washington Townships), historically focused on Marlton Village, named for the locally-mined, natural fertilizer named “marl” or “green sand”(Wikipedia, n.d.). Marl supported agriculture in the Pinelands region, with its sandy and relatively infertile soils of the Inner Coastal Plain. Both Evesham and Medford Townships were sparsely populated until suburban development encroached from the Delaware River towns and Philadelphia to the west after World War II. The townships were selected for this study as examples of typical post-war suburban development patterns within a Pinelands context. All of Medford Lakes is within the Pinelands Area, the jurisdiction of the Pinelands Commission pursuant to the Pinelands Protection Act, but the northern portions of both townships are not. As shown in the figure above, essentially all of Medford Lakes and a significant portion of the townships are within the Regional Growth Area and Rural Development Area in the Pinelands Comprehensive Management Plan (CMP), while relative small areas are within the very low density Forest Area and Preservation Area.

Hammonton is a center of agriculture in western Atlantic County, calling itself the Blueberry Capital of the World in recognition of a major local crop. Within Atlantic County, Hammonton is bordered by Folsom Borough to the southwest, and both Hamilton and Mullica Townships to the southeast. The Town is bordered by Camden County municipalities of Waterford and Winslow Townships to the northwest, and the Burlington County municipalities of Shamong and Washington Townships to the northeast. It was settled somewhat later than Marlton and Medford Villages, in 1812, originally around a glassworks and mill but then as a major agricultural area (Hammonton Chamber of Commerce). Unlike the Medford/Evesham area, Hammonton is a true town with a significant downtown commercial center and grid street layout, with little development of the typical suburban style. Development of the town was influenced by construction of a railroad through the town center. Hammonton was selected for this study as a rare example of a town center surrounded by agriculture, and because the sewage treatment plant has been a long-standing management issue for the Pinelands Commission. As shown in the figure, nearly all the land outside of the town center is Agricultural Production Area and Preservation Area. All of Hammonton is subject to Pinelands Commission jurisdiction.



Tuckerton Borough is a small town center historically focused on Tuckerton Creek, a tributary of the Little Egg Harbor at the south end of Barnegat Bay. It began as a mill site and was a significant center of ship building in the 1800s; it eventually became a port for shore visitors to Long Beach Island before bridges were built to that location (Tuckerton.com). It now serves as the town center for both the Borough and Little Egg Harbor Township. The Township's south end surrounds the Borough and also fronts on the Little Egg Harbor. The Township remained very rural until after World War II, at which point lagoon development along the Little Egg Harbor both north and south of Tuckerton (e.g., Mystic Island) spurred an increase in population. Only in the last 20 years has the population greatly increased, primarily through retirement communities and the conversion of seasonal lagoon homes to year-round residences. The interior portions (north of the Garden State Parkway) remain rural (Wikipedia). This area was selected as an example of an area of recent growth that is mostly not subject to direct Pinelands Commission authority but is within the Pinelands National Reserve (established in 1978 through federal legislation) and primarily regulated under the Coastal Area Facility Review Act (CAFRA) by the NJ Department of Environmental Protection (NJDEP). As shown in the figure, Tuckerton is a designated Pinelands Town while much of the remaining area south of the Garden State Parkway is Regional Growth Area and Rural Development Area. (The large area shown as Forest Area is actually comprised of regulated coastal wetlands that are unlikely to be developed.) These areas are not within the jurisdiction of the Pinelands Commission. Most of the northern part of Little Egg Harbor Township is within the Pinelands Preservation Area and subject to stringent provisions of the Pinelands CMP.



Municipal Land Development Status

The development status of the six municipalities is reflected in **Figure 1-1**, which shows the percent impervious surface by municipality. Impervious surface is a good indicator of development density, as it includes residential, industrial, commercial, business and public buildings with their associated parking lots and roads. Of the six municipalities, Medford Lake Borough is by far the most densely developed at nearly 25% impervious surface, while Evesham Township is next at 15% and Tuckerton Borough is roughly 10%. Only Evesham shows a change of more than 1%, up from 12% in 1995. Impervious surface by subwatershed is addressed in the sections below for each target area.

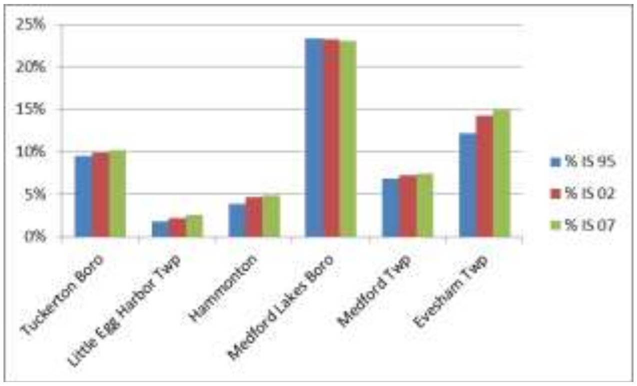


Figure 1-1. Impervious Surface by Municipality

Target Area Subwatersheds

In addition to the focus on the municipalities, this study also addresses the associated HUC14 subwatersheds that are directly affected by the target areas in terms of land with Pinelands Regional Growth Areas and Pinelands Towns, water supply source areas and wastewater effluent discharge areas. A HUC14 subwatershed is a watershed area designated using a 14-digit Hydrologic Unit Code established by the U.S. Geological Survey in collaboration with the NJ Department of Environmental Protection. The following HUC14 subwatersheds are associated with the three target areas (see **Figures ES-2** to **ES-4**).

Table 1-1. Target Area Subwatersheds

Target Area	HUC14	Subwatershed Name	Acres	Square Miles
Medford/ Evesham	02040202060010	Kettle Run (above Centennial Lake)	3564.821	5.57
	02040202060020	Lake Pine / Centennial Lake & tribs	5749.439	8.98
	02040202060030	Haynes Creek (below Lake Pine)	7026.066	10.98
	02040202060040	Barton Run (above Kettle Run Road)	3700.298	5.78
	02040202060050	Barton Run (below Kettle Run Road)	5697.811	8.90
	02040202060080	Rancocas Creek SW Branch (above Medford Br)	4429.49	6.92
	02040202060100	Rancocas Creek SW Branch (below Medford Br)	6027.315	9.42
Hammonton	02040301160110	Albertson Brook	2000.342	3.13
	02040301160120	Great Swamp Branch (above Rt 206)	5164.308	8.07
	02040301160130	Great Swamp Branch (below Rt 206)	5561.026	8.69
	02040301160150	Nescochague Creek	4457.608	6.97
	02040301160160	Gun Branch	2898.544	4.53
	02040301160170	Sleeper Branch	4683.002	7.32
	02040301170010	Hammonton Creek (above 74d43m)	6092.41	9.52
	02040302030070	Penny Pot Stream (GEHR)	7867.969	12.29
	02040302040080	Great Egg Harbor River (GEHR) (39d32m50s to Hospitality Branch)	7286.69	11.39
Tuckerton/ Little Egg Harbor	02040301130060	Westecunk Creek (below GS Parkway)	5961.046	9.31
	02040301140020	Mill Branch (below GW Parkway)	3249.324	5.08
	02040301140030	Tuckerton Creek (below Mill Branch)	3846.56	6.01
	02040301140040	LEH Bay tribs (Westecunk Ck-Tuckerton Ck)	4441.851	6.94
	02040301200070	Ballanger Creek	5387.753	8.42
Comparison	02040202030070	McDonalds Branch	3525.853	5.51

McDonalds Branch (HUC14 02040202030070) has been the focus of environmental and water resources investigations for decades, and is a hydrologic benchmark watershed and monitoring station used by the U.S. Geologic Survey (Mast and Turk, 1999). It is a relatively natural area within the Pinelands Preservation Area. While essentially all forests of the Pinelands Region were harvested at least once, the McDonalds Branch watershed is highly forested and shows few ecological or water quality alterations from what are considered typical Pinelands characteristics. As such, this watershed was selected for comparison to the developed areas.

Population and Employment Status and Trends

The six Pinelands case-study municipalities are grouped into three target areas, each in a different county, and with each county, as it happens, falling into the jurisdictional area of a different one of New Jersey's Metropolitan Planning Organizations (MPOs):[2] 1) the borough of Medford Lakes and the townships of Evesham and Medford, in Burlington County; 2) the town of Hammonton, in Atlantic County; and 3) Tuckerton borough and Little Egg Harbor township in Ocean County. Each target area contains territory that is designated for growth by the Pinelands Comprehensive Management Plan.

Overall, the population growth pattern anticipated by all three sets of MPO forecasts can be described as a combination of 1) continued but attenuated growth at the outer edges of New Jersey's two major metropolitan areas (New York and Philadelphia) and 2) a new focus on redevelopment, the accommodation of new growth in built-out areas via infill, densification, and the reuse of previously-developed lands. This can be seen in our Pinelands case-study municipalities in that the older, compactly-built boroughs of Hammonton, Medford Lakes, and Tuckerton are all projected to grow faster from 2010 to 2040 than they did from 1980 to 2010, while growth is expected to slow down in the more suburban townships of Medford, Evesham, and Little Egg Harbor. See Appendix A for more detailed discussion of the underlying MPO projections used in this report.

For the target area in Burlington County, the Delaware Valley Regional Planning Commission (DVRPC) appears to have made the assumption that population and employment will grow at equal rates for Burlington County, because the projected population and employment growth rates for 2010-2040 are identical in all three municipalities. Medford Lakes is almost completely built-out[3] and is only projected to grow by 1.0 percent over the 30-year period to 2040. Evesham Township was more than 70 percent built-out as of 2007 and is projected to experience a substantially slowed rate of growth from 2010 to 2040 as compared to the previous 30 years: Evesham more than doubled in population from 1980 to 2010 but is expected to grow by only 4.8 percent from 2010 to 2040. Medford Township had a bit more developable land remaining in 2007 (only 63 percent built-out) and is projected to grow faster than Evesham from 2010 to 2040 (by 16.8 percent), although, like Evesham, this represents a slowdown compared to its growth rate of 30.7 percent from 1980 to 2010.

Hammonton, in Atlantic County, was only 44 percent built-out as of 2007, although this statistic is somewhat misleading. The town of Hammonton contains a built-up downtown area but also large tracts of undeveloped land. Much of the undeveloped land in Hammonton is not environmentally constrained and is hence still technically "developable" by the standards of the researchers at Rowan and Rutgers

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[2] The MPOs are the Delaware Valley Regional Planning Commission, the North Jersey Transportation Planning Authority and the South Jersey Transportation Planning Organization.

[3] "Built-out" refers to the percent of a municipality's *developable* land that is actually developed. It does *not* refer to the percent of total municipal land area that is developed, because it excludes from the denominator any lands that are undevelopable, due to being either permanently preserved or environmentally constrained. In mathematical terms, % built-out = [developed acres] / ([total acres] – [undevelopable acres]).

universities who prepare the statistics on land development,[4] but because Hammonton's development is governed by the Pinelands Comprehensive Management Plan (CMP), most new development will be steered toward the downtown area, which the CMP designates as a growth area. Indeed, consistent with a recent general statewide trend toward more redevelopment of older cities and towns, Hammonton's population is projected to grow by 31.8 percent from 2010 to 2040, a rate 1 ½ times as fast as its growth rate of 20.3 percent over the previous 30 years (1980 to 2010). Its employment is also expected to grow by almost the same amount, at 26.1 percent.

Finally, the same trend toward more redevelopment can be seen in the southern Ocean County target area. Ocean County is one of the outer growth frontiers of the New York metropolitan area (hence Ocean's inclusion in the territory of the North Jersey Transportation Planning Authority) and continues to grow rapidly, with the southern end of the county also experiencing northward growth out of Atlantic City. Little Egg Harbor Township, at the intersection of these two growth waves, more than doubled in population between 1980 and 2010 (136.6 percent growth), while the older, more developed borough of Tuckerton grew by only one-quarter that rate (35.5 percent). For the 30-year period to 2040, Little Egg Harbor is still projected to grow fairly rapidly, by 54.1 percent, but Tuckerton is now projected to grow nearly as fast, with a growth rate of 44.5 percent, greatly exceeding its growth rate for the previous 30 years. Of course, a big unknown is how future growth patterns along the Shore will change in the wake of Hurricane Sandy.

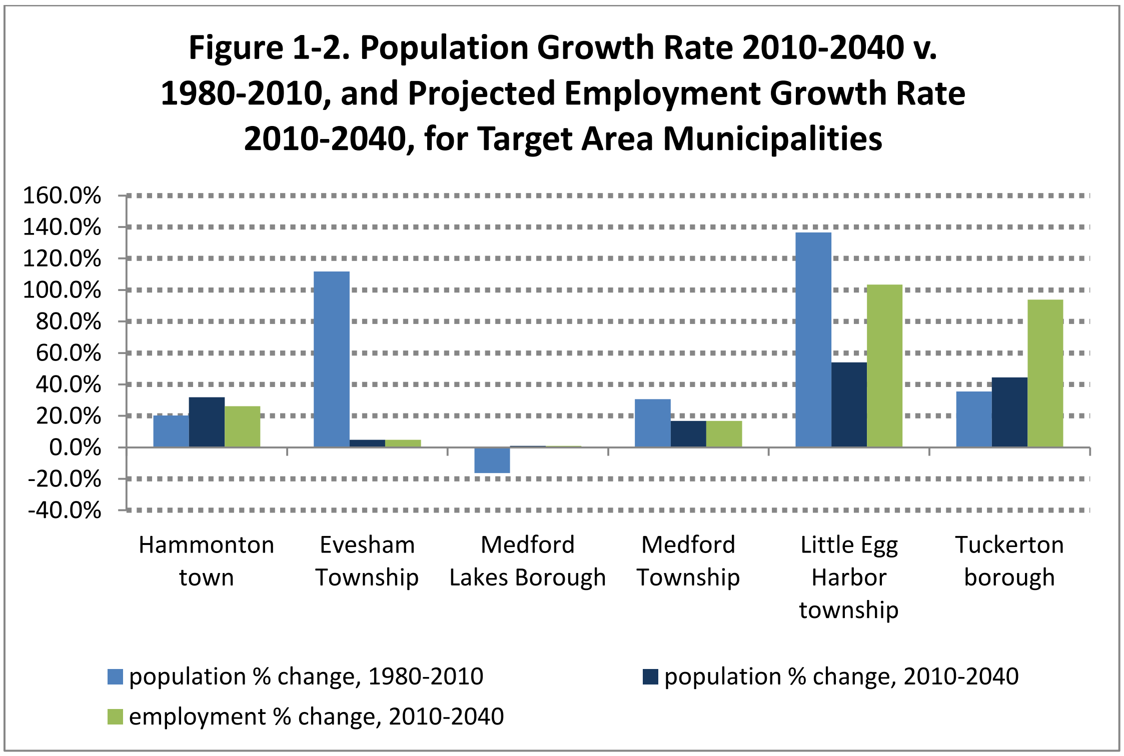
Municipal population and employment status and trends are as shown in **Table 1-2** and **Figure 1-2**, based upon the 2010 population from the United States Census and MPO projections.

Table 1-2. Population, Development Potential, Housing and Employment for Target Area Municipalities

	Evesham Township	Medford Lakes Borough	Medford Township	Hammonton Town	Little Egg Harbor Township	Tuckerton Borough
Population						
1980	21,508	4,958	17,622	12,298	8,483	2,472
2010	45,538	4,146	23,033	14,791	20,070	3,350
2040 (projected)	47,720	4,187	26,897	19,490	30,930	4,840
population % change, 1980-2010	111.7%	-16.4%	30.7%	20.3%	136.6%	35.5%
population % change, 2010-2040	**4.8%**	**1.0%**	**16.8%**	**31.8%**	**54.1%**	**44.5%**
numerical change, 2010-2040	2,182	41	3,864	4,699	10,860	1,490
decade of max influx (thru 2010)	1980s	1950s	1970s	2000s	1970s	1980s
Land development						
% developed, 2007	42.3%	95.0%	30.0%	18.7%	13.9%	32.1%
% undevelopable[5]	40.6%	2.9%	52.6%	57.0%	72.6%	60.0%
% still developable	17.2%	2.1%	17.4%	24.2%	13.5%	8.0%
% built-out[6]	71.1%	97.9%	63.4%	43.6%	50.6%	80.1%
Housing						
total housing units, 2010	18,699	1,483	8,443	9,080	10,045	2,177
total COs issued, 2003-2012	1,094	17	364	550	1,823	185

[4] Data on land development analyzed by New Jersey Future from Haase and Lathrop (2010)
[5] Permanently preserved or environmentally constrained
[6] Developed as % of total developable

Table 1-2. Population, Development Potential, Housing and Employment for Target Area Municipalities						
	Evesham Township	**Medford Lakes Borough**	**Medford Township**	**Hammonton Town**	**Little Egg Harbor Township**	**Tuckerton Borough**
Employment						
2010 - MPOs	26,020	703	11,500	8,838	2,990	490
2040 (projected) - MPOs	27,267	710	13,429	11,142	6,080	950
employment % change, 2010-2040	**4.8%**	**1.0%**	**16.8%**	**26.1%**	**103.3%**	**93.9%**
2010 - NJ Department of Labor	24,595	515	7,872	8,206	2,405	842
2040, deflated using ratio of 2010 numbers (MPO and NJDOL)	25,774	520	9,192	10,346	4,891	1,632
Ratio of employment change to population change, 2010-2040	1.00	1.01	1.00	0.82	1.91	2.11



Municipal Development Potential

The growth potential based on land availability and current regulatory controls (e.g., municipal zoning, Pinelands Comprehensive Management Plan) was evaluated by New Jersey Future for each municipality. Residential and non-residential development potentials were generated separately, providing a more detailed view of how a municipality might develop if all available land were utilized. The New Jersey Future build-out evaluation was then used to evaluate potential water supply demand and wastewater generation. This section provides a brief overview of the methodology and the build-out results in terms of residential units and non-residential space. (Appendix B provides more detail on the methodology.) Later sections on Public Community Water Supply and Public Sewerage systems address the implications of the build-out for water and sewer utilities.

The build-out model run by New Jersey Future used parcel-level data on local zoning, sewer and water service areas, wetlands, water bodies, urban land cover, preserved lands, and Pinelands Management Areas to develop its findings. This methodology closely followed the Pinelands Commission's build-out under their scenario utilizing wetlands and environmental constraints, but with some exceptions. By combining these data together with the use of Geographic Information Systems (GIS) software, New Jersey Future examined the build-out potential at the parcel level for the six towns.

The findings suggested potential for continued development in each of the six municipalities, but to greatly different degrees. **Table 1-3** shows the estimated amount of additional non-residential space (in square feet) and number of residential units, by municipality at build-out. It is important to note that the study intentionally used out the highest permitted density allowed in each district. In addition, in areas outside of Pinelands Commission jurisdiction, it is expected that higher density development would occur.[7]

Table 1-3. Total Build-out in Study Area

	Evesham Twp	Medford Lakes	Medford Twp	Hammonton Town	Little Egg Harbor Twp	Tuckerton Boro
Non Residential Development (1,000's Square Feet)	1,038.9	69.7	2,242.5	13,693.5	39,999.3	879.1
Residential Units	2,281	33	6,989	3,083	3,506	899
Existing Residential Units (2010 Census)	17,620	1,483	8,277	5,408	8,060	1,396

Table 1-4 shows the number of acres available for development under the zoning ordinances. It also includes a field for "non-buildable acreage." This value does not include the acreage removed prior to the build-out, such as public lands, or lands completely covered by water, but rather the parcels that were eligible for build-out calculations, based upon the tax data and zoning, but that did not meet the minimum zoning or upland requirements.

Table 1-4. Acreage By Build-out Type

	Residential Land	Non Residential	Non Buildable	Total Examined in Analysis
Evesham Twp	1,731	227	7,687	9,646
Hammonton Town	2,266	1,221	6,681	10,168
Little Egg Harbor Twp	1,703	793	2,877	5,373
Medford Lakes Boro	15	2	261	278
Medford Twp	5,865	573	7,359	13,796
Tuckerton Boro	307	92	368	767
GRAND TOTAL	**11,887**	**2,908**	**25,233**	**40,028**

Table 1-5 uses the findings in the first two tables to show the average number of acres required for each housing unit developed, as well as the percent of area developed for non-residential development in relation to the minimum required lot size. The build-out suggests that the average residential density across the six towns is slightly under ½ acre per unit, ranging from 5/6 acre per unit in Medford

[7] The municipalities in the study area were not all completely within the boundary of the Pinelands Commission. For reference: 55% of Evesham is in the Pinelands Area, Hammonton 100%, Little Egg Harbor 24%, Medford Lakes 100%, Medford Township 78%, and Tuckerton 0%.

Township to 1/3 acre per unit in Tuckerton (first column). On the non-residential side, it is interesting to note the Floor Area Ratio (FAR), or the ratio of allowable development to the amount of land required. While FAR equals about 10% in Medford Township, in Little Egg Harbor Township, 116% of the site can be used for non-residential development (last column). This does not mean that the entire site will be occupied by hardscape, but rather reflects the fact that Little Egg Harbor Township permits building coverage to occupy up to half of a property, and permits a maximum height of 2.5 stories.

Table 1-5. Development Densities Related to Build-out		
	Acres Per Housing Unit	**Floor Area Ratio**
Evesham Twp	0.76	10%
Hammonton Town	0.73	26%
Little Egg Harbor Twp	0.49	116%
Medford Lakes Boro	0.45	72%
Medford Twp	0.84	9%
Tuckerton Boro	0.34	22%

Chapter 2: Watershed Characterization and Integrity

This section is organized in two ways. First, it addresses all characteristics for each target area. Second, it provides an overview of how the characteristics differ among the target areas and McDonalds Branch, the comparison subwatershed. The comprehensive assessment approach provides an easier overview of each target area and allows for understanding of how the specific characteristics relate within one area. The comparison approach provides an easier understanding of how each characteristic differs among the target areas. All analyses cover the full area of all HUC14 subwatersheds being studied, but are also described by municipality and Pinelands growth designation where appropriate. The following characteristics are described.

Table 2-1. Watershed Integrity Characteristics

Characteristic	Description
Land use/land cover (LU/LC) and trends	NJDEP LU/LC data are available from early 1986, which is relatively close to the 1981 adoption date of the Pinelands Comprehensive Management Plan (CMP). Development through 1986 is expected to primarily reflect prior and grandfathered development activity following CMP adoption (including development authorized under interim controls under the Pinelands Protection Act). Therefore 1986 can be used to represent baseline land use/land cover conditions. Overviews are provided regarding land use and land cover trends, with statistics and maps that highlight changes from one period to the next, by subwatershed, municipality and growth area designation. NJDEP LU/LC data are also available from 1995, 2002 and 2007. Although NJDEP has released 2012 aerial orthophotography, these images were not available for this report as GIS land use/land cover data. The 2012 images can be used to assess qualitative changes in land cover where major developments have occurred. However, this period coincides with the recent major recession and a very low level of new development.
Development trends and patterns	Using Census data and LU/LC data from 1986 through 2007, assess how development patterns have changed through 2007 using development density, shift from grid to non-grid streets, etc.
Impervious surfaces	Using LU/LC data from 1995 through 2007, assess impervious surface trends. Characterize the relationship of development patterns and impervious surface to stormwater systems and surface waters, by subwatershed
Riparian areas and trends	Evaluate riparian areas (using an approach adapted from Highlands Council, 2008,) to identify relative losses of natural riparian areas by subwatershed. Riparian areas are defined as the following lands that are contiguous to non-tidal natural rivers, streams and lakes: freshwater wetlands, floodprone areas, hydric soils and a wildlife corridor of 300 feet perpendicular to the water body.
Flood prone areas and trends	Using flood prone areas from 1986 LU/LC data and FEMA, assess development through 2007, by subwatershed.
Forest areas and trends	Using forested areas from 1986 LU/LC data, assess forest loss or gain through 2007, by subwatershed.
Wetland areas and trends	Using wetlands areas from 1986 LU/LC data, assess development through 2007, by subwatershed.

Table 2-1. Watershed Integrity Characteristics	
Characteristic	**Description**
Ground water recharge	Prime Ground Water Recharge Areas (PGWRA) are defined as the portions of a subwatershed with the highest recharge potential that in combination contribute 40% of total subwatershed recharge. This report relies on NJDEP mapping of ground water recharge potential using the GSR-32 method (Charles, et al. 1993) with 1995 Land Use/Land Cover data, and therefore 1995 is used as the point of comparison with 2007, rather than 1986, to assess losses of PGWRA from development by subwatershed.
Protected areas	Using available municipal, county, State and land trust data, identify areas that are protected from development by fee simple ownership or easements. Identify those currently used for active recreation or farmland, and the potential for environmental effects from those uses.

Evesham/Medford Target Area

Land use/land cover and trends

The graphs in **Figures 2-1** show the modifications in land use/ land cover (LU/LC) for the full municipalities and then for each of the HUC14 subwatersheds (see **Figure ES-2**) within the target area. Overall urban land uses increased by 3000 acres in Evesham Township and nearly 2000 acres in Medford Township, while changing little in Medford Lakes. These urban land changes are related to population trends. Evesham has undergone the most rapid change in population, adding 24,030 people (112%) from 1980 to 2010, with an average increase of around 8,000 people per decade. Medford Township with its larger area has seen only a comparatively modest increase of 5,411 people (31%). The only municipality of the three to decrease in population size was Medford Lakes, decreasing by 812 people (-16%) in the same period. The new urban areas in Medford Township were mostly from forests but a significant portion also came from agricultural lands and (in 1995-2002) partially from wetlands. In both cases, urbanization was greatest in the 1986-1995 period. **Figure 2-2** below shows the actual LULC distribution for each year in the three municipalities and related subwatersheds.

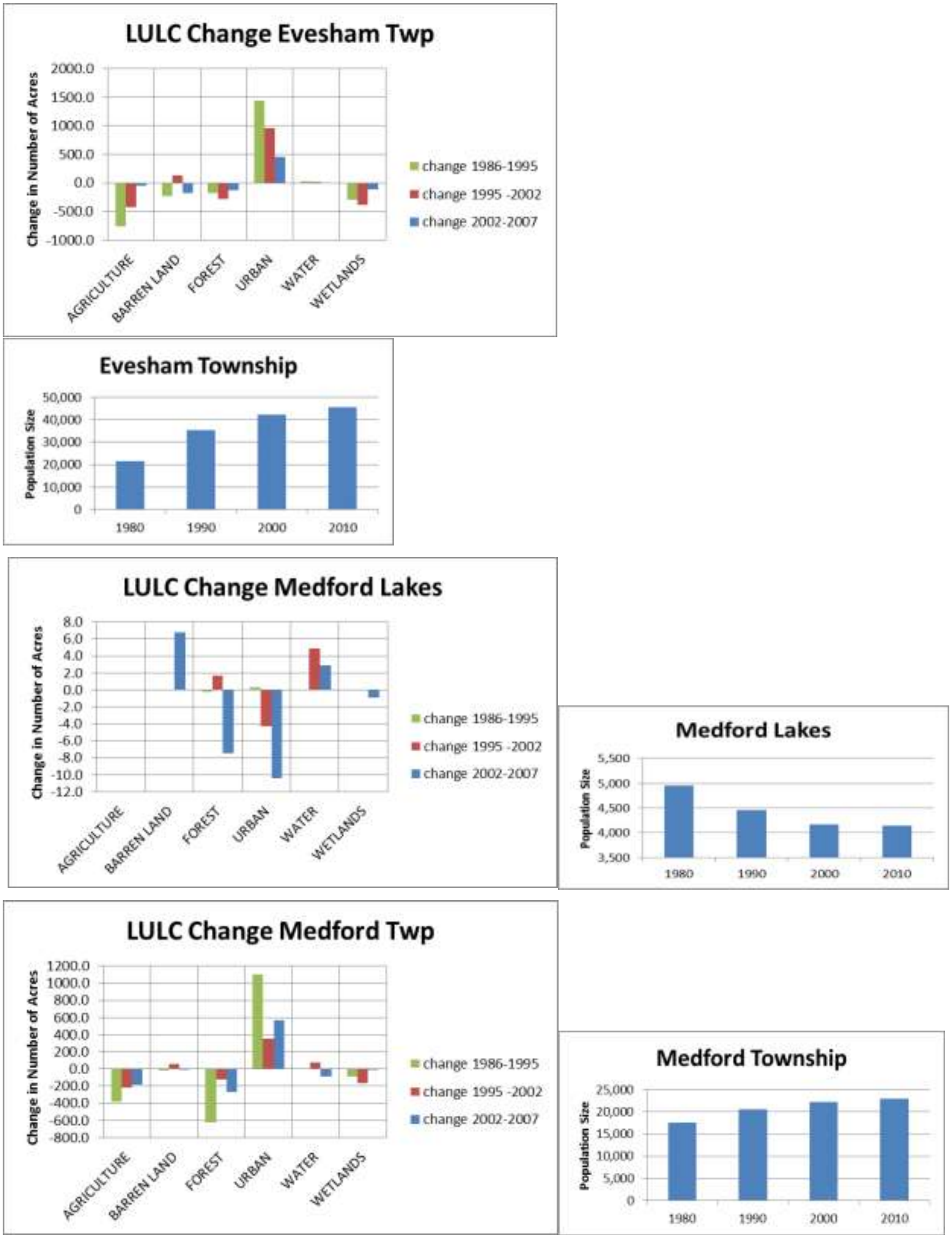


Figure 2-1: Land Use Land Change by Municipality (a) Evesham Township (b) Medford Lake (c) Medford Township

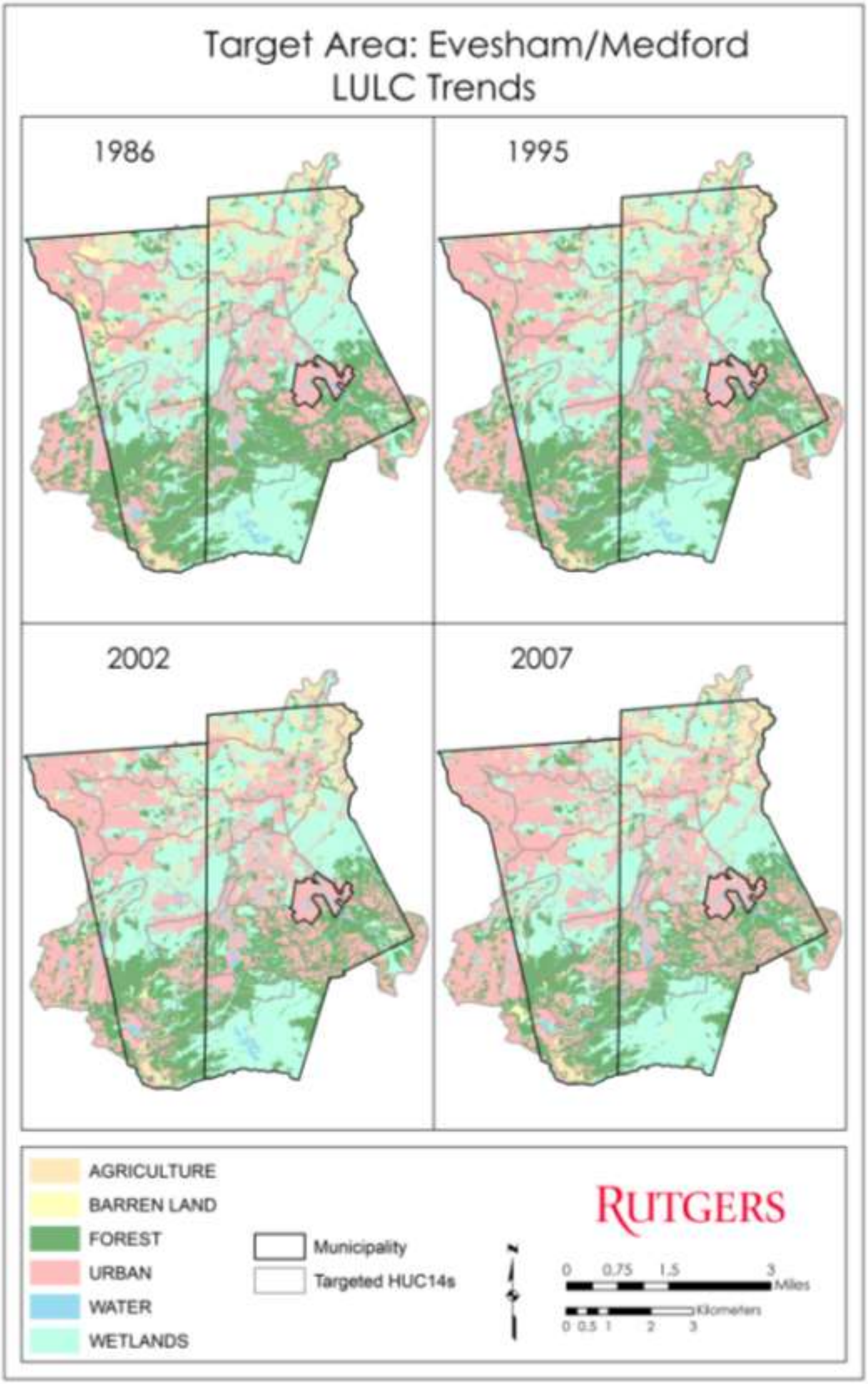
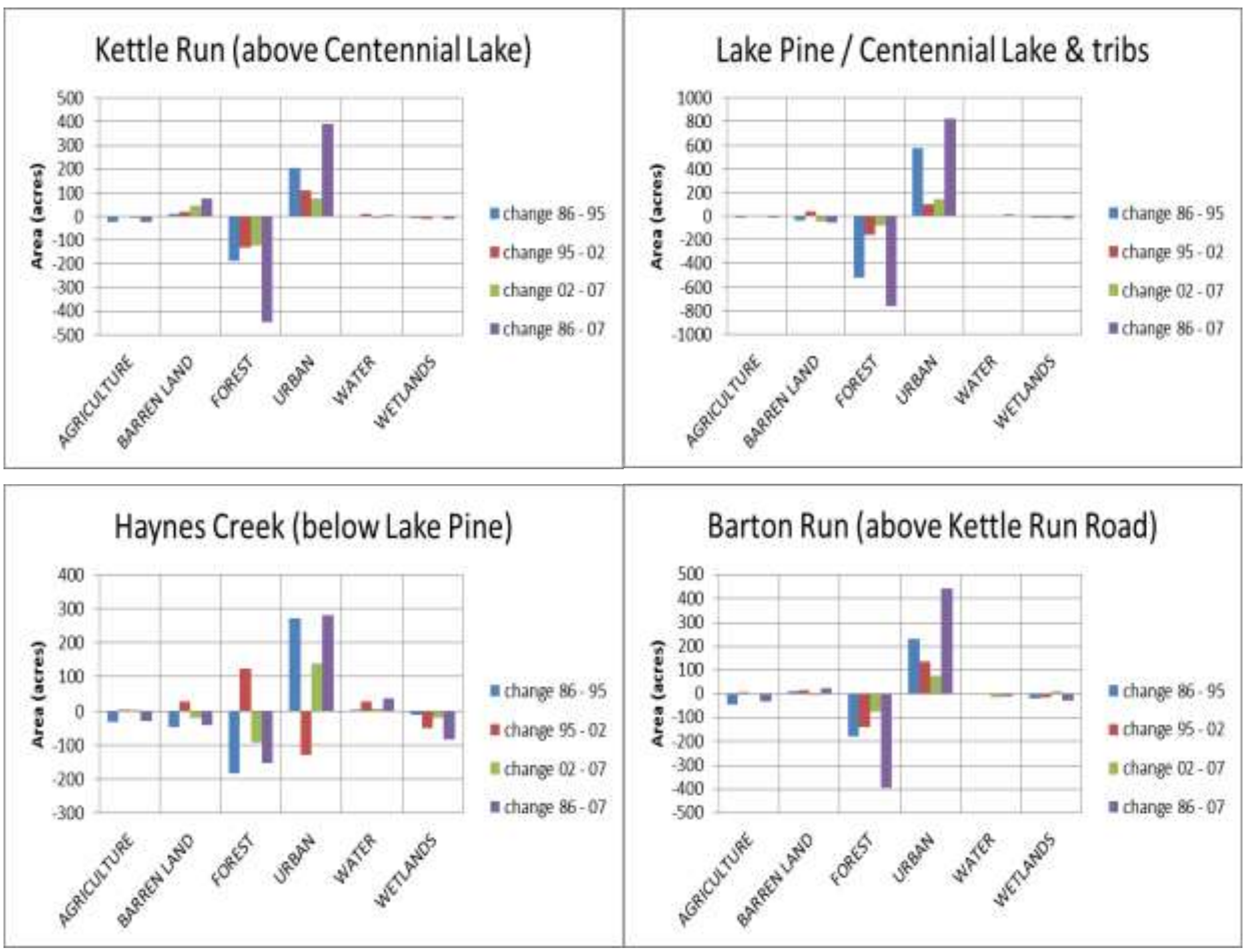


Figure 2-2: Land Use Land Change by Municipality 1986 through 2007

The subwatersheds with the greatest increases in urban land use were as listed in **Table 2-2** and shown in **Figure 2-3**. Of all subwatersheds in the target area, only Haynes Creek (below Lake Pine) saw an increase of less than 300 acres of urban land from 1986-2007.

Table 2-2. Overview of Urban Land Use Gains by Subwatershed

HUC14	Subwatershed Name	Urban Land Use Gains (acres)	Primary Affected Areas
02040202060010	Kettle Run (above Centennial Lake)	390	mostly from forests
02040202060020	Lake Pine / Centennial Lake & tribs	825	mostly from forests
02040202060030	Haynes Creek (below Lake Pine)	282	mostly from forests and wetlands
02040202060030	Barton Run (above Kettle Run Road)	442	mostly from forests
02040202060040	Barton Run (below Kettle Run Road)	563	mostly from agriculture and wetlands
02040202060050	Rancocas Creek SW Branch (above Medford Br)	770	mostly from agriculture but also from wetlands
02040202060080	Rancocas Creek SW Branch (below Medford Br)	838	mostly from agriculture but also from wetlands



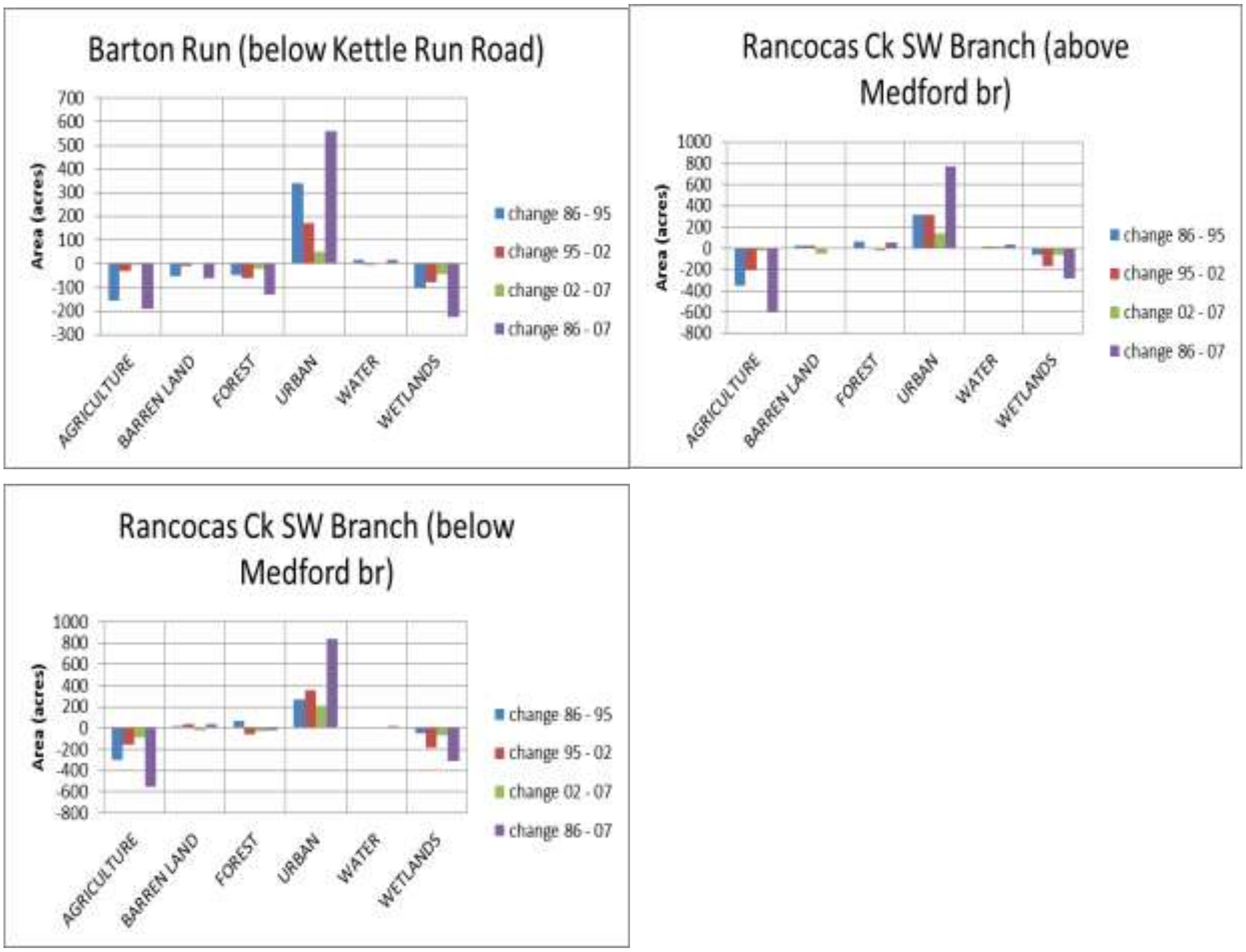


Figure 2-3: Land Use Land Change by Subwatershed

Impervious surfaces

As noted above, Evesham was 15% impervious surface in 2007 (up from 12% in 1995) with new areas of moderate and higher density development at both the southern end (in the Pinelands Area) and the northern end (out of the Pinelands Area). Medford Lakes remained essentially unchanged at 23%. Medford Township also remained relatively stable at roughly 7%, though as shown on **Figure 2-4** there were new higher density developments in the Pinelands Area portion of the Township. However, from a land use perspective, having concentrated growth in local centers can be desirable. From an environmental perspective, the issue is more appropriately focused on impervious surfaces at a subwatershed or watershed scale, rather than on a parcel, project or municipal scale. **Figure 2-5** shows impervious surface for each of the subwatersheds. Of note is that four show increases of 2% or more, with Rancocas Creek SW Branch (above Medford br) increasing by 4% in just 12 years.

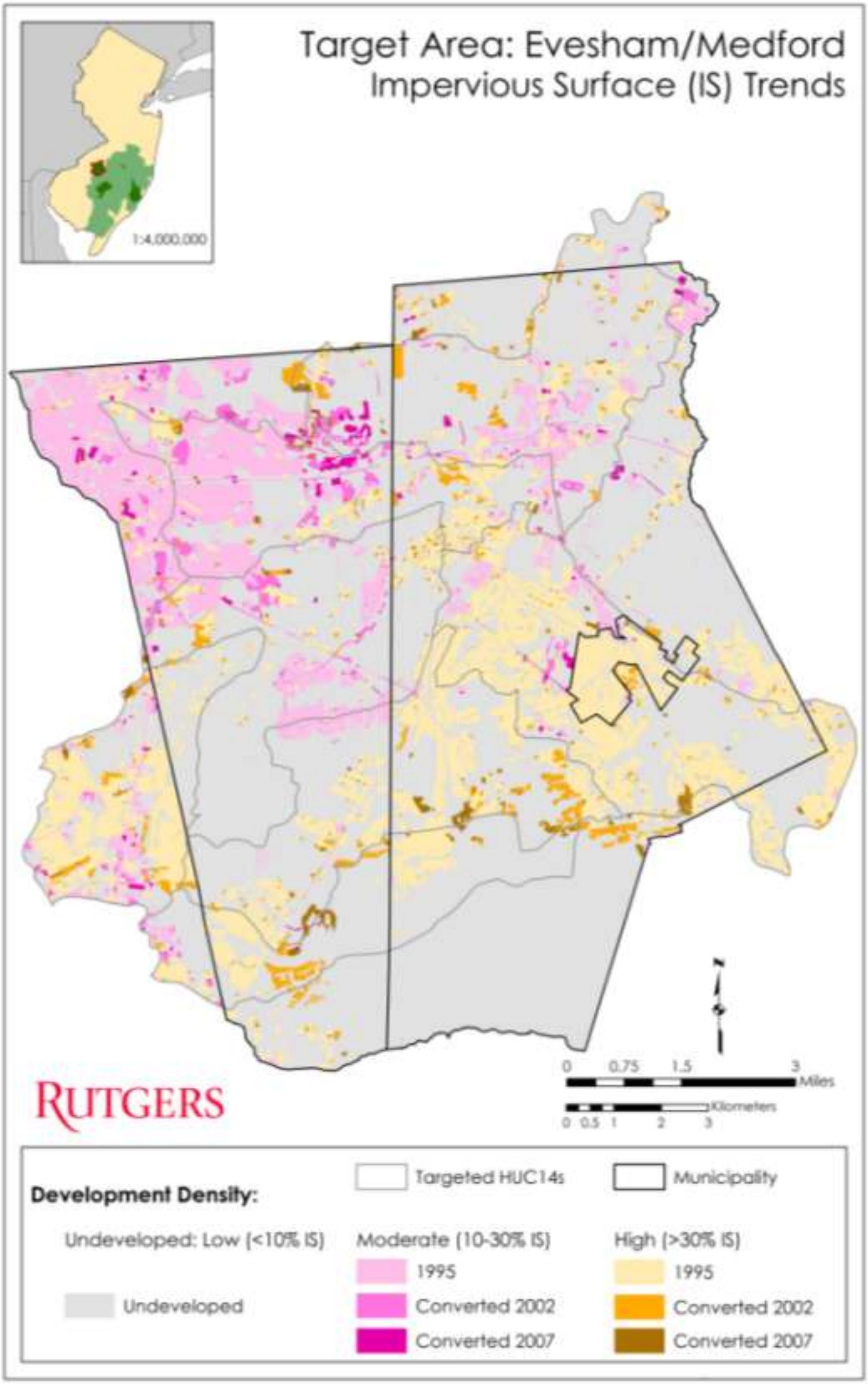


Figure 2-4: Impervious Surface Changes by Municipality 1995 through 2007

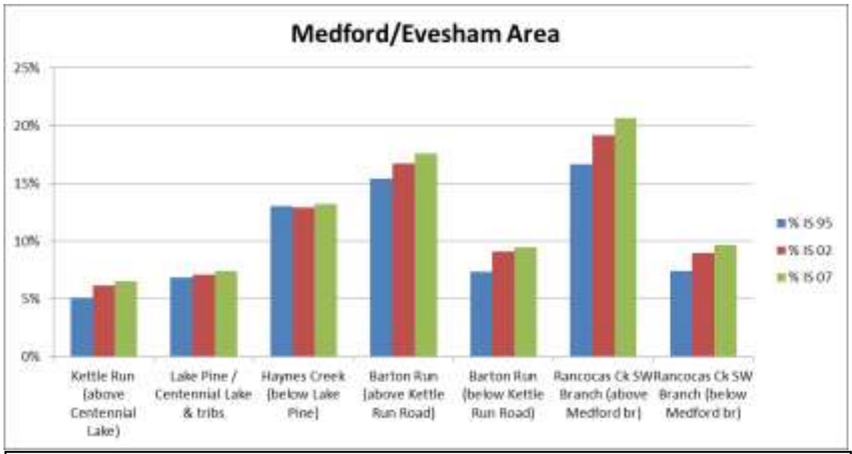


Figure 2-5: Impervious Surface by Subwatershed

Riparian areas and trends

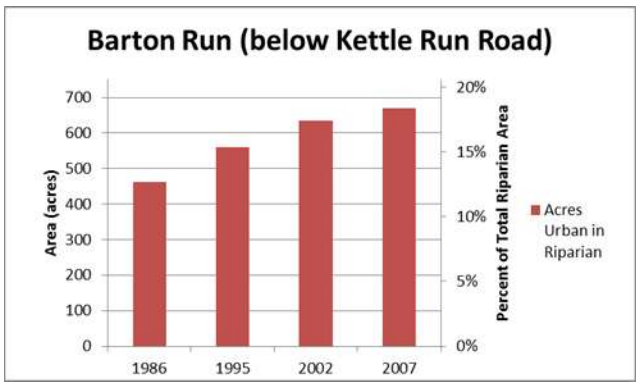
The natural extent of riparian areas in the target subwatershed was estimated using the method outlined in the introduction to this chapter. GIS analysis was used to determine the estimated natural riparian areas converted to urban land uses by 1986, 1995, 2002 and 2007. In the Evesham/Medford target area, riparian area losses ranged greatly with Medford Lakes (which has 21 lakes and connecting streams) showing by far the largest by percentage of losses but essentially no change since 1986. Both Evesham and Medford Townships evidence considerable urban development within riparian areas from 1986 to 2007.

Table 2-3. Riparian Area Development 1986 to 2007 by Municipality

Municipality	Total acres original riparian area	Acres urban in riparian 1986	Acres urban in riparian 2007	% Urban 2007	Acres urbanized 1986-2007
Evesham Township	7354	1138	1577	21.4%	439
Medford Lakes Boro	443	341	334	75.4%	-7
Medford Township	13949	1991	2264	16.2%	274

From an environmental perspective, the issue is more appropriately focused on riparian area losses at a subwatershed or watershed scale, rather than on a parcel, project or municipal scale. **Table 2-4** shows that three subwatersheds in the area lost more than 4% of additional riparian area from 1986 through 2007, while four subwatersheds had greater than 20% urbanization of riparian areas as of 2007. The graphs for the subwatersheds with the greatest increases (**Figure 2-6**) indicate a gradual development process through the period. **Figure 2-7** shows the riparian areas and losses for the target area.

Table 2-4. Riparian Area Development 1986 to 2007 by Subwatershed				
HUC14	**Subwatershed Name**	**Percent Riparian Area that is Urban 1986**	**Percent Riparian Area that is Urban 2007**	**Change of Acres of Urban In Riparian Areas**
02040202060010	Kettle Run (above Centennial Lake)	12.2%	12.2%	0
02040202060020	Lake Pine / Centennial Lake & tribs	20.4%	23.3%	69
02040202060030	Haynes Creek (below Lake Pine)	40.5%	43.2%	84
02040202060040	Barton Run (above Kettle Run Road)	28.0%	31.6%	43
02040202060050	Barton Run (below Kettle Run Road)	12.7%	18.4%	208
02040202060080	Rancocas Ck SW Branch (above Medford br)	23.8%	31.3%	118
02040202060100	Rancocas Ck SW Branch (below Medford br)	10.1%	14.9%	98



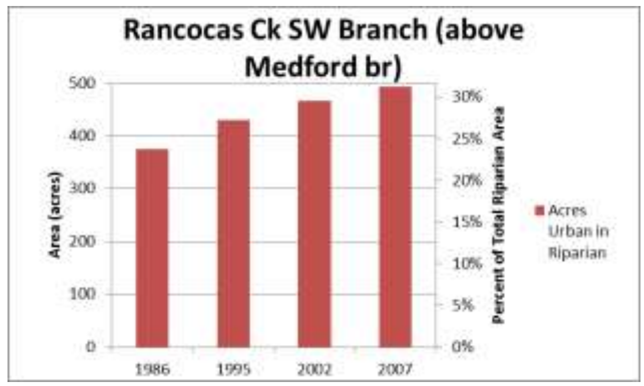


Figure 2-6: Riparian Areas in Urban Land Use for Selected Subwatersheds

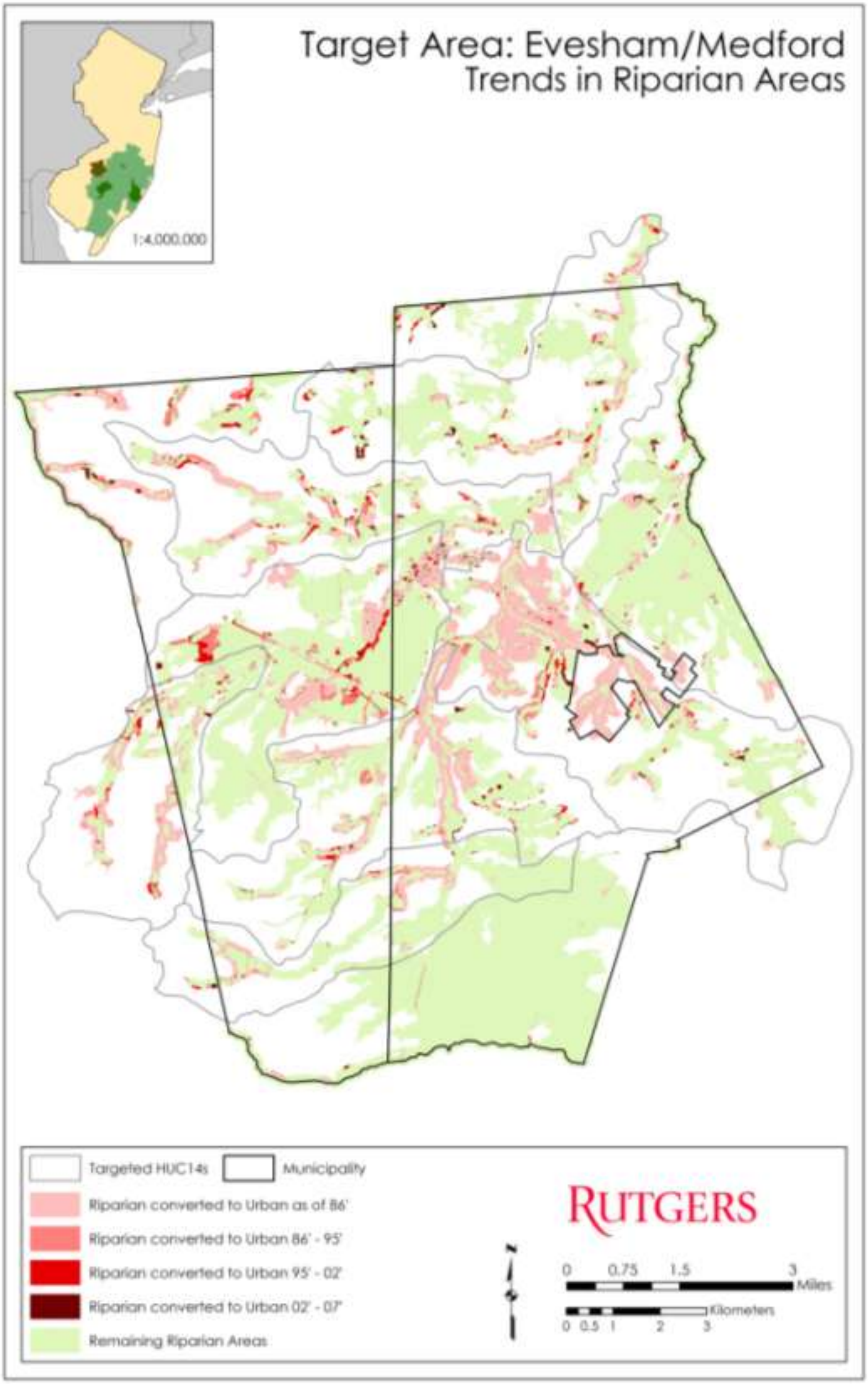


Figure 2-7: Conversion of Riparian Areas to Urban Land Use 1986 through 2007

Flood prone areas and trends

As shown in **Table 2-5**, Barton Run (below Kettle Run Road) has had the most development of urban onto flood prone areas, adding 71 acres in the 21 year time frame from 1986 to 2007. Haynes Creek (below Lake Pine) has the greatest overall development of flood prone areas in this area, at 31%, while Rancocas Ck SW Branch (above Medford br) is nearly as high at 26%. These values indicate subwatersheds where considerable urban areas are at risk of flooding unless elevated. The Rancocas Creek experienced disastrous flooding in July 2004 (USGS, n.d.). **Figure 2-8** shows both the flood prone areas already developed as of 1986 and the additional areas developed by 2007. As can be seen, several streams are lined with development on both sides as of 1986, with even more development added from 1986 to 1995.

Table 2-5. Flood Prone Area Development 1986 to 2007 by Subwatershed

HUC14	Subwatershed Name	Percent Flood Prone Area as Urban 1986	Percent Flood Prone Area as Urban 2007	Change of Urban Acres In Flood Prone Areas
02040202060010	Kettle Run (above Centennial Lake)	8%	7%	-5
02040202060020	Lake Pine / Centennial Lake & tribs	20%	21%	5
02040202060030	Haynes Creek (below Lake Pine)	28%	31%	12
02040202060040	Barton Run (above Kettle Run Road)	11%	8%	-1
02040202060050	Barton Run (below Kettle Run Road)	10%	16%	71
02040202060080	Rancocas Ck SW Branch (above Medford br)	20%	26%	20
02040202060100	Rancocas Ck SW Branch (below Medford br)	6%	9%	25

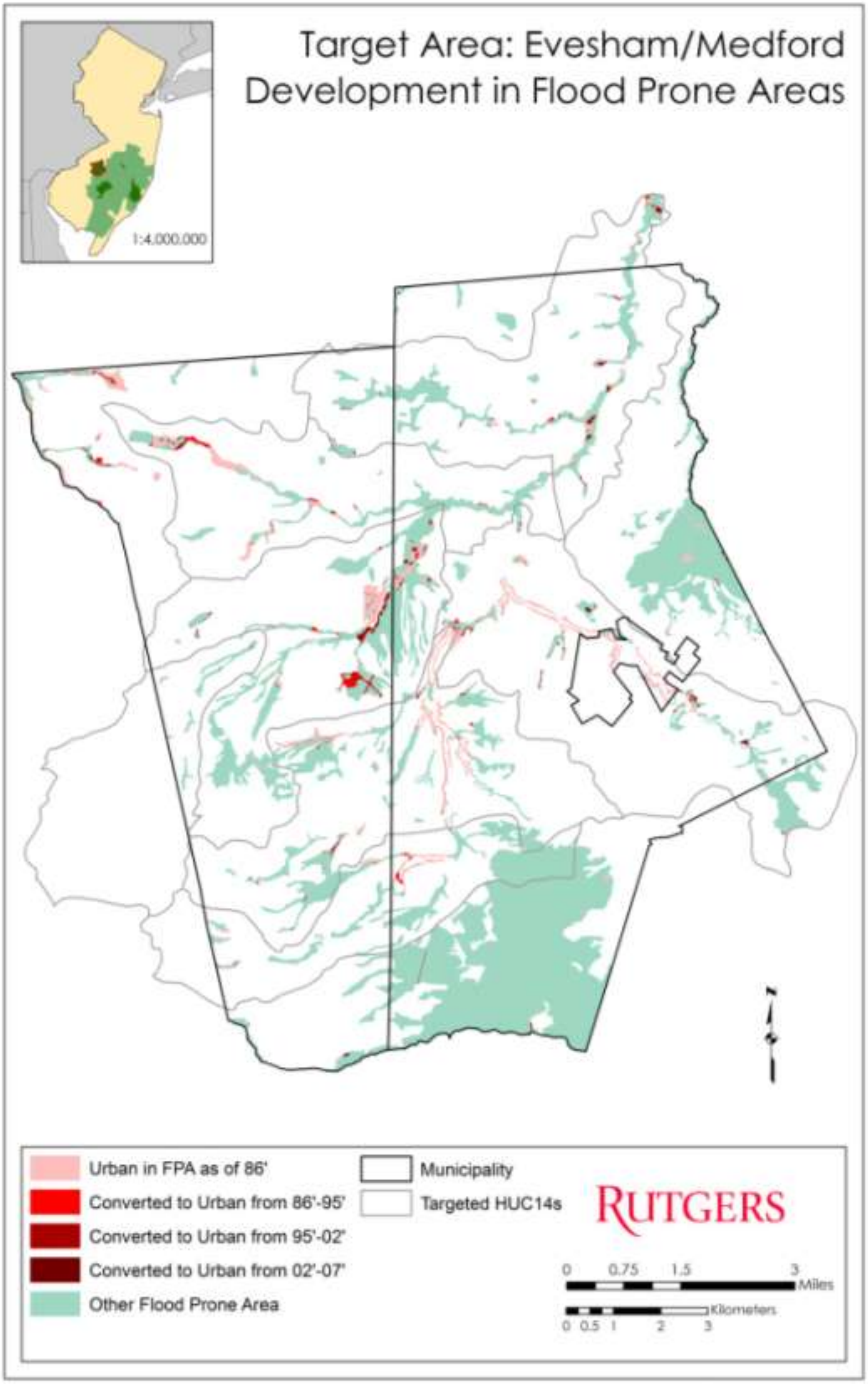


Figure 2-8: Conversion of Flood Prone Areas to Urban Land Use 1986 through 2007

Forest areas and trends

Non-wetland forests have important functions for water resources and ecological purposes. (Wetland forests are included within the wetlands section below.) Medford Lakes has very little forest area remaining, due to its high level of urban development and impervious surfaces, but this forest area is essentially unchanged through the project period of 1986 through 2007. Medford Township, however, lost over 1000 acres of forest (4% of its total area), while Evesham lost nearly 600 acres (3% of its total area).

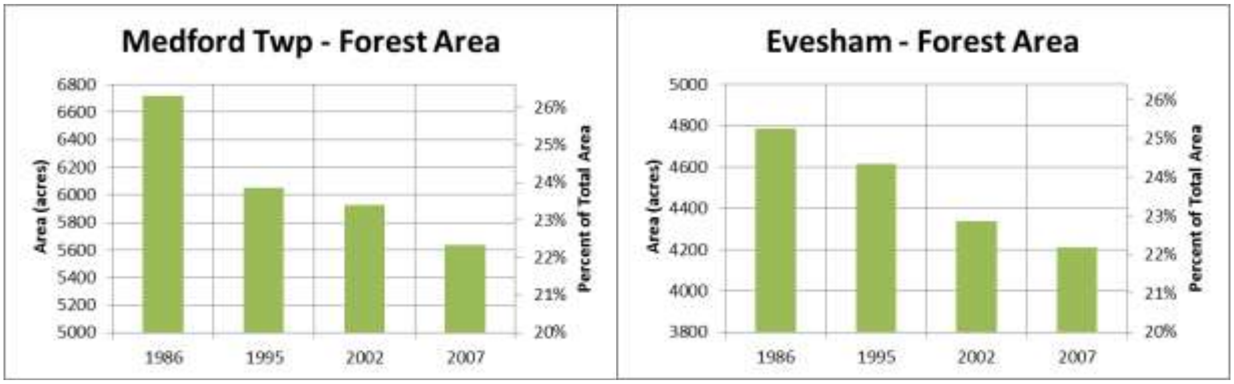


Figure 2-9: Evesham and Medford Townships: Forested Areas 1986 through 2007

The results by subwatershed are mixed, as shown in **Table 2-6**. Three subwatersheds saw forest cover decline by 10% or more of the total subwatershed area (and at least 300 acres of forest loss), in two cases where forest cover shifted from a majority of the subwatershed to less than 50%. As shown in **Figure 2-10**, many of these losses are within the Pinelands Area in the southern portions of the two townships, which is also where most of the remaining forest lands are located.

Table 2-6. Forest Losses 1986 to 2007 by Subwatershed

HUC14	Subwatershed Name	1986 Forest	2007 Forest	Forest Losses	Forest Lost (Acres)
02040202060010	Kettle Run (above Centennial Lake)	61%	49%	12%	-444.92
02040202060020	Lake Pine / Centennial Lake & tribs	56%	43%	13%	-763.83
02040202060030	Haynes Creek (below Lake Pine)	31%	29%	2%	-152.85
02040202060040	Barton Run (above Kettle Run Road)	31%	21%	10%	-395.48
02040202060050	Barton Run (below Kettle Run Road)	17%	14%	3%	-128.55
02040202060080	Rancocas Ck SW Branch (above Medford br)	5%	6%	-1%	54.57
02040202060100	Rancocas Ck SW Branch (below Medford br)	8%	7%	1%	-25.47

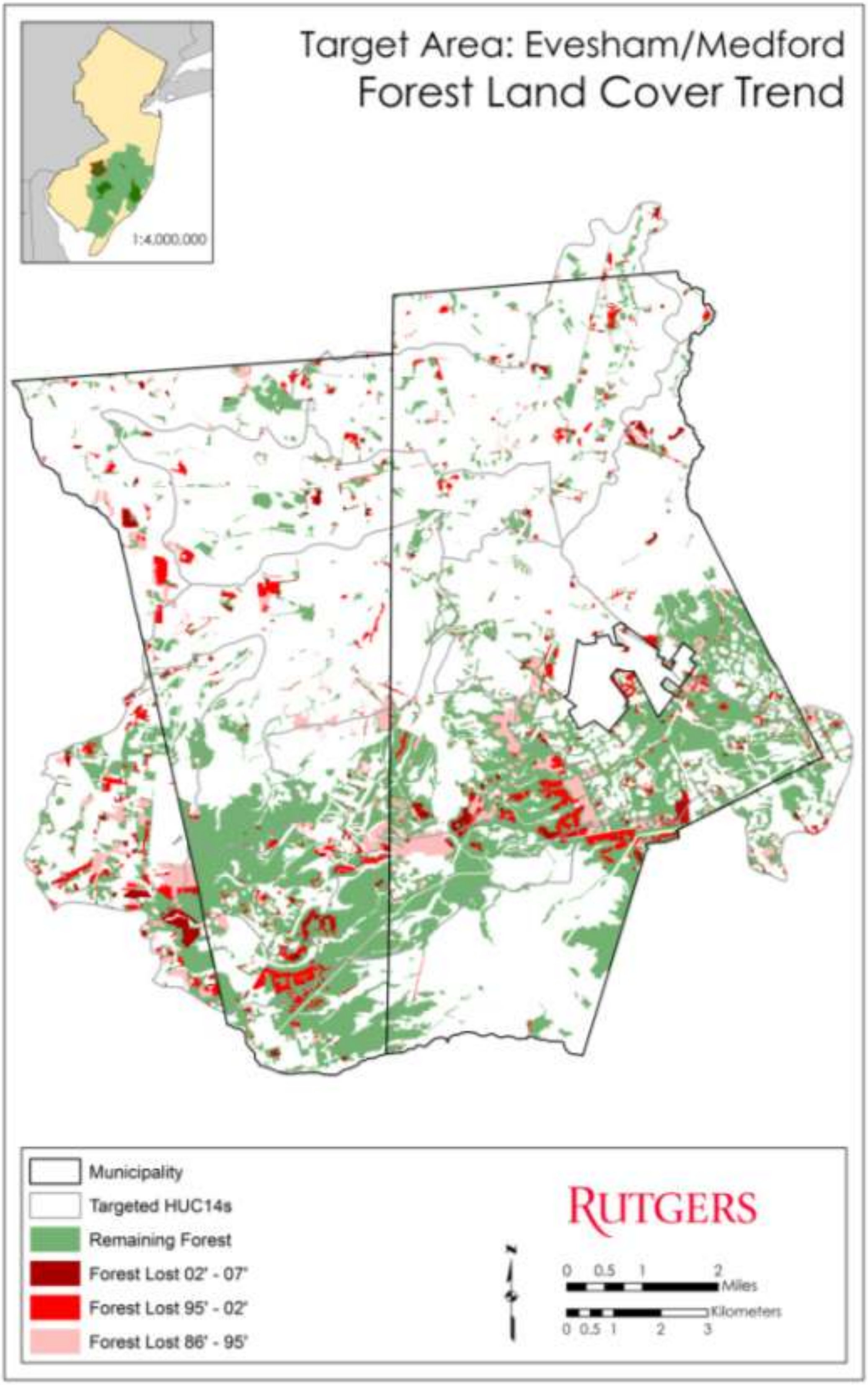
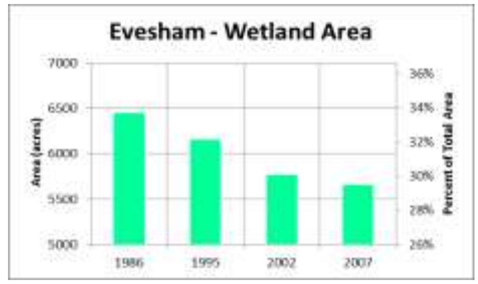


Figure 2-10: Forest Losses 1986 through 2007

Wetland areas and trends

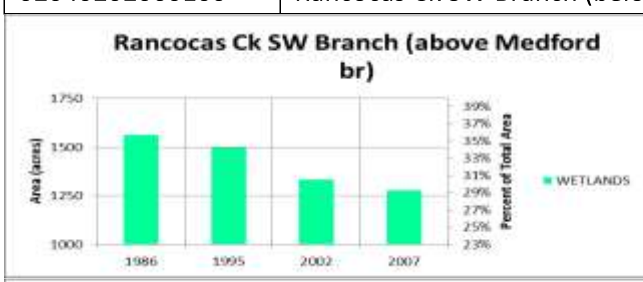
Evesham has the highest percentage of wetlands loss, 4.2%, and the largest area loss, 798 acres, from 1986 to 2007. The remaining municipalities all lost no more than 1.2% of their wetlands. The next largest area loss in this target area is Medford Township with 262 acres.

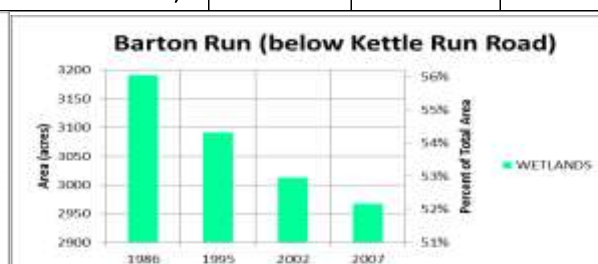
Table 2-7. Wetlands by Municipality			
	Wetlands as % of total municipal area		Change 1986-2007 (acres)
Municipality	**1986**	**2007**	
Evesham Twp	34%	30%	-798.4
Medford Lakes Boro	1%	1%	-0.9
Medford Twp	39%	38%	-262.1



The Medford/Evesham target area had the highest loss of wetlands of the three target areas. Three of its subwatersheds lost from 224 to 314 acres of wetlands, as shown in **Table 2-8** and **Figure 2-11**. These HUC14s had a 3.9%, 6.4% and 5.2% reduction respectively of wetlands (as a percentage of total subwatershed area), which is higher than any other subwatersheds from the 2 other target areas. However, despite significant losses, one subwatershed – Barton Run (below Kettle Run Road) – remains more than 50% wetlands. As can be seen in **Figure 2-12**, many of the lost wetlands were in the northern portions of Evesham and Medford Townships, portions of which are not within the Pinelands Area.

Table 2-8. Wetlands Losses 1986 to 2007 by Subwatershed				
HUC14	**Subwatershed Name**	**Wetlands as % of subwatershed**		**Change 1986-2007 (acres)**
		1986	**2007**	
02040202060010	Kettle Run (above Centennial Lake)	17%	17%	-10.09
02040202060020	Lake Pine / Centennial Lake & tribs	18%	17%	-25.43
02040202060030	Haynes Creek (below Lake Pine)	14%	13%	-85.58
02040202060040	Barton Run (above Kettle Run Road)	18%	17%	-27.01
02040202060050	Barton Run (below Kettle Run Road)	56%	52%	-224.39
02040202060080	Rancocas Ck SW Branch (above Medford br)	35%	29%	-284.51
02040202060100	Rancocas Ck SW Branch (below Medford br)	43%	37%	-314.11





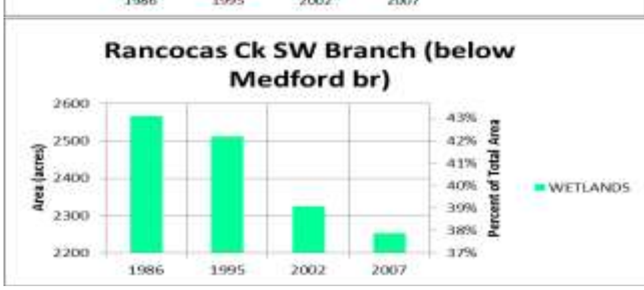


Figure 2-11: Wetlands 1986 through 2007 by Subwatershed

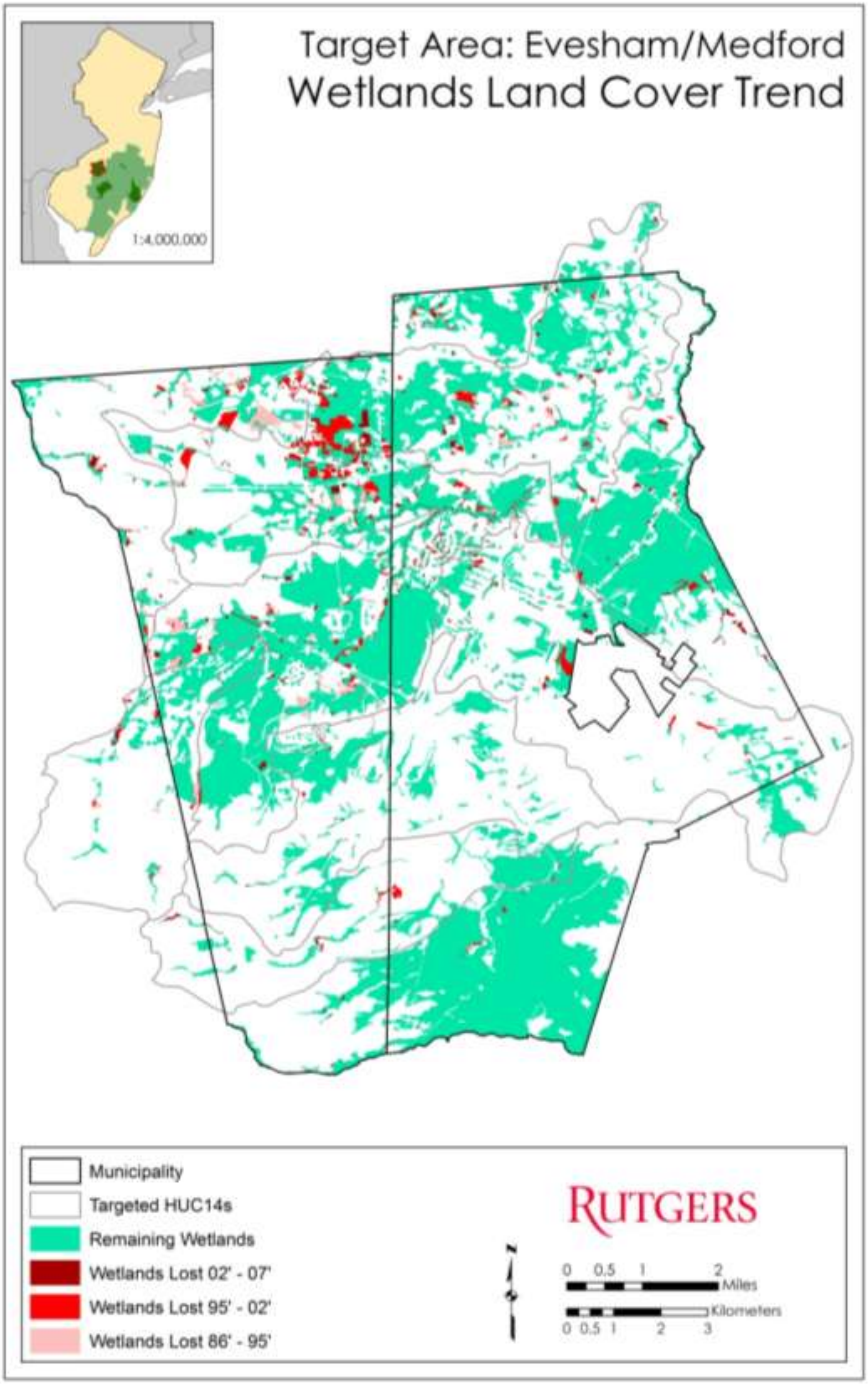


Figure 2-12: Wetlands Losses 1986 through 2007

Ground water recharge

Ground water recharge is the primary source of water to both wells and stream flow in the Pinelands. NJDEP evaluated total ground water recharge by subwatershed using its GSR-32 method (NJDEP, 2005). **Table 2-9** shows the total recharge values for subwatersheds in this target area. Drought recharge is based upon precipitation values during the 1960s drought, which is New Jersey's drought of record for long-term droughts of the type most likely to reduce ground water contributions to surface water flows and wetlands inundation.

Table 2-9. Ground Water Recharge by Subwatershed

HUC14	Subwatershed Name	Annual Average Recharge (MGY)	Drought Recharge (MGY)	% Difference
02040202060010	Kettle Run (above Centennial Lake)	988	810	18%
02040202060020	Lake Pine / Centennial Lake & tribs	1642	1374	16%
02040202060030	Haynes Creek (below Lake Pine)	1736	1455	16%
02040202060040	Barton Run (above Kettle Run Road)	885	757	14%
02040202060050	Barton Run (below Kettle Run Road)	537	447	17%
02040202060080	Rancocas Ck SW Branch (above Medford br)	655	540	18%
02040202060100	Rancocas Ck SW Branch (below Medford br)	860	693	19%

In each subwatershed, some land areas provide better recharge than others; the best are termed Prime Ground Water Recharge Areas (PGWRA). Unlike most of the other evaluations, the definition and mapping of PGWRA are only at the subwatershed scale, not the municipal level. In this target area, four of the six subwatersheds have over 10% of their 1995 PGWRA covered by urban land use, as listed in **Table 2-10**, with Rancocas Ck SW Branch (above Medford br) having 19% of its prime GWR land covered by urban. **Figure 2-13** shows the distribution of developed PGWRA. Most of the urban land is low density development, which may allow for some level of recharge to continue on those properties; the major exceptions are the two Rancocas Creek SW Branch subwatersheds, which have roughly 50% of the developed PGWRA in higher density urban uses that would largely eliminate natural recharge. Most development through 2007 was likely approved prior to NJDEP's more recent recharge retention requirements.

Table 2-10. Prime Ground Water Recharge Area Development 1995 to 2007 by Subwatershed

HUC14	Subwatershed Name	Acres of PGWRA lost to Urban (1995-2007)	Percent PGWRA Occupied by Urban (2007)
02040202060010	Kettle Run (above Centennial Lake)	60	8%
02040202060020	Lake Pine / Centennial Lake & tribs	215	13%
02040202060030	Haynes Creek (below Lake Pine)	142	8%
02040202060040	Barton Run (above Kettle Run Road)	112	13%
02040202060050	Barton Run (below Kettle Run Road)	6	1%
02040202060080	Rancocas Ck SW Branch (above Medford br)	151	19%
02040202060100	Rancocas Ck SW Branch (below Medford br)	112	12%

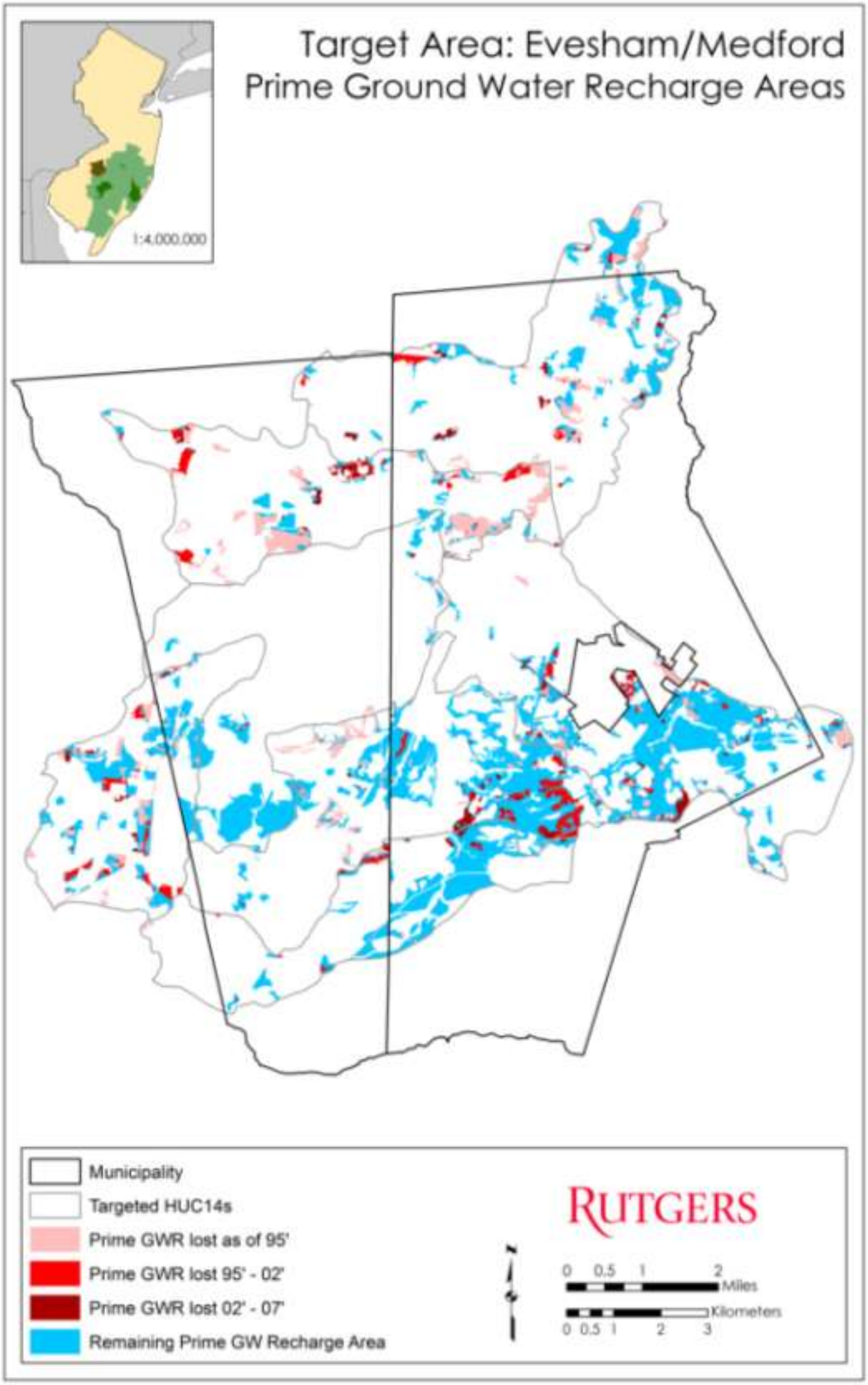


Figure 2-13: Prime Ground Water Recharge Areas Losses 1995 through 2007

Protected areas

As shown in **Figure 2-14**, preserved areas are clustered in the southern and eastern portions of Medford Townships, but scattered within Evesham Township. Medford Lakes has no appreciable preserved lands. Preserved lands in the targeted subwatersheds are shown in the following table, by preservation category.

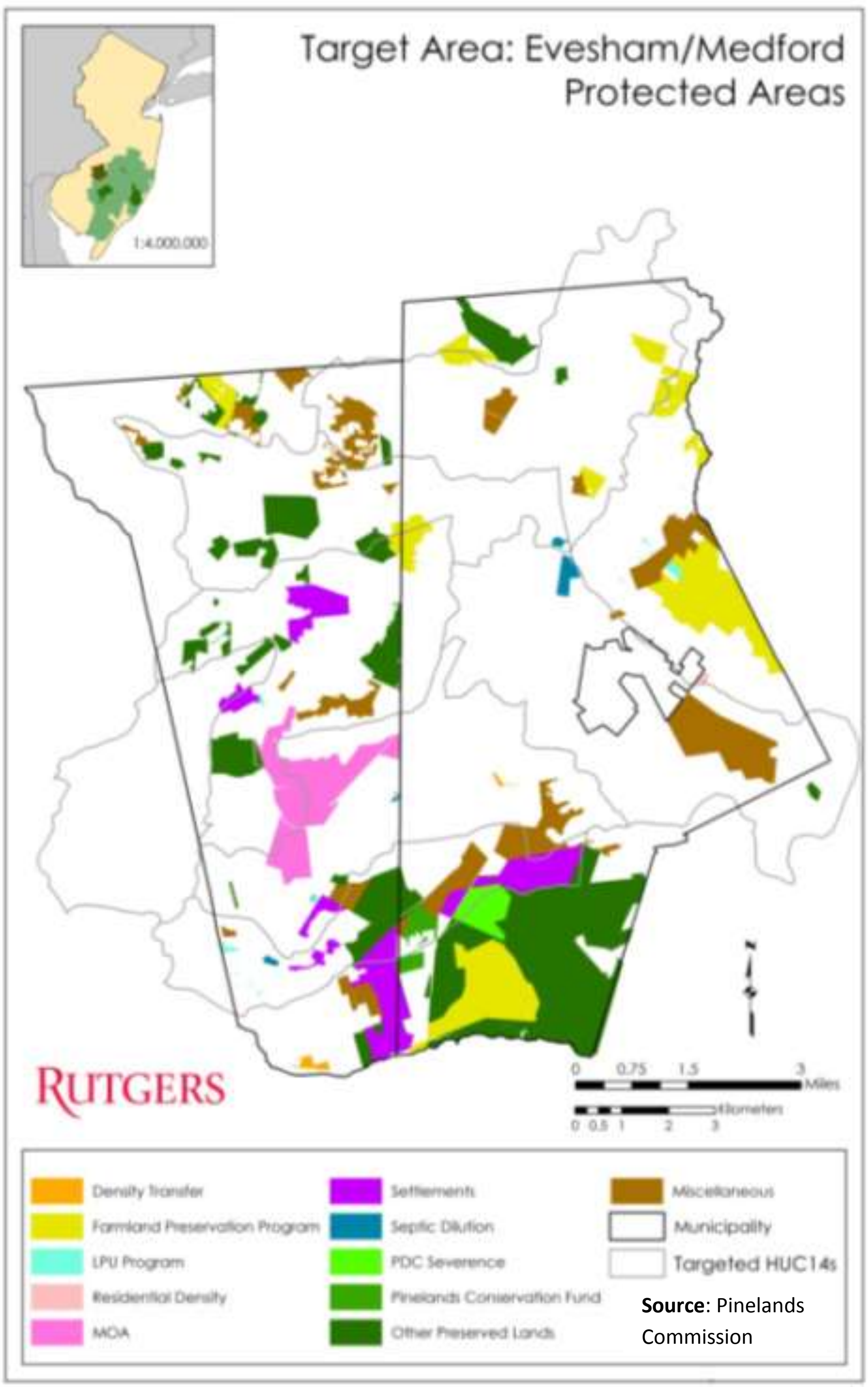


Figure 2-14: Protected Areas

Table 2-11. Preserved Lands by Subwatershed and Category			
HUC14	**Subwatershed Name**	**Preservation Category**	**Acres**
02040202060010	Kettle Run (above Centennial Lake)	State	1400.7
		Land Trusts	492.1
		Conservation Easements	57.6
		Municipal	99.6
02040202060020	Lake Pine / Centennial Lake & tribs	Density Transfer	7.8
		State	60.6
		Conservation Easements	941.5
02040202060030	Haynes Creek (below Lake Pine)	Conservation Easements	680.7
		Land Trusts	5.4
		State	17.3
02040202060040	Barton Run (above Kettle Run Road)	Conservation Easements	759.1
		Municipal	504.5
		Farmland Easement	112.7
		State	77.6
		County	54.7
02040202060080	Rancocas Ck SW Branch (above Medford br)	Farmland Easement	363.7
		Conservation Easements	302.3
		County	39.5
		Municipal	453.5
02040202060100	Rancocas Ck SW Branch (below Medford br)	Land Trusts	25.7

Summary for Target Area

The indicators described above provide different perspectives on watershed and ecological integrity within the target areas. **Table 2-12** provides an overview of the indicator results by subwatershed. It does not represent a definitive analysis, as no generally accepted method exists for comparing the relative importance or value of these indicators. Each has its own value and plays its own part in overall integrity. Indications of significant additional stress over the study period (1986 to 2007) are especially apparent in the last three subwatersheds, with major increases in urban area, loss of riparian areas, loss of wetlands, and for two of the three also losses of flood prone areas and prime ground water recharge areas (PGWRA). These three subwatersheds also have relatively high impervious surface levels and two of the three have minimal preserved open space.

All but one subwatershed lost significant PGWRA (1995-2007), which often will be the highly developable areas with good soils and minimal wetlands or flood potential. Forest losses were also high in several subwatersheds but not in the last three.

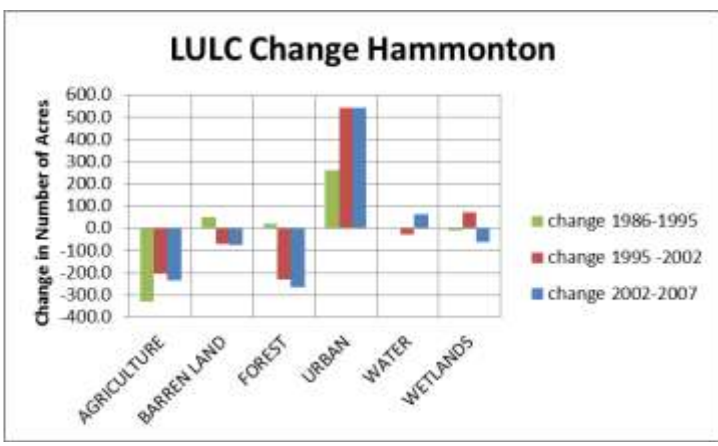
Table 2-12. Compilation of Target Area Indicators of Watershed Integrity
(Values in bold indicate significant increases during period of analysis)

Indicator	02040202060010 Kettle Run (above Centennial Lake)	02040202060020 Lake Pine / Centennial Lake & tribs	02040202060030 Haynes Creek (below Lake Pine)	02040202060040 Barton Run (above Kettle Run Road)	02040202060050 Barton Run (below Kettle Run Road)	02040202060080 Rancocas Ck SW Branch (above Medford br)	02040202060100 Rancocas Ck SW Branch (below Medford br)
Urbanization 1986-2007 (Acres)	390	**825**	282	442	563	**770**	**838**
Impervious Surfaces (%)	7	7	13	18	9	**21**	10
Riparian Area (% Urban)	12.2	23.3	43.2	31.6	**18.4**	**31.3**	**14.9**
Flood Prone Area (% Urban)	7	21	31	8	**16**	**26**	9
Forest % Losses (1986-2007)	**12**	**13**	2	**10**	3	-1	1
Wetlands % Losses (1986-2007)	0	1	1	1	**4**	**6**	**6**
PGWRA (% Urban)	**8**	**13**	**8**	**13**	1	**19**	**12**
Protected Areas (%)	57.5	17.6	10.0	40.8	0	26.2	0.4

Hammonton Target Area

Land use/land cover and trends

Figure 2-15 shows the modifications in land use/ land cover (LU/LC) for the full municipalities and then for each of the HUC14 subwatersheds (see **Figure ES-3**) within the target area. Urban area in the municipality increased by roughly 1300 acres from 1986-2007, mostly from agriculture and forest lands. The losses were primarily in the two most recent periods. Hammonton's population increased by 2,493 from 1980 to 2010, or 20%. **Figure 2-16** shows the actual LULC distribution for each year in Hammonton and related subwatersheds.



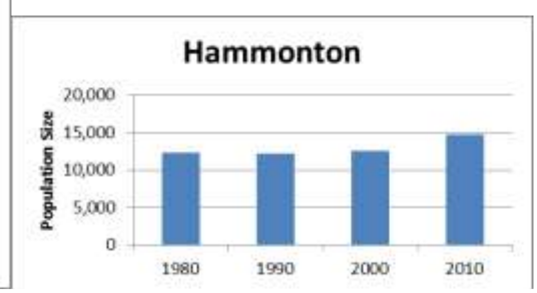


Figure 2-15: Land Use Land Change, Hammonton

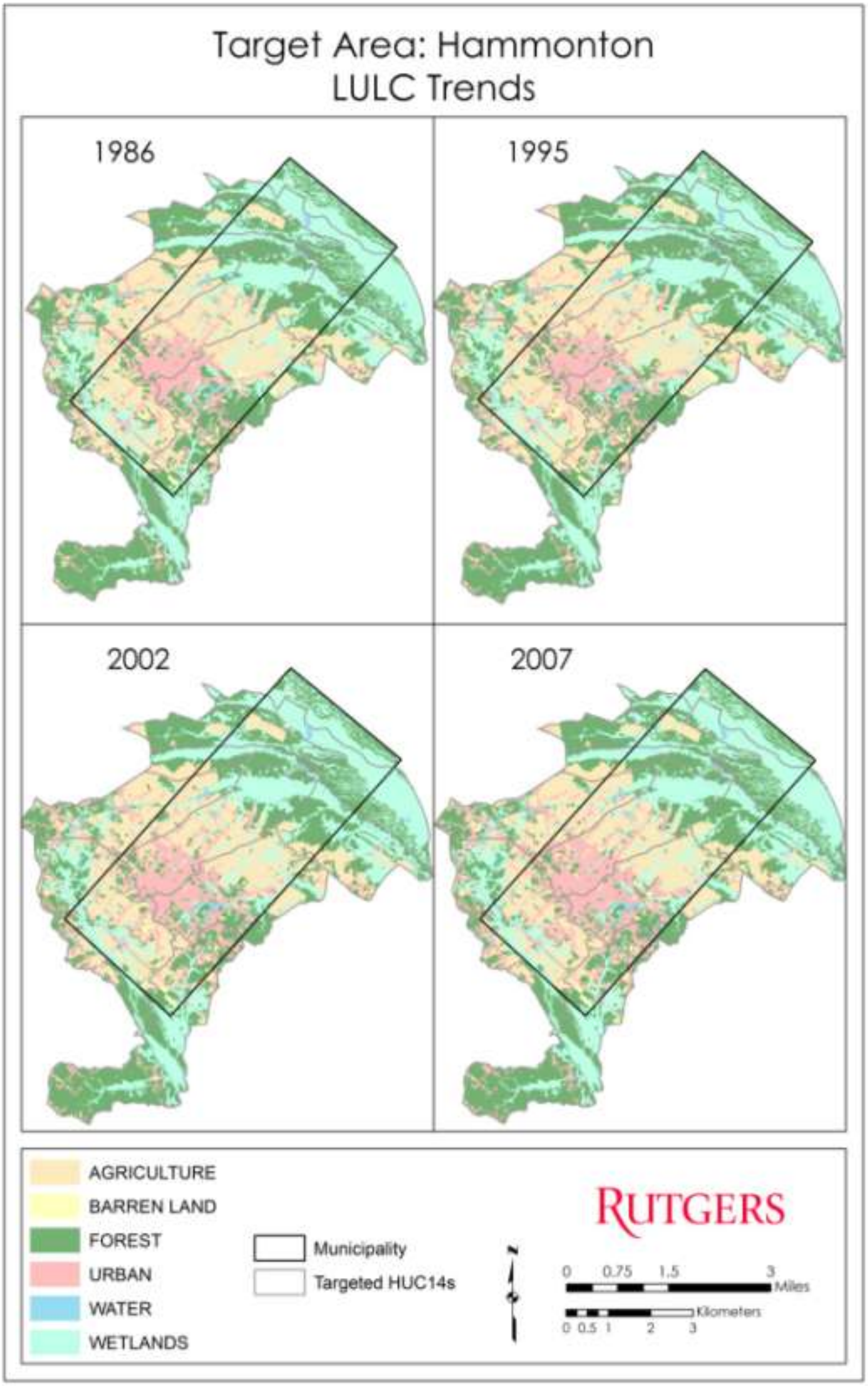
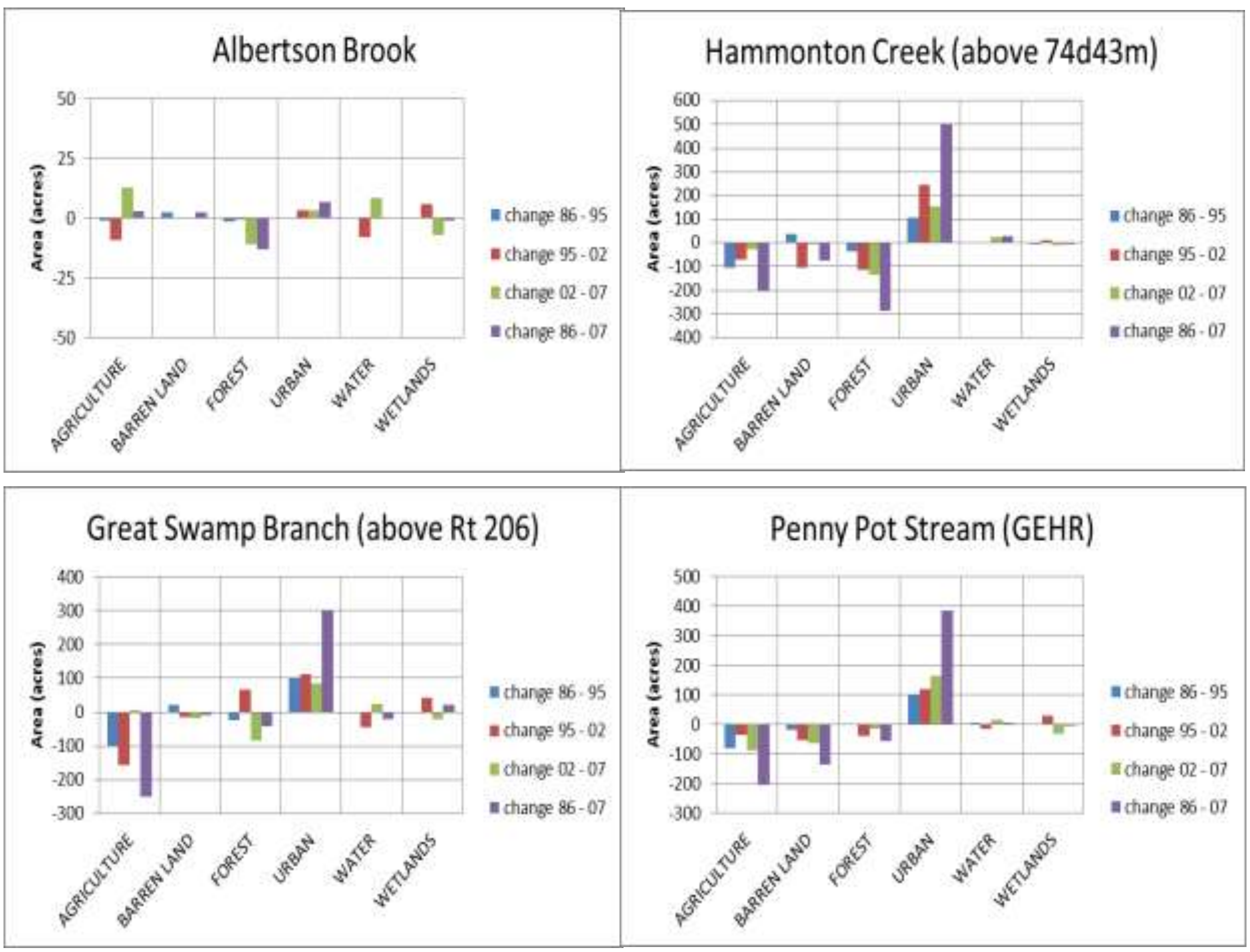


Figure 2-16: Land Use Land Change 1986 through 2007, Hammonton

The subwatersheds with the greatest increases in urban land use were as listed in **Table 2-13** and **Figure 2-17**. Of all subwatersheds in the target area, Albertson Brook, Gun Branch, Nescochague Creek and Sleeper Branch saw an increase of less than 300 acres of urban land from 1986-2007.

Table 2-13. Overview of Urban Land Use Gains by Subwatershed

HUC14	**Subwatershed Name**	**Urban Land Use Gains**	**Primary Affected Areas**
02040301170010	Hammonton Creek (above 74d43m)	Over 500 acres	Mostly from forest and agriculture
02040301160120	Great Swamp Branch (above Rt 206)	300 acres	Mostly from agriculture
02040302030070	Penny Pot Stream (GEHR)	Nearly 400 acres	Mostly from agriculture and barren land
02040301160130	Great Swamp Branch (below Rt 206)	Over 300 acres	Mostly from agriculture
02040302040080	Great Egg Harbor River (GEHR) (39d32m50s to Hospitality Branch)	Over 300 acres	Mostly from forest



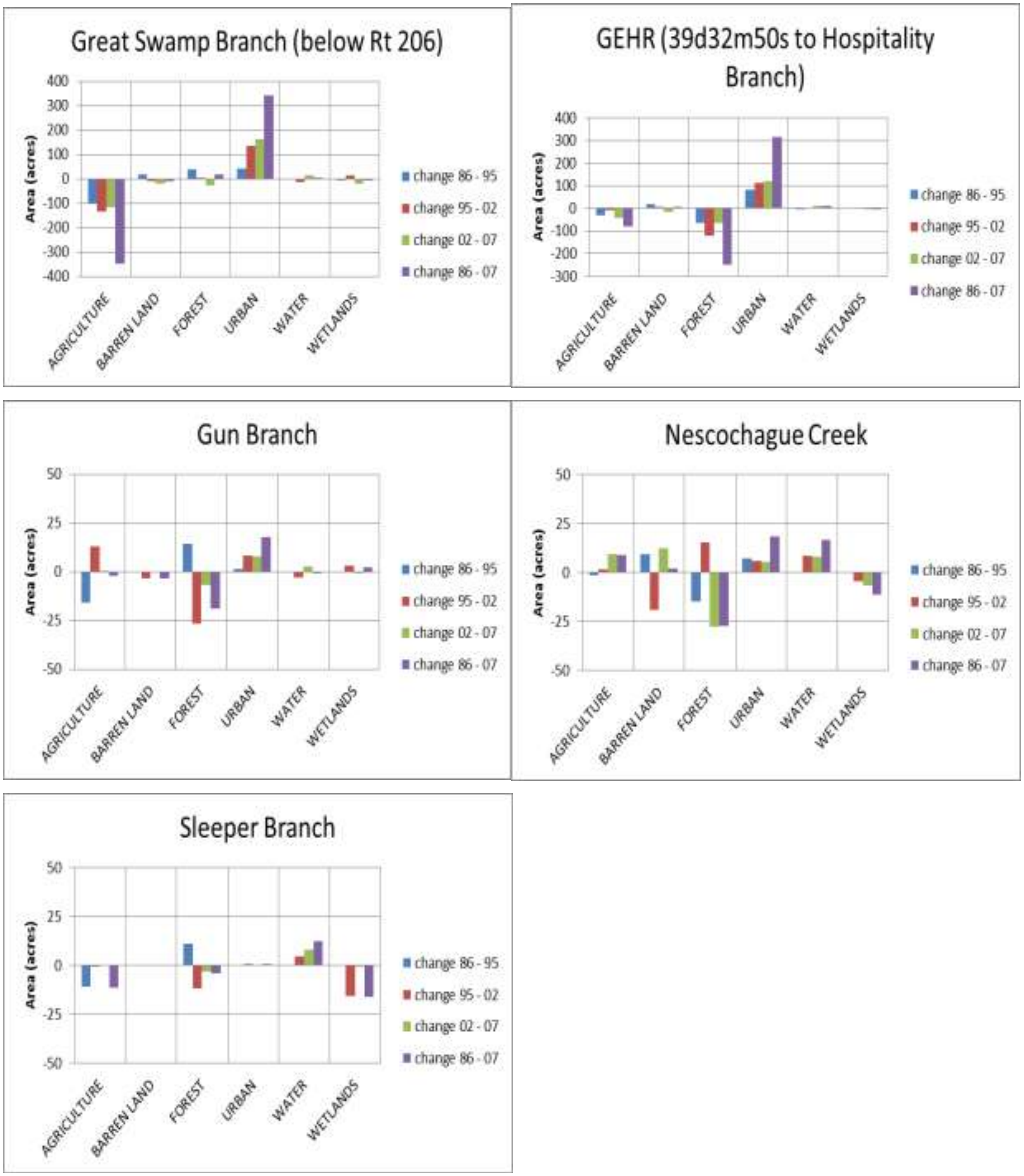


Figure 2-17: Land Use Land Change by Subwatershed

Impervious surfaces

As noted above, Hammonton is 12% impervious surface, an increase of 1% between 1995 and 2007. However, as shown In **Figures 2-18** and **2-19** and implied by the Pinelands CMP Management Area designations, the distribution of that impervious surface among subwatersheds is highly variable. Four subwatersheds have less that 1% impervious surface, indicating a very low level of urbanization. Three additional subwatersheds are below 4%, while two are near or above 8%. It should be noted that extensive agricultural areas will have similar levels of impervious surface to forested areas, but far greater negative impacts on water quality and availability. Therefore, impervious surface is only one indicator of watershed integrity. The following figure shows the timing of impervious surface additions in the target area.

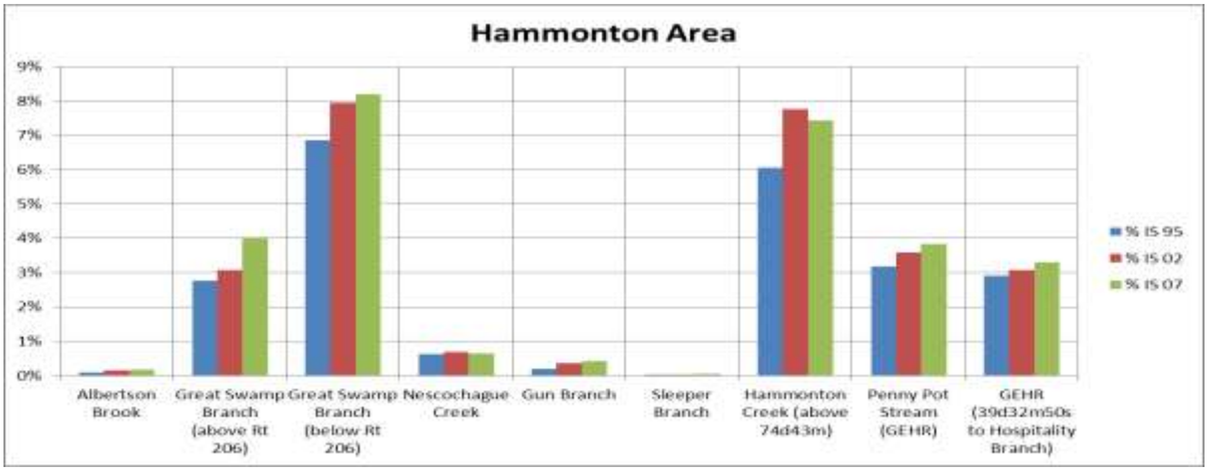


Figure 2-18: Impervious Surface by Subwatershed

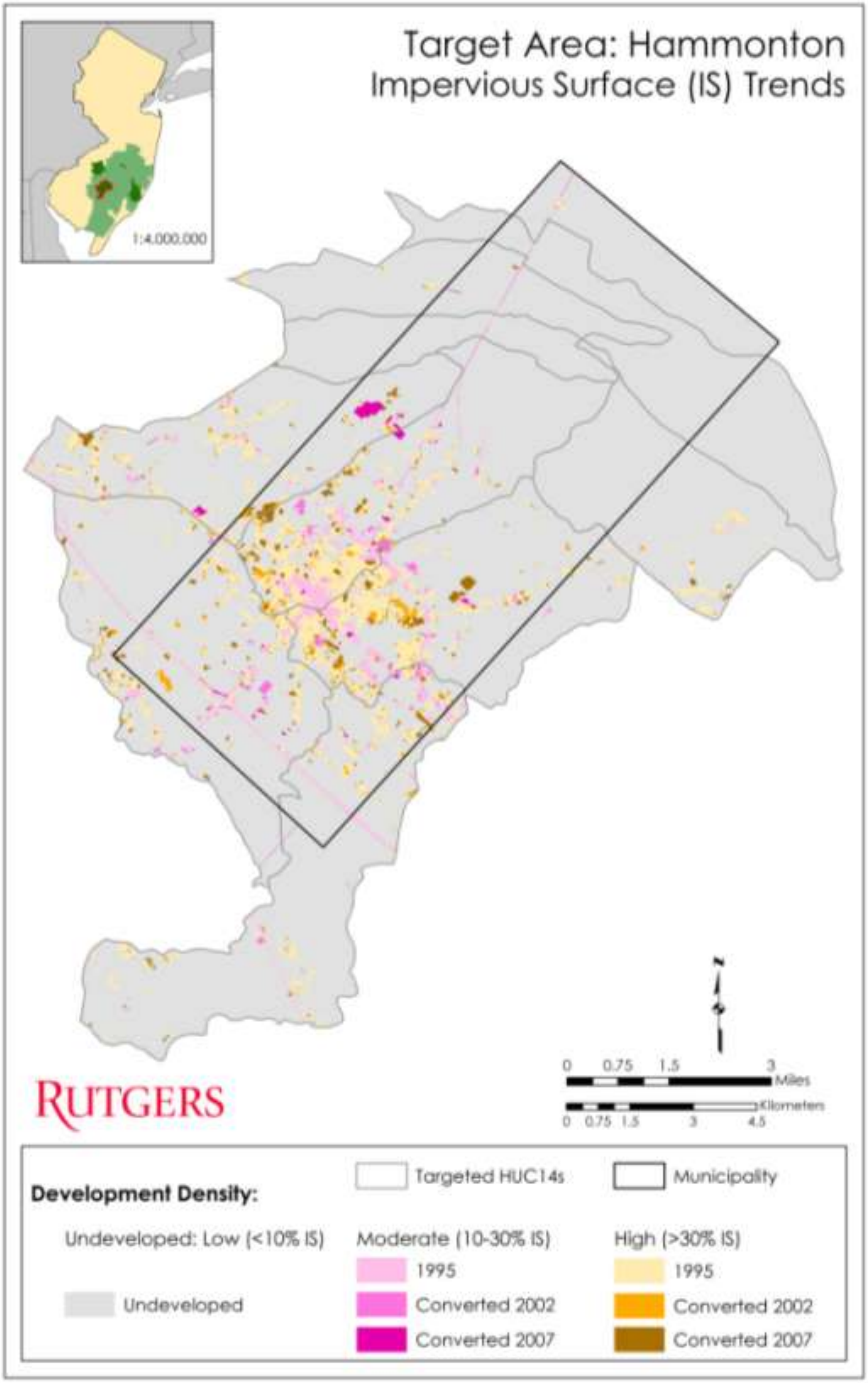


Figure 2-19: Impervious Surface Changes 1995 through 2007, Hammonton

Riparian areas and trends

The natural extent of riparian areas in the target subwatershed was estimated using the method outlined in the introduction to this chapter. GIS analysis was used to determine the estimated natural riparian areas converted to urban land uses by 1986, 1995, 2002 and 2007. While there are extensive riparian areas in the Hammonton target area, total riparian area losses are low (5%), with minimal losses from 1986 to 2007. While significant riparian areas may be in agriculture production use, this land use is not considered a permanent alteration of the riparian area.

From an environmental perspective, the issue is more appropriately focused on riparian area losses at a subwatershed or watershed scale, rather than on a parcel, project or municipal scale. **Table 2-14** shows that no subwatersheds in the area lost more than 4% of additional riparian area from 1986 through 2007, while only one subwatershed had greater than 10% urbanization of riparian areas as of 2007. The **Figure 2-20** shows the riparian areas and losses for the target area.

Table 2-14. Riparian Area Development 1986 to 2007 by Subwatershed

HUC14	Subwatershed Name	Percent Riparian Area that is Urban 1986	Percent Riparian Area that is Urban 2007	Change of Acres of Urban In Riparian Areas
02040301160110	Albertson Brook	0.4%	0.8%	4
02040301160120	Great Swamp Branch (above Rt 206)	7.1%	9.3%	31
02040301160130	Great Swamp Branch (below Rt 206)	5.9%	7.3%	33
02040301160150	Nescochague Creek	1.3%	1.3%	2
02040301160160	Gun Branch	0.1%	0.6%	9
02040301160170	Sleeper Branch	0.1%	0.1%	0
02040301170010	Hammonton Creek (above 74d43m)	7.4%	10.9%	82
02040302030070	Penny Pot Stream (GEHR)	5.9%	7.1%	40
02040302040080	GEHR (39d32m50s to Hospitality Branch)	4.7%	5.1%	12

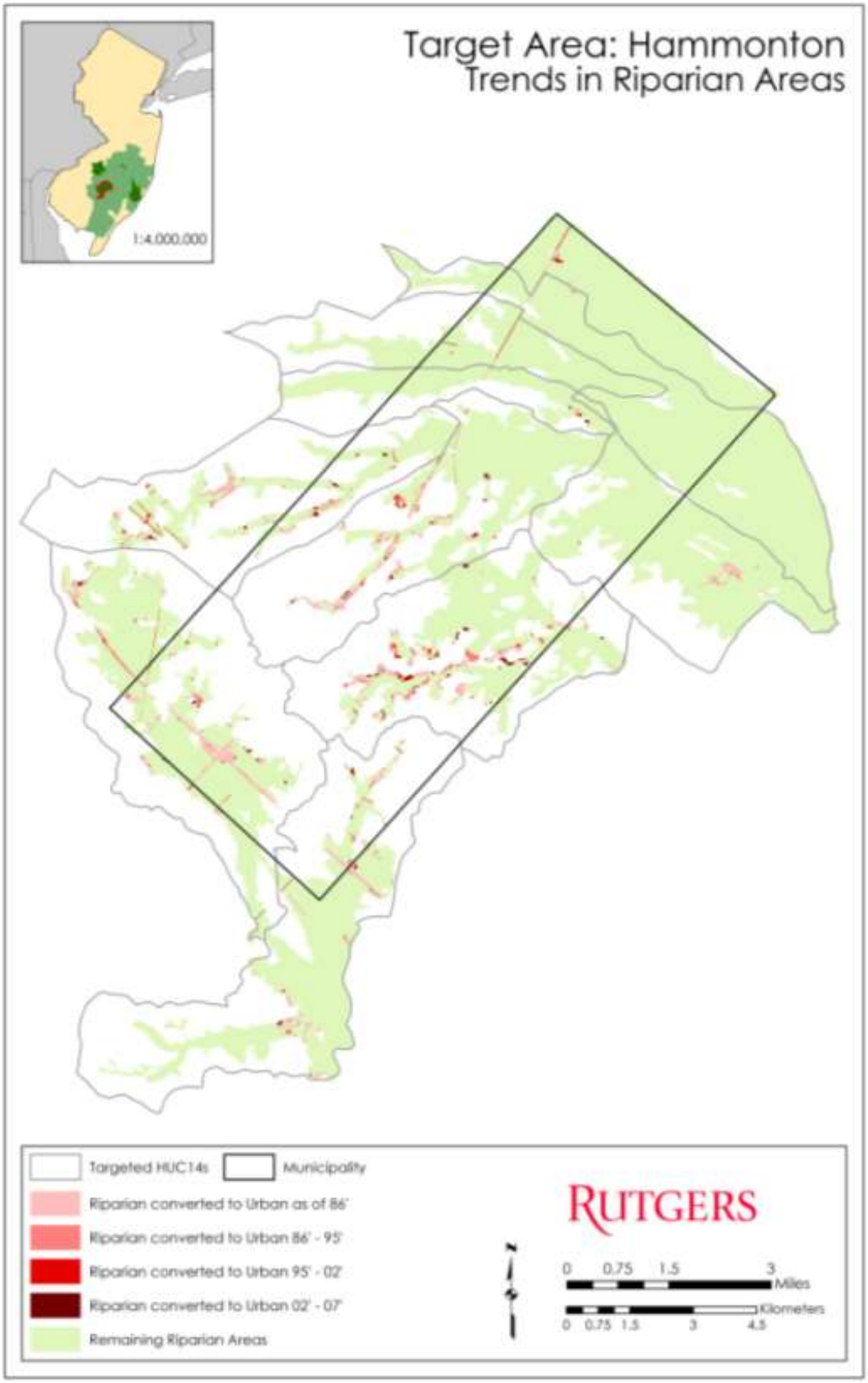


Figure 2-20: Conversion of Riparian Areas to Urban Land Use 1986 through 2007

Flood prone areas and trends

All of the subwatersheds in the Hammonton area have relatively low levels of urban land in flood prone areas, with the highest level being Penny Pot Stream (GEHR) at 8% and Great Swamp Branch (above Rt 206) at 7%. Compared to levels above 20% in the Medford/Evesham area, these levels represent a much more limited exposure of development to flooding potential.

Table 2-15. Flood Prone Area Development 1986 to 2007 by Subwatershed

HUC14	Subwatershed Name	Percent Flood Prone Area as Urban 1986	Percent Flood Prone Area as Urban 2007	Change of Urban Acres In Flood Prone Areas
02040301160110	Albertson Brook	0%	1%	2
02040301160120	Great Swamp Branch (above Rt 206)	5%	7%	7
02040301160130	Great Swamp Branch (below Rt 206)	1%	2%	9
02040301160150	Nescochague Creek	1%	1%	1
02040301160160	Gun Branch	0%	1%	9
02040301160170	Sleeper Branch	0%	0%	0
02040301170010	Hammonton Creek (above 74d43m)	4%	6%	25
02040302030070	Penny Pot Stream (GEHR)	7%	8%	10
02040302040080	GEHR (39d32m50s to Hospitality Branch)	3%	4%	6

Forest areas and trends

Non-wetland forests have important functions for water resources and ecological purposes. (Wetland forests are included within the wetlands section below.) Hammonton saw a 2% decline in total forest cover, with 474 acres deforested from 1986 to 2007. However, subwatershed results varied considerably, with only two subwatersheds having greater than 1% decline in forested areas (**Table 2-16**). Hammonton Creek (above 74d43m) lost 286 acres of forest which equates to 4.7% of its total land, while GEHR (39d32m50s to Hospitality Branch) lost 250 acres which equates to 3.4% of its total land. However, in the latter case the subwatershed remains 54% forested. As can be seen in **Figure 2-21**, most of these losses are in the central and southern portions of the municipality.

Table 2-16. Forest Losses 1986 to 2007 by Subwatershed

HUC14	Subwatershed Name	1986 Forest	2007 Forest	Forest Losses	Forest Lost (Acres)
02040301160110	Albertson Brook	44%	43%	1%	-13.08
02040301160120	Great Swamp Branch (above Rt 206)	23%	22%	1%	-41.68
02040301160130	Great Swamp Branch (below Rt 206)	18%	19%	-1%	18.00
02040301160150	Nescochague Creek	40%	39%	1%	-27.27
02040301160160	Gun Branch	57%	56%	1%	-18.92
02040301160170	Sleeper Branch	35%	34%	1%	-3.90
02040301170010	Hammonton Creek (above 74d43m)	25%	21%	4%	-286.43
02040302030070	Penny Pot Stream (GEHR)	26%	26%	0%	-58.43
02040302040080	GEHR (39d32m50s to Hospitality Branch)	57%	54%	3%	-250.54

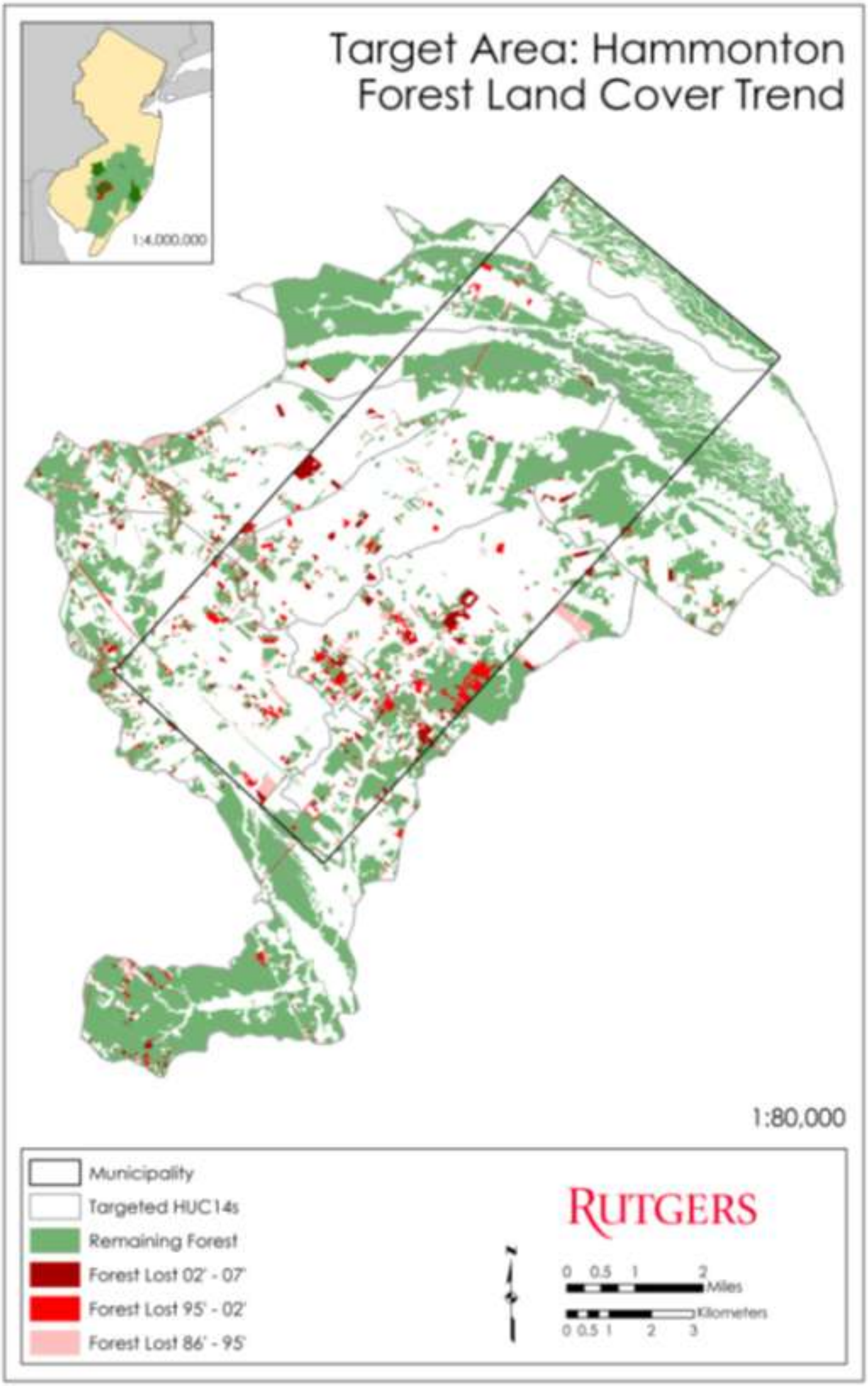


Figure 2-21: Forest Losses 1986 through 2007

Wetland areas and trends

Hammonton's total wetland acreage is essentially unchanged from 1986 to 2007, remaining at 28% of the total municipal area. No subwatershed lost more than 20 acres of wetlands.

Ground water recharge

Ground water recharge is the primary source of water to both wells and stream flow in the Pinelands. NJDEP evaluated total ground water recharge by subwatershed using its GSR-32 method (NJDEP, 2005). **Table 2-17** shows the total recharge values for subwatersheds in this target area. Drought recharge is based upon precipitation values during the 1960s drought, which is New Jersey's drought of record for long-term droughts of the type most likely to reduce ground water contributions to surface water flows and wetlands inundation.

Table 2-17. Ground Water Recharge by Subwatershed

HUC14	Subwatershed Name	Annual Average Recharge (MGY)	Drought Recharge (MGY)	% Difference
02040301160110	Albertson Brook	430	302	30%
02040301160120	Great Swamp Branch (above Rt 206)	1441	979	32%
02040301160130	Great Swamp Branch (below Rt 206)	1120	757	32%
02040301160150	Nescochague Creek	733	520	29%
02040301160160	Gun Branch	503	355	29%
02040301160170	Sleeper Branch	213	156	27%
02040301170010	Hammonton Creek (above 74d43m)	1369	946	31%
02040302030070	Penny Pot Stream (GEHR)	1594	1078	32%
02040302040080	GEHR (39d32m50s to Hospitality Branch)	1715	1135	34%

In each subwatershed, some land areas provide better recharge than others; the best are termed Prime Ground Water Recharge Areas (PGWRA). Unlike most of the other evaluations, the definition and mapping of PGWRA are only at the subwatershed scale, not the municipal level. Only one subwatershed, Hammonton Creek (above 74d43m), has over 10% of its PGWRA covered by urban land use. As can be seen in **Figure 2-22**, the developed PGWRA are primarily across the south-central portion of Hammonton.

Table 2-18. Prime Ground Water Recharge Area Development 1995 to 2007 by Subwatershed

HUC14	Subwatershed Name	Acres of PGWRA lost to Urban (1995-2007)	Percent PGWRA Occupied by Urban (2007)
02040301160110	Albertson Brook	2	1.4%
02040301160120	Great Swamp Branch (above Rt 206)	27	11.5%
02040301160130	Great Swamp Branch (below Rt 206)	98	19.4%
02040301160150	Nescochague Creek	0	0.6%
02040301160160	Gun Branch	0	0.3%
02040301160170	Sleeper Branch	0	0.1%
02040301170010	Hammonton Creek (above 74d43m)	215	29.9%
02040302030070	Penny Pot Stream (GEHR)	107	18.0%
02040302040080	GEHR (39d32m50s to Hospitality Branch)	95	14.0%

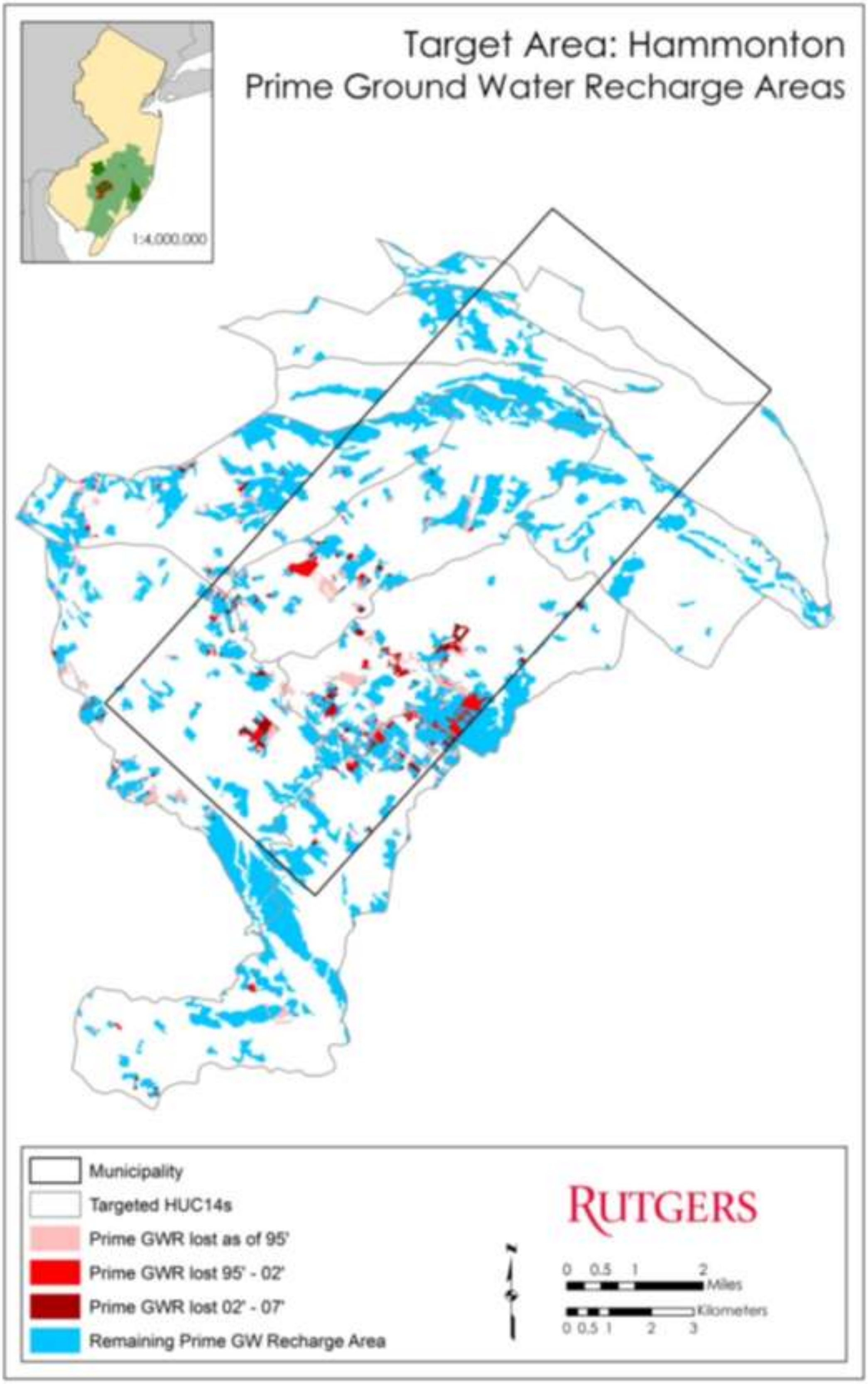


Figure 2-22: Prime Ground Water Recharge Areas Losses 1995 through 2007, Hammonton

Protected areas

Much of the northeastern part of Hammonton is preserved land, mostly within the Wharton State Forest. Additional areas of farmland have been preserved through the NJ Farmland Preservation Program and the transfer of Pinelands Development Credits to other properties. Preserved lands in the targeted subwatersheds are shown in **Figure 2-23** and **Table 2-19**, by preservation category.

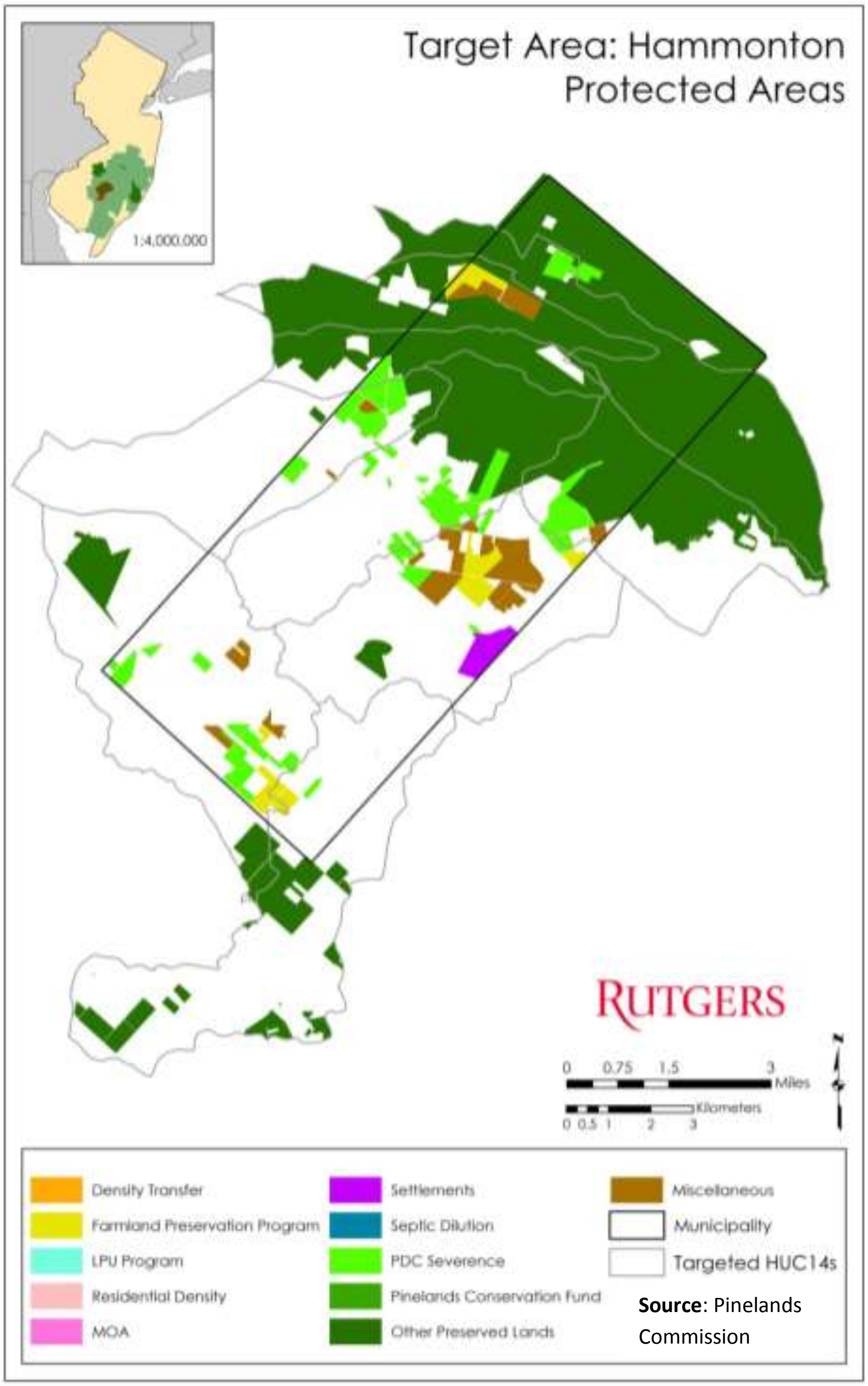


Figure 2-23: Protected Areas, Hammonton

Table 2-19. Preserved Lands by Subwatershed and Category			
HUC14	**Subwatershed Name**	**Preservation Category**	**Acres**
02040301160110	Albertson Brook	State	2389.2
02040301160120	Great Swamp Branch (above Rt 206)	Conservation Easements	833.3
		Farmland Easement	26.2
		State	4122.6
02040301160150	Nescochague Creek	State	3508.8
		Conservation Easements	248.4
		Farmland Easement	37.5
02040301160160	Gun Branch	Farmland Easement	328.8
		State	3212.5
02040301160170	Sleeper Branch	State	6716.8
		Conservation Easements	90.8
02040301170010	Hammonton Creek (above 74d43m)	Farmland Easement	880.7
		Conservation Easements	374.7
		State	210.5
02040302030070	Penny Pot Stream (GEHR)	Farmland Easement	252.4
		County	0.1
		Conservation Easements	383.4
		State	635.9
02040302040080	GEHR (39d32m50s to Hospitality Branch)	Farmland Easement	63.3
		State	926.2
		Conservation Easements	24.1

Summary for Target Area

The indicators described above provide different perspectives on watershed and ecological integrity within the target areas. **Table 2-20** provides an overview of the indicator results by subwatershed. It does not represent a definitive analysis, as no generally accepted method exists for comparing the relative importance or value of these indicators. Each has its own value and plays its own part in overall integrity.

Table 2-20. Compilation of Target Area Indicators of Watershed Integrity
(Values in bold indicate significant increases during period of analysis)

Indicator	**02040301160110 Albertson Brook**	**02040301160120 Great Swamp Branch (above Rt 206)**	**02040301160130 Great Swamp Branch (below Rt 206)**	**02040301160150 Nescochague Creek**	**02040301160160 Gun Branch**	**02040301160170 Sleeper Branch**	**02040301170010 Hammonton Creek (above 74d43m)**	**02040302030070 Penny Pot Stream (GEHR)**	**02040302040080 GEHR (39d32m50s to Hospitality Branch)**
Urbanization 1986-2007 (Acres)	7	298	343	18	18	1	**504**	385	314
Impervious Surfaces (%)	0	4	8	1	0	0	7	4	3
Riparian Area (% Urban)	0.8	9.3	7.3	1.3	0.6	0.1	10.9	7.1	5.1
Flood Prone Area (% Urban)	1	7	2	1	1	0	6	8	4
Forest % Losses (1986-2007)	1	1	-1	1	1	1	4	0	3
Wetlands % Losses (1986-2007)	0	0	0	0	0	1	0	0	0
PGWRA (% Urban)	1.4	11.5	**19.4**	0.6	0.3	0.1	**29.9**	**18.0**	**14.0**
Protected Areas (%)	75.4	12.1	41.0	56.9	87.4	99.0	22.5	16.2	13.9

For the most part, the subwatersheds saw little change in status. Though five had increased urbanization of 300 acres or more, all five are large subwatersheds (5000 acres or more) and so the % impervious surface barely changed, and only two had notable forest losses. Four of the nine subwatersheds lost significant PGWRA (1995-2007), which often will be the highly developable areas with good soils and minimal wetlands or flood potential.

Tuckerton/Little Egg Harbor Township Target Area

Land use/land cover and trends

Figure 2-24 shows the modifications in land use/ land cover (LU/LC) for the full municipalities and then for each of the HUC14 subwatersheds (see **Figure ES-4**) within the target area. Little Egg Harbor Township experience an increase of urban land exceeding 1700 acres, spread fairly evenly over the three periods, essentially all of which came from a loss in forests. Tuckerton is a smaller town with much less available land, but still experienced over 100 acres of new urban land, mostly from forests but also (during the 1995-2002 period) from wetlands. Little Egg Harbor Township has seen a large increase of 11,582 people in the last 30 years, an increase of 137% over 1980. Tuckerton increased its population by 875 in the same period, or 35%. **Figure 2-25** shows the actual LULC distribution for each year in the three municipalities and related subwatersheds.

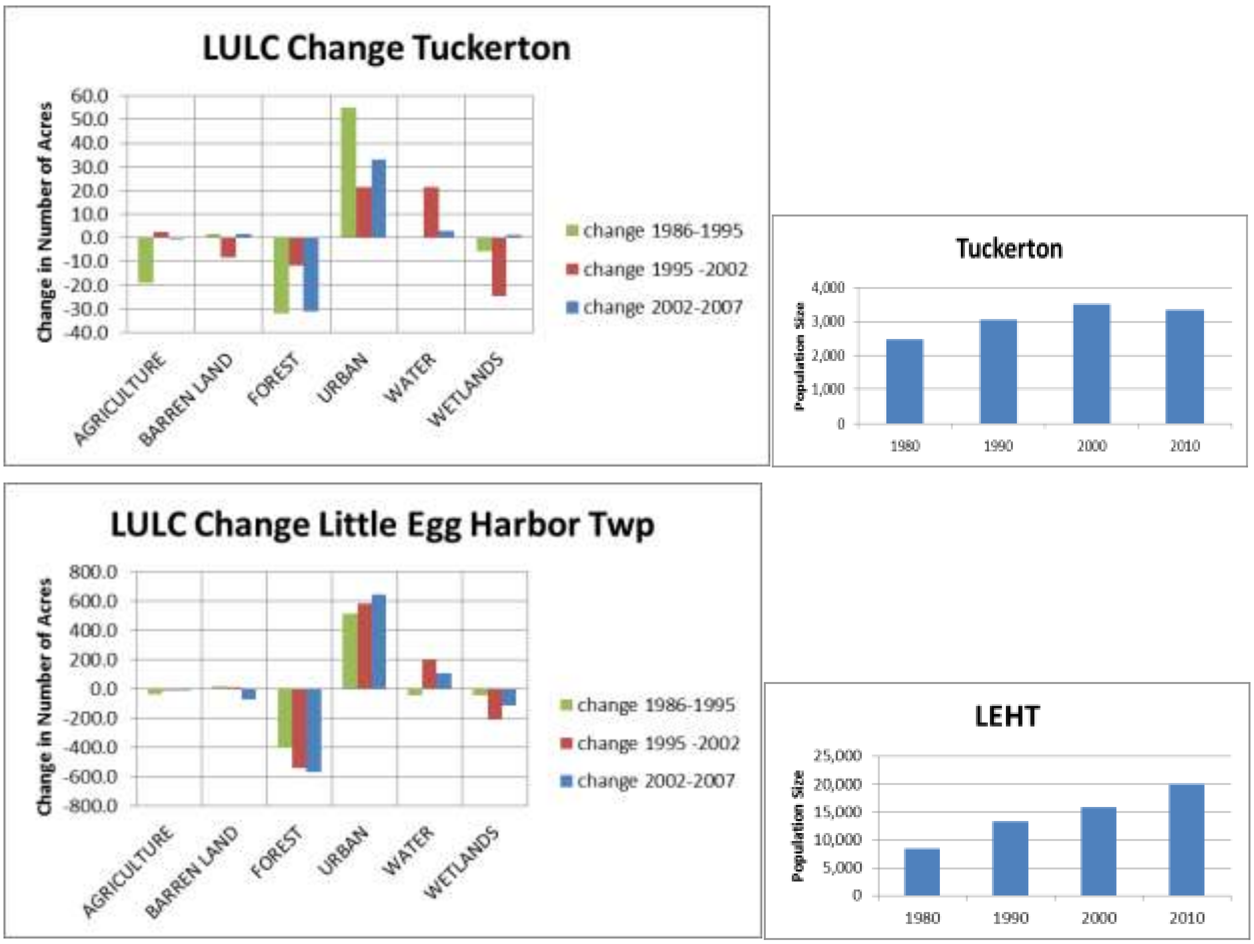


Figure 2-24: Land Use Land Change by Municipality (a) Tuckerton (b) Little Egg Harbor Township

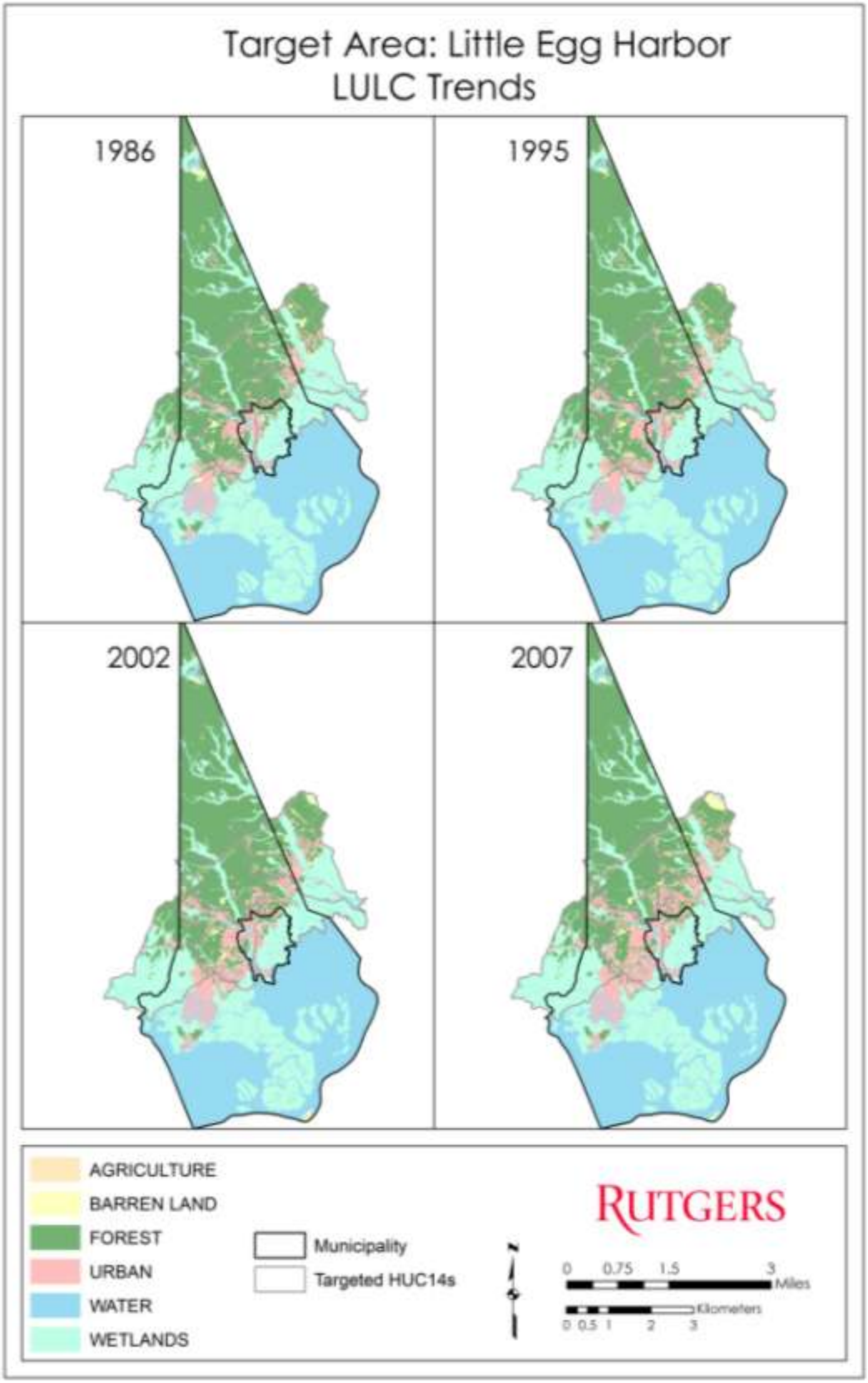
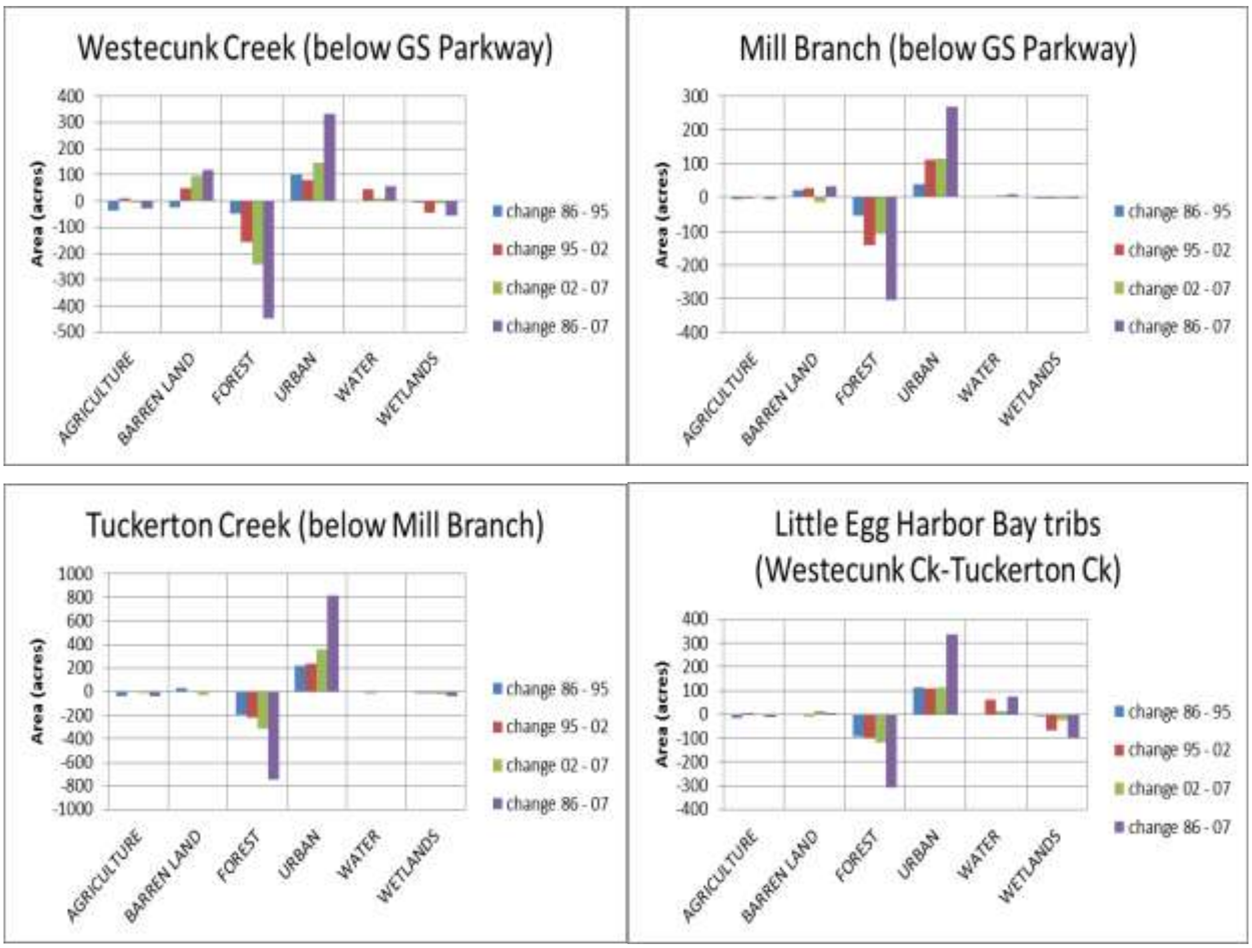


Figure 2-25: Land Use Land Change by Municipality 1986 through 2007

The subwatersheds with the greatest increases in urban land use were as listed in **Table 2-21** and shown in **Figure 2-26**. Of all subwatersheds in the target area, Mill Branch (below GW Parkway) and Ballanger Creek saw an increase of less than 300 acres of urban land from 1986-2007.

Table 2-21. Overview of Urban Land Use Gains by Subwatershed			
HUC14	**Subwatershed Name**	**Urban Land Use Gains**	**Primary Affected Areas**
02040301130060	Westecunk Creek (below GS Parkway)	Over 300 acres	Nearly all from forests
02040301140040	LEH Bay tribs (Westecunk Ck-Tuckerton Ck)	Over 300 acres	Nearly all from forests
02040301140030	Tuckerton Creek (below Mill Branch)	Over 800 acres	Nearly all from forests



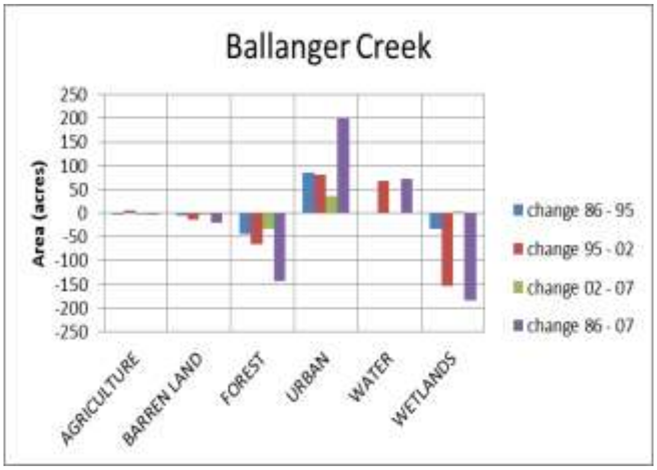


Figure 2-26: Land Use Land Change by Subwatershed

Impervious surfaces

As noted above, Tuckerton and Little Egg Harbor Township have 10% and 3% impervious surface. However, that impervious surface is concentrated in an area south of the Garden State Parkway and west of the wetlands adjoining Little Egg Harbor. As shown on **Figure 2-27**, only one subwatershed (Tuckerton Creek) has an impervious surface greater than 10%, at 14%, and is also the only subwatershed showing an increase greater than 1% between 1995 and 2007, at 9%. This subwatershed therefore shows a very significant level of recent development activity. **Figure 2-28** shows the timing of impervious surface development in the target area.

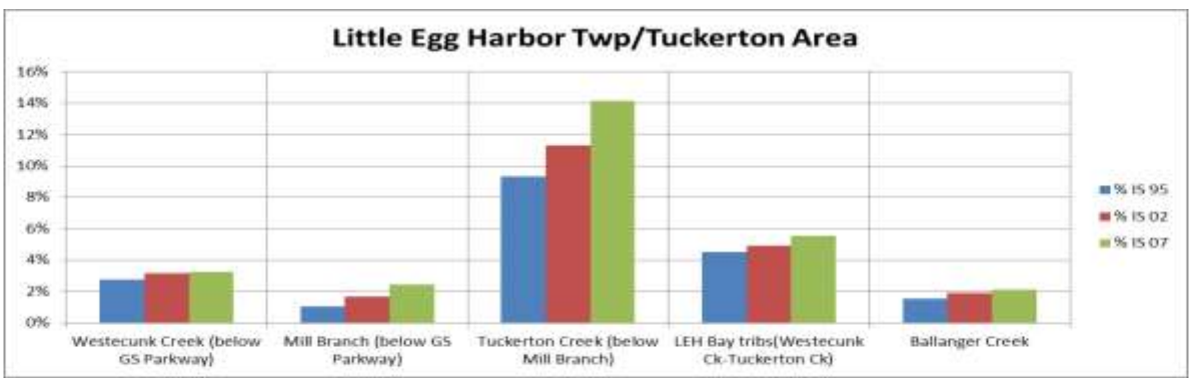


Figure 2-27: Impervious Surface by Subwatershed

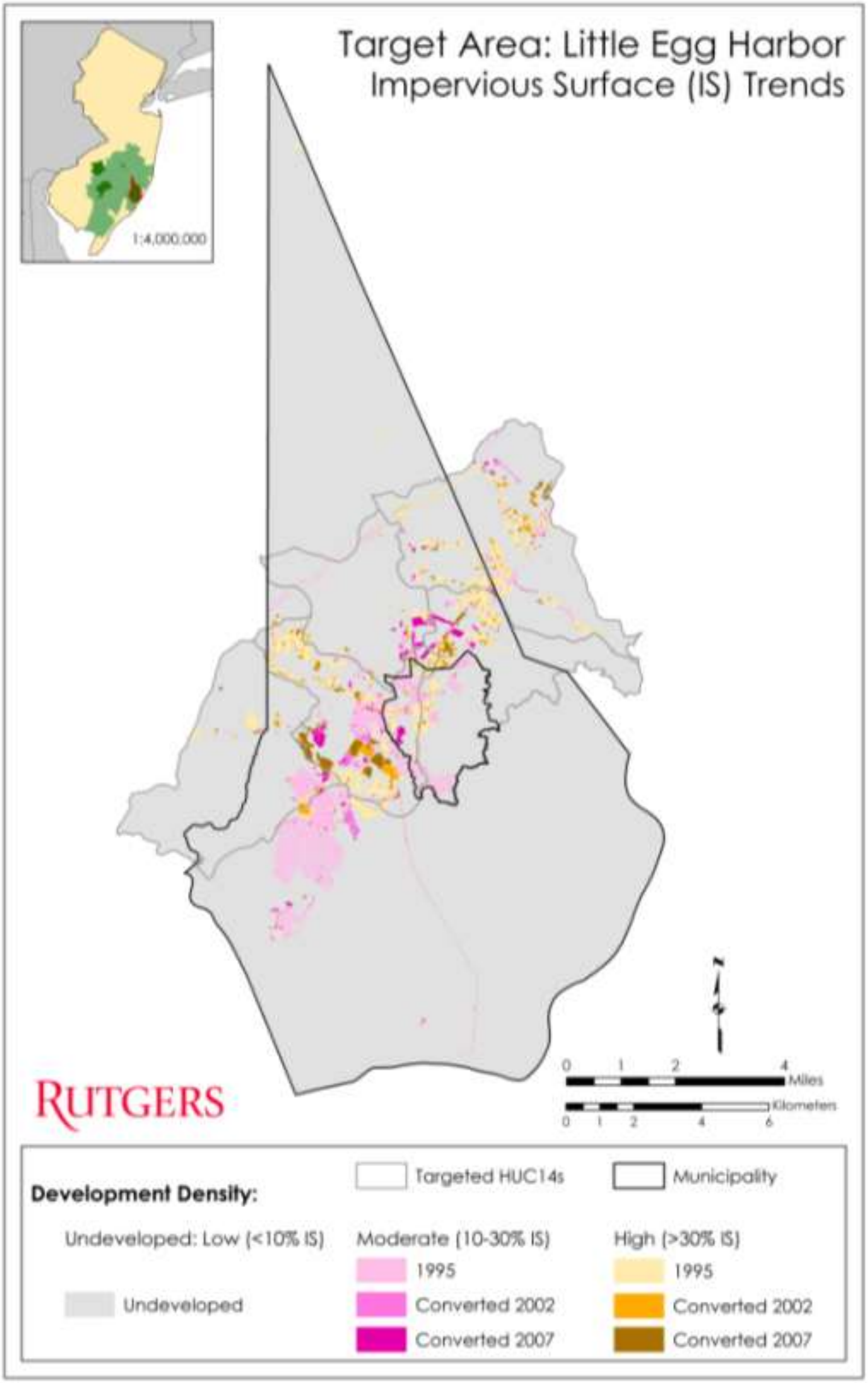


Figure 2-28: Impervious Surface Changes by Municipality 1995 through 2007

Riparian areas and trends

The natural extent of riparian areas in the target subwatershed was estimated using the method outlined in the introduction to this chapter. GIS analysis was used to determine the estimated natural riparian areas converted to urban land uses by 1986, 1995, 2002 and 2007. In this particular case, significant areas of both municipalities are within coastal wetlands and tidal streams, which were not included in the riparian area analysis. For this reason, the analysis here was limited to the target subwatersheds as the more valid focus for riparian area losses. **Table 2-22** and **Figure 2-29** show that two subwatersheds in the area lost more than 10% of additional riparian area from 1986 through 2007, both of which had greater than 20% urbanization of riparian areas as of 2007. However, the losses occurred at different times, with Tuckerton Creek showing the most recent riparian area losses. **Figure 2-30** shows the riparian areas and losses for the target subwatersheds in the area.

Table 2-22. Riparian Area Development 1986 to 2007 by Subwatershed

HUC14	Subwatershed Name	Percent Riparian Area that is Urban 1986	Percent Riparian Area that is Urban 2007	Change of Acres of Urban In Riparian Areas
02040301130060	Westecunk Creek (below GS Parkway)	8.2%	10.1%	20
02040301140020	Mill Branch (below GS Parkway)	1.0%	1.6%	3
02040301140030	Tuckerton Creek (below Mill Branch)	17.6%	32.5%	105
02040301140040	LEH Bay tribs(Westecunk Ck-Tuckerton Ck)	13.5%	25.9%	27
02040301200070	Ballanger Creek	2.2%	5.8%	12

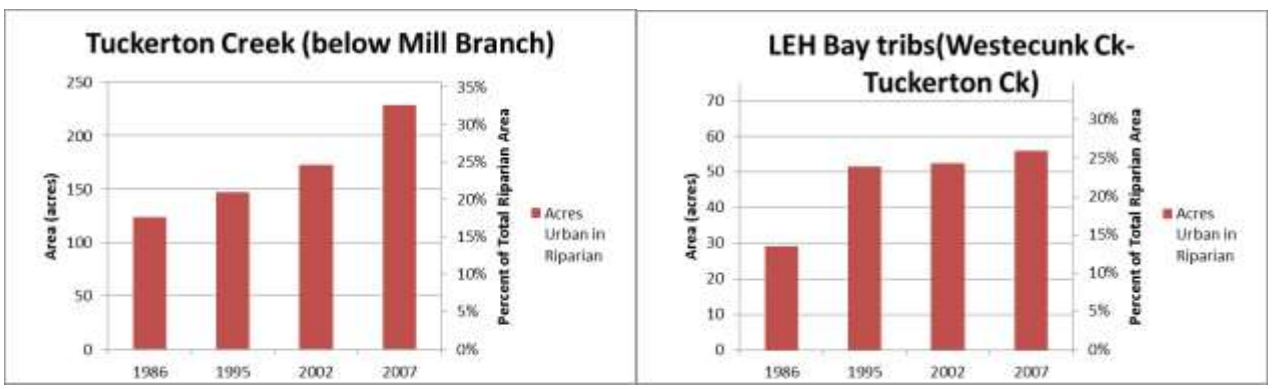


Figure 2-29: Riparian Areas in Urban Land Use for Selected Subwatersheds

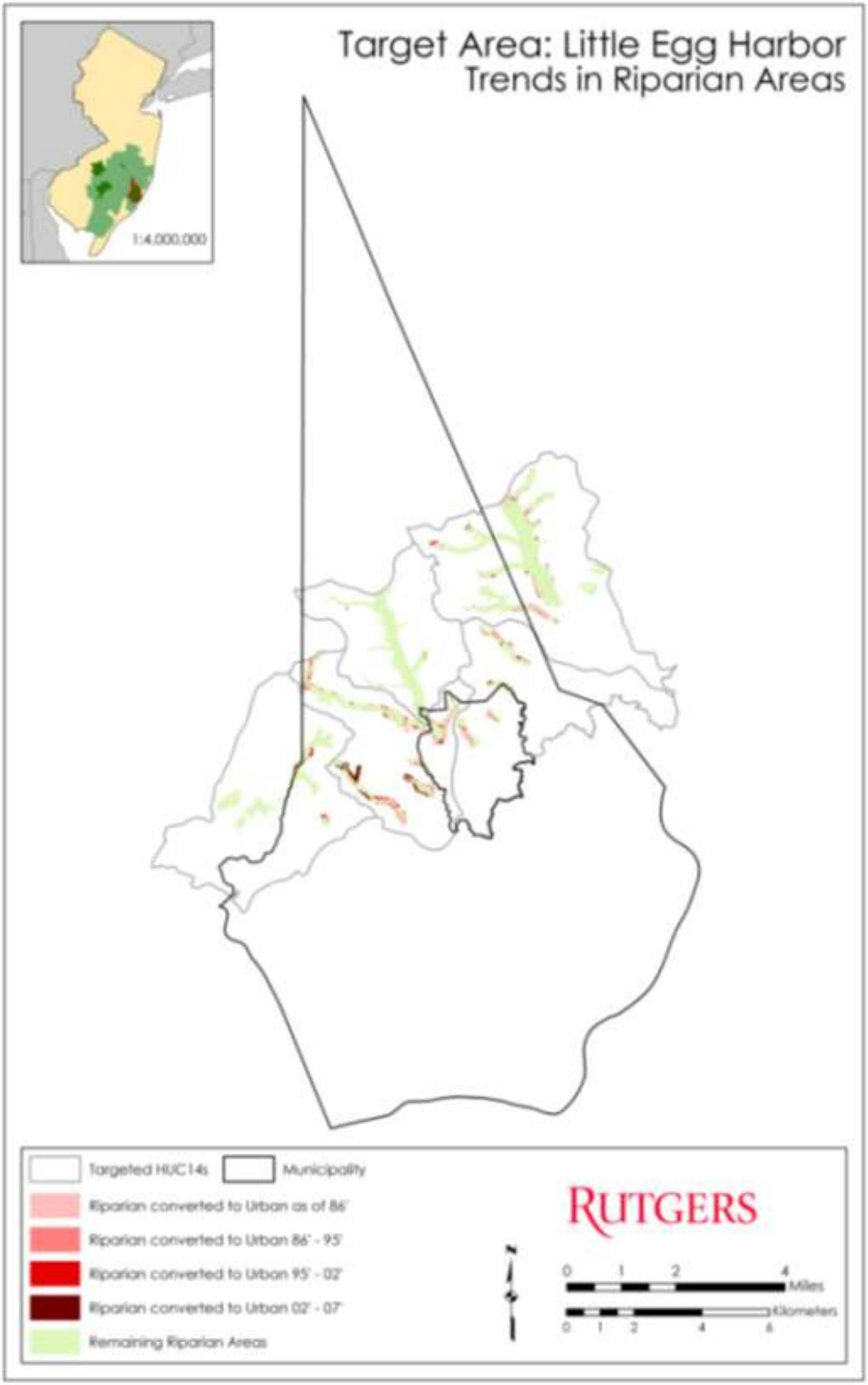


Figure 2-30: Conversion of Riparian Areas to Urban Land Use 1986 through 2007

Flood prone areas and trends

Tuckerton Creek (below Mill Branch) has had the most development of urban onto flood prone areas, adding 71 acres in the period from 1986 to 2007, and also has the highest level of any subwatershed in the three target areas, at 39%. This represents a very high exposure to flooding, as demonstrated by the storm surge associated with Hurricane Sandy. In addition, LEH Bay tribs (Westecunk Ck-Tuckerton Ck) also had a significant increase, adding 29 acres, but overall has only 7% of its flood prone area in urban land cover. **Figure 2-31** shows clearly the flood prone areas already developed as of 1986, with the lagoon developments prominent in Tuckerton and the southwestern corner of the township (e.g., Mystic Island).

Table 2-23. Flood Prone Area Development 1986 to 2007 by Subwatershed

HUC14	Subwatershed Name	Percent Flood Prone Area as Urban 1986	Percent Flood Prone Area as Urban 2007	Change of Urban Acres In Flood Prone Areas
02040301130060	Westecunk Creek (below GS Parkway)	5%	6%	25
02040301140020	Mill Branch (below GS Parkway)	1%	1%	1
02040301140030	Tuckerton Creek (below Mill Branch)	30%	39%	71
02040301140040	LEH Bay tribs(Westecunk Ck-Tuckerton Ck)	6%	7%	39
02040301200070	Ballanger Creek	1%	2%	29

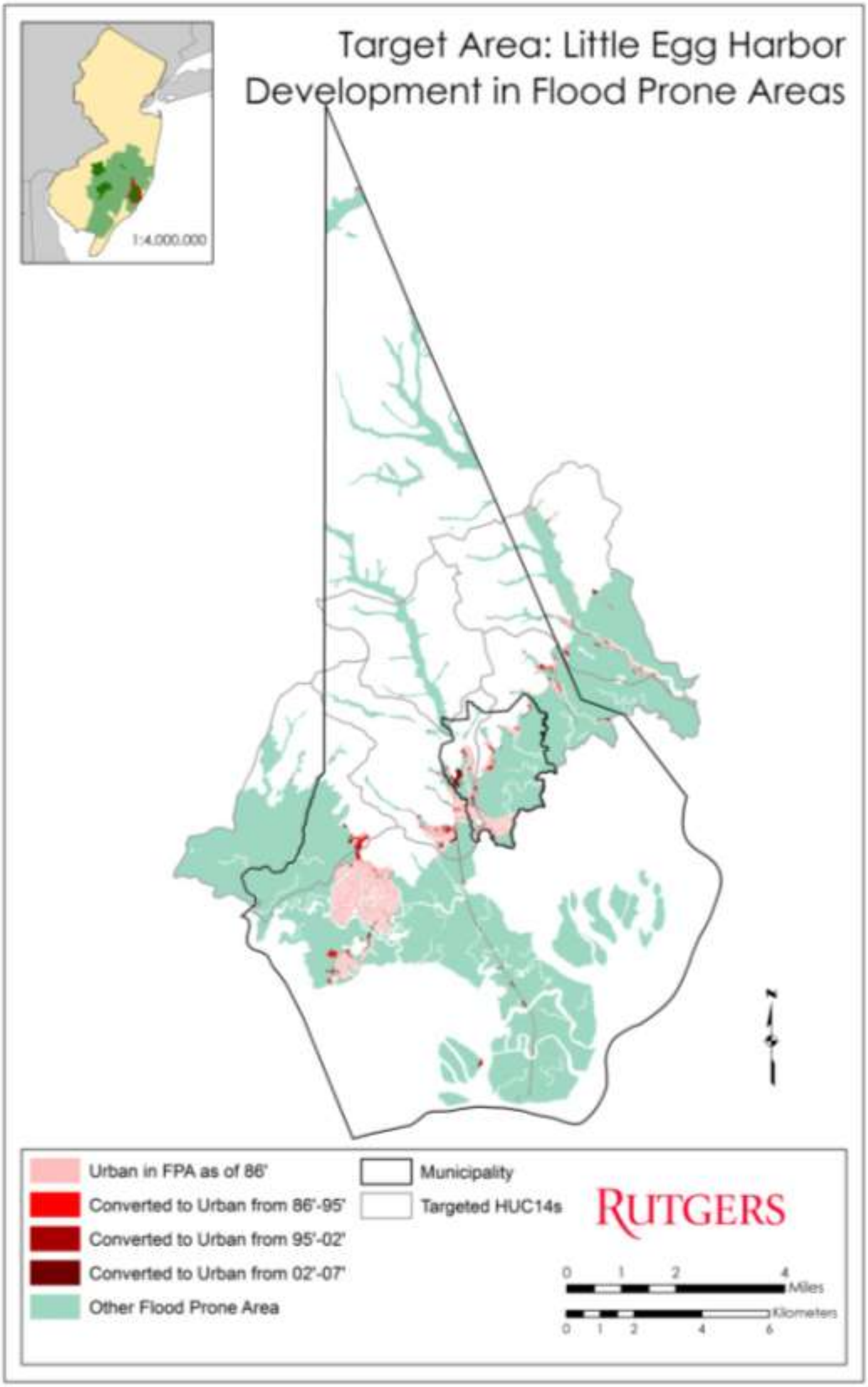


Figure 2-31: Conversion of Flood Prone Areas to Urban Land Use 1986 through 2007

Forest areas and trends

Non-wetland forests have important functions for water resources and ecological purposes. (Wetland forests are included within the wetlands section below.) This target area saw significant declines in forest cover. Both Tuckerton and Little Egg Harbor Township lost 3% of their forest cover. However, this loss represents only 75 acres in Tuckerton but over 1500 acres in Little Egg Harbor Township. Tuckerton Creek (below Mill Branch) lost 19% (742 acres) of its total forest cover, the most in this target area. Three other subwatersheds lost 6% or more of their total forest cover, with only one retaining more than 50% forest cover – Mill Branch (below GS Parkway). As shown in **Figure 2-32**, most of these losses were just north and west of Tuckerton and occurred in the 1995-2002 period.

Table 2-24. Forest Losses 1986 to 2007 by Subwatershed

HUC14	Subwatershed Name	1986 Forest	2007 Forest	Forest Losses	Forest Lost (Acres)
02040301130060	Westecunk Creek (below GS Parkway)	50%	43%	7%	-446.88
02040301140020	Mill Branch (below GS Parkway)	84%	74%	10%	-304.81
02040301140030	Tuckerton Creek (below Mill Branch)	50%	31%	19%	-741.99
02040301140040	LEH Bay tribs (Westecunk Ck-Tuckerton Ck)	20%	13%	7%	-305.82
02040301200070	Ballanger Creek	28%	25%	3%	-143.73

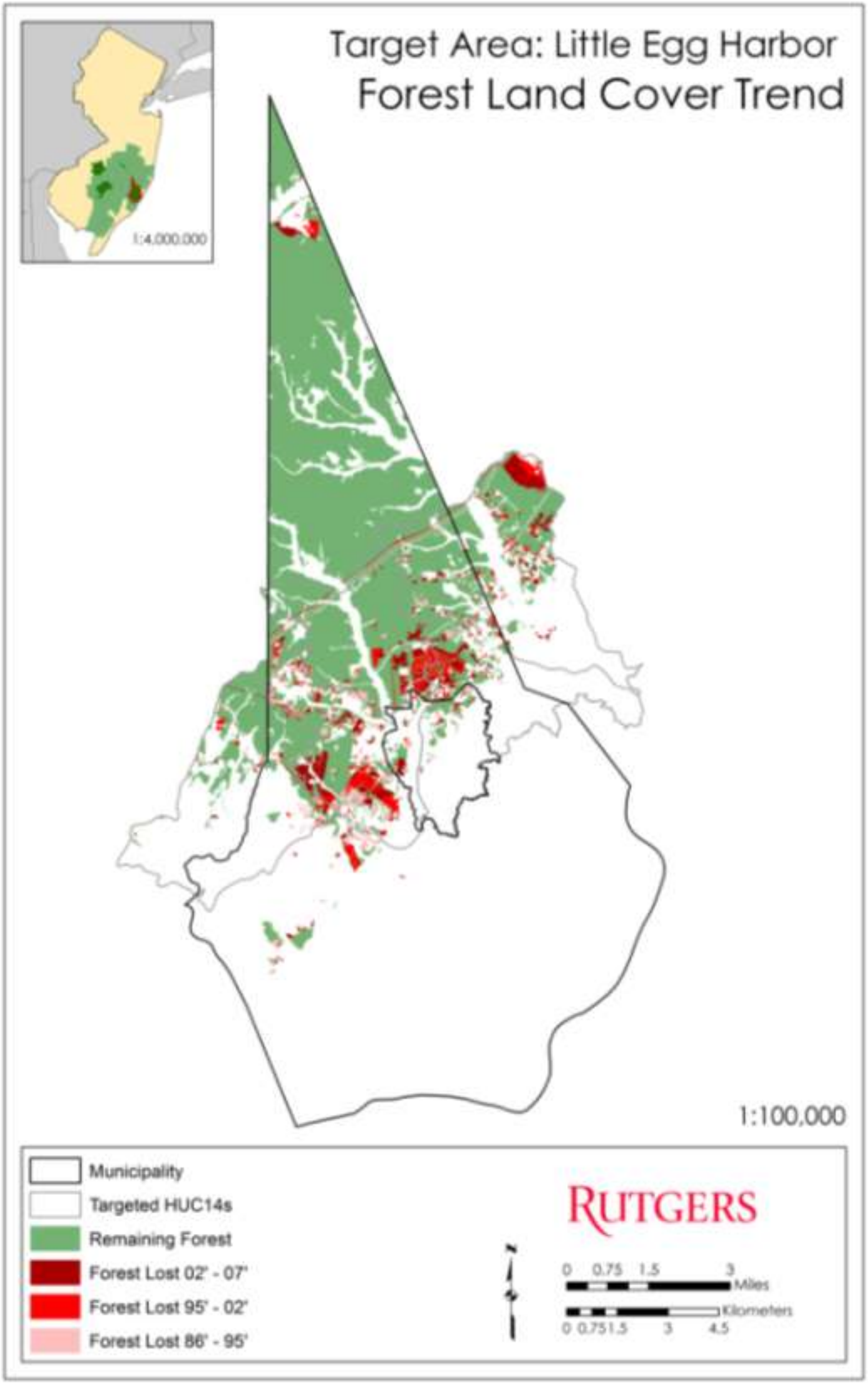


Figure 2-32: Forest Losses 1986 through 2007

Wetland areas and trends

This target area is unlike the others, in that much of the wetlands are tidal (coastal). Tuckerton lost less than 30 acres of wetlands and has the highest proportion of wetlands of any municipality in this study. Little Egg Harbor Township lost 366 acres (second highest amount in this study) but that comprises less than 1% of the total land area in the municipality.

Table 2-25. Wetlands by Municipality			
	Wetlands as % of total municipal area		Change 1986-2007 (acres)
Municipality	1986	2007	
Little Egg Harbor Twp	25%	24%	-366.4
Tuckerton Boro	52%	51%	-29.1

Of the subwatersheds, Ballanger Creek lost the most wetlands, 185 acres or 3.4% of total subwatershed area, followed by LEH Bay tribs (Westecunk Ck-Tuckerton Ck), at 96 acres or 2.2%. The remaining subwatersheds lost wetlands no more than 1% of their total area. Some of the wetlands lost are in tidal area, while others are inland.

Table 2-26. Wetlands Losses 1986 to 2007 by Subwatershed				
HUC14	Subwatershed Name	Wetlands as % of subwatershed		Change 1986-2007 (acres)
		1986	2007	
02040301130060	Westecunk Creek (below GS Parkway)	34%	33%	-55.96
02040301140020	Mill Branch (below GS Parkway)	12%	12%	-3.24
02040301140030	Tuckerton Creek (below Mill Branch)	14%	13%	-37.44
02040301140040	LEH Bay tribs (Westecunk Ck-Tuckerton Ck)	63%	61%	-95.87
02040301200070	Ballanger Creek	67%	63%	-185.04

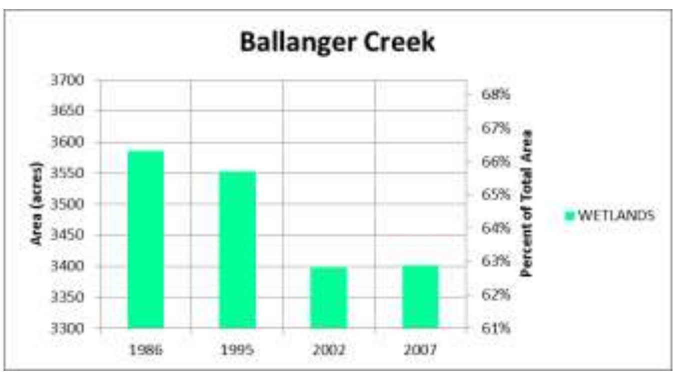


Figure 2-33. Wetlands Acres for Ballanger Creek 1986 through 2007

Ground water recharge

Ground water recharge is the primary source of water to both wells and stream flow in the Pinelands. NJDEP evaluated total ground water recharge by subwatershed using its GSR-32 method (NJDEP, 2005). **Table 2-27** shows the total recharge values for subwatersheds in this target area. Drought recharge is based upon precipitation values during the 1960s drought, which is New Jersey's drought of record for long-term droughts of the type most likely to reduce ground water contributions to surface water flows and wetlands inundation.

Table 2-27. Ground Water Recharge by Subwatershed				
HUC14	**Subwatershed Name**	**Annual Average Recharge (MGY)**	**Drought Recharge (MGY)**	**% Difference**
02040301130060	Westecunk Creek (below GS Parkway)	1353	1178	13%
02040301140020	Mill Branch (below GS Parkway)	1054	917	13%
02040301140030	Tuckerton Creek (below Mill Branch)	986	867	12%
02040301140040	LEH Bay tribs(Westecunk Ck-Tuckerton Ck)	435	382	12%
02040301200070	Ballanger Creek	543	471	13%

In each subwatershed, some land areas provide better recharge than others; the best are termed Prime Ground Water Recharge Areas (PGWRA). Unlike most of the other evaluations, the definition and mapping of PGWRA are only at the subwatershed scale, not the municipal level. As shown in **Table 2-28**, two subwatersheds in this target area have over 10% of their prime GWR land covered by urban land use: Tuckerton Creek (below Mill Branch) and LEH Bay tribs (Westecunk Ck-Tuckerton Ck). Most of the urbanized PGWRA are near Tuckerton within the Township, as shown on **Figure 2-34**.

Table 2-28. Prime Ground Water Recharge Area Development 1995 to 2007 by Subwatershed			
HUC14	**Subwatershed Name**	**Acres of PGWRA lost to Urban (1995-2007)**	**Percent PGWRA Occupied by Urban (2007)**
02040301130060	Westecunk Creek (below GS Parkway)	50	13%
02040301140020	Mill Branch (below GS Parkway)	28	10%
02040301140030	Tuckerton Creek (below Mill Branch)	135	37%
02040301140040	LEH Bay tribs (Westecunk Ck-Tuckerton Ck)	33	29%
02040301200070	Ballanger Creek	32	10%

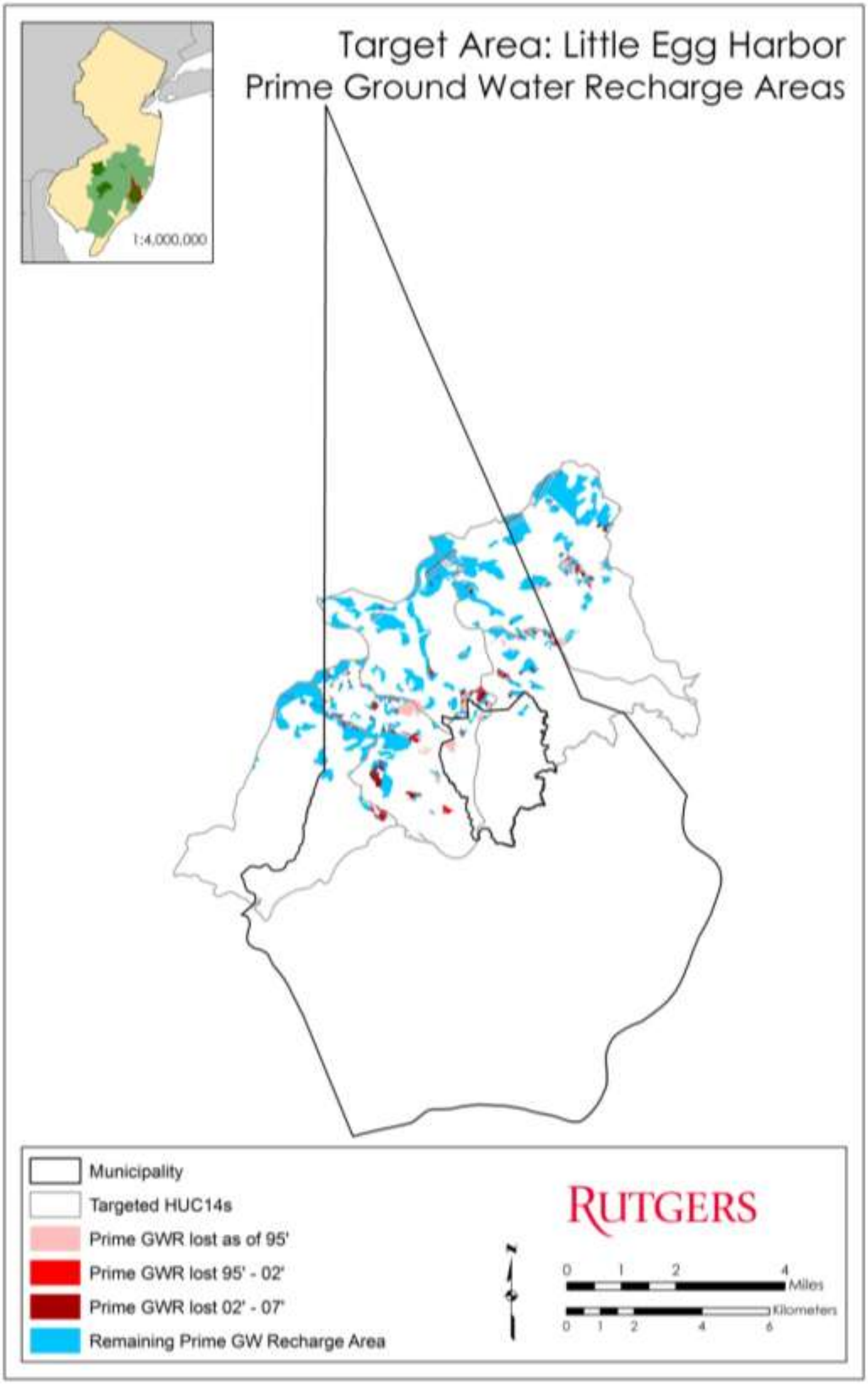


Figure 2-34: Prime Ground Water Recharge Areas Losses 1995 through 2007

Protected areas

As shown on **Figure 2-35**, much of northern Little Egg Harbor Township is preserved open space, as are large areas of coastal wetlands in the southern portion. Little of Tuckerton Borough is preserved open space. Preserved lands in the targeted subwatersheds are shown in **Table 2-29**, by preservation category.

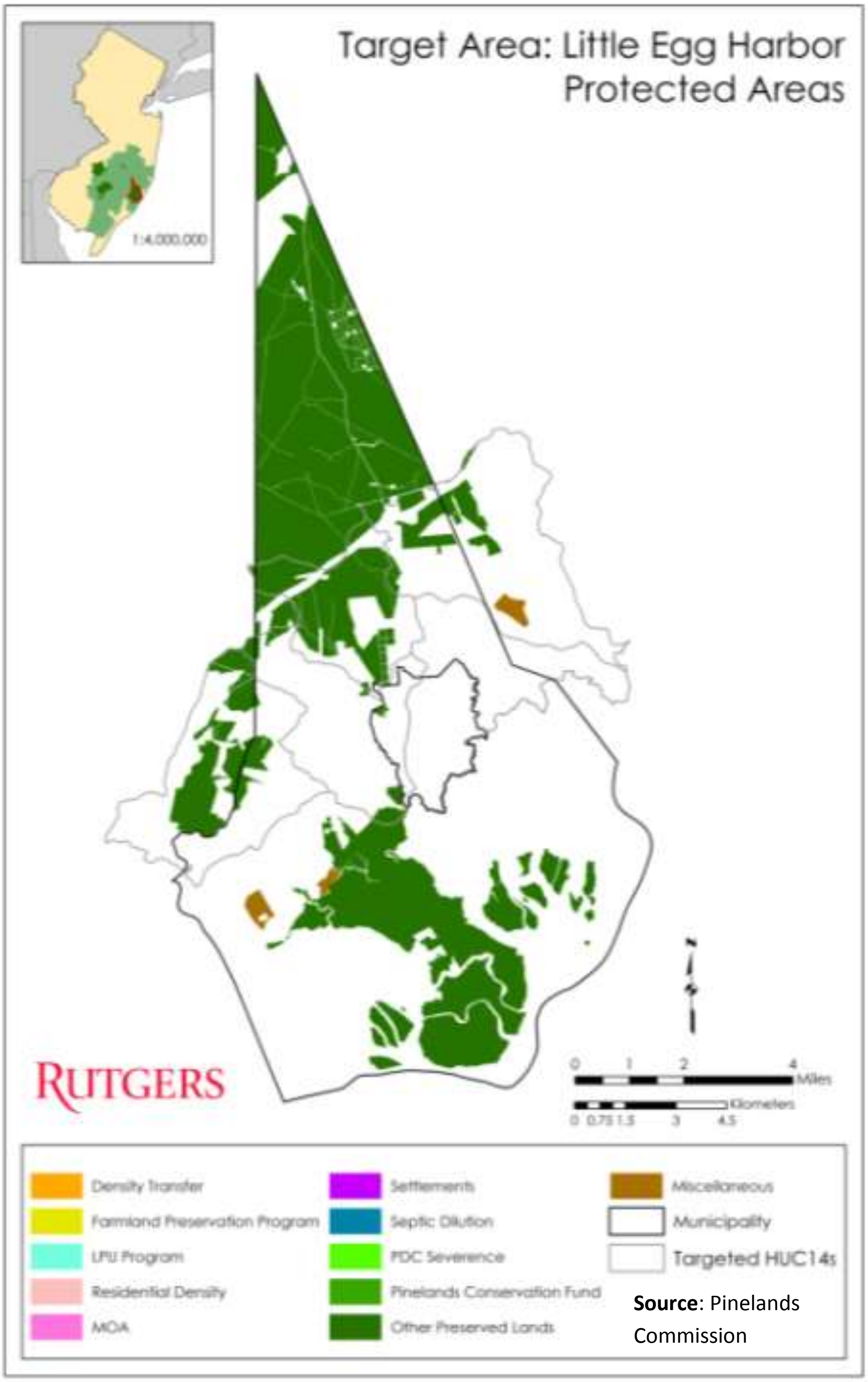


Figure 2-35: Protected Areas

Table 2-29 Preserved Lands by Subwatershed and Category			
HUC14	**Subwatershed Name**	**Preservation Category**	**Acres**
02040301130060	Westecunk Creek (below GS Parkway)	County	202.6
		State	797.9
02040301140020	Mill Branch (below GS Parkway)	County	992.8
		State	1393.5
02040301140030	Tuckerton Creek (below Mill Branch)	County	159.6
		State	251.9
02040301140040	LEH Bay tribs(Westecunk Ck-Tuckerton Ck)	County	0.7
02040301200070	Ballanger Creek	County	0.8
		State	1514.7

Summary for Target Area

The indicators described above provide different perspectives on watershed and ecological integrity within the target areas. **Table 2-30** provides an overview of the indicator results by subwatershed. It does not represent a definitive analysis, as no generally accepted method exists for comparing the relative importance or value of these indicators. Each has its own value and plays its own part in overall integrity.

Table 2-30. Compilation of Target Area Indicators of Watershed Integrity
(Values in bold indicate significant increases during period of analysis)

Indicator	**02040301130060 Westecunk Creek (below GS Parkway)**	**02040301140020 Mill Branch (below GS Parkway)**	**02040301140030 Tuckerton Creek (below Mill Branch)**	**02040301140040 LEH Bay tribs (Westecunk Ck-Tuckerton Ck)**	**02040301200070 Ballanger Creek**
Urbanization 1986-2007 (Acres)	333	268	**817**	336	202
Impervious Surfaces (%)	3	2	**14**	6	2
Riparian Area (% Urban)	10.1	1.6	**32.5**	**25.9**	5.8
Flood Prone Area (% Urban)	6	1	**39**	7	2
Forest % Losses (1986-2007)	7	**10**	**19**	7	3
Wetlands % Losses (1986-2007)	1	0	1	2	**4**
PGWRA (% Urban)	13.0	9.6	**37.1**	**29.3**	**10.3**
Protected Areas (%)	16.8	73.4	10.7	0.0	28.1

Tuckerton Creek clearly shows the greatest impacts of development during the study period, with significant development, increased impervious surface and urbanization of riparian areas, flood prone areas and forests. Three of the five subwatersheds lost significant PGWRA (1995-2007), which often will be the highly developable areas with good soils and minimal wetlands or flood potential.

McDonalds Branch Comparison Area

Land use/land cover and trends: **Figure 2-36** shows the very limited modifications in land use/ land cover (LU/LC) for the McDonalds Branch HUC14 subwatershed. These changes may reflect aerial photographical interpretation differences and gradual ecosystem shifts, rather than any specific development activity.

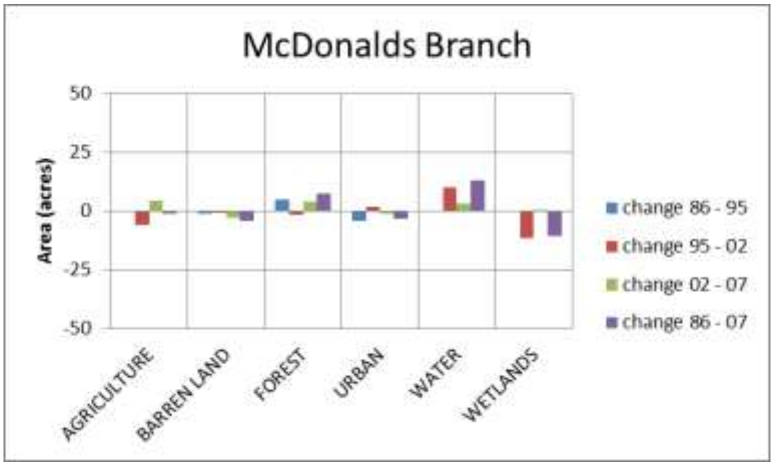


Figure 2-36. McDonalds Branch Land Use Land Cover

Impervious surfaces: McDonalds Branch has 0.04 acres of impervious surface in a subwatershed of more than 3500 acres. It also has less than 10 acres of agricultural lands, indicating that the subwatershed is essentially undeveloped.

Riparian areas and trends: This subwatershed had essentially no riparian area losses as of 1986 and lost no riparian area from 1986 to 2007.

Flood prone areas and trends: This subwatershed has no urban land within its flood prone areas.

Forest areas and trends: Land Use/Land Cover mapping for this subwatershed indicates an increase of 8 acres of forest lands (from 2268 to 2276) from 1986 to 2007.

Wetland areas and trends: Land Use/Land Cover mapping for this subwatershed indicates a loss of 11 acres of wetlands (from 1163 to 1152) from 1986 to 2007.

Ground water recharge: Annual average ground water recharge in McDonalds Branch subwatershed is 890 million gallons per year (MGY), with drought annual recharge being 736 MGY, for a difference of 154 MGY, or 17%. The subwatershed has had no development of Prime Ground Water Recharge Areas from 1995 through 2007.

Protected areas: The McDonald Branch subwatershed is entirely within the Brendan T. Byrne State Forest (formerly the Lebanon State Forest) with 3486.3 acres of State-owned property.

Summary for Comparison Area: McDonald Branch is not a wholly natural or pristine watershed but is nearly so, as ecological processes over the years have restored forest cover to the subwatershed. The area is frequently used as an area against which other watersheds are compared, and the results discussed here represent a watershed that has not been subject to development over the entire study period (1986-2007) or before. Any historic changes would have been in renewable resource extraction, such as for timber and charcoal production.

Overview and Summary

Of the subwatersheds in the three target areas, **Table 2-31** shows those with the most significant impacts of development during the study period of 1986 through 2007, indicating that the stresses are increasing over time. In each case, ecological damages and water quality stresses would be predicted based on the loss of natural vegetation (e.g., forests and wetlands) and hydrological capacity (e.g., flood prone and riparian areas). Stormwater discharge volumes will have increased due to increases in urbanization and impervious surface, even where peak discharges may be mitigated through stormwater basins.

Other subwatersheds as discussed above have extensive development that would cause environmental damages, but experienced far less development since 1986. As such those subwatersheds can be considered stressed but stable. Later sections of this report address related issues of water availability, ambient quality, and infrastructure capacity. The final section draws overall conclusions.

Table 2-31. Compilation of Target Area Indicators of Watershed Integrity
(Values in bold indicate significant increases during period of analysis)

Indicator	**02040202060020 Lake Pine / Centennial Lake & tribs**	**02040202060080 Rancocas Ck SW Branch (above Medford br)**	**02040202060100 Rancocas Ck SW Branch (below Medford br)**	**02040301140030 Tuckerton Creek (below Mill Branch)**
Urbanization 1986-2007 (Acres)	**825**	**770**	**838**	**817**
Impervious Surfaces (%)	7	**21**	10	**14**
Riparian Area (% Urban)	23.3	**31.3**	**14.9**	**32.5**
Flood Prone Area (% Urban)	21	**26**	9	**39**
Forest % Losses (1986-2007)	**13**	-1	1	**19**
Wetlands % Losses (1986-2007)	1	**6**	**6**	1
PGWRA (% Urban)	**13**	**19**	**12**	**37.1**
Protected Areas (%)	17.6	26.2	0.4	10.7

Chapter 3: Water Quality

The Pinelands ecological region harbors an ecomosaic (an assemblage of ecosystems) that is arguably unique; that is, the Pinelands has a compilation of species that is matched by no other place in the world, leading to designation of the area as an International Biosphere Reserve by the United Nations Educational, Scientific and Cultural Organization (UNESCO) in 1988. Many researchers from academia, the Pinelands Commission, state and federal agencies and other organizations have been conducting biological and ecological research in the Pinelands for over a century, compiling detailed reports of biological life in the region. A major factor in the area is how hydrology interacts with the ecosystems. The Pinelands soils are for the most part highly porous sands with minimal organic content, and so the soils tend to be dry except for immediately after a precipitation event. Forest fires are common and were more so prior to human intervention, so that the emblematic pines of the Pinelands represent a fire climax forest, where hardwoods are naturally suppressed by fire and the major pine species, the Pitch Pine (*Pinus rigida*), requires the heat of fires to release seeds from its serotinous cones. Water is available primarily where the ground water table approaches or reaches the surface of the land, in ponds and streams. A second factor is the very natural low pH of the ground water, which in turn results in low pH within the surface waters that depend primarily on discharge from ground water for their flows. Along with the low pH are naturally low nutrient levels. These factors have limited the viability of species from surrounding ecosystems. Pinelands species are tolerant of these constraining characteristics and are highly susceptible to competition from non-native species where natural water quality has been changed through the introduction of lime as a soil amendment to allow the production of non-native food and plant products, increased nutrients either from fertilizers or wastewater effluent, and other modifications.

This chapter summarizes the water uses supported by water quality standards, and assesses available information on water quality based on water and biological monitoring, assessments, designation of polluted areas, etc. The comparison of target area subwatersheds to the McDonalds Branch subwatershed helps provide an understanding of the impacts from intensive land use patterns.

Surface Water Quality Standards

The NJDEP assigns surface water quality classifications to all surface waters in the state through the Surface Water Quality Standards (N.J.A.C. 7:9B), using the system outlined in **Table 3-1**, as applicable to the target areas. Each classification is intended to protect specific designated uses as shown.

Table 3-1. Surface Water Quality Standards: Classifications and Designated Uses (from N.J.A.C. 7:9B, Amended April 4, 2011)

Classification	**Description**	**Designated Uses** (all include "any other reasonable uses")
SC (Saline Coastal)	General surface water classification applied to coastal saline waters (salinities generally greater than 3.5 parts per thousand at mean high tide)	1. Shellfish harvesting 2. Maintenance, migration and propagation of the natural and established biota 3. Primary contact recreation
SE1 (Saline Estuary)	General surface water classification applied to saline waters of estuaries (salinities generally greater than 3.5 parts per thousand at mean high tide)	Same as SC

Table 3-1. Surface Water Quality Standards: Classifications and Designated Uses (from N.J.A.C. 7:9B, Amended April 4, 2011)

Classification	**Description**	**Designated Uses** (all include "any other reasonable uses")
Outstanding National Resource Waters (ONRW)	High quality waters that constitute an outstanding national resource (for example, waters of National/State Parks and Wildlife Refuges and waters of exceptional recreational or ecological significance). FW1 waters and Pinelands waters are Outstanding National Resource Waters.	
• FW1 (Fresh Water 1)	Fresh waters that are to be maintained in their **natural state of quality** (set aside for posterity) and not subjected to any man-made wastewater discharges or increases in runoff from anthropogenic activities. These waters are set aside for posterity because of their clarity, color, scenic setting, other characteristic of aesthetic value, unique ecological significance, exceptional recreational significance, exceptional water supply significance or exceptional fisheries resource(s).	1. Set aside for posterity to represent the natural aquatic environment and its associated biota 2. Primary contact recreation 3. Maintenance, migration and propagation of the natural and established aquatic biota
• Pinelands waters	All waters within the boundaries of the Pinelands Area as established in the Pinelands Protection Act, except those waters designated as FW1. Depicted on the following maps as PL. Special surface water quality criteria apply to PL waters: pH level between 3.5 and 5.5; and Nitrate-Nitrogen level of 2 mg/L or the existing surface water quality, whichever is lower.	1. Cranberry bog water supply and other agricultural uses 2. Maintenance, migration and propagation of the natural and established biota indigenous to this unique ecological system 3. Public potable water supply after conventional filtration treatment[8] and disinfection 4. Primary contact recreation
FW2 (Fresh Water 2)	General surface water classification applied to those fresh waters that are not designated as FW1 or Pinelands Waters.	1. Maintenance, migration and propagation of the natural and established biota 2. Primary contact recreation 3. Industrial and agricultural water supply 4. Public potable water supply after conventional filtration treatment and disinfection
• Nontrout waters	FW2 waters that have not been designated as trout production or trout maintenance. These waters are generally not suitable for trout because of their physical, chemical or biological characteristics, but are suitable for a wide variety of other fish species. Depicted on the following maps as FW2-NT.	

[8] Defined as "a series of processes including filtration, flocculation, coagulation, and sedimentation, resulting in substantial particulate removal but no consistent removal of chemical constituents"

Further, each classification is associated with an antidegradation policy (**Table 3-2**) that determines whether water quality should reflect natural quality, be protected against any degradation from current quality (which may or may not be equivalent to natural quality) or be protected against water quality degradation that would harm designated uses.

Table 3-2. Surface Water Quality Standards: Antidegradation Policies (from N.J.A.C. 7:9B, Amended April 4, 2011)

Antidegradation Policy Category	**Description**
Nondegradation waters	**Waters set aside for posterity** because of their clarity, color, scenic setting, other characteristic of aesthetic value, unique ecological significance, exceptional recreational significance, or exceptional water supply significance. These waters include all waters designated as FW1 in this subchapter. The antidegradation policy requires that "The quality of nondegradation waters shall be maintained in their natural state (set aside for posterity) and shall not be subject to any manmade wastewater discharges. The Department shall not approve any activity which, alone or in combination with any other activities, might cause changes, other than toward natural water quality, in the existing surface water quality characteristics."
Category one (C1) waters	Waters designated for **protection from measurable changes in water quality** based on exceptional ecological significance, exceptional recreational significance, exceptional water supply significance or exceptional fisheries resource(s) to protect their aesthetic value (color, clarity, scenic setting) and ecological integrity (habitat, water quality and biological functions). The antidegradation policy requires that "water quality characteristics that are generally worse than the water quality criteria, except as due to natural conditions, shall be improved to maintain or provide for the designated uses where this can be accomplished without adverse impacts on organisms, communities, or ecosystems of concern."
Category two (C2) waters	Waters not designated as Outstanding National Resource Waters or Category One. The antidegradation policy requires that "water quality characteristics that are generally better than, or equal to the water quality standards shall be maintained within a range of quality that shall protect the existing/designated uses… Water quality characteristics that are generally worse than the water quality criteria shall be improved to meet the water quality criteria."

The classifications applicable to three target areas and associated subwatersheds are shown in **Figures 3-1** through **3.3**. Within the three target areas, all of Hammonton and Medford Lakes, the southern portions of Evesham and Medford Townships, and the northern portion of Little Egg Harbor Township are all designated PL. The northern portions of Evesham and Medford Townships are primarily designated FW2-NT and are Category 2 waters. Tuckerton Borough and the southern portion of Little Egg Harbor Township have various combinations of SE1 waters (both Category 1 and 2), in some places combined with FW2-NT (both Category 1 and 2), with the latter tidal streams perhaps indicating uncertainty regarding their salinity. All along the coast, the existence of lagoon developments and ditches in coastal wetlands creates great complexity in the drainage systems shown. However, these areas are nearly all outside of the target subwatersheds.

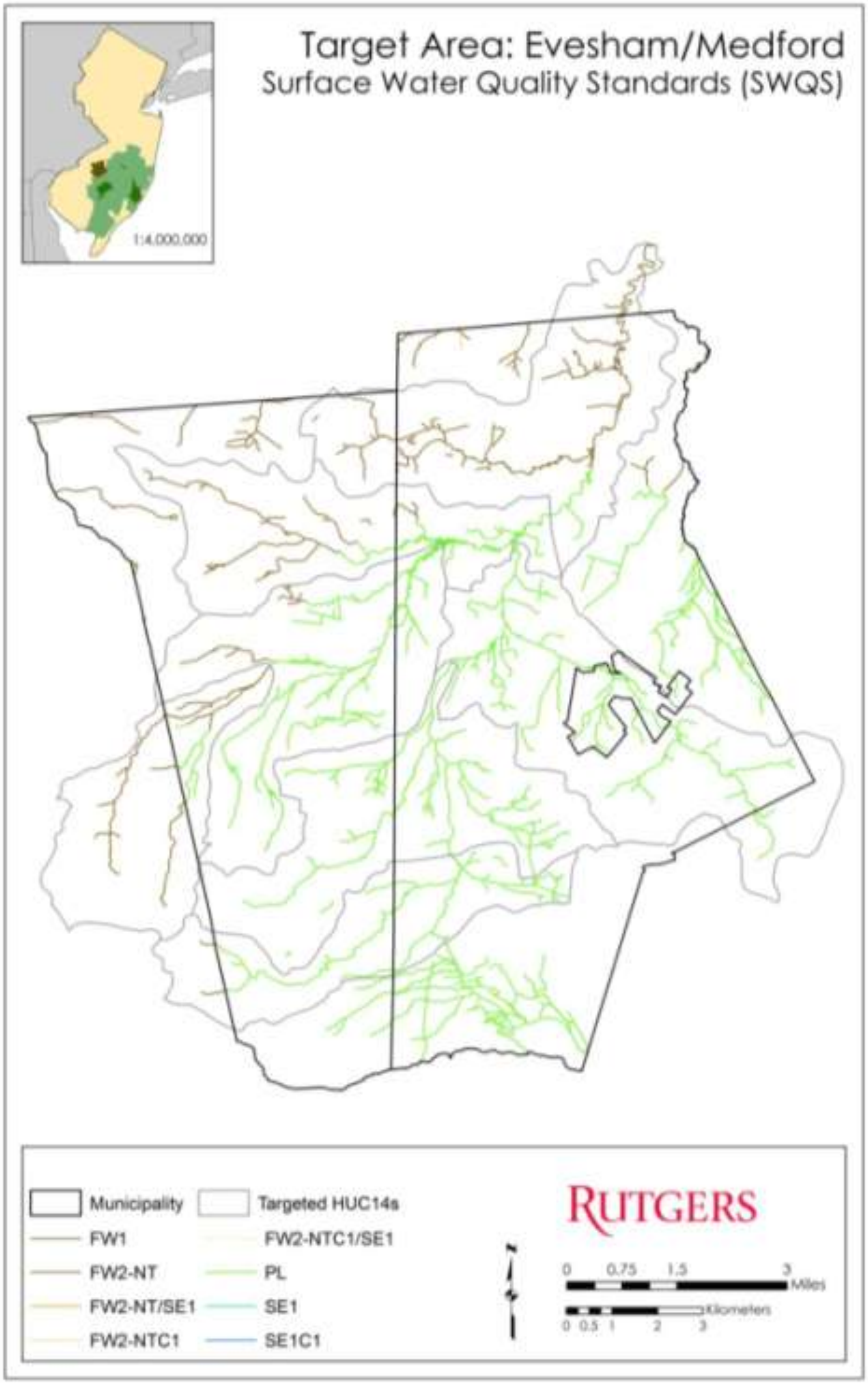


Figure 3-1. SWQS Classifications: Evesham/Medford Target Area

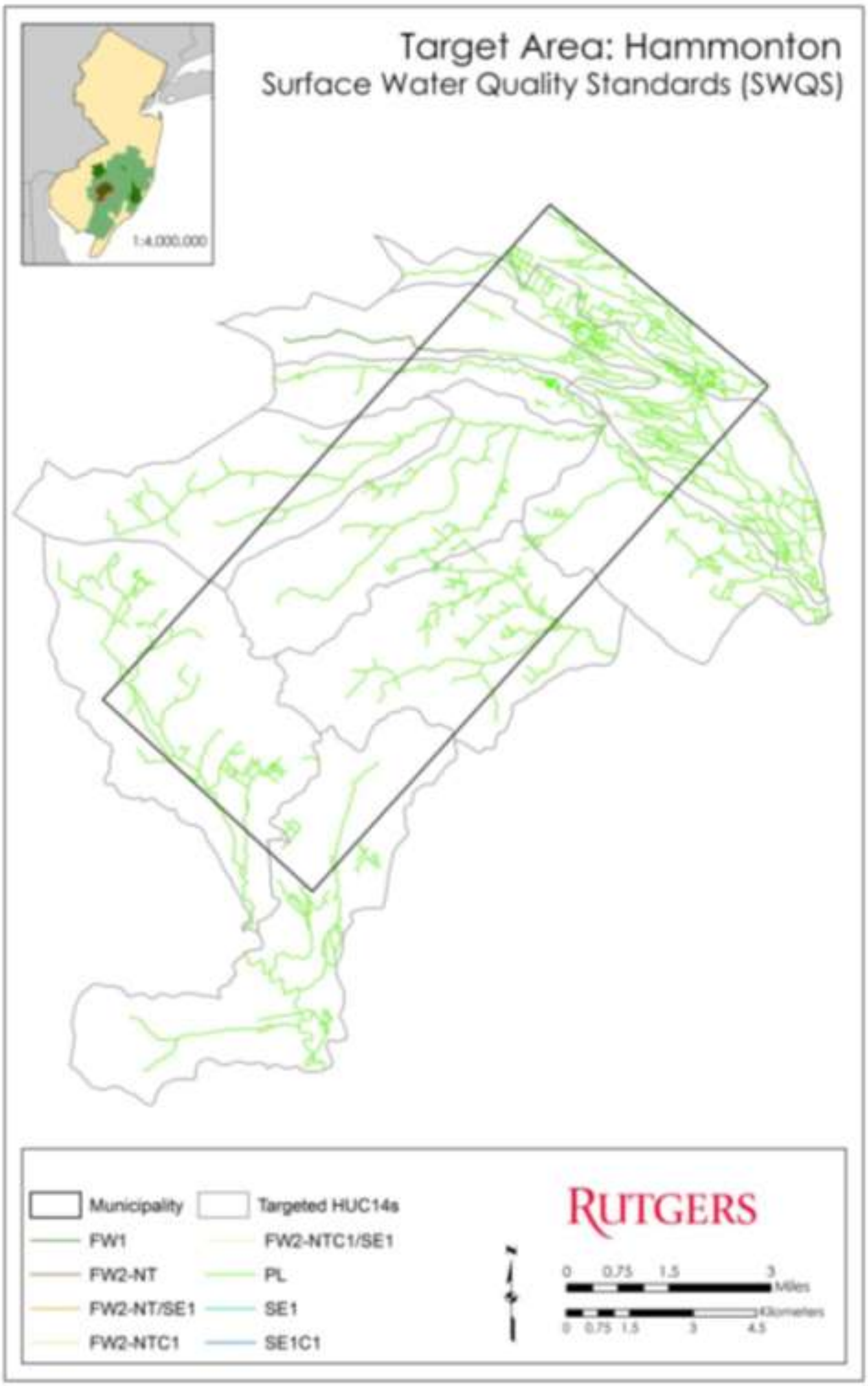


Figure 3-2. SWQS Classifications: Hammonton Target Area

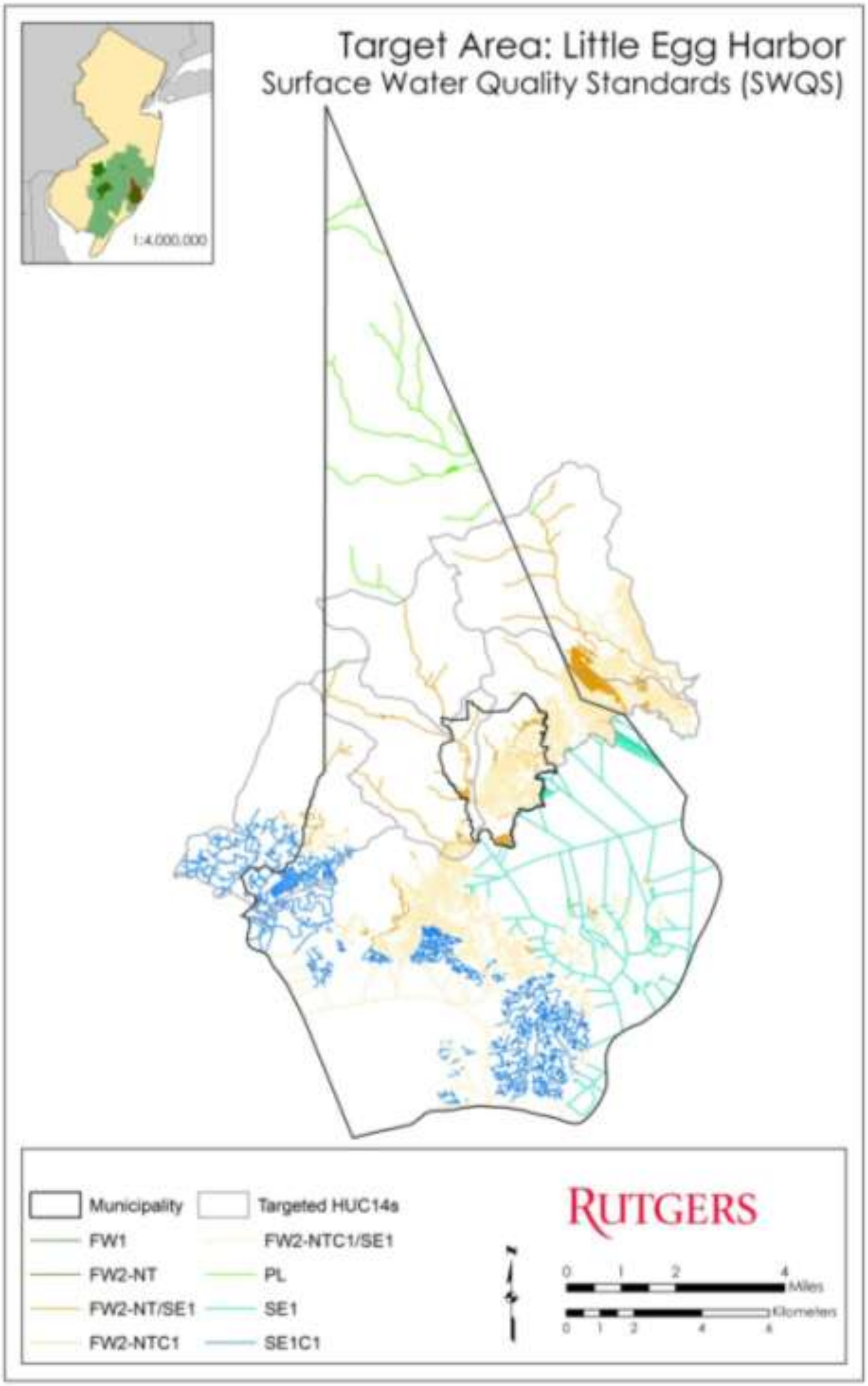


Figure 3-3. SWQS Classifications: Little Egg Harbor/Tuckerton Target Area

Surface Water Quality – Chemical and Physical

Several reports are available that compile available information regarding common surface water quality contaminants. The following table is drawn from report by USGS (Hunchak-Kariouk, 1999) and the Pinelands Commission (Zampella et al., 2001, 2003, 2005 and 2006).

Table 3-3. Water Quality Conditions of Selected Pinelands Streams											
	Target Area	**McDonalds Branch**		**LEHT**		**Hammonton**				**Medford/Evesham**	
	Study Basin	Greenwood Branch Study Basin		Westecunk Creek Study basin		Hammonton Creek basin	Nescochague Creek Basin	Sleep Branch Basin	All sites in target area	Southwest Branch Rancocas Creek Study Basin	
	Station Name	McDonalds Branch at Butterworth Road		Westecunk Creek at Forge Road		Hammonton Creek at Westcoatville	Multiple	Clark Branch near Atsion		Multiple	
Parameter	**units**	**Median Value**	**Year(s) Recorded**	**Median Value**	**Year(s) Recorded**	**Median Value**	**Median Value**	**Median Value**	**Year(s) Recorded**	**Median Value**	**Year(s) Recorded**
pH	standard unit	4.1	2001	4.9	1988-1992	6.5	6.3*	4.6	1995-1998	5.5[&]	2001
Specific Conductivity (SC)	uS/cm	37	2001	28	" "	118	84*	63	" "	89[&]	" "
Nitrite + Nitrate	mg/L	<0.06	1989 - 93	0.02	" "	1.27	0.9*	0.05	" "	0.26[#]	1984-1990
Ammonia	mg/L	0.02	" "	<0.05	" "	<0.03	<0.02*	<0.02	" "	0.22[#]	" "
Total P	mg/L	0.01	" "	0.01	" "	0.13	<0.01*	<0.01	" "	0.08[#]	" "
Sulfate	mg/L	-	-	-	-	12	10*	9.3	" "	-	-
Alkalinity	mg/L as CaCO3	<1	" "	-	-	6	-	-	1989 - 93	-	-
Dissolved solids	mg/L	22	" "	-	-	6	-	-	" "	-	-
Dissolved Oxygen	mg/L	3.4	" "	-		5.9	-	-	" "	-	-

***** Average of: Blue Anchor Brook at Elm, Albertson Brook near Elm, Great Swamp Branch, Nescochague Creek at Pleasant Mills

& Average of: Barton Run below Jennings Lake, Black Run at Route 544,Black Run abandoned cranberry bog, Black Run tributary at Kettle Run Road

Average of: Black Run at Route 544, Haynes Creek at Breakneck Avenue, Haynes Creek at Centennial Dam Road, Haynes Creek Trib. at Hopewell Road, Barton Run at Tuckerton Road, Haynes Creek Trib. at Beach Trail, Southwest Branch Rancocas Creek at Rout 541, Kettle Run at Hopewell Road , Haynes Creek Trib. at Lower Aetna Lake outlet at Stokes Road, Southwest Branch Rancocas Creek at Hartford Road, Barton Run Trib. at Kenilworth Road

The table shows clearly the difference of other monitoring stations from McDonalds Branch, with the latter having the lowest pH, low Specific Conductivity (along with Westecunk Creek), and very low nutrients. Hammonton Creek is notable as having the highest pH, Specific Conductance and nutrient levels among the stations, with the stations of the Nescochague Creek drainage showing similar levels.

While water quality trend data for the specific target areas of this study are not available, **Tables 3-4** and **3-5** present trend data for New Jersey and for the Northeastern United States from 1975 to 2003 below (Trench et al., 2012). Though the application of these data to the target areas in this study is not direct, they provides a general sense of water quality trends within these areas.

Table 3-4. Water quality trend data from NJ

	1975–2003, 1979–2003, or 1982–2003				1993–2003			
Water-quality constituent	Number of stations analyzed	Upward trend	Downward trend	No significant trend	Number of stations analyzed	Upward trend	Downward trend	No significant trend
Total nitrogen	11	27%	36%	36%	33	9%	24%	67%
Nitrate + Nitrite Nitrogen	10	50%	20%	30%	22	5%	23%	73%
Total phosphorous	10	10%	50%	40%	35	6%	11%	83%

Table 3-5. Water quality trend data from the Northeastern United States

	1975–2003, 1979–2003, or 1982–2003				1993–2003			
Water-quality constituent	Number of stations analyzed	Upward trend	Downward trend	No significant trend	Number of stations analyzed	Upward trend	Downward trend	No significant trend
Total nitrogen	32	13%	56%	31%	81	15%	19%	67%
Ammonia nitrogen	6	0%	100%	0%	15	13%	40%	47%
Nitrate + Nitrite Nitrogen	32	34%	31%	34%	52	2%	23%	75%
Total phosphorous	32	9%	59%	31%	83	20%	7%	72%
Suspended sediment	4	0%	100%	0%	8	13%	25%	63%

The Pinelands Commission also evaluated the relationship between water quality parameters (pH and specific conductance) and the proximity of development to streams (Zampella and Procopio, 2009), finding compelling but not conclusive evidence that development proximity to streams affects the magnitude of water quality changes from Pinelands-typical levels.

Surface Water Quality – Biological

Academic researchers, the Pinelands Commission, the U.S. Geological Survey, NJDEP and others have undertaken both primary research and compilations of research from multiple sources over the last 30 years and more. As discussed above, the Pinelands ecological region has an unusual water chemistry and hydrology, which then leads to a unique assemblage of aquatic species. Three types of data are available regarding the extent to which Pinelands aquatic ecosystems have been modified from their natural state: macroinvertebrate life in streams; fish in streams; and fish in ponds and lakes. It should be noted that all permanent ponds and lakes in the Pinelands are the result of human action, generally associated with historic development of mill ponds, water supplies and cranberry bogs. Natural ephemeral ponds (vernal ponds) do exist, where a rising water table (generally during the winter and spring) creates a surface water area that is not connected to a stream system and then a declining water table (generally during the summer) eliminates the surface water. These vernal pools represent highly specialized aquatic ecosystems and are important for the survival of amphibians and other species.

Macroinvertebrate species found in streams provide a good indicator of aquatic conditions that are typical for that stream. Researchers have found that the degree of urbanization and watershed change provide good indicators of the existence of pollution-tolerant species in aquatic ecosystems (Kennen and Ayers, 2002). Most such species can survive very short-term shifts in conditions but are influenced by conditions that last for somewhat longer periods of time. Given their short life-cycles, though, they are more sensitive to changing conditions than many fish or reptiles, and so provide a good indicator of intermediate-period conditions. **Table 3-6**, derived from NJDEP's Ambient Biomonitoring Network reports (NJDEP 2010 and 2012c) on macroinvertebrate and habitat quality, provides information on macroinvertebrates associated with subwatersheds of the three target areas. Note that no sites with an "Excellent" or "Good" PMI Rating have an elevated pH (above 5.0). In this case, no data are available from McDonalds Branch.

Table 3-6. Pinelands macroinvertebrate Index

Target Area	AMNET SITE #	Stream Name	PMI Rating	Habitat Analysis	pH	DO (mg/L)	T (deg C)
LEHT	AN0557A	Westecunk Ck	68.61 Excellent	160 Optimal	4.01	5	18.85
	AN0559	Mill Br of Tuckerton Ck	60.84 Good	162 Optimal	4.18	7.6	18.48
	AN0559A	Mill Br	73.11 Excellent	**131 Suboptimal**	4.03	6.78	19.04
Hammonton	AN0572	Albertson Bk	**50.12 Fair**	172 Optimal	**6.23**	6.87	22.90
	AN0574	Great Swamp Bk	**54.85 Fair**	**141 Suboptimal**	**5.68**	5.58	19.24
	AN0575	Cedar Bk	**52.12 Fair**	**125 Suboptimal**	**6.21**	4.27	22.58
	AN0577	Hammonton Ck	**43.03 Fair**	**131 Suboptimal**	**5.92**	5.72	22.77
Evesham/ Medford	AN0162	Southwest Br Rancocas Ck	**27.50 Poor**	**117 Suboptimal**	**7.1**	5.78	22.65
	AN0164	Black Run	75.70 Excellent	**152 Suboptimal**	4.64	6.45	19.43
	AN0165	UNT to Black Run	57.79 Good	**142 Suboptimal**	4.95	1.62	25.76
	AN0167	Kettle Run	**38.36 Fair**	**124 Suboptimal**	**6.79**	7.4	27.94
	AN0158	Little Ck	**41.65 Fair**	**142 Suboptimal**	**6.29**	4.11	23.00
	AN0159	Bear Swamp River	**49.01 Fair**	169 Optimal	4.02	4.98	22.21
	AN0166	Barton Run	**30.10 Poor**	**154 Suboptimal**	**6.28**	4.43	25.73
	AN0168	Haynes Ck	**37.32 Fair**	**129 Suboptimal**	**6.16**	6.08	27.05
	AN0169	Southwest Br Rancocas Ck (Haynes Ck)	**52.23 Fair**	**118 Suboptimal**	**6.41**	4.86	26.41
	AN0170	Sharps Run	**33.61 Poor**	**138 Suboptimal**	**6.92**	3.37	24.75
	AN0146	McDonalds Branch	60.52 Good	168 Optimal	4.03	5.90	17.20

Table 3-7, derived from Zampella et al. (2007), provides information on fish and anurans (amphibian) species in ponds associated with subwatersheds of the three target areas and McDonalds Branch. This table addresses the number of species associated with each pond from three classes of species, with non-native species representing the degree of modification from the natural system. As shown in the table, Pakim Pond in McDonalds Branch has no non-native fish or anurans species. All ponds in the Evesham/Medford and Hammonton target areas have many non-native fish species and most have at least one non-native anurans species. In this case, no data are available from the Little Egg Harbor target area.

Table 3-7. Fish and Anurans Species in Selected Pinelands Ponds							
Target Area	Impoundment	# Fish Species			# Anurans Species		
		Restricted-native	Widespread-native	Non-native Species	Restricted-native	Widespread-native	Non-native Species
McDonalds Branch	Pakim Pond	1	2	0	1	2	0
Hammonton	Hammonton Lake	1	2	6	0	0	2
	Paradise Lake	4	5	4	1	2	1
Medford/Evesham	Jennings Lake	1	5	3	0	1	1
	Kettle Run Imp.	5	1	4	1	2	0
	Lady's Lake	4	3	4	0	2	1
	Mimosa Lake	4	0	4	0	2	1

SWQS Violations

NJDEP compiles a biennial Integrated Water Quality Monitoring and Assessment Report, an evaluation of surface water quality for all subwatersheds and coastal waters of the state, in compliance with Section 305b of the federal Clean Water Act. Part of that report responds to Section 303d of the Clean Water Act in identifying areas that are non-attainment for the state's Surface Water Quality Standards (SWQS), and for each such area whether Total Maximum Daily Loads (TMDLs) are required or have been developed, and whether TMDLs are anticipated to be developed during the subsequent reporting period. A TMDL is essentially a water pollution control plan that identifies the current water quality, the improvement necessary to meet SWQS requirements, and the allocation of allowable pollutant loads among point and nonpoint source discharges, future needs, and inherent modeling uncertainty. The final 2012 List was not posted as of March 2014; **Table 3-8** provides information from the Draft 2012 Integrated Report, by target subwatershed, regarding whether a water quality parameter is in violation of the SWQS, when the issue was first listed in a Water Quality Inventory Report, the status of TMDL development, affected designated uses and the cause of impairment. None of the listed subwatersheds were scheduled for TMDL development in the 2013-2014 period. The final 2012 List is not expected to change substantively from the draft, but the Report requires review by USEPA prior to finalization.

Table 3-8. TMDL Status in Target Subwatersheds (Draft 2012 303d List)						
HUC14	Subwatershed Name	Listed Parameter	Cycles First Listed	TMDL Status	Affected Designated Use	Cause of Impairment (if identified)
02040202030070	McDonalds Branch	None	N/A	N/A	N/A	N/A
02040202060010	Kettle Run (above Centennial Lake)	pH	2008	Medium Priority	Aquatic Life	Agriculture, Urban runoff/ storm sewers
02040202060020	Lake Pine / Centennial Lake & tribs	pH	2010	Medium Priority	Aquatic Life	
02040202060030	Haynes Creek (below Lake Pine)	pH	2010	Medium Priority	Aquatic Life	

Table 3-8. **TMDL Status in Target Subwatersheds (Draft 2012 303d List)**

HUC14	Subwatershed Name	Listed Parameter	Cycles First Listed	TMDL Status	Affected Designated Use	Cause of Impairment (if identified)
02040202060040	Barton Run (above Kettle Run Road)	Oxygen, Dissolved	2008	Medium Priority	Aquatic Life	Urban Runoff/ Storm Sewers, Agriculture, Natural sources
		pH	2006	Medium Priority	Aquatic Life	
		Arsenic	2008	Low Priority	Public Water Supply	
02040202060050	Barton Run (below Kettle Run Road)	Oxygen, Dissolved	2008	Medium Priority	Aquatic Life	Agriculture, Urban runoff/ storm sewers
		pH	2006	Medium Priority	Aquatic Life	
		Phosphorus, total	2010	Medium Priority	Aquatic Life	
		Arsenic	2008	Low Priority	Public Water Supply	
02040202060080	Rancocas Ck SW Branch (above Medford br)	pH	2008	Medium Priority	Aquatic Life	Municipal point source discharges, agriculture, urban runoff/ storm sewers
		Phosphorus, total	2006	Medium Priority	Aquatic Life	
		Total suspended solids (TSS)	2008	Medium Priority	Aquatic Life	
		E. coli	2006	Completed	Primary Contact Recreation	
		Arsenic	2008	Low Priority	Public Water Supply	
		Nitrates	2008	Medium Priority	Public Water Supply	
02040202060100	Rancocas Ck SW Branch (below Medford br)	Oxygen, Dissolved	2008	Medium Priority	Aquatic Life	Municipal point source discharges, agriculture, urban runoff/ storm sewers, atmospheric deposition - toxics
		pH	2008	Medium Priority	Aquatic Life	
		Phosporus, total	2006	Medium Priority	Aquatic Life	

Table 3-8. **TMDL Status in Target Subwatersheds (Draft 2012 303d List)**

HUC14	Subwatershed Name	Listed Parameter	Cycles First Listed	TMDL Status	Affected Designated Use	Cause of Impairment (if identified)
		PCB(s) in fish tissue	2006	Low Priority	Fish Consumption	
		Fecal Coliform	2006	Completed	Primary Contact Recreation	
		Arsenic	2006	Low Priority	Public Water Supply	
02040301130060	Westecunk Creek (below GS Parkway)	Total Coliform	2008	Completed/ Medium Priority	Shellfish Harvesting	Urban Runoff/ Storm Sewers
02040301140020	Mill Branch (below GS Parkway)	PCB(s) in fish tissue	2010	Low Priority	Fish Consumption	
		Mercury in fish tissue	2010	Completed	Fish Consumption	
		pH	2006	Medium Priority	Aquatic Life	
02040301140030	Tuckerton Creek (below Mill Branch)	Mercury in fish tissue	2010	Completed	Fish Consumption	
		Phosphorus, total	2008	Completed	Aquatic Life	
		Total Coliform	2006	Completed	Shellfish Harvesting	
02040301140040	LEH Bay tribs (Westecunk Ck-Tuckerton Ck)	None	N/A	N/A	N/A	N/A
02040301160110	Albertson Brook	pH	2006	Medium Priority	Aquatic Life	
02040301160120	Great Swamp Branch (above Rt 206)	Arsenic	2012	Low Priority	Public Water Supply	Agriculture, Urban Runoff/ Storm Sewers, Upstream Impoundments
		Nitrates	2006	Medium Priority	Public Water Supply	
		Temperature, water	2008	Medium Priority	Aquatic Life	
		pH	2006	Medium Priority	Aquatic Life	Agriculture, Urban Runoff/ Storm Sewers
02040301160130	Great Swamp Branch (below Rt 206)	Arsenic	2012	Medium Priority	Public Water Supply	
		Nitrates	2006	Completed/ Medium Priority	Public Water Supply	
		E. coli	2008	Low Priority	Primary Contact Recreation	

Table 3-8. **TMDL Status in Target Subwatersheds (Draft 2012 303d List)**

HUC14	Subwatershed Name	Listed Parameter	Cycles First Listed	TMDL Status	Affected Designated Use	Cause of Impairment (if identified)
		pH	2006	Medium Priority	Aquatic Life	
02040301160150	Nescochague Creek	None	N/A	N/A	N/A	N/A
02040301160160	Gun Branch	pH	2010	Medium Priority	Aquatic Life	
02040301160170	Sleeper Branch	DDD	2010	Low Priority	Fish Consumption	
		DDE	2010	Low Priority	Fish Consumption	
		DDT	2010	Low Priority	Fish Consumption	
		Mercury in fish tissue	2010	Low Priority	Fish Consumption	
		PCB(s) in fish tissue	2010	Low Priority	Fish Consumption	
		pH	2010	Medium Priority	Aquatic Life	
02040301170010	Hammonton Creek (above 74d43m)	pH	2006	Medium Priority	Aquatic Life	Agriculture, Urban runoff/ storm sewers, natural sources, industrial point source discharge
		Phosphorus, total	2006	Medium Priority	Aquatic Life	
		Total suspended solids (TSS)	2012	Medium Priority	Aquatic Life	
		Mercury in fish tissue	2008	Medium Priority	Fish Consumption	
		E. coli	2006	Completed	Primary Contact Recreation	
		Arsenic	2006	Low Priority	Public Water Supply	
		Nitrates	2006	Medium Priority	Public Water Supply	
02040301200070	Ballanger Creek	-	-	-	-	
02040302030070	Penny Pot Stream (GEHR)	pH	2006	Medium Priority	Aquatic Life	Agriculture, Urban runoff/ storm sewers
02040302040080	GEHR (39d32m50s to Hospitality Branch)	Copper	2006	Low Priority	Aquatic Life	Agriculture, Urban runoff/ storm sewers
		pH	2006	Medium Priority	Aquatic Life	

Table 3-8. TMDL Status in Target Subwatersheds (Draft 2012 303d List)						
HUC14	**Subwatershed Name**	**Listed Parameter**	**Cycles First Listed**	**TMDL Status**	**Affected Designated Use**	**Cause of Impairment (if identified)**
02040301140020 (Lake)	Pohatcong Lake (Tuckerton Borough)	Phosphorus, total	2002	Completed	Aquatic Life	Urban runoff, septic systems
02040301170010 (Lake)	Hammonton Lake (Hammonton)	Phosphorus, total	2002	Completed	Aquatic Life	Urban runoff/ storm sewers

TMDLs for the two lakes listed at the end of **Table 3-8** were established by NJDEP (2003). Pohatcong Lake is a 35-acre, shallow impoundment on Tuckerton Creek (primarily Mill Branch), with most of its total phosphorus load from various types of development and some septic systems within its watershed; a 32% reduction in total phosphorus is needed to achieve the TMDL, representing a 49% reduction from each developed land use and from septic systems. Hammonton Lake is a 65-acre former millpond on Hammonton Creek, with most of its total phosphorus load from residential development and some commercial/industrial land uses; a 76% reduction in total phosphorus is needed to achieve the TMDL, representing an 81% reduction from each developed land use.

In addition to TMDLs for freshwater resources, NJDEP (2006) also established a TMDL for total coliform bacteria in the Tuckerton Creek estuary, with a required reduction of 81% from then-current conditions. A total of 23.5 acres in this tidal area of Tuckerton Creek were subsequently closed to shellfishing by NJDEP (2014) due to elevated bacteria levels.

Ground Water Quality Standards

The NJDEP assigns ground water quality classifications to all ground waters in the state through the Ground Water Quality Standards (N.J.A.C. 7:9C), using the system outlined in **Table 3-9**.

Table 3-9. Ground Water Quality Standards: Classifications and Designated Uses (from N.J.A.C. 7:9C, Amended July 22, 2010)		
Classification	**Description**	**Designated Uses**
Class I	**Ground Water of Special Ecological Significance**	
• Class I-A	Exceptional Ecological Areas: Public land that “Contributes to the transmittal of ground water to surface water in FW1 watersheds,” and Natural Areas as designated by the Department pursuant to N.J.A.C. 7:5A-1.13	Primary: maintenance of special ecological resources supported by the ground water within the classification area. Secondary: potable water, agricultural water and industrial water to the extent that these uses are viable using water of natural quality and do not impair the primary use, such as by altering ground water quality.
• Class I-PL (Pinelands)	All ground water in the Cohansey and Kirkwood Formations located within the Pinelands area as designated by the Pinelands Protection Act, N.J.S.A. 13:18A-1 et seq. Further delineated based the Preservation Area and the Protection Area.	Class I-PL (Preservation Area): Primary is the support and preservation of unique and significant ecological resources of the Pinelands, through the restoration, maintenance and preservation of ground water quality in its natural state. Secondary: include compatible agricultural uses in conformance with N.J.A.C. 7:50-6 et seq. and potable water uses.

Table 3-9. Ground Water Quality Standards: Classifications and Designated Uses (from N.J.A.C. 7:9C, Amended July 22, 2010)		
Classification	**Description**	**Designated Uses**
		Class I-PL (Protection Area): Primary is the preservation of Pinelands plant and animal species and their habitats through the protection and maintenance of the essential characteristics of Pinelands ground water quality. Secondary: include potable and agricultural water.
Class II	**Ground Water for Potable Water Supply**	
• Class II-A	Class II-A shall consist of all ground water of the State, except for ground water designated in Classes I, II-B or III.	Primary: potable water and conversion (through conventional water supply treatment, mixing or other similar technique) to potable water. Secondary: include agricultural water and industrial water.
• Class II-B	By petition only. None designated.	Not applicable to target areas
Class III	**Ground Water With Uses Other Than Potable Water Supply**	
• Class III-A	Ground water in an aquitard (layer of low permeability that serves to confine a lower aquifer)	Primary: the release or transmittal of ground water to adjacent classification areas and surface water, as relevant. Secondary: any reasonable uses.
• Class III-B	Ground water having natural concentrations or regional concentrations (through the action of salt-water intrusion) exceeding 3,000 mg/l Chloride or 5,000 mg/l Total Dissolved Solids, or where the natural quality of ground water is otherwise not suitable for conversion to potable uses.	Any reasonable uses for such ground water other than potable water, using water of existing quality.

The GWQS also have antidegradation policies applicable to each classification, as follows:

Table 3-10. Ground Water Quality Standards: Antidegradation Policies (from N.J.A.C. 7:9C, Amended July 22, 2010)	
Antidegradation Policy Category	**Description**
Class I-A	Nondegradation classification where natural quality is to be maintained or restored. The Department shall not approve any discharge to ground water or approve any human activity which results in a degradation of natural quality within a Class I-A classification area
Class I-PL (Preservation)	Nondegradation classification where natural quality is to be maintained or restored. The Department shall not approve any discharge or any other activity which would result in the degradation of natural quality, unless in conformance with the Pinelands CMP.

Table 3-10. Ground Water Quality Standards: Antidegradation Policies (from N.J.A.C. 7:9C, Amended July 22, 2010)	
Antidegradation Policy Category	**Description**
Class I-PL (Protection)	Nondegradation classification where background quality is to be maintained. The Department shall not approve any discharge or any other activity which would result in the degradation of background quality, unless in conformance with the Pinelands CMP.
Class II-A Class III-A Class III-B	Antidegradation classification, where NJDEP shall not approve a discharge to Class II or Class III ground water from: (1) a new or expanded domestic treatment works that requires a water quality management plan amendment pursuant to N.J.A.C. 7:15 unless the existing ground water quality (based on an assumed background nitrate concentration of 2 mg/L) will be maintained on a HUC 11 basis; (2) a NJPDES discharge to ground water permit pursuant to N.J.A.C. 7:14A unless the total nitrate load to the property served by the treatment works, when expressed as a concentration, shall not exceed 6 mg/L nitrate; or (3) a new or expanded industrial treatment works that requires a NJPDES industrial discharge to ground water permit pursuant to N.J.A.C. 7:14A unless the total load of each constituent discharged to the property served by the treatment works, when expressed as a concentration, shall not exceed half of the sum of background water quality for that constituent and the applicable ground water quality criterion, where background water quality does not exceed such criterion.

Of greatest importance to this study is the nondegradation policy applicable to the Pinelands waters (Class I-PL) along with the provision that the nondegradation policy does not apply where a discharge is in conformance with the Pinelands Comprehensive Management Plan. The GWQS classifications in the target areas follow the borders of the Pinelands Area, outside of which the surficial ground waters in all land areas of the Evesham/Medford and Little Egg Harbor/Tuckerton areas are designated Class II-A.

Ground Water Quality

This section focuses on water quality of the surficial aquifers, with regard to contaminants that tend to be associated with developed and agricultural areas (e.g., pH, nutrients, pesticides, bacteria, TDS). All of the public community water supply wells are in the confined aquifers, rather than the surficial aquifers, and are addressed in **Chapter 5** on PCWS systems.

Ambient ground water quality monitoring network

The NJDEP and USGS maintain a cooperative ambient ground water quality monitoring network; some monitoring wells are located in the Pinelands Area or nearby. The following table provides the results of four monitoring locations in the area. Of note are the results in the highlighted cells. Monitoring Well #13 in Medford Township shows significantly elevated sodium and chloride, indicating infiltration of salts that likely derive from road salting in the winter. The same well is somewhat higher than the others in pH, though still at a pH of 5.0. Monitoring Well #54 shows highly elevated levels of Nitrate-Nitrogen. It is located in an agricultural area, where the use of fertilizer is common. Monitoring Well #51, on the other hand, has very elevated levels of the metals iron and aluminum, which may be natural contaminants.

Table 3-11. Ambient Ground Water Quality Network: Selected Data from Pinelands Monitoring Wells

Station ID	Units	393415074564000	394123074435000	393129074383000	395836074543000	GWQS Criteria for II-A
Groundwater Site Inventory Number		291404	11402	11404	51486	
Mon. Well #		57	51	54	13	
Municipality		Little Egg Harbor Twp	Hammonton Twp	Hammonton Twp	Medford Twp	
GWQS Classification		I - PL	I - PL	I - PL	II - A	
Name of Aquifer		Kirkwood-Cohansey water-table aquifer system	Kirkwood-Cohansey water-table aquifer system	Kirkwood-Cohansey water-table aquifer system	composite confining unit	
Land Use		Undeveloped	Undeveloped	Agriculture	Agriculture	
Name of stratigraphic unit		Cohansey & Kirkwood Formations	Cohansey & Kirkwood Formations	Cohansey & Kirkwood Formations	Hornerstown Formation	
Date Sampled		7/12/2005	4/18/2005	7/27/2005	6/24/2004	
pH in the field	pH	4	4.5	3.6	5	-
Calcium Dissolved as Ca	(mg/L)	28	0.08	3	35	250
Sodium Dissolved as Na	mg/L	11.7	2.42	6.99	124	50
Chloride Dissolved as Cl	mg/L	62	5.66	14.8	203	250
Sulfate Dissolved as SO4	mg/L	0.9	11	22.9	77.4	250
Arsenic Dissolved as As	µg/L	<0.2	0.8	0.18	0.6	3
Barium Dissolved as Ba	µg/L	24	8	73	23	6
Iron Dissolved as Fe	µg/L	<6	4360	26	<6	300
Aluminum Dissolved as Al	µg/L	103	1540	234	8	200
Nitrogen, Nitrite + Nitrate Dissolved as N	mg/L	0.84	<0.06	18.1	2.16	10

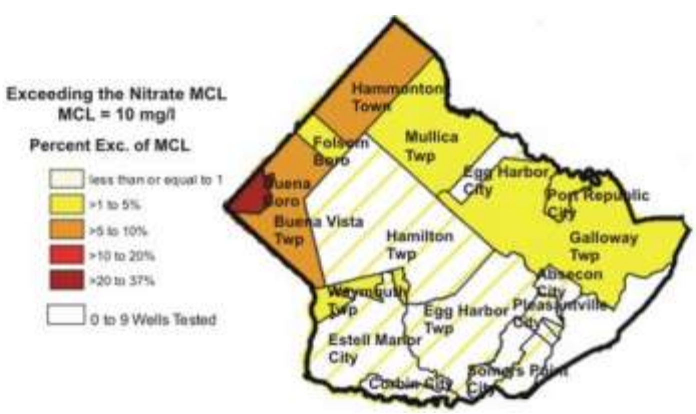
Private Well Testing Act data

New Jersey's Private Well Testing Act (PWTA) requires that private wells (those serving individual residential properties) be tested prior to the sale or transfer of the homes. The individual test results are confidential but NJDEP provides assessments at the municipal level. (No private wells are located in the McDonalds Branch subwatershed and therefore no data are available from the PWTA for this area.) The parameters in **Table 3-12** are of major concern:

Table 3-12. Private Well Testing Act Parameters	
Parameter (Maximum Contaminant Level)	**Sources of Contaminant (NJDEP)**
Gross Alpha (15 pCi/L)	Erosion of natural deposits of certain minerals that are radioactive may emit a form of radiation known as alpha radiation. The alpha radiation is emitted from both short-lived and long-lived radionuclides. In the Southern part of the state, it is probably the decay of radium and its radio-isomers that result in the alpha radiation.
Nitrate (10 mg/L)	Nitrate and in its reduced form nitrite are found in ground water due to a number of factors including natural deposition, runoff from fertilizer use, leaching from septic tanks, and from sewage.
Volatile Organic Chemicals (VOCs) (various MCLs, often in the low parts per billion)	VOCs include solvents, degreasers, and components of gasoline. VOCs are found in ground water due to contamination by industrial or homeowner uses of these compounds.
Mercury (2 µg/L)	Mercury sources can include air deposition, past pesticide use, or discharges from industrial facilities. In addition certain ground water conditions could lead to mobilization of naturally occurring mercury from the subsoil.

For this analysis, nitrate and VOC levels are most related to local anthropogenic sources, while gross alpha radiation is from natural sources and mercury is often from non-local anthropogenic sources. However, it should be recognized that both gross alpha radiation and mercury are significant problems in the Pinelands, driving a need for treatment of both public and private wells. The results for nitrates are listed in **Table 3-13** and shown in the **Figure 3-4** for the Hammonton and Little Egg Harbor/Tuckerton target areas. Less than 1 percent of wells in the Evesham/Medford target area exceeded the nitrate MCL.

Table 3-13. Nitrate Results from PWTA Data, Selected Municipalities				
Municipality	**Number of wells**	**Total Exceeded**	**Percent Exceeded**	**Max mg/L**
Hammonton	214	17	7.9%	22.6
Little Egg Harbor	295	3	1.0%	17.7



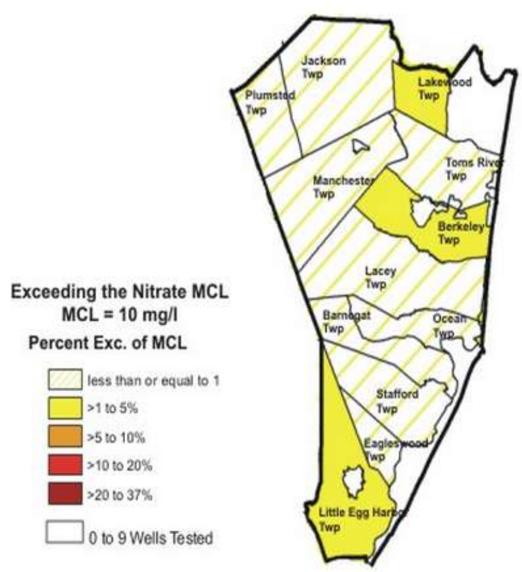


Figure 3-4. Nitrate Contamination by Municipality, PWTA Data

VOC results from the target areas are provided in **Figure 3-5** and **Table 3-14** for the Evesham/Medford and Hammonton areas. None of wells in the Little Egg Harbor/Tuckerton target area exceeded an MCL for VOCs.

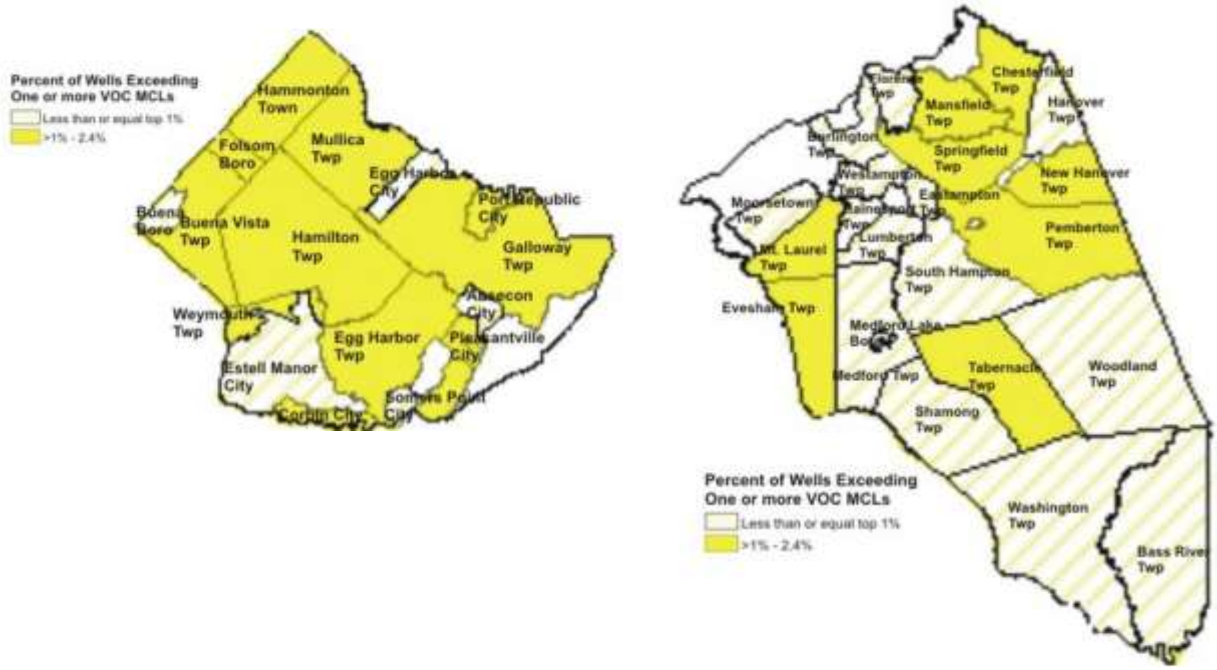


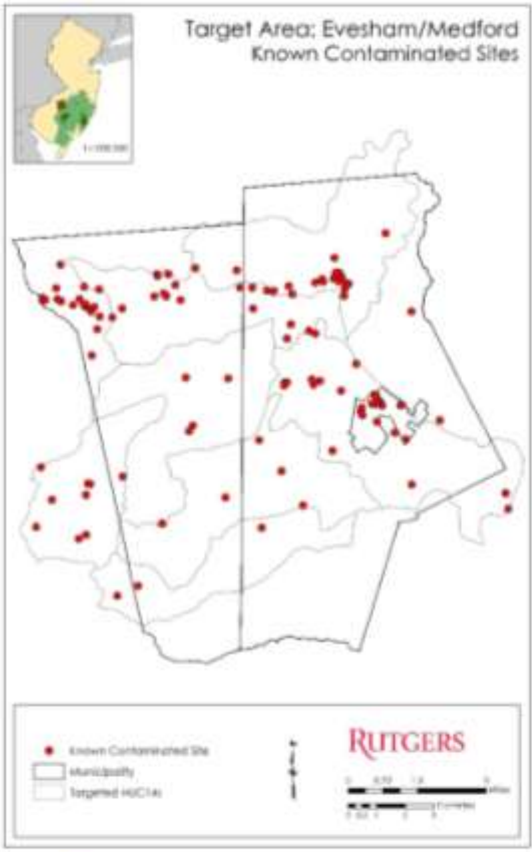
Figure 3-5. VOC Contamination by Municipality, PWTA Data

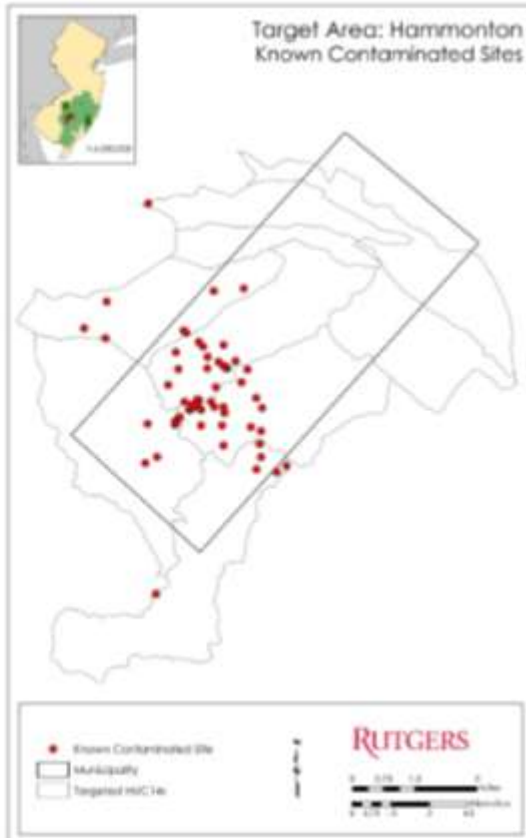
Table 3-14. VOC Results from PWTA Data, Selected Municipalities			
Municipality	**Number of wells**	**Total Exceeded**	**Percent Exceeded**
Evesham Twp	279	5	1.8%
Medford Twp	861	4	0.5%
Medford Lakes	433	0	0.0%
Hammonton	214	20	4.7%

Contamination Sites

There are two data sets available for identification of contamination problems. The NJDEP maintains the Known Contaminated Site List, an inventory of sites that have confirmed soil, ground water, surface water or building contamination that requires remedial action to mitigate public health and environmental damages or risks. **Table 3-15** provides an overview of the number of sites per subwatershed. There are 155 sites on the KCLS within the target subwatersheds, with five subwatersheds containing nearly 80% of such sites (123), as depicted in Figure 3-6. These five subwatersheds are among the most densely developed. Not all of the sites have the same potential for public health or environmental concern.

Table 3-15. Known Contaminated Sites per Target Subwatershed		
HUC14	**Subwatershed Name**	**# KCSL Sites**
2040202060010	Kettle Run (above Centennial Lake)	3
2040202060020	Lake Pine / Centennial Lake & tribs	4
2040202060030	Haynes Creek (below Lake Pine)	27
2040202060040	Barton Run (above Kettle Run Road)	14
2040202060080	Rancocas Ck SW Branch (above Medford br)	36
2040301130060	Westecunk Creek (below GS Parkway)	2
2040301140030	Tuckerton Creek (below Mill Branch)	6
2040301140040	LEH Bay tribs(Westecunk Ck-Tuckerton Ck)	1
2040301160120	Great Swamp Branch (above Rt 206)	27
2040301160160	Gun Branch	1
2040301170010	Hammonton Creek (above 74d43m)	19
2040301200070	Ballanger Creek	1
2040302030070	Penny Pot Stream (GEHR)	8
2040302040080	GEHR (39d32m50s to Hospitality Branch)	6
TOTAL		155





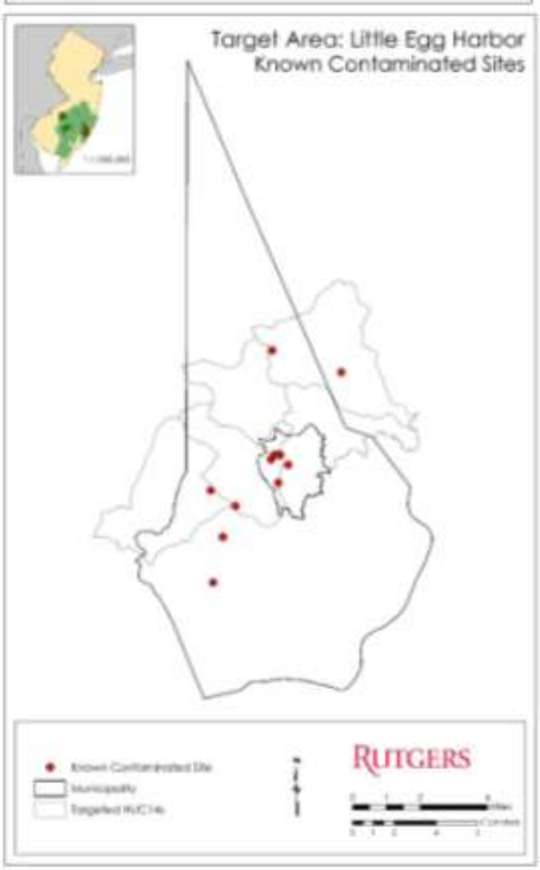


Figure 3-6. Known Contaminated Sites

GWQS Violations

More specific to ground water contamination are the GIS data sets for Classification Exception Areas (designated pursuant to the Ground Water Quality Standards at N.J.A.C. 7:9C) and delineations of the Current Known Extent of contamination plumes. **Tables 3-16** and **3-17** provide the sites within the target areas that are on either listing. In most cases, the contaminants are gasoline components or industrial solvents.

Table 3-16. Classification Exception Areas In Target Areas*

HUC14	Subwatershed Name	CEA Name	Acres	KCSL ID code	GWQS Class
2040301140030	Tuckerton Creek (below Mill Branch)	Getty Service Station #56258	0.61	NJL600102214	II-A
2040301140030	Tuckerton Creek (below Mill Branch)	Cedar Cove Marina	0.01	-	II-A
2040301160120	Great Swamp Branch (above Rt 206)	Deficcios Brothers Farm	2.00	NJL600156996	I-PL
2040301160120	Great Swamp Branch (above Rt 206)	Metec Inc.	612.05	-	I-PL
2040301160130	Great Swamp Branch (below Rt 206)	Exxon Service Station #3-0167	0.34	NJD986595460	II-A
2040301170010	Hammonton Creek (above 74d43m)	Agway Energy Products Facility	0.06	NJD039023874	I-PL
2040302030070	Penny Pot Stream (GEHR)	Kirschner Brothers Co.	0.46	NJL600176135	I-PL
2040202060030	Haynes Creek (below Lake Pine)	Mike Easi (former Medford Lakes)	0.03	-	I-PL
2040202060030	Haynes Creek (below Lake Pine)	Medford Lakes Municipal Garage	0.24	NJL600023113	I-PL
2040202060040	Barton Run (above Kettle Run Road)	Scarborough/Pulte Inc.	1.50	NJL600019236	II-A
2040202060040	Barton Run (above Kettle Run Road)	Atlas Building Systems	10.07	NJL500003256	II-A
2040202060080	Rancocas Ck SW Branch (above Medford br)	Engar Machine Co.	0.42	NJD002385714	II-A
2040202060080	Rancocas Ck SW Branch (above Medford br)	Sunoco Service Station #0004-5781	24.57	-	II-A
2040202060100	Rancocas Ck SW Branch (below Medford br)	Ellis Property Superfund Site	34.92	NJD980529085	II-A
2040202060100	Rancocas Ck SW Branch (below Medford br)	Sunoco Service Station #0004-5781	2.34	-	II-A
2040202060100	Rancocas Ck SW Branch (below Medford br)	Medford Outlet Store	0.38	NJL600193635	I-PL
2040202060100	Rancocas Ck SW Branch (below Medford br)	Merit's Gulf Station	0.52	NJL600193726	II-A

*NJDEP Classification Exception Areas-Well Restriction Areas for New Jersey, Edition 20130230

Table 3-17. Known Contaminant Extent Listing**

HUC14	Subwatershed Name	Name	Acres
2040301140030	Tuckerton Creek (below Mill Branch)	St. Andrews Drive (Atlantic)	36.18
2040301200070	Ballanger Creek	St. Andrews Drive (Atlantic)	0.01
2040301170010	Hammonton Creek (above 74d43m)	Lakeshore Gardens	67.30
2040302040080	GEHR (39d32m50s to Hospitality Branch)	Giordano Lane	64.24
2040202060010	Kettle Run (above Centennial Lake)	Marlton Lakes GW	48.40

**NJDEP Currently Known Extent of Groundwater Contamination (CKE) for New Jersey, 2007

Summary

For the Pinelands Area, NJDEP's surface and ground water quality standards have a special Pinelands classification (Class PL and Class I-PL, respectively) with stringent antidegradation policies. In both cases, the antidegradation policies are linked to the Pinelands CMP, so that what is allowed by the CMP is generally allowed by the standards. Only in the areas of northern Evesham and Medford townships and in Tuckerton and southern Little Egg Harbor Township do non-Pinelands standards and antidegradation policies apply.

The three study areas have significant water quality problems from a wide variety of sources. Some are inherent to the land uses. For instance, agriculture for non-native species requires modification of the sandy soils to support fertility, shifting pH, alkalinity, carbon content and nutrients; each has effects on water quality. Urban land uses poses some of the same issues (e.g., soil alterations to allow viability of New Jersey's top crop by acreage, grass) but also poses a variety of other issues from industrial contamination to stormwater volumes and rates that badly damage stream channels. **Table 3-18** provides an overview of the water quality indicators showing significant differences from McDonalds Branch or clear water quality violations, as identified within or affecting each of the subwatersheds in the study area. Some information is not directly associated with the subwatershed due to data available. For example, some monitoring stations are within the relevant watershed but not necessarily the specific subwatershed, while summary statistics from the Private Well Testing Act are provided only by municipality.

The aggregate results clearly show major water quality issues related to land uses in all three target areas, especially:

- Evesham/Medford
  - Barton Run, which receives drainage from the King's Grant area in Evesham Twp.
  - Rancocas Creek SW Branch, which receives drainage from Medford Lakes and the Medford village area
  - Both watersheds have a Poor rating for Pinelands Macroinvertebrate Index (PMI), and they have a high incidence of hazardous contaminated sites (as does Haynes Creek).
- Hammonton:
  - Great Swamp Branch, which has a largely agricultural drainage area
  - Hammonton Creek, which receives drainage from downtown Hammonton (including Hammonton Lake) and downstream agricultural areas; further downstream it has been historically the receiving water for the sewage treatment plant (see **Chapter 6**)
  - Both of these areas also have a high incidence of hazardous contaminated sites
  - Sleeper Branch, which has extensive agriculture and some urban areas within its drainage, but is also one-third forested
- Little Egg Harbor/Tuckerton:
  - Westecunk Creek, which has some urban land but is primarily forest and wetlands, as indicated by the Excellent rating for PMI.
  - Tuckerton Creek, which drains from Pohatcong Lake and goes through a developed area east of Route 9 (Main Street) in Tuckerton

More generally, pH violations exist in every subwatershed in the Evesham/Medford target area and nearly every subwatershed in the Hammonton target area, but only one subwatershed (Westecunk Creek) in the Little Egg Harbor/Tuckerton target area.

Table 3-18. Water Quality Issues in Target Area Subwatersheds									
HUC14	**Subwatershed Name**	**Surface Water Chemistry**	**PMI**	**Existing Non-Native Pond Fish**	**SWQS Violations**	**GW Contaminants (Municipal)**	**PWTA > DWQS (Municipal)**	**KCSL Sites**	**CEAs/KCEs**
02040202060010	Kettle Run (above Centennial Lake)		Fair	High	pH	Na, Cl, Ba	1.8% VOCs (Eve. Twp)	3	0/1
02040202060020	Lake Pine / Centennial Lake & tribs				pH			4	
02040202060030	Haynes Creek (below Lake Pine)		Fair	High	pH			**27**	**2/0**
02040202060040	Barton Run (above Kettle Run Road)		**Poor**	High	**DO, pH, As**			**14**	**2/0**
02040202060050	Barton Run (below Kettle Run Road)				**DO, TP, pH, As**			0	
02040202060080	Rancocas Creek SW Branch (above Medford Br)	**pH, SC, NO_3-N, NH_4, Sulfate**	**Poor**		**pH, TP, TSS, E. coli, As, NO_3**			**36**	**2/0**
02040202060100	Rancocas Creek SW Branch (below Medford Br)				**DO, pH, TP, FC, As, PCB**			0	4/0
02040301160110	Albertson Brook		Fair	High	pH	NO_3-N,	**7.9% NO_3 4.7% VOC**		
02040301160120	Great Swamp Branch (above Rt 206)		Fair		**pH, As, NO_3, Temp**			**27**	**2/0**
02040301160130	Great Swamp Branch (below Rt 206)				**As, pH, NO_3, E. Coli**				
02040301160150	Nescochague Creek	**pH, SC, NO_3-N, Sulfate**			None				
02040301160160	Gun Branch				pH			1	
02040301160170	Sleeper Branch	SC, Sulfate			**DDD, DDE, DDT, Hg, PCB, pH**				
02040301170010	Hammonton Creek (above 74d43m)	**pH, SC, NO_3-N, Sulfate**	Fair	High	**pH, TP, TSS, Hg, As, NO_3, E. coli**			**19**	**1/1**
02040302030070	Penny Pot Stream (GEHR)				pH			8	1/0
02040302040080	Great Egg Harbor River (GEHR) (39d32m50s to Hospitality Branch)				Cu, pH			6	0/1
02040301130060	Westecunk Creek (below GS Parkway)	None	Exc		**TC**		1% NO3 (LEHT)	2	
02040301140020	Mill Branch (below GS Parkway)		Good		**PCB, Hg, pH**				
02040301140030	Tuckerton Creek (below Mill Branch)				**Hg, TP, TC**			6	2/1
02040301140040	LEH Bay tribs (Westecunk Ck-Tuckerton Ck)				None			1	
02040301200070	Ballanger Creek				N/A			1	0/1

Legend – Target Areas
Evesham/Medford Target Area
Hammonton Target Area
Little Egg Harbor/Tuckerton Target Area

Legend - Terminology		
Header Terms	**Parameter Abbreviations**	
PMI – Pinelands Macroinvertebrate Index	As – Arsenic	PCB – Polychlorinated Biphenyls (in fish tissue)
SWQS – Surface Water Quality Standards	Cu - Copper	SC – Specific Conductance
GW – Ground Water	DDT, DDD, DDE – Banned pesticide and breakdown products	TC – Total Coliform bacteria
PWTA – Private Well Testing Act	DO – Dissolved Oxygen	Temp – Temperature
DWQS – Drinking Water Quality Standards	FC – Fecal Coliform bacteria	TP – Total Phosphorus
KCSL – Known Contaminated Sites List	Hg – Mercury (in fish tissue)	TSS – Total Suspended Solids
CEA – Classification Exception Area (GW)	NO_3 – Nitrates	VOC – Volatile Organic Chemical
KCE – Known Contaminant Extent (GW)	NO_3-N – Nitrates in the form of Nitrogen	**Blank Cells are N/A – Not available/applicable**

Chapter 4: Water Availability

This chapter assesses ground water availability from analyses by the Pinelands Preservation Alliance using results from the USGS Kirkwood-Cohansey aquifer study, and from a new report from the New Jersey Geological Survey. The comparison of target area subwatersheds to the McDonald Branch subwatershed helps provide an understanding of the impacts from intensive land use patterns. Other information on water availability is examined as well.

Overview of Water Availability Concepts for New Jersey

Water availability concepts have evolved considerably over the last 50 years. Within the Pinelands Area and National Reserve, developed water supplies are primarily from ground water, with the exception of a small reservoir operated by the Atlantic City Municipal Utility Authority and the provision of Delaware River water to a few western areas such as Evesham Township. Therefore, this overview focuses on ground water. For many years, the primary focus of ground water availability was on the ability of individual wells to withdraw water without excessive drawdown of the aquifer immediately around the well and without interference with the pumping capacity of nearby wells. Both the upper, water table aquifers and the lower, confined aquifers in the Pinelands region are prolific, as the sand formations allow for the storage and release of large quantities of water.

However, over the years and especially upon expansion of suburban development, New Jersey regulators and scientists recognized that current withdrawals were causing confined aquifers in several areas to decline to the point where saltwater intrusion into those aquifers was either happening or a significant possibility (NJDEP, 1996). The wells of Cape May City were eventually lost to saltwater intrusion, and NJDEP designated Critical Water Supply Areas #1 (affecting Monmouth and northern Ocean Counties) and #2 (affecting the Camden metropolitan area from Burlington County to Gloucester County). Research in the 1990s concluded that some water table aquifers were also at risk, such as those in the Maurice River watershed in Cumberland County. These issues focused largely or exclusively on the potential losses of potable water supplies.

Ecological impacts of water withdrawals also became an issue in the 1990s, leading eventually to two major research efforts. NJDEP and the U.S. Geological Survey (USGS) cooperated on the development of a method to assess the impact of aquifer withdrawals and other hydrologic changes on stream flows, and therefore stream ecosystems, within watersheds and subwatersheds. The general concept is known as the Ecological Limitations of Hydrologic Alteration, or ELOHA. The NJ Hydroecological Integrity Assessment Tool (NJHAT) is a mathematical tool for assessing changes in high, low and median flows, frequency of different types of flows, etc., for New Jersey streams (Kennen et al., 2007; Hoffman and Rancan, 2009). The second research project was directly funded by the New Jersey Legislature. The Pinelands Commission, USGS and NJDEP collaborated on a study of the Kirkwood-Cohansey aquifer system, which is the primary water table aquifer system in the Pinelands Region. The project focused on how ground water withdrawals from the aquifer system affected water table levels in the affected subwatershed, as the viability of wetlands, vernal pool and open water ecosystems in the Pinelands are closely linked to water table levels. USGS has released a final report on the hydrologic modeling performed for this study (Charles and Nicholson, 2012) with other reports (such as Kennen and Riskin, 2010) focused on ecological implications of stream flow changes. The Pinelands Commission has published a variety of specific reports and is preparing a final summary report on its ecological field work involved with this project.

Another tool with potential application to the Pinelands is the Low Flow Margin (LFM) method, which was developed by the N.J. Geological Survey (a part of NJDEP) for use in a major revision of the New

Jersey Statewide Water Supply Plan (last published in 1996). While the new statewide plan has not yet been released for public comment as of June 2014, the LFM method was used by the Highlands Water Protection and Planning Council to determine water availability in that region at the HUC14 subwatershed level (Highlands Council, 2008), and the New Jersey Geological Survey recently released a report on the general methodology and relevant statistics at the HUC11 watershed level (Domber et al., 2013). The LFM examines two stream low-flow levels (September median flow and 7Q10) at the watershed or subwatershed level. September median flow is a typical flow during the month that most often has the lowest median flows. 7Q10 is the seven-day average low flow that has a 10% probability of occurring in any year (also described as a return period of 10 years, though this phrasing can be misleading, as the 7Q10 flow can occur more than once in ten years), and is always less than the September median flow. The difference between the two is termed **Ground Water Capacity**, which is the focus of Domber et al. (2013), the results of which are reported below. This study incorporates an extensive analysis of stream flows by watershed for all watersheds of New Jersey. However, no organization has completed an analysis for Pinelands subwatersheds, which would allow for a direct comparison of the results from the LFM method and the USGS Kirkwood-Cohansey method as applied by the Pinelands Preservation Alliance.

Using the LFM approach, a percentage of Ground Water Capacity is assigned to human use for consumptive and depletive purposes and termed **Ground Water Availability**, while the remainder is reserved to maintenance of the aquatic and wetlands ecosystems during stressed periods. (As of June 2014, Ground Water Availability thresholds have not been established for any New Jersey waters outside of the Highlands Region.) Consumptive water uses result in the evaporation of water (e.g., irrigation), while depletive uses result in the removal of water from the watershed or subwatershed through water supply or wastewater pipelines. **Net Water Availability** is the result of subtracting all consumptive and depletive water uses from Ground Water Availability and then factoring in any artificial transfers of flows into the system. NJDEP has published an evaluation of consumptive and depletive water use by watershed (Snook et al., 2013), including all regulated water demands such as public water supplies, self-supplied industrial and commercial demands, and agricultural demands.

Kirkwood-Cohansey Study

As noted above, the New Jersey Legislature funded a major investigation of the Kirkwood-Cohansey aquifer in the Pinelands Region, to evaluate the effects of withdrawals from the surficial aquifer on wetlands, streams, ponds and lakes in the region.[9] USGS performed the hydrogeologic modeling component of the project (Charles and Nicholson, 2012). MODFLOW models were constructed for this purpose for three drainage basins: McDonalds Branch, Morses Mill Stream; and Albertson Brook, as shown in Figure 4-1.[10] The models were developed using a combination of stream flow data, aquifer withdrawal tests and other field data. Scenarios were developed to simulate effects on wetlands, stream flow and aquatic habitat based on withdrawal of 5, 10, 15 and 30 percent of overall recharge, and with simulated (hypothetical) wells located close to and distant from wetlands both in surface distance and depth. Both short-term and long-term stresses were evaluated.

USGS found that stream flow reductions closely tracked the withdrawal rates (relative to total recharge) for the “best case” scenarios where wells were distant from wetlands, but stream flow reductions somewhat exceeded the withdrawal rates in the “worst case” scenarios where wells were proximate to

[9] The Pinelands Commission provides an overview of the project objectives, methodology and related reports at <www.state.nj.us/pinelands/science/current/kc/index.html>

[10] Two of these areas (McDonalds Branch and Albertson Brook) are also used in this Rutgers report, the former as a relatively natural subwatershed for comparison to the three target areas.

wetlands. Drawdown of the water table in wetlands (using a 15 cm threshold) in general showed a far greater variation between "best case" and "worst case" scenarios and between lower and higher withdrawal rates. Whereas the 5 percent withdrawal rate resulted in exceedance of the 15 cm threshold ranging from up to 1.5-9.7 percent of wetlands (best to worst case), for a 30 percent

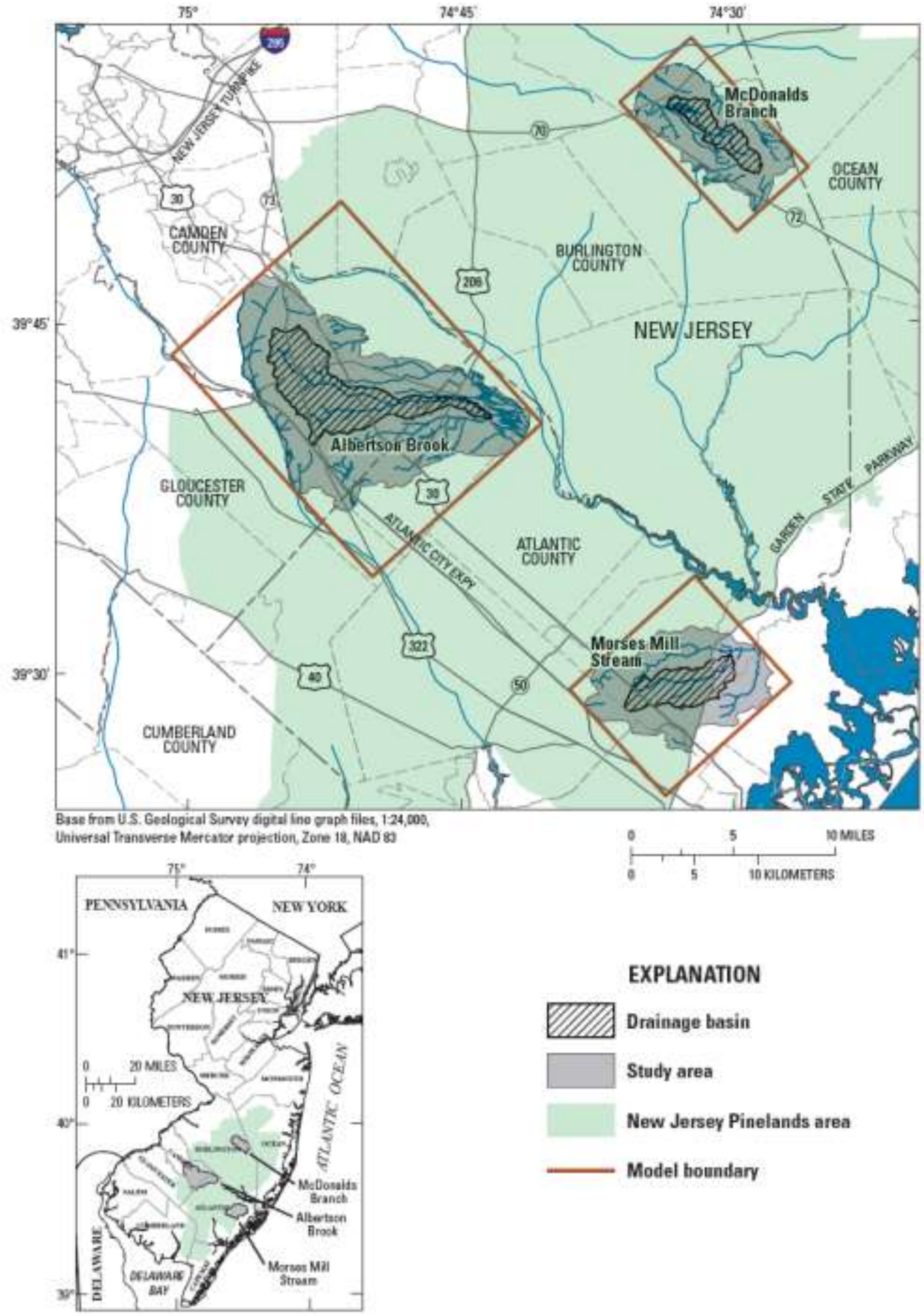


Figure 4-1. Location of the study areas, model areas, and New Jersey Pinelands area, New Jersey (from Charles and Nicholson, 2012)

withdrawal rate the 15 cm threshold was exceeded in up to 75-84 percent of wetlands in the drainage areas studied (Charles and Nicholson, 2012). These finding indicate that water table levels in wetlands are more sensitive to both withdrawal rates and well locations than are stream flows. From the results of the detailed model, USGS then developed a model for more general use that uses an index of wetland vulnerability to drawdown, using as factors the proximity of wetlands to streams, the proximity of wetlands to pumped wells, and the vertical conductance of the aquifer system. This general use model was used by the Pinelands Preservation Alliance to evaluate impacts of existing wells in the target area subwatersheds.

The Pinelands Commission was responsible for extensive field studies of vegetation and animal species incidence relative to water depth and inundation frequency in both wetlands and ponds. Individual reports have been published and a summary report is in preparation. Pinelands Commission staff provided insights regarding the results at a briefing for the NJ Water Supply Advisory Council (20 September 2013). The Pinelands Commission evaluated the effects of water level drawdowns on habitat volume (acres of wetlands, acres and depth profiles of ponds) and species (taxa) richness. The following results were presented:

- **Intermittent ponds**: Vegetation in ponds seems to be very sensitive to water depth, with a 5 cm change having significant effects. The Pinelands Region has perhaps 3,000 such ponds.
- **Frog larval development**: In this case, the study used borrow pits (from sand excavation), which tend to be shallow and old. Based on this research, noticeable effects occur at a drop of 10-15 cm in water depth.
- **Swamp Pink**: This endangered plant species was studied in two watersheds. Here, noticeable effects occur at a drop of 10 cm depth or more, but stress on the species appears evident at even a 5 cm drop.
- **Wetlands forests**: In this study, 200 forest plots in five watersheds were evaluated for the probability of occurrence for ecosystems and species based on ground water depth. The results were being evaluated as of the meeting.

In general, the results showed significant effects for wetlands generally at 15 cm reduction in water levels, and for ponds at 5 cm. Modeling is necessary to equate these reductions with withdrawal rates for each subwatershed, especially as many areas lack direct stream flow or water table level monitoring stations.

Ground Water Withdrawal Impacts on Wetlands

The Pinelands Preservation Alliance (PPA) evaluated wetland impacts of 2012 regulated agricultural and non-agricultural withdrawals, using the USGS methods from the Kirkwood-Cohansey study (Charles and Nicholson, 2012) and data from the NJDEP Data Miner. The results are incorporated here as preliminary findings, subject to modification upon finalization of a separate Pinelands Preservation Alliance report, which will provide detailed information on their methodology. Their study estimates the wetlands in each target area subwatershed that experience reductions in water levels of 5, 10, 15 and 30 centimeters (cm) based on current withdrawals, as acreage and percent. The results are summarized in the following tables and figures for each of the target areas (see also **Figures ES-2** through **ES-4**). The McDonalds Branch subwatershed is not discussed as there are no active wells in the subwatershed.

Several notes are required regarding use of the USGS model. First, the model allows for use of a default value for the aquifer composition. PPA used the default values of 80% sand and <15ft clay for all modeling scenarios, as the available well drilling logs are inconsistent and lacking data. PPA tested a wide range of values for percent sand and clay thickness and determined that variation in these values only change the drawdown results up to roughly 2 percentage points. As such, the model appears fairly insensitive to use of values other than the default values.

Second, the Little Egg Harbor/Tuckerton target area posed special analytical problems (as was true for the riparian area evaluation discussed in **Chapter 2**) due to the widespread existence of tidal wetlands. Therefore, the analysis was focused on three target subwatersheds and tidal wetlands in those subwatersheds were excluded to the extent feasible given available information.

Third, in the same Little Egg Harbor/Tuckerton target area, USGS (Pope, 2006) has estimated that withdrawals in the confined Atlantic City 800 Foot Sands aquifer contribute to drawdown in the overlying unconfined Kirkwood-Cohansey aquifer, due to local aquifer conditions including the location, extent and thickness of the confining layer. Approximately 27% of total withdrawals from the 800 Foot Sands are derived from the upper aquifer. For this reason, results are shown for this target area for two scenarios: one as if the confined aquifer withdrawals had no effect on the unconfined aquifer, and the other using the 27% estimate.

Fourth, the drawdown estimates for the Evesham/Medford target area are very low relative to the other target areas, especially given that this target area has the highest total population. Two reasons apply. All public supply wells in the target area are in the confined aquifer, which unlike the Little Egg Harbor/Tuckerton target area does not appear to have significant localized effects on the unconfined aquifers. In addition, Evesham Township receives part of its water supply from the Delaware River through the NJ American Water Company pipeline, thus reducing overall aquifer withdrawals.

The detailed results are presented in the tables and figures below. Each of the figures uses the legend to the right for Pinelands Management Areas. As shown in **Table 4-1** and **Figure 4-2**, no subwatershed in the Evesham/Medford target area has wetlands drawdowns exceeding even 5% at the 5 cm level, as all the wells draw from the confined aquifers. The Hammonton target area (**Table 4-3** and **Figure 4-3**) shows the greatest effects by far, as some of the local wells are from the unconfined aquifer. The Little Egg Harbor/Tuckerton target area (**Table 4-3** and **Figure 4-4**) shows intermediate impacts under the assumption that confined aquifer use affects the shallow aquifer (Scenario B), with all three subwatersheds showing at least 15% of wetlands affected at the 5 cm level. More critically, one shows over 15% of wetlands affected at the 10 cm level. Nearly all subwatersheds (7 of 9) show greater than 15% of wetlands affected at the 5 cm level (from 22% to over 80%); all but one of those (6 of 9) at the 10cm level; three at 15 cm; and even two at 30cm. If the 15 cm threshold is accepted by the Pinelands Commission for wetlands, the three worst subwatersheds would be considered impaired due to water level declines.

Table 4-1. Wetlands Drawdown from Current Aquifer Withdrawals: Evesham/Medford Target Area							
Wetlands Impact	**HUC14 Subwatershed (0204020 + Last 7 Digits)**						
Percent of Basin Wetland Area Experiencing Drawdowns Greater Than or Equal To:	**2060010**	**2060020**	**2060030**	**2060040**	**2060050**	**2060080**	**2060100**
5cm	2.1%	3.5%	1.6%	1.4%	1.8%	1.2%	1.1%
10cm	1.5%	2.2%	1.2%	1.0%	1.3%	0.9%	0.8%
15cm	0.8%	1.2%	0.7%	0.6%	0.7%	0.5%	0.5%
30cm	0.2%	0.3%	0.2%	0.1%	0.2%	0.1%	0.1%
Wetland Drawdown Threshold							
Current Wetland Area	**608**	**1014**	**1008**	**653**	**3194**	**1564**	**2568**
Estimated 5cm drawdown (acres)	13	35	16	9	58	20	29
Estimated 10cm drawdown (acres)	9	23	12	7	43	14	21
Estimated 15cm drawdown (acres)	5	12	7	4	24	8	12
Estimated 30cm drawdown (acres)	1	3	2	1	6	2	3

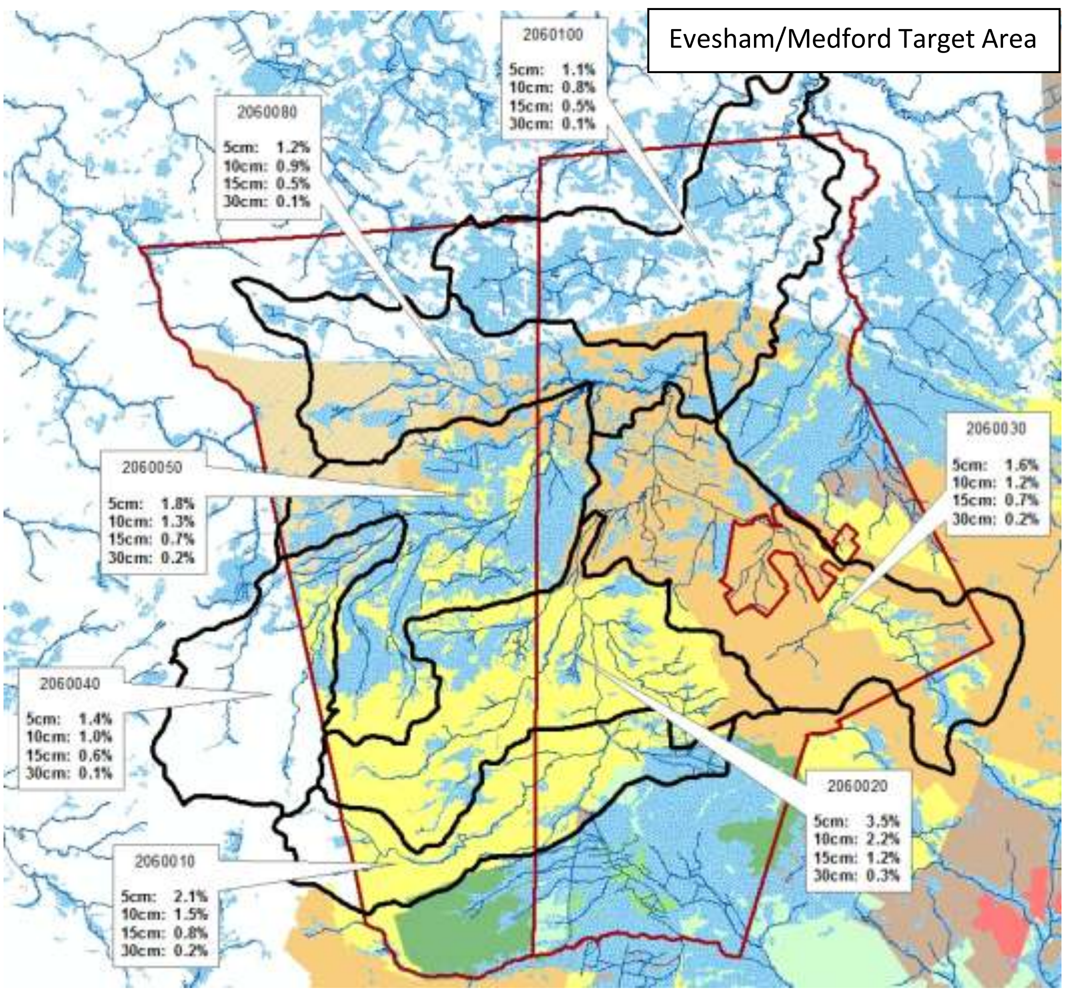


Figure 4-2. Wetlands Impacts from Current Aquifer Withdrawals: Evesham/Medford Target Area

Table 4-2. Wetlands Drawdown from Current Aquifer Withdrawals: Hammonton Target Area									
Wetlands Impact	**HUC14 Subwatershed (0204030 + Last 7 Digits)**								
Percent of Basin Wetland Area Experiencing Drawdowns Greater Than or Equal To:	**1160110**	**1160120**	**1160130**	**1160150**	**1160160**	**1160170**	**1170010**	**2030070**	**2040080**
5cm	**22.1%**	**55.4%**	**73.5%**	**83.9%**	**35.8%**	2.3%	**73.4%**	**61.4%**	12.5%
10cm	10.9%	**32.2%**	**53.4%**	**77.4%**	**15.3%**	1.6%	**71.0%**	**36.6%**	6.0%
15cm	6.6%	21.5%	**39.3%**	**67.4%**	8.4%	0.9%	**67.2%**	24.3%	3.4%
30cm	2.7%	9.3%	17.4%	**37.5%**	2.2%	0.2%	**56.2%**	9.6%	1.1%
Wetland Drawdown Threshold									
Current Wetland Area	**688**	**606**	**1427**	**1608**	**775**	**2979**	**938**	**1816**	**1720**
Estimated 5cm drawdown (acres)	152	336	1049	1348	278	69	689	1116	215
Estimated 10cm drawdown (acres)	75	195	762	1244	119	47	666	664	104
Estimated 15cm drawdown (acres)	45	130	561	1083	65	26	630	442	58
Estimated 30cm drawdown (acres)	19	56	249	602	17	7	527	175	18

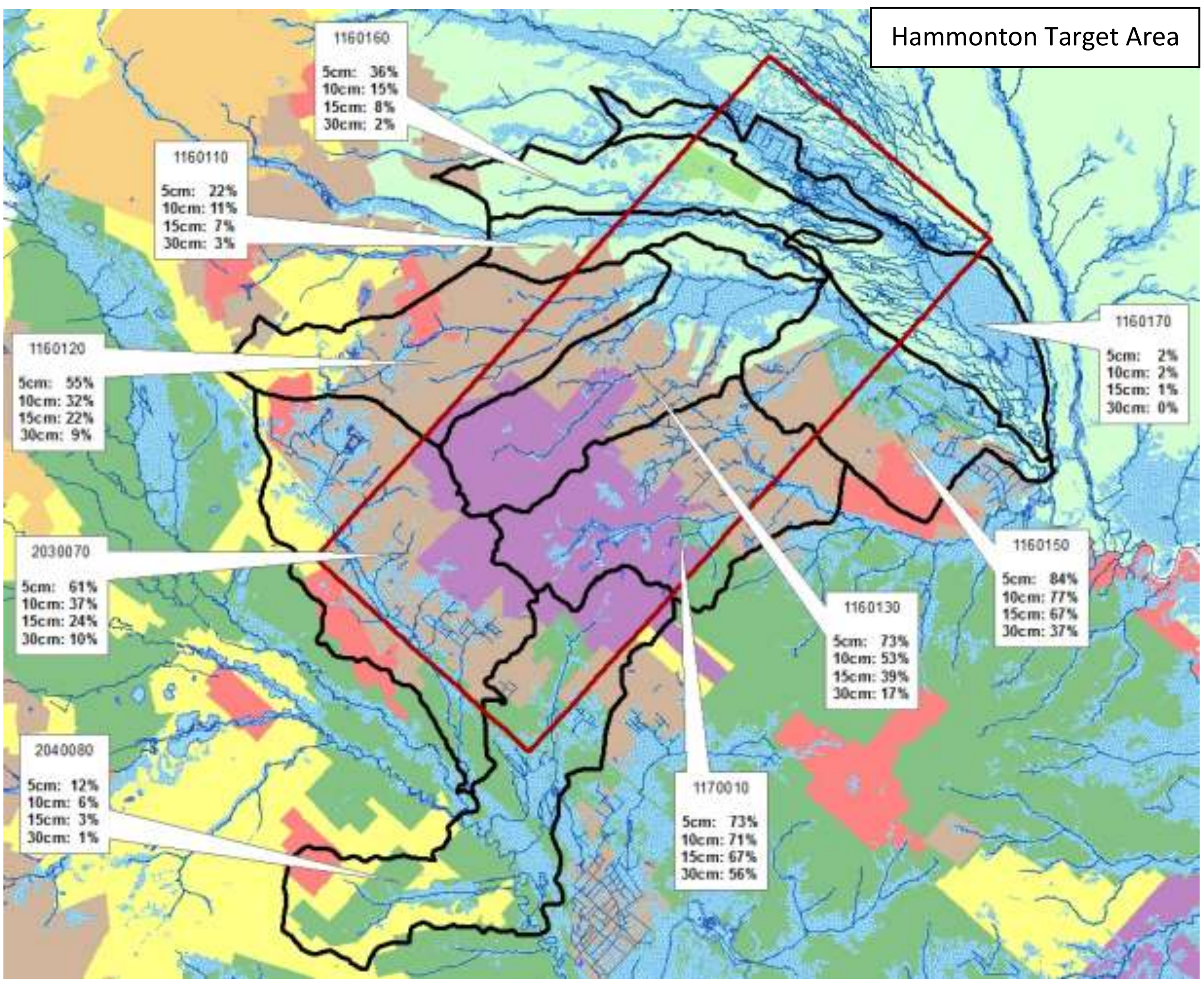


Figure 4-3. Wetlands Impacts from Current Aquifer Withdrawals: Hammonton Target Area

Table 4-3. Wetlands Drawdown from Current Aquifer Withdrawals: Little Egg Harbor/Tuckerton Target Area

Wetlands Impact	**HUC14 Subwatershed (0204030 + Last 7 Digits) and Scenario**					
Percent of Basin Wetland Area Experiencing Drawdowns Greater Than or Equal To:	**1130060 Scenario A**	**1130060 Scenario B**	**1140020 Scenario A**	**1140020 Scenario B**	**1140030 Scenario A**	**1140030 Scenario B**
5cm	4.4%	**25.8%**	7.9%	**47.2%**	3.2%	19.1%
10cm	2.7%	9.1%	3.9%	**17.8%**	2.1%	8.5%
15cm	1.5%	4.3%	2.0%	8.8%	1.1%	4.6%
30cm	0.4%	0.8%	0.5%	1.6%	0.3%	1.3%
Wetland Drawdown Threshold						
Current Wetland Area	**926**	**926**	**401**	**401**	**370**	**370**
Estimated 5cm drawdown (acres)	40	239	32	189	12	71
Estimated 10cm drawdown (acres)	25	84	16	71	8	31
Estimated 15cm drawdown (acres)	14	40	8	35	4	17
Estimated 30cm drawdown (acres)	3	7	2	6	1	5

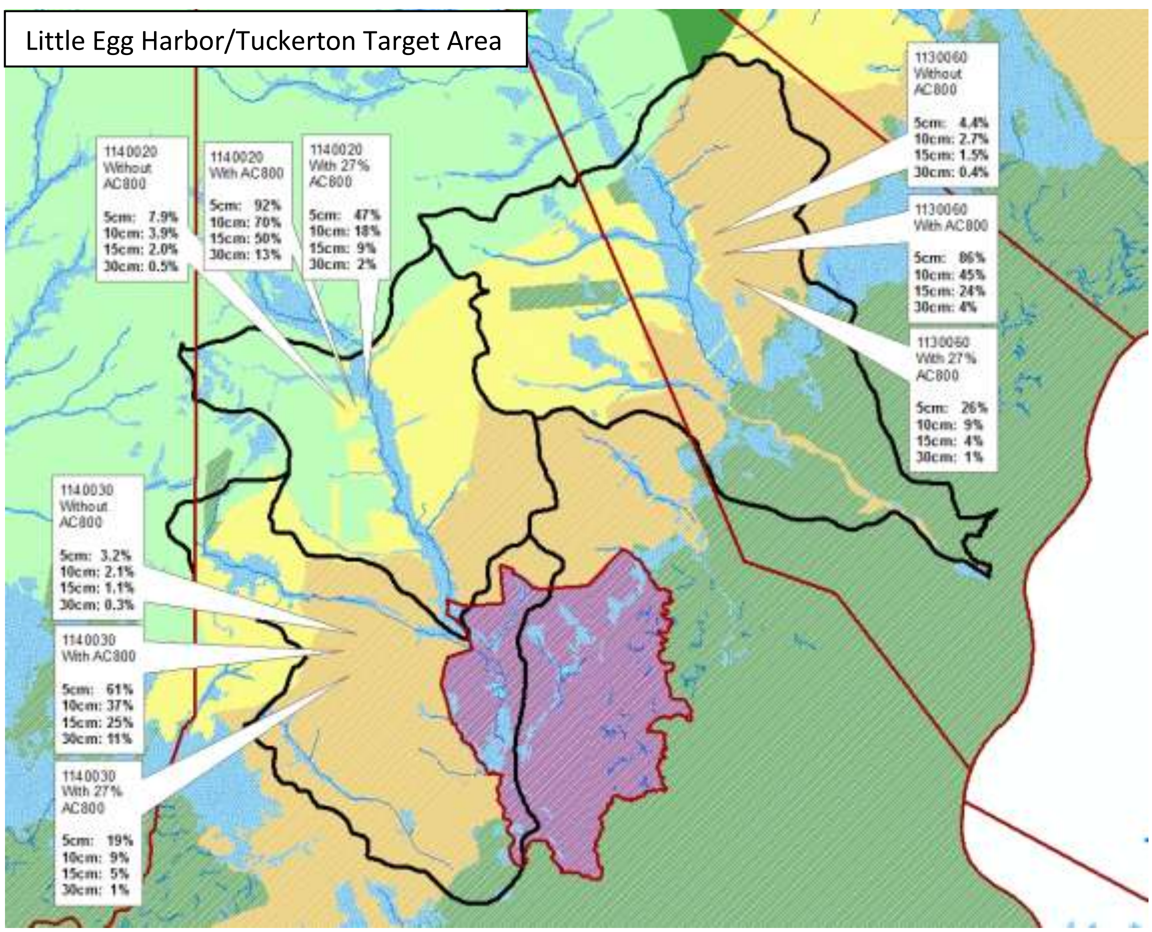


Figure 4-4. Wetlands Impacts from Current Aquifer Withdrawals: Little Egg Harbor/Tuckerton Target Area

Recharge and Water Availability

Annual average recharge and drought period recharge by subwatershed were provided **Chapter 2** for each target area. These recharge rates (especially drought recharge) provide one rough indicator of water availability, as long-term recharge is a good proxy for stream flow in a region such as the Pinelands where most annual average stream flow is derived from ground water. Assuming, for example, that no more than 5% of drought recharge can be removed from a subwatershed as consumptive or depletive water uses without damaging aquatic ecosystems, **Table 4-4** shows the available water using that approach. Given that subwatersheds range in size, the most important values are in MGD/square mile (mi2). As noted at the bottom of the table, these values range very widely, from 0.002 to 0.052 MGD/mi2, with a median of 0.015 MGD/mi2. These resulting values are compared by subwatershed to another water availability approach in the following section.

Table 4-4. Conceptual Availability of Ground Water as 5% of Drought Recharge

HUC14	Subwatershed Name	Annual Average Recharge (MGY)	Drought Recharge (MGY)	% Difference (Average-Drought)	5% of Drought Recharge (MGD)	5% of Drought Recharge (MGD/mi2)
02040202030070	McDonalds Branch	889.83	736.23	17%	0.101	0.0183
02040202060010	Kettle Run (above Centennial Lake)	987.94	810.33	18%	0.111	0.0199
02040202060020	Lake Pine / Centennial Lake & tribs	1642.11	1374.44	16%	0.188	0.0210
02040202060030	Haynes Creek (below Lake Pine)	1736.04	1454.99	16%	0.199	0.0182
02040202060040	Barton Run (above Kettle Run Road)	884.80	756.62	14%	0.104	0.0179
02040202060050	Barton Run (below Kettle Run Road)	536.81	447.16	17%	0.061	**0.0069**
02040202060080	Rancocas Ck SW Branch (above Medford br)	655.16	539.61	18%	0.074	0.0107
02040202060100	Rancocas Ck SW Branch (below Medford br)	859.86	692.95	19%	0.095	0.0101
02040301130060	Westecunk Creek (below GS Parkway)	1352.85	1177.67	13%	0.161	0.0515
02040301140020	Mill Branch (below GS Parkway)	1054.15	916.72	13%	0.126	0.0156
02040301140030	Tuckerton Creek (below Mill Branch)	985.54	866.63	12%	0.119	0.0137
02040301140040	LEH Bay tribs(Westecunk Ck-Tuckerton Ck)	435.36	382.07	12%	0.052	**0.0075**
02040301160110	Albertson Brook	430.01	302.25	30%	0.041	**0.0091**
02040301160120	Great Swamp Branch (above Rt 206)	1441.20	978.94	32%	0.134	0.0183
02040301160130	Great Swamp Branch (below Rt 206)	1119.60	756.54	32%	0.104	0.0109
02040301160150	Nescochague Creek	732.96	519.84	29%	0.071	**0.0058**
02040301160160	Gun Branch	502.51	354.86	29%	0.049	**0.0043**
02040301160170	Sleeper Branch	213.24	155.51	27%	0.021	**0.0023**
02040301170010	Hammonton Creek	1368.73	945.70	31%	0.130	0.0255

Table 4-4. Conceptual Availability of Ground Water as 5% of Drought Recharge						
HUC14	**Subwatershed Name**	**Annual Average Recharge (MGY)**	**Drought Recharge (MGY)**	**% Difference (Average-Drought)**	**5% of Drought Recharge (MGD)**	**5% of Drought Recharge (MGD/mi2)**
	(above 74d43m)					
02040301200070	Ballanger Creek	543.36	470.58	13%	0.064	0.0107
02040302030070	Penny Pot Stream (GEHR)	1593.80	1077.78	32%	0.148	0.0213
02040302040080	GEHR (39d32m50s to Hospitality Branch)	1715.29	1134.68	34%	0.155	0.0185
	Median	**937.69**	**756.58**	**18%**	**0.104**	**0.015**
	Maximum	1736.04	1454.99	34%	0.199	0.052
	Minimum	213.24	155.51	12%	0.021	0.002

Ground Water Capacity using Low Flow Margin

The Low Flow Margin methodology report by NJDEP (Domber et al., 2013) provides values for the Low Flow Margin (September median flow minus 7Q10), or Ground Water Capacity, for each HUC11 watershed that contains a target area HUC14 subwatershed, as shown in **Table 4-5**. The report also normalizes the resulting Ground Water Capacity by drainage area size, as flow per square mile. By using these normalized values for each HUC11, it is possible to interpolate the HUC11 results to the target area HUC14 subwatersheds, with the understanding that actual results will likely vary somewhat due to varying conditions within the watershed. To determine Ground Water Availability, one or more thresholds are required as a percentage of the LFM/Ground Water Capacity, to indicate how much water is available for consumptive or depletive water uses. No thresholds have been established in the Pinelands region. Therefore, the Highlands Council approach (Highlands Council, 2008) is applied to the target area subwatersheds to provide example estimates of Ground Water Availability. That approach, which uses 5% LFM for sensitive subwatersheds and 20% LFM for other subwatersheds, is replicated here for comparison purposes but should not be considered a definitive recommendation for policy. **Table 4-5** provides the results for each subwatershed at both thresholds.

Table 4-6 provides information from a USGS Regional Aquifer Study Area (RASA) model on the average induced leakage rates from the surficial coastal plain aquifer to the confined aquifers below, as reported in Domber et al. (2013). A portion of recharge to the HUC11 watersheds moves to the lower aquifer and therefore is lost to streamflow in the watersheds. The rates per square mile are generally 0.01 MGD but range up to 0.03 MGD.

As shown on **Table 4-7**, the values for 5% LFM are mostly less than 5% of drought recharge for the same subwatersheds, while the values for 20% LFM are consistently higher. More importantly, the ratio between the recharge and LFM values are widely different between the subwatersheds, indicating that recharge values alone do not explain variability in stream flow statistics. The highest outliers are shown in bold; these have the lowest rates of ground water recharge among the target subwatersheds. The subwatersheds associated with HUC11 #02040202060, Rancocas Creek SB SW Branch, are shown with a (*) next to the subwatershed name – these subwatershed would be more affected by induced leakage to the underlying confined aquifer (as indicated on **Table 4-6**); it is assumed that such leakage is reflected in September median flow and 7Q10 values, and therefore in the LFM values, as the leakage reduces the total water available for stream flow.

Table 4-5. Low Flow Margin Estimates by Watershed and Subwatershed, with Example Ground Water Availability By Target Area Subwatershed[11]

LFM By Watershed (Domber et al., 2013)									Interpolated LFM and Example Ground Water Availability by Subwatershed							
HUC11	Watershed Name	Area (mi2)	Sept Median Flow (MGD)	7Q10 (MGD)	LFM (MGD)	Sept Median Flow (MGD/ mi2)	7Q10 (MGD/ mi2)	LFM (MGD/ mi2)	HUC14 (Last 3 digits)	Subwatershed Name	Area (mi2)	Sept Median Flow (MGD)	7Q10 (MGD)	LFM (MGD)	5% LFM	20% LFM
02040202030	Greenwood Branch (NB Rancocas Creek)	78.15	31.29	13.69	17.6	0.40	0.18	0.23	070	McDonalds Branch	5.51	2.21	0.97	1.24	0.062	0.248
02040202060	Rancocas Creek SB SW Branch	75.99	26.81	12.9	13.91	0.35	0.17	0.18	010	Kettle Run (above Centennial Lake)	5.57	1.97	0.95	1.02	0.051	0.204
									020	Lake Pine / Centennial Lake & tribs	8.98	3.17	1.52	1.64	0.082	0.329
									030	Haynes Creek (below Lake Pine)	10.98	3.87	1.86	2.01	0.100	0.402
									040	Barton Run (above Kettle Run Road)	5.78	2.04	0.98	1.06	0.053	0.212
									050	Barton Run (below Kettle Run Road)	8.9	3.14	1.51	1.63	0.081	0.326
									080	Rancocas Ck SW Branch (above Medford br)	6.92	2.44	1.17	1.27	0.063	0.253
									100	Rancocas Ck SW Branch (below Medford br)	9.42	3.32	1.60	1.72	0.086	0.345
02040301130	Manahawkin/Upper Little Egg Harbor tribs	71.58	58.55	37.74	20.81	0.82	0.53	0.29	060	Westecunk Creek (below GS Parkway)	3.13	2.56	1.65	0.91	0.045	0.182
02040301140	Lower Little Egg Harbor Bay tribs	35.2	11.8	4.82	6.98	0.34	0.14	0.20	020	Mill Branch (below GS Parkway)	8.07	2.71	1.11	1.60	0.080	0.320
									030	Tuckerton Creek (below Mill Branch)	8.69	2.91	1.19	1.72	0.086	0.345
									040	LEH Bay tribs (Westecunk Ck-Tuckerton Ck)	6.97	2.34	0.95	1.38	0.069	0.276
02040301160	Mullica River (above Batsto River)	127.3	48.36	19.43	28.93	0.38	0.15	0.23	110	Albertson Brook	4.53	1.72	0.69	1.03	0.051	0.206
									120	Great Swamp Branch (above Rt 206)	7.32	2.78	1.12	1.66	0.083	0.333
									130	Great Swamp Branch (below Rt 206)	9.52	3.62	1.45	2.16	0.108	0.433
									150	Nescochague Creek	12.29	4.67	1.88	2.79	0.140	0.559
									160	Gun Branch	11.39	4.33	1.74	2.59	0.129	0.518
									170	Sleeper Branch	9.31	3.54	1.42	2.12	0.106	0.423

[11] Watershed values from Domber et al. (2013).

Table 4-5. Low Flow Margin Estimates by Watershed and Subwatershed, with Example Ground Water Availability By Target Area Subwatershed[11]

LFM By Watershed (Domber et al., 2013)									Interpolated LFM and Example Ground Water Availability by Subwatershed							
HUC11	**Watershed Name**	**Area (mi2)**	**Sept Median Flow (MGD)**	**7Q10 (MGD)**	**LFM (MGD)**	**Sept Median Flow (MGD/ mi2)**	**7Q10 (MGD/ mi2)**	**LFM (MGD/ mi2)**	**HUC14 (Last 3 digits)**	**Subwatershed Name**	**Area (mi2)**	**Sept Median Flow (MGD)**	**7Q10 (MGD)**	**LFM (MGD)**	**5% LFM**	**20% LFM**
02040301170	Mullica River (Turtle Ck to Batsto River)	109.9	53.66	22.92	30.74	0.49	0.21	0.28	010	Hammonton Creek (above 74d43m)	5.08	2.48	1.06	1.42	0.071	0.284
02040301200	Mullica River (GSP bridge to Turtle Ck)	95.65	56.4	29.58	26.82	0.59	0.31	0.28	070	Ballanger Creek	6.01	3.54	1.86	1.69	0.084	0.337
02040302030	Great Egg Harbor R (above Hospitality Br)	71.01	35.47	17.47	18	0.50	0.25	0.25	070	Penny Pot Stream (GEHR)	6.94	3.47	1.71	1.76	0.088	0.352
02040302040	Great Egg Harbor R (Lk Lenape to HospBr)	133.4	59.2	13.71	45.49	0.44	0.10	0.34	080	GEHR (39d32m50s to Hospitality Branch)	8.42	3.74	0.87	2.87	0.144	0.574
				Median		**0.44**	**0.18**	**0.25**								

Table 4-6. Induced Leakage from HUC11 Watersheds to Underlying Coastal Plain Aquifers (from Domber et al., 2013)

HUC11	Watershed Name	Leakage	Leakage/mi2
02040202030	Greenwood Branch (NB Rancocas Creek)	0.01	0.00
02040202060	Rancocas Creek SB SW Branch	2.11	0.03
02040301130	Manahawkin/Upper Little Egg Harbor tribs	1.09	0.02
02040301140	Lower Little Egg Harbor Bay tribs	0.27	0.01
02040301160	Mullica River (above Batsto River)	0.86	0.01
02040301170	Mullica River (Turtle Ck to Batsto River)	1.57	0.01
02040301200	Mullica River (GSP bridge to Turtle Ck)	0.91	0.01
02040302030	Great Egg Harbor R (above Hospitality Br)	0.00	0.00
02040302040	Great Egg Harbor R (Lk Lenape to HospBr)	1.40	0.01

Table 4-7. Comparison of LFM to Ground Water Recharge for Target Subwatersheds							
HUC14	**Subwatershed Name**	**LFM Approaches**			**Comparison to Recharge**		
		LFM (MGD) (a)	**5% LFM (b)**	**20% LFM (c)**	**5% Drought GWR (d)**	**(b) as % of (d)**	**(c) as % of (d)**
02040202030070	McDonalds Branch	1.24	0.06	0.25	0.101	62%	246%
02040202060010	Kettle Run (above Centennial Lake)	1.02	0.05	0.20	0.111	**46%**	**184%**
02040202060020	Lake Pine / Centennial Lake & tribs*	1.64	0.08	0.33	0.188	**44%**	**175%**
02040202060030	Haynes Creek (below Lake Pine)*	2.01	0.10	0.40	0.199	**50%**	**202%**
02040202060040	Barton Run (above Kettle Run Road)*	1.06	0.05	0.21	0.104	**51%**	**204%**
02040202060050	Barton Run (below Kettle Run Road)*	1.63	0.08	0.33	0.061	133%	532%
02040202060080	Rancocas Ck SW Branch (above Medford br)*	1.27	0.06	0.25	0.074	86%	343%
02040202060100	Rancocas Ck SW Branch (below Medford br)*	1.72	0.09	0.34	0.095	91%	363%
02040301130060	Westecunk Creek (below GS Parkway)	0.91	0.05	0.18	0.161	**28%**	**113%**
02040301140020	Mill Branch (below GS Parkway)	1.60	0.08	0.32	0.126	64%	255%
02040301140030	Tuckerton Creek (below Mill Branch)	1.72	0.09	0.34	0.119	73%	290%
02040301140040	LEH Bay tribs(Westecunk Ck-Tuckerton Ck)	1.38	0.07	0.28	0.052	132%	528%
02040301160110	Albertson Brook	1.03	0.05	0.21	0.041	124%	497%
02040301160120	Great Swamp Branch (above Rt 206)	1.66	0.08	0.33	0.134	62%	248%
02040301160130	Great Swamp Branch (below Rt 206)	2.16	0.11	0.43	0.104	104%	418%
02040301160150	Nescochague Creek	2.79	0.14	0.56	0.071	196%	785%
02040301160160	Gun Branch	2.59	0.13	0.52	0.049	**266%**	**1065%**
02040301160170	Sleeper Branch	2.12	0.11	0.42	0.021	**497%**	**1987%**
02040301170010	Hammonton Creek (above 74d43m)	1.42	0.07	0.28	0.130	55%	219%
02040301200070	Ballanger Creek	1.69	0.08	0.34	0.064	131%	523%
02040302030070	Penny Pot Stream (GEHR)	1.76	0.09	0.35	0.148	60%	238%
02040302040080	GEHR (39d32m50s to Hospitality Branch)	2.87	0.14	0.57	0.155	92%	369%

Net Water Availability

As discussed above, estimating net water availability requires definition of Ground Water Availability, which to date has not occurred at either the watershed or subwatershed level for this region. Consumptive and depletive water uses are measured on a net volume basis, by identifying the total withdrawals from surface waters and the unconfined aquifers, and all water returns to the same waters within the watershed or subwatershed (Highlands Council, 2008; Snook et al., 2013). Extensive information on withdrawals and returns is available from Snook et al. (2013), which in turn is derived from the NJ Water Tracking System, NJWaTr (NJDEP, 2012b). All classes of water withdrawals are included. One issue in the Pinelands area is that withdrawals from confined aquifers are generally discharged to unconfined ground waters or surface waters, or to the ocean. A second issue is that two target area municipalities, Evesham and Medford Townships, import water from the Delaware River (via NJ American Water Company) that is then discharged to surface waters within the Townships. In both cases, a policy decision is required regarding the “credit” allowable to any watershed or subwatershed for discharges of external water supplies. Otherwise, the Net Water Availability of an area could actually increase above natural levels if imports exceed internal consumptive uses, resulting in ample stream flow only for waters downstream of the sewage treatment plant, but with major flow reductions elsewhere in the watershed. A third issue is that information currently available at the watershed level cannot be attributed to the subwatershed level without greater evaluation that goes beyond available resources for this study. However, with these caveats in mind, the following table provides total withdrawals and return flows related to surface waters and unconfined aquifers, by watershed, and net withdrawals.

Table 4-8. Water Withdrawals and Returns for Surface Waters and Unconfined Aquifers in Target Area Watersheds

HUC11	Watershed Name	100% LFM	Average Withdrawals (MGD)		Average Returns (MGD)				Net Withdrawal (MGD)	Largest Use Category
			Surface Water	Unconfined GW	SW from Potable	GW from Potable	Agriculture	Mining		
02040202030	Greenwood Branch (NB Rancocas Creek)	17.60	6.5	0.9	0.7	0.0	2.1	3.8	0.8	Mining
02040202060	Rancocas Creek SB SW Branch	13.91	1.4	1.7	1.5	3.5	0.5	0.0	-2.4	Potable
02040301130	Manahawkin/ Upper Little Egg Harbor tribs	20.81	1.2	2.7	1.1	0.0	0.1	1.2	1.5	Potable
02040301140	Lower Little Egg Harbor Bay tribs	6.98	0.1	0.4	0.2	0.0	0.0	0.3	0.0	Potable
02040301160	Mullica River (above Batsto River)	28.93	1.9	6.3	2.8	0.0	0.6	0.4	**4.4**	Potable/ Agriculture
02040301170	Mullica River (Turtle Ck to Batsto River)	30.74	1.2	3.2	0.8	0.8	1.3	0.0	1.5	Agriculture
02040301200	Mullica River (GSP bridge to Turtle Ck)	26.82	2.0	2.9	0.6	0.0	2.0	0.3	**2.0**	Potable/ Agriculture
02040302030	Great Egg Harbor R (above Hospitality Br)	18.00	1.2	7.1	1.5	0.0	0.1	1.3	**5.4**	Potable
02040302040	Great Egg Harbor R (Lk Lenape to HospBr)	45.49	2.7	6.8	1.9	0.3	0.4	2.5	**4.4**	Agriculture

As shown in bold, several watersheds have net withdrawals from surface water and unconfined ground water exceeding 2 MGD. Conversely, one watershed (02040202060) has a net influx of water, due in part to the heavy use of the confined aquifer (where returns from ground water exceed withdrawals from unconfined ground water by 1.8 MGD) and in part to importation of Delaware River water to the watershed.

Summary

Given these various measures of water availability and withdrawal impacts, and the continuing nature of research on ecological impacts from water table fluctuations, it is difficult to make any firm conclusions as to the most appropriate approach to water availability. However, we have at this time clear indications of subwatersheds where current Net Water Availability is likely to be minimal or negative. **Table 4-9** provides a general overview of the results from this chapter.

Table 4-9. Overview of Ground Water Availability Indicator Results for Target Area Subwatersheds

HUC14	Subwatershed Name	5% of Drought Recharge (MGD)	5% LFM (MGD)	20% LFM (MGD)	Wetlands Drawdown >=5 cm	Wetlands Drawdown >=15 cm	Wetlands Drawdown >=30 cm	Net Withdrawal (Unconfined and SW) (MGD by HUC11)
2040202030070	McDonalds Branch	0.101	0.06	0.25	0	0	0	0.8
2040202060010	Kettle Run (above Centennial Lake)	0.111	**0.05**	**0.2**	2.10%	0.80%	0.20%	-2.4
2040202060020	Lake Pine / Centennial Lake & tribs	0.188	**0.08**	**0.33**	3.50%	1.20%	0.30%	
2040202060030	Haynes Creek (below Lake Pine)	0.199	**0.1**	**0.4**	1.60%	0.70%	0.20%	
2040202060040	Barton Run (above Kettle Run Road)	0.104	**0.05**	**0.21**	1.40%	0.60%	0.10%	
2040202060050	Barton Run (below Kettle Run Road)	**0.061**	0.08	0.33	1.80%	0.70%	0.20%	
2040202060080	Rancocas Ck SW Branch (above Medford br)	0.074	0.06	0.25	1.20%	0.50%	0.10%	
2040202060100	Rancocas Ck SW Branch (below Medford br)	0.095	0.09	0.34	1.10%	0.50%	0.10%	
2040301130060	Westecunk Creek (below GS Parkway)	0.161	**0.05**	**0.18**	**25.80%**	4.30%	0.80%	1.5
2040301140020	Mill Branch (below GS Parkway)	0.126	0.08	0.32	**47.20%**	8.80%	1.60%	0
2040301140030	Tuckerton Creek (below Mill Branch)	0.119	0.09	0.34	**19.10%**	4.60%	1.30%	
2040301140040	LEH Bay tribs(Westecunk Ck-Tuckerton Ck)	**0.052**	0.07	0.28	N/A	N/A	N/A	
2040301160110	Albertson Brook	**0.041**	0.05	0.21	**22.10%**	6.60%	2.70%	**4.4**
2040301160120	Great Swamp Branch (above Rt 206)	0.134	0.08	0.33	**55.40%**	**21.50%**	9.30%	
2040301160130	Great Swamp Branch (below Rt 206)	0.104	0.11	0.43	**73.50%**	**39.30%**	**17.40%**	
2040301160150	Nescochague Creek	**0.071**	0.14	0.56	**83.90%**	**67.40%**	**37.50%**	
2040301160160	Gun Branch	**0.049**	0.13	0.52	**35.80%**	8.40%	2.20%	
2040301160170	Sleeper Branch	**0.021**	0.11	0.42	2.30%	0.90%	0.20%	
2040301170010	Hammonton Creek (above 74d43m)	0.130	0.07	0.28	**73.40%**	**67.20%**	**56.20%**	1.5
2040301200070	Ballanger Creek	0.064	0.08	0.34	N/A	N/A	N/A	2
2040302030070	Penny Pot Stream (GEHR)	0.148	0.09	0.35	**61.40%**	**24.30%**	9.60%	**5.4**
2040302040080	GEHR (39d32m50s to Hospitality Branch)	0.155	0.14	0.57	12.50%	3.40%	1.10%	**4.4**

The results shown in **bold** in the table above are as follows:

- **5% of Drought Recharge (MGD)** – Less than 0.01 MGD/square mile (median value of 0.015 MGD/mi2 for all subwatersheds), potentially indicating land conditions that limit recharge potential such as high levels of clay soils, wetlands or urban land relative to watershed size.
- **5% LFM (MGD)** – Less than 50% of the value for 5% of Drought Recharge (median value of 80% for all subwatersheds). Two important caveats must be stated for this and the next indicator. First, in most cases the LFM values are derived through statistical evaluations of comparable areas, not directly from flow monitoring. Second, while the recharge values were directly derived on a subwatershed basis, the LFM values are interpolated from the watershed level to the subwatersheds using average <u>watershed</u> LFM per square mile multiplied by the <u>subwatershed</u> area. The results for any one subwatershed may differ significantly from the results that would be achieved through direct evaluation of LFM at the subwatershed level.
- **20% LFM (MGD)** – Less than 200% of the value for 5% of Drought Recharge (median value of 316% for all subwatersheds).
- **Wetlands Drawdown >=5 cm** – Greater than 15% of wetlands affected. Pinelands Commission preliminary research results indicate that 5 cm may be an important threshold for pond habitats, and so this value for wetlands is used as an indicator of pond water elevation impacts.
- **Wetlands Drawdown >=15 cm** – Greater than 15% of wetlands affected. Pinelands Commission preliminary research results indicate that 5 cm may be an important threshold for wetlands.
- **Wetlands Drawdown >=30 cm** – Greater than 15% of wetlands affected. This value is twice the 15 cm threshold and would indicate <u>very</u> large stresses.
- **Net Withdrawal (Unconfined and SW)** (MGD by HUC11) – Greater than 4 MGD net withdrawal. In this case comparisons are not directly feasible between the subwatershed results and the watershed results, given that some subwatersheds within the overall watersheds are not included in the tables. However, these watershed-level results provide an indication of stress.

Based on the tabulated results, several subwatersheds (highlighted) have multiple indicators of stress, indicating that they may be incapable of supporting addition consumptive and depletive water uses, at least without a more detailed analysis and identification of reasons that such water uses would not be harmful. In other words, the presumption in these subwatersheds is one of constraints. These subwatersheds are all in the Hammonton target area:

- Mill Branch (below GS Parkway)
- Great Swamp Branch (above Rt 206)
- Great Swamp Branch (below Rt 206)
- Nescochague Creek
- Gun Branch
- Hammonton Creek (above 74d43m)
- Penny Pot Stream (GEHR)

Other subwatersheds such as Westecunk Creek (below GS Parkway) and Tuckerton Creek (below Mill Branch), both in the Little Egg Harbor/Tuckerton target area, may have limited potential but are not showing multiple indicators of problems. Still other subwatersheds do not show indications of stress at this time but may have limited capacity. More evaluations using a consistent subwatershed scale would provide further clarity, but were not feasible given current information sources.

Chapter 5: Public Community Water Supply (PCWS) Systems

This section identifies the available water supplies for PCWS systems in the target areas, and potential constraints on future service areas, needs and allocations. Evaluation of the non-target subwatersheds is not necessary for this purpose, as the focus is on infrastructure capacity and integrity for developed areas. The utilities of each target area are described along with available information regarding their systems, service areas, major infrastructure, firm capacity, contracts to/from other systems, water allocation permit limits, vulnerability to pollution, etc.

The NJDEP Division of Water Supply and Geoscience determines whether a PCWS system has a water supply deficit or surplus summary based on a comparison of monthly demands (within the last five years) to firm capacity and both monthly and annual water allocations. Tables in this chapter provide the available information from the NJDEP web site as of December 2013. A surplus means that firm capacity and/or diversion privileges or available supplies through bulk purchase agreements can be provided to new or increased uses. “Firm capacity” is the ability of the utility to provide water to customers in the absence of the utility’s largest water source (i.e., its largest well). For example, a system with only one well and no interconnections to another supply would have a firm capacity of zero.

Evesham/Medford Target Area

Figure 5-1 shows to the left the general location of wells serving the public community water supply systems in this target area, and to the right the most recent available depiction of the water supply service areas. The latter figure relies on public information downloaded from NJDEP on water supply service areas (data from 1998), from which preserved lands were excluded. Given the indirect derivation of these service areas, they are not considered definitive and should be updated as feasible. Medford Lakes Borough has no PCWS system, as all developed properties rely on individual wells located on-site.

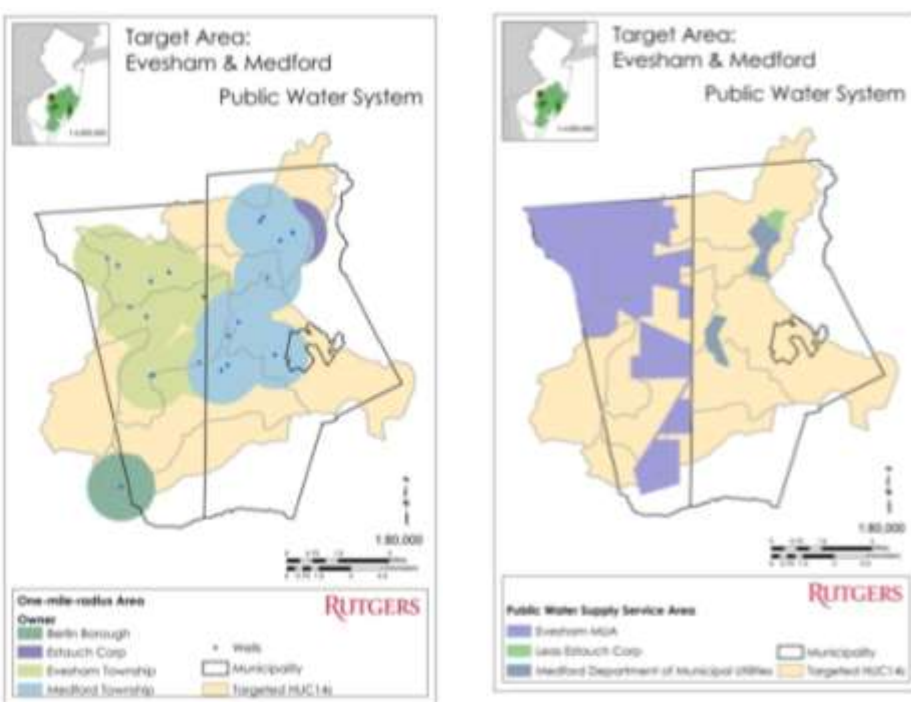


Figure 5-1. PCWS Wells and 1998 Service Areas, Evesham/Medford Target Area

Evesham Township

The Evesham Township Municipal Utility Authority (MUA) was formed in 1959 to address the needs of increasing suburban development, and grew with over time as development occurred mostly in the northern portion of the township but also the King's Grant development within the Pinelands, which occurred in the 1980s based on approvals from before the Pinelands CMP. Evesham MUA is the only public community water system in the Township, and also serves small neighboring areas in Mount Laurel and Medford Townships. Virtua Hospital is the only large customer at perhaps 100,000 gpd, while several restaurants may approach 50,000 gpd.

Evesham MUA derives its local water supplies from eleven (11) wells and related treatment facilities, and 179 miles of water distribution mains. All of the wells draw from confined aquifers and are limited in total pumping capacity and water allocation due to Water Supply Critical Area #2. For this reason, the MUA also is a customer of New Jersey American Water Company, which provides treated water from the Delaware River. NJ American (Delran) provides significant flow (94 MGM or roughly 3 MGD). Mount Laurel provides a small portion of the MUA's supply (21,000 gpd). According to its Source Water Assessment Report, the MUA served a population of 42,000 in 2003. The total firm capacity is reported by NJDEP as 11.57 MGD, including the contract supplies. Available information from NJDEP did not identify any recent drinking water quality violations for the MUA. However, according to the MUA, the historic Rancocas flood in 2007 submerged and damaged Well #6, causing contamination to that well through the well casing. Total coliform bacteria issues were addressed over two days.

Evesham Township Municipal Utilities Authority has a net surplus for firm capacity of 4.869 MGD, for monthly water allocation of 42.333 MGM, and for annual water allocation of 44.78 MGY.

Table 5-1. Evesham Township Municipal Utilities Authority						
Supply			**Demand**			
	Monthly	Yearly		Daily	Monthly	Yearly
Allocation	149	1118.732	Current Peak	6.252	193.823	1579.964
Contract	94.116	560.64	Date	Jul-12	Jul-12	2008
Total	243.116	1679.372	Committed Peak	0.449	6.96	54.628
Firm Capacity	11.57 MGD		Total	6.701	200.783	1634.592
Water Supply Deficit or Surplus						
Firm Capacity			4.869			
Monthly Water Allocation Permit			42.333			
Year Water Allocation Permit			44.78			

Water losses to the system have been identified as required by the Delaware River Basin Commission, through a report filed in 2013. Total non-revenue water is estimated at 7.3%, with water losses estimated at 4.8%. Based on the monthly water allocation and the potential to increase its contract with NJ American Water, Evesham MUA has ample water supply for further growth.

Projected Demands

Evesham MUA does not expect to add water supply service area. From the MUA perspective, the Pinelands area is constrained and much of the non-Pinelands area is either wetlands or preserved open space. Outside of the Pinelands in the north, there are a few residential developments (Raven Cliff; Haverhill in Medford) either under construction or planned.

New Jersey Future's build-out evaluation for Evesham Township was used to estimate increases in system demand and whether these demands can be accommodated within the net available capacity. The results may or may not occur, as they reflect the land-based build-out development capacity at current zoning. Actual land use approvals may be lower or higher, or land acquisition for open space may remove development potential. Water supply demand is based on 100 gallons per person per day for residential development,[12] and 0.10 gallons/day/sf for non-residential (based on office and commercial use).[13] Average household size used is 2.822 persons, assuming on average 2-3 bedroom, single-family detached housing in the South Jersey region (Listokin et al., 2006). The build-out PCWS demands for Evesham Township are as follows:

Table 5-2. Build-out Analysis: Evesham Township		
Development Category	**Development Potential**	**PCWS Demand (gpd, rounded)**
Residential (dwelling units)		
• Outside Pinelands	951	268,370
• Regional Growth Area	1133	319,730
• Rural Development Area	197	0
Non-Residential (square feet)		
• Outside Pinelands	454,625	45,460
• Regional Growth Area	567,694	56,770
• Rural Development Area	16,609	0
TOTAL		**690,330**

The residential and non-residential developments in the Rural Development Area are assumed to be within areas reliant on water supply from on-site wells, thus posing no demand on the PCWS system. Evesham MUA has ample firm capacity (4.869 MGD) and monthly water allocation capacity (1.39 MGD average) to support the estimated build-out demand. Even if the Rural Development Area development were to be added (slightly more than 57,000 gpd), no capacity constraints are seen. Evesham also has the ability to increase its contract with NJ American Water Company if existing capacity were limited.

Utility asset management

The MUA contracted for a 2011 Operations Assessment to serve as the basis for identification of needed projects and development of asset management. The report provides an assessment of cash balances, deferred maintenance based on budgeted expenditures relative to needed levels of reinvestment, the Capital Improvement Plan, benchmarking techniques for Authority evaluations of performance, and financial strength for the full system, and is the start for an asset management system. At this point in time, the MUA does not have a complete inventory of asset quality or priority list of capital project needs. Staff is providing the momentum for this effort as time permits. A previous GIS-based data system is being resumed and upgraded to help with the asset management efforts. Hydrant replacement and other capital projects have been completed or are in progress, some previously planned and some as a direct result of the operations assessment. The MUA tracks effective pumping capacity from its wells, which are affected by losses in capacity over time due to iron deposition and other factors, and redevelops wells as needed (Wells 6 and 9 most recently).

Evesham MUA approved a 2013 increase in water rates (now $3.94 per 1000 gallons) and connection fees, which did not attract significant opposition. Funding for capital improvements is provided through the budget process, with the MUA emphasizing use of system revenues (cash flow) for smaller projects,

[12] See NJDEP N.J.A.C. 7:10, Safe Drinking Water Act Regulations Adopted November 4, 2004, 7:10-12.6 Water Volume Requirements and State Plan Impact Assessment

[13] See: NJDEP N.J.A.C. 7:14A-23.3, Pollutant Discharge Elimination System: Technical Requirements For TWA Applications; Projected flow criteria

and loans from the NJ Environmental Infrastructure Finance Program for larger projects. Evesham MUA maintains a significant financial reserve to provide funds for major repairs without the need for borrowing. The Township does receive revenue from the MUA for direct costs, along with five percent of the MUA operating budget ($750K) for general township purposes. Of 46 filled staff positions (both water and sewer), less than a third are 55 years of age or more, and 17 have been with the MUA for at least 20 years. However, a majority of the staff has been with the MUA for less than 15 years, allowing for staff succession over time.

Medford Township

There are two public community water systems in Medford Township; one is the Medford Township Neighborhood Services Department, and the other is Medford Leas/Estauch Corporation.

Medford Township derives its water supplies from eleven (11) wells and related treatment facilities, and also receives 18.6 MGM of water from the NJ American Water Company (Delran facility) as required by NJDEP to address confined aquifer constrains in Water Supply Critical Area #2 (as with Evesham Township). All of the wells draw from the Mt. Laurel/Wenonah and PRM confined aquifers. According to its Source Water Assessment Report, it served a population of 16,807 in 2003. The total firm capacity is reported by NJDEP as 4.272 MGD. Three private water utilities initially provided drinking water to portions of the township, but were purchased by township in 1980s using federal grants. Most of township's development was constructed in 1960s through 1990s and therefore between rebuilding of the old lines and the newer system components, many of the water pipelines are relatively new. The system currently has 185 miles of water mains and serves nearly all densely developed portions of the Township. There are no large customers. Water losses are minimal (recently estimated at 7%).

Medford Leas/Estauch Corporation derives its water supplies from two (2) wells and related treatment facilities. Both of the wells draw from confined aquifers. According to its Source Water Assessment Report, it served a population of 600 in 2003. The total firm capacity is reported by NJDEP as 0.144 MGD. This system was constructed to supply water to a specific development, and no further development is anticipated.

Medford Township has a net surplus for firm capacity of 0.348 MGD, for monthly water allocation permit of 13.46 MGM, and for annual water allocation permit of 111.134 MGY. The peak summer demands exceed winter demands by roughly two-thirds, indicating outdoor uses.

Table 5-3. Medford Township Municipal Utilities Authority						
Supply			Demand			
	Monthly	Yearly		Daily	Monthly	Yearly
Allocation	97	647.335	Current Peak	2.666	82.641	602.144
Contract	18.6	219	Date	Jul-10	Jul-10	2010
Total	115.6	866.335	Committed Peak	1.258	19.499	153.057
Firm Capacity	4.272 MGD		Total	3.924	102.14	755.201
Water Supply Deficit or Surplus						
Firm Capacity			0.348			
Monthly Water Allocation Permit			13.46			
Year Water Allocation Permit			111.134			

Medford Leas/Estauch Corporation has a net surplus for firm capacity of 0.074 MGD, for monthly water allocation permit of 0.086 MGM, and for annual water allocation permit of 14.046 MGY.

Table 5-4. Medford Leas/Estauch Corporation						
Supply			**Demand**			
	Monthly	Yearly		Daily	Monthly	Yearly
Allocation	4.9	47	Current Peak	0.059	4.643	31.616
Contract	N/A	N/A	Date	Jul-11	Jul-08	2008
Total	4.9	47	Committed Peak	0.011	0.171	1.338
Firm Capacity	0.144 MGD		Total	0.07	4.814	32.954
Water Supply Deficit or Surplus						
Firm Capacity			0.074			
Monthly Water Allocation Permit			0.086			
Year Water Allocation Permit			14.046			

In Medford Township, NJDEP records show that violations occurred mainly for inorganic contaminants, such as the copper detected by the Township in 2012 and the lead (Pb) detected by Medford Leas/Estaugh Corporation in 2010, and microbiological contaminants, such as the Coliform bacteria detected by the Medford Township in 2006. The potential sources of copper and lead contamination are corrosion from household plumbing systems and the erosion of natural deposits, while for coliform bacteria common sources are wildlife, livestock, pets and septic systems. According to the 2012 Annual Drinking Water Quality Report (Consumer Confidence Report) released by Medford Township in 2013, four out of 10 sites containing copper in excess of the action level. In response to this issue, they performed a corrosion control study and took actions to make water less likely to absorb these materials. This issue is common in areas with naturally aggressive water supplies.

Projected Demands

New Jersey Future's build-out evaluation for Medford Township was used to estimate increases in system demand and whether these demands can be accommodated within the net available capacity. The results may or may not occur, as they reflect the land-based build-out development capacity at current zoning. Actual land use approvals may be lower or higher, or land acquisition for open space may remove development potential. Water supply demand is based on 100 gallons per person per day for residential development, and 0.10 gallons/day/sf for non-residential (based on office and commercial use). Average household size used is 2.822 persons, assuming on average 2-3 bedroom, single-family detached housing in the South Jersey region (Listokin et al., 2006). The build-out PCWS demands for Medford Township are as follows:

Table 5-5. Build-out Analysis: Medford Township		
Development Category	**Development Potential**	**PCWS Demand (gpd, rounded)**
Residential (dwelling units)		
• Outside Pinelands	3,084	870,305
• Regional Growth Area	3,625	1,022,975
• Rural Development Area	278	0
Non-Residential (square feet)		
• Outside Pinelands	1,420,199	142,020
• Regional Growth Area	816,233	81,623
• Rural Development Area	0	0
TOTAL		**2,116,923**

The residential and non-residential developments in the Rural Development Area are assumed to be within areas reliant on water supply from on-site wells, thus posing no demand on the PCWS system. Medford Township has entirely inadequate firm capacity (0.348 MGD) and monthly water allocation capacity (13.46 MGM or 0.449 MGD average) to support the estimated build-out demand. If the Rural Development Area development were to be added (slightly more than 78,000 gpd), the capacity constraints are even greater. Regarding anticipated development, active adult communities are under construction (over 300 units in total), and another project was approved and has treatment works approvals from NJDEP for over 600 units and 1.2 million square feet of commercial uses. The Township anticipates no need for additional water supply capacity based on local growth expectations. As such, the New Jersey Future build-out is quite different from Township expectations, and the Township should consider the extent to which local zoning may require unanticipated capacity.

Utility asset management

The Township is working toward development of a formal asset management program, building on its ongoing efforts to improve water lines from their initial 1980s condition when the Township purchased the three private water utilities. The result of these improvements and the fairly recent development of portions of the Township is that much of the existing system is either relatively new or recently upgraded. The asset management program will address the full system, including benchmarking for comparison to current integrity and other systems. Capital plans are developed looking forward five to ten years, and in general the Township finds that it needs to spend $1.5-2 million per year. Recent fiscal issues resulted in no capital projects budget for the last two years, but the Township now intend to restart its capital program. Wherever possible, capital projects on mains are coordinated with the Township's road improvement program to reduce overall costs. Emergency repair costs are typically low, approximately $50,000 to $75,000 per year for both water and sewer, except in response to major storm events such as the 2004 Rancocas Creek flood.

Residential water rates are $25.00 per quarter for 5,000 gallons, and then $3.50 per thousand gallons up to 20,000 gallons, with an inclining structure above that. These rates were established a few years ago to address a situation where the earlier rates did not reflect full pricing for the system. Medford Township recently completed a rate comparison, finding that its rates are mid-range for water supply systems in the area. The water system is charged for services provided by Township staff, but no revenue is exacted for use in the general Township budget.

Hammonton Target Area

There is one public community water system in Hammonton Township, the Hammonton Water and Sewer Department, which is directly owned and operated by the municipality. It was initially created in the 1920s to provide public utilities to the downtown area that had previously relied on on-site wells and sewage disposal. The utility service area has grown with development, but Hammonton lost significant industry flows of roughly 0.25-0.4 MGD in the last 30 years (e.g., Whitehall Labs – pharmaceuticals; Hammonton Brewery; textiles). There are no remaining major users within the service area.

Hammonton derives its water supply from four (4) wells (plus one backup well) and related treatment facilities. Two of the wells are reported as being in confined aquifers while the other two are in water table aquifers. According to its Source Water Assessment Report, Hammonton served a population of 11,900 in 2003. According to the township, nearly all of the township's residences and businesses are served by the Town PCWS. **Figure 5-2** shows to the left the general location of wells serving the public community water supply systems in this target area, and to the right the most recent available depiction of the water supply service areas. The latter figure relies on public information downloaded from NJDEP on water supply service areas (data from 1998), from which preserved lands were excluded. Given the indirect derivation of these service areas, they are not considered definitive and should be updated as feasible. The total firm capacity is reported by NJDEP as 2.16 MGD.

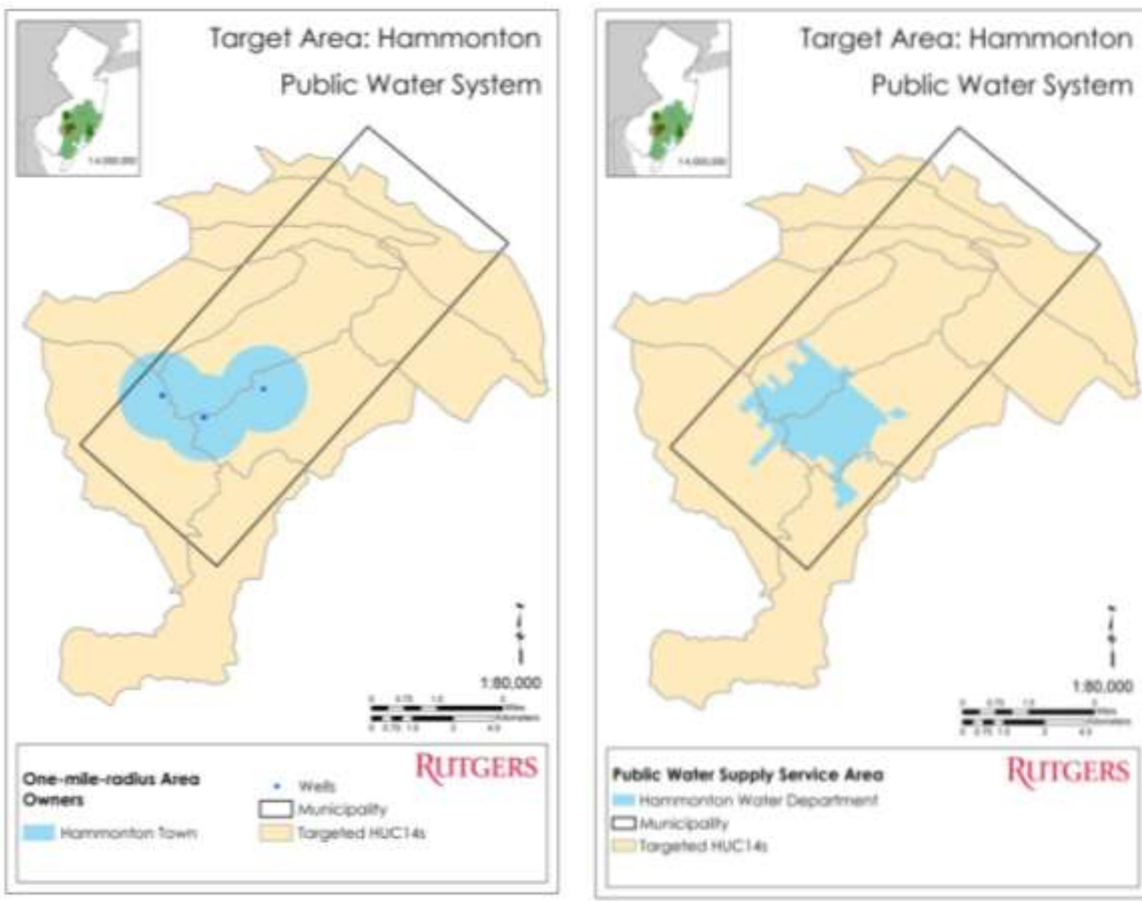


Figure 5-2. PCWS Wells and 1998 Service Areas, Hammonton Target Area

Hammonton Water Department has a net firm capacity of -0.735 MGD, a deficit, which means a shortfall in firm capacity and/or diversion privileges or available supplies through bulk purchase agreements, and for net capacity for monthly water allocation of -0.008 MGM. However, it has a surplus for annual water allocation permit of 47.421MGY. Given that the firm capacity and monthly allocation are showing deficits, Hammonton would be required to address those deficits prior to initiating further water supply connections, though natural growth within its existing service connections is possible. NJDEP has required action on the deficits, leading the Town to raise water rates, include a water conservation rate structure, and provide other conservation incentives to reduce demands such as rebates for water conservation devices and irrigation systems using a Sustainable Jersey grant. Hammonton indicates that summer demands decreased significantly from 2012 to 2013, but several years of results will be needed to verify that the reduction is sustained.

Table 5-6. Hammonton Water Department						
Supply			Demand			
	Monthly	Yearly		Daily	Monthly	Yearly
Allocation	88.872	647.996	Current Peak	2.839	88.012	593.762
Contract	N/A	N/A	Date	Jul-10	Jul-10	2010
Total	88.872	647.996	Committed Peak	0.056	0.868	6.813
Firm Capacity	2.16 MGD		Total	2.895	88.88	600.575
Water Supply Deficit or Surplus						
Firm Capacity			-0.735			
Monthly Water Allocation Permit			-0.008			
Year Water Allocation Permit			47.421			

Hammonton reported violations of drinking water quality system for disinfectants and disinfection by-products (Ethylene Dibromide, or EDB), radioactive contaminants (Gross Alpha and Radium) and volatile organic chemicals (Tetrachloroethylene) in 2012, 2011, 2010, 2009 and 2003. The potential sources of contamination respectively are the by-products of drinking water disinfection, naturally occurring minerals, and discharges from industrial facilities. The VOC contamination in one well is a long-term issue that was addressed by activated carbon and air stripping, but now EDB is also present. According to the Consumer Confidence Report released by Hammonton Water Department in 2013, treatment using granular activated carbon was installed during December 2012 to correct the Ethylene Dibromide (EDB) contamination in Well No. 1. The levels of EDB are now in compliance with drinking water standards. The radium problems are relatively new, requiring the addition of treatment to the affected wells, of an adsorption process. Well No. 4 was taken off-line during September 2012 and remains inactive (as of early 2014) due to excessive Gross Alpha and Radium activity. Treatment for removal of those radiological contaminants in Well No. 4 was anticipated to be initiated by September, 2013. Wells No. 5 and 7 have successful treatment to remove Gross Alpha and Radium activity.

Projected demands

Based on interviews with the utility, a few areas remain where the Pinelands CMP allows for growth that would be served by the water utility. Hammonton has been experiencing flat or declining demands, with little redevelopment, and anticipates this situation to continue. Demand growth is also constrained by limitations in water supply capacity as discussed above.

New Jersey Future's build-out evaluation for Hammonton was used to estimate increases in system demand and whether these demands can be accommodated within the net available capacity. The results may or may not occur, as they reflect the land-based build-out development capacity at current zoning. Actual land use approvals may be lower or higher, or land acquisition for open space may remove development potential. Water supply demand is based on 100 gallons per person per day for residential development, and 0.10 gallons/day/sf for non-residential (based on office and commercial use). Average household size used is 2.822 persons, assuming on average 2-3 bedroom, single-family detached housing in the South Jersey region (Listokin et al., 2006). The build-out PCWS demands for Hammonton are as follows:

Table 5-7. Build-out Analysis: Hammonton Town		
Development Category	**Development Potential**	**PCWS Demand (gpd, rounded)**
Residential (dwelling units)	3,083	870,020
Non-Residential (square feet)	13,693,485	1,369,350
TOTAL		**2,239,370**

Hammonton's PCWS system serves essentially all development within the municipality, and therefore this evaluation assumes that all future development within the Town would likewise have public water service. Hammonton, with its existing deficit in both firm capacity and monthly water allocation, lacks any capacity to service any portion of the build-out demand of over 2.2 MGD.

Utility asset management

Hammonton does not have a formal asset management program at this time but is interested. Currently, they target projects based upon operator experience with the system, and also will do line work when local road projects are implemented, to reduce the number of road openings. Emergency repairs have an allocation of generally 2-5% of the operational budget (combining sewer and water); repairs to the collection system are not extensive. Water loss rates are currently low, though a formal survey has not been completed.

Water rates are based on winter demand. Major projects are funded through NJEIFP loans, as with the major water supply treatment system upgrades to address both natural and industrial pollution. The town determines what municipal costs are directly associated with the utility, and those are charged to the budget with an administrative fee, but there are no "excess revenue" exaction per se. The staff is relatively small and highly experienced (all over 45), but with no younger staff in line at this time.

Tuckerton/Little Egg Harbor Township Target Area

Figure 5-3 shows to the left the general location of wells serving the public community water supply systems in this target area, and to the right the most recent available depiction of the water supply service areas. The latter figure relies on public information downloaded from NJDEP on water supply service areas (data from 1998), from which preserved lands were excluded. Given the indirect derivation of these service areas, they are not considered definitive and should be updated as feasible.

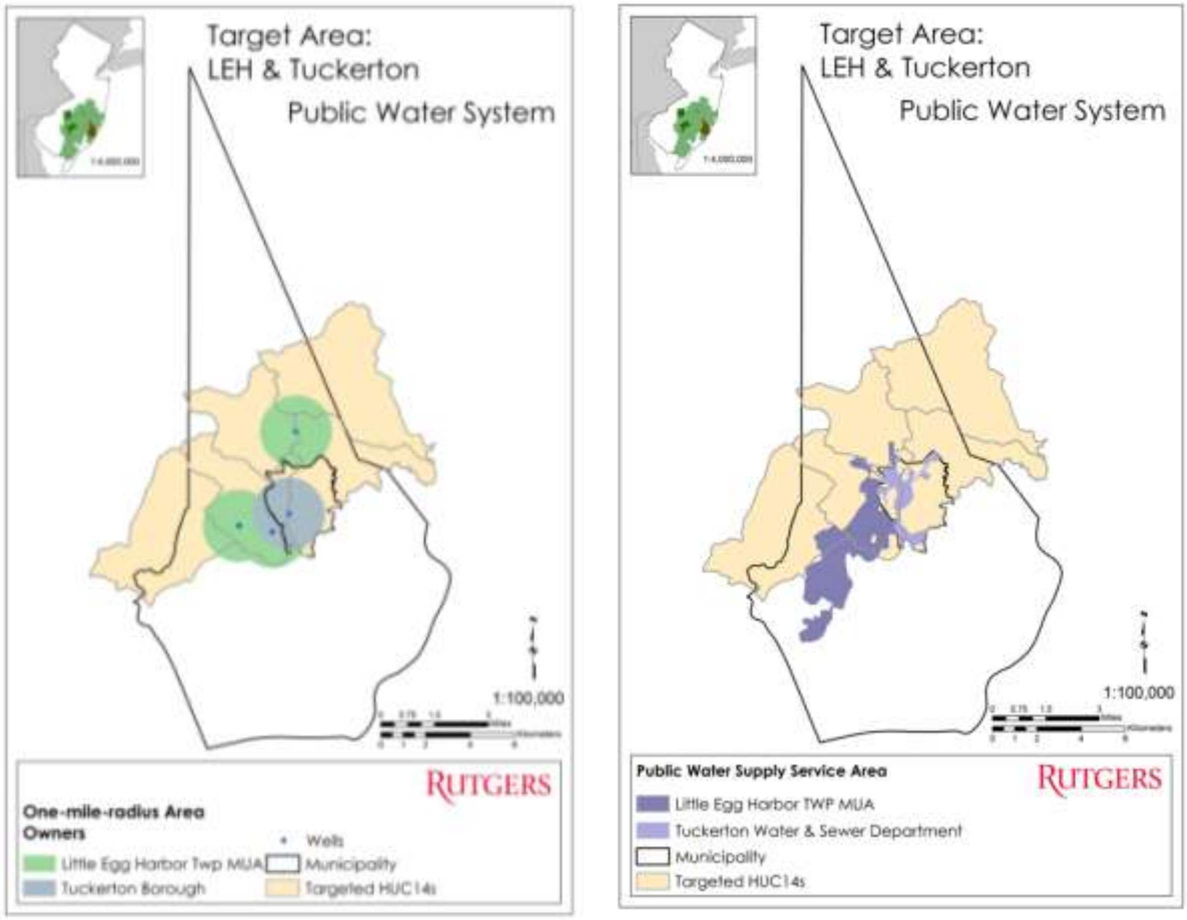


Figure 5-3. PCWS Wells and 1998 Service Areas, Little Egg Harbor/Tuckerton Target Area

Little Egg Harbor Township

There is one public community water system in Little Egg Harbor Township. The Little Egg Harbor Township Municipal Utilities Authority (LEHTMUA) was formed in 1972 to serve developed areas of town other than the Mystic Island area where the developer had a private water/sewer system (developed in the 1960s). In 1977, the LEHTMUA purchased the water and sewer systems from the Mystic Island developer, and also expanded its service area in response to considerable growth that occurred in the mainland area. Mystic Island is perhaps half seasonal and half year-round homes at this point. There are no major customers in the Township.

LEHTMUA derives its water supply from six (6) wells and related treatment facilities, and approximately 96 miles of distribution lines. All six wells withdraw from confined aquifers; those at 350 feet are in the Kirkwood-Cohansey aquifer, while others at 500 feet are in the Atlantic City 800-foot Sands. According to its Source Water Assessment Report, in 2003 the Authority served populations of 23,595 in Little Egg Harbor Township and 516 in Tuckerton Borough. The total firm capacity is reported by NJDEP as 5.4 MGD. Little Egg Harbor Municipal Utilities Authority has a net surpluses for firm capacity of 2.002 MGD, for monthly water allocation permit of 17.808 MGM, and for annual water allocation permit of 185.558 MGY. Normal winter water demands are roughly 1.2 MGD, but demands increase to roughly 3 MGD in the summer. Peak use is generally in the summer, when effects of lawn watering are noticeable, as 4:00 AM to noon in the summer is a peak use period. However, intense cold can also drive demand, with periods in January 2014 nearing summer peaks, apparently due to people running water to avoid having internal pipes freeze.

Table 5-8. Little Egg Harbor Township Municipal Utilities Authority						
Supply			Demand			
	Monthly	Yearly		Daily	Monthly	Yearly
Allocation	112.7	867	Current Peak	2.724	84.445	599.439
Contract	N/A	N/A	Date	Jul-08	Jul-08	2008
Total	112.7	867	Committed Peak	0.674	10.447	82.003
Firm Capacity	5.4 MGD		Total	3.398	94.892	681.442
Water Supply Deficit or Surplus						
Firm Capacity			2.002			
Monthly Water Allocation Permit			17.808			
Year Water Allocation Permit			185.558			

LEHTMUA experienced past violations of drinking water quality standards for Coliform bacteria, as detected by the MUA in 2005. According to the 2012 Annual Drinking Water Quality Report (Consumer Confidence Report) released by the MUA in 2013, were no violations of the maximum contaminant level detected in the drinking water quality system, indicating that the earlier problems were resolved.

Projected Demands

The northern portion of the township is within the Pinelands Area and is largely in preserved open space. Land use in the southern portion is regulated by NJDEP under the CAFRA program. The township has a number of approved developments that haven't been built due to economic conditions, and so are locking up water supply capacity, as unbuilt projects have commitments based on peak flow requirements per NJDEP rules. According to LEHTMUA, existing development approvals of perhaps 500 units exist within the SSA, but most of remaining undeveloped lands are preserved or constrained. Perhaps one site could generate less than 500 homes but to date lacks approvals, while small subdivisions may be feasible for other lots. Demand from existing developed areas has been increasing in recent years, as seasonal housing in the lagoon developments such as Mystic Island transition to year-round housing. LEHTMUA sought and received additional pumping capacity from NJDEP to address these increasing needs, through approval for a new well to allow meeting peak demands, but within the existing water allocation permit limitations. Hurricane Sandy damaged a very large number of homes in the shore areas, with unknown future impacts on water demands. The system estimates 9-10% unaccounted for water, indicating that losses are being kept to acceptable levels.

New Jersey Future's build-out evaluation for Little Egg Harbor Township was used to estimate increases in system demand and whether these demands can be accommodated within the net available capacity. The results may or may not occur, as they reflect the land-based build-out development capacity at current zoning. Actual land use approvals may be lower or higher, or land acquisition for open space may remove development potential. Water supply demand is based on 100 gallons per person per day for residential development, and 0.10 gallons/day/sf for non-residential (based on office and commercial use). Average household size used is 2.822 persons, assuming on average 2-3 bedroom, single-family detached housing in the South Jersey region (Listokin et al., 2006). The build-out PCWS demands for the township are as follows:

Table 5-9. Build-out Analysis: Little Egg Harbor Township		
Development Category	**Development Potential**	**Water Demand (gpd, rounded)**
Residential (dwelling units)		
• Pinelands Town	13	3,670
• Pinelands Village	2	560
• Regional Growth Area	3,189	899,940
• Forest Area	13	0
• Rural Development Area	289	0
Non-Residential (square feet)		
• Pinelands Town	0	0
• Pinelands Village	0	0
• Regional Growth Area	24,174,672	2,417,470
• Forest Area	471,289	0
• Rural Development Area	0	0
TOTAL		**3,321,640**

The residential and non-residential developments in the Forest Area and Rural Development Area are assumed to be within areas reliant on water supply from on-site wells, thus posing no demand on the PCWS system. With a net available Firm Capacity of 2 MGD and Monthly Water Allocation Permit capacity of 17.808 MGM (0.586 MGD on average), Little Egg Harbor has inadequate capacity to serve the build-out demand. Addition of the more than 130,000 gpd of water demand from the Forest Area and Rural Development Area (assuming that water services were provided to those areas) would increase the deficit in available water supply capacity.

LEHTMUA conducted a build-out analysis in 2003 that yielded fewer units (2260) than the New Jersey Future estimate. There are several differences between the two analyses. In its analysis, LEHTMUA:

- capped potential development projects to 24 units per parcel as an assumption that developers would opt to avoid the CAFRA process if the development potential was not significantly larger.
- only included entirely undeveloped parcels of land, and so did not include infill potential of partially-developed parcels.
- reserved 20% of a parcel's buildable land area for infrastructure, something the New Jersey Future study did only if a development exceeded five lots.
- only measured residential development potential, not commercial.

Finally, the impacts of Hurricane Sandy on potential build-out, and more particularly on the potential for transition of seasonal housing to year-round occupancy, are not yet known but could be significant.

Utility asset management

LEHTMUA has a formal asset management plan and program, where all assets over $5,000 are recorded and tracked, and the utility audits include depreciation evaluation. Routine, programmed maintenance needs are identified and budgeted. Each year, the LEHTMUA updates its facility needs, in part to address information requirements regarding the self-insurance policy. Work is performed in-house where possible, and contracted otherwise. LEHTMUA and the Township have cooperated on shared services for 30 years, which helps contain costs.

The asset management process started in 1960s with the first system components, and is a routine program with funds budgeted "pay as you go" as much as possible. The MUA budgets $250,000 to

350,000 per year for emergency repairs. With any small bad area of water or sewer, the LEHTMUA looks to replace the full section. Anything that is not spent goes to programmed capital projects. $1.5 million was in maintenance reserves prior to Hurricane Sandy, much of which had to be reprogrammed for repairs until the MUA is reimbursed.

Water rates use an EDU[14] of 15,000 gallons/quarter as the basis for billing. Commercial buildings are billed based on building size, seats (for restaurants), etc., on an EDU basis. Water use at or below the nominal EDU amount is charged at the base rate per EDU. Any water demand beyond the EDU is billed in addition to the base rate. The MUA also uses EDUs as the basis for reporting capacity reserves to NJDEP. The LEHTMUA went 16 years without rate increase on water. Two years ago they increased water rates by a small amount with no major adverse public reaction, and remain with fairly low rates. LEHTMUA conducts routine customer surveys on repair jobs, etc., and indicates that it gets positive feedback mostly. LEHTMUA will be debt free in 2 years, which provides an opening for more aggressive pipeline replacements or rehabilitation work without a need to increase rates. They currently are paying less than $1 million per year for debt service on bonds (with no bonding of major costs since 1988), and a small amount for debt service on a NJEIFP loan. LEHTMUA has 10 field and 8 office staff, most of whom are mid-career with some close to retirement, so hiring of younger staff is becoming an issue to ensure that system knowledge is retained.

Tuckerton Borough

There is one public community water system in Tuckerton Borough, Tuckerton Borough Water Department. Originally, water service was provided by Tuckerton Water Company, a private company that was eventually acquired by the then-existing Tuckerton Municipal Utility Authority, which was dissolved in 1990s. Population growth occurred primarily from 1960 to 2000, going from 1500 to 3500, with a small loss of population to 3300 people, from 2000 to 2010. The water system serves nearly all the borough, with an increase in demands during summer as vacation homes and visitors increase the user base. There are no major users. Roughly 130 units were disconnected from water service because of Hurricane Sandy, which will have a short-term effect on demand. Tuckerton derives its water supply from three (3) wells and related treatment facilities. All three wells withdraw from confined aquifers (the 800 Foot Sands). The total firm capacity is reported by NJDEP as 0.72 MGD. Tuckerton Water and Sewer Department has net surpluses for firm capacity of 0.231 MGD, for monthly water allocation permit of 5.587 MGM, for annual water allocation permit of 49.882 MGY, as shown in the table below.

Table 5-10. Tuckerton Water and Sewer Department

Supply			Demand			
	Monthly	Yearly		Daily	Monthly	Yearly
Allocation	20	180	Current Peak	0.441	13.669	124.278
Contract	N/A	N/A	Date	Jul-10	Jul-10	2011
Total	20	180	Committed Peak	0.048	0.744	5.84
Firm Capacity	0.72 MGD		Total	0.489	14.413	130.118
Water Supply Deficit or Surplus						
Firm Capacity			0.231			
Monthly Water Allocation Permit			5.587			
Year Water Allocation Permit			49.882			

Tuckerton Borough experienced violations of drinking water quality standards for Coliform bacteria as detected by the Tuckerton Water and Sewer Department in 2002 and 2006. Tuckerton indicates that

[14] Equivalent Dwelling Units, based on a nominal residential water use.

they re-sampled based on the initial results and the new samples were clean, indicating potential lab or sampling error, not a confirmed contamination issue. According to the 2012 Annual Drinking Water Quality Report (Consumer Confidence Report) released by the Tuckerton Borough in 2013, there were no violations of the maximum contaminant level detected in the drinking water quality system, indicating that the earlier problems were resolved.

Projected Demands

The borough is extensively developed. According to the borough, there is minimal potential for increased PCWS service area. A couple of projects have approvals, but are on hold; one is an apartment complex for veterans, and the other is a small development. Tuckerton is outside the Pinelands Area but within the CAFRA jurisdiction of NJDEP. The Wetlands Act also limits growth potential, as part of the borough is designated as coastal wetlands. Tuckerton may be constrained by its limited available land area and also by limitations on water supply capacity.

New Jersey Future's build-out evaluation for Tuckerton was used to estimate increases in system demand and whether these demands can be accommodated within the net available capacity. The results may or may not occur, as they reflect the land-based build-out development capacity at current zoning. Actual land use approvals may be lower or higher, or land acquisition for open space may remove development potential. Water supply demand is based on 100 gallons per person per day for residential development, and 0.10 gallons/day/sf for non-residential (based on office and commercial use). Average household size used is 2.822 persons, assuming on average 2-3 bedroom, single-family detached housing in the South Jersey region (Listokin et al., 2006). The build-out PCWS demands for Tuckerton are as follows:

Table 5-11. Build-out Analysis: Tuckerton Borough

Development Category	**Development Potential**	**Water Demand (gpd, rounded)**
Residential (dwelling units)		
• Pinelands Town	891	251,440
• Regional Growth Area	8	2,258
Non-Residential (dwelling units)		
• Pinelands Town	867,224	86,722
• Regional Growth Area	11919	1,192
TOTAL		**341,612**

Tuckerton has net available Firm Capacity of 0.231 MGD and Monthly Water Allocation Permit capacity of 5.587 MGM (0.184 MGD), both of which are <u>inadequate</u> to fully address the build-out demand. Roughly <u>half of the necessary capacity is available</u>.

Utility asset management

The borough does not have a formal asset management program, but has been discussing the issue. However, they have been implemented a 10 year plan that focused on known infrastructure needs (e.g., customer water metering, pumps, water storage tank). Implementation has been limited due to financial limitations. Estimated non-revenue water prior to Hurricane Sandy was 15%, though a formal audit has not been conducted. After Hurricane Sandy, the borough decided to evaluate the sewer and water systems, especially within the hard-hit Tuckerton Beach area. The process has begun and they hope to continue. However, recovering from Sandy has required major expenditures with limited repayments to date, stressing municipal finances and slowing potential improvements.

The largest concern is the Tuckerton Beach area, a lagoon development. The borough replaced the water, sewer and stormwater lines in three entire streets in Tuckerton Beach. Major improvements (reduced repair needs) have been seen on these three Tuckerton Beach streets, but more work needs to be done in other areas.

Tuckerton charges a flat quarterly fee for water ($79.39) based on an annual Equivalent Residential Unit (EDU) water demand (18,250 gallons per quarter), and then annually bills for excess use ($4.55 per 1000 gallons). Homes can have secondary water meters for outdoor use, which results in a reduced sewer bill (but not water). According to the borough, there have been no public issues on rates within last couple of years. However, rates may remain below sustainable levels for long-term operations and maintenance/repairs, which requires evaluation once the full extent of repairs is known. The borough merged water and sewer revenues recently into a single account, a portion of which is earmarked for repairs such as the more routine maintenance. Major repairs are not in the O&M budget; rather, all major projects rely on outside grants or loans. Loans from NJEIFP have been used for the last few projects, but the borough also routinely investigates the potential for USDA Rural Development Administration grants and other non-traditional funding. The water and sewer department has five people with formal training in water and sewer systems, but many engage in cross-over work with DPW. The five are a mix of ages, as the borough was able to hire some younger staff to fill openings from retirements in last few years.

Summary for PCWS Systems

The PCWS systems in the three target areas vary greatly in their capacity to address additional demands from future development, as assessed using a build-out analysis. Evesham Township would expect additional demands of under 0.7 MGD at build-out, and has sufficient current supplies to meet those demands. Further, the Evesham/Medford target area shows little current or potential impact of water withdrawals on wetlands ecosystems, due to their reliance on confined aquifers. Evesham Township also is prohibited from increasing its withdrawals from the confined aquifer through NJDEP controls on Water Supply Critical Area #2, but can increase its contract with NJ American Water Company to import Delaware River water supplies. Medford Township, on the other hand, has an additional demand at build-out of over 2 MGD but almost no net available supply. Medford Lakes has no PCWS system.

Hammonton is by far the most stressed system, with an additional demand at build-out of 2.24 MGD and a current deficit in available capacity. Even with the water conservation actions being undertaken by the municipality, capacity is likely to remain well below build-out demand. Further use of the unconfined aquifers would likely increase the already high levels of stress on wetland habitats in the relevant subwatersheds.

Little Egg Harbor Township and Tuckerton both have some net available capacity but not enough to serve all new demands that would result from build-out of the municipalities (3.32 MGD and 0.34 MGD, respectively.

Table 5-12. Comparison of Build-out Demands to Net Available Capacity		
Municipality	**Additional Demand at Build-out (MGD)**	**Net Available Capacity (MGD)**
Evesham Township	0.69	4.869 (Firm Capacity) 1.39 (Water Allocation)
Medford Township	2.12	0.074 (Firm Capacity) 0.0028 (Water Allocation)
Medford Lakes Borough	No PCWS system	No PCWS system
Hammonton Town	2.24	-0.74 (Firm Capacity) 0.0 (Water Allocation)
Little Egg Harbor Township	3.32	2.002 (Firm Capacity) 0.586 (Water Allocation)
Tuckerton Borough	0.34	0.231 (Firm Capacity) 0.184 (Water Allocation)

However, a major point must be raised regarding the results posed above. Build-out may not occur for long periods, or even at all, depending on market conditions, land acquisition for open space and farmland preservation, approvals at less than zoned maximums, etc. The following table provides a comparison of the housing units from the build-out assessment and from population projections to the year 2040 from the relevant Metropolitan Planning Organizations. In several municipalities the projected housing units through 2040 are far lower than the build-out conditions, with Medford Township showing the most striking difference. Conversely, the population projections for 2040 in Little Egg Harbor Township would require more housing than the build-out demand indicates is feasible under existing zoning. However, the township has a large stock of seasonal housing that has been shifting to year-round use, though Hurricane Sandy impacts may slow that trend.

Table 5-13. Comparison of New Housing: Population Projections (2040) v. Build-out Conditions						
	Evesham Township	**Medford Lakes Borough**	**Medford Township**	**Hammonton Town**	**Little Egg Harbor Township**	**Tuckerton Borough**
Population						
2010	45,538	4,146	23,033	14,791	20,070	3,350
2040 (projected)	47,720	4,187	26,897	19,490	30,930	4,840
2010-2040	2,182	41	3,864	4,699	10,860	1,490
Housing Units	*774*	*15*	*1,370*	*1,666*	*3,851*	*528*
Build-out						
Build-out Units	*2,281*	*24*	*6,987*	*3,083*	*3,506*	*899*
Difference	**1,507**	**9**	**5,617**	**1,417**	**-345**	**371**
Difference (%)	**66.1%**	**37.5%**	**80.4%**	**46.0%**	**-9.8%**	**41.3%**

The water supply demands generated by the build-out analysis cannot be directly compared to the water demands generated by increased population, as not all of the new population through 2040 will be in areas served by PCWS systems, and population projections do not provide information about additional demands from business, commerce and industrial needs. However, a rough sense of the shift in water demands can be inferred by the percent difference in new housing units. Using that general guide, no municipality would have a significant shift regarding the adequacy of their capacity to handle build-out demands, but may have adequate capacity to address demands through 2040. Even Medford Township, with an 80% difference in housing units, would still have inadequate capacity to address demands projected for 2040.

Of the five municipalities with PCWS systems, only Little Egg Harbor Township MUA has indicated that it has a comprehensive, formal system for asset management. The other four municipalities are investing in their assets based on local knowledge. However, all five acknowledge that advancing age of water systems will increase necessary capital investment costs, which will strain resources at current rates. Little Egg Harbor Township MUA is in a favorable position, as the payoff of existing debt will allow for capital expenditures using the revenue stream that currently goes to debt payments, but conversely the MUA maintains only a small reserve fund for capital costs. Evesham Township MUA has maintained a somewhat larger reserve account for capital costs that will help, though not solve, the revenue stresses it faces.

Chapter 6: Public Sewerage Systems

This chapter identifies the available capacity for public sewerage systems in the target areas, and potential constraints on future flows and service areas. Net available capacity is provided for all public sewer treatment systems that are required to report monthly discharge flows to NJDEP. Two values are reported, both with respect to the permitted, design or planning flows approved for the facility (whichever is less). One uses annual average discharge flows, which value corresponds to NJDEP's Water Quality Management Planning Rules (N.J.A.C. 7:15-5). The other uses the maximum 3-month average (MAX3MO) flow from 2005 to 2013 (September), as in NJDEP's Capacity Assurance Program rules (N.J.A.C. 7:14A-22.16) and the Highlands Regional Master Plan (Highlands Council, 2008). Evaluation of the non-target subwatersheds is not necessary for this purpose, as the focus is on infrastructure capacity and integrity for developed areas.

Evesham/Medford Target Area

There are fourteen NJPDES-permitted sewage treatment facilities serving Evesham Township, Medford Township, and Medford Lakes Borough within their contiguous HUC14 subwatersheds, as shown in **Figure 6-2**. Not all of these facilities are public sewerage systems and not all portions of the approved sewer service areas are currently served. The public sewer service area in Evesham Township is 9,757 acres, in Medford Township is 20,161 acres and in Medford Lake Borough is 721 acres. **Table 6-1** shows the sewer service area in each HUC 14 subwatersheds. The total acreage in the subwatersheds is larger than the municipal sewer service areas because there are sewer service areas within the subwatersheds but outside of the municipalities.

Table 6-1. Sewer Service Areas in the Evesham/Medford Target Area

HUC14	Subwatershed Name	Acres Served	Percentage of Subwatershed
02040202060010	Kettle Run (above Centennial Lake)	1954.51	8.28%
02040202060020	Lake Pine / Centennial Lake & tribs	2493.71	10.57%
02040202060030	Haynes Creek (below Lake Pine)	4344.91	18.42%
02040202060040	Barton Run (above Kettle Run Road)	3041.28	12.89%
02040202060050	Barton Run (below Kettle Run Road)	2747.42	11.65%
02040202060080	Rancocas Creek SW Branch (above Medford Br)	4036.10	17.11%
02040202060100	Rancocas Creek SW Branch (below Medford Br)	4974.53	21.09%

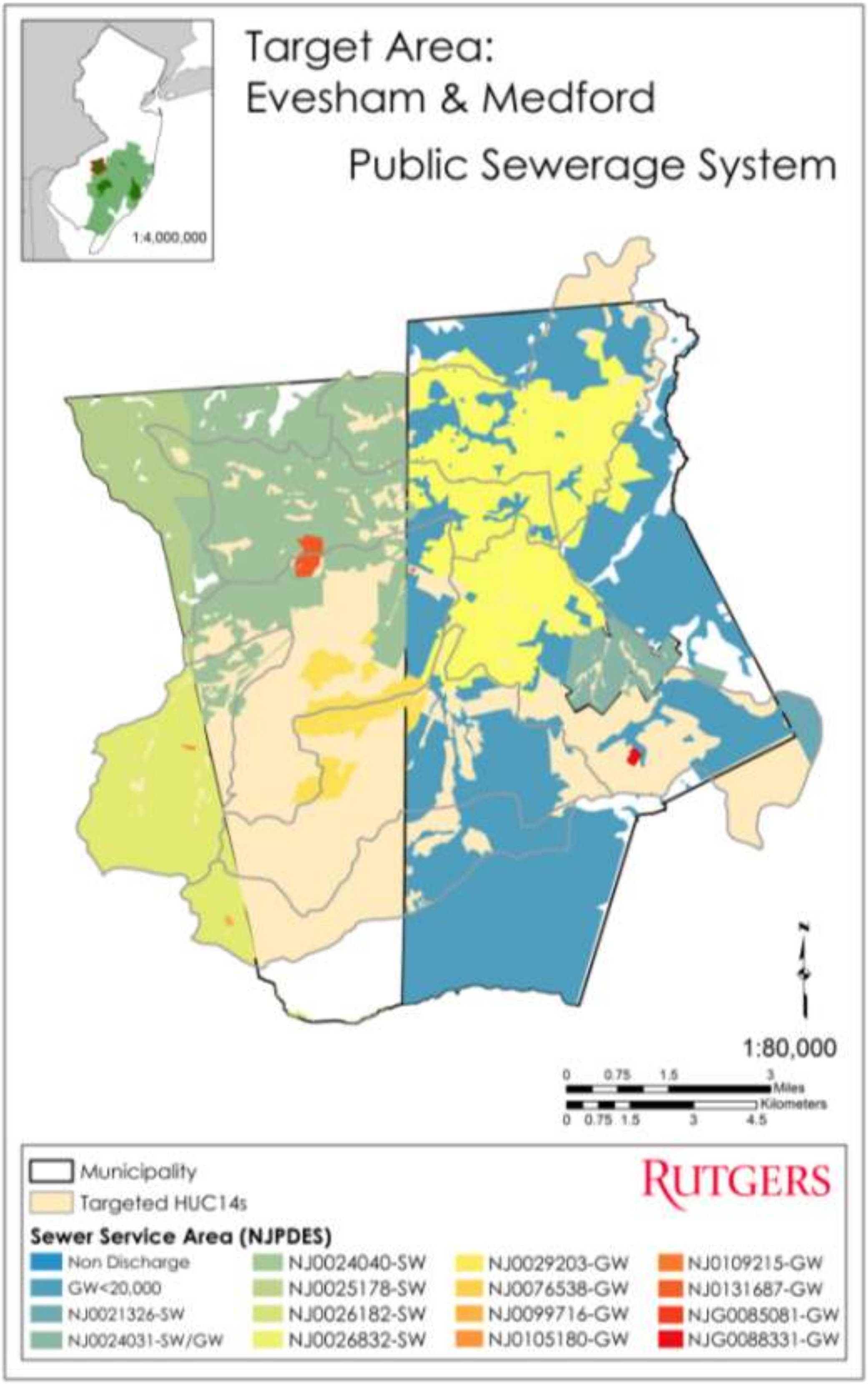


Figure 6-1. Sewer Service Areas: Evesham/Medford Target Area

Evesham Township

The Evesham Township Municipal Utility Authority (MUA) was formed in 1959 to address the needs of increasing suburban development. There are two sewage treatment plants operated by the Evesham Township MUA for which monthly flows are available from NJDEP, plus a third facility. The total system includes 174 miles of sewer collection mains. The Elmwood Wastewater Treatment Plant (NJ0024031) has a permitted capacity of 2.987 MGD. The MAX3MO flow from 2005 to 2013 (September) is 2.292 MGD, while the annual average flow is 2.142 MGD. These values are little different, indicating relatively limited seasonal changes in flow that might be associated with Infiltration & Inflow (I&I). According to the MUA, Elmwood dry weather flows are generally 1.85 MGD but flow jumps briefly to 2.1-2.2 MGD in a storm. Correspondingly, the net available capacity for the MAX3MO flow is 0.695 MGD, and for annual average flow is 0.845 MGD. Most but not all of its service area is north of the Pinelands Area. This facility provides treated effluent for beneficial reuse for Indian Springs Golf Course, a municipal facility, which is piped from the facility to an irrigation pond at the golf course. The water allocation for the golf course was intended to shift to the MUA.

The Woodstream Wastewater Treatment Plant (NJ0024040) has a permitted capacity is 1.5 MGD. The MAX3MO flow from 2005 to 2013 (August) is 1.367 MGD, while the annual average flow is 1.255 MGD. Again, these values are little different, indicating relatively limited seasonal changes in flow that might be associated with I&I. According to the MUA, Woodstream dry weather flows are generally 0.95 MGD but flows increase briefly to 1.2 MGD in storms. Correspondingly, the net available capacity for the MAX3MO flow is 0.133 MGD, and for annual average flow is 0.245 MGD. Most but not all of its service area is north of the Pinelands Region.

Within these two service areas, the only major customer is Virtua Hospital, at approximately 100,000 gpd. Some of the larger restaurants may approach 50,000 gpd.

The Evesham Township MUA also operates a third treatment plant, which served the King's Grant development (in the Pinelands area). This development started in the early 1980s with a package plant that had significant operational problems. The MUA took ownership to correct the problems. King's Grant is a 0.6 MGD facility with discharge to ground water, unlike the other two facilities that discharge to surface water. According to the MUA, King's Grant dry weather flows are generally from 0.4-0.5 MGD but approach 0.6 MGD during storms due to I&I; the MUA is requesting an increase to 0.7 MGD to avoid permit violations, though the area served and customer base would not increase. Within the last few years, the original facility was demolished and rebuilt. The infiltration basins near the facility have been abandoned and the expectation is to restore that area for natural vegetative growth as part of a passive recreation park. The new basins are well to the south of the King's Grant development, and are underutilized relative to design capacity.

Projected Demands

Evesham MUA does not expect to add sewer service area (SSA) for any of its facilities. From the MUA perspective, the Pinelands area is constrained and much of the non-Pinelands area is either wetlands or preserved open space. A developer with land in the Pinelands (Forest Area) has indicated a desire to be included in the SSA for 300+ homes but the Pinelands Commission must approve the proposal first. Outside of the Pinelands but within the existing SSA in the north, there are a few residential developments (Raven Cliff; Haverhill in Medford) either under construction or planned. The MUA does not plan to upgrade or increase design capacity at any of the three facilities.

New Jersey Future's build-out evaluation for Evesham Township was used to estimate increases in system demand and whether these demands can be accommodated within the net available capacity. The results may or may not occur, as they reflect the land-based build-out development capacity at current zoning. Actual land use approvals may be lower or higher, or land acquisition for open space may remove development potential. Sewage generation is based on 75 gallons per person per day for residential development, and 0.10 gallons/day/sf for non-residential (based on office and commercial use).[15] Average household size used is 2.822 persons, assuming on average 2-3 bedroom, single-family detached housing in the South Jersey region (Listokin et al., 2006). The build-out wastewater demands for Evesham Township are as follows:

Table 6-2. Build-out Analysis: Evesham Township		
Development Category	**Development Potential**	**Sewage Generation (gpd, rounded)**
Residential (dwelling units)		
• Outside Pinelands	951	201,137
• Regional Growth Area	1133	239,630
• Rural Development Area	197	0
Non-Residential (square feet)		
• Outside Pinelands	454,625	45,463
• Regional Growth Area	567,694	56,769
• Rural Development Area	16,609	0
TOTAL		**542,998**

The residential and non-residential developments in the Rural Development Area are assumed to be within areas reliant on individual on-site wastewater treatment systems, thus posing no demand on the sewer system. No additional demand would occur due to development in the King's Grant SSA, as that is fully developed. Given that the net available capacity for the Elmwood STP based on MAX3MO flow is 0.695 MGD, and for Woodstream is 0.133 MGD (total of 0.828 MGD), Evesham MUA has sufficient sewer capacity to support the estimated build-out demand. Addition of the demand from the Rural Development Area, if served by sewers, of roughly 43,000 gpd would not change this conclusion.

Utility asset management

The MUA contracted for a 2011 Operations Assessment to serve as the basis for identification of needed projects and development of asset management. The report provides an assessment of cash balances, deferred maintenance based on budgeted expenditures relative to needed levels of reinvestment, the Capital Improvement Plan, benchmarking techniques for Authority evaluations of performance, and financial strength for the full system, and is the start for an asset management system. At this point in time, the MUA does not have a complete inventory of asset quality or priority list of capital project needs. Staff is providing the momentum for this effort as time permits. A previous GIS-based data system is being resumed and upgraded to help with the asset management efforts. Hydrant replacement, treatment plant improvements, SCADA system improvements, the King's Grant STP reconstruction and other capital projects have been completed or are in progress, some previously planned and some as a direct result of the operations assessment. The MUA has also purchased specialized equipment to provide video monitoring of sewer lines.

Sewer rates are roughly $88 per quarter for residential customers using 18,000 gallons of water per quarter. Funding for capital improvements is provided through the budget process, with the MUA emphasizing use of system revenues (cash flow) for smaller projects, and loans from the NJ Environmental Infrastructure Finance Program for larger projects. Evesham MUA maintains a significant

[15] See: NJDEP N.J.A.C. 7:14A-23.3 Pollutant Discharge Elimination System: Technical Requirements For TWA Applications; Projected flow criteria

financial reserve to provide funds for major repairs without the need for borrowing. The Township does receive revenue from the MUA for direct costs, along with five percent of the MUA operating budget ($750K) for general township purposes. Of 46 filled staff positions (both water and sewer), less than a third are 55 years of age or more, and 17 have been with the MUA for at least 20 years. However, a majority of the staff has been with the MUA for less than 15 years, allowing for staff succession over time.

Medford Lakes

The sewer system for Medford Lakes was linked to the original creation of the Medford Lakes development project. The treatment plant was built as a Works Public Administration (WPA) project in 1930s, with a design capacity of perhaps 0.2 MGD, parts of which are still in use. As the community grew and shifted from seasonal to full-time residences, the treatment plant capacity was increased. The Medford Lakes Borough Sewage Treatment Plant (NJ0021326) now has a permitted capacity of 0.550 MGD, based on a 1960s expansion and upgrade. In the 1970s, treatment was added for total phosphorus (TP) and biological oxygen demand (BOD) to address water quality concerns for a downstream lake. The facility continues to discharge to Aetna Run, based on a negotiated variance from Pinelands CMP requirements to discontinue such discharges. A lack of available land for ground water discharge was a factor, along with a commitment by the Borough that no further expansions of the treatment plant would occur. The only large users are two public schools.

The MAX3MO flow from 2005 to 2013 (September) is 0.513 MGD, while the annual average flow is 0.442 MGD. Correspondingly, the net available capacity for the MAX3MO flow is 0.037 MGD, and for annual average flow is 0.108 MGD. I&I rates are generally low. According to the operators, there are 20-25 miles of sewer lines, which are cleaned every three years. The system experiences very short peaks from rain events, with 1.5-2 MGD for a few hours, which do not pose an issue at the treatment plant. The cause of these peaks is uncertain, but illicit sump pump connections are a major problem. The borough recently updated the local ordinance for clarity on illicit connections and enforcement provisions.

Projected Demands

The borough expects no significant changes in its SSA or customer base, as there are few undeveloped lots in Medford Lakes and some potential for connection of existing residential lots (currently served by septic systems) in nearby portions of Medford Township. A total of 27,000 gpd of capacity has been sold to local camps but remains unused; they could possibly use those flows for redevelopment.

New Jersey Future's build-out evaluation for Medford Lakes was used to estimate increases in system demand and whether these demands can be accommodated within the net available capacity. The results may or may not occur, as they reflect the land-based build-out development capacity at current zoning. Actual land use approvals may be lower or higher, or land acquisition for open space may remove development potential. Sewage generation is based on 75 gallons per person per day for residential development, and 0.10 gallons/day/sf for non-residential (based on office and commercial use).[16] Average household size used is 2.822 persons, assuming on average 2-3 bedroom, single-family detached housing in the South Jersey region (Listokin et al., 2006). The build-out wastewater demands for Medford Lakes are as follows:

[16] See: NJDEP N.J.A.C. 7:14A-23.3 Pollutant Discharge Elimination System: Technical Requirements For TWA Applications; Projected flow criteria

Table 6-3. Build-out Analysis: Medford Lakes Borough		
Development Category	**Development Potential**	**Sewage Generation (gpd, rounded)**
Residential (dwelling units)	24	5,080
Non-Residential (square feet)	69,736	6,970
TOTAL		**12,050**

Medford Lakes is a fully developed, low-density residential lake community with minimal potential for extensive growth. It is located entirely within the Pinelands Area and has little potential for extension of sewer lines outside the borough to Medford Township, except to serve existing homes with septic systems on small lots. The treatment plant net available capacity is very limited and much of that is already contracted to the local camps. Design capacity is highly unlikely to increase, as that would trigger Pinelands CMP requirements to cease the surface water discharge and move to an infiltration approach for ground water discharge. Evaluate available sewer utility capacity, system management and potential for growth either within or near existing service areas, for each target area.

Utility asset management

The borough does not have comprehensive asset management process, but rather uses a combination of formal and informal processes. As mentioned, they clean the collection system every three years. Routine O&M for the treatment plant is based on a 5-year plan. The early collection system pipes were terra cotta. Based on some video investigations, the pipes are still solid, but significant problems exist at the joints (every three feet) and both active and inactive (stub) connections. To address a variety of issues, the borough now plans to line the entire sewer collection system at $4-5 million using a 40 year loan. The intent is to reduce I&I and potentially make room for flows from existing properties on septic systems in Medford Township.

The borough funds many smaller capital projects and emergency repairs by borrowing from borough reserves, which are then replenished through sewer rates that are set at $700 per house per year, as there is no water system to use as the basis for rate setting. Larger projects are generally funded through a NJEIFP loan, if appropriate to the situation. A recent rate increase met with no significant opposition, following a public process to explain the needs. The borough assesses costs of providing sewer services to the sewer rates, but does not exact sewer revenue for non-sewer purposes.

While the borough does not have a formal asset management program for its system, recent and planned capital projects show a strong interest in maintaining the treatment plant and in collection system improvements to offset the aging pipes and significant (though very short-duration) I&I issues posed within the system. The process of lining the entire collection system will not only seal off the flow of water through joints and stubs of the terra cotta pipes, it will also allow the municipality to identify and eliminate any illicit connections from sump pumps and other sources. The borough appears to have a routine approach for financing and use of reserves that allows for the sewer system to borrow from the borough reserves and repay over time, rather than engaging in frequent small-scale bonding. Finally, the sewer department staff, while small, is of varying ages and has a succession plan in place that will allow for good transfer of knowledge within the staff.

Medford Township

Medford Township Wastewater Treatment Plant (NJ0026832) was constructed in the mid-1960s and has been enlarged as needed; it currently has a permitted capacity of 1.750 MGD and was most recently upgraded in 2013. It discharges to the SW Branch of the Rancocas River. Most of the existing sewer service area is north of Medford Lakes, even though significant areas just south and southwest of

Medford Lakes are developed with small lots and lack sewerage (but have public water supply). The 80 miles of sewer mains cover a significantly smaller area than is served with public water supply. The very southern part of the Township is mostly undeveloped and entirely outside of the sewer service area. Small areas of the Township are served by the Borough of Medford Lakes, and the Township serves a few small areas outside its borders. There are no large customers. The MAX3MO flow from 2005 to 2013 (August) is 1.514 MGD, while the annual average flow is 1.382 MGD. Correspondingly, the net available capacity for the MAX3MO flow is 0.209 MGD, and for annual average flow is 0.368 MGD. I&I rates are generally low. The Township has lined many sewer mains and installed water-tight manholes, especially in areas with high water tables and near streams such as along the SW Branch of the Rancocas Creek, in a $3 million project. Sewer flows now are approximately the same as 15 years ago, despite growth in the customer base. The Township has identified and is working on resolving similar issues in other locations, and has a routine inspection and sewer cleaning program.

NJDEP data indicate past substantive effluent quality violations (as differentiated from administrative violations) for the Medford Township facility, running from late 2008 to early 2009 (all of which were deemed satisfied in June 2011), and in portions of 2009 and 2010 that were addressed by findings of "Affirmative Defense Approved." The distinction between the two results is that the first set were addressed through system modifications, while the second set were deemed the result of outside forces that caused the violations and therefore did not require system changes.

Projected Demands

New Jersey Future's build-out evaluation for Medford Township was used to estimate increases in system demand and whether these demands can be accommodated within the net available capacity. The results may or may not occur, as they reflect the land-based build-out development capacity at current zoning. Actual land use approvals may be lower or higher, or land acquisition for open space may remove development potential. Sewage generation is based on 75 gallons per person per day for residential development, and 0.10 gallons/day/sf for non-residential (based on office and commercial use).[17] Average household size used is 2.822 persons, assuming on average 2-3 bedroom, single-family detached housing in the South Jersey region (Listokin et al., 2006). The build-out wastewater demands for Medford Township are as follows:

Table 6-4. Build-out Analysis: Medford Township

Development Category	Development Potential	Sewage Generation (gpd, rounded)
Residential (dwelling units)		
• Outside Pinelands	3,084	652,266
• Regional Growth Area	3,625	766,688
• Rural Development Area	278	0
Non-Residential (square feet)		
• Outside Pinelands	1,420,199	142,020
• Regional Growth Area	816,233	81,623
• Rural Development Area	0	0
TOTAL		**1,642,597**

The residential and non-residential developments in the Rural Development Area are assumed to be within areas reliant on septic systems, thus posing no demand on the sewer system. Medford Township

[17] See: NJDEP N.J.A.C. 7:14A-23.3 Pollutant Discharge Elimination System: Technical Requirements For TWA Applications; Projected flow criteria

has entirely inadequate available capacity (0.209 MGD based on MAX3MO flow; 0.368 MGD based on annual average flow) to support the estimated build-out demand of 1.643 MGD.

Regarding anticipated development, active adult communities are under construction (over 300 units in total), and another project was approved and has treatment works approvals from NJDEP for over 600 units and 1.2 million square feet of commercial uses. The Township anticipates no need for additional sewer capacity based on local growth expectations. As such, the New Jersey Future build-out is quite different from Township expectations, and the Township should consider the extent to which local zoning may require unanticipated capacity.

Utility asset management

The Township is working toward development of a formal asset management program, building on past improvement projects. The asset management program will address the full system, including benchmarking for comparison to current integrity and other systems. Capital plans are developed looking forward five to ten years, and in general the Township finds that it needs to spend $1.5-2 million per year. Recent fiscal issues resulted in no capital projects budget for the last two years, but the Township now intend to restart its routine program. Wherever possible, capital projects on mains are coordinated with the Township's road improvement program to reduce overall costs. Emergency repair costs are typically low, approximately $50,000 to $75,000 per year for both water and sewer, except in response to major storm events such as the 2004 Rancocas Creek flood.

Residential sewer rates are charged as a flat fee per residential unit, of $141.48 per quarter. Non-residential rates are based on water demand. These rates were established a few years ago to address a situation where the earlier rates did not reflect full pricing for the system. A flat residential fee is somewhat unusual when the same utility handles both water supply and sewerage, where sewer rates can be based on off-peak (winter) demands. Medford Township recently completed a rate comparison, finding that its rates are mid-range for sewer systems in the area. The sewer system is charged for services provided by Township staff, but no revenue is exacted for use in the general Township budget.

Hammonton Target Area

There are nine NJPDES-permitted sewage treatment facilities serving Hammonton within its contiguous HUC14 subwatersheds, shown in in **Figure 6-2**, of which one is a public utility and the other eight serve individual properties. The public sewer service area in Hammonton Township is 5,928 acres. **Table 6-5** shows the sewer service area in each HUC 14 subwatershed. The total acreage in the subwatersheds is larger than the Hammonton sewer service area because there are other sewer service areas within the subwatersheds but outside of Hammonton.

Table 6-5. Sewer Service Areas in the Hammonton Target Area

HUC14	Subwatershed Name	Acres Served	Percentage of Subwatershed
02040301160110	Albertson Brook	2.99	0.05%
02040301160120	Great Swamp Branch (above Rt 206)	590.21	8.95%
02040301160130	Great Swamp Branch (below Rt 206)	1903.01	28.86%
02040301170010	Hammonton Creek (above 74d43m)	2000.17	30.34%
02040302030070	Penny Pot Stream (GEHR)	1360.54	20.64%
02040302040080	Great Egg Harbor River (GEHR) (39d32m50s to Hospitality Branch)	736.31	11.17%

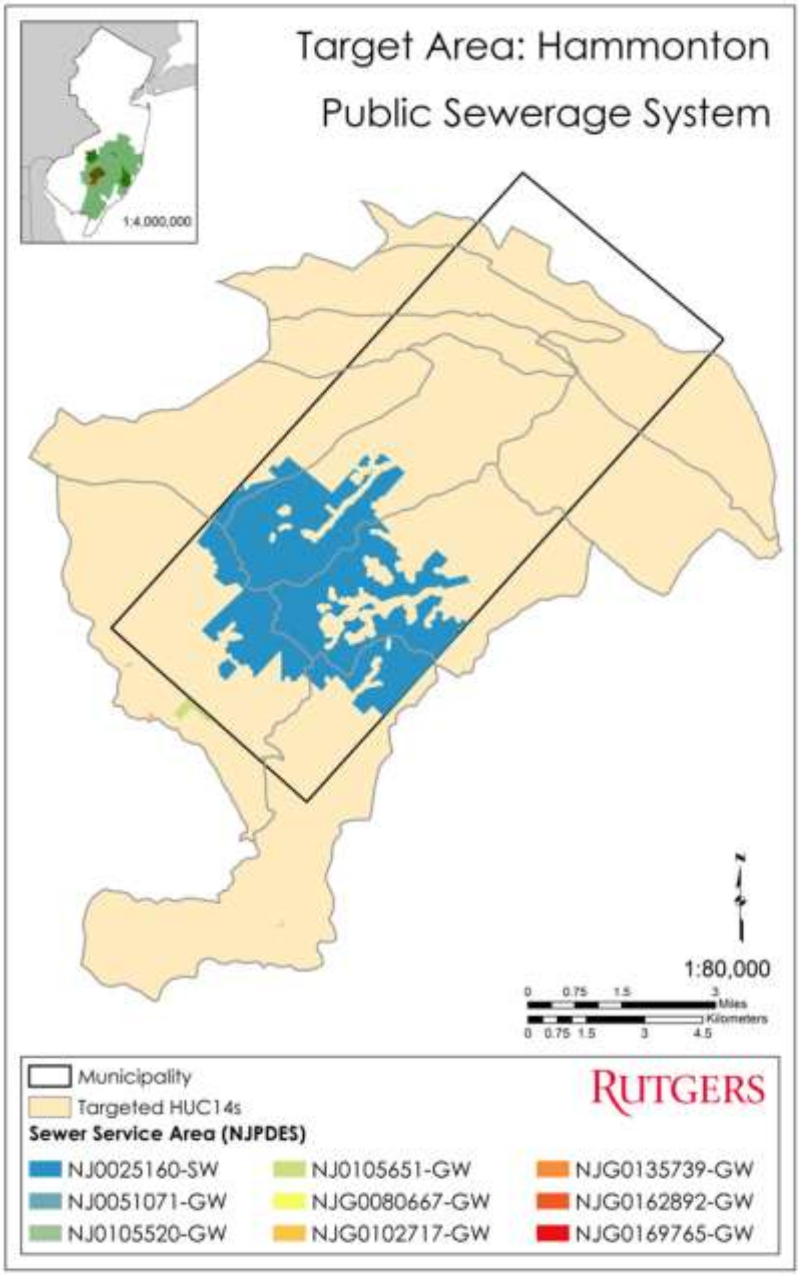


Figure 6-2. Sewer Service Areas: Hammonton Target Area

The Hammonton Water and Sewer Department operates the public sewer system, which was initially created in the 1920s to provide public utilities to the downtown area that had previously relied on on-site wells and sewage disposal (most likely cesspools). The utility service area has grown with development, but Hammonton lost significant industry flows of roughly 0.25-0.4 MGD in the last 30 years (e.g., Whitehall Labs – pharmaceuticals; Hammonton Brewery; textiles). There are no remaining major users within the service area.

The Hammonton Waste Water Treatment Plant (NJ0025160 and NJ0104990) has a permitted capacity of 1.6 million gallons per day (MGD) but a design capacity of 2.5 MGD (expanded in 1994); given the loss of industrial flows and issues with Pinelands CMP, Hammonton has not requested an increase in its permit to reflect this design capacity. The first NJPDES permit is for the surface water discharge (DSW) that

Hammonton historically operated. The second NJPDES permit is for the discharge to ground water (DGW) system that has been in testing and evaluation for the last two years, in response to Pinelands CMP requirements that Hammonton cease its discharge to Hammonton Creek. The treated effluent from the plant is pumped to a lagoon, from which discharge is through infiltration fields. Two fields are used. One 25-acre field has both surface drip irrigation and below-grade infiltration lines, while the other 25-acre field has only surface drip irrigation; the surface drip irrigation systems cannot be used when the ground is frozen. For the last year, the facility has discharged entirely to ground water to test whether the infiltration beds can handle the flow. Hammonton intends to use the recharge lagoons and drip irrigation as the routine discharge, but wants to keep the DSW permit for emergency use, such as if the infiltration beds can't handle the necessary flows due to ground water mounding during periods of high precipitation. The Town is concerned about the feasibility of handling all flows all the time through the recharge site, which from their perspective is not working entirely to specifications. Final evaluation and conclusions are expected in 2014. The Pinelands Commission staff prepared a draft report and recommendations for consideration by the Pinelands Commission at its March 2014 meeting, in response to a revised Long Term Comprehensive Plan for Treatment and Disposal of Wastewater from the Town of Hammonton, submitted on 18 February 2014. The staff report notes the Commission's expectations that the surface water discharge be permanently discontinued, and raised concerns that the drip irrigation system would not be operable during winter months when surface discharges have been most prevalent, and that the process of replacing sewer system components (for I&I reduction) would occur over a 25 year period. Commission staff recommended a conditional approval for Hammonton's planned approach, with conditions including sewer replacements within ten years, that any surface discharges be "emergency discharges" and that failure to achieve the expected results would trigger a sewer connection ban. The Commission approved this approach.

The MAX3MO flow from 2009 to 2013 is 1.661 MGD, while the annual average flow is 1.180 MGD (with 2010 flows being highest for both), but since then annual average flows to the treatment plant have declined. Correspondingly, the net available capacity for the MAX3MO flow is -0.061 MGD, and for the annual average flow is 0.42 MGD. I&I rates have varied significantly from year to year, with some years showing less in the way of I&I and other years showing larger levels, as indicated by the 0.481 MGD difference between MAX3MO and annual average flows in 2010, a significant difference. The system experiences considerable increase in short-term daily flows during rainstorms; seasonal differences in flows do exist that appear related to I&I levels. Sump pump connections to sewer system are considered a problem. The original terra cotta (vitrified clay) sewer pipes remain in many locations, but are being replaced gradually to reduce I&I; in the process, Hammonton is discovering and correcting illicit connections.

Projected demands

Based on interviews with the utility, a few areas remain where the Pinelands CMP allows for growth within the sewer service area (SSA) and these areas have not changed from prior approved Future SSAs in the wastewater management plan. Hammonton has been experiencing flat or declining demands, with little redevelopment, and anticipates this situation to continue. Demand growth is also constrained by limitations in water supply capacity (see prior section on PCWS systems).

New Jersey Future's build-out evaluation for Hammonton was used to estimate increases in system demand and whether these demands can be accommodated within the net available capacity. The results may or may not occur, as they reflect the land-based build-out development capacity at current zoning. Actual land use approvals may be lower or higher, or land acquisition for open space may remove development potential. Sewage generation is based on 75 gallons per person per day for residential development, and 0.10 gallons/day/sf for non-residential (based on office and commercial use). Average household size used is 2.822 persons, assuming on average 2-3 bedroom, single-family detached housing in the South Jersey region (Listokin et al., 2006). The build-out wastewater demands for Hammonton are as follows:

Table 6-6. Build-out Analysis: Hammonton Town		
Development Category	**Development Potential**	**Sewage Generation (gpd, rounded)**
Residential (dwelling units)	3,083	652,055
Non-Residential (square feet)	13,693,485	1,369,348
TOTAL		**2,021,403**

Hammonton's sewer system serves essentially all development within the municipality, and therefore this evaluation assumes that all future development within the Town would likewise have public sewer service. Given that Hammonton's treatment plant has a current permit of 1.6 MGD (and even with a design capacity of 2.5 MGD), net available capacity is entirely inadequate to support the build-out demand even if Hammonton could increase its permit to 2.5 MGD with the attendant difficulties of having sufficient infiltration beds for its discharge to ground water.

Utility asset management

Hammonton does not have a formal asset management program at this time but is interested. Currently, they target projects based upon operator experience with the system, and also will do line work when local road projects are implemented, to reduce the number of road openings. No major capital needs exist for the treatment plant, which was upgraded and expanded in 1994 and is subject to a strong maintenance program. Emergency repairs have an allocation of generally 2-5% of the operational budget (combining sewer and water); repairs to the collection system are not extensive. An example is a sewer line replacement on Route 54/Bellevue Ave in concert with road project, which essentially eliminated significant problems with line clogging. The Long Term Control Plan will require a more comprehensive analysis of the existing sewer lines.

Sewer rates are based on winter water demand. Major projects are funded through NJEIFP loans. The town determines what municipal costs are directly associated with the utility, and those are charged to the budget with an administrative fee, but there are no "excess revenue" exaction per se. The staff is relatively small and highly experienced (all over 45), but with no younger staff in line at this time.

Tuckerton/Little Egg Harbor Township Target Area

There are five NJPDES-permitted sewage treatment facilities serving Little Egg Harbor Township and Tuckerton Borough within their contiguous HUC 14 subwatersheds, shown in **Figure 6-3**. One is a public utility (Ocean County Utility Authority) while the other four provide service to small areas, two of which are outside of the two municipalities but within the target subwatersheds. The public sewer service area in Little Egg Harbor Township is 4,901 acres, and in Tuckerton Borough is 879 acres. **Table 6-7** shows the sewer service area in each HUC14 subwatershed. The total acreage in the subwatersheds is larger than the municipal sewer service areas because there are sewer service areas within the subwatersheds but outside of the municipalities.

Table 6-7. Sewer Service Areas in the Tuckerton/Little Egg Harbor Township Target Area			
HUC14	**Subwatershed Name**	**Acres Served**	**% Subwatershed**
02040301130060	Westecunk Creek (below GS Parkway)	275.41	5.56%
02040301140020	Mill Branch (below GW Parkway)	474.18	9.58%
02040301140030	Tuckerton Creek (below Mill Branch)	2362.06	47.72%
02040301140040	LEH Bay tribs (Westecunk Ck-Tuckerton Ck)	1367.90	27.63%
02040301200070	Ballanger Creek	470.57	9.51%

The Southern Water Pollution Control Facility of Ocean County Utilities Authority (NJ0026018) has a permitted capacity of 20 MGD. The MAX3MO flow from 2005 to 2013 (September) is 9.567 MGD, while the annual average flow is 7.875 MGD. Correspondingly, the net available capacity for the MAX3MO flow is 10.433 MGD and for the annual flow is 12.125 MGD. While significantly different, the facility as a whole has a large percentage of its total capacity (over 50%) available. Much of the service area for this treatment facility is outside of the target area, as is the treatment plant itself. No substantive effluent violations were identified through NJDEP records.

Little Egg Harbor Township and Tuckerton Borough operate the sewer collection systems from their respective municipalities that flow into to the OCUA main interceptor line to the Southern Water Pollution Control Facility. These two utilities are discussed separately.

Little Egg Harbor Township

The Little Egg Harbor Township Municipal Utilities Authority (LEHTMUA) was formed in 1972 to serve developed areas of town other than the Mystic Island area where the developer had a private water/sewer system (developed in the 1960s). In 1977, the LEHTMUA purchased the water and sewer systems from the Mystic Island developer, and also expanded its service area in response to considerable growth that occurred in the mainland area. Mystic Island is perhaps half seasonal and half year-round homes at this point. The sewer connection to OCUA occurred in the mid-1970s. At this time, the sewer collection system includes approximately 82 miles of pipes, with pumps up to the OCUA main interceptor. OCUA has several pump stations along the interceptor to its treatment plant.

Winter water demands (and therefore sewer flows) are roughly 1.2 MGD. These water demands increase to roughly 3 MGD in the summer, only part of which generates sewer flows. LEHTMUA tracks water demand against sewage flow to OCUA; there are some I&I issues, but these are not yet seen as a significant issue. Tides can introduce water through laterals. Sewer pipes in the lagoon developments are asbestos cement pipe, which are having degradation issues due to a combination of sulfides and aggressive water conditions.

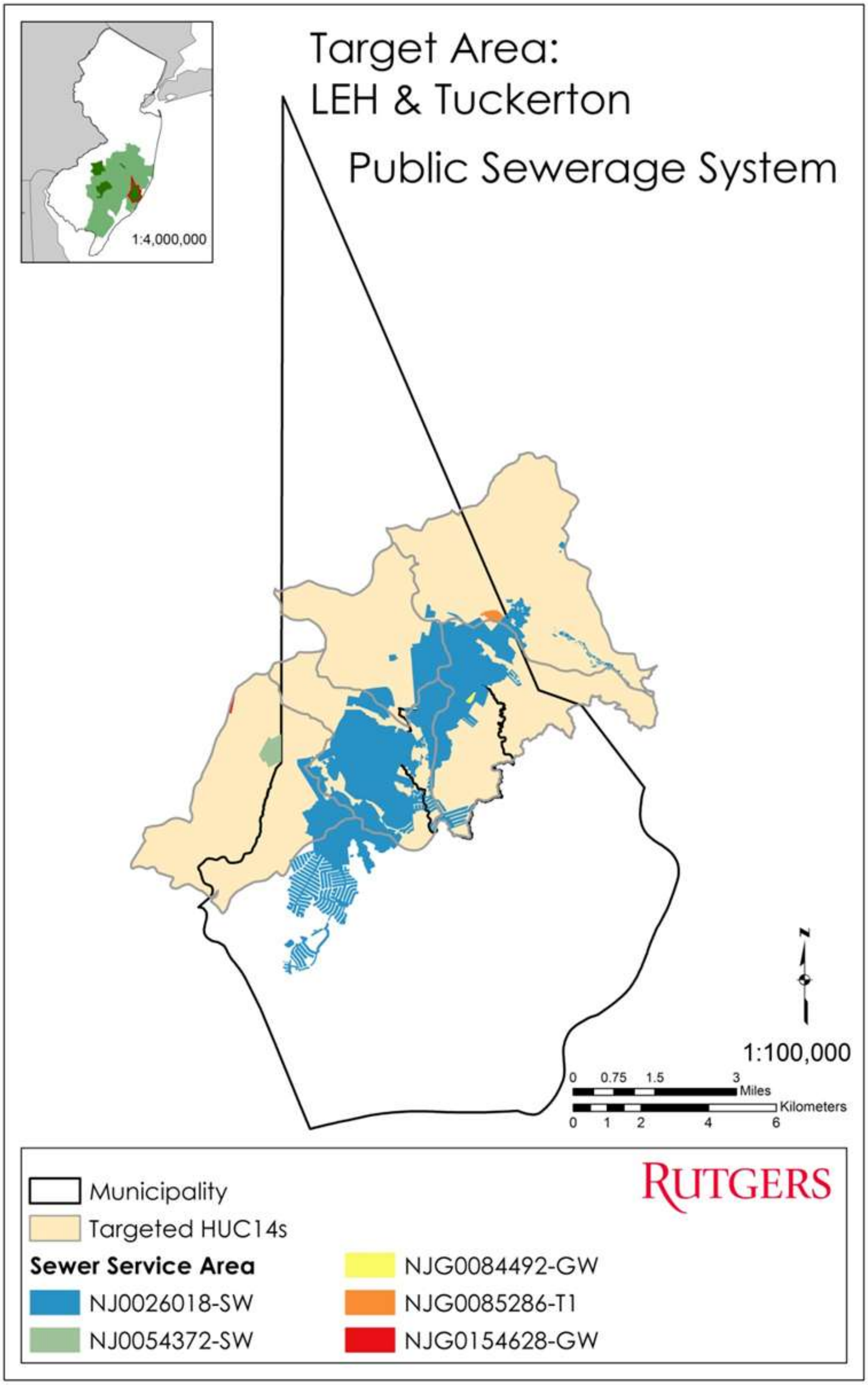


Figure 6-3. Sewer Service Areas: Little Egg Harbor/Tuckerton Target Area

Projected Demands

The Future SSA for the township has not changed from prior approved designations. The northern portion of the township is within the Pinelands Area and is largely in preserved open space. Land use in the southern portion is regulated by NJDEP under the CAFRA program. The township has a number of approved developments that haven't been built due to economic conditions, and so are locking up sewage capacity, as unbuilt projects have commitments based on peak flow requirements per NJDEP rules. According to LEHTMUA, existing development approvals of perhaps 500 units exist within the SSA, but most of remaining undeveloped lands are preserved or constrained. Perhaps one site could generate less than 500 homes but to date lacks approvals, while small subdivisions may be feasible for other lots. Demand from existing developed areas has been increasing in recent years, as seasonal housing in the lagoon developments such as Mystic Island transition to year-round housing. However, Hurricane Sandy damaged a very large number of homes in the shore areas, with unknown future impacts on flows.

New Jersey Future's build-out evaluation for Little Egg Harbor Township was used to estimate increases in system demand and whether these demands can be accommodated within the net available capacity. The results may or may not occur, as they reflect the land-based build-out development capacity at current zoning. Actual land use approvals may be lower or higher, or land acquisition for open space may remove development potential. Sewage generation is based on 75 gallons per person per day for residential development, and 0.10 gallons/day/sf for non-residential (based on office and commercial use). Average household size used is 2.822 persons, assuming on average 2-3 bedroom, single-family detached housing in the South Jersey region (Listokin et al., 2006). The build-out wastewater demands for Little Egg Harbor Township are as follows:

Table 6-8. Build-out Analysis: Little Egg Harbor Township

Development Category	**Development Potential**	**Sewage Generation (gpd, rounded)**
Residential (dwelling units)		
• Pinelands Town	13	2,750
• Pinelands Village	2	420
• Regional Growth Area	3,189	674,470
• Forest Area	13	0
• Rural Development Area	289	0
Non-Residential (square feet)		
• Pinelands Town	0	0
• Pinelands Village	0	0
• Regional Growth Area	24,174,672	2,417,470
• Forest Area	471,289	0
• Rural Development Area	0	0
TOTAL		**3,095,110**

The residential and non-residential developments in the Forest Area and Rural Development Area are assumed to be within areas reliant on individual on-site sewage disposal systems, thus posing no demand on the sewer system. Little Egg Harbor is part of the OCUA-Southern system, which has over 10 MGD in available capacity. Therefore, sewer capacity is not a constraint on build-out demand, assuming that water supply constraints were addressed. As mentioned in the **future demands** discussion for water supply, LEHTMUA conducted a build-out analysis in 2003 that yielded fewer units (2260) than the New Jersey Future estimate.

Utility asset management

LEHTMUA has a formal asset management plan and program, where all assets over $5,000 are recorded and tracked, and the utility audits include depreciation evaluation. Routine, programmed maintenance needs are identified and budgeted. Each year, the LEHTMUA updates its facility needs, in part to address information requirements regarding the self-insurance policy. Work is performed in-house where possible, and contracted otherwise. LEHTMUA and the Township have cooperated on shared services for 30 years, which helps contain costs.

The asset management process started in 1960s with the first system components, and is a routine program with funds budgeted "pay as you go" as much as possible. The MUA budgets $250,000 to 350,000 per year for emergency repairs. Anything that is not spent goes to programmed capital projects. $1.5 million was in maintenance reserves prior to Hurricane Sandy, much of which had to be reprogrammed for repairs, until the MUA is reimbursed.

I&I issues have been minimal recently, but pipes are now coming of age for replacements. All sewer replacement lines are PVC piping. LEHTMUA will be going to bid soon for a project to studying lagoon development sewer lines (e.g., video inspections) to look in more detail for damage from Sandy, such as clogging of lines. Pipeline repairs and replacements are anticipated to increase significantly in future years. There are several examples of areas with frequent repair needs that were then improved, resulting in fewer problems. Recently the LEHTMUA replaced 880 feet of sewer pipe in the lagoon development at a cost of $340,000. With any small bad area of water or sewer, the LEHTMUA looks to replace the full section.

Sewer service for residential is billed at a flat rate regardless of water demand. Commercial properties are billed for sewer service based on water demand EDUs,[18] with any water demand beyond the appropriate EDUs billed in excess. LEHTMUA conducts routine customer surveys on repair jobs, etc., and indicates that it gets positive feedback mostly. LEHTMUA will be debt free in 2 years, which provides an opening for more aggressive pipeline replacements or rehabilitation work without a need to increase rates. They currently are paying less than $1 million per year for debt service on bonds (with no bonding of major costs since 1988), and a small amount for debt service on a NJEIFP loan. LEHTMUA has 10 field and 8 office staff, most of whom are mid-career with some close to retirement, so hiring of younger staff is becoming an issue to ensure that system knowledge is retained.

Tuckerton Borough

The sewer system in Tuckerton was built by the Tuckerton Municipal Utility Authority, which was dissolved in 1990s. The earliest pump stations to local sewer plant were built in the 1960s, when the Tuckerton Beach development project needed sewers. Tuckerton closed the local treatment plant and shifted to OCUA when the interceptor was built. Population growth occurred primarily from 1960 to 2000, going from 1500 to 3500, with a small loss of population to 3300 people, from 2000 to 2010. The sewer system serves nearly all the borough using 22 miles of sewer, with an increase in demands during summer as vacation homes and visitors increase the user base. There are no major users. Roughly 130 units were disconnected from water service because of Hurricane Sandy, which will have a short-term effect on sewage flows. Tuckerton has 11 sewage pump stations to raise the sewage to a point where it can gravity-flow into OCUA interceptor. In addition, one development has direct gravity flow to the interceptor. OCUA estimates Tuckerton flow by deducting LEHTMUA flow from total metered flow, with 2011, 2012 and 2013 flows averaging 0.4112, 0.3884 and 0.3584 MGD, respectively.

[18] Equivalent Dwelling Units, based on a nominal residential water use.

Projected demands

The borough is extensively developed. According to the borough, there is minimal potential for increased service area. A couple of projects have approvals, but are on hold; one is an apartment complex for veterans, and the other is a small development. Tuckerton is outside the Pinelands Area but within the CAFRA jurisdiction of NJDEP. The Wetlands Act also limits growth potential, as part of the borough is designated as coastal wetlands. While OCUA has ample capacity for growth within its service area, Tuckerton may be constrained both by its limited available land area and by limitations on water supply capacity (see discussion in the PCWS Systems section).

New Jersey Future's build-out evaluation for Tuckerton was used to estimate increases in system demand and whether these demands can be accommodated within the net available capacity. The results may or may not occur, as they reflect the land-based build-out development capacity at current zoning. Actual land use approvals may be lower or higher, or land acquisition for open space may remove development potential. Sewage generation is based on 75 gallons per person per day for residential development, and 0.10 gallons/day/sf for non-residential (based on office and commercial use). Average household size used is 2.822 persons, assuming on average 2-3 bedroom, single-family detached housing in the South Jersey region (Listokin et al., 2006). The build-out wastewater demands for Tuckerton are as follows:

Table 6-9. Build-out Analysis: Tuckerton Borough

Development Category	**Development Potential**	**Sewage Generation (gpd, rounded)**
Residential (dwelling units)		
• Pinelands Town	891	188,447
• Regional Growth Area	8	1,692
Residential (dwelling units)		
• Pinelands Town	867,224	86,722
• Regional Growth Area	11919	1,192
TOTAL		**278,053**

Tuckerton is part of the OCUA-Southern system, which has over 10 MGD in available capacity. Therefore, sewer capacity is <u>not a constraint</u> on build-out demand, assuming that water supply constraints were addressed.

Utility asset management

The borough does not have a formal asset management program, but has been discussing the issue. However, they have been implemented a 10 year plan that focused on known infrastructure needs (e.g., metering, pumps). Implementation has been limited due to financial limitations. After Hurricane Sandy, the borough decided to evaluate the sewer and water systems, especially within the hard-hit Tuckerton Beach area, using video inspection of sewer lines. The process has begun and they hope to continue. However, recovering from Sandy has required major expenditures with limited repayments to date, stressing municipal finances and slowing potential improvements. For example, the borough had to replace most of a stretch of sewer line due to Sandy, where the pressure of the overlying water caused the line to shift significantly.

The largest concern is the Tuckerton Beach area, a lagoon development, where the original lines were asbestos cement sewers. Aggressive soils (where decaying organic material gives off sulfides) are decaying the lines, a common problem for lagoon developments around the coast. Infiltration of this water into the pipes is happening, so deterioration is occurring from both inside and out, leading in some cases to sewer collapses. All replacements are with PVC lines. The borough replaced the water, sewer and stormwater lines in three entire streets in Tuckerton Beach. Major improvements (reduced repair needs) have been seen on these three Tuckerton Beach streets, but more work needs to be done in other areas; problems in the overall area overwhelm what could be shown from the three streets regarding I&I reductions. In other places, some lines are only 20 years old, but already are a problem. In 2008, the borough had to repair four pumping stations in Tuckerton Beach that were likewise damaged by sulfides; all were changed to submersible pumps.

Tuckerton charges a flat quarterly fee for sewer ($145.09) based on an annual Equivalent Residential Unit (EDU) water demand (18,250 gallons per quarter), and then annually bills for excess use ($8.15 per 1000 gallons). Homes can have secondary water meters for outdoor use, which results in a reduced sewer bill (but not water). According to the borough, there have been no public issues on rates within last couple of years. The borough recently revised its rules and regulations to address illicit connections and such, with expectations of further modifications. However, rates may remain below sustainable levels for long-term operations and maintenance/repairs, which requires evaluation once the full extent of repairs is known. The borough merged water and sewer revenues recently into a single account, a portion of which is earmarked for repairs such as the more routine maintenance. Major emergency repairs are not in the O&M budget; rather, all major projects rely on outside grants or loans. Loans from NJEIFP have been used for the last few projects, but the borough also routinely investigates the potential for USDA Rural Development Administration grants and other non-traditional funding. The water and sewer department has five people with formal training in water and sewer systems, but many engage in cross-over work with DPW. The five are a mix of ages, as the borough was able to hire some younger staff to fill openings from retirements in last few years.

Summary

As with water supply, the municipalities vary greatly in their ability to handle additional flows associated with build-out development. Evesham Township has ample capacity between its two treatment facilities (King's Grant is not included due to its constrained service area). Medford Lakes has almost no build-out demand or available capacity, though they look to increase capacity through a major capital project to line their entire collection system. Medford Township, as with water supply, has some sewer capacity but not sufficient to meet even a large fraction of its build-out demand. Hammonton is a special situation, as it is shifting to ground water discharge that may limit its capacity regardless of the potential design capacity at its treatment plant. However, even with an increase from 1.6 to 2.5 MGD, that capacity would address less than half of the build-out demand, and water supply is also a constraint. Finally, Little Egg Harbor and Tuckerton have essentially no wastewater constraints on their build-out demand (unlike for water supply) due to their connection to Ocean County Utilities Authority.

<table>
<tr><th colspan="3">Table 6-10. Comparison of Build-out Sewer Demand to Net Available Capacity</th></tr>
<tr><th>Municipality</th><th>Additional Demand at Build-out (MGD)</th><th>Wastewater Net Available Capacity (MAX3O/Annual Average Methods) (MGD)</th></tr>
<tr><td>Evesham Township</td><td>0.54</td><td>0.828/1.090</td></tr>
<tr><td>Medford Lakes Borough</td><td>0.012</td><td>0.037/0.108</td></tr>
<tr><td>Medford Township</td><td>1.64</td><td>0.209/0.368</td></tr>
<tr><td>Hammonton Town</td><td>2.02</td><td>-0.061/0.420</td></tr>
<tr><td>Little Egg Harbor Township</td><td>3.10</td><td rowspan="2">10.4/12.125
(OCUA Southern STP)</td></tr>
<tr><td>Tuckerton Borough</td><td>0.28</td></tr>
</table>

However, a major point must be raised regarding the results posed above. Build-out may not occur for long periods, or even at all, depending on market conditions, land acquisitions for open space and farmland preservation, approvals at less than zoned maximums, etc. **Table 6-11** provides a comparison of the housing units from the build-out assessment and from population projections to the year 2040. In several municipalities the projected housing units through 2040 are far lower than the build-out conditions, with Medford Township showing the most striking difference. Conversely, the population projections for 2040 in Little Egg Harbor Township would require more housing than the build-out demand indicates is feasible under existing zoning. However, the township has a large stock of seasonal housing that has been shifting to year-round use, though Hurricane Sandy impacts may slow that trend.

Table 6-11. Comparison of New Housing: Population Projections (2040) v. Build-out Conditions

	Evesham Township	**Medford Lakes Borough**	**Medford Township**	**Hammonton Town**	**Little Egg Harbor Township**	**Tuckerton Borough**
Population						
2010	45,538	4,146	23,033	14,791	20,070	3,350
2040 (projected)	47,720	4,187	26,897	19,490	30,930	4,840
2010-2040	2,182	41	3,864	4,699	10,860	1,490
Housing Units	*774*	*15*	*1,370*	*1,666*	*3,851*	*528*
Build-out						
Build-out Units	*2,281*	*24*	*6,987*	*3,083*	*3,506*	*899*
Difference	**1,507**	**9**	**5,617**	**1,417**	**-345**	**371**
Difference (%)	**66.1%**	**37.5%**	**80.4%**	**46.0%**	**-9.8%**	**41.3%**

The sewer demands generated by the build-out analysis cannot be directly compared to the sewer demands generated by increased population, as not all of the new population through 2040 will be in areas served by sewer systems, and population projections do not provide information about additional demands from business, commerce and industrial needs. However, a rough sense of the shift in sewer demands can be inferred by the percent difference in new housing units. Using that general guide, the only municipality that would have a significant shift in situation is Medford Township, which has entirely inadequate sewage capacity to handle build-out demands, but may have adequate capacity to address demands through 2040.

Of the municipalities, only Little Egg Harbor Township MUA has indicated that it has a comprehensive, formal system for asset management. The other municipalities are investing in their assets based on local knowledge. However, all six acknowledge that advancing age of water systems will increase necessary capital investment costs, which will strain resources at current rates. Little Egg Harbor Township MUA is in a favorable position, as the payoff of existing debt will allow for capital expenditures using the revenue stream that currently goes to debt payments, but conversely the MUA maintains only a small reserve fund for capital costs. Evesham Township MUA has maintained a somewhat larger reserve account for capital costs that will help, though not solve, the revenue stresses it faces.

Chapter 7: Stormwater Management Systems

Stormwater systems are closely aligned with denser development. Rural areas will generally have minimal constructed stormwater management except where road drainage is needed near bridges or to avoid ponding in confined locations. The purposes of stormwater systems have evolved over time; applicable standards have evolved to match the purposes. Stormwater systems initially were created to move stormwater from developed areas to surface waters as rapidly as possible, to avoid street flooding and such. In much of New Jersey, older development typically has this kind of stormwater management. Controls on discharge rates followed, to avoid stream scouring, and the use of detention basins for this purpose provided some treatment benefits as well, especially for litter and sediment. New Jersey now has a fairly extensive approach, including updated regulations applicable to new development to better control the rate and velocity of stormwater discharges to protect streams, control sediment and solids discharges, and maintain ground water recharge. The Pinelands Comprehensive Management Plan includes specific stormwater management requirements as well, as noted previously.

Even so, treatment is primarily focused on sediment; other contaminants such as bacteria may not be addressed well, and redevelopment may not require implementation of water quality controls. Further, most stormwater conveyance systems lack the design capacity to address flows from the largest storms, even under current rules, potentially causing street flooding at the neighborhood level. If the frequency and intensity of storms increase with climate change, as anticipated, the existing standards will no longer achieve even their intended purpose. Poor maintenance can cause similar system failures.

Stormwater infrastructure is rarely subject to modification once built, unless as part of a redevelopment project or in response to system failure such as street flooding. As noted in Van Abs (2013), because the rules have changed only a few times in the last thirty years, the date of construction provides a useful surrogate for the sophistication and standards to which most stormwater infrastructure was built. Each age cohort will have its dominant tendencies, and therefore will have different needs in terms of retrofit, rehabilitation, replacement and upgrades. In many areas (e.g., most suburban residential developments), stormwater system improvement through redevelopment is highly unlikely, and so it would be valuable to improve our understanding of priorities for action to improve water quality, ground water recharge and watershed integrity. This indicator results in an assessment of development prior to and after adoption of two distinct sets of standards: (a) the Residential Site Improvement Standards and the NJDEP coastal and flood hazard area rules in 1996; and (b) the 2004 NJDEP Stormwater Rules (NJAC 7:8) for previously developed areas (only partial application of the rules required) and for greenfield development (full application of the rules required).

Overview of Municipal Stormwater Systems

Each of the municipal stormwater systems within the target area is managed by the municipality through a Department of Public Works or Highways, though in Hammonton the water and sewer department manages some capital projects for the Department of Highways, in Little Egg Harbor Township the municipality and MUA have shared services agreements, and in Tuckerton the water and sewer department routinely contributes labor to the DPW for activities such as snow removal. However, in all cases the financial responsibility for municipal stormwater systems remains with the municipal government.

Development that occurred prior to 1986 is more likely to use older technology such as direct discharge to streams (with or without energy dissipation techniques). The original Residential Site Improvement Standards (RSIS) were adopted in 1997, triggering new requirements for the rate of discharge from stormwater basins. NJDEP developed the approach used in the RSIS and adopted the same provisions into its coastal and flood hazard area rules.

NJDEP's most recent major changes to the stormwater management rules were adopted in 2004, which incorporated the discharge rate standards from the various 1996 regulations and also required no loss in ground water recharge from development actions. The coastal and flood hazard area rules were revised at the same time. The Pinelands Commission also adopted stormwater management requirements that incorporate the NJDEP rules but also prohibit direct discharges to wetlands or transition areas, require more recharge than the NJDEP rules, increase the requirement for TSS removal to 90% (from 80% in the NJDEP rules) and require oil/grease removal where the proposed land use would involve discharge of such substances.

The implementation periods for these various rules can be compared to available land use/land cover data from 1986, 1995, 2002 and 2007. Residential development between 1995 and 2002 would in part have been subject to RSIS, and some municipalities adopted the same standards for other types of development; beyond 2002 a greater portion of residential development would have been subject to RSIS. Development shown as of 2002 would not have been subject to the NJDEP rules at NJAC 7:8 (but may have been subject to the coastal and flood hazard area rules), while some but perhaps a minority of development that occurred between 2002 and 2007 would have been regulated under the 2004 requirements. This timeline is not perfect. For example, in some cases, detention basins are located within the 1986 developed area, indicating that peak discharge rate controls were required for those developments. Complicating this timeline are the various permit extension acts, which allowed development with lapsing or lapsed development permits to extend the life of all applicable permits, rather than getting new approvals that would have triggered application of the new stormwater rules. It was not feasible to conduct a detailed analysis of stormwater management requirements applicable to individual developments.

Table 7-1 and **Figures 7-1** through **7-3** provide an evaluation of developed areas (moderate/high density residential) and impervious surfaces (greater than or equal to 10 percent) likely associated with stormwater management infrastructure in each year for which Land Use/Land Cover information is available – 1986, 1995, 2002, 2007. Stormwater basins were available from the same years except 1986, and the maps show basins as of 2007. In all cases, and especially in the Little Egg Harbor/Tuckerton target area, the area associated with stormwater infrastructure increased significantly over 21 years, while the acreage of stormwater basins increased far more quickly over only 12 years.

Table 7-1. Developed Areas Associated with Stormwater Infrastructure				
	Developed Areas (acres)	**Increase from 1986 to 2007 (%)**	**Stormwater Basins (acres)**	**Increase from 1995 to 2007 (%)**
Evesham/Medford Target Area				
2007	9392.92	44%	256.16	299%
2002	9269.53		201.28	
1995	8769.11		58.29	
1986	6882.99		N/A	
Hammonton Target Area				
2007	2314.39	36%	60.59	399%
2002	2217.65		51.56	
1995	2298.10		15.18	
1986	1601.89		N/A	
Little Egg Harbor/Tuckerton Target Area				
2007	3383.46	57%	64.25	1980%
2002	3071.27		26.76	
1995	2636.19		3.09	
1986	2153.81		N/A	

In the Evesham/Medford target area, most development within the Pinelands Area existed as of 1986, and most subsequent development occurred in the northern areas. Development in Hammonton after 1986 was mostly along Route 30 and the periphery of the town center area. Most of the development after 1986 in the Little Egg Harbor/Tuckerton area was southwest of Tuckerton and along the Route 9 corridor. In all three areas, the stormwater basins in existence as of 2007 are generally associated with newer development.

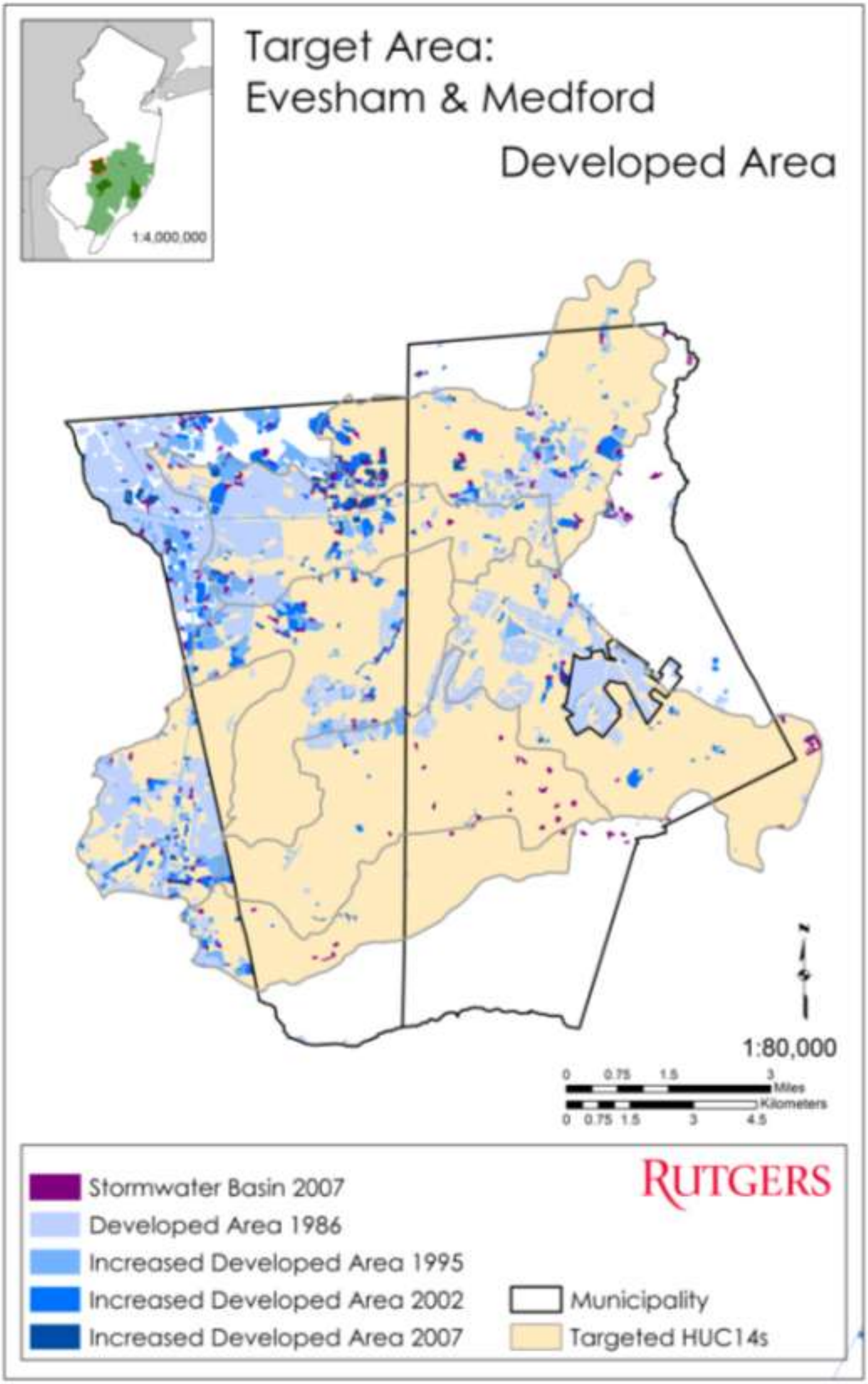


Figure 7-1. Developed Areas: Evesham/Medford Target Area

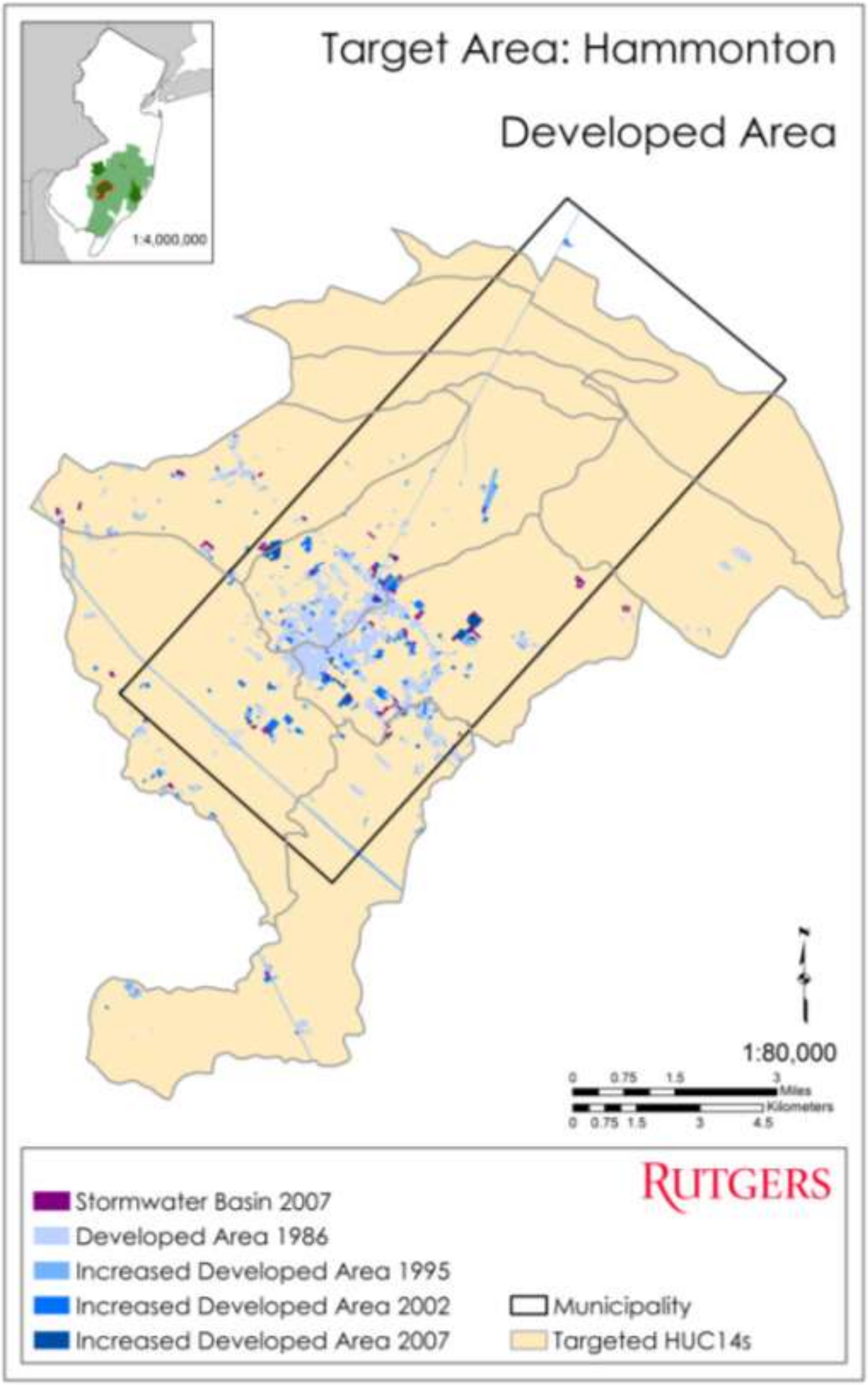


Figure 7-2. Developed Areas: Hammonton Target Area

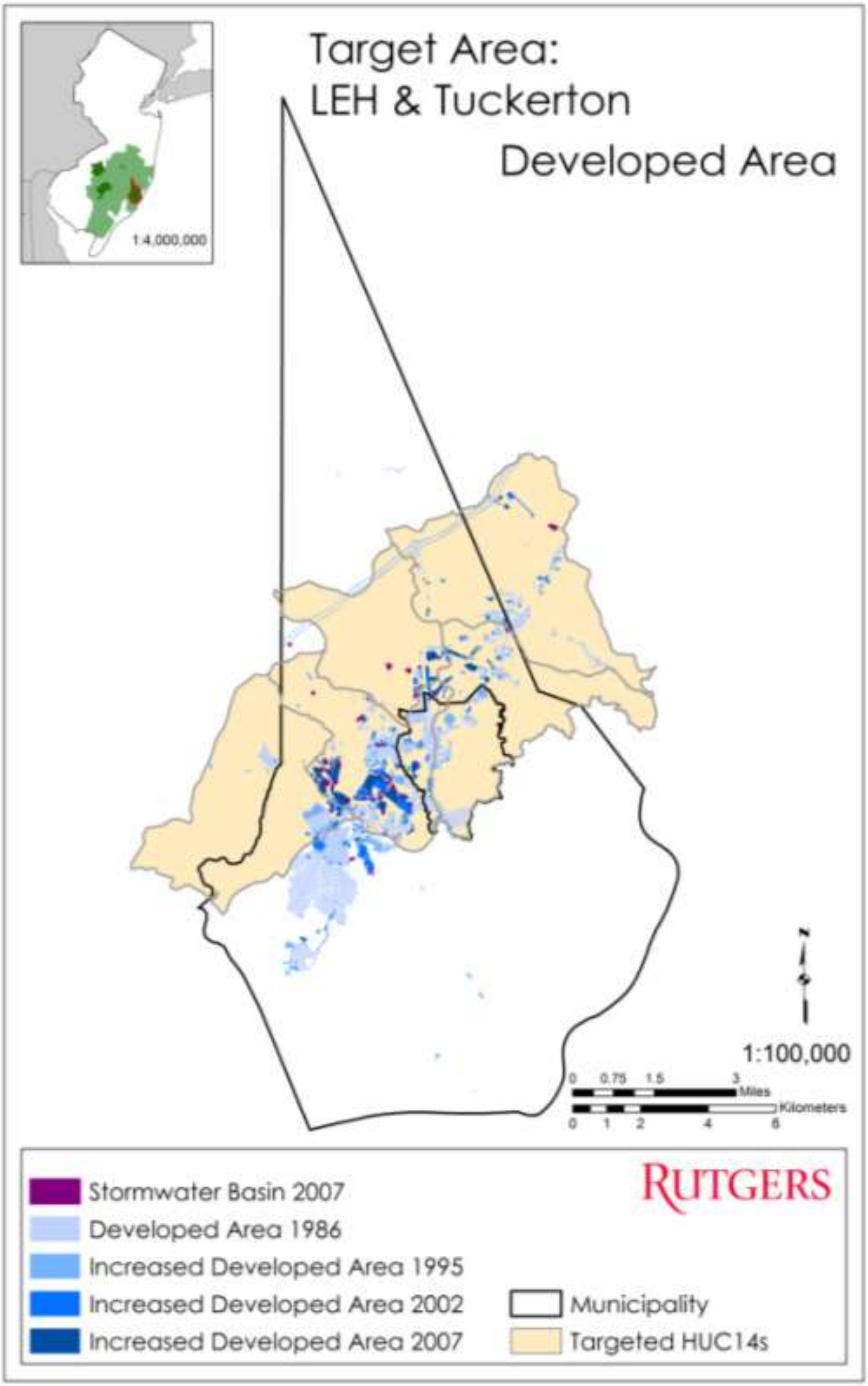


Figure 7-3. Developed Areas: Little Egg Harbor/Tuckerton Target Area

Chapter 8: Watershed and Natural Resource Protection Systems

This chapter addresses regulatory systems and protection mechanisms of the Pinelands Comprehensive Management Plan and NJPDES rules that are applicable to land development, land uses and water utility services within the target areas, and identifies approaches for regulatory modifications by the Pinelands Commission or NJDEP that could be applicable to the target areas. The mechanisms are provided in a tabular form for ease of use. Details may be found in the rules and plans themselves, as referenced. This study is focused on regulations adopted by the two agencies and does not include an evaluation of whether municipal ordinances (e.g., zoning, subdivision, environmental) or utility operations are more stringent than the Pinelands CMP or NJDEP regulations. Open space and farmland preservation plans and acquisition efforts are complementary to these programs. The federal, state, county and local government levels all have been actively engaged in land acquisition and preservation, as have a wide variety of land trust organizations. The existing preserved lands for each target area are identified in **Chapter 2**.

State Agency Regulations

The Pinelands CMP and NJDEP rules interweave considerably, with one either deferring to the other or building upon the other, but they also have distinct provisions and different approaches. A major similarity is that most (but not all) applicable regulations are applied to specific development projects and do not assess how the impacts of existing development may interact with the effects of new projects. However, some rules are specifically applicable to the broader municipal or regional planning process and affect site development primarily within the context of the resulting plans. The following table provides an overview of pertinent rules, recognizing that the complete provisions are generally more complex.

Table 8-1. Pinelands Commission and NJDEP Rules Relevant to Development Activities in the Pinelands Area and Pinelands National Reserve			
Mechanism	**Pinelands CMP**	**Relevant NJDEP Regulations**	**Major Distinctions**
Development Density (R= Residential; C=Commercial/ Retail; I-Industrial)	**NJAC 7:50-5.11-5.35** Densities are determined by Pinelands Management Area (PMA): • **Preservation Area District**: R & C infill (7:50-68(a)4; meet nitrate dilution model target of 2 mg/L regardless of sewage treatment method; 1 acre minimum); "cultural housing" (3.2 acres) • **Forest Areas**: R 28 acres/DU; C must meet 7:50-68(a)4 or 1 ac min • **Agricultural Production Areas**: R for farm-related (10 ac/DU), non-farm (40 ac/DU); farm-related C proximate to existing C only, and must meet 7:50-68(a)4 or 1 ac min • **Special Agricultural Production Areas**: R for farm-related only (40 ac/DU); C only for expansion of existing buildings, must meet 7:50-68(a)4 or 1 ac min • **Rural Development Areas**: R 5 ac/DU; roadside C only, must meet 7:50-68(a)4 or 1 ac min • **Pinelands Villages and Pinelands Towns**: In both, non-sewered R at 1 ac/DU; in Towns, sewered R at 2-4 DU/ac. C & I permitted. Village delineations must limit inclusion of constrained lands, agricultural land and forests, by affected PMA. • **Regional Growth Areas**: C & I permitted. R as follows plus PDC (50% additional), based on the developable area:	**WQMP Rules, NJAC 7:15**[19] • **Sewer Service Areas**: Existing SSA must be mapped (5.16). Future SSA must be compatible with zoning but "consistent with the intent and programs of the Pinelands Protection Act" and the Pinelands National Reserve (5.18). SSAs must exclude environmentally sensitive areas aggregating to 25 or more acres (wetlands, riparian zones, T&E wildlife habitat, Natural Heritage Priority Sites), low density coastal planning areas, (5.24). Large-scale delineations are rebuttable by site-specific data. • **SSA Relationship to Sewage Treatment Plant Capacity**: Demands at build-out must be met by existing or planned (5.18) STPs. • **Septic System Density**: New septic system density in non-SSAs must have achieve average 2 mg/L on HUC11 basis for available lands (5.25) • **Plan Compatibility**: WMP must be compatible with NJ Statewide Water Supply Plan, regional water supply plans, TMDLs (5.25) **ISSDS (Septic System) rules (NJAC 7:9A)** • **Pinelands**: Approval by Pinelands Commission required, or lack of jurisdiction. • **50-Unit subdivision or development**: Requires treatment works approval based on nitrate	CMP combines nitrate targets (based on septic systems density) and minimum lot sizes, by PMA. NJDEP regulates SSA extent by excluding environmentally sensitive areas and limiting SSAs to match available or planned capacity; septic system density is regulated outside of the SSA. Both agencies use a 2 mg/L threshold, except that the 5-Unit rule uses the GWQS antidegradation outside the Pinelands Area. In the coastal zone, NJDEP regulates allowable impervious surface by development. For both agencies, the density of existing development is not factored into the analyses.

[19] State law delayed implementation of the full Water Quality Management Rules (NJAC 7:15) until January 2016. Issues of treatment plant capacity and septic system density are among the deferred components. Sewer Service Areas are being approved by NJDEP in the interim, and full WMPs may be approved at any time. In the Pinelands Region, these SSAs and WMPs must be in conformance with the Pinelands CMP.

Table 8-1. Pinelands Commission and NJDEP Rules Relevant to Development Activities in the Pinelands Area and Pinelands National Reserve			
Mechanism	**Pinelands CMP**	**Relevant NJDEP Regulations**	**Major Distinctions**
	• Evesham Twp: 2 DU/ac • Little Egg Harbor Twp: 3.5 DU/ac • Medford Twp: 1 DU/ac • Medford Lakes Boro: 3 DU/ac • **Military and Federal Installation Areas**: Based on facility needs. • **Parkway Overlay District**: Road and associated service infrastructure. • **Wetlands**: Allocated 20% of upland density, but not to be developed. • **Cluster Development**: permitted with constraints related to septic system dependence, use of non-developed areas, etc. • **Public Service Infrastructure**: Allowed in Preservation Area District, Forest Area, Agricultural Production Area, and Special Agricultural Production Area only as required to serve relevant PMA.	dilution model of NJDEP or Pinelands, as appropriate (3.9) to achieve GWQS requirements. **Coastal Zone Management Rules (7:7E)** • **Pinelands National Reserve**: Pinelands Commission serves as a reviewing agency through MOA with NJDEP • **Impervious cover limits**: Based on the relevant CAFRA Planning Area from Environmentally Sensitive and Rural Planning at 3%, to 5% for Suburban Planning outside a SSA, to 30% for Suburban Planning within a SSA. Villages, Hamlets and Towns have higher limits (5B.4).	
Wetlands (Fresh and Tidal Waters)	**NJAC 7:50-6.1-6.13** • **Coastal wetlands**: as delineated by NJDEP. • **Freshwater wetlands**: delineated for each site. Includes all open waters (lakes, ponds, streams and rivers) • Development of wetlands and transition area (300 ft buffer) prohibited generally; forestry and agriculture for native species and berries allowed. • Transition area may be reduced with finding of no significant adverse impact to wetlands • Linear infrastructure development may be permitted if no alternative and no substantial impairment	• **Coastal wetlands**: as delineated by NJDEP, N.J.A.C. 7:7-2.2. Strict development controls. No buffer established by Wetlands Act of 1970, but in areas regulated through the Coastal Zone Management Rules, a buffer of 300 ft is established (NJAC 7:7E-3.28) with disturbance prohibited unless no alternative and no significant adverse impact including through use of mitigation. • **Freshwater wetlands**: delineated for each site, NJAC 7:7A-1.13. Strict development controls. Transition areas (buffers) of 150 ft and 75 ft based on SWQS classification and presence of T&E species.	The CMP and coastal zone rules for wetlands are compatible. CMP freshwater wetlands buffers are greater than those of NJDEP under the FWPA. Regulation is per application, with no assessment of prior or aggregate impacts.

Table 8-1. Pinelands Commission and NJDEP Rules Relevant to Development Activities in the Pinelands Area and Pinelands National Reserve			
Mechanism	**Pinelands CMP**	**Relevant NJDEP Regulations**	**Major Distinctions**
	• Water dependent recreational facilities allowed if no significant adverse impact		
Vegetation, Fish & Wildlife (including threatened or endangered species)	**NJAC 7:50-6.21-6.27** • Minimize disruption of native vegetation by any permitted use • Avoid irreversible adverse impacts on survival of local populations of endangered species plants designated by NJDEP (N.J.A.C 7:5C-5.1) plus CMP-listed species. **NJAC 7:50-6.31-6.34** • Avoid irreversible adverse impacts on habitats critical to the survival of any local populations of T&E animal species designated by NJDEP (N.J.S.A. 23:2A) • Avoid harm to habitats essential to nesting, resting, breeding and feeding of significant populations of fish and wildlife in the Pinelands.	**Coastal Zone Management Rules (7:7E)** • **Vegetative Cover**: Retain based on the relevant CAFRA Planning Area from 70% of forested area for areas outside a SSA, to 35% for Suburban Planning within a SSA, and equal or lower limits for Villages, Hamlets and Towns (5B.5). • **T&E species**: Delineate T&E wildlife and plant species habitats with buffers. Development prohibited unless proof of no adverse primary or secondary impact. (3.38) **WQMP Rules, NJAC 7:15** – see also Development Density	NJDEP coastal rules are more specific than CM regarding vegetation retention, especially forests. CMP and coastal rules compatible on T&E species protection.
Forestry	**NJAC 7:50-6.41-6.48** • Permit required for commercial forestry, with forest management plan; protection of endangered plant species required per the Vegetation Standards. • Not applicable to operations under NJ Forest Stewardship Program. • Native forest types must be maintained or restored.	**Coastal Zone Management Rules (7:7E) –** see also Vegetation	CMP more specific on forestry practices than coastal rules, which focus on the vegetation rather than the practice of forestry.

Table 8-1. Pinelands Commission and NJDEP Rules Relevant to Development Activities in the Pinelands Area and Pinelands National Reserve			
Mechanism	**Pinelands CMP**	**Relevant NJDEP Regulations**	**Major Distinctions**
Agriculture	**NJAC 7:50-6.51-6.53** • Best practices of NJDA, USDA and NJAES required • **Agricultural Production Areas and Special Agricultural Production Area**: Resource Conservation Plan required		CMP addresses; coastal rules do not.
Resource Extraction (Mining)	**NJAC 7:50-6.61-6.69** • **Preservation Area District, Agricultural Production Area, Special Agricultural Production Area**: New operations prohibited. • **Forest Area**: Nonconforming use. • **Other**: May receive permits for phased mining if special resources avoided, and phased restoration plan approved.	**Coastal Zone Management Rules (7:7E)** • Mining for specified materials is conditionally acceptable. Must minimize disturbance of wetlands and other wildlife habitats, have a post-mining restoration plan.	CMP more limiting for specific PMAs, but otherwise compatible with coastal rules.
Waste Management	**NJAC 7:50-6.71-6.73** • **Facilities**: Limited to handling Pinelands wastes (special exception for Cape May Landfill) except for recyclables, sewage sludge, etc.; no hazardous waste facilities;		CMP focuses on facilities, which are addressed by NJDEP waste management rules (not covered here).
Wastewater Discharges	**NJAC 7:50-6.81-6.84-85** • No direct wastewater discharges to surface waters, except where no practicable alternative, no increase in approved capacity, and 2 mg/L Nitrate-N at point of discharge. • New or expanded discharges to ground water must not exceed 2 mg/L Nitrate-N at property boundary or surface water based on dilution model. Applies to treatment facilities or to aggregate septic system load of development. • Exception to 2 mg/L if to serve existing development and improve water quality to	**WQMP Rules, 7:15** • **Antidegradation analysis**: Provide, for any proposed new or expanded treatment facility (5.25) • **TMDLs**: NJPDES permits must incorporate wasteload allocations (7:15-6 generally, and NJAC 7:14A). **NJDEP rules (7:14A)** • Permits for new, expanded and existing discharges must ensure compliance with SWQS, GWQS and WQMP rules including TMDLs. Permits for existing and expanding	CMP proscribes surface water discharges. CMP otherwise compatible with NJDEP rules, with cross-references.

Table 8-1. Pinelands Commission and NJDEP Rules Relevant to Development Activities in the Pinelands Area and Pinelands National Reserve			
Mechanism	**Pinelands CMP**	**Relevant NJDEP Regulations**	**Major Distinctions**
	maximum extent cost-effective and less than 5 mg/L • Alternative on-site systems allowed in certain circumstances. • On-site systems must be inspected and cleaned every 3 years	facilities may include compliance schedules for construction.	
Stormwater Management	**NJAC 7:50-6.84(a)6** • Meet NJAC 7:8 and: • No direct discharge to wetlands or transition areas; • Major developments must infiltrate the increase in volume from the 10-year, 24-hour storm; • Stormwater from high pollutant loading areas (HPLA) must be segregated and treated to 90% TSS removal and removal of oil/grease	**FHACA rules (NJAC 7:13)** • **Flood fringe**: Stormwater facilities restricted except under specific circumstances and designs. **Stormwater rules (NJAC 7:8)** • **Post- v. pre-construction**: Recharge must equal; discharge volumes reduced based on storm size (for two, 10 and 100-year storm events the reductions are to 50, 75 and 80 percent); water quality design storm used for 80% TSS controls.	CMP more restrictive recharge standards, otherwise compatible with NJDEP rules regarding C-1 streams.
Water Allocation and Transfers	**NJAC 7:50-6.86** • Minimize interbasin transport. Development in sewered areas must use water-conserving devices • Wells with new or increased Water Allocations must minimize impact on wetlands and incorporate water conservation. • No new diversions (other than ag) of greater than 100,000 gpd from Kirkwood-Cohansey unless no viable alternative or no adverse environmental impact to Pinelands	**Water Allocation rules (NJAC 7:19)** • **Safe or dependable yield (6.3)**: Must be established; declining ground water level presumptive evidence that dependable yield is lower. • **Allocations (2.2)**: Must be less than the natural replenishment or safe yield or threaten to exhaust such waters or to render them unfit for use; must also be equitable to other water users and not cause or increase saltwater intrusion; and that diversions are outside of wetlands and transition areas. • **Critical Areas**: Limits imposed on aquifer withdrawals in Water Supply Critical Area #2, the Camden regional area (8.5)	CMP and NJDEP rules generally compatible, with additional CMP restriction on use of Kirkwood-Cohansey aquifer.

Table 8-1. Pinelands Commission and NJDEP Rules Relevant to Development Activities in the Pinelands Area and Pinelands National Reserve			
Mechanism	**Pinelands CMP**	**Relevant NJDEP Regulations**	**Major Distinctions**
		Coastal Zone Management Rules (7:7E) • **Ground and Surface Water Use**: Developments may not themselves or with other uses are within PCWS capacity and will not cause adverse consequences.	
Scenic Resources	**NJAC 7:50-6.111** • New utility distribution lines to areas not previously served shall be underground (except agricultural).	**Coastal Zone Management Rules (7:7E)** – site design criteria apply	CMP and coastal rules have different focus; distribution lines (what should not be seen) v. site design for new development (what will be seen along scenic corridors.
Flood Plains and Riparian Areas/ Stream Buffers	Incorporated into regulations for Wetlands and Wetlands Transition Areas	**FHACA rules (NJAC 7:13)** • **Flood hazard areas and floodway**: delineated (3.1-3.6), area varies by stream reach. Construction in channels (10.1) and floodways (10.3) strictly limited. Flood fringe area construction (10.4) limits loss of flood storage capacity on-site to 20%, with compensation for net 0% either on-site or upstream in same HUC14 subwatershed. T&E species must be protected. • **Riparian zones**: delineated by SWQS classification. 300 ft for C-1 waters and tributaries in same HUC14; 150 ft for FW2-TP (and all tribs); TM (and upstream for 1 mile), waters through T&E habitat, and waters through acid-producing soils; 50 ft otherwise (4.1). Disturbance of vegetation must be avoided, minimized, and within limits by disturbance purpose for necessary and	CMP has larger buffers than NJDEP rules for FWPA and much of non-Pinelands streams; NJDEP more detailed on flood plain development in riparian areas.

Table 8-1. Pinelands Commission and NJDEP Rules Relevant to Development Activities in the Pinelands Area and Pinelands National Reserve			
Mechanism	**Pinelands CMP**	**Relevant NJDEP Regulations**	**Major Distinctions**
		unavoidable purposes (10.2). No significant adverse impacts allowed on various resources (11.1). • **Acid-producing soils**: Disturbance must be avoided, minimized and mitigated to maximum extent (10.7). **WQMP Rules, NJAC 7:15**: See Development Density **Stormwater Management Rules, NJAC 7:8** • **Buffer**: for C-1 waters, a 300-foot special water resource protection area, with allowance for 150 feet if already disturbed and functional value maintained. **Coastal Management Rules, NJAC 7:7E** • **Freshwater and Tidal Wetlands and buffers**: See also Wetlands (Fresh and Tidal Waters) • **Riparian Zones** (3.26). Delineated as for FHACA rules (NJAC 7:13-4.1). Regulated as Special Areas, through cross-reference to FHACA rules but additional T&E species protection. **Freshwater Wetlands Protection Act rules (N.J.A.C. 7:7A)** • Transition areas of 50-foot and 150-foot along freshwater wetlands and other features	
Adopted TMDLs and subwatershed management plans	None	TMDLs are implemented through a combination of NJPDES point source discharge permits, NJPDES municipal stormwater management permits, and NJDEP requirements under NJAC 7:8 for stormwater management (see also Water Quality chapter).	CMP does not address remedial efforts for water quality.

Chapter 9: Evaluation and Conclusions

The previous chapters of this report focused on land use and land cover conditions (Chapter 2), water quality (Chapter 3), water availability (Chapter 4) and water utilities (Chapters 5 through 7). Chapter 8 provided an overview of existing regulatory and planning programs of the NJDEP and Pinelands Commission that relate to the integrity of water resources and watersheds. This final chapter provides an overview of the results by target area and then provides thoughts regarding how NJDEP and Pinelands Commission efforts could use the results to modify their approaches.

Overview of Target Areas

The three target areas were deliberately selected to allow the evaluation of very different development prototypes: suburban expansion, town center, and bayshore community. Each has distinct issues and effects on water resources. The following sections provide a brief synopsis of the major issues identified in the report for each target area. The results are by necessity qualitative, as no system exists for providing a numerical output on water resources integrity from the large variety of considerations.

Evesham/Medford Target Area

This target area has the broadest expanse of low to moderate density suburban development, which has had widespread effects on stream corridors (12% to 43% loss of riparian areas) and moderate to high levels of impervious surface (7% to 21%) and losses of flood prone areas (7% to 31%). The target area subwatersheds also have seen significant losses of recharge areas. However, some of these losses occurred prior to 1986. Most of the affected subwatersheds have limited preserved open space, but two have greater than 40% preserved lands.

Every subwatershed violates the Surface Water Quality Standards for pH, an important Pinelands criterion, but the Rancocas Creek and Barton Run subwatersheds have additional violations that are very typical of areas affected by land development – nutrients including total phosphorus (TP) and nitrates, bacteria (E. coli and fecal coliform) and dissolved oxygen (DO). The only available ground water quality data available from a formal monitoring well are from Medford Township, again showing some impacts from land uses, such as elevated sodium, chloride and nitrates. Both Evesham Township and Medford Township have limited levels of VOCs in private wells, which correlate well with the relatively large number of Known Contaminated Sites in several of the target area subwatersheds. Consumptive and depletive water uses have very limited impacts on wetlands, and indeed the overall watershed achieves a net increase in water flows because imported waters are discharged within the watershed – the opposite of the norm.

The three municipalities have very different conditions regarding water utilities. Evesham Township has sufficient capacity to address water demands and sewage generation from both projected 2040 population and the much larger demands of full build-out. Medford Township lacks sufficient water and sewer capacity for full build-out of the municipality but may have sufficient capacity for projected 2040 population. Medford Lakes expects little growth and has sufficient sewer capacity; it has no public water supply utility.

The net result is that this target area shows water stresses from the existing development and can anticipate additional stresses in the two townships at anticipated growth rates, with far greater stresses if build-out levels were attained up to available water utility capacity.

Table 9-1. Compilation of Target Area Indicators of Watershed Integrity
(Values in bold indicate significant increases during period of analysis)

Indicator	02040202060010 Kettle Run (above Centennial Lake)	02040202060020 Lake Pine / Centennial Lake & tribs	02040202060030 Haynes Creek (below Lake Pine)	02040202060040 Barton Run (above Kettle Run Road)	02040202060050 Barton Run (below Kettle Run Road)	02040202060080 Rancocas Ck SW Branch (above Medford br)	02040202060100 Rancocas Ck SW Branch (below Medford br)
Urbanization 1986-2007 (Acres)	390	**825**	282	442	563	**770**	**838**
Impervious Surfaces (%)	7	7	13	18	9	**21**	10
Riparian Area (% Urban)	12.2	23.3	43.2	31.6	**18.4**	**31.3**	**14.9**
Flood Prone Area (% Urban)	7	21	31	8	**16**	**26**	9
Forest % Losses (1986-2007)	**12**	**13**	2	**10**	3	-1	1
Wetlands % Losses (1986-2007)	0	1	1	1	**4**	**6**	**6**
PGWRA (% Urban)	**8**	**13**	**8**	**13**	1	**19**	**12**
Protected Areas (%)	57.5	17.6	10.0	40.8	0	26.2	0.4
Surface Water Quality – selected streams						Elevated pH, nitrates, ammonia	
Surface Water – 303d Listings	pH	pH	pH	pH, DO	pH, DO, TP	pH, TP, E coli, Nitrates	pH, DO, TP, FC
Known Contaminated Sites	3	4	27	14	0	36	0
Wetlands impacts from water withdrawals (>=5cm)	<5%	<5%	<5%	<5%	<5%	<5%	<5%

Hammonton Target Area

Hammonton has seen relatively little change in land use and land cover since 1986, with almost no change in its limited losses of riparian area, flood prone areas, wetlands, and forests; only recharge areas have shown significant losses since 1986, mostly likely reflecting their status as well-drained lands that would seem desirable for development. Some of the subwatersheds have significant surface water quality problems, however, even in Sleeper Branch which is mostly preserved lands. Hammonton has a high degree of agricultural lands, which would influence surface water quality regarding nutrients such as nitrates. The only subwatershed with a phosphorus issue is Hammonton Creek, to which the local sewage treatment plant discharges. Two ground water monitoring wells are located in Hammonton, and both retain low pH levels but one has a very high nitrate level. Private wells show considerable evidence of elevated nitrate levels as well. Agriculture is the likely source, given that the entire area has been sewered since the 1920s. Hammonton also shows one of the higher incidences of VOC contamination in private wells.

Water availability is a major issue in Hammonton, both for aquatic ecosystems and for the municipality. Wetlands impacts from water withdrawals are the highest of the three target areas, a result of using the water table aquifer for part of Hammonton's supplies. Six subwatersheds show very high impacts on wetlands. In addition, existing demands are exceeding both the firm capacity and the water allocation permit for the local water supply system, leaving no capacity for growth unless water conservation is exceptionally successful. The sewage treatment plant also is constrained in its ability to serve increased demands, due to limitations of the new ground water discharge system.

The net result is that the Hammonton target area shows high levels of stress in many subwatersheds due to a combination of existing lands uses and utility constraints, but this situation has not changed a great deal since 1986. Both the demands of build-out and of 2040 population projections cannot be met under existing utility conditions, and if they were, the additional environmental impacts (e.g., drawdown of the water levels in wetlands) could be severe.

Table 9-2. Compilation of Target Area Indicators of Watershed Integrity
(Values in bold indicate significant increases during period of analysis)

Indicator	02040301160110 Albertson Brook	02040301160120 Great Swamp Branch (above Rt 206)	02040301160130 Great Swamp Branch (below Rt 206)	02040301160150 Nescochague Creek	02040301160160 Gun Branch	02040301160170 Sleeper Branch	02040301170010 Hammonton Creek (above 74d43m)	02040302030070 Penny Pot Stream (GEHR)	02040302040080 GEHR (39d32m50s to Hospitality Branch)
Urbanization 1986-2007 (Acres)	7	298	343	18	18	1	**504**	385	314
Impervious Surfaces (%)	0	4	8	1	0	0	7	4	3
Riparian Area (% Urban)	0.8	9.3	7.3	1.3	0.6	0.1	10.9	7.1	5.1
Flood Prone Area (% Urban)	1	7	2	1	1	0	6	8	4
Forest % Losses (1986-2007)	1	1	-1	1	1	1	4	0	3
Wetlands % Losses (1986-2007)	0	0	0	0	0	1	0	0	0
PGWRA (% Urban)	1.4	11.5	**19.4**	0.6	0.3	0.1	**29.9**	**18.0**	**14.0**
Protected Areas (%)	75.4	12.1	41.0	56.9	87.4	99.0	22.5	16.2	13.9
Surface Water Quality – selected streams				pH, NO3			pH, TP, NO3		
Surface Water – 303d Listings	pH	NO3, pH	NO3, pH, E. coli	none	pH	pH, Hg, DDT	pH, TP, TSS, Hg NO3, e. coli	pH	pH, Cu
Known Contaminated Sites	0	27	0	0	1	0	19	8	6
Wetlands impacts from water withdrawals (>=5cm) (%)	22.1	55.4	73.5	83.9	35.8	2.3	73.4	61.4	12.5

Little Egg Harbor/Tuckerton Target Area

While Tuckerton has seen relatively little development since 1986, Little Egg Harbor Township has grown considerably. Tuckerton Creek has had the most changes in land use and land cover, with increases in urbanization and impervious surface, and in urban lands with riparian areas and flood prone areas. Forest and recharge area losses are also significant, though wetlands losses have been minimal. Only one subwatershed (Mill Creek) has a high level of preserved lands at 73%, while Ballanger Creek is next highest at 28%.

Surface water quality issues are clearly evident in some subwatersheds, particularly Tuckerton Creek, but not in others. The one ground water quality monitoring well in Little Egg Harbor Township shows minor water quality impacts, with a low pH but a slightly elevated level of sodium and chloride. Private well data indicated very limited contamination problems with nitrates.

Three subwatersheds show significant impacts of existing water withdrawals on wetlands, and increased water demands would likely affect the same areas. Both Little Egg Harbor Township and Tuckerton have water allocation and firm capacity constraints relative to their build-out potential, though Tuckerton may have sufficient capacity to meet 2040 population projects. Little Egg Harbor Township, on the other hand, is the only municipality in this report that has a housing demand by 2040 that is greater than its build-out capacity, most likely due to expectations that seasonal housing will convert to year-round housing. However, the result is that water supply availability could be a major issue for the Township. Both municipalities are in the sewer service area of Ocean County Utility Authority's Southern Treatment Plant, which has ample capacity. Both municipalities have significant coastal lagoon development, which raises major issues regarding both recovery from Hurricane Sandy damages and the potential for future flood and storm damages.

The net result is that Tuckerton Creek especially, and other subwatersheds to a lesser extent, are showing stresses from existing development. Future development will be constrained by water supply availability and the environmental impacts of more water withdrawals, and by the impacts of sea level rise and storms on densely developed areas along the bay shore.

Table 9-3. Compilation of Target Area Indicators of Watershed Integrity
(Values in bold indicate significant increases during period of analysis)

Indicator	**02040301130060 Westecunk Creek (below GS Parkway)**	**02040301140020 Mill Branch (below GS Parkway)**	**02040301140030 Tuckerton Creek (below Mill Branch)**	**02040301140040 LEH Bay tribs (Westecunk Ck-Tuckerton Ck)**	**02040301200070 Ballanger Creek**
Urbanization 1986-2007 (Acres)	333	268	**817**	336	202
Impervious Surfaces (%)	3	2	**14**	6	2
Riparian Area (% Urban)	10.1	1.6	**32.5**	**25.9**	5.8
Flood Prone Area (% Urban)	6	1	**39**	7	2
Forest % Losses (1986-2007)	7	**10**	**19**	7	3
Wetlands % Losses (1986-2007)	1	0	1	2	**4**
PGWRA (% Urban)	13.0	9.6	**37.1**	**29.3**	**10.3**
Protected Areas (%)	16.8	73.4	10.7	0.0	28.1
Surface Water – 303d Listings	Total coliform	pH, Hg, PCBs	TP, Total Coliform, Hg	None	None
Known Contaminated Sites	2	0	6	1	1
Wetlands impacts from water withdrawals (>=5cm) (%)	25.8	47.2	19.1	N/A	N/A

Considerations for State Agency Action

The environmental impacts of existing land uses can be mitigated in some cases through regulatory programs, such as those of NJDEP mandating the management of municipal stormwater systems to reduce litter and sediments from entering the systems, and to reduce stream scour from stormwater discharges to streams. Existing impacts may also be mitigated by voluntary programs such as state and federal agricultural assistance programs. However, impacts of future development are addressed primarily through regulatory requirements for planning, site design and construction methods. The Pinelands CMP and NJDEP provide a management matrix regarding development intensity, site design and construction, within which municipal ordinances regulate development type and further site design issues of local concern.

The regulations of the two state agencies are compatible or mutually supportive for many issues and resources. However, some areas exist where improved management will require consideration of additional rules and planning:

- **Water Allocations**: The recently completed USGS study and Pinelands Commission ecological reports provide a basis for major modifications to water allocation policy in the Kirkwood-Cohansey Aquifer area, both in the Pinelands Area and outside of it. The Pinelands Commission and NJDEP now have the opportunity to provide much more detailed environmental objectives and regulatory approaches that can provide subwatershed-specific water availability based on ecologically-derived thresholds. As part of this process, all requests for additional water allocation should require proofs that existing water uses are efficient and that the PCWS systems have minimized water losses prior to granting the allocation. Finally, more consideration can be given to water cycling, where water that is used comes back into the hydrologic system of the Pinelands in an environmentally beneficial manner, rather than being discharged outside of the region or to the ocean.
- **Water Quality Standards**: The Pinelands CMP uses a single parameter (Nitrate-N) as its focus for water quality in both ground and surface waters; NJDEP's water quality standards incorporate that standard while also providing for broader nondegradation policies. However, NJDEP's nondegradation policies for the Pinelands include specific wording that defers to the Pinelands CMP regarding development activities.[20] While this approach reduces the potential for a Pinelands-approved development to be rejected by NJDEP and vice versa, it raises a substantive issue regarding how firm the nondegradation policy truly is. Individual developments that meet the nitrate standard and perhaps have minimal other impacts may still, in aggregate, diminish water quality in larger ways including pH modifications related to lawn maintenance, salts from winter road maintenance and point-of-use water treatment systems, etc. Consideration should be given to establishing a firmer relationship between growth expectations of the Pinelands CMP and nondegradation policies of the NJDEP water quality standards.
- **Environmental Enhancement through Redevelopment**: The Pinelands CMP primarily addresses the impacts of new development. Somewhat like NJDEP's current stormwater rules for urban redevelopment, the CMP does not effectively seek to increase and harness redevelopment activities to improve watershed integrity. The CMP could establish rules that either are prescriptive or that provide incentives toward improved stormwater management (especially in areas where development predates any of the more modern stormwater requirements of the 1990s and later), naturalized vegetative cover where lawns currently exist, and improved wastewater management.
- **Watershed Plans for Boundary Waters**: A number of subwatersheds in both the Evesham/Medford and Little Egg Harbor/Tuckerton target areas overlap between the Pinelands Area and non-Pinelands areas. In the first area, applicable regulations are those of NJDEP's normal statewide rules, while the Coastal Zone Management rules apply in the second area. Consideration should be given to collaborative watershed management plans, including regional stormwater management plans and TMDLs, where the statewide NJDEP rules would be supplemented by watershed-specific objectives and standards. Such plans are already allowed

[20] For example, the Ground Water Quality Standards at NJAC 7:9C state: "The Department shall not approve any discharge or any other activity which would result in the degradation of natural quality, unless in conformance with the Pinelands CMP." (emphasis added)

by NJDEP rules (see NJAC 7:15-3 and -6). The ongoing work for the Barnegat Bay watersheds is an example of such planning efforts, and also is a very good example of why these cross-boundary, multi-governmental watersheds are so difficult to address.

- **Watershed Plans for Pinelands Waters**: Both NJDEP rules and the Pinelands CMP focus on new development. However, watersheds in the Pinelands are showing clear signs of stress, such as high levels of wetlands stress due to water withdrawals. Unlike the Highlands Regional Master Plan, for example, the CMP does not have a specific mechanism for identifying, assessing and remedying these existing problems, or of future problems, through means other than development controls. Mitigation of environmental impacts from existing development could also help offset the inevitable impacts of even well-designed, appropriate development that occurs in the future. These plans can also help focus land preservation priorities, which can be implemented through fee simple acquisition, easement acquisition, contiguous and non-contiguous cluster development and the Pinelands Development Credit program.
- **Prime Ground Water Recharge Areas**: Neither the Pinelands CMP nor NJDEP rules provide for any direct protection of these areas, which by their nature tend to be well-drained lands that will be targeted for development. Protection of net recharge volume is established policy for both agencies, but this objective is much more easily achieved if the best recharge areas are protected. Consideration can be given to mapping prime recharge areas (however defined) and establishing protective policies. Unlike protection of resources such as wetlands, it may not be appropriate to protect all prime recharge areas, but rather to ensure that a major portion remain in natural vegetation through such techniques as cluster development.
- **Incorporate Existing Development Impacts**: Building on the point of improved watershed plans, each watershed has a unique pattern of land uses, and yet environmental regulations apply the same standards to new development regardless of the ambient conditions – good or bad. A more nuanced approach would have a baseline regulatory process, with more restrictive standards applied where necessary to offset existing damages. For example, a subwatershed with few septic systems would use the baseline rule at 2 mg/L Nitrate-N. Development with septic systems within a subwatershed that already has a large number of existing septic systems would be more constrained. As an incentive for better watershed plans, the more restrictive conditions could then be offset by off-site activities (by the developer or by other entities entirely) that will achieve the same environmental result. As an example, the State of Maine has long had policies to protect its lakes, where a development that seeks to add phosphorus loads (beyond a stringent level) must implement off-site controls that provide a net phosphorus load meeting the policies.
- **Septic System Densities**: NJDEP should consider application of its septic system density thresholds at the subwatershed level, rather than the watershed level, at least for Pinelands region streams, to allow for a finer-grained evaluation of water quality impacts.
- **Sewer Service Areas**: Low density development on sewers results in a low revenue per linear mile for all utilities, driving up the cost of system operations. Policies and regulations can establish clear differentiation between the appropriate densities for septic systems and for sewer areas. Sewer service areas should be at development densities that will be cost-effective both at the development stage and for lifetime operation and maintenance of the water supply, sewer, stormwater and road infrastructure.
- **High Density Septic System Areas**: As with other regions of the state, the Pinelands include older, densely developed areas that have relied on septic systems (or even cesspools) due to the

lack of public sewer systems. Development at that density would not be approved now without sewer service, and yet these areas exist and have ongoing impacts on water quality and (if combined with shallow domestic wells) public health. The Pinelands CMP could include a planning component to both identify such areas and address means to provide tailored wastewater solutions that will significantly increase environmental quality, reduce public health threats, and yet ensure that secondary growth is constrained to appropriate areas only.

- **Development Using Septic Systems**: Many jurisdictions including the Pinelands Commission use a nitrate dilution model to estimate the sustainable level of development using septic systems, which discharge pollutants to ground water after limited treatment (primarily for control of pathogens, solids and suspended solids). Nitrates are normally used as the metric, as an indicator for other pollutants that are not as conservative in water, and as a pollutant of concern in and of itself. Water quality thresholds are established as a modeling target. In most cases, mass balance dilution models are used, but in some cases more sophisticated models provide a better sense of pollutant fate and transport. However, three significant issues arise from the use of dilution models, as in the Pinelands CMP. First, nitrate is a useful indicator but there are other pollutants of concern (such as endocrine-like compounds) that may be of greater concern. The relationship of nitrates to these other pollutants is not clear, and so the use of nitrates as the sole indicator may or may not be sufficient protective. Second, mass dilution models assume that the septic system plumes do, in fact, dilute. Instead, they tend to travel in discrete plumes until encountering a discharge point. In some cases, the assumptions behind dilution models work well, but in others they may not. Third, other sources of nitrates from residential development may not be fully reflected in the modeling assumptions. These issues have not been explored in sufficient detail.
- **Stormwater Management**: Existing stormwater rules are far superior to what existed in 1979, but several major issues exist that need to be addressed. First, the stormwater rules address maintenance of ground water recharge, certain pollutant controls (primarily suspended solids) and stormwater discharge rates. However, they do not address total stormwater volume discharged or other pollutants that can be discharged to or from stormwater systems. Development tends to cause increased volumes, which have effects on streams even if peak stream flows do not increase. Pollutants such as pH modifiers, nitrates, pathogens and oils are of concern in the Pinelands due to potential effects on endemic plants and animals. The Pinelands region could benefit from specialized stormwater requirements that specifically address Pinelands conditions. Additional emphasis can be placed on shifting stormwater systems to methods that mimic the natural hydrograph, including green infrastructure approaches.
- **Riparian Areas Protection:** Many programs that seek to protect wetlands or surface waters do so by establishing a buffer around the resource within which development is prevented or limited. Most of these buffers are fixed distances, such the provisions of N.J.A.C. 7:8 establishing 300 foot buffers on both sides of Category One streams. However, in terms of ecosystem functions wetlands and open waters do not have fixed boundaries, but rather blend with the adjacent ecosystems and land areas. This issue has been explored by some programs, including the Raritan Basin Watershed Management Project and the Highlands Council. NJDEP, the Pinelands Commission and research ecologists could review the functionality of alternative buffer approaches for protection of wetlands and open waters.
- **Water Utility Asset Creation and Management**: The Pinelands Commission does not have extensive regulatory authority regarding management of existing assets but can play a

significant role with NJDEP in ensuring that new utility assets that are created through development (Pinelands Commission and NJDEP) or through utility management (NJDEP) are associated with cost-effective development densities, will have the lowest possible life cycle cost, and minimize the potential for future water losses and I&I. NJDEP can play a significant role by increasing its focus on regulation of utility asset integrity, by establishing metrics, norms, reporting requirements and management requirements for utility assets.

- **Growth Area Plans**: Again based on the project-specific nature of existing rules, there is a benefit to facilitating community and environmental planning for Pinelands Towns, Villages and Regional Growth Areas that explicitly address aggregate environmental metrics, impacts and objectives. The plans would then be used as part of the watershed planning process, but more directly would increase the ability of each area to better design its future. The Pinelands Commission can incorporate an economic improvement mission in a way that actually enhances environmental quality and community viability.

County and Municipal Actions

Counties in the Pinelands region can play important roles in many of the concepts discussed in the prior section, especially regarding targeted land preservation (open space and farmland), wastewater management planning for sewer service areas and septic system densities, and coordination of watershed management plans, especially for those watersheds that overlap the Pinelands Area boundaries. Counties have little regulatory authority, but do have the ability to bring expertise to collaborative planning and policy development.

Municipalities in the Pinelands Area are subject to the requirements of the Pinelands CMP regarding new development and redevelopment. However, they can engage in significant efforts to improve the environmental and economic impacts of existing development, set the stage for redevelopment that will actually improve environmental conditions, emphasize the proper management of water utility assets, and facilitate innovative development approaches that provide greater benefits than currently required by NJDEP or the Pinelands Commission, such as enhanced use of green infrastructure for stormwater management. A critical role for municipalities is to ensure the effective combination of economic improvement with environmental improvement, resulting in more sustainable communities.

Issues for Further Evaluation

A synthesis report of this nature must address a large number of environmental issues, impacts and considerations, but no single rubric exists for evaluating the net impact of these factors. This study is not the first to acknowledge this methodological constraint and will not be the last. Important to the process is recognition that environmental impacts are in part objective (e.g., X change in water quality or Y loss of wetlands acres) and in part subjective (i.e., is a change in water quality more or less important than a loss of wetland acres). Further, a study that relies on existing information may be (and in this case at times was) unable to definitively ascribe certain impacts to specific policies. Much of the existing development in the Pinelands region predates the Pinelands Protection Act of 1979 and also most NJDEP regulations. The available data on environmental impacts do not always line up well with the periods under study. Based on the report findings, several suggestions can be proposed as next steps in developing a more rigorous assessment of cause and effect, both past and future:

- **Water Availability**: A fundamental question facing the Pinelands region is how much water can be abstracted without damaging the ecosystems that make this area unique. The region now has more technical tools available, but policies must be generated that make sense from an ecological perspective and are feasible to implement. As noted in Chapter 4, there are several different metrics that can be used, and it may be that more than one metric should be used given the various environmental impacts that can occur (e.g., wetlands impacts, pond impacts, stream flow impacts, saltwater intrusion). Given the extremely strong relationship of the ecosystems to water resources, further evaluation of effective metrics, thresholds and implementation approaches may be the most critical recommendation for further work.

- **Ground Water Quality**: In the surficial aquifers, the primary difference between ground water and surface water is time, and so attention to ground water quality is critically important to the question of surface water quality. Ground water quality data are available from the monitoring well network over decades of time. Perhaps more importantly, water quality data may be available from public water supply wells. The land areas that affect the water quality of these wells can be defined, and the development intensity of these areas can be tracked using a combination of aerial photography and other data. The relationship between land uses and water quality impacts can then be described in a more rigorous manner than was feasible in this study.
- **Watershed Impact Analysis**: This study focused on three target areas and all of the associated subwatersheds. Another study approach would be to identify a small number of subwatersheds with different land use patterns, each of which has a very high data density that would allow the tracking of water quality, water flow, land cover change and other factors over time and in relationship to varying regulatory approaches during the study period. The result could be used to help predict impacts of future development activities in the target subwatershed (which would be tracked using a continuing monitoring network) and to help set policies that would apply to all subwatersheds.
- **Multi-parameter Management**: Regardless of how important water is to the Pinelands, it is not the only important factor. Management of the various key issues will be neither effective nor cost-effective if each is addressed in isolation. The question is how to meld all the major issues within a multi-parameter approach that allows for the weighing of multiple positive and negative impacts from any specific action, and to plan for the future in a manner that optimizes benefits and minimizes costs and losses. A major problem encountered in any effort of this nature is that benefits and costs may be quantitative or qualitative, antagonistic or synergistic, related or unrelated. Conceptual systems do exist for addressing this methodological mess, but they require extensive involvement of committed parties that are willing to engage in interest-based discussions and negotiations, rather than statement of fixed positions. However, even partial success in the development of a more comprehensive analytical approach would be valuable, as it would help address the question: How do we know what the future will look like if we take specific actions?

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Appendix A - Selection of Population and Employment Projections

Projections - Sources

New Jersey Future considered several possible sources for population and employment projections, including the New Jersey Department of Labor, the State Plan Impact Assessment, and New Jersey's three Metropolitan Planning Organizations (MPOs). But some of these sources have limitations that make them unsuitable for our needs. The New Jersey Department of Labor[21] only produces projections at the county level, whereas we need municipal-level projections. The State Plan Impact Assessment,[22] released in May 2010 (a date that precedes the availability of data from the 2010 Census), does include municipal-level population forecasts, but they only extend to 2028, which is not sufficiently far enough in the future for our needs.

Metropolitan Planning Organizations (MPOs) are a good source for population and employment projections because these organizations are required to prepare projections when developing their long-range transportation plans. Each of our three clusters of Pinelands case-study municipalities is actually located in the jurisdiction of a different one of New Jersey's three MPOs: Medford, Medford Lakes, and Evesham are in the Delaware Valley Regional Planning Commission (DVRPC) region;[23] Hammonton is in the South Jersey Transportation Planning Organization (SJTPO) region;[24] and Tuckerton and Little Egg Harbor Township are actually in the jurisdiction of the North Jersey Transportation Planning Authority (NJTPA),[25] which extends to the extreme southern tip of Ocean County. It is thus necessary to consult three different sets of population and employment projections in assembling projections for our Pinelands municipalities. Fortunately, as the MPOs all conform to the same Federal requirements, all three have produced projections at the municipal level out to 2040.

Population Growth

New Jersey Future reviewed all three sets of MPO population projections at both the county level and the municipal level. This review included every municipality in the state, not just those in the Pinelands region, as a way of assessing the reliability of the projections overall. Among considerations were whether the projections are generally consistent with past population trends, to see if anything looked out of the ordinary, and expectations for new growth in municipalities with little or no developable land remaining, as possibly reflecting a growing move toward more redevelopment. A limited supply of developable land should probably no longer be viewed as precluding substantial future growth. The rise of redevelopment all over the state, and not just in the big urban centers, has resulted in large numbers of building permits being issued in all kinds of mostly built-out municipalities, as New Jersey Future has documented.[26] For each municipality, New Jersey Future assembled:

- Decennial Census population history from 1970 through 2010
- 2040 population projections (from respective MPO)
- The decade in which the municipality experienced its maximum population influx

[21] http://lwd.dol.state.nj.us/labor/lpa/dmograph/lfproj/lfproj_index.html
[22] www.state.nj.us/state/planning/publications/185-dfplan_ia-methods.pdf
[23] www.dvrpc.org/reports/ADR018.pdf
[24] http://sjtpo.org/RTP.html
[25] www.njtpa.org/Planning/Plan-Update-to-2040/Plan2040Draft_for_Comment_Appendices.aspx
[26] www.njfuture.org/research-publications/research-reports/built-out-but-still-growing/

- Percent built-out (i.e. percent of developable land that has actually been developed) in 1986, 1995, 2002, and 2007
- Population changes 1986-95, 1995-2002, and 2002-07
- Total certificates of occupancy (COs) issued, 2003 through 2012
- Net activity density in 2007 – population plus employment divided by developed land area
- Urbanized acres in 2007

Using the number of urbanized acres from 2007 and the population and employment projections for 2040, New Jersey Future computed an upper bound on each municipality's projected 2040 net activity density. It is an upper bound because it assumes no new urbanized acres – i.e., it assumes that all new development will be redevelopment on already-urbanized land. If any new land were urbanized (which is likely in any place that isn't currently close to build-out), that would increase the denominator of the fraction and hence reduce the 2040 net activity density. Estimating 2040 net activity density using 2007 urbanized acres thus represents the most extreme scenario for the increase in net activity density (the case in which all new growth occurs on already-developed land), so if this upper bound does not look unreasonable, then the 2040 projections on which it is based are probably not unreasonable either.

There are 72 municipalities whose populations are projected to grow by more than one-third from 2010 to 2040. In 33 of them, this represents a slowdown compared to the previous 30 years (1980 to 2010). Most of the municipalities in this group are outer suburban townships that were less than 2/3 of the way built-out as of 2007 (in terms of developable land area), so their continued but slowing growth, probably still mostly on newly-developed land and with some densification, seems likely. The remainder of this group of 33 are places that were more than 2/3 of the way built-out as of 2007 but continued to issue COs at a healthy rate over the last 10 years, including in some cases where the build-out percentage hardly changed from 1995 to 2007, indicating that redevelopment is likely already underway in these places.

The other 39 municipalities projected to grow by more than a third are projected to grow at rates faster than the rates at which they grew between 1980 and 2010. About half of them (19 municipalities) were already at least 75% built-out as of 2007. Most of this group of 19 experienced their growth spurts in the 1960s or earlier, and the ones with more recent growth spurts (like Jersey City and New Brunswick) were actually second-wind growth spurts due to redevelopment. Yet most of this group also issued non-negligible numbers of COs over the last 10 years, pointing to redevelopment already being underway. The small handful of exceptions - places that did not issue many COs recently but are nonetheless projected to experience a new spate of growth – are older boroughs that are near the Pinelands or Highlands and thus are perhaps anticipated to serve as centers, absorbing some of the new growth that might otherwise have gone into those protected areas. In short, nothing on this list raises any obvious red flags.

The other 20 municipalities whose growth rates are expected to accelerate (vs. 1980-2010) but that were not substantially built-out by 2007 are mainly exurban townships in Sussex, Warren, Ocean, Gloucester and Salem counties, places where the full force of the outward growth wave was just beginning to hit as of 2010. Accelerating status-quo growth in these places would not be unexpected. The small handful of exceptions are, again, older but not fully built-out towns (e.g., Alpha, Andover, or Buena boroughs) that are likely to serve as centers for absorbing some Pinelands or Highlands growth. Again, no obvious red flags are identified.

At the municipal level, therefore, the 2040 population projections from the three New Jersey MPOs appear to be reasonable, reflecting both past trends and a new movement toward more redevelopment.

The same two competing trends are visible at the county level. Among New Jersey's 21 counties, there are eight whose growth rates between 2010 and 2040 are projected to be greater than their growth rates for the previous 30-year period, 1980 to 2010. Three of them -- Cumberland, Salem, and Sussex -- can generally be classified as "status quo" counties. They represent the next outward ring of growth, the next step away from Philadelphia (in the case of the first two) or New York (in the case of Sussex) beyond the suburban counties that grew the fastest over the previous 30 years. And many of the fastest-growing counties from 1980 to 2010 will continue to be among the fastest-growing from 2010 to 2040, particularly Ocean, Gloucester, Middlesex, Atlantic, and Warren. Suburban sprawl may be diminishing somewhat, but it certainly has not yet been reduced to a historical artifact. Some of the maturing suburban counties will see their growth rates taper off substantially, however, namely Hunterdon, Somerset, Monmouth, Morris, and Burlington, all of which were among the faster-growing half of the state from 1980 to 2010 but are projected to see their growth rates cut in half for the next 30-year period.

The other counties whose growth rates for 2010-2040 are expected to outstrip their 1980-2010 growth rates are what we may call "redevelopment" counties -- counties with little developable land remaining, which experienced their main population growth spurts many decades ago, and which have seen their populations stagnate in recent decades. This group consists of Bergen, Passaic, Hudson, Union and Essex counties, essentially the urban core of counties around New York. In these counties, new growth is almost by definition going to be accommodated through reuse of already-developed land. The same trend toward redevelopment can be seen at the municipal level in other less-developed counties, in places like Atlantic City, Egg Harbor City, Hammonton, Bordentown, Burlington city, Mount Holly, most of Camden County (including the city of Camden), Glassboro, Woodbury, Lambertville, Princeton, Trenton, Metuchen, New Brunswick, Asbury Park, Long Branch, Red Bank, Morristown, Netcong, Lakehurst, Tuckerton, Salem, Somerville, Hackettstown, and Phillipsburg -- older cities and boroughs that saw little to no growth during the great wave of suburbanization that began in the 1950s but that are now projected to begin growing again over the next 30 years, as demographic shifts and economic recentralization spark a return to older centers. All of these already-built municipalities are projected to grow faster from 2010 to 2040 than they did from 1980 to 2010.

Overall, the population growth pattern anticipated by all three sets of MPO forecasts can be described as a combination of 1) continued but attenuated growth at the outer edges of New Jersey's two major metropolitan areas (New York and Philadelphia) and 2) a new focus on redevelopment, the accommodation of new growth in built-out areas via infill, densification, and the reuse of previously-developed lands. This can be seen in our Pinelands case-study municipalities in the fact that older, compactly-built municipalities of Hammonton, Medford Lakes and Tuckerton are all projected to grow faster from 2010 to 2040 than they did from 1980 to 2010, while growth is expected to slow down in the more suburban townships of Medford, Evesham, and Little Egg Harbor.

One caveat that needs to be attached to population growth is that all three MPOs' population growth projections were prepared before Hurricane Sandy struck the Jersey Shore in late 2012. (The storm affected municipalities in all three MPO jurisdictions.) Growth projections that pre-date Sandy may now be unrealistic for Shore towns that sustained heavy damage, potentially due to existing residents' inability or unwillingness to rebuild in place and also to future residents' reluctance to move into harm's way. Sandy's long-term effects on population growth at the Shore depend on many competing factors and will likely take years to play out. This uncertainty directly affects two of our Pinelands case-study municipalities -- Tuckerton and Little Egg Harbor Township. As of October 2013, just under 2,000 damage claims had been filed in Little Egg Harbor Township, but because the filing process was so problematic, local officials believe the true number of damaged units could be more than double that number – nearly half the housing units in the entire township, in fact (a recent article quotes township officials as pegging the suspected number at 5,000 units[27]). Similarly, 220 claims were filed in Tuckerton but officials believe the true number could be much higher. At this point we don't know in which direction and by what magnitude the after-effects of Sandy will cause population growth to diverge from what the NJTPA projects; all we can do is be aware that growth patterns at the Shore are likely to change, and to be on the lookout for signs of what the "new normal" is going to look like.

Employment Growth

All three MPOs also produce employment projections at the municipal level out to 2040. It is not possible to compare these projections to past trends as thoroughly as with population statistics because historical annual employment data are only available at the municipal level back to 1997, and county-level employment data are only available from the New Jersey Department of Labor website back as far as 1993. Also, the Department of Labor only produces projections at the county level, and only out to 2020. So Department of Labor data are not particularly useful as an independent check on the trends produced from the MPO data.

It should be noted that the baseline 2010 employment numbers used by the MPOs do not line up with 2010 employment statistics from the New Jersey Department of Labor, at the municipal or county level or for any of the three MPOs. When added together, county employment totals from the three MPOs exceed the Department of Labor's 2010 statewide total employment by about 9 percent. Staff at the Department of Labor attributes this disparity to a difference in source data, namely that the MPOs are likely using wage data, which counts employees rather than jobs. This can produce an overcount, especially in businesses with a lot of turnover where counting employees can end up counting multiple people for a single actual job. Because the MPOs' methodology is consistent across years, however, it should not affect the accuracy of their projected growth *rates*; counting employees rather than jobs should result in the count being off in a consistent direction, and by a consistent proportion, as long as a municipality's share of high-turnover jobs remains roughly the same over time. For absolute counts of jobs, however, the MPO projections are likely to err on the high side. If desired, they can be revised using a deflation factor computed from 2010 county-level employment totals for the MPO and the Department of Labor for each county, under the assumption that the Department of Labor methodology is more accurate.

Overall, the three MPOs project New Jersey's employment to grow by 26.8 percent from 2010 to 2040; this is nearly half again the projected rate of population growth (18.4 percent) over the same time period. This disparity is consistent with the recent (starting around 1980) growth of northern New Jersey, in particular, as an employment market. Historically, New Jersey was more dependent on New York City and, to a lesser extent, Philadelphia, to provide jobs for its residents, so New Jersey's ratio of jobs to employed residents was relatively low. With the suburbanization of employment starting in the 1980s, New Jersey began playing catch-up. The fact that projected employment growth exceeds projected population growth likely reflects a continuation of this trend toward more intra-New Jersey commuting.

Another important trend at work that is likely having a similar effect is the tendency of New Jersey jobs to be filled by non-New Jersey residents, especially via the phenomenon of people moving out of New Jersey into eastern Pennsylvania in search of cheaper housing but continuing to commute back to their

[27] Weaver, Donna. 2014 (January 5). State wants Little Egg Harbor to list homes abandoned after Sandy. Press of Atlantic City. http://www.pressofatlanticcity.com/news/breaking/state-wants-little-egg-harbor-to-list-homes-abandoned-after/article_1c2884f4-761e-11e3-94e9-001a4bcf887a.html

jobs in New Jersey.[28] If a large proportion of jobs created in New Jersey over the next 30 years end up being filled by people who commute in from eastern Pennsylvania, this would indeed manifest itself in New Jersey's employment growth rate outstripping its population growth rate.

At the county level, the fastest-growing counties from 2010 to 2040 are projected to be Sussex, Hunterdon, Ocean, Hudson, Somerset, Salem and Monmouth, all of which are projected to increase their employment by a third or more. Sussex, Hunterdon and Salem all begin from relatively small bases and are poised at the edges of the New York or Philadelphia urbanized areas, so even a modest continuation of the suburbanization of employment could be expected to produce such percentage increases. Somerset and Monmouth represent maturing suburban counties where population growth is expected to tail off but employment growth will continue, as jobs follow people into these counties. In Ocean County, the leading edge of growth is still happening, with population growth projected to continue to outstrip employment growth (and with a large percentage of new Ocean County residents hence continuing to commute northward to jobs). The only surprise is Hudson County, where the recent revitalization in Jersey City and Hoboken (both of which posted job gains of greater than 10 percent between 1997 and 2010) is projected to spread to the rest of the county, with the result that county-wide employment is projected to grow by 47 percent from 2010 to 2040, substantially outstripping the statewide growth rate.

The MPOs' employment growth projections only result in one notable change in the county rankings, pointing toward the recentralization of jobs into more urbanized counties being primarily a North Jersey phenomenon: Hudson, Monmouth, and Union counties are all projected to overtake Camden and Mercer counties in terms of their total number of jobs. Otherwise only minor changes to the rankings are projected to occur, with Somerset overtaking Burlington, Hunterdon overtaking Cumberland, and Sussex overtaking Cape May. All of these projections sound reasonable, given the general greater robustness of the New York metropolitan economy compared to that of Philadelphia.

[28] New Jersey Future has documented this phenomenon in a 2006 report, Moving Out: New Jersey's Population Growth and Migration Patterns. See www.njfuture.org/research-publications/research-reports/moving-out/

Appendix B – Build-out Methodology

Build-out Analysis For Pinelands Towns

Future water quality and availability will largely depend upon the extent and distribution of development. To understand the effect of existing land use regulations on water quality and availability, New Jersey Future developed a build-out analysis that projects future development under the present zoning framework.

Study Areas:

Evesham Township, Burlington County, New Jersey
Town of Hammonton, Atlantic County, New Jersey
Little Egg Harbor Township, Ocean County, New Jersey
Medford Lakes Township, Burlington County, New Jersey
Medford Township, Burlington County, New Jersey
Tuckerton Borough, Ocean County, New Jersey

Build-out Overview

A build-out is a tool used by planners to understand how existing regulatory constraints, such as zoning, will affect the built environment once all vacant lots within a study area are "built out." This information can then help communities to understand what potential challenges may result from this pattern and extent of growth. While a build-out will vary in method, at their most basic, they examine the extent of development based upon existing zoning. A build-out may include a variety of other environmental, regulatory and physical constraints, such as waterways, preserved lands, steep slopes, deed restrictions, or access to utilities in order to provide a more realistic expectation for future development. The availability of information, time, and resources will limit the extent of the analysis. It cannot be overemphasized that planners cannot completely predict the future through a build-out because it is impossible to measure every factor at play and a number of assumptions must be made. The build-out is, in the end, an estimate or "educated guess". Further, it is an estimate of what could occur, not what will occur, as market conditions, future land preservation efforts, site-specific negotiations (for higher or lower densities or shifts in approved land uses), redevelopment agreements, rezoning and regulatory changes, among other factors, could cause development that is more, less or different than that in the build-out. A build-out analysis is a planning tool.

Existing Research

The New Jersey Pinelands Commission recently completed a build-out assessment for the portions of each of the communities within their jurisdiction (Kirkwood Cohansey Build-out Model, September 2013—DRAFT).[29] These build-outs utilized tax data, parcel lines, zoning, water bodies, land use data, and their internal permitting system to estimate the potential development of the municipalities through three scenarios: 1) Build-out based upon zoning alone without any constraints; 2) Build-out that factors in wetlands and other environmental constraints; and 3) Build-out that examines past development density trends to project future development.

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[29] New Jersey Future would like to thank the Pinelands Commission Staff in providing spatial data, their draft results, and the time taken to explain everything. In particular, special thanks go out to Larry Liggett, John LaMacchia and Joseph Sosick.

While these reports provided a useful reference in determining the needs for this project, they had some limitations which created the need for our own research:

1) The Pinelands Commission Build-out did not project where development would occur in relation to subwatershed boundaries, specifically HUC14 subwatersheds. For the purposes of the present study, the location of development in relation to watershed boundaries will help to understand how localized demand for water may affect the surrounding natural communities.

2) The Pinelands Build-out work was started nearly a decade ago and used data that have since been updated. In their study, parcel information utilizes year 2000 data, while the state has now released parcel and tax data for 2010. The build-out also utilizes Land Use/Land Cover data from 2002, while the state has released updated information from 2007 aerial imagery.

3) Since the study area for New Jersey Future includes three municipalities that are only partially within the Pinelands Commission boundary, and another that is entirely outside the boundary, it was necessary to run a build-out analysis for these areas.

4) Finally, zoning in the study area municipalities has been updated. While some changes are minor, the Town of Hammonton recently (July 2013) updated their zoning to utilize form-based codes.

As a result of these factors, New Jersey Future decided to run a new build-out using a consistent methodology for the study area.

New Jersey Future Build-out Methodology

The build-out model run by New Jersey Future utilized parcel-level data on local zoning, sewer and water service areas, wetlands, water bodies, urban land cover, preserved lands, and Pinelands Management Areas to develop its findings. This methodology closely followed the Pinelands Commission's build-out under their second scenario, which utilizes wetlands and environmental constraints, with some exceptions. By combining these data together with the use of Geographic Information Systems (GIS) software, we examined the build-out potential at the parcel level for the six towns.

While a detailed methodology can be found at the end of this summary, the basic steps used to complete the build-out were as follows:

1) Collected data to populate fields on the parcel level:
    a. Collection of spatial data (Land Use—Water and Developed "Urban", Zoning, Parcels, Roads, Zoning, watershed boundaries, sewer service areas, water service areas, preserved lands, Pinelands Management Areas)
    b. Collection of tabular data (Parcel tax records, zoning ordinances)
2) Removed parcels that would not be used in the analysis:
    a. Where zoning was unavailable (only a few parcels total)
    b. Where parcels were publicly preserved
    c. Where parcels were completely covered by water
    d. Where parcels were assumed to be completely developed, either through assumptions made from the tax data, or with residential properties that had an urbanized land cover of 100%
3) Assigned information to each parcel regarding water and sewerage service present.

4) Researched zoning ordinances of case study municipalities for development potential, based on:
    a. Minimum lot size (with and without sewer, and likewise water if specified)
    b. Minimum lot density (with and without sewer, and likewise water if specified)
    c. Minimum floor area ratio (with and without sewer)
    d. Options for higher density cluster or Planned Unit Development
    e. If non-residential development permitted upstairs living units or not
5) Calculated the amount of housing units and developable square footage of non-residential development.

Similar to the Pinelands Commission, the property classifications taken from New Jersey's Department of the Treasury Office of Taxation helped to determine whether properties were evaluated as already developed, vacant, publicly owned, or underutilized.

Caveats

1) The NJF model did not have access to the internal permitting data used by the Pinelands Commission that helped to correct for parcels that may have been approved for development that is either greater than or less than the densities listed in the zoning code.
2) The NJF model operated under the assumption that land would be built out to its most dense principally permitted use by its respective zoning district. For example, if the zoning permitted, and the acreage existed to build a large age-restricted community that permitted densities exceeding 10 units per acre, we opted for that. If the zoning permitted single-family or two-family dwelling units on a lot, we opted for the two-family, unless the required lot size was larger and thus prohibitive. If a developer could pay for higher density or use PDC credits, those densities were used, if available.
3) The NJF model operated under the assumption that development would only take place using zoning's principally permitted uses, and that no variances would be given.
4) Due to time limitations, environmental constraints were limited to areas designated by the 2007 Land Use/Land Cover data as being wetlands or water. Consideration was not given to flood zones, or any required buffer setbacks critical waterways, or the presence of state or federally protected species.
5) The NJF model used minimum lot sizes and floor area ratio (FAR) values that were derived from the local ordinances, when found. If these values were not available, the NJF model deferred to the Pinelands Commission model for default values.
6) While the build-out generally followed either a "Residential" or "Nonresidential" path, for mixed-use properties where zoning permitted for new development, second floor dwelling units were added *on a parcel basis*. Because these units would likely be assigned by individual building instead of by lot, our estimation will be lower than what could occur.
7) The timeframe required to develop and run the NJF Build-out Model (10 weeks) was significantly less than that of the Pinelands Commission. The major assumptions noted here and others discussed in the detailed methodology allowed completion of the build-out in a timely fashion, with limited impact on the accuracy of the results.

Results

Our findings suggested potential for continued development in each of the six municipalities, but to greatly different degrees. Table 1 shows the estimated amount of additional non-residential space (in square feet) and number of residential units, by municipality at build-out. It is important to note that the study intentionally sought out the highest permitted density allowed in each district. In addition, in areas outside of Pinelands Commission jurisdiction, it is expected that higher density development would occur.[30]

Table 2 shows the number of acres available for development under the zoning ordinances. It also includes a field for "non-buildable acreage." This value does not include the acreage removed prior to the build-out, such as public lands, or lands completely covered by water, but rather the parcels that were eligible for build-out, based upon the tax data and zoning, but that did not meet the minimum zoning or upland requirements.

Table 1: Total Build-out in Study Area

	Evesham	Hammonton	Little Egg Harbor	Medford Lakes	Medford	Tuckerton
Non Residential Development In Square Feet	1,038,928	13,693,485	39,999,304	69,736	2,242,487	879,143
Residential Units	2,281	3,083	3,506	33	6,989	899
Existing Residential Units (2010 Census)	17,620	5,408	8,060	1,483	8,277	1,396

Table 2: Acreage By Build-out Type

	Residential Land	Non Residential	Non Buildable[31]	Total Examined in Analysis
Evesham	1,731	227	7,687	9,646
Hammonton	2,266	1,221	6,681	10,168
Little Egg Harbor	1,703	793	2,877	5,373
Medford Lakes	15	2	261	278
Medford Township	5,865	573	7,359	13,796
Tuckerton	307	92	368	767
Grand Total	**11,887**	**2,908**	**25,233**	**40,028**

Tables 3 and 4 use the findings in the first two tables to show the average number of acres required for each housing unit developed, as well as the percent of area developed for non-residential development in relation to the minimum required lot size. The build-out suggests that the average residential density across the six towns is slightly under ½ acre per unit, ranging from 5/6 acre per unit in Medford Township to 1/3 acre per unit in Tuckerton (Table 3). On the non-residential side, it is interesting to note the Floor Area Ratio (FAR), or the ratio of allowable development to the amount of land required. While FAR equals about 10% in Medford Township, in Little Egg Harbor Township, 116% of the site can be used for non-residential development (Table 4). This does not mean that the entire site will be occupied by hardscape, but rather reflects the fact that Little Egg Harbor Township permits building coverage to occupy up to half of a property, and permits a maximum height of 2.5 stories.

[30] The municipalities in the study area were not all completely within the boundary of the Pinelands Commission. For reference: 55% of Evesham is in the Pinelands, Hammonton 100%, Little Egg Harbor 24%, Medford Lakes 100%, Medford Township 78%, and Tuckerton 0%.

[31] As noted above, "non-buildable" includes only those parcels that were initially deemed eligible for build-out. They do not include parcels on public lands, lots developed to capacity, parcels covered completely by water or wetlands, institutional or civic zones, areas where zoning was unavailable. These parcels were those that did not meet the minimum size, sewage, water, or other requirements of their respective zoning districts.

Table 3: Acreage Used Per Housing Unit	
Municipality	**Acres Per Housing Unit**
Evesham	0.76
Hammonton	0.73
Little Egg Harbor	0.49
Medford Lakes	0.45
Medford Township	0.84
Tuckerton	0.34

Table 4: Non Residential Development	
Municipality	**Floor Area Ratio**
Evesham	10%
Hammonton	26%
Little Egg Harbor	116%
Medford Lakes	72%
Medford Township	9%
Tuckerton	22%