TOGETHER NORTH JERSEY.

Water Resources Baseline Topic Report

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Prepared for NJ Future by

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Executive Summary

New Jersey depends on water resources for the health of its people, the strength of its economy, and the vitality of its ecosystems. The availability and quality of our water resources, the integrity of our watersheds, and the dependability of our water infrastructure (water supply, wastewater and stormwater) are fundamental elements of sustainable communities and are critical to sustainable development, which can be stated generally as society's ability to achieve balanced improvements to its economy, environmental quality and social equity over time. Many other resources and types of infrastructure are important to New Jersey – water is irreplaceable.

This report examines water resource and infrastructure issues in northern New Jersey (Chapter 2), reports on current and possible future conditions (Chapter 3), and recommends water resource objectives, outcomes, metrics and indicators (Chapter 4) for use by the Together North Jersey in its Regional Plan for Sustainable Development (RPSD). For each element of water sustainability, the report addresses whether sustainability is being achieved under current conditions and demands, and whether capacity exists for increased future demands. This report supports in particular the following Livability Principles of the U.S. Department of Housing and Urban Development (HUD), though water resources and water infrastructure play a part in supporting all aspects of sustainability:

- HUD Livability Principle #4: **Support Existing Communities**
- HUD Livability Principle #5: **Coordinate Policies and Leverage Investment**

Water is a public trust resource owned by the public of current and future generations, and managed on their behalf by the State of New Jersey. Water is a natural resource that supports every ecosystem in New Jersey. It is also a resource commodity used by all of society. The infrastructure necessary for water supply and wastewater treatment relies on the availability of water as a natural resource. The viability of every urbanized area relies on public water supplies, sewage systems and stormwater systems. Insufficient water availability or infrastructure will fundamentally undermine our society. Use of water resources beyond environmentally sustainable levels will damage their long-term utility in support of our economy and quality of life. Inequitable or inefficient distribution of water supply and wastewater services also damages economic and social viability.

Water Resource and Infrastructure Assessment

Planners, practitioners, non-governmental organizations, the private sector and decision makers should be aware of the following general conclusions and key issues regarding current and anticipated conditions, all of which are discussed in detail within the report:

- **WATER AVAILABILITY** – Water availability is the quantity of water that can be used for human purposes without significant harm to ecosystems or other users. New Jersey receives sufficient precipitation to support current human uses and protect aquatic ecosystems in normal rainfall years, in most areas of the state. Northern New Jersey has many large and small reservoirs built over more than a century that support our urban areas. Aquifers also provide high quality water in many areas. However, mild to severe droughts are fairly frequent and New Jersey's population increases are adding to and shifting the location of demands, stressing some resources. In addition, recent research has highlighted problems with historic methods of assessing the viability of water withdrawals; more care is needed regarding ground water withdrawals and reservoir releases to avoid damaging wetlands and streams.

  The NJ Department of Environmental Protection (NJDEP) and the Highlands Water Protection and Planning Council (Highlands Council) have developed improved Water Availability methods. Based on these methods, it is clear that some aquifers have been over-exploited, representing a threat to aquatic ecosystems as well as competing human uses. However, critical information from the pending NJ Statewide Water Supply Plan (NJSWSP) is not yet available for public review. Only the results of the Highlands Regional Master Plan are currently available regarding the new water availability approach. Therefore, few conclusions can be drawn at this time regarding ground water availability outside of the Highlands.

Sustainability Issues: Future demands through 2040 for Newark and Jersey City may approach or exceed the capacity of their reservoir systems; more detailed evaluations are needed, which may come from the pending NJSWSP. Some aquifers in the region have been long known to be constrained, such as Water Supply Critical Area #1 (Monmouth and northern Ocean Counties), the Central Passaic Buried Valley Aquifers (eastern Morris and western Essex Counties) and the Lamington Valley Aquifer (western Morris County). In addition, nearly two-thirds of the Highlands Region has been identified as having aquifer deficits based on the new ecologically-based analytical approaches. The pending NJSWSP is likely to identify additional aquifers of concern. Some municipalities with significant project growth are affected by these issues, especially those supplied by the Passaic and Hackensack river reservoirs (see Appendix D).

- **WATER QUALITY AND WATERSHED INTEGRITY** – These two concepts are related but not equivalent. Water quality is very important for the protection of water supplies, human health, aesthetics and recreational use of water, and is critical for the protection of aquatic life. As such, water quality is part of watershed integrity. Water quality issues also apply in our coastal waters for ecological and human health protection. Watershed integrity includes water quality but is far broader. It also includes the status and sustainability of watershed hydrologic functions, stream channels, riparian areas, wetlands, etc., all of which affect ecosystem health and public welfare.

The quality of some New Jersey surface waters is far better than in the 1970's, primarily due to the closing or upgrading of industrial wastewater and public sewage treatment plants. Unfortunately, many waters in suburban and exurban areas have declined in quality over the same period, primarily due to the development of formerly rural areas. Agricultural contributions to rural water quality problems have shifted over the years with changes in dominant products, farming practices, fertilizer costs, available pesticides, irrigation practices, etc., but are still of concern in some areas. New Jersey is well known for both its suburban sprawl and its agriculture. These "nonpoint" pollutant sources will be extremely difficult to control, but failing to do so threatens the long-term utility of these waters.

In urban areas, major surface water quality concerns come from Combined Sewer Overflows (CSOs), a legacy of 19th century wastewater practices that now represent the largest sewage discharges in New Jersey that lack effective treatment. New Jersey's CSOs are mostly in the urban northeast, and therefore the high costs of controlling them will fall on cities of this region, including Bayonne, Elizabeth, Jersey City, Newark, Paterson and Perth Amboy. New Jersey is tackling this problem later than many other areas (including our neighbors, New York City and Philadelphia) but consequently is well positioned to learn the best and most cost-effective practices from others. Regardless, the minimum estimated costs for this effort are in the low billions of dollars.

Finally, ground water is a major source of supply through most rural and exurban and many suburban areas of the region. Contamination by fertilizers, septic systems and our industrial legacy has damaged the aquifer quality in many areas, though most areas still have good quality. Many industrial pollution sites will require decades to restore. Addressing pollution problems associated with suburban development and agriculture will be difficult also. Once polluted, ground water tends to stay polluted for long periods of time. Prevention is generally the only rational approach.

Watershed integrity has likewise been damaged by a wide array of causes, both historic and recent. Development of floodplains and wetlands from historic times through the 1970's and 1980's placed large areas and thousands of properties at risk of frequent flooding along our rivers, especially in the Passaic River Basin and portions of the Raritan and Delaware River Basins. Poor stormwater management through the 1990's resulted in widespread damage to stream channels from excessive flows and velocities. Destruction and fragmentation of forests, riparian areas and wetlands damaged both habitat integrity and the quality of surface waters. Ground water recharge losses from development has reduced flows to streams, harming aquatic ecosystems and other water uses. Correction of these problems, from flood damages to ecosystem health, poses a major challenge and cost, but also a major opportunity to improve regional sustainability.

<u>Sustainability Issues</u>: Poor surface water quality deters development potential and damages ecosystem values in most urban areas of the region, despite improvements. Ground water contamination of industrial sites delays reuse of these areas in many cities and older suburbs. Flood plain development in historic urban areas and post-World War II suburbs results in repetitive flood damages that have high costs. Finally, the costs of CSO controls will affect some of the least wealthy municipalities in the region, though success in managing CSOs will also benefit the same communities.

- **WATER INFRASTRUCTURE: PUBLIC WATER SUPPLY, SEWER AND STORMWATER SYSTEMS** – No urbanized area in New Jersey (or elsewhere) is sustainable without these three infrastructure systems. In this case "public" refers to the clientele, not the system ownership. There are 18 public water systems in northern New Jersey with total capacity exceeding 15 million gallons per day (MGD). Tracking "available capacity" (total capacity minus current or future demands) for the largest (and therefore most critical) public water supply systems can be difficult, as they often have multiple sources, contracts to both buy and sell water, and service areas that cover many municipalities. However, a preliminary analysis indicates that most of the seven largest systems have sufficient capacity to address growth through 2035, with the smallest margins (and therefore greatest concerns) found for Newark, Jersey City and Passaic Valley Water Commission. These systems are all in the Passaic River Basin. The combined needs of the Raritan River Basin systems are well within the capacity of the NJ Water Supply Authority's Raritan System. The pending NJ Statewide Water Supply Plan from NJDEP should provide additional information on these and all other systems.

  There are 15 public sewer systems with a total capacity exceeding 15 MGD. Of these, the Passaic Valley Sewerage Commissioners facility is by far the largest – fifth largest in the nation – and their service area (including municipalities that feed to the system) also includes most of northern New Jersey's combined sewers. The presence of combined sewers is a very expensive future issue, and also complicates assessments of available capacity. However, a preliminary analysis using a conservative measure of available capacity indicates that existing plus projected demands may near or exceed total capacity for the Middlesex County Utility Authority, Ocean County Utility Authority-Central STP, Joint Meeting of Essex & Union, Bergen County Utility Authority and Somerset Raritan Valley Sewerage Authority. More detailed facility evaluations would be needed to refine this planning-level analysis.

  Another major problem New Jersey faces is that our water infrastructure suffers from extensive and costly deferred maintenance, as repeatedly noted by the NJ Clean Water Council and the Water Supply Advisory Council. Too much emphasis has been placed on reducing current rates, creating a major risk of system failures in the future; emergency maintenance costs will rise rapidly as systems literally crumble. The threats to regional sustainability are profound. <u>Nothing</u> works in urban areas without water and sewer. We face a collision between desired growth and infrastructure failure in many areas. Each system failure will result in lost value, higher costs and greater uncertainty for future investment. <u>Consider</u>: New Jersey's major growth period was from 1960 to around 1990, with 80 percent of all existing New Jersey office space having been built in the 1980's (Hughes and Seneca, 2012). Consider further: Water infrastructure inevitably wears out. Infrastructure from the 1960's is now entering its fifth decade, and already the third decade for 1980's vintage infrastructure. The aging process can only be offset by well-planned, ongoing maintenance. Otherwise, we face increasing failures combined with increasing costs, placing our economic competitiveness at risk (not to mention our quality of life and environmental quality). While accurate figures are not yet available, it is clear that the necessary costs will be in the tens of billions of dollars over the next several decades.

Sustainability Issues: Public sewer capacity is limited in most of the region's urban areas, due to treatment plant size, CSO problems or both. The greatest available capacity (other than PVSC, which has CSO issues) is in Ocean County, which mostly depends on aquifers that may face future limitations. Public water supply system capacity from reservoirs may be sufficient for the region, but a more rigorous evaluation is needed for the Passaic and Hackensack river reservoir systems. Many aquifer-based water supply systems face potential limitations due to aquifer constraints. Finally, the reliability and resilience of all public water infrastructure is at risk due to deferred maintenance.

Taken together, these issues facing northern New Jersey constitute major challenges that will require concerted, well-planned, well-funded and well-managed efforts by both the public and private sectors. It is important to note that planning for and allocating water availability, as well as protecting and restoring water quality and watershed integrity, are necessarily government functions; they involve responsibilities for allocation of public trust resources that cannot be delegated. Water infrastructure can have various types of owners, but government again has a necessary function to ensure that the public is well served and protected, with proper asset management at the lowest possible lifecycle (not current) cost that protects the public interest and the environment. A critical balance must be struck between the roles of government and the roles of other sectors to ensure that a sustainable economy, environment and social equity are supported by a sustainable water resources and water infrastructure system.

Sustainability thresholds

How, then, do we determine whether our water resources and infrastructure systems are sustainable? While considerable methodological development is still needed in this field, some concepts can be proposed. Sustainability regarding water resources is an inherently systems-based issue that requires simultaneous consideration of the following integrated concepts:

- Watershed integrity, including water quality and flows to support ecosystem and environmental service values
- Adequate and reliable water supply, wastewater and stormwater management to meet human and economic needs, efficiently provided at affordable prices, with acceptable environmental impacts
- Maintenance of water amenity values to support quality of life and community vitality

In general, then, **sustainable development requires watersheds that exhibit or attain sufficient integrity to support human and ecological uses and needs, where water is: withdrawn from and returned to the environment in a manner that protects aquatic ecosystems and other uses; used at a rate and in a manner that provides for and protects both human and ecological needs; and managed where appropriate through water utilities that can provide affordable services while continually maintaining all necessary infrastructure.** Specifically, the following sustainable objectives are proposed:

- Water Availability – Water availability provides for human needs in an equitable manner that may be maintained through foreseeable drought periods without significant harm to the integrity of aquatic ecosystems.

- Self-Supplied Industrial and Agricultural Water Supply – Water supplies are available in sufficient quantity and quality to support efficient uses that sustain industry and agricultural productivity, within the limits of water availability.

- Ground and Surface Water Quality – Ground and surface water quality support and protect reasonable human needs (e.g., public health and sanitation, agriculture, commerce and industry, recreation, aesthetic, spiritual) and natural ecosystem functions, in a manner that optimizes societal health and function.

- Watershed Integrity – Watersheds are maintained or restored to a level of integrity in which: natural land cover supports dynamic hydrologic and geomorphic processes within their natural range of variation; habitat of sufficient size and connectivity supports native aquatic and riparian ecosystems and species; and water quality supports healthy biological communities.

- Ecosystem Vitality and Biodiversity – Water resources remain in natural water bodies in sufficient quantity and quality to support overall ecosystem vitality and biodiversity, such that aquatic ecosystems of each major watershed have or are restored to a level of integrity that supports a full complement of organisms, including rare, threatened and endangered species, aquatic species, and species reliant on aquatic ecosystems for a critical portion of their lifecycle.

- Water Supply Infrastructure - Public water supply infrastructure has and will have sufficient capacity and reliability to meet customer needs with minimal service disruptions at sufficient quantity and quality (including peak demands and drought needs) at the lowest possible lifecycle cost, using water supplies that do not exceed sustainable levels of water availability.

- Human Health and Welfare – Water supplies are available in sufficient quantity and quality to support efficient uses that sustain human health, sanitation and consumption from residences and businesses, and for recreational and outdoor uses, within the limits of water availability.

- Water Quality Infrastructure

  Public wastewater infrastructure has and will have sufficient capacity and reliability to collect and treat sewage of sufficient quantity and quality to meet customer needs with minimal service disruptions at the lowest possible lifecycle cost, while protecting public health and the environment.

  Public stormwater infrastructure protects public health and safety and the waters of the State from flooding, contamination, recharge loss and surface water damages during normal operating conditions, with minimal service disruptions at the lowest possible lifecycle cost, while protecting public health and the environment.

1 Overview and Scope

New Jersey is by far the most densely populated state in the nation, and also has a long legacy of both extensive agriculture and industrialization. In the post-World War II era, New Jersey became famous for its suburban development, including generation of the fifth largest business office market in the nation (Hughes and Seneca 2012), along the major highways of northern New Jersey. At the same time, land preservation efforts have resulted in protection of a full two-fifths of the state's area. More recently, economic changes are challenging the economic power of New Jersey, and demographic changes seem to be causing a shift in market interest from suburban offices to city development.

Through all of this history, from its early ports in Newark and Perth Amboy to industrial development in Paterson to suburban Edge City areas, the availability and viability of water and water infrastructure have played important and often critical roles. This chapter provides a discussion of the focus and scope of the report, and a brief overview of the major water resources issues facing northern New Jersey.

1.1. Focus of the Report

First and foremost, water is a public trust resource owned by the public of current and future generations; it is managed on their behalf by the State of New Jersey. Water resources are not and cannot be alienated from the public through ownership by individuals in New Jersey, but they can be allocated to uses that benefit the public interest. Water is a natural resource supporting aquatic and terrestrial ecosystems, aesthetic enjoyment, recreation and fisheries. It is also a public resource commodity, used for public and domestic water supplies, irrigation and industry. The infrastructure necessary for delivery of water as a commodity, and for treatment of the resulting wastewater, relies on the availability of water as a natural resource. The viability of every urbanized area relies on public water supplies, sewage systems and stormwater systems. Insufficient water availability, quality or infrastructure will fundamentally undermine our society. Use of water resources beyond environmentally sustainable levels will damage their long-term viability in support of our economy and quality of life. Inequitable or inefficient distribution of water supply and wastewater services also damages economic and societal viability. These issues are addressed extensively within this report.

1.2. Overview of Water Resources and Water Infrastructure Issues

A wide variety of issues exist in an urban society regarding water resources and infrastructure. This section provides a general overview of the major categories of issues addressed in this paper. These issues are all discussed from a general perspective in Chapter 2 (Defining the Water Systems) and in more detail with respect to northern New Jersey in Chapter 3 (Existing Conditions, Trends and Future Needs).

1) **Water Availability:** Essentially, water availability is the capacity of a water resource to meet aggregate demands during stressed periods such as droughts. Consideration is given to demands from human <u>and</u> ecosystem needs, equitable apportionment of water among uses, and indicators of stress to the water resource. Water is rarely transported more than 40 miles from its source in New Jersey,[1] and so water availability for our state is an inherently local issue,[2] with regional implications due to interconnections.

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[1] The most notable exception is the Delaware & Raritan Canal, which transports water roughly 60 miles from the Delaware River to New Brunswick.

[2] "Local" in this case is used as meaning within watersheds and river basins, but not referring to neighborhoods or municipalities.

2) **Water Quality and Watershed Integrity:** A water resource of sufficient quantity to support demands is of no value if the quality is degraded (naturally or anthropogenically) so that it does not support the desired water uses. Therefore, the quality of waters is an integral aspect of water resources sustainability. Water quality is inherently at the scale of the water resource in question, whether ground water (including aquifers) or surface water (e.g., lakes, streams, rivers, estuaries, ocean).

   Water availability and water quality exist within the context of geophysical areas called watersheds, defined as a land area from which surface waters exit through a single outlet. Watersheds range from small (for individual small streams) to very large areas (e.g., the Delaware and Hudson River basins); the larger watersheds are comprised of many smaller nested watersheds. Each watershed supports environmental and ecological functions, including services such as water availability, recreation, flood protection and habitat.

3) **Public Community Water Supply Systems:** Public Community Water Supply (PCWS) systems are defined as water systems with at least 15 or more service connections used by year-round residents or regularly serving at least 25 year-round residents. As such, "public" refers to the customers, not the ownership. Public community water supply systems (whether owned privately, by investors or by government) serve small to very large areas of developed lands, ensuring reliable provision of potable and production water to customers within their service areas. New Jersey has among the highest share of customers served by investor-owned water utilities in the nation (especially northern New Jersey, with United Water-NJ, NJ American Water, Middlesex Water and Aqua-NJ all having major operations), though most individual systems are government entities (e.g., municipalities, municipal utility authorities, county MUAs, county improvement authorities, regional agencies, state agencies). However, regarding the allocation of water and the protection of public health and the environment, State environmental regulations for water supply systems apply regardless of the form of ownership. Sustainable communities must consider water supply infrastructure as a fundamental component. Developed areas not served by public community water supply systems generally rely on on-site wells, one for each property.

4) **Public Sewerage Systems:** Likewise, public sewerage systems serve small to very large areas of developed lands, ensuring reliable management of public and industrial wastewater from or affecting customers within their service areas. Sewerage systems include the lines that collect and deliver sewage for treatment, the treatment plant, and the discharge works. Not all sewerage systems include all three components – some just collect sewage for deliver to another system that provides the treatment. Northern New Jersey includes the two largest sewer systems in the state – Passaic Valley Sewerage Commissioners (PVSC) and Middlesex County Utility Authority (MCUA). Nearly all systems are government-owned (e.g., municipalities, municipal utility authorities, county MUAs, county improvement authorities, regional agencies), but there are a few small exceptions. Again, regarding the protection of public health and the environment, State environmental regulations wastewater systems apply regardless of the form of ownership. Sustainable communities must consider water quality infrastructure as a fundamental component. Developed areas not served by sewers rely on Individual Subsurface Disposal Systems, commonly known as septic systems.

5) **Public Stormwater Systems:** Public stormwater systems individually tend to serve very small areas, discharging stormwater to local streams either untreated or with minimal treatment, rather than being collected into large systems for treatment. However, in aggregate these systems manage stormwater from nearly all urbanized areas. The major exceptions are the Combined Sewer Systems, which function as both sewer systems and stormwater systems, providing treatment at the sewage treatment plant up to the pipeline or plant capacity, but discharging to local waters with minimal or no treatment when the collection system or treatment plant reach capacity. The PVSC service area and some facilities of eastern Union County

include large areas of combined sewers; most other Northern New Jersey stormwater and wastewater systems do not.

6) **Relationship to the RPSD:** Water supply, wastewater and stormwater infrastructure are essential to the proper functioning of an industrial or post-industrial society in urbanized areas. They in turn rely heavily on natural capacity for supplying water resources (water availability), receiving and attenuating the effluent from wastewater and stormwater facilities (affecting water quality) and supporting ecological services (based on watershed integrity). Failure to properly address the associated issues leads to long-term decline of ecological services and increase of infrastructure failure and costs.

1.3. Desired Long Term Outcomes

Of the HUD Livability Principles for Sustainable Communities, two are particular importance to this report.

- HUD Livability Principle #4: **Support existing communities**: *Target federal funding toward existing communities—through strategies like transit-oriented, mixed-use development, and land recycling—to increase community revitalization and the efficiency of public works investments and safeguard rural landscapes.*

Most of New Jersey's population lives in relatively densely-developed areas, despite our reputation for suburban sprawl. Urban core areas, inner ring suburbs and the more densely developed portions of second-tier suburbs and historic towns provide many areas for residential, commercial, business and industrial development. All are dependent on water supply and water quality infrastructure for their future, which is threatened by deferred maintenance, disinvestment and inadequate capacity. Further, urbanized areas are dependent on the long-term viability of rural and exurban areas that provide water supply and ecological services necessary for support of urban life.

- HUD Livability Principle #5: **Coordinate Policies and Leverage Investment**: *Align federal policies and funding to remove barriers to collaboration, leverage funding, and increase the accountability and effectiveness of all levels of government to plan for future growth, including making smart energy choices such as locally generated renewable energy.*

New Jersey has a diverse and fragmented water infrastructure community. Public community water supply (PCWS) and public sewer infrastructure are under common ownership and management in some communities, but not in most. Municipal utility authorities may own and operate one or both of water supply and sewage utility systems, but do not own or operate stormwater systems, which are primarily the responsibility of municipalities and to a certain extent private landowners (for on-site systems). As noted above, investor-owned PCWS systems are common in New Jersey. Even where owned by government entities, PCWS and public sewer systems may be managed by contractors under a public-private service agreement. As a result, it is common in New Jersey to have municipal and private stormwater systems, a public sewer system owned by a municipal utility authority, and a PCWS system owned by an investor-owned utility, all within a single area. The inherent difficulties of coordination and policy integration are readily apparent.

State planning requirements also influence both investor-owned and publicly-owned systems. The NJDEP requires that wastewater management plans with designated sewer service areas be developed by counties (or municipalities where a county opts out); the sewer service areas have direct implications for local land use plans and development potential, upon NJDEP adoption. Similar planning for the designation of service areas does not exist for water supply. Individual utilities may have more or less detailed plans, but these plans are not necessarily integrated with local land use plans or the plans of related utilities (i.e., of water supply with wastewater). Stormwater utility functions of municipal governments are not regulated as utilities per se, but NJDEP's regulates some aspects of municipal separate stormwater systems operations under the NJPDES permit program (NJAC 7:14A).

Capital investments are largely a matter of utility-generated priorities, as the State lacks a general requirement or methodology for asset management by public water supply, wastewater or stormwater system owners. Financing of investment is supported to a certain extent by the Environmental Infrastructure Financing Program (including NJDEP and the Environmental Infrastructure Trust). Investment budgets are regulated in very different manners by the Board of Public Utilities (for investor-owned utilities) and the Department of Community Affairs (for municipalities and utility authorities). No general system exists for compiling the net investments or comparing them to long-term needs aggregated for the state.[3] The State is taking initial steps toward asset management requirements in 2013, particularly for municipalities with CSOs.

Water quality and watershed integrity management are even less integrated. Point source pollution is regulated by NJDEP through a detailed and largely effective permit program, but nonpoint sources are far less effectively managed. Management plans for water quality have been developed in many watersheds and subwatersheds (e.g., TMDLs to restore water quality), but their implementation is not at all assured as many of the remaining problems are caused by nonpoint source pollution or physical disruption of the watershed, both of which are harder to control than a relatively small number of point sources. Regional and watershed-based planning does occur for water supply (e.g., safe yield studies, Water Supply Critical Areas to restore confined aquifer levels), but these efforts are rarely integrated with other aspects of water resources management. In most areas of the state, and especially in urbanized areas, land development is regulated primarily by municipal governments with an overlay of State regulations regarding flood plains, wetlands and the coastal zone. In most areas, there is little attention to the effects of land development and redevelopment on watershed integrity beyond the minimum state requirements.

As can be seen, New Jersey faces major challenges in coordinating policies and leveraging investment within the water resources area to achieve the HUD Livability Principles and sustainable development.

1.4. Scope and Content of Report

This report assesses water availability, quality and utilities. It also assesses the roles they can play in a Regional Plan for Sustainable Development (RPSD) for northern New Jersey that responds to HUD's "Principles for Livable Communities," which calls among other things for coordinated plans including for water resources. The report emphasizes issues regarding water resource and water infrastructure (water supply, wastewater, stormwater) that will provide significant opportunities for, or constrain, sustainable communities in areas otherwise considered beneficial for concentrated development, redevelopment, existing development and economic activity.

Chapter 2 defines the five elements of water resources management systems as used in the report: water availability; water quality and watershed integrity; public community water supply systems; public sewerage systems; and public stormwater systems. Chapter 3 then examines these five elements in northern New Jersey, establishing the existing conditions, trends and future needs to the extent feasible based on readily available information. Chapter 4 identifies water resource outcomes of interest for each of the elements, links these

[3] As they are not public infrastructure, septic systems and on-site wells are managed by property owners, and any issues are addressed generally either at time of property transfer or when problems occur.

outcomes to the Principles and Long-term Outcomes of the Together North Jersey project, and recommends metrics and indicators for future assessment. The report as a whole serves as one source of information for consideration in creating the Regional Plan for Sustainable Development.

2. Defining the Water Systems

This chapter provides a more detailed discussion of water resources system components and the New Jersey planning and policy context for them. In each case, information is provided regarding both the broader issue and the Northern New Jersey context. It must be recognized that each component of the water resources system is inextricably connected with all other components. A systems analysis approach is the only valid perspective for water resources management (and, indeed, for sustainability overall), but the individual components are discussed separately to enhance understanding.

2.1. Synopsis of the Water Resources Systems

The availability and provision of water resources and the management of wastewater to protect environmental quality are fundamental aspects of sustainable communities and are critical to sustainable development. The renewability of water resources differs seasonally, in drought, and in time, where some aquifer resources are only renewed over centuries. These water resources exist within natural systems such as watersheds and aquifers, the management of which significantly affects the water quantity, quality and environmental services provided. Management of water utilities must also be addressed. Water utilities deliver water to urbanized areas and manage both wastewater and stormwater from such areas. The ability of such utilities to provide their services effectively is a significant issue of sustainability. For these reasons, the evaluation of sustainability issues regarding water resources must be addressed from two different perspectives - the uses/users, and the systems that provide services to the uses/users. The discussion that follows is focused on the systems, and incorporates issues regarding the uses/users.

Beneficial Uses of Water Resources	Systems Providing Water Resources Services
Human Health and Welfare	Water Availability
Production (industry, agriculture)	Water Quality
Ecosystem Vitality and Biodiversity	Watershed Integrity
	Water Supply Infrastructure
	Water Quality Infrastructure

It should be noted that many of the issues discussed below relate in some fashion to natural watersheds, the lands that flow to a single surface water discharge point, such as a river flowing into a bay or the ocean. New Jersey uses the Hydrologic Unit Code (HUC) system of the U.S. Geological Survey, with an 8-digit watershed (HUC-8) denoting large **basins** such as the full Raritan or Passaic Basins, HUC-10 **watersheds** such as the Rahway River watershed, and HUC-12 **subwatersheds** such as Primrose Brook subwatershed in the Great Swamp watershed.[4]

[4] New Jersey originally relied upon a system that used 11-digit designations for watersheds and 14-digit designations for subwatersheds. The numbering has been revised as part of the National Water Database program of the federal government.

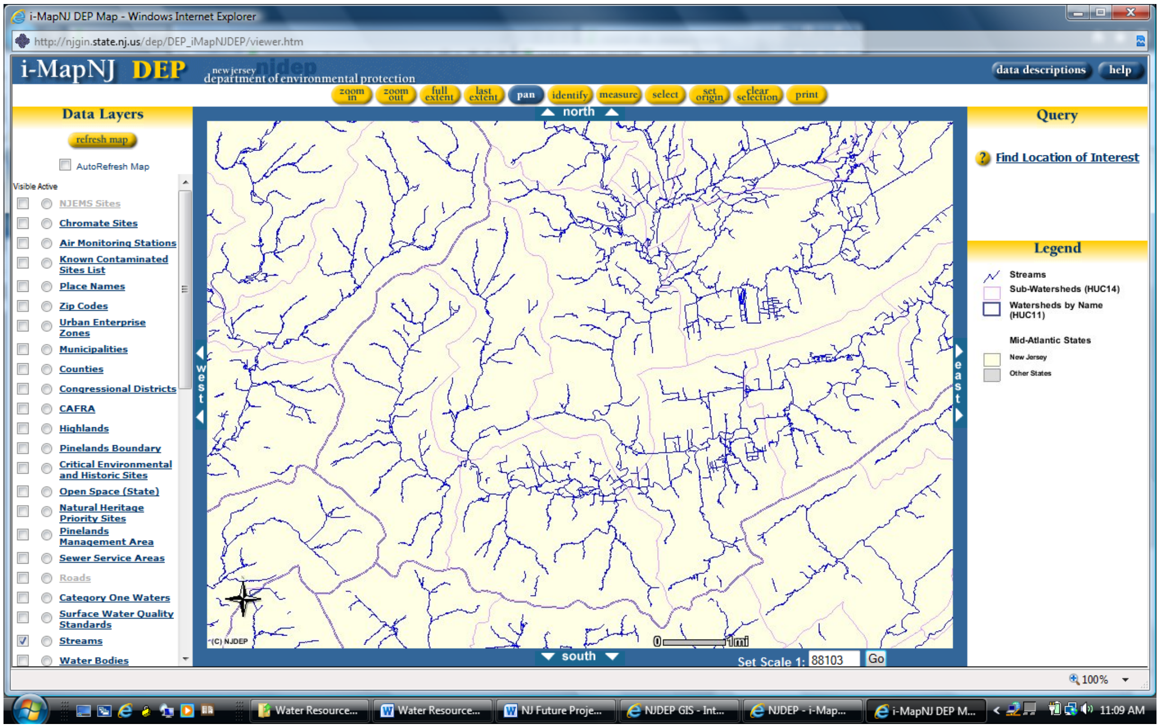


Figure 2.1 Upper Passaic River Watershed, with Subwatersheds (www.nj.gov/dep)

2.2. Water Availability

All water resources in New Jersey are linked in some way, through the hydrologic cycle (see Figure 2.2). Surface waters don't only get runoff from the land surface; they also are highly dependent on discharges from ground water. Ground water, in turn, relies on water infiltration and recharge from the land surface. Aquifers are those parts of ground water that can provide economically useful amounts of water for human use,[5] and are divided generally into surficial (i.e., unconfined or water table) aquifers near the land surface, and confined aquifers that are separated from the surface and upper levels of ground water by relatively impermeable layers of geologic materials such as clay. Water often flows between the surficial and confined aquifers, though slowly. Northern New Jersey has few confined aquifers outside of the Coastal Plain of Middlesex, Monmouth and Ocean counties, but those coastal confined aquifers are important water sources for the coastal counties.

Water availability is a general concept that applies in different ways to different aspects of water resources. Essentially, water availability is the capacity of a water resource to meet aggregate demands (human and ecological) during stressed periods such as droughts. Reservoir systems are addressed in a manner distinct from aquifers, due to the artificial storage available for reservoirs. Withdrawals from surficial aquifers and streams that lack reservoirs are addressed differently from streams with reservoir support, due to the ability of reservoirs to provide controlled releases during dry periods to maintain stream flow below the reservoir.

[5] As such, all aquifers are ground water, but not all ground water is within aquifers. Some ground water is too limited in quantity or quality, or is too expensive to capture, to be of use.

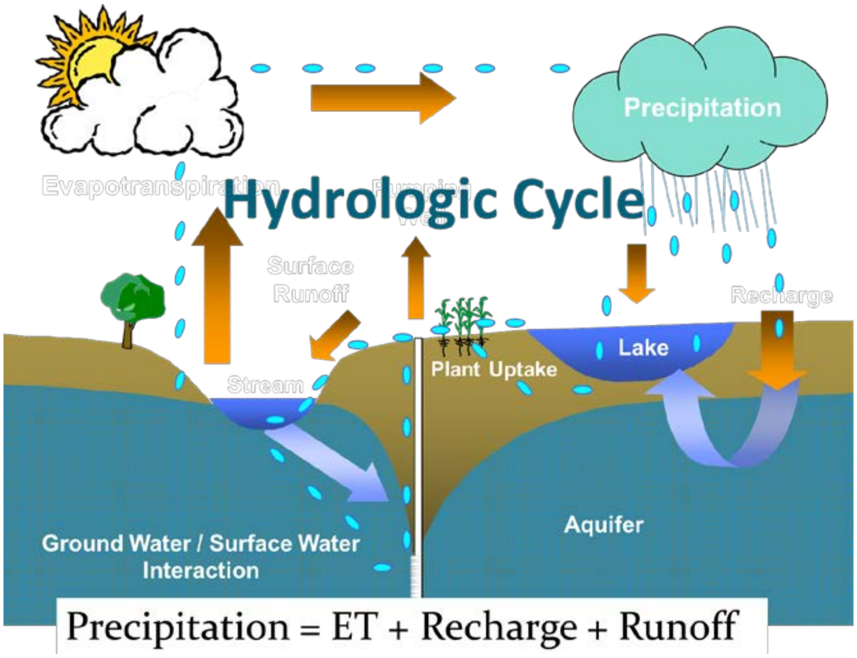


Figure 2.3 Hydrologic cycle overview

Confined aquifers are likewise addressed in a manner distinct from surficial aquifers, because confined aquifers are not directly linked to surface water features and related aquatic habitats, may have restricted or no recharge potential, and may or may not have potential for artificial storage. Therefore, the current national practice regarding sustainability for water availability is to address three classes of water resources separately, while recognizing that they often interconnect and those interconnections must be addressed.

- ***Reservoirs Systems***: Water supply systems with reservoirs rely on storage of water from wet periods to support demands during dry periods. As such, they reduce stream flows during wet periods, but can sustain stream flows during dry periods through mandatory releases, a common practice in New Jersey. System sustainability is achieved when anticipated and actual demands do not exceed the system's ***Safe Yield***, generally defined as the amount of water that may be provided routinely during a repeat of the drought of record. In New Jersey, the 1960's drought is the drought of record for most systems, but some systems use other droughts due to system-specific vulnerabilities. Demands beyond the safe yield would have to be curtailed during a drought, and therefore are by definition not sustainable. Specific methods for safe yield derivation differ in their technical details, but the general approach involves a mass balance approach of calculating storage changes (starting from full conditions), inflow, required release flows and demands during drought conditions.

  However, new ecological studies indicate that reservoir release schedules have a major influence on downstream aquatic ecosystems, both within streams and in downstream estuaries. A sustainable safe yield therefore would be one that provides for a quantity and pattern of reservoirs releases that minimize or effectively mitigate downstream ecological effects. The Ecological Limits of Hydrologic Alteration (ELOHA) approach is the emerging standard for assessing such effects; it is being tested in various reservoir systems nationally (see Higgins, et al. 2011). However, this approach is highly data intensive and therefore can be difficult to apply, though river-specific flow data are often more readily available where a reservoir exists. The major advantages with applying this approach to reservoirs are that reservoir storage is readily measured and reservoir releases are relatively easy to manage. The ELOHA approach for reservoir safe yield is applicable in New Jersey, but has not yet been applied (other than a recent attempt in Pequannock Watershed to manage stream temperatures for ecological protection).

- ***Surficial Aquifers and Surface Water Intakes Lacking Reservoir Support***: Most surface waters are closely linked with surficial aquifers, which serve as a major and often primary source of flow in the streams ("baseflow"). Withdrawals from either surficial aquifers or streams will reduce stream flows that support aquatic ecosystems, downstream water uses, and contaminant dilution and treatment. The reduction approaches parity (1:1) with withdrawals over time.[6] Historically, ecosystem protection received limited attention, but this attitude is changing. Consumptive and depletive water uses (i.e., those withdrawals that are not returned to the same watershed due to evaporation, transpiration or transport) from such surficial aquifers and streams should be managed so as to not damage other human uses or aquatic ecosystems. Alley and others (1999, as cited in Reilly et al., 2008) defined ***ground water sustainability*** as the "development and use of ground water in a manner that can be maintained for an indefinite time without causing unacceptable environmental, economic, or social consequences." This concept applies to all withdrawals, whether for public use (potable water), irrigation of lawns or farms, recreation, manufacturing or power generation. It also applies to withdrawals from surface waters lacking reservoir storage, as the flows in these streams are dependent on ground water discharge to them during dry periods and direct withdrawals have an effect very similar to ground water withdrawals.

  In the field of water resources regulation, site-specific assessment is the most common method of restricting withdrawals from surficial aquifers under riparian or modified riparian law, the system applicable to New Jersey and most eastern states. This approach involves an assessment of local impacts from the withdrawal, with a requirement that the proposed use not interfere with existing residential, industrial, agricultural and public water system wells. Well tests with monitoring of nearby wells are used to evaluate potential effects. Local impacts can also include reductions of streams flows, a relatively new concern that has resulted in controls on well withdrawals. This approach is implemented on each application independently, and does not incorporate regional effects of projected aggregate water demands.

  A less common but more rigorous approach is an evaluation of impacts on a regional aquifer through use of computer-based aquifer models. This approach does allow for projection of future impacts through water demand projections for all withdrawal points. However, this approach also does not provide a watershed-based evaluation of ecological impacts from aggregate water uses, as currently formulated, though stream flow reductions can be estimated.

  The Ecological Limits of Hydrologic Alteration (ELOHA) approach (Poff et al. 2009) is the emerging standard approach for assessing ecological effects of stream flow alterations from surficial aquifer and stream withdrawals, using a suite of flow targets (e.g., high flows, median flows, low flows, frequencies of high and low flows). As noted in Kendy (2012:7), "Environmental flows describe the timing and amount of water to be retained in lakes, rivers, streams, and estuaries to sustain seasonal patterns of high and low water levels needed for natural functions, processes and resilience to persist."

[6] This report is not intended as a detailed primer on water resources systems. For more information on the characteristics, functions and interconnections of surface waters and aquifers, see Watt (2000).

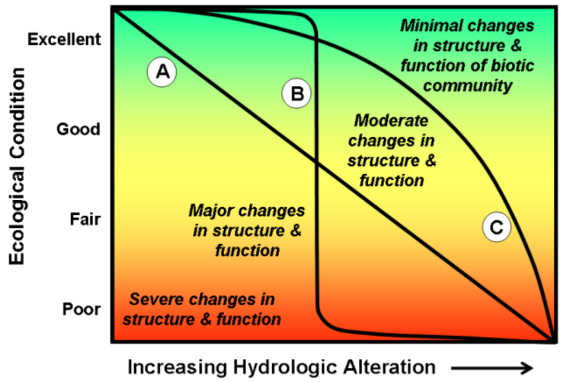


Figure 2.3 Relationship of Hydrologic Alteration to Ecological Condition (http://conserveonline.org/workspaces/eloha/documents/flow-ecology-relationships-0)

However, this approach is highly data intensive and therefore difficult to apply directly in a regional or larger setting. Some regional or state programs use variations on or aspects of the ELOHA approach (Kendy 2012:11), such as using multiple site-specific ELOHA results to establish generalized regional or statewide thresholds. Further, it should be noted that even a major advance such as ELOHA is an indicator approach, based on correlations between flows and ecological effects. It is therefore inferential, rather than a direct measure of sustainable alterations. However, site-specific ecological studies necessary to derive direct assessments of sustainability would be extremely expensive and time consuming.

New Jersey has relied on the first two methods for decades (site-specific evaluations and regional aquifer models), and is at the cutting edge nationally (NJDEP, pending; Highlands Council, 2008 and 2008c) regarding application of the ELOHA approach to withdrawals from surficial aquifers and streams without flow support from artificial storage, especially in the Highlands Region.

- ***Confined Aquifers***: Withdrawals from confined aquifers may have adverse impacts over time, including saltwater intrusion (from oceans, estuaries or underlying saline ground waters), induced infiltration from underlying or overlying aquifers, reductions in flows to other wells, dewatering of the aquifer, or land subsidence due to reduced water pressures in the aquifers; subsidence can exacerbate relative sea level rise (Reilly et al., 2008; Watt, 2000). The use of confined aquifers is considered sustainable when the potentiometric surface (indicating aquifer pressure) is high enough that harmful effects are avoided. While some western U.S. aquifers have negligible recharge and therefore no truly sustainable yield, this situation is not typical of New Jersey aquifers. As with unconfined and surface water systems, this concept applies to all types of withdrawals. However, as a practical matter, most confined aquifer uses are for public water supply, with limited industrial and agricultural uses due to the expense of deep well construction and of energy for pumping water. New Jersey's confined aquifer approach meets national state-of-the-art, including two areas (one of which is in Monmouth and northern Ocean counties) in which confined aquifer withdrawals were restricted to allow restoration of pressure levels to avoid saltwater intrusion.

Water availability is used to address a variety of demands and needs, from ecosystem maintenance to a wide range of residential, commercial, business, industry and agricultural needs. Most residences, commercial establishments and businesses in New Jersey are supplied through public community water supply (PCWS) systems. Generally, only low-density areas are self-supplied through on-site private wells, involving perhaps one-seventh of all people statewide. These self-served areas can be mapped, as being the areas not served by PCWS systems. Current mapping of this nature exists for most Highlands Region municipalities but is not readily available for much of the state.

New Jersey will need to address industrial or agricultural uses in the context of water availability and water utility capacity. New Jersey agriculture constitutes less than 1% of total national withdrawals for agriculture, and application rates per irrigated acre are roughly 36% of the national average (Kenny et al., 2009:24). The industry, however, is projecting a need for increased water for irrigation purposes (Agriculture Water Subcommittee, 2006), which will raise issues regarding the ability of surficial aquifers and local streams to support major irrigation increases without harm to aquatic ecosystems. Industrial needs have been declining over the years (NJDEP, 2012d). Most of New Jersey's electricity generation capacity relies on saline, estuarine or reused water for cooling, limiting the effects on freshwater systems.

2.3. Water Quality and Watershed Integrity

Sustainable communities must rely on ground and surface water quality that meets human needs, including protection of ecological functions. Ground water quality is important for potable water supply wells, and indirectly for the quality of streams that rely heavily on ground water for their flows, especially during dry periods. Surface water quality is also important for public water supply, as well as recreation and ecosystem maintenance. Guidance for national standards has been adopted by USEPA for surface water quality under the Clean Water Act (USEPA 2012b). These standards protect intended (or “designated”) uses such as drinking water, recreation, aquatic ecosystems, industrial use and agriculture, and protect waters from degradation (i.e., antidegradation and nondegradation policies). NJDEP has been delegated state lead for implementation of the relevant Clean Water Act programs and has adopted analogous standards. While USEPA has not adopted national standards for ground water quality, New Jersey has, primarily to protect drinking water uses but in specific areas to protect ecological uses as well. Generally, sustainability for ground and surface water quality requires meeting established standards to protect designated uses. The national approach for parameter-specific standards and development of restoration plans is used in New Jersey for both ground and surface waters.

Watersheds provide ecological, environmental and human service functions (e.g., flooding in natural rather than developed areas) associated with the ground and surface water systems and resources within them. Degradation of watersheds can damage or destroy their value to society. National practice in the recent past focused heavily on relating watershed integrity to the percent of impervious cover, using thresholds such as 10% impervious to indicate a watershed with significant impairment, and 25% to indicate a watershed that is highly urbanized and cannot support sound ecosystems (CWP, 2003). However, impervious surface is an indicator rather than a direct measure of watershed integrity, and cannot address watershed impacts from agriculture, forestry, point source discharges, excessive withdrawals, riparian area disruption, etc.

Benchmarks and acceptable levels other than percent impervious cover are mostly lacking. However, biological and other indicators are becoming more commonly used. One issue has been a decades-long focus on chemical and physical indicators of water quality, rather than on watershed integrity. USEPA has developed a new Healthy Watersheds Initiative as an enhancement to the existing "pollution focused" approach. The Initiative is intended "to protect and maintain remaining healthy watersheds having natural, intact aquatic ecosystems; prevent them from becoming impaired; and accelerate restoration successes." (USEPA 2012c) USEPA defines a healthy watershed as "one in which natural land cover supports dynamic hydrologic and geomorphic processes within their natural range of variation; habitat of sufficient size and connectivity supports native aquatic and riparian species; and water quality supports healthy biological communities… based on an integrated evaluation of: 1) Landscape Condition, 2) Habitat, 3) Hydrology, 4) Geomorphology, 5) Water Quality, and 6) Biological Condition." (See Figure 2.4) The Initiative therefore provides a framework for watershed management, but does not identify specific thresholds for sustainable watershed integrity; these are determined for each watershed in a stakeholder-driven process. The USEPA Healthy Watersheds Initiative incorporates a well-defined and holistic approach that serves as the national approach for watershed integrity, which is directly applicable in

New Jersey. New Jersey lacks an explicit and comprehensive planning and adaptive management approach to address degraded waters that cannot easily be restored, though significant efforts have occurred over the last 20 years. Watershed management efforts in New Jersey previously have been sporadic, experimental, changing in approach, and not well integrated with national practice field science or theory. They also are not well supported by a regulatory framework. NJDEP is currently reviewing its approach to watershed management to determine the extent to which a more viable approach can be developed.

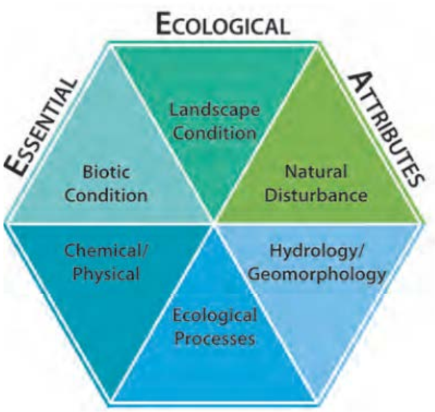


Figure 2.4 Essential Ecological Attributes (USEPA Science Advisory Board, 2002)

National regulatory practice related to watershed integrity focuses on protection of wetlands and open surface waters (e.g., Section 404 wetlands regulations of the USEPA and Corps of Engineers and related "no net loss" policies), surface water quality standards for aquatic life protection (USEPA 2012b) and the aspects of watershed management under USEPA control (USEPA 2012c) including point source regulation of wastewater, stormwater and construction site discharges. The Endangered Species Act may also be applicable to relevant species that rely on aquatic ecosystems, in that maintenance of viable populations is an explicit goal of the Act. New Jersey has mature programs for protection of wetlands, floodplains and open surface waters, and a significant program for threatened and endangered species, though these programs have not achieved sustainable watershed integrity.

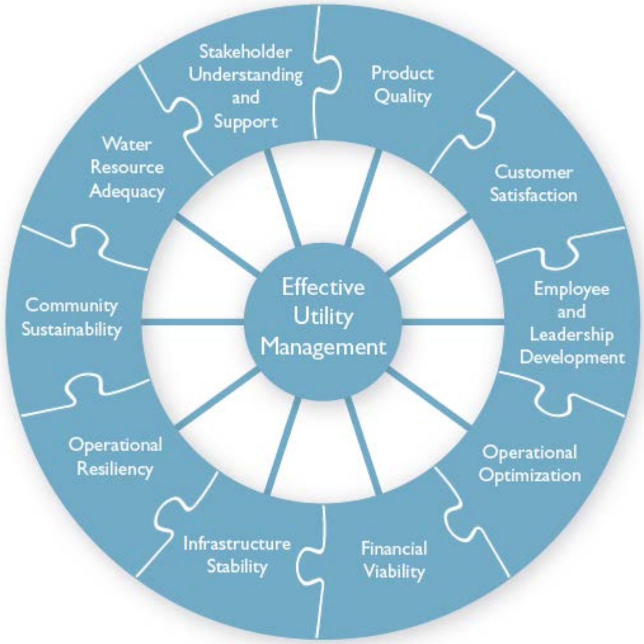
2.4. Public Community Water Supply Systems

Most of New Jersey residents and businesses receive their drinking water from public community water supply (PCWS) systems – only approximately one-seventh of residents are supplied by private, on-site wells. Chapter 3 provides more detailed information on the PCWS systems supplying northern New Jersey.

USEPA's Clean Water and Drinking Water Infrastructure Sustainability Policy (2010) notes:

> "Sustainable water infrastructure is critical to providing the American public with clean and safe water. Further, water infrastructure can only be sustainable if the communities it serves are sustainable, and if local decision makers and citizens understand the value of water infrastructure and the services provided."

This policy statement recognizes the close link between the infrastructure and the community it supports. USEPA and a number of professional and utility associations are promoting the concept of Effective Utility Management, including national asset management practice concepts (USEPA 2008). For both water supply and wastewater utilities, they identify ten attributes of effectively managed water sector utilities (see Figure 2.5).



Ten Attributes of Effectively Managed Water Sector Utilities

Figure 2.5 Effective Utility Management Cycle (USEPA, 2008)

However, to date benchmarks and acceptable levels are lacking for most of these ten attributes other than regulatory requirements such as drinking water quality. Therefore, utilities generally approach issues of sustainability from the perspective of ongoing utility operations and budgets.

Two generally accepted measures of utility sustainability are:

a) ***Public Water Supply System Net Available Capacity***: Related to USEPA's concepts of *Infrastructure Stability* and *Water Resource Adequacy*, a useful measure of system available capacity is the Net Surplus/Deficit Analysis of a water supply system, defined as the firm capacity (i.e., the ability to meet demands during periods of foreseeable system limitations), contracted imported supplies (less contracted exported supplies) minus its highest monthly demand during recent years. Net Available Capacity may be increased by reducing peak demands, including by conservation, or by augmenting supply through a new source or contract. Projected Net Available Capacity can be defined as the total capacity of a water supply system minus its highest projected monthly demand during the period of interest. New Jersey routinely maintains and provides to the public a Deficit/Surplus Analysis for PCWS systems, and tracks water supply contracts between water supply systems.

b) ***Water System Reliability***: Related to USEPA's concepts of *Product Quality*, *Infrastructure Stability*, and *Operational Resiliency*, water system reliability must be considered separately from nominal system capacity. Nominal capacity is irrelevant if the water cannot be used for its intended purpose due to contamination, or cannot reach its intended user due to treatment or delivery system failure. National standards exist for delivered drinking water quality, as adopted by USEPA. However, there are no national standards for system reliability regarding consistency of delivery. Several asset management programs do exist which help ensure that infrastructure is maintained[7] in a manner that minimizes lifecycle costs. Doing so avoids situations where investments and maintenance are deferred, creating short-term rate benefits while imposing long-term rate shocks and higher overall costs. However, each asset management program is a process, rather than a regulatory threshold (USEPA, 2012a). A sustainable system is one that provides the required service at lowest lifecycle costs with rates that can be absorbed by the affected community without economic dislocation or inequity. Part of reliability involves ensuring that critical infrastructure is protected from extreme weather events and other causes of catastrophic failure. Resiliency is another aspect of reliability, where systems are capable of coming back up to acceptable operating parameters when damage does occur.

Although New Jersey has some general regulatory requirements regarding asset conditions, it has not implemented a rigorous system of sustainable utility management; the concept is being explored but many utilities do not apply national state-of-the-art approach, and few if any that do have fully implemented their programs.

2.5. Public Sewerage Systems

Each public sewerage system has a unique set of components (e.g., pipelines, pumps, wastewater treatment plants, discharge points). Most systems rely on gravity rather than pumping to ensure waste flow, and so service areas tend to mimic small watersheds. Ownership is almost entirely governmental in nature, ranging from municipal departments to regional authorities. Older urban areas often have combined sewer systems, in which sewage and stormwater are combined. During wet weather events, stormwater inflows to these systems can generate combined sewer overflows (CSOs), where raw sewage mixed with stormwater is discharged with minimal treatment, such as control of larger solids and floatable materials, or at best limited treatment for pathogens. New Jersey has over 200 CSOs, most in the urban northeast, while other states such as Pennsylvania and New York have many more (e.g., Philadelphia has roughly 1500). In general, the intent of public sewerage systems is to be able to meet routine and peak system demands while ensuring that effluent quality and environmental impacts remain adequate at all times. Such systems must also be capable of continuing service during natural disasters and quickly recovering service when damage does occur.

The Effective Utility Management concepts described in Section 2.4 are relevant also to wastewater systems. The lack of available benchmarks and thresholds for sustainability likewise is an issue for these utilities. Two generally accepted measures of wastewater utility sustainability are:

a) ***Sewerage System Net Capacity***: Related to USEPA's concepts of *Water Resource Adequacy* and *Product Quality*, one measure of system capacity is the available capacity, calculated as system design or planning flows minus peak flows. The type of the system guides the selection of appropriate peak flows. Systems with CSOs would focus more on peak daily flows, as these trigger the greatest water quality problems due to discharges of highly contaminated effluent. Other systems may focus more appropriately on monthly, seasonal or annual flows. In any case, the capacity of the wastewater treatment plant to accept flows is a factor. NJDEP uses two different systems statewide, with a separate approach for CSOs. The Water Quality Management Planning (WQMP) Rules requires that Wastewater Management Plans compare projections of future demands against total system capacity using annual average flows[8]. The Capacity Assurance Program

[7] See USEPA's discussion of asset management: http://water.epa.gov/infrastructure/sustain/asset_management.cfm

[8] This comparison of projected flows to total capacity is temporarily in abeyance until early 2014 as a result of 2012 legislation, but is still a valid issue for long-term planning purposes.

compares the Maximum Three-month Average Flow (MAX3MO) against total system capacity and requires that facilities exceeding 80% prepare a Capacity Assurance Plan (CAP) to ensure continuing compliance with the NJPDES discharge permit for the facility. The Highlands Regional Master Plan (Highlands Council, 2008a) also uses the MAX3MO metric but for purposes of wastewater management planning; this approach is more stringent than the WQMP rules (and is not directly affected by changes in the Water Quality Planning Act).

b) ***Wastewater System Reliability***: Related to USEPA's concepts of *Product Quality*, *Infrastructure Stability*, and *Operational Resiliency*, wastewater system reliability must be considered separately from system capacity. Nominal capacity is irrelevant if the treated wastewater violates water quality standards, or the wastewater cannot even reach the treatment plant due to system failure or CSOs. National standards and policies have been adopted by USEPA for maintaining effluent quality, prohibiting sanitary sewer overflows and regulating CSO discharges. However, there are no national standards for system reliability regarding pipeline breaks that prevent collection and delivery to the treatment plant. The resulting discharge would then be subject to enforcement penalties, but not so the lack of maintenance that caused the break in the first place. As with drinking water infrastructure, asset management programs do exist, but as noted, asset management is a process, rather than a regulatory threshold (USEPA, 2012a). A sustainable system is one that provides the required service at lowest lifecycle costs with rates that can be absorbed by the affected community without economic dislocation or inequity. Part of reliability involves ensuring that critical infrastructure is protected from extreme weather events and other causes of catastrophic failure. Resiliency is another aspect of reliability, where systems are capable of coming back up to acceptable operating parameters when damage does occur.

As with water supply, New Jersey has not implemented a rigorous system of sustainable wastewater utility management; the concept is being explored but many utilities do not apply national state-of-the-art approach, and few that do have fully implemented their programs.

2.6. Public Stormwater Systems

More difficult to determine is the sustainability of separate stormwater systems (i.e., those that are not combined sewers), including net capacity. Stormwater systems include collection systems, storage facilities (e.g., detention, retention and infiltration basins), treatment (which may occur in the storage facilities), and discharge points. Stormwater systems rely on gravity to ensure flow, and each specific system tends to serve small catchment areas within larger watersheds as a means of minimizing pipe sizes and transport distances to surface waters. Urban and large suburban municipalities may have hundreds or even thousands of individual stormwater outfalls to various water bodies.

Most stormwater conveyance pipelines are not designed to capture and convey the largest storms, but rather the somewhat more common storms (e.g., 25-year storm). Stormwater basins are generally designed to handle much larger events such as the 100-year storm to avoid overtopping; emergency spillways address larger events. In either case, the stormwater system generally is designed for the development it supports, and therefore net (available) capacity often is zero, especially regarding on-site components within developments. New development that generates more stormwater may require reconstruction of the local stormwater system.

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. 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 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. This program incorporates Federal regulations that address stormwater pollution, sediment control and system maintenance to a limited extent through municipal stormwater permits and construction permits. Upgrades to facilities may occur over time; where a repair is needed to an existing stormwater facility or system, that repair must be made to meet current rules. However, 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 storm intensity increases with climate change, as anticipated, the existing standards will no longer achieve their intended purpose.

Unlike drinking water and wastewater infrastructure, 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. Stormwater systems are provided limited maintenance at best, primarily regarding removal of debris from gutters and catch basins in the more highly developed areas. Generally, maintenance occurs to correct system failure such as subsidence, street flooding, etc. While many states authorize stormwater utilities to generate revenues necessary for improved stormwater management, New Jersey has no stormwater utilities and little if any statutory support for them.

Integrated sustainability thresholds and metrics for stormwater were not found in the literature. Sustainable stormwater systems require that the system routinely and effectively function to meet modern expectations for water quality, stream integrity and neighborhood protection at the lowest lifecycle cost. There are no national standards for effective and sustainable stormwater management, though some local stormwater utilities have implemented effective programs. New Jersey has no comparable programs beyond the minimums required by the USEPA's National Pollutant Discharge Elimination Program for municipal stormwater systems.

2.7. Equity issues related to water resources and water infrastructure

Historic urban areas of Northern New Jersey tend to have older water infrastructure, including all of the combined sewer systems in the region. Water supply and sewer lines can be over a century old. These areas were developed long before modern concerns with water quality and watershed integrity. Many streams were channelized or simply buried in combined sewers, and few if any have good ecosystem integrity. Wetlands were filled and developed (e.g., Newark Liberty Airport) as were floodplains.

Newer suburban areas, conversely, have newer water infrastructure built to more modern standards (though still not to the most current standards in most areas), and in many areas retain a significant portion of their wetlands, floodplains, streams and ecosystem integrity (though major losses did occur through the 1960’s to 1980’s). Rural areas have even more undeveloped land and natural ecosystems, though water quality problems may still exist from rural land uses such as intensive agriculture.

Wealth distribution is significantly skewed toward the more modern suburban and exurban areas, with the cities and inner ring suburbs and some rural areas have significantly lower average household incomes and accumulated wealth. As such, the developed areas with the greatest legacies of infrastructure disinvestment and environmental damage also tend to have the fewest financial resources to address those problems. These disparities in environmental quality, infrastructure integrity and fiscal capacity raise major problems of equity.

2.8. Planning and Policy Context

This section provides an overview of the major actors and their roles, key state and regional plans and policies, and important public resources and incentives available for water resources management.

2.8.1. Water Availability

2.8.1.1. Key actors/roles in water resources

There are five key actors within the water availability field, four of which have direct regulatory authority. The key actors do not include those who withdraw water, as they have no specific role in determining or allocating available water. The federal government has no regulatory role in water availability, but the U.S. Geological Survey is an important source of field data and scientific evaluation used by the other agencies.

Table 2.1 Key Actors and Roles in Water Availability

Key Actors	Roles
NJ Department of Environmental Protection (NJDEP)	NJ Statewide Water Supply Plan Water Allocation Rules and Withdrawal Data Aquifer and watershed monitoring and modeling
Highlands Water Protection and Planning Council (Highlands Council)	Highlands Regional Master Plan, including the Net Water Availability analyses and planning process
Pinelands Commission	Pinelands Comprehensive Management Plan
Delaware River Basin Commission (DRBC)/ Consent Decree Parties/ Office of the Delaware River Master	Water Allocation Rules 1954 U.S. Supreme Court Decree on water supply
U.S. Geological Survey (USGS)	Aquifer and watershed monitoring and modeling NJ Hydrologic Alteration Tool development (ELOHA)

2.8.1.2. Key state and regional plans and policies

The NJ Statewide Water Supply Plan is the primary state-level planning and policy document for water availability. The current plan dates from 1996, with the new plan pending release. NJDEP regulations provide specific policies for water availability, as does the Highlands Regional Master Plan. Both plans and regulations differentiate among water sources.

Reservoirs are required to provide releases (passing flows) to maintain downstream flows. The release flows are set either by statute or by the individual water allocation permit from NJDEP, and in general are static low flows rather than ecologically based flows. Safe yields are established by NJDEP for each major reservoir or reservoir system; the calculations also use these static passing flows rather than ELOHA-based flows. The Highlands Regional Master Plan incorporates these safe yields by reference.

Confined aquifers in New Jersey are managed to maintain or restore potentiometric surfaces (an assessment of water pressure levels within the aquifer) so that saltwater intrusion is avoided or minimized. The Water Supply Management Act authorizes NJDEP designation of critical water supply areas where aquifers have been over-exploited, with the condition that NJDEP must ensure provision of alternative water supplies where it intends to require reduced aquifer withdrawals. The first such Water Supply Critical Area is located in the area of Monmouth and northern Ocean counties; it required 50% reductions in aquifer withdrawals from three confined aquifers in the area. Alternative supplies were provided from the Manasquan Reservoir for southern and central Monmouth County and a pipeline to northern Monmouth County from the Raritan System.

For surficial aquifers and streams not supported by reservoir releases, NJDEP and USGS have developed regional aquifer models for a number of surficial aquifers over the last 30-40 years, including several in northern New Jersey (e.g., the Central Passaic Buried Valley Aquifers in eastern Morris and western Essex Counties, the Lamington Buried Valley Aquifer in western Morris County, the Germany Flats Aquifer in the Sparta area of Sussex County, the Toms River/ Metedeconk watersheds in northern Ocean and southern Monmouth Counties).

Work on incorporation of the ELOHA concept is much more recent. The Highlands Regional Master Plan (RMP) incorporates protection and where feasible restoration of base flows to streams for ecosystem maintenance, using a "Low Flow Margin of Safety" (LFM) approach to protecting low flows. This approach was initially developed by the NJ Geological Survey of NJDEP and is being used also in the pending NJ Statewide Water Supply Plan. The LFM approach of the Highlands RMP relies in part on the ELOHA concept for establishing maximum consumptive/depletive withdrawals, including one threshold specifically for protection of sensitive ecosystems. Water Availability is defined for each HUC14 (now HUC12) subwatershed. The 1996 Statewide Water Supply Plan recommended limits on ground water withdrawals from surficial aquifers as a percent of average annual recharge to minimize the potential for stream flow reductions; this simple approach was recommended based on regional models available at the time but is limited in its technical basis. The pending NJ Statewide Water Supply Plan is expected to use an LFM approach very similar to the Highlands Regional Master Plan, but at the HUC11 (now HUC10) watershed level and with a single statewide threshold. This approach does not explicitly protect sensitive ecosystems except where it incorporates the findings and policies of the Highlands Regional Master Plan for Highlands Region watersheds. The Highlands results are regulatory in nature, while the Statewide Water Supply Plan is a policy document that must be implemented through other regulatory actions.

The Water Supply Management Act Regulations have narrative standards requiring proof that new or increased water allocations will not harm existing uses or the environment, though these standards are not directly linked to water availability as a concept – they are more focused on localized effects. The standards have been evolving as more scientific information has become available regarding links between surficial aquifers and stream flows. However, under the regulations the requirements for agricultural withdrawals are less rigorous than for other uses.

In addition, the Freshwater Wetlands, Flood Hazard Area Control, Highlands and Coastal Regulations of NJDEP regulate changes to critical land areas that affect ecosystem vitality and biodiversity within watersheds, with policies that relate to sustainability such as "no net loss of wetlands values." The Pinelands Comprehensive Management Plan and the Highlands Regional Master Plan establish more comprehensive requirements for new development within those regions, based on part on maintenance of riparian areas and other water-related land resources.

2.8.1.3. Key public resources and incentives

The 1981 Water Supply Bond Fund has for decades covered costs of NJDEP work on the NJ Statewide Water Supply Plan, aquifer studies, water supply feasibility studies, and infrastructure loans. The loan program was then integrated within the NJ Environmental Infrastructure Financing Program, a cooperative program of NJDEP and the Environmental Infrastructure Trust. The funds for planning and technical studies still exist. The Highlands Council has grant funds for conformance planning by municipalities and counties; these funds can be used for the development of Water Use and Conservation Management Plans to avoid, reduce or eliminate deficits in Net Water Availability.

2.8.2. Water Quality and Watershed Integrity

2.8.2.1. Key actors/roles in water resources

While state and interstate agencies play the primary roles in water quality and watershed integrity, responsibilities and authorities are widely disseminated within government. As with water availability, those responsible for pollutant discharges are not listed here, as they are recipients or targets of plans and regulations.

Table 2.2 Key Actors and Roles in Water Quality and Watershed Integrity

Key Actors	Roles
NJDEP	Surface Water Quality Standards Ground Water Quality Standards TMDLs (Total Maximum Daily Loads) Municipal Stormwater Management Rules, including Riparian Zone requirements Subwatershed Management Plans Wastewater Management Plans • Sewer Service Area Limitations • Septic System Density Requirements Pollutant Discharge Regulations (NJPDES Program) • Point Source Effluent Limitations • Municipal Stormwater Systems • Construction Stormwater Management Standards for Individual Subsurface Sewage Disposal Systems Flood Hazard Area Control Act Rules Freshwater Wetlands Protection Act Rules Coastal Permit Program Rules Underground Storage Tank Rules Hazardous Site Remediation Rules
Highlands Council	Highlands Regional Master Plan, with requirements for: • Forest Protection • Highlands Open Waters and Riparian Area • Steep Slopes • Critical Habitat • Carbonate Rock (Karst Topography) • Lake Management • Septic System Density • Wellhead Protection Areas
Pinelands Commission	Pinelands Comprehensive Management Plan, incorporating many requirements similar to the Highlands Regional Master Plan (primarily affects portions of Ocean County within the northern New Jersey region)
Delaware River Basin Commission	Surface Water Quality Standards Pollutant Discharge Requirements TMDLs (with USEPA)
NJ Dep't of Community Affairs/Site Improvement Advisory Board	Residential Site Improvement Standards
State Soil Conservation Committee/Soil Conservation Districts	Soil Erosion and Sediment Control Regulations Delegated Implementation of NJDEP Construction Stormwater Permit Rules
Municipalities	Zoning, Site Plan and Subdivision Ordinances Stream Buffer Ordinances (some) Steep Slope Ordinances (some)

2.8.2.2. Key state and regional plans and policies

NJDEP's influence in water quality and watershed integrity is very extensive, but largely through regulations that apply to site-specific pollutant sources and development proposals. Broader regulatory efforts are rarely achieved through plans, though TMDLs have been adopted and are being implemented in some areas through subwatershed-based water quality plans.[9] The Ground Water Quality Standards and the Surface Water Quality Standards are key regulations that incorporate parameter-specific and narrative water quality criteria, plus policies for maintenance and restoration of water quality. The NJPDES rules require compliance with these Standards for regulated point source discharges.[10] The Water Quality Management Planning Rules include an approach for determining actions necessary to restore surface water quality (TMDLs), to control the intensity of development on new septic systems and to avoid sewer extensions in environmentally sensitive areas. The Municipal Stormwater rules, the Soil Erosion and Sediment Control regulations (established jointly by the Departments of Agriculture and Environmental Protection) and the Residential Site Improvement Standards are closely aligned programs that address the design and construction standards for new stormwater systems, but do not require retrofit or maintenance of systems that were constructed prior to the rules. The NJPDES rules for municipal stormwater systems can result in retrofit of existing stormwater outfalls that cause stream erosion, but do not affect other parts of stormwater systems.

Various regulations address restoration of ground water quality from industrial contamination, and the NJPDES rules control current and potential pollutant discharges to ground water. The Underground Storage Tank rules have tank construction and monitoring requirements focused on prevention of discharges from existing and new tanks.

The DRBC regulations predate the existence of most environmental agencies in New Jersey but are similar in nature to existing NJ water quality programs, though primarily focused on the mainstem Delaware River.

The Freshwater Wetlands, Flood Hazard Area Control Act, Highlands and Coastal Regulations of NJDEP regulate changes to critical land areas within watersheds. The Pinelands Comprehensive Management Plan and the Highlands Regional Master Plan establish more comprehensive requirements for new development within those regions. As these programs regulate land development directly, they place significant controls on the creation of pollutant sources and damages to watershed integrity. The Soil Erosion and Sediment Control Act Regulations also control site-specific development methods to limit soil erosion.

Nearly all of these programs and requirements directly or indirectly affect municipal policies and actions regarding development regulation, but municipalities generally retain control of the specific zoning of land uses that are allowed, conditional or prohibited within specific areas. State regulations generally have more of an effect on bulk provisions and site development requirements, but in some cases (e.g., designation of sewer service areas) may fundamentally change the viability of land development.

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[9] A TMDL is a Total Maximum Daily Load, as defined by the federal Clean Water, and with its implementation program is essentially a water quality management plan for a specific contaminant.

[10] Septic systems are regulated separately, through the Standards for Individual Subsurface Sewage Disposal Systems (N.J.A.C. 7:9A), which are focused primarily on site suitability and construction standards for new and replacement systems, not water quality compliance per se.

The provisions noted in the Water Availability discussions above are also applicable regarding watershed integrity. However, there is no overarching set of targets and measures for watershed integrity.

2.8.2.3. Key public resources and incentives

The federal Clean Water Act has for decades covered some costs of NJDEP work on the water quality monitoring and planning, nonpoint source pollution control and infrastructure loans (and previously grants, which have since been eliminated). The State Revolving Fund loan program was then integrated within the NJ Environmental Infrastructure Financing Program. The federal funds for planning and monitoring studies still exist. NJDEP also receives funding from the Corporate Business Tax for water quality planning, monitoring, modeling and capital projects. Much of that funding was dedicated to watershed management plan development and implementation until the recent recession; essentially all of this constitutionally dedicated funding now supports NJDEP internal costs within the water programs. The Highlands Council has grant funds for conformance planning by municipalities and counties; these funds can be used for the development of conforming ordinances, but cannot support implementation of capital projects.

2.8.3. Public Community Water Supply Systems

2.8.3.1. Key actors/roles in water resources

State agencies play the major roles in regulation and oversight of public community water supply systems. As with water availability, those responsible for actual provision of water supplies are not listed here, as they are recipients or targets of plans and regulations.

Table 2.3 Key Actors and Roles in Public Community Water Supply Systems

Key Actors	Roles
NJDEP	Safe Drinking Water Act Rules, including the Drinking Water Quality Standards Well Construction Standards Water Allocation Rules Coastal Permit Program Rules
Highlands Council	Regulation of water supply service areas
Pinelands Commission	Regulation of water supply service areas
Board of Public Utilities	Regulation of public water supply rates by investor-owned water systems
NJ Dep't of Community Affairs	Regulation of public water supply budgets by municipal water systems and municipal utility authorities Residential Site Improvement Standards Uniform Construction Code

2.8.3.2. Key state and regional plans and policies

The Safe Drinking Water Act Regulations address requirements for construction and connection of new public community water supply infrastructure, adequate water line pressure to minimize contamination, and the quality of delivered water. These meet sustainability norms. Both the Uniform Construction Codes and Residential Site Improvement Standards have construction standards regarding water infrastructure plumbing and connections to protect human health when part of broader development projects. The regulations do not currently address ongoing maintenance of distribution systems other than broad statements of intent, but do affect the design and construction of any replacement infrastructure.

Controls over the financing of public community water supply systems are bifurcated in New Jersey, with the Board of Public Utilities having detailed oversight regarding the rates and profit margins of investor-owned utilities, while the Department of Community Affairs provides more general budget oversight of utilities that are owned by municipalities and municipal utility authorities. DCA (through the Local Government Review Board) provides more intensive oversight when a municipality or authority requests bonding beyond generally acceptable limits. NJDEP does not control utility rates or budgets.

The Well Construction Regulations in part minimize the potential for contamination of wells by pollutant sources at the land surface (e.g., requiring casing of at least 50 feet or into competent bedrock). Finally, the Water Supply Management Act Regulations have narrative standards requiring proof that new or increased water allocations will not harm existing uses or the environment, though these requirements currently are not directly linked to the concept of water availability as discussed previously.

The Highlands and Pinelands Plans and the NJDEP Coastal Permit Program have major implications for the extension of new water supply service areas, as such extensions will not be viable in areas that are designated for very low density growth.

2.8.3.3. Key public resources and incentives

The primarily public resources in the area of water supply utilities are for the management of such systems (primarily funded through rates) and for the regulatory process (primarily funded through permit fees). The NJ Environmental Infrastructure Finance Program provides low-interest loans to public community water supply systems to defray the costs of infrastructure needs, incorporating funds from the 1981 Water Supply Bond Act, State Revolving Funds from USEPA and the Environmental Infrastructure Trust.

2.8.4. Public Sewerage Systems

2.8.4.1. Key actors/roles in water resources

State and interstate agencies play the major roles in regulation and oversight of public sewerage systems. As with water supply systems, those responsible for actual provision of sewer services are not listed here, as they are recipients or targets of plans and regulations.

Table 2.4 Key Actors and Roles in Public Sewer Systems

Key Actors	Roles
NJDEP	NJ Pollutant Discharge Elimination System Rules Treatment Works Approval rules Water Quality Management Planning Rules Coastal Permit Program Rules
Highlands Council	Regulation of sewer service areas
Pinelands Commission	Regulation of sewer service areas
NJ Dept of Community Affairs	Regulation of sewer utility budgets by municipal sewer systems and municipal utility authorities Residential Site Improvement Standards Uniform Construction Code
Board of Public Utilities	Regulation of public sewer rates by investor-owned sewer systems

2.8.4.2. Key state and regional plans and policies

NJDEP's Treatment Works Approval and NJPDES regulations respectively address requirements for construction and connection of new sewer system infrastructure and for pollutant discharges of treated effluent. The Residential Site Improvement Standards and the Uniform Construction Code include additional requirements regarding construction of sewer infrastructure when part of broader development projects. None of these regulations provide clear guidance regarding ongoing maintenance of collection systems,[11] but the NJDEP rules do affect the design and construction of any replacement infrastructure.

Controls over the financing of public sewer systems are bifurcated in New Jersey, with the Board of Public Utilities having detailed oversight regarding the rates and profit margins of investor-owned utilities, while the Department of Community Affairs provides more general oversight of utilities that are owned by municipalities and municipal utility authorities. DCA (through the Local Government Review Board) provides more intensive oversight when a municipality or authority requests bonding beyond generally acceptable limits. Again, NJDEP has no authority over utility rates or budgets.

The NJDEP wastewater management plan requirements, Highlands and Pinelands Plans, and the NJDEP Coastal Permit Program have major implications for the extension of new sewer service areas, as such extensions will not be viable in areas that are designated for very low density growth. NJDEP is currently in the process of reviewing and approving revised sewer service area mapping for all of New Jersey (see www.nj.gov/dep/wqmp). Development proposals reliant on sewer extensions not allowed by NJDEP regulations will not be viable.

2.8.4.3. Key public resources and incentives

The primarily public resources in the area of sewer utilities are for the management of such systems (primarily funded through rates) and for the regulatory process (primarily funded through permit fees). The NJ Environmental Infrastructure Finance Program provides low-interest loans to public sewer systems to defray the costs of infrastructure needs, using State Revolving Funds from USEPA along with the Environmental Infrastructure Trust.

2.8.5. Public Stormwater Systems

2.8.5.1. Key actors/roles in water resources

State agencies play the major roles in regulation and oversight of stormwater systems, though many of these requirements are actually implemented through municipal ordinances and Soil Conservation District reviews. As with water supply and sewer systems, those responsible for actual provision of stormwater services are not listed here, as they are recipients or targets of plans and regulations.

[11] NJDEP rules do include general requirements that NJPDES permit holders and licensed operators must effectively maintain collection systems, but lack clear guidance. Recent evaluations have clearly identified shortfalls in utility operations regarding asset management, resulting in ongoing efforts by NJDEP to establish clearer standards and guidance. One component of this new effort is the requirement for asset inventories and assessments in the new draft individual CSO permits being issued by NJDEP.

Table 2.5 Key Actors and Roles in Public Stormwater Systems

Key Actors	Roles
NJDEP	Municipal Stormwater Management Rules NJPDES Municipal Stormwater Permitting Program Coastal Permit Program Rules
Highlands Council	Highlands Regional Master Plan
Pinelands Commission	Pinelands Comprehensive Management Plan
State Soil Conservation Committee/Soil Conservation Districts	Soil Erosion and Sediment Control Regulations
NJ Dep't of Community Affairs/Site Improvement Advisory Board	Residential Site Improvement Standards
Municipalities	Zoning, Site Plan and Subdivision Ordinances

2.8.5.2. Key state and regional plans and policies

The NJDEP rules affecting municipal stormwater planning and systems (NJAC 7:8 and NJAC 7:14A, respectively), the Residential Site Improvement Standards and the Soil Erosion and Sediment Control (SESC) regulations are closely aligned programs that address the design and construction standards for new and replacement stormwater systems. All but the SESC regulations are implemented primarily through municipal planning and development reviews, and in some municipalities the SESC requirements are also implemented locally rather than by a Soil Conservation District. These regulations do not affect the operations of existing stormwater systems. However, the NJPDES rules (NJAC 7:14A) for municipal stormwater systems can result in retrofit of existing stormwater outfalls that cause stream erosion. As discussed in Chapter 1, more attention is being given in recent decades to stormwater management methods that more closely mimic natural functions, such as maintenance of recharge, attenuation of peak flows and treatment prior to discharge. A multi-agency Best Management Practices manual describes many of these "greener" methods. A recent report by New Jersey Future describes some of the potential for and difficulties of implementing these methods on a broader scale (see http://www.njfuture.org/wp-content/uploads/2013/01/New-Jersey-Future-Statutory-Regulatory-Barriers-to-Green-Infrastructure-in-NJ.pdf).

Both the Highlands and Pinelands plans indirectly affect the construction of stormwater systems, as they determine which areas can receive development at a density that makes necessary the provision of stormwater systems.

2.8.5.3. Key public resources and incentives

The primarily public resources in the area of stormwater systems are for the management of such systems (primarily funded through municipal ad valorem taxes and, for on-site systems, by the relevant landowners) and for the regulatory process (primarily funded through permit fees). The NJ Environmental Infrastructure Finance Program provides low-interest loans to public stormwater systems to defray the costs of infrastructure maintenance or reconstruction needs, using State Revolving Funds from USEPA along with the Environmental Infrastructure Trust. A few municipalities have taken advantage of such funding to address specific retrofit needs, such as alteration of stormwater systems to protect local lakes and ponds.

2.8.6. Opportunities for integration of existing policies, plans and programs and relevance to the RPSD

There are several critical opportunities for integration that could provide significant benefits to the RPSD, as follows:

- ***Infrastructure Asset Management Programs*** – The foremost concern is that many water infrastructure systems are not being maintained and improved in a manner that minimizes lifecycle costs while providing appropriate services and environmental benefits. This is especially true of the “orphan utility” of stormwater systems, the only one that lacks a rate-based financing system. However, even many water supply and sewer systems are deferring maintenance and improvements as a means of reducing current rates. In some cases, municipal governing bodies are demanding and receiving payment of supposed “excess revenues” from municipal utility authorities that are used to reduce local property taxes; this process is legal but transfers cost burdens from property tax payers to utility customers and often results in more deferred maintenance. What most system decision-makers (though often not the utility executives) and ratepayers are ignoring is the potential for these deferred costs to result in later emergency repairs and projects with far higher costs and potential for disruption of local residents and businesses. The State and the utilities need to address both the public communication and utility management issues that result in poor asset management. In the absence of greatly improved asset management, older urban and suburban areas will be less viable locations for continued economic vitality and redevelopment.

- ***Watershed Management*** – A variety of regulatory programs at all governmental levels address water withdrawals, pollutant discharges and land uses, each in isolation from the others. In reality, all have direct implications for the quality and quantity of water resources available to support human uses and aquatic ecosystems. Improved decision making and management of the various regulatory programs requires integrated monitoring, evaluation, planning and implementation decisions. New Jersey is making progress in various aspects of this effort, such as Net Water Availability evaluations in the Highlands Regional Master Plan and pending NJ Statewide Water Supply Plan, and the recent Kirkwood/Cohansey Aquifer study in the Pinelands Area. Regarding water quality and watershed integrity, efforts funded by NJDEP and others to develop watershed management plans also have value. The Highlands Regional Master Plan, Pinelands Comprehensive Management Plan and NJDEP Coastal Zone Program rules also are critical components of this process.

  However, very little effort has occurred in the places where most people reside – the urban areas of northern New Jersey. Many examples exist in this and other countries of urban areas that have capitalized – literally – on water quality improvements that attract waterfront development and recreation. In New Jersey, waterfront revitalization in Perth Amboy and the Hudson “Gold Coast” are clear examples of economic benefits that depended on improved water quality. However, significantly more work is necessary to extend this potential into the Newark Bay and Arthur Kill areas.

  Further, there is no overarching State program that brings together all aspects of the issue – land development, water availability, water supply, sewer and stormwater systems, water quality and watershed integrity. In the absence of a broadly based program, efforts are likely to work haphazardly, at cross purposes or at best inefficiently.

- ***Utility Service Area Coordination*** – The history of water utility development in New Jersey makes it highly unlikely that we will see a significant degree of utility integration, though doing so would make sense. In looking across the rivers at Philadelphia and New York City, we can see the direct benefits of having water supply, sewerage and stormwater systems under unified management. Especially in CSO areas, stormwater reductions are sewage reductions, and water supply conservation also reduces sewage flows. The net effects are reduced costs for water supply and sewage infrastructure, reduced stresses on water availability, and improved water quality. In the absence of unified utility management, the next best level would be a formal program of coordination among the separate utility systems, with dedicated funding programs for stormwater management as authorized in over 30 other states. In the long run, the question is not whether we are going to pay for these services, but how and how much we are going to pay.

- ***Land Use Controls*** – Some State regulations are implemented at the municipal level, while others are not. The Pinelands and Highlands programs rely heavily on municipal conformance to regional plans, after which the implementation process becomes a local responsibility with agency oversight. During the 1990's, NJDEP attempted to develop a program under the Coastal Permit Program rules where urban municipalities could conform their rules to the coastal program and receive delegation of permit authority. While some regulatory programs require a significant level of technical expertise or professional judgment, others are well within the potential for municipal staff and consultants. The larger issue will be the difference in "norms." Municipalities are used to a regulatory process that allows for fairly routine granting of variances and waivers that would not be viable under State and federal regulatory programs; a much higher level of discipline is required. Still, New Jersey will benefit if the costs of development can be reduced while maintaining high environmental standards. Integration of specific State regulations into municipal ordinances, similar to the Pinelands and Highlands programs, could reduce the number of decisions for which direct State approval is required.

2.8.7. Summary

Water resources issues involve several critical components, some of which relate to the natural resource (water availability, water quality and watershed integrity) and some of which relate to the provision of utility services to the public (water supply, sewerage and stormwater). These components are not currently but must be managed through a comprehensive, integrated approach that does not favor one aspect over another. Further, the management of all components must be appropriately related to other societal needs for a high quality of life, equitable distribution of benefits and costs, economic viability.

3. Existing Conditions, Trends and Future Needs

3.1. Water Availability

As discussed in Chapter 2, water availability in New Jersey is calculated differently for reservoir systems (safe yields), confined aquifers (changes in potentiometric surface) and surficial aquifers (Low Flow Margin approach). Total water availability in each case is based on the method used, and does not change absent new data, new models or new methods. Therefore, there are no "trends" for total water availability. Rather, there are trends in net water availability – the total water availability minus water uses that do not return water to the system.

These uses are termed "consumptive" and "depletive." Consumptive withdrawals result in losses to evaporation (e.g., from cooling systems and irrigation) and transpiration (from plants). Consumptive loss percentages can range from very low (e.g., indoor household uses, non-evaporative cooling systems) to very high (e.g., agricultural and lawn irrigation, evaporative cooling systems). Depletive uses result in the transport of water across watershed boundaries as untreated water, potable water or wastewater. Depletive losses to the source water are always 100%, but the transported water can become an addition to the receiving water, if not discharged to the ocean or estuarine waters. However, roughly 80 percent of all wastewater from public sewerage systems is ultimately discharged to the ocean or estuarine areas.

This section provides an overview of demand patterns and trends, net water availability and areas showing significant current and future deficits, key issues regarding water availability, and management opportunities and concerns. It is important to note that a major source of new information, the anticipated NJ Statewide Water Supply Plan (NJSWSP), is not yet public, and therefore a large amount of useful information was not available for inclusion in this report. NJDEP public databases were used to recreate information that will be in the draft NJSWSP. However, estimation of Net Water Availability at the watershed (HUC-11) or any other scale was not feasible at this time.

3.1.1. Key water demand patterns and trends

NJDEP has created an extensive database of water withdrawals in cooperation with the US Geological Survey, the NJ Water Transfer Model (NJWaTr; NJDEP 2012d). NJWaTr tracks freshwater withdrawals and also the discharge of return flows by economic sector and by geographic area. It is a mass balance model, summing the withdrawals and discharges for each area rather than tracking specific water flows from "source to sink." The database covers the years 1990 to 2007, with years being added as data become available and are checked for quality and consistency. The database is considered more robust for recent years, with a critical point of 2003 when new data systems were put in place by NJDEP (noted as NJEMS database on Figure 3.2 below). Six freshwater "withdrawals" for hydropower generation are not included, which represent perhaps 40-50% of all water "withdrawals" in the state. However, hydropower uses generally are neither consumptive nor depletive, as the water passes through the power station essentially without loss. Estuarine water withdrawals for electric power generation are not included in the system, as they do not affect freshwater resources.

3.1.1.1. Per capita demands

Per capita demands indicate the efficiency of water use to meet needs. Figure 3.1 shows total and consumptive per capital demands. Both graphs calculate per capita demand based on all categories of water use – residential, industrial, commercial, mining and agricultural –a common approach. As shown in the top graph total demands have not dropped below 130 gallons per capita per day (gpcd) in the period from 1990 to 2007 except briefly in response to the 2002 drought. Meanwhile, per capita consumptive/depletive demands have gradually increased, reflecting increased lawn and agricultural irrigation uses, as shown in the bottom graph.

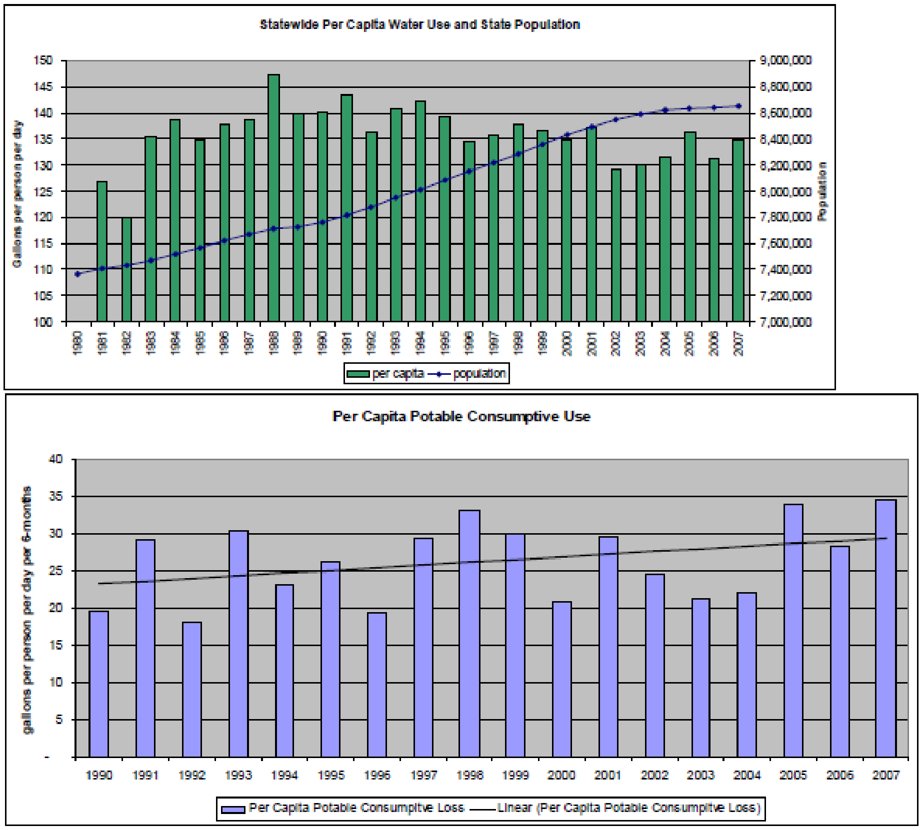


Figure 3.1 Total and Consumptive NJ Potable Water Use Per Capita (derived from NJDEP 2012d)

Anecdotally, a number of water purveyors in developed areas have reported a decline in per capita water use to roughly 60-75 gpcd for residential purposes during the non-growing season, but a significant increase in summer water use, most likely for lawn and garden irrigation, pools, etc. Roughly 60 percent of potable water demands are met by surface water supplies; the other 40 percent are met by aquifers (ground water).

3.1.1.2. 1990-2007 demand trends by economic sector

As can be seen in Figure 3.2, annual water withdrawals in New Jersey are dominated by potable water supplies. In recent years, the demands for agricultural and commercial/ industrial/mining withdrawals have been nearly equal, with agriculture somewhat lower. Irrigation other than agriculture and potable water supply is primarily related to golf courses. Total withdrawals in 2007 for all four purposes were approximately 530 billion gallons per year, or an average of roughly 1.45 billion gallons per day.

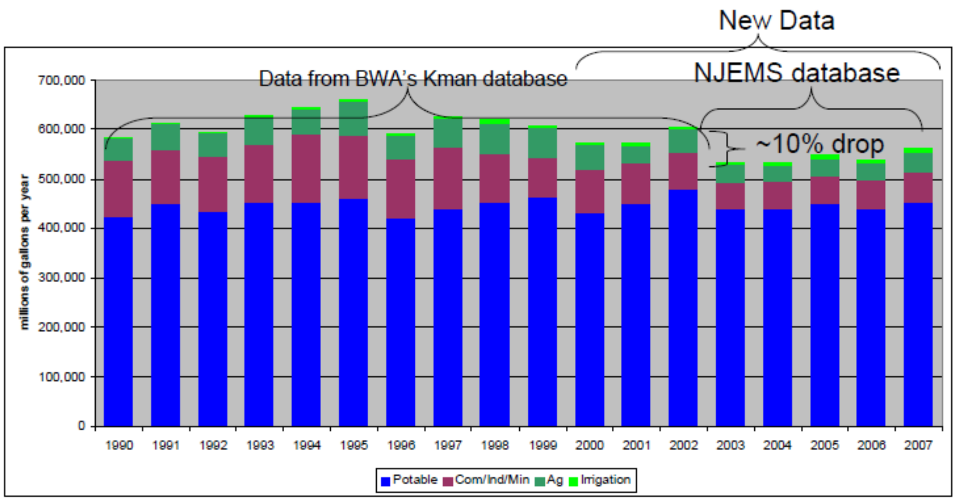


Figure 3.2 Annual NJ Water Withdrawals without Power Generation (derived from NJDEP 2012d)

However, total withdrawals can overstate the environmental impact of water use, as some water is used and then returned to the same subwatershed or watershed. Consumptive use indicates how much water is not returned to any water body. Figure 3.3 shows consumptive water use for the various sectors. As can be seen, potable uses still dominate, primarily reflecting consumptive losses due to lawn irrigation in the summer, but the proportions attributed to agricultural and non-agriculture irrigation uses are much higher than in Figure 3.2. The consumptive use totals are approximately 95 billion gallons per year, or 18% of total withdrawals of 530 billion gallons per year. The vast majority of consumptive losses occur during the summer, due to lawn and agricultural irrigation, at a time when aquatic and riparian ecosystems most need water.

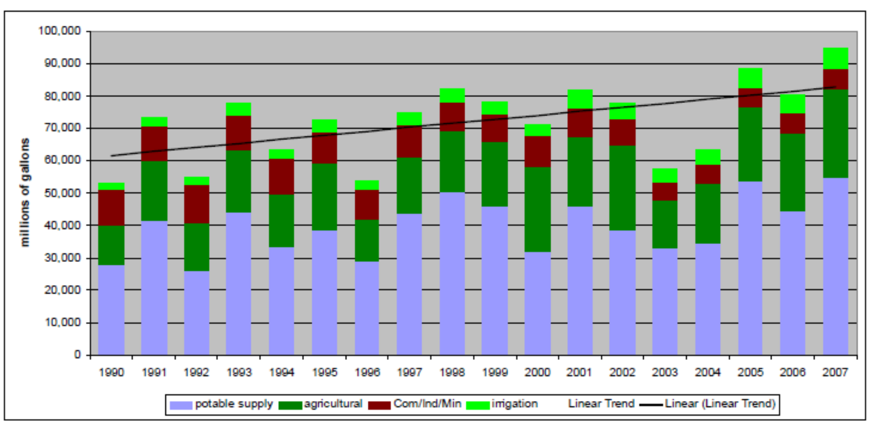


Figure 3.3 Annual NJ Consumptive Uses (derived from NJDEP 2012d)

A comparison of 1990 and 2007 charts in Figure 3.4 provides a good overview of how total and consumptive water uses have changed, though it is important to recognize that the recent data are more robust than the 1990 data. An important point is that the relative importance of commercial/industrial/mining withdrawals has decreased a great deal for both total and consumptive uses, while both potable and agricultural withdrawals and consumptive uses (the latter being related to irrigation) have significantly increased. During this period, low density suburban development in New Jersey has greatly increased (Haase and Lathrop, 2010), and agriculture water demands have increased to produce more sod, ornamental shrubs and other valuable crops that now constitute a majority of gross sales from New Jersey farms.

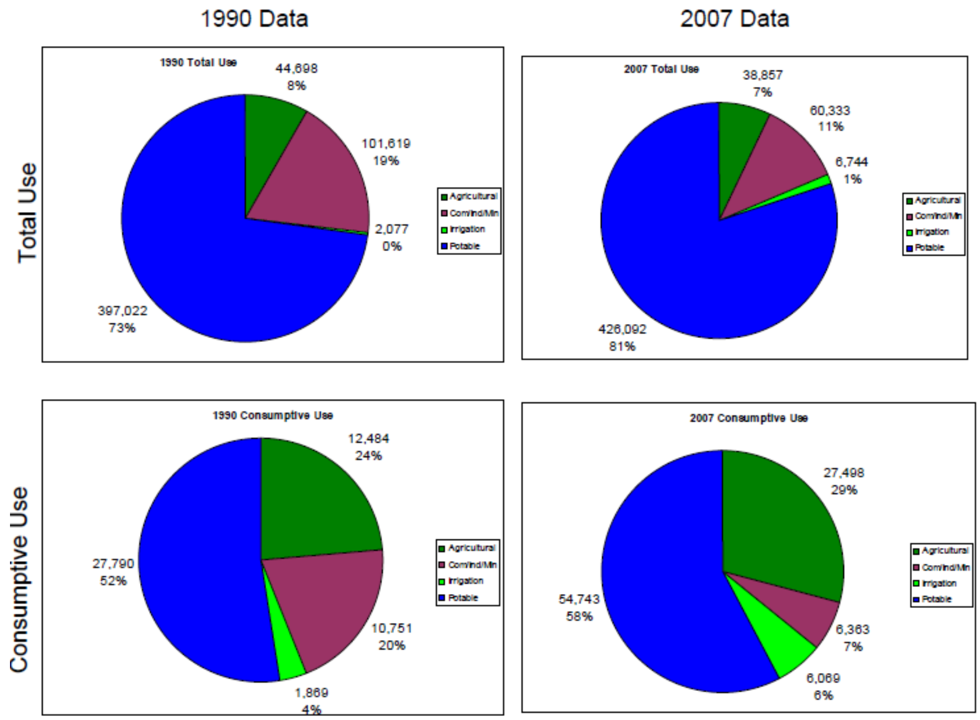


Figure 3.4 Total and Consumptive NJ Water Use, 1990 and 2007 (derived from NJDEP 2012d)

3.1.1.3. 1990-2007 demand trends by region

The NJWaTr model tracks water uses by watershed. Two examples are provided below from the northern New Jersey area, for the Hackensack and Pascack WMA in Figure 3.5 and the Monmouth County WMA in Figure 3.6. As can be seen in both sets of graphs, potable water use is nearly the only water use. The consumptive use for "irrigation" is primarily golf courses, which are more prominent in Monmouth County. These total use and consumptive water use relationships are typical of highly developed suburban and urban areas. The graphs also indicate the complexity of water availability issues. The 2002 total withdrawals for the Hackensack WMA are significantly lower than normal but the consumptive losses are higher, while the 2002 total and consumptive withdrawals for the Monmouth County WMA are lower. 2002 was a drought year when uses were restricted to conserve water, which shows clearly for the Monmouth County WMA. However, the Hackensack WMA is interconnected with the Upper Passaic WMA and derives considerable drought supply from that area (from the Wanaque South Project on the Pompton River). The result could be that the withdrawals within the WMA were reduced but imports from the Upper Passaic WMA were increased, which may account for the increase in consumptive use within the WMA.

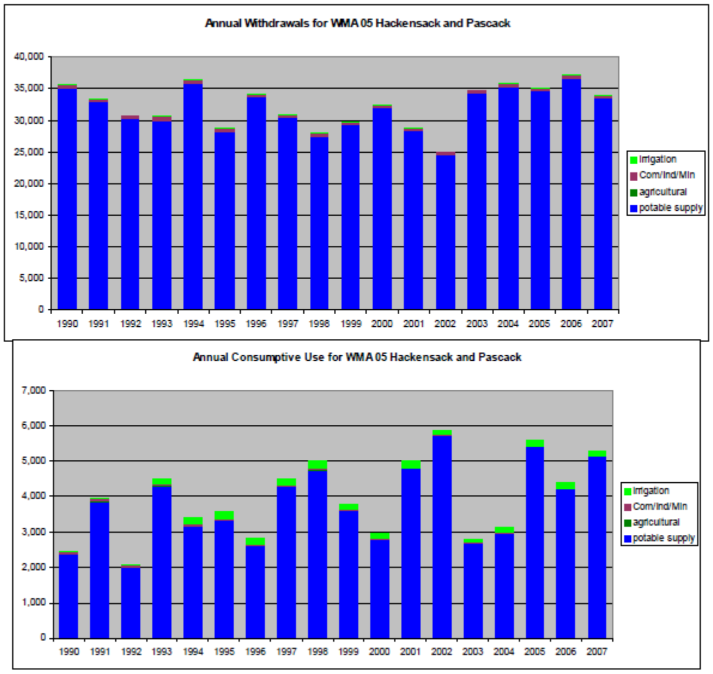


Figure 3.5 Total and Consumptive Annual Water Use, WMA5 (derived from NJDEP 2012d)

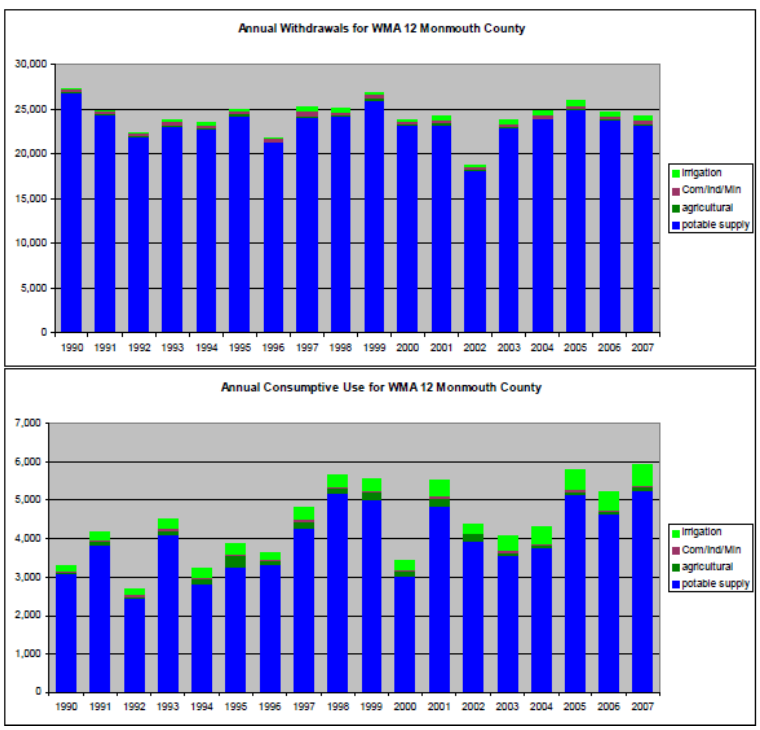


Figure 3.6 Total and Consumptive Annual Water Use, WMA12 (derived from NJDEP 2012d)

Figure 3.7 provides an overview of annual consumptive and depletive water uses in the 151 watersheds of New Jersey for 1990 and 2007. It is important to note that the gains shown in the coastal waters are essentially artificial, reflecting wastewater discharges into ocean and estuarine areas, which as noted previously have represented roughly 80% of all public wastewater discharges. Although the system tracks these coastal discharges, the wastewater is not available for reuse unless redirected from the discharge. For the actual watersheds, comparison of 1990 to 2007 shows some additional areas of significant losses in northern New

Jersey (the orange and red areas), primarily in northern Bergen County, eastern Middlesex County, western Morris County and northern Ocean County. It is important to note that these losses are not necessarily a problem – they represent a summary of consumptive/depletive water uses, not an evaluation of net water availability.

3.1.2. Needs and disparities under existing conditions

To determine whether the demands summarized above represent a current problem, we must compare them to the total available water relevant to the demands. The assessments are derived separately for each of three major water sources: reservoirs; surficial aquifers; and confined aquifers. Demands from estuarine and saline waters for industrial cooling are not addressed here, nor are demands for once-through uses (including hydroelectric power generation) that discharge back to the same water body and have no consumptive component; essentially, the accounting process does not "see" these non-consumptive uses. While there certainly are important links among them, the calculation of available water for each includes approaches for assuring either that water withdrawals from one have no unacceptable impacts on the others, or that unacceptable impacts are incorporated in the assessment. As such, the total available water for a region is roughly the sum of water availability for each of the three, though improved modeling approaches will allow for more accurate assessments in the future. Demands are then assessed against these measures of water availability to determine net water availability from each.

3.1.2.1. Reservoir Systems

The pending NJ Statewide Water Supply Plan is not available as of this writing. However, safe yields are rarely revised and so the most recent public information is valid for use here. The surface water supply systems that own reservoirs in northern New Jersey are shown in Table 3.1, with the largest systems shown in bold. Of these, United Water-NJ and NJ American Water Company are investor-owned water utilities while the others are state, state/local hybrid or municipal agencies. This group of utilities supplies the most urbanized areas in the region and would be best positioned to support major redevelopment if water remains available.

Table 3.1 Northern New Jersey Safe Yields (Largest to Smallest)

Surface Water Supply System	Reservoir or Reservoir System	Nominal Safe Yield (MGD)
NJ Water Supply Authority (NJWSA) **(Raritan System)**	Round Valley and Spruce Run Reservoirs, Delaware & Raritan Canal	**241**
North Jersey District Water Supply Commission (NJDWSC)	Wanaque Reservoir, Monksville Reservoir and Wanaque South Project and river intakes	**173** (proposed to be increased to 190)
United Water-NJ	Hackensack System	**77** (plus 39.5 MGD from Wanaque South Project)
Passaic Valley Water Commission	Point View Reservoir and river intakes	**75**
Jersey City (City of)	Boonton and Splitrock	**56.8**
Newark (City of)	Pequannock System (five reservoirs)	**49.1**
NJ Water Supply Authority (Manasquan System)	Manasquan Reservoir	30
NJ American Water Company (Monmouth County System)	Swimming River Reservoir Glendola Reservoir	21.5 11.1 (plus 5.4 from NJWSA)
Brick Township Municipal Utilities Authority	BTMUA Reservoir	17
NJ American Water Company (Canoe Brook System)	Four pumped storage reservoirs	10.8

Table 3.1 Northern New Jersey Safe Yields (Largest to Smallest)

Surface Water Supply System	Reservoir or Reservoir System	Nominal Safe Yield (MGD)
Butler (Town of)	Kakeout Reservoir	6
Boonton (Town of)	Taylortown Reservoir	1.5
Southeast Morris County Municipal Utilities Authority	Clyde Potts Reservoir	<1
Newton (Town of)	Lake Morris	No listing

Most of the largest systems serve their customers directly with treated water (retail services). United Water-NJ is concentrated in Bergen County. Newark and Jersey City serve their own cities (with United Water-NJ operating the Jersey City system through a public/private contract), but also provide bulk treated water to surrounding municipalities. Passaic Valley Water Commission serves primarily the Passaic County cities of Clifton, Passaic and Paterson. NJ American serves three regions. Their Raritan Basin system depends almost entirely on bulk water supplies from the NJWSA Raritan System, and so is not listed in Table 3.1 as NJ American owns no reservoirs in this river basin. In Monmouth County, NJ American has its own reservoirs (the largest of which is Swimming River Reservoir) but also draws heavily on the NJWSA Manasquan Reservoir in southern Monmouth County. NJWSA has no direct service area in either the Raritan or Manasquan areas, being entirely a provider of bulk untreated water.[12] North Jersey Water Supply Commission is the other major water system that for the most part does not provide water directly to a service area, but rather provides treated water to other entities for distribution through their own systems. NJDWSC customers consist of 12 member municipalities and water systems with the distribution of currently approved allocations as shown in Table 3.2, based on the current safe yield of 173 MGD:

Table 3.2 North Jersey District Water Supply Commission Customers

Customer	Allocation (MGD)	Customer	Allocation (MGD)
Bayonne	10.500	Montclair	4.700
Bloomfield	6.510	Passaic	10.340
Cedar Grove	1.200	Newark	49.400
Clifton	6.345	Nutley	3.000
Glen Ridge	0.705	Wayne	9.000
Kearny	13.000	United Water	39.500

A significant point in the NJDWSC allocations is that Newark's share (49.4 MGD) essentially equals the safe yield of its own Pequannock System (49.1 MGD). However, Newark also has many municipal customers, which makes understanding the available supply for the City of Newark itself somewhat complicated.

The critical question, then, is whether any of these systems have available capacity for growth beyond current demands. This issue is addressed below in the section on Public Community Water Supply Systems, which assesses information from NJDEP's Deficit/Surplus analysis for public community water supply systems. As the pending NJ Statewide Water Supply Plan is not yet available, information regarding future demands is limited. However, New Jersey Geological Survey (NJGS) prepared an analysis for the Highlands Council of 2030 growth projections for water systems outside of the Highlands that utilize water from within the Highlands (Highlands

[12] However, NJWSA does operate a small (4 MGD) water treatment plant under contract from the Southeast Monmouth Municipal Utilities Authority (SMMUA), using Manasquan Reservoir water, which supplies part or all of five customer municipalities.

Council 2008c). Based on then-available population projections for 2030 (prior to the 2010 Census), only Jersey City and Newark were projected to have demands nearing or reaching their total available supplies within the period. The pending NJ Statewide Water Supply Plan uses a 2025 planning period, and therefore even when available for use, this report will not have detailed information available on projected needs through the entire RPSD planning period of 2040.[13] Therefore, this report also provides in Section 3.2.2 a preliminary analysis based on 2035 projections with a focus on municipalities with the greatest projected growth.

3.1.2.2. Surficial Aquifers, Existing Deficit Areas

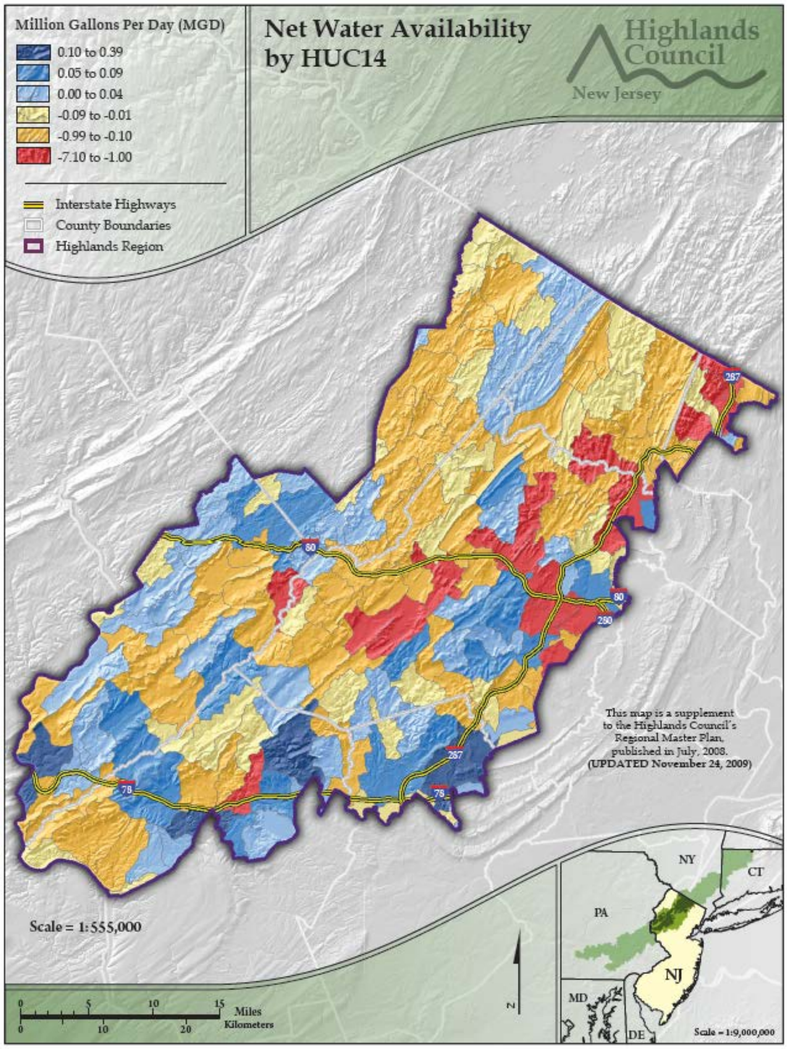
Of the three methods for water availability analysis discussed in Chapter 2, only one, the Net Water Availability (Low Flow Margin of Safety) approach using the ELOHA concept, has the potential to provide comparable information on available water across regions of the state. Site-specific evaluations of water allocation applications are inherently localized. Regional aquifer models are based on varying interpretations of thresholds for aquifer sustainability and therefore are not comparable. However, as the pending NJ Statewide Water Supply Plan has not yet been released, statewide information regarding Net Water Availability and potential deficits is not yet available.

Information is available from the Highlands Regional Master Plan regarding deficits in Highlands Region subwatersheds; these results will be incorporated into the NJ Statewide Water Supply Plan as required by the Water Supply Management Act. The detailed methodology for calculation of Net Water Availability in the Highlands Region can be found in Highlands Council (2008c) and is not repeated here. Figure 3.8 shows that of the 183 subwatersheds in the Highlands Region, 114 are in deficit. Highlands Council (2008c) shows that the deficits range from minimal to over 7 MGD, a very large amount for a single subwatershed. Net Available Water in surplus subwatersheds likewise ranges from minimal values and up, but the largest positive values are 0.39 MGD. As a result, the Regional Master Plan imposes management requirements and constraints on new uses that are subject to the Highlands Act.

A small portion of the Together North Jersey region is also within the Pinelands National Reserve, which has been the focus of a major study of the Kirkwood/Cohansey aquifer system by the U.S. Geological Survey on behalf of the Pinelands Commission and NJDEP, to evaluate the effects of surficial aquifer use on Pinelands ecosystems. This study has been completed. Next steps involve determination of how the model will be used in a regulatory and planning context. Deficit areas and quantities have not yet been defined.

[13] Projections to 2035 are used in this report as the approved NJTPA population projections. A comparison to 2040 projections may be developed to determine the extent to which modifications are needed to findings of this report.

Figure 3.8 Net Water Availability by HUC14 (Highlands Council, 2008 as amended)



3.1.2.3. Confined Aquifers, Existing Deficit Areas

In northern New Jersey, the only major confined aquifers are in the Coastal Plain areas of eastern Middlesex County and all of Monmouth and Ocean Counties. Water Supply Critical Area #1 in Monmouth and northern Ocean Counties was designated by NJDEP to address depressed and declining potentiometric surface (water pressure levels) that threatened the aquifers with saltwater intrusion from both the Raritan Bay and the Atlantic Ocean. A 50 percent reduction in water withdrawals was imposed on ground water withdrawals from the affected aquifers, which resulted in the desired improvements. Alternative supplies were provided from reservoirs, including the new Manasquan Reservoir. These aquifers appear to have improved to levels that should prevent future problems but apparently cannot support renewal of past uses, according to presentations before the Water Supply Advisory Council. Therefore, increased water demands in this region must be met through surface water supplies, including but not limited to the Manasquan Reservoir and interconnections with the Raritan System. Conjunctive use of surface water and confined aquifer systems, where each source is used during its lowest period of stress, may also provide additional yields without compromising protection of the aquifers.

3.1.3. Needs and disparities under future projections

3.1.3.1. Water Availability Projections

As the pending NJ Statewide Water Supply Plan has not yet been released, information regarding projected water availability deficits is not yet available. Therefore, at this time the only available detailed information is for the Highlands Region.

The Highlands Council evaluated the build-out potential in the region (Highlands Council, 2008b). Build-out projections assess complete development potential using several zoning density scenarios, and may be higher or lower than population projections developed regionally or at the state level. Build-out projections are higher when available land is more than enough to accommodate projected population within a specific time period, and they are lower when land availability constrains projected growth. The build-out results were based on two scenarios: existing zoning (without application of the Highlands Act or Regional Master Plan (RMP)), and Highlands conformance (land development in conformance with the development density requirements of the Highlands RMP). The report found that Net Water Availability would constrain 27% of the 6 MGD of new demand under the first scenario, but only 2% of the 1.4 MGD in new demand under the RMP conformance scenario. Put another way, development based on the pre-existing (2005) zoning would worsen existing deficits in many subwatersheds, while conformance with the RMP would greatly lessen the potential for worsening deficits.

3.1.3.2. Implications of 2035 NJTPA projections

Water supply demand projections and the resulting wastewater generation are usually based on population projections, though these do not incorporate any major industrial demands that may occur. However, based on recent trends in New Jersey it is reasonable to assume that most industrial demands will be in existing industrial locations, at rates that are not higher than prior years. The North Jersey Transportation Planning Agency has formally adopted population projections for the region from 2010 through 2035. As shown in Table 3.3, the total population is projected to grow by over 18%, or 1.2 million people. More important is the location of this growth. As shown on the right hand column (in **bold**), other than Ocean County, the greatest shares of the region's growth are expected to occur in already urban counties – Bergen, Essex, Hudson, Middlesex and Passaic.

Table 3.3 Population Growth Projections by County (from NJTPA)

County	2010 Population	2035 Population	Growth 2010-2035 (%)	Growth 2010-2035 Net	Growth 2010-2035 % of Region
Bergen	905,116	1,024,300	13.2%	119,184	**9.8%**
Essex	783,969	899,800	14.8%	115,831	**9.6%**
Hudson	634,266	781,100	23.2%	146,834	**12.1%**
Hunterdon	128,349	147,800	15.2%	19,451	1.6%
Middlesex	809,858	989,700	22.2%	179,842	**14.8%**
Monmouth	630,380	717,900	13.9%	87,520	7.2%
Morris	492,276	523,500	6.3%	31,224	2.6%
Ocean	576,567	776,300	34.6%	199,733	**16.5%**
Passaic	501,226	609,000	21.5%	107,774	**8.9%**
Somerset	323,444	371,000	14.7%	47,556	3.9%
Sussex	149,265	196,600	31.7%	47,335	3.9%
Union	536,499	621,200	15.8%	84,701	7.0%
Warren	108,692	134,200	23.5%	25,508	2.1%
Grand Total	**6,579,907**	**7,792,400**	**18.4%**	**1,212,493**	**100.00%**

These are also areas with major existing surface water supply systems serving nearly all the heavily developed areas, unlike Ocean County which relies heavily on aquifers (other than the Brick Township MUA Reservoir). However, the availability of additional supplies for these areas varies; the systems are highly interconnected, complicating evaluations in the Passaic and Hackensack River watersheds especially. Bergen County is heavily dependent on United Water-NJ, which has a history of significant drought problems despite its interconnection with North Jersey District Water Supply Commission (NJDWSC). An increase in the NJDWSC safe yield to 190 MGD (an increase of 17 MGD) could allow United Water-NJ to increase its contract with the NJDWSC. Essex and Passaic Counties are also potentially affected by the same safe yield issue. The Passaic Valley Water Commission cities are NJDWSC customers, and Newark is a major customer that in turn provides supplies to many other municipalities. Hudson County relies on Jersey City supplies for a significant portion of its supply; the Jersey City system is also drought sensitive and as noted above, prior demand projections by the NJ Geological Survey indicated a potential shortfall in safe yield by 2030. However, it is important to note that the major Passaic River Basin water suppliers are linked through the Great Notch Interconnection, which allows for transfers among the utilities in case of need. NJDEP is working on a major safe yield model to provide a combined analysis of all the affected systems, which will greatly improve system management. However, completion of this complex model is not expected until 2015 at best.

Middlesex County has a significant water supply advantage, as it is served primarily by the NJ Water Supply Authority's Raritan System, which has ample safe yield and also several viable projects for increasing that safe yield (unlike the Passaic and Hackensack systems, which do not). Parts of Union and Monmouth Counties are served by the NJWSA Raritan System as well, and opportunities exist to increase supply opportunities to the Passaic through expansion of an existing interconnection in Newark.

While Net Water Availability information is not yet available statewide for the surficial and confined aquifers, we do know that Water Supply Critical Area #1 is constrained by law and designation regarding use of its confined aquifers. The Lamington Buried Valley Aquifer System (western Morris County) and the Central Passaic Buried Valley Aquifers (eastern Morris County and western Essex and Union Counties) are also known to be constrained based on prior water allocation permit cases. The latter aquifer systems are entirely or mostly within the Highlands Region and therefore subject to Highlands RMP restrictions pursuant to the Water Supply Management Act.

3.1.4. Key factors likely to influence future trends and the region's ability to address needs and disparities

3.1.4.1. Regulatory and planning application of Net Water Availability concepts

As discussed in Chapter 2, water availability is an evolving concept, which only recently has included explicit consideration of ecological maintenance. This evolution is not complete, and agencies differ in how to apply the concept. NJDEP has stated that the Net Water Availability calculations will be used to determine where requests for increased or new water allocations must include more detailed proofs that the requests will not harm other uses, aquifers, streams and estuaries. However, they might not use the Net Water Availability deficits as a "bright line" regulatory tool, where failure to mitigate or eliminate the calculated deficit will result in permit denial. Based on discussions with the Water Supply Advisory Council, NJDEP also intends to use the NJ Statewide Water Supply Plan as a basis and justification for developing plans for specific watersheds to reduce or eliminate deficits, to avoid situations where designation of new critical areas would be required.

The Highlands Regional Master Plan uses the Net Water Availability calculations as "bright line" regulatory tools. Developments and water allocation permit requests entailing water uses that would increase a deficit not only must meet requirements to avoid that deficit increase, but must establish a means by which the deficit will be reduced based on formulas in the RMP. The Highlands Council is also using the Net Water Availability results as the basis for developing Water Use and Conservation Management Plans to avoid, reduce or eliminate the deficits – these plans are required for all subwatersheds.

As such, both agencies intend similar use of Net Water Availability for planning purposes, but differ in their regulatory approach for new or increased water allocations; this distinction is based in law, as the Highlands RMP is specifically intended to be a regulatory tool, while the NJ Statewide Water Supply Plan is clearly a policy document that can only have regulatory implications to the extent that separate regulations are adopted by NJDEP. As noted above, the Pinelands Commission has not determined the approach it will use regarding water availability, which could affect allowable land development densities and future water allocations. How the new concept of Net Water Availability is applied, and whether the concept is retained in the face of drought or development pressures, will make a major difference in water availability in this region.

3.1.4.2. Protection of reservoir safe yields

Reservoir safe yields are highly dependent on inflowing water from tributary streams, and on release (or passing) flow requirements. Protection of inflows requires that consumptive and depletive water uses upstream of the reservoir not increase, or that flow mitigation be achieved, such as by increased recharge in compensation for increased losses. The NJDEP has denied allocations where stream flows to a reservoir or surface water intake would be reduced. Highlands Council has used mitigation approaches in decisions regarding proposed new or increased water allocations in similar situations. Another approach applied by NJDEP is to require that the new user compensate the reservoir owner for the loss of safe yield, essentially by becoming a customer. Regardless of the method used, reservoir safe yields are essential thresholds for determining available water to nearly all of northern New Jersey's urban areas.

Another perennial threat to reservoir safe yields comes from demands that reservoirs maintain a void space for flood control. None of New Jersey's reservoirs were constructed for this purpose, lacking the necessary discharge mechanisms to quickly create voids in advance of storms. Therefore, the only feasible method of creating significant void space is to do so long-term. Given that safe yields are calculated from a point where the reservoir is at its maximum capacity, if void space is routinely required, the safe yields are no longer valid and must be reduced. The owners would need to be compensated for the lost ability to supply water during droughts, drought declarations and conservation mandates would be more frequent, and the region would face a higher potential for running out of water in a severe drought. Unfortunately, the creation of any void space that doesn't destroy the reservoir's value for water supply will have little effect on floods; based on modeling work done to date, the reservoirs are either too small or too distant from the major flood areas to be useful, or both.

3.1.4.3. Water supply development projects

As briefly mentioned above, all of northern New Jersey's significant potential water supply projects are in the Raritan Basin. There are no significant options for new water supply projects in either the Passaic River Basin or the Hackensack River watershed. The Delaware River Basin is regulated under the 1954 Court Decree, with essentially all of the available depletive water use for New Jersey being allocated to the Delaware & Raritan Canal. New Jersey municipalities can take water from Delaware River Basin supplies under the condition that the wastewater be discharged back into the watershed, so that only consumptive losses occur. The only significant water supply project planned for the Delaware Basin that would benefit New Jersey is actually in Pennsylvania (the F.E. Walter Reservoir Project) and requires an amendment to the interstate compact that has been contemplated but not achieved for decades. It is unlikely to occur.

The Raritan Basin is a different case. Three major projects are potentially feasible. One is the Confluence Pumping Station, which would pump water from the confluence of the North and South Branches of the Raritan

River up to Round Valley Reservoir. The costs are within reason, but an issue has been raised regarding potential water quality changes in the reservoir (which is designated as Category One waters) due to the pumping. A water quality model will be required to determine whether the issue is valid. The second project is the Kingston Quarry Reservoir, which would store excess water from the Delaware & Raritan Canal in the quarry pits (Franklin Township, Somerset County). This project is highly effective and would not have water quality issues, but must wait for completion and closure of the quarry, which could take decades. The third and most problematic project is the Six Mile Run Reservoir in Franklin Township, which would impound water from that stream, a tributary of the Millstone River. Construction of a new reservoir raises significant issues regarding loss of habitat, the shallow nature of much of the reservoir, and possible pollutant loadings from the agricultural soils within and urban areas upstream of the reservoir.

3.1.5. Challenges and Opportunities

One major challenge for demands against water availability is that per capita water demands in New Jersey have not significantly changed despite decades of efforts to conserve water using improved building codes, better irrigation practices, etc. As noted in Figure 3.1, above, total demands have not dropped below 130 gallons per capita per day (gpcd) in the period from 1990 to 2007 except briefly in response to the 2002 drought. Meanwhile, per capita winter demands are declining in many locations, while consumptive demands have gradually increased, reflecting increased lawn and agricultural irrigation uses. These trends put a major burden on water resources and potable water systems to provide sufficient water during peak summer months, and especially during droughts. Reservoir systems tend to be highly sensitive to summer demand peaks, as this season is also a time of reduced stream flows into the reservoirs and increased evaporation from the reservoir surface.

The other major challenge will be explicit and meaningful incorporation of ecological considerations into water availability calculations and water allocation regulations. While important to New Jersey, it is clear that during drought periods heavy emphasis will be placed on providing water for human needs.

However, both of these challenges also constitute opportunities. Regarding per capita demands, there are many opportunities to reduce residential lawn irrigation demands, reduce water losses from water supply infrastructure, increase the efficiency of agricultural water uses, and continue reduction of indoor water demands through water conserving devices and appliances. Incorporation of ecological issues in the water allocation process can lead to improved or sustained water ecosystems, with significant societal benefits. As can be seen, all of these opportunities will entail significant challenges in their implementation.

3.2. Water Quality and Watershed Integrity

3.2.1. Key patterns and trends

New Jersey has monitored surface water quality for decades, in both fresh and saline waters. The freshwater monitoring system has grown to address the standard physical/chemical parameters as well as indicators of biological health using macroinvertebrates and fish tissue sampling.[14] The evolution of the monitoring network has changed not only what is monitored, but where monitoring occurs and how the results are interpreted. Where the water quality at a sampling site was at one time associated only with the nearby waters, statistical tests and relationships to land use patterns are now used to associate monitoring results with the general status

[14] Freshwater beach monitoring is conducted by local health officials and the results are not compiled at the state level.

of subwatersheds. This shift is in response to USEPA interest in assessing the chemical, biological and physical health of watersheds, rather than just individual monitoring stations, and also reflects major advances in GIS information about watershed land uses. The NJDEP report (now called the New Jersey Integrated Water Quality Monitoring and Assessment Report) has become focused primarily on the subwatershed interpretations with lists of subwatersheds that show impairment or not.

> "The Surface Water Quality Standards establish stream classifications and the designated uses for all waters of the State. Designated uses include aquatic life support (maintenance, migration, and propagation), recreation, fish consumption, shellfish harvest for consumption, drinking water supply, industrial water supply, and agricultural water supply. The Department assesses each applicable designated use for all of the State's 952 subwatersheds (assessment units), to determine whether each subwatershed is "fully supporting" the use, "not supporting" the use, or if insufficient information is available to assess the use." (NJDEP 2012a)

Saline water monitoring has long been focused on bathing beaches and shellfish areas, the latter as a critical step in determining whether the beds should be open under state and federal law to shellfish harvesting, and under what conditions. Monitoring here includes a number of parameters but has an emphasis on indicators of pathogens and algal blooms that would endanger public health directly or indirectly. Additional monitoring is focused on water quality in areas affected by coastal sewage discharges, especially in areas with Combined Sewer Overflows and areas that are part of the National Estuary Program (Delaware Bay, Hudson/Raritan Estuary and Barnegat Bay).

Surface water is far easier to monitor than ground water. Ground water quality patterns and trends are not as well understood. Unlike streams, most ground water does not flow in discrete channels. Unlike lakes and coastal waters, ground water is not readily accessible for sampling. Three general types of ground water monitoring data exist in New Jersey. First, and smallest, is a network of wells to monitor natural ground water quality as a baseline for understanding natural contaminants to drinking water, contamination problems in other locations, etc. By definition, natural contaminants at natural levels do not violate the Ground Water Quality Standards (GWQS). Second is the monitoring of contaminated sites; these monitoring locations are determined on a site-specific basis, data are collected solely for the purpose of assessing sites and developing and tracking cleanup measures, and the data are not compiled in a general database. However, the data are used to determine ground waters (mapped as areas, but representing volumes) that violate the GWQS for industrial contaminants, resulting in the designation of Classification Exception Areas where remedial efforts are ongoing, and other known contamination areas.

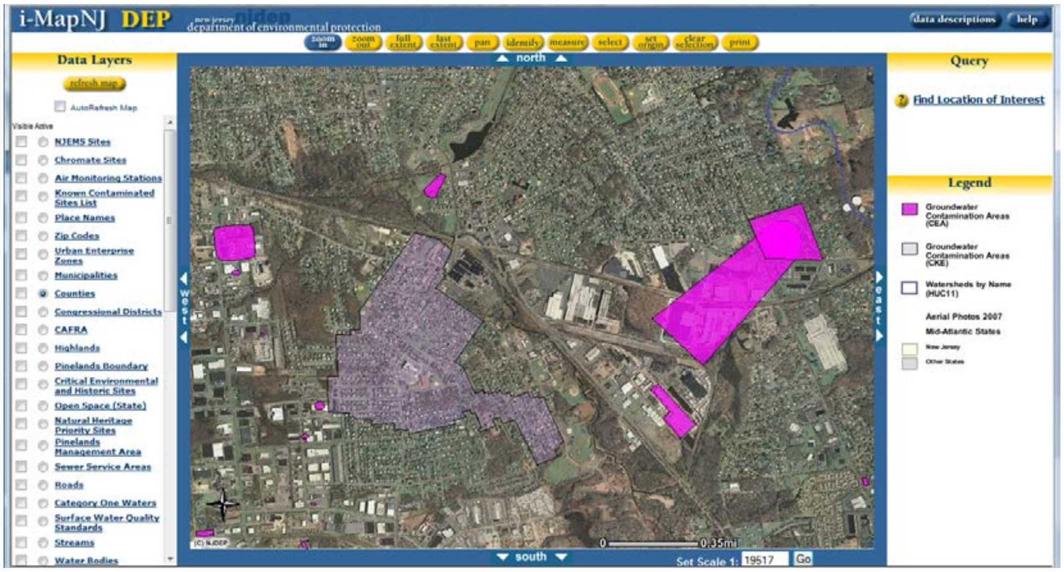


Figure 3.9 Example Classification Exception Areas and Ground Water Contamination Areas (from NJDEP i-Map, http://www.nj.gov/dep/gis/depsplash.htm#)

The third category is a more recent program compiling monitoring data from residential wells tested as required by the Private Well Testing Act (at time of property transfer). The precise locations associated with the monitoring data are confidential, though aggregated results are compiled by NJDEP at the municipal scale, as in Figure 3.10, an example from Middlesex County; assessments at this level are sufficient for a regional evaluation. The condition and characteristics of the wells often are not known, raising some issues about data quality. Still, the database is enormous (over 50,000 individual wells from 2002 to 2007) and growing, which enhances the utility of the data. NJDEP estimated that over one-fifth of all private wells in New Jersey had been tested under this program as of 2009. Additional information on the results is provided in the following section and can be reviewed at NJDEP's web site for the program. (http://www.nj.gov/dep/dsr/pwta/index.htm)

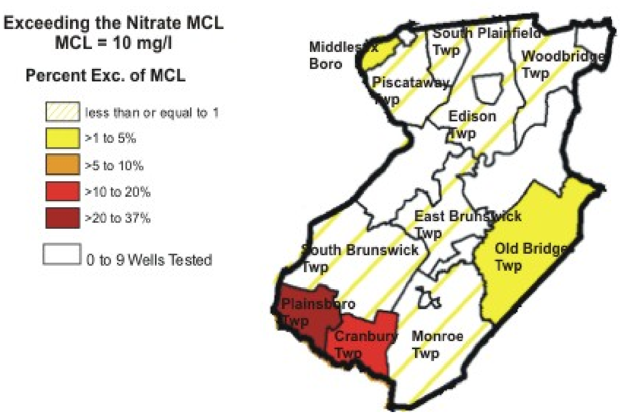


Figure 3.10 Middlesex County Nitrate Concentrations in Ground Water (NJDEP, 2009)

3.2.1.1. Water quality trends and key parameters

As shown in Figure 3.11 from NJDEP, 2012a, the northern New Jersey region falls within a large number of Watershed Management Areas (WMAs, primarily those numbered 1 through 13), each of which is comprised of multiple watersheds. WMAs 3, 4 and 6 comprise the Passaic River Basin. The Raritan River Basin includes WMAs 9, 10 and 11. The Upper and Central Delaware are WMAs 1 and 11, while the Wallkill River watershed is WMA 2, the Hackensack River watershed is within WMA 5 (along with a portion of the Hudson River drainage), WMA 7 has Newark Bay and Arthur Kill drainages, and WMAs 10 and 12 are coastal drainages.

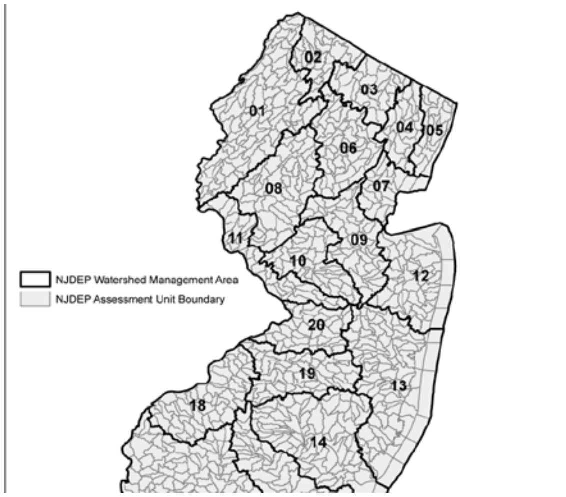


Figure 3.11 NJ Assessment Units and Watershed Management Areas, 2010 (NJDEP, 2012a)

As noted above, NJDEP (2012a) reports that the best water quality is located within the least developed parts of the state (with "development" including both urbanized development and agricultural development). USGS studies for the Raritan Basin Watershed Management Project found that higher water quality is correlated with high percentages of forested lands (NJWSA, 2002).

In Water Quality Inventory Reports through the 1990's, chemical data indicated that many surface water monitoring stations were showing significant improvements in water quality while many others showed declining water quality. Most of those showing improvements were downstream of discharges from public sewer system or industrial treatment plants (point source discharges), and the improvements reflected the closure or improved treatment of these systems through the 1970's and 1980's, and into the 1990's. Many of those showing degradation were upstream of all major point source discharges, and were primarily affected instead by nonpoint sources, the ubiquitous small sources associated with land uses, roads and personal habits such as littering and yard care.

The Draft 2012 New Jersey Integrated Water Quality Monitoring and Assessment Report (NJDEP, 2012b) is the most recent such report and provides the best sense of current water quality issues in New Jersey. The results of the 2012 report are based on data from 2006-2010, and are summarized in Figure 3.12.

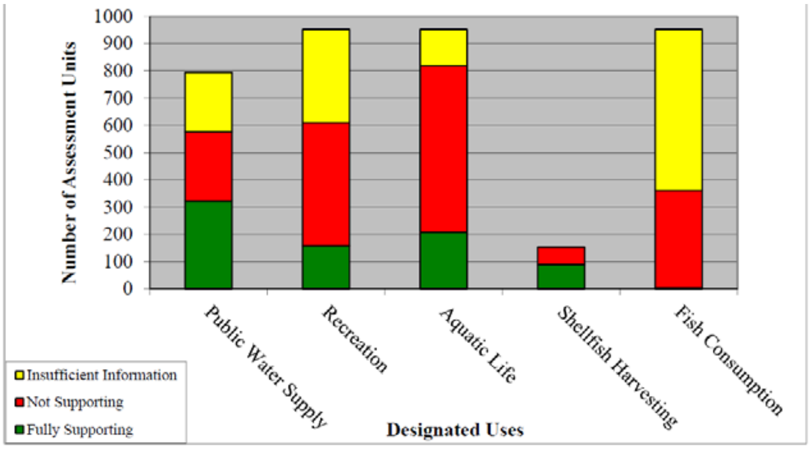


Figure 3.12 Draft Designated Use Assessment Results for 2012 (NJDEP, 2012b)

Nearly all streams and lakes are non-supporting for at least one designated use, even when fish consumption problems (primarily related to mercury or PCB contamination) are excluded. Major water quality concerns include nutrient over-enrichment, elevated bacteria levels, and elevated temperatures (primarily regarding trout production waters, all of which are in northern New Jersey), as shown in Figure 3.13, which also indicates the proportion of waters for which Total Maximum Daily Loads (TMDLs) have been developed; TMDLs are essentially water quality improvement plans based on modeling and assessments.

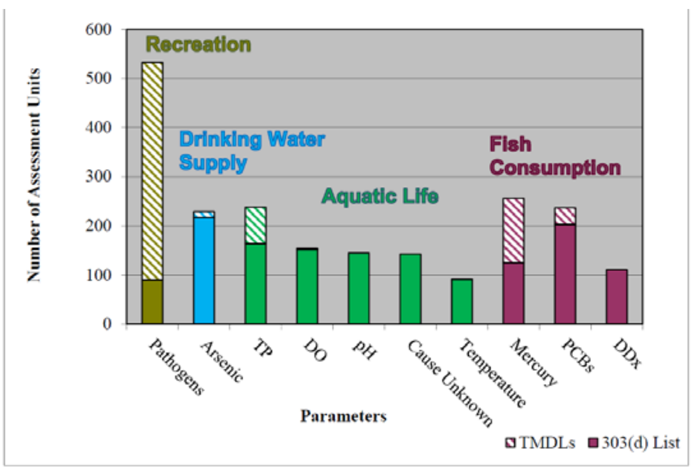


Figure 3.13 Top Ten Causes of Water Quality Impairment (NJDEP, 2012b)[15]

Coastal water monitoring for bathing beaches and shellfish harvesting within this region is concentrated in Monmouth and Ocean Counties in the Raritan Bay, Atlantic Ocean and back bay areas. Shellfish harvesting is supported without restrictions in 60 percent of shellfish waters, and supported with restrictions in another 30 percent, for a total of 90 percent that can be harvested in some manner. This level is greatly improved from decades ago, in large part due to improvements and closures in coastal sewage treatment plants. Ocean bathing beaches also show significant improvements, with essentially all now fully supporting the designated use. Bathing beaches on the estuarine bays show more frequent non-support due to stormwater discharges (NJDEP, 2012b).

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[15] TP=Total Phosphorus; DO=Dissolved Oxygen; DDx=degradation products of DDT

The final 2010 New Jersey Integrated Water Quality Monitoring and Assessment Report (NJDEP 2012a) provided a summary of trends in freshwater quality and biological indicators:

> "Water quality trends in rivers and streams indicate that water quality in New Jersey has improved dramatically over the past 30 years, likely the result of elimination of point sources, upgrades in wastewater treatment and natural attenuation of toxic substances. Long-term trends in chemical water quality data show generally stable water quality conditions statewide, with improving conditions for some parameters (e.g., total phosphorus) and declining conditions for others (total dissolved solids and nitrates). Long-term water quality data also show that nutrient levels and dissolved oxygen conditions statewide have significantly improved over time. …
>
> "Analysis of biological data over the past ten years indicates that water quality has generally remained stable with a slight negative trend. Almost as many stations are showing improvement as are exhibiting degradation over a ten-year time period. Biological data also indicate a correlation between benthic macroinvertebrate community impairment and different physiographic land types, land uses, and other anthropogenic factors such as total urban land, total upstream wastewater flow, increase in impervious surface, and decrease in forests and wetlands in a stream's drainage basin. Biological data for fish communities also showed a correlation between impairment and human activity, such as increased impervious cover, siltation, and increased run-off from stormwater outfalls.
>
> "While overall statewide water quality has improved or remained stable over time, localized changes in water quality also occur and they are usually associated with changes in land use. Generally, water quality declines as the intensity of land use increases; this applies to agricultural uses as well as urban/suburban development."

The Draft 2012 report (NJDEP, 2012b) amplified on these findings (see Figure 3.14), noting that "The 1998 to 2007 trend analysis results show that water quality conditions remained relatively stable (i.e., no trend observed) for all constituents except TDS [Total Dissolved Solids], nitrate, and TP [Total Phosphorus]. TDS and nitrate results over this time period indicate declining conditions, while TP results indicate overall improving conditions – even though TP is still one of the top ten most frequent pollutants on the 2012 303(d) List." TDS in water creates stresses for aquatic organisms, while nitrates are of concern for drinking water quality and TP is a primary cause of eutrophication (excessive plant growth) in fresh waters.

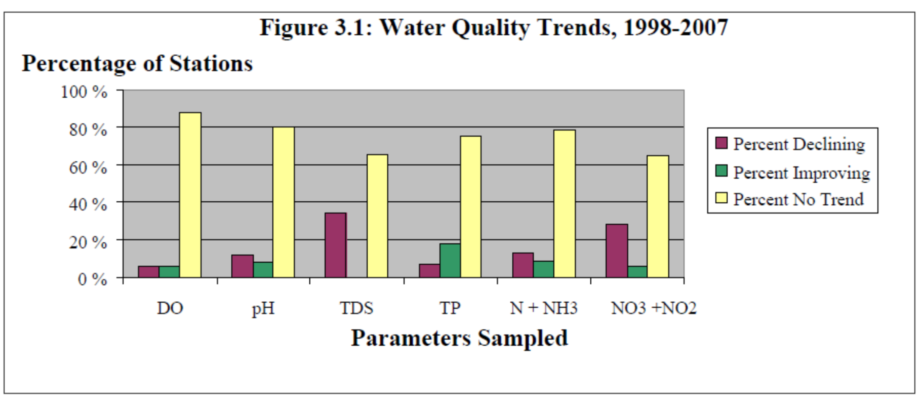
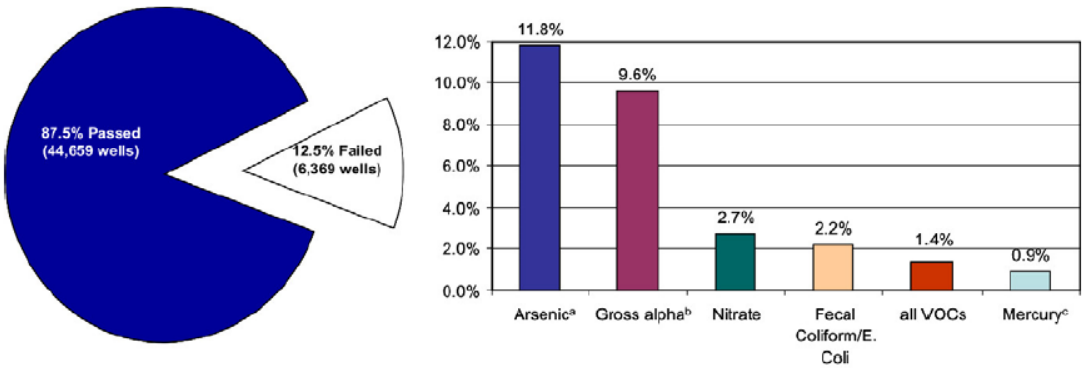


Figure 3.14 Water Quality Trends, 1998-2007 (NJDEP, 2012b)

The Private Well Testing Act data cannot be used as easily for trend analysis, as the sampled wells are not the same from year to year. However, the NJDEP report (NJDEP, 2008) indicated that 12.5% of the wells failed for at least one parameter. Figure 3.15 shows the primary contaminants of concern based on the first five years of data from over 50,000 wells (see Figure 3.16). Arsenic, a natural contaminant, is a significant issue in northern New Jersey. Gross alpha is an indicator of radium, also a natural contaminant. In these cases, natural contaminants at natural levels do not violate the GWQS, though in a water supply they may violate the drinking water quality standards.

The remaining contaminants of greatest concern are related to human activity. Nitrates result primarily from fertilization and septic systems. Fecal coliform is an indicator of pathogenic bacteria, also from human sources but sometimes from livestock. VOCs, or volatile organic chemicals, are industrial chemicals that have been discharged from manufacturing sites or points of use. Mercury is primarily a concern in southern New Jersey, including Monmouth and Ocean Counties.



a. Ten counties were required to test for arsenic: Bergen, Essex, Hudson, Hunterdon, Mercer, Middlesex, Morris, Passaic, Somerset and Union. A total of 12,263 wells were test for arsenic using a sensitive analytic method.
b. Twelve counties were required to test for gross alpha: Atlantic, Burlington, Camden, Cape May, Cumberland, Gloucester, Hunterdon, Mercer, Middlesex, Monmouth, Ocean and Salem. A total of 22,904 wells were tested for gross alpha.
c. Nine counties were required to test for mercury: Atlantic, Burlington, Camden, Cape May, Cumberland, Gloucester, Monmouth, Ocean and Salem. A total of 25,270 wells were tested for mercury.

Figure 3.15 Statewide Summary of Private Well Testing Act Results for Primary Drinking Water Standards, September 2002-April 2007, of 51,028 Wells (NJDEP, 2008)

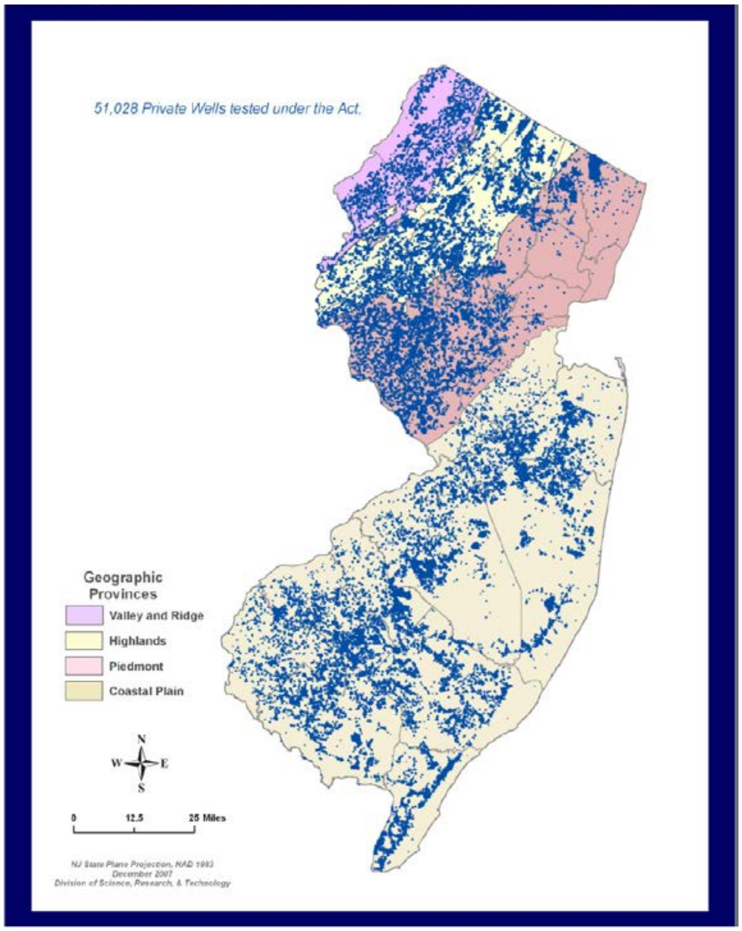


Figure 3.16 Wells Sampled and Submitted to the PWTA Program (NJDEP, 2008)

The following two figures (3.17 and 3.18) show the results for fecal coliform bacteria and nitrates, as the two most common anthropogenic contaminants. The nitrate violations tend to be more concentrated in southern New Jersey, within areas that have or recently had intensive agriculture. The fecal coliform bacteria violations are more widespread, and would be associated more frequently with areas reliant on septic systems, with perhaps some relationship to animal feedlots. There is a tendency among homeowners to see private wells as having “safe” water; these results show clearly that private wells can be contaminated by the surrounding land uses. In most cases, however, the high-growth municipalities of northern New Jersey rely on public water systems, rather than private wells, and therefore will not be affected by this issue.

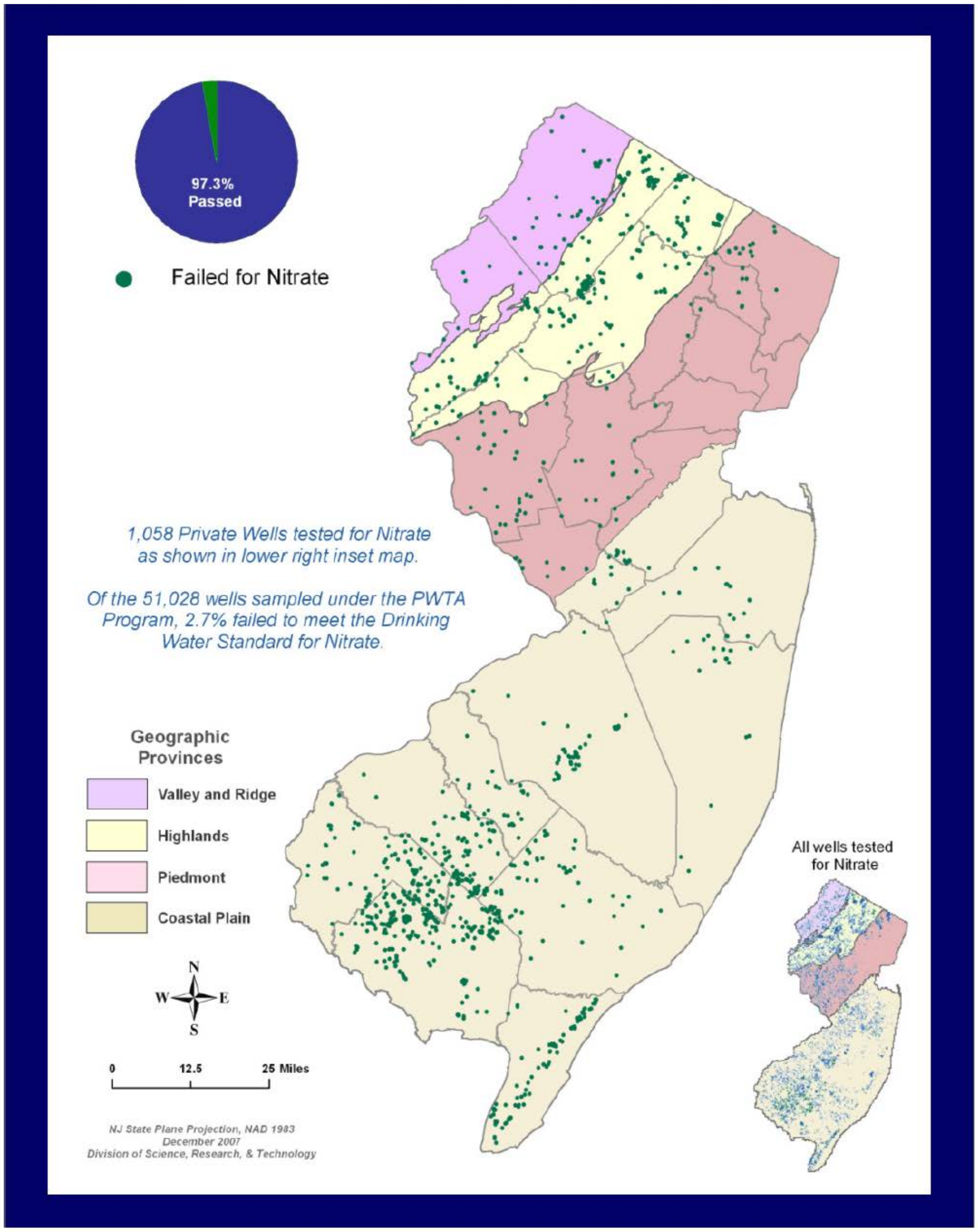


Figure 3.17 Nitrate Exceedances Reported to the PWTA Program (NJDEP, 2008)

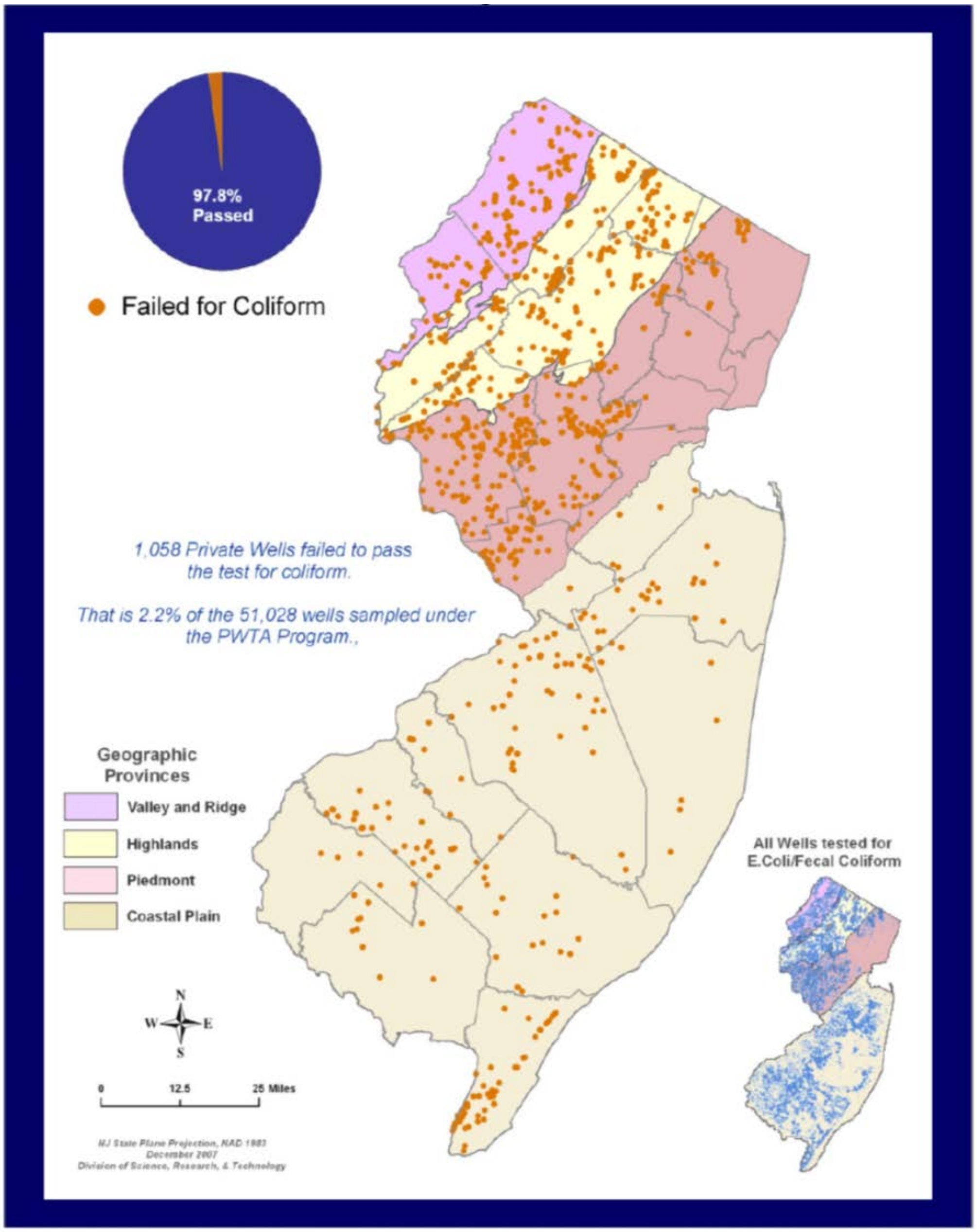


Figure 3.18 Positive E. coli/Fecal Coliform Exceedances Reported to the PWTA Program (NJDEP, 2008)

3.2.1.2. Designation of Category 1 (nondegradation) waters

Category 1 (C-1) waters are designated by the SWQS "for protection from measurable changes in water quality" for any water quality parameter (see Figure 3.19). These waters have been designated by NJDEP to protect trout production waters (Exceptional Fisheries Resources), aquatic habitat for threatened and endangered species (Exceptional Ecological Significance), and water supply reservoirs (Exceptional Water Supply Significance). Designation as a C-1 does not mean that the waters are pristine, but rather that public policy should ensure no further degradation from the quality at the time of designation. Improvement of water quality is supported as long as doing so does not cause "adverse impacts on organisms, communities, or ecosystems of concern." Northern New Jersey has a large share of all C-1 waters in the state. All Trout Production waters are in this region (mostly in the northwestern hill terrain), as are most of New Jersey's reservoirs and all of the largest ones. As such, many streams, lakes and reservoirs in the region are protected against degradation, which imposes significant constraints on increased capacity of sewage treatment plants, development within 300 feet of open waters, stormwater discharges, etc. It should be noted that C-1 status has not been applied to all waters used for potable water supply; intakes along rivers (such as for Passaic Valley Water Commission on the Passaic River and NJ American Water on the Raritan River) have not provided this protection by NJDEP at this time. Coastal waters have also been designated Category One, notably the Barnegat Bay/Great Egg Harbor Estuary area in Ocean County.

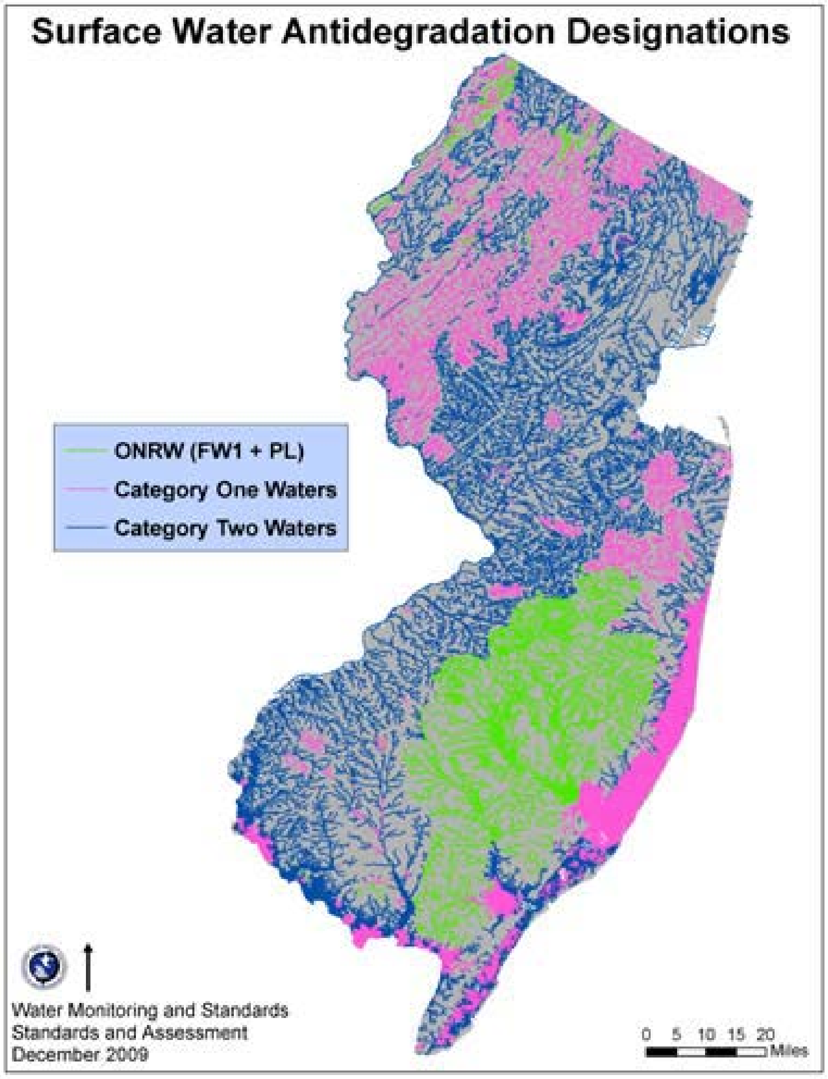


Figure 3.19 Surface Water Antidegradation Designations (NJDEP, 2009)

3.2.2. Needs and disparities under existing conditions

Northern New Jersey has many water bodies that are impaired or degraded for a variety of reasons, but it also has many water bodies that are in relatively good health, supporting species such as trout and amphibians that are sensitive to poor water quality. Critical issues include the extent to which damaged waters can be restored to relative health, and the extent to which maintenance of high water quality requires restrictions on land uses and pollutant sources.

3.2.2.1. Impaired water bodies and causes

Some water quality problems are natural, such as arsenic that is the primary cause of waters not sustaining the drinking water designated use. However, most problems are directly related to pollutant discharges from point and nonpoint sources or modification of streams and their watersheds. Some of these are primarily a legacy of past chemical production and use (e.g., PCBs and DDT) or air deposition caused by sources from other states (e.g., mercury from coal power plants). The others are from in-state sources and causes and are more readily addressed through State and local programs. Figures 3.20, 3.21 and 3.22 are derived from the Draft 2012 New Jersey Integrated Water Quality Monitoring and Assessment Report (NJDEP, 2012b), and provide the subwatershed assessments within the northern New Jersey area for pathogens and nutrients, two of the most common anthropogenic causes of water quality problems, and for aquatic life. These figures support the findings from the 2010 report regarding the influence of urban and agricultural land uses on water quality and watershed integrity. However, they do not provide a good indication of the severity of the degradation beyond noting which subwatersheds violate standards or show biological impairment; evaluation of the underlying data is needed to provide that level of information. The management implications of these findings vary by issue. Nutrients are commonly associated with both point sources (primarily sewage treatment plants) and nonpoint sources (primarily fertilizers and eroded soil). Point sources can be regulated by NJDEP, but nonpoint sources are less easily controlled. Pathogen contamination is almost entirely from nonpoint sources, and may be anthropogenic or natural. Aquatic life impacts can be from a very wide variety of causes, from pollution to physical damage to water bodies. Watershed assessments are generally necessary to determine causes and develop management approaches.

3.2.3. Needs and disparities for future conditions

Violations of water quality standards can have an immediate effect on land uses and pollutant sources; designation of waters as Category One can have similar effects. In both cases, public policy says that no more pollution is to be allowed, and in the case of pollution, pollutant reductions must occur. Any point source pollutant discharges will be regulated to ensure these results. Water quality plans (discussed below) may affect stormwater requirements, nonpoint source pollution controls, and land development controls.

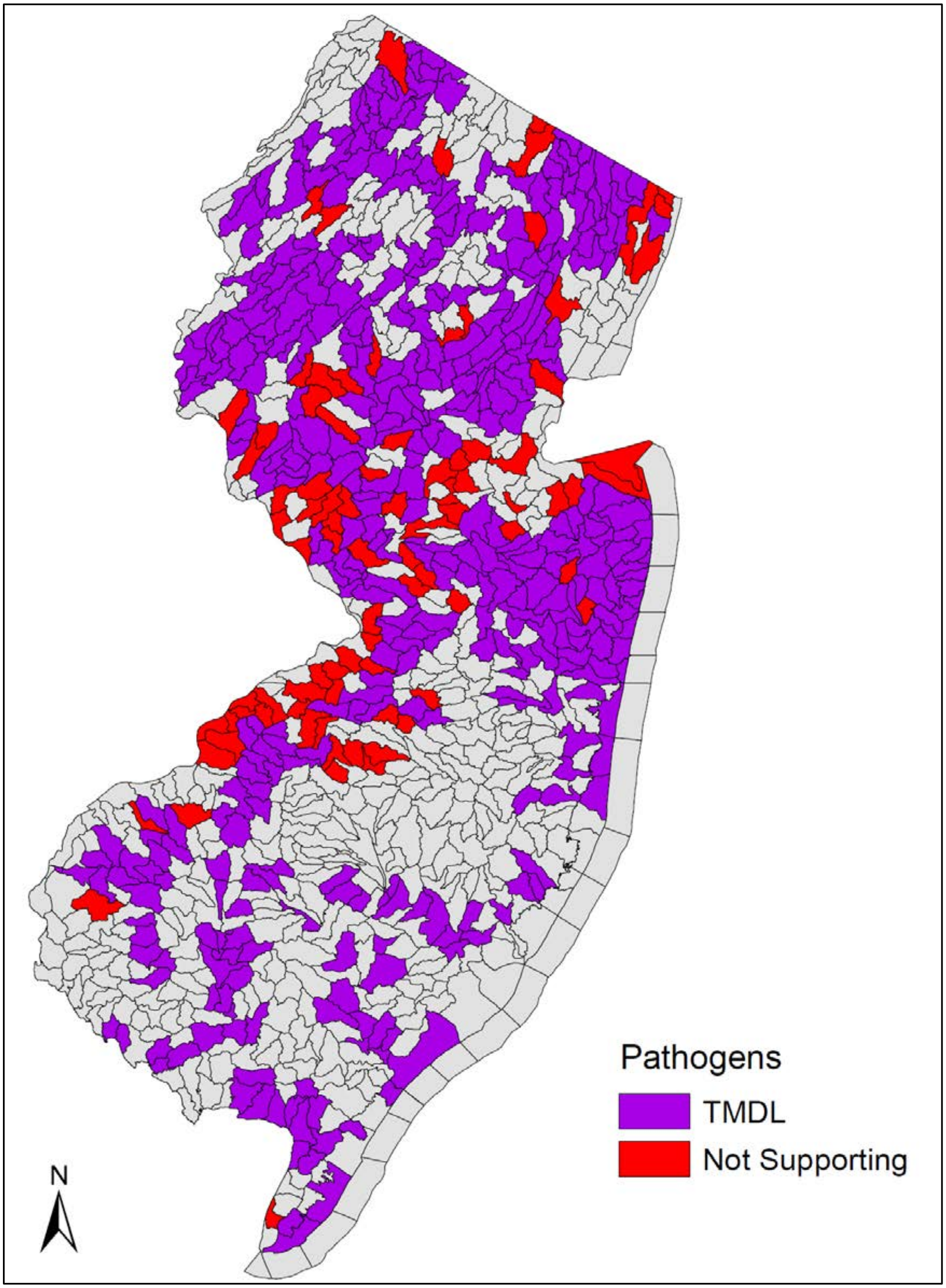


Figure 3.20 Surface Water Quality Assessments for Pathogens (NJDEP, 2012b)

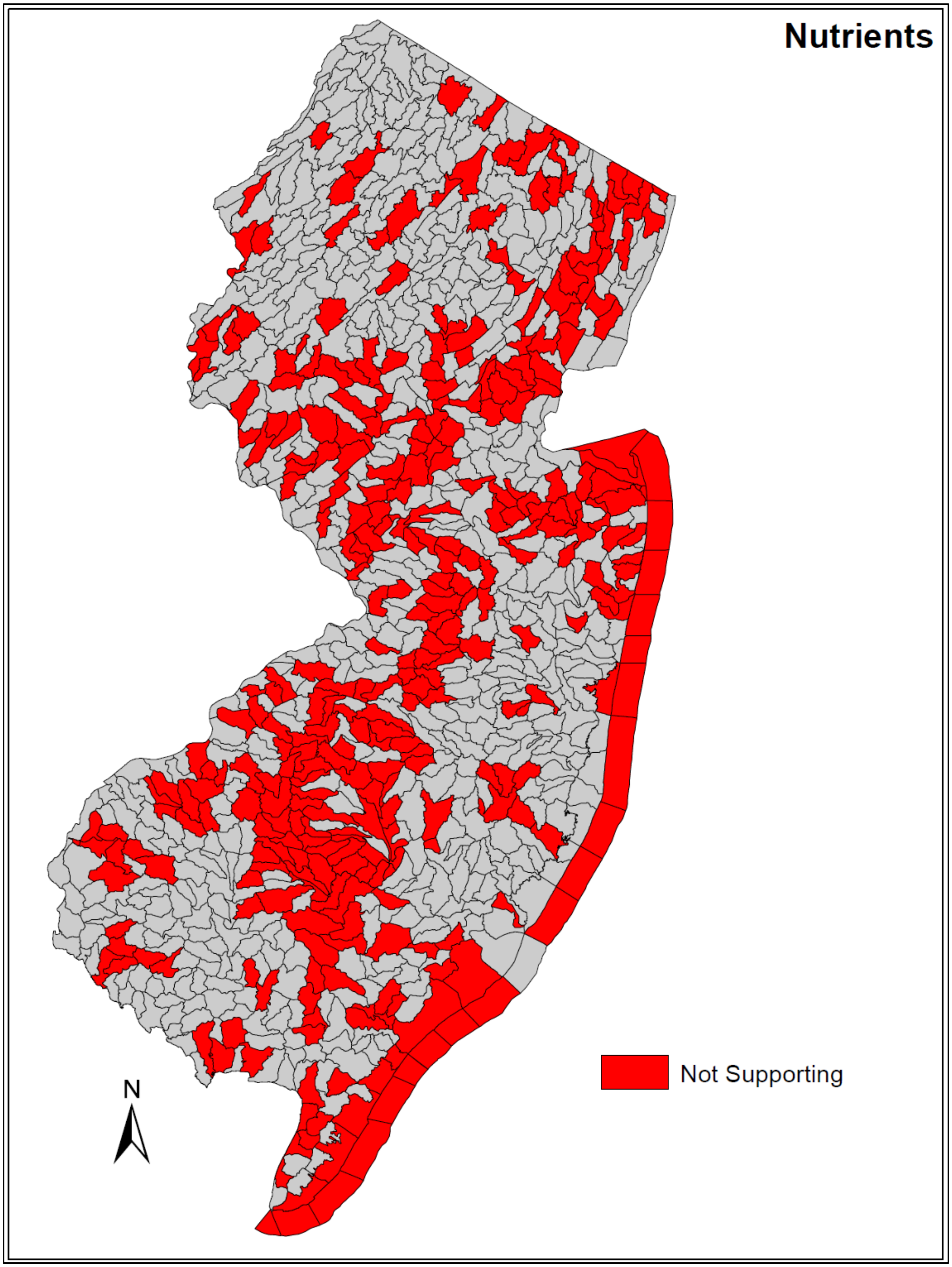


Figure 3.21 Surface Water Quality Assessments for Nutrients (Provided by NJDEP, derived from NJDEP, 2012b)

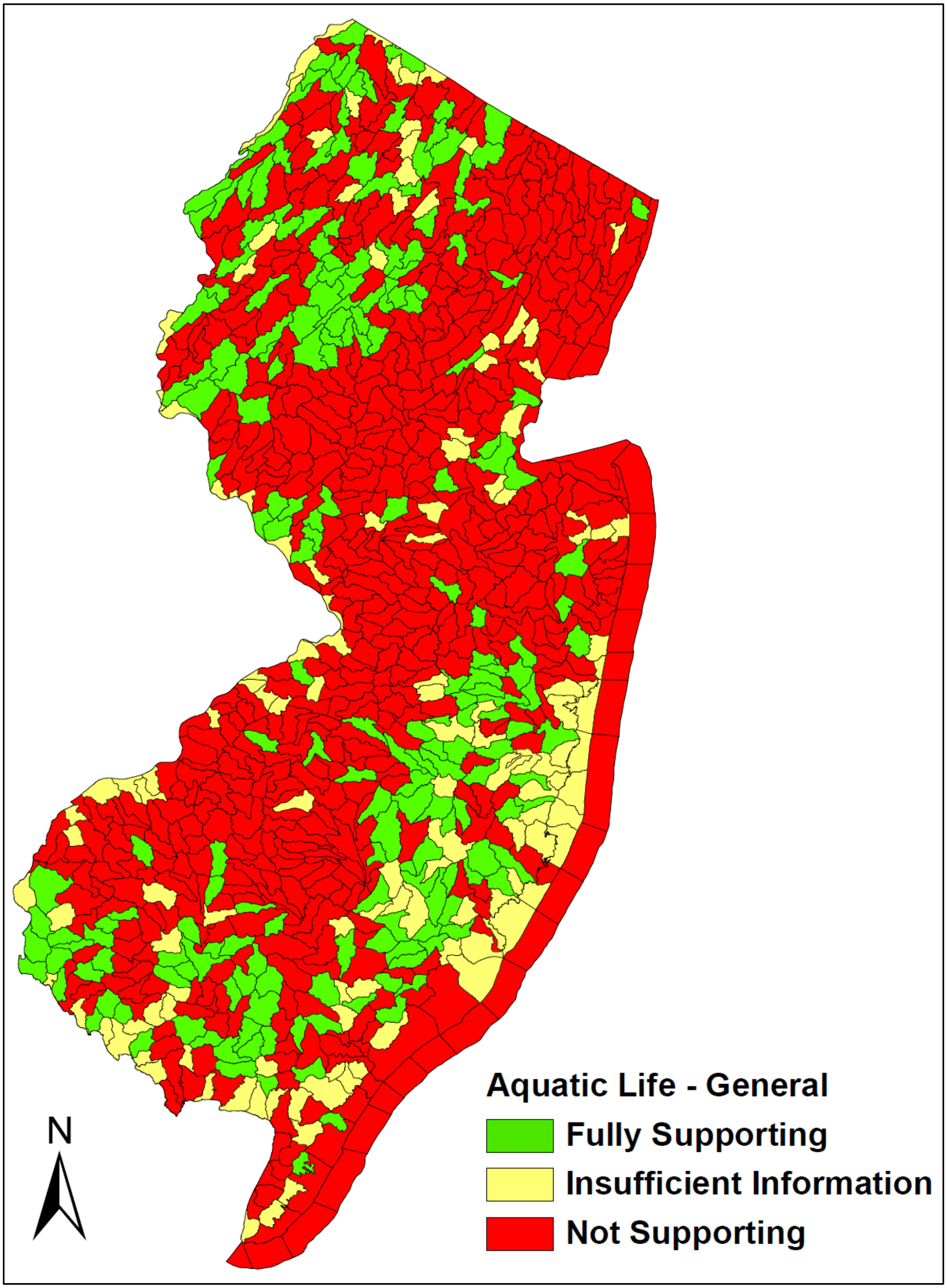


Figure 3.22 Surface Water Quality Assessments for Aquatic Life (NJDEP, 2012b)

3.2.3.1. Assimilative capacity of non-impaired waters

As can be seen from Figures 20-22, most non-impaired waters are in relatively undeveloped, forested regions. Most of these areas have relatively small surface waters. Such waters have very limited capacity for additional pollutant loads, and all are protected to some extent by the antidegradation policies of the Surface Water Quality Standards. Even where a water body is not designated Category One, discharges are not allowed to degrade water quality down to the standards without a public dialogue on the extent to which the degradation is necessary, unavoidable and in the public interest. Dischargers rarely request that NJDEP initiate a formal antidegradation evaluation process for degradation of surface water quality, as most point sources discharge to either impaired or Category One waters, or avoid the review by agreeing to increase their capacity with no increase in pollutant loads. Therefore, it is unlikely that major additions to treatment capacity will occur for sewage treatment plants discharging to inland waters; where expansions do occur, the costs will include significant treatment upgrades to avoid an increase in pollutant loads. However, an evaluation of high-growth municipalities in the region[16] indicates that none rely on major treatment plants of this category (see Appendix D). New or increased nonpoint pollutant sources are not regulated through formal antidegradation reviews, but rather are subject to stormwater controls, soil erosion and sediment control review, wetlands and flood plain protections, and other requirements related to the location, design and construction of the projects.

3.2.3.2. Impaired waters for which additional sewage effluent discharges or water diversions may exacerbate violations of the SWQS

NJDEP is required by federal law to identify waters that violate the Surface Water Quality Standards and to develop and either achieve those standards through enforceable measures (e.g., NJPDES permits, which may include site-specific water quality-based effluent limits, or WQBELs) or adopt Total Maximum Daily Loads (TMDLs) that allocate wasteload limits to existing, new or increased regulated point source discharges and determine how to reduce nonpoint source loads. Many TMDLs have been adopted, primarily for pathogens (mostly a nonpoint source problem) and nutrients (from both point and nonpoint sources). As seen from Figure 20, pathogen contamination is common. NJDEP has been working with USEPA to determine the relevance and applicability of TMDLs to Combined Sewer Overflows, which are significant pathogen sources, but none have been proposed or adopted such to date. NJDEP has adopted a phosphorus TMDL for the Passaic River Basin which is now being implemented through NJPDES permits for affected sewage treatment facilities. A similar nutrient TMDL for the Raritan Basin is under development but not yet proposed or adopted. The Passaic water quality issues are more severe than the Raritan, but both require action. Of the sewage treatment plants serving high-growth municipalities in the region (see Appendix D), Wayne Township STP is in the Passaic River Basin; Somerset Raritan Valley Sewerage Authority (serving Hillsborough and Somerville), Stony Brook Regional Sewerage Authority (serving Plainsboro) and Western Monmouth Utility Authority (serving Manalapan) are in the Raritan Basin.

In each case where a SWQS violation exists, additional withdrawals of water (other than from reservoirs) can exacerbate water quality problems, as less water would be available to dilute contaminant loads. Problematic water withdrawals could be from either surface waters or aquifers upstream of pollutant discharges.

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[16] High-growth municipalities are discussed in more detail in the sections on PCWS systems and public sewer systems, below.

3.2.3.3. Nondegradation waters for which additional sewage effluent discharges or water diversions may cause violations of the SWQS

As discussed above, Category One waters are designated to prohibit measurable changes in water quality by pollutant sources regulated by NJDEP. Therefore, approval of a new sewage effluent diversion would be extremely unlikely, as the new discharge would lower water quality. Category One status may have a significant effect on high-growth municipalities in Ocean County, regarding nonpoint source pollution to Barnegat Bay. As discussed previously, viability of the Confluence Pumping Station project in the NJWSA Raritan System could be limited by the Category One status of Round Valley Reservoir, affecting areas that might need water from that project. No high-growth municipalities rely on sewage treatment plants that discharge to Category One waters, though the Sussex County Municipal Utilities Authority facility on the Wallkill River (which serves Vernon Township) discharges just upstream of the Wallkill River National Wildlife Refuge.

In addition, NJDEP regulations for Category One waters prohibit development within 300 foot of the water bodies (including stormwater lines, facilities or direct discharges through the buffer), and there will be limitations on water withdrawals that would lower water quality. For these reasons, concentrated development in Category One watersheds will be very difficult and very rare. Most development in such areas will be low to very low density development that can be designed to avoid the buffer areas and use septic systems or other discharges to ground water, such as community on-site wastewater systems.

3.2.3.4. Impaired waters that affect urban sustainability

Streams and lakes in highly urbanized areas are often highly degraded, with extensive impervious surfaces, myriad stormwater systems discharges, highly disturbed riparian areas and stream beds, and even “buried streams” that flow only in stormwater systems. Coastal waters in such areas tend to have urban edges, low water quality and extensive debris, as can be seen nearly everywhere along Newark Bay (and much of the tidal sections of its tributaries), the Hudson River, the Arthur Kill and the Raritan Bay. And yet, all of these waters have retained some relatively natural areas and could have potential urban amenity values, as has been demonstrated in many other cities around the country, from the Charles River Esplanade of Boston to the wharf areas of San Francisco to the waterfront areas of Sydney, Australia and Vancouver, Canada. Cities have created urban amenities from streams and ponds that had been dumping grounds previously, such as the RiverWalk in San Antonio, Texas. To the extent that our urban waters remain highly degraded, urban sustainability is damaged. In northern New Jersey, the most degraded urban waters are those affected by Combined Sewer Overflows (primarily the lower Hudson River, lower Passaic River and Arthur Kill area, see discussion below), legacy industrial contaminants (e.g., the dioxin contamination on the lower Passaic River), and the highly industrialized Lower Hudson/Raritan Estuary complex.

3.2.4. Key factors likely to influence future trends and the region’s ability to address needs and disparities

Three major initiatives could play a major role in water quality and watershed integrity in northern New Jersey. Each may result in both costs and benefits for the region. The benefits will be higher and the costs will be lower if these initiatives are well planned and integrated with other components of sustainable development. Conversely, if these initiatives are seen only as constraints, impediments or regulatory requirements and addressed in uninspired ways, the costs will mount significantly and the benefits will be reduced.

3.2.4.1. TMDL adoption and implementation

The federal Clean Water Act requires that quality of the nation’s waters support designate water uses that benefit society, which translates into meeting the Surface Water Quality Standards but also in ensuring or restoring biological integrity of the waters. The TMDL is one part of the Clean Water Act’s process for restoring the integrity of surface waters. Through this program, the causes of water quality impairments are determined, responsibility for improvements are allocated among point sources, nonpoint sources and other causes, and a schedule for implementation is developed. This program has had very mixed results in New Jersey. In some cases, point source regulation could achieve implementation of the TMDL; point sources are the easiest to regulate and have users that pay the costs, so restoration of water quality is feasible. Financial assistance is available through the NJ Environmental Infrastructure Finance Program. However, where costs are high, litigation often slows implementation as occurred in the Passaic Basin TMDL. Where nonpoint sources are implicated, regulation and enforcement are more difficult and there is no single, manageable group of responsible parties that can pay the costs. NJDEP tends to rely heavily on grant funding and partnerships for implementation in this case, through its nonpoint source grant program. This funding is minimal relative to the needs (averaging $3-4 million per year for the entire state), and so these projects have achieved very limited gains to date. In addition, it takes a significant amount of time for nonpoint source reductions to be reflected in water quality improvements in most watersheds.

NJDEP began to increase its TMDL development and adoption efforts in the 1990's at a time when USEPA was being sued by third parties for lack of progress in meeting Clean Water Act requirements within many states. A memorandum of agreement between NJDEP and USEPA provided a schedule for TMDL adoption and shielding from such lawsuits. While considerable progress has been made in TMDL development and adoption, far less progress is evident in TMDL achievement, especially for nonpoint source pollution. A major implementation effort could perhaps be triggered by legal action similar to that of the 1900's, but would be much more effective if directly linked to sustainability and redevelopment needs, so that water quality and watershed improvements are integrated with sustainable development and social needs.

3.2.4.2. Barnegat Bay initiative

Governor Chris Christie on December 9, 2010 announced an action plan to address the ecological health of the Barnegat Bay watershed, a 660-square-mile area that provides freshwater flows to the state's preeminent boating area (www.nj.gov/dep/barnegatbay). The Barnegat Bay 10 point Action Plan entails:

- Close Oyster Creek Nuclear Power Plant
- Fund Stormwater Runoff Mitigation Projects
- Reduce Nutrient Pollution from Fertilizer
- Require Post-Construction Soil Restoration
- Acquire Land in the Watershed
- Establish a Special Area Management Plan
- Adopt More Rigorous Water Quality Standards
- Educate the Public
- Fill in the Gaps on Research
- Reduce Water Craft Impacts

Of these action steps, the most critical for water resource management will be preservation (with a target of 30,000 acres in new acquisition) and the Special Area Management Plan. The latter effort is described as a five-year process to create coastal management requirements that are specific to needs of the Barnegat Bay and its watersheds. In many ways, the Barnegat Bay initiative has the potential to serve as the equivalent of a broad-ranged TMDL for the Bay, and could have similar implications for land use and sustainable development. While there is recognition that pollution and biological impairment of the Bay can greatly damage the area economy, there is little consensus among the various stakeholders regarding necessary remedial actions and responsibilities for costs. As with TMDLs in general, costs will likely be lower and benefits higher if the process is integrated with sustainability in mind.

3.2.4.3. Combined Sewer Overflow requirements from USEPA and NJDEP

Federal CSO policies have evolved over time, in an effort to better control CSOs so that water quality standards are met and designated water uses are supported. New Jersey policies and regulatory requirements have followed the federal approach over time, with some successes and some delays. The greatest successes to date have been the closure of roughly a fifth of all CSO points in New Jersey and the control of solids and floatable materials from nearly all remaining CSO points. However, considerable work will be needed to achieve the purposes of this program. Doing so requires the development of Long Term Control Plans (LTCP). Due to slow progress on LTCPs in many cities around the country, USEPA and the Department of Justice have been taking direct action to require CSO reductions in cities across the country. Initially, the focus was on structural approaches that ranged from separation of sewers to wastewater storage in large tunnels with treatment after the storm passes (as in Chicago). Various cities, including both Philadelphia and New York, responded to the costs of such CSO controls by proposing and receiving USEPA approval to combine standard structural projects with a wide variety of projects that divert stormwater from the combined sewers. Such projects include green roofs, stormwater infiltration in parks and streetscapes, rain gardens, etc., which have become known as “green infrastructure.” These techniques are intended to de-concentrate stormwater, provide green amenities and enhance streetscapes and parks. Both cities still face costs than can reach into the billions of dollars, even with the use of such “green” technologies. A critical aspect of the Philadelphia program is that the city is attempting to use the CSO effort to create neighborhood and economic development benefits as well through an integrated approach with other departments.

NJDEP has developed a regulatory approach to achieve the equivalent of the federal approach but through the NJPDES permit program instead of court or enforcement actions. The current approach is discussed in more detail in Section 3.4. However, the CSO issue will have a significant effect on municipal and utility budgets regardless of the method selected. The CSO communities of New Jersey, all of which are smaller than New York City or Philadelphia and many of which are poorer, will face a major challenge to achieve similar results. In addition, as discussed in Section 3.5, New Jersey lacks authorizing legislation for creation of stormwater utility authorities, and what statutory authority exists for creation of ratepayer based municipal stormwater utilities (rather than separate authorities) is vague and has never been used.

3.2.5. Challenges and Opportunities

New Jersey has a long history of industrial development, urbanization, suburban sprawl and agriculture. Every one of these land uses has harmed waters of the state, resulting in widespread pollution problems and watershed impairment. At the same time, New Jersey still has high quality waters and opportunities to restore water quality and watershed integrity in a manner that supports sustainable development from all three perspectives:

> **Environmental** – through restoration of resources that support ecosystems and public health
> **Economic** – through creation of amenities that support and foster land values and communities
> **Equity** – through restoration of amenities that will benefit urban populations in areas that previously had been excluded from their local waters by barriers and poor quality

The greatest challenge facing the Together North Jersey region will be integrating water quality restoration and protection with appropriate redevelopment and development activities. The region cannot afford to assume that water quality and watershed integrity are secondary issues, to be achieved primarily through regulatory actions of NJDEP. It is clear from decades of experience that no State or even multi-level regulatory system can achieve good water quality and watershed integrity by itself. Our regulatory systems have been moderately effective at improving water quality or at least preventing further degradation in some areas, primarily regarding point sources, but are ineffective in many other ways. However, evidence from other urban areas shows that water quality and watershed improvements can have direct and profound economic benefits – their example presents both the opportunity and the challenge.

3.3. Public Community Water Supply Systems

Public Community Water Supply (PCWS) systems are defined as water systems with at least 15 or more service connections used by year-round residents or regularly serving at least 25 year-round residents. New Jersey has just over 600 PCWS systems supplying anywhere from the minimum 25 people to over 1 million; three-quarters serve fewer than 3,000 customer accounts (roughly 10,000 people). New Jersey is somewhat unusual in that many PCWS customers are served by investor-owned utilities, most of which serve large areas in northern New Jersey. The state also has a few large regional providers that are government-owned, but most government-owned systems supply smaller areas, comprising part or all of individual municipalities. In northern New Jersey, there are 151 PCWS systems with "firm capacity"[17] of at least 1 million gallons per day (MGD), as listed in Appendix A, enough to supply water for roughly 8,000 people at the statewide average of 130 gallons per person per day (gpcd); only 18 have firm capacities of 15 MGD or more.

All PCWS systems, regardless of ownership, are required to comply with the same NJDEP regulations regarding drinking water quality, system construction, licensed operators, etc. Likewise, under New Jersey law no PCWS actually "owns" the water it delivers. Rather, the waters of the state are public resources held in trust by the State and allocated by NJDEP under the Water Supply Management Act. Rather than owning the waters they provide, each PCWS system is given the right to deliver the state's waters to its customers, charging for the cost of withdrawing, storing, treating and delivering the water.

3.3.1. Key patterns and trends

3.3.1.1. Residential water demand trends

As discussed in Section 3.1 on water availability, annual potable water withdrawals have been relatively stable over a 17-year period through 2007 at roughly 130 gpcd, but consumptive water uses have been rising during that same time. While annual amounts vary considerably in response to wet and dry periods, the increase reflects more water use for lawn irrigation, a highly consumptive use. Conversely, interior domestic uses may be declining, based on anecdotal evidence of winter use rates.

3.3.1.2. Industrial water demand trends

Over the years, New Jersey has seen a significant decline in direct (self-supplied) water withdrawals for industrial, commercial and mining uses that are not supplied by PCWS systems, as discussed in Section 3.1. More difficult to determine are trends for industrial and commercial uses that <u>are</u> supplied by PCWS systems; to date, no statewide or regional estimates are available for current industrial use supplied by PCWS systems. However, there are reasons to assume that the trends (excluding mining) are similar as for self-supplied users. First, wastewater treatment charges are sufficiently high that industries increase water use efficiency to reduce both water supply and wastewater charges. Second, industry generally has a reduced presence in New Jersey for a wide variety of reasons that are both international and local in nature. Third, the nature of industry shifts over time, with production efficiency providing cost-saving benefits.

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[17] See Chapter 2 for a discussion of firm capacity.

3.3.1.3. Relative reliance on aquifers and surface waters

New Jersey generally relies on aquifers for approximately 40% and surface waters for approximately 60% of potable water supply. The aquifer supplies are partially used for PCWS systems but also include residential (private) wells for individual homes, which supply perhaps one-seventh of the state's population. Surface water supplies are entirely used by PCWS systems, not for individual homes. These proportions have not changed a great deal over time. However, aquifers in many parts of the state are fully allocated and so further growth may come predominantly from surface water. Mining, agriculture and industry tend to rely on surface waters and surficial aquifers for their water supplies.

3.3.1.4. Key issues: Lawn irrigation; aging infrastructure

Suburban development over the last several decades has caused a significant increase in demand for lawn irrigation. More efficient systems are only recently coming into the market in a major way. Peak uses and peak consumptive uses are in summer, which has increased PCWS system demands during that period relative to annual average demands. To the extent that low density suburban development (i.e., densities of one unit per half acre to two or three acres) continues, these demands are likely to increase. Demands from existing suburban development may also increase as more homeowners install lawn irrigation systems. While modern systems are more water efficient than older systems, to the extent that homeowners are unwilling to let cool season grasses go brown in the summer, peak demands are likely to increase. These peak demands stress infrastructure and water sources.

Another major issue is aging infrastructure. Historic urban areas in some cases have original pipes in place, over 100 years old. Even suburban areas are aging – what were once thought of as the newly developed areas were in many cases built in the 1960's or soon after and are approaching 40-50 years of age. Public pressure to keep rates low has a perverse result – deferred maintenance that will result in future system breaks and emergency repairs at great cost.

3.3.1.5. Priority Systems for existing urban areas and major growth areas

Given the large number of PCWS systems in the northern New Jersey region, this report focuses primarily on a smaller subset of the largest (capacity over 15 MGD) and most important systems that provide water to existing urban areas and the major growth areas as anticipated by population projections. These 18 systems are listed in Table 3.4, where "Total Limits" provided by NJDEP reflects a combination of "Firm Capacity" (the ability of the system's internal supplies to provide water under specific conditions) and contracted capacity from other systems. North Jersey District Water Supply Commission is shown in bold as it is unlike the other systems; it functions primarily as a bulk provider of treated water to many other systems, with only a very limited retail distribution network of its own. New Jersey Water Supply Authority is not included in this table because it is not a PCWS system – it is a bulk provider of untreated water to other systems within the Raritan River Basin.

Table 3.4 Major PCWS Systems in Northern New Jersey

PCWS System	Total Limits	General Area Served
New Jersey American Water Company – Raritan System	222.4	Parts of Hunterdon, Mercer, Middlesex, Somerset, Union Counties
United Water New Jersey – Haworth	167.0	Parts of Bergen, Hudson Counties
North Jersey District Water Supply Commission	173	12 bulk purchasers in Bergen, Essex, Passaic and Hudson Counties, many of which have their own systems as well (e.g., Newark, PVWC, United Water)
Newark Water Department	115.1	Newark and neighboring towns
Passaic Valley Water Commission	112.7	Clifton, Passaic, Paterson and neighboring

Table 3.4 Major PCWS Systems in Northern New Jersey

PCWS System	Total Limits	General Area Served
		towns
United Water (Jersey City)/Jersey City MUA	86.7	Jersey City, Bayonne and neighboring towns
New Jersey American Water Company – Coastal North	81.6	Parts of Monmouth and northern Ocean Counties
New Jersey American Water Company – Short Hills	68.8	Parts of Union County
Middlesex Water Company	68.0	Parts of Middlesex County
United Water Toms River	24.2	Toms River Township/neighboring towns
Sayreville Borough Water Department	23.2	Sayreville
Brick Township MUA	21.4	Brick Township
NJ American Water (formerly operated as Liberty Water Company)	21.3	Elizabeth City
New Brunswick Water Department	20.9	New Brunswick
Southeast Morris County MUA	18.0	Morristown and neighboring towns
East Brunswick Water Utility	16.6	East Brunswick
Old Bridge Township MUA	16.5	Old Bridge
New Jersey American Water Company – Edison	15.2	Part of Edison

Most other PCWS systems in the region serve individual municipalities or small groups of municipalities, where anticipated population growth is not a major factor compared with total regional growth.

3.3.2. Needs and disparities for Priority Systems

One way of assessing stresses for future needs is to compare projected population increases within PCWS system service areas. For this purpose, the NJTPA projections to 2035 were analyzed to identify each municipality that would comprise at least 0.4% of the region's projected population growth from 2010 to 2035. A total of 67 municipalities were in this set, out of 384 municipalities in the region. The breakdown in number of municipalities is as follows in Table 3.5 (see also Appendix B):

Table 3.5 Number of Municipalities by Share of Projected Regional Growth through 2035 (based on NJTPA projections)

Percent of Regional Growth	# of Municipalities
>3.0	4
2<3	3
1<2	18
0.8-0.9	6
0.6-0.7	13
0.4-0.5	23

These municipalities were then examined regarding their PCWS systems. Fifty of the 67 high-growth municipalities are within the service areas of the largest PCWS systems.

3.3.2.1. Growth projections

Table 3.6 compares the 50 high-growth municipalities (with those over 1.5% of the regional gain through 2035 shown in bold) that rely entirely or mostly on surface water systems. (The remaining 17 high-growth municipalities rely on aquifer supplies as their primary water source.) The two right-hand columns are of particular interest, as they show the aggregated percentage of projected regional growth represented by the high-growth municipalities for each major system, and the system surplus (none have current deficits). It is important to note that the total projected regional growth within these same systems will be somewhat greater, as there are many municipalities with regional growth shares of 0.3% or less, and few with declines. However, the evaluation captures the impacts of high-growth areas. More exhaustive analysis will be available with publication of the pending NJ Statewide Water Supply Plan.

The 2012 System Surplus values were calculated by NJDEP through a comparison of peak demands to the system's firm capacity (the ability of the system's internal supplies to provide water under specific conditions). None of the 2012 System Surplus values are negative, though some (Newark, Brick Twp MUA, Newton-Lake Morris) are near zero, indicating extremely limited capacity for future growth in the absence of alternative water supplies. However, it is important to note that these values do not include water that is available through contracts for water from other systems, nor does it reflect water committed to other systems through contracts. A case in point is the Newark system, which has a 49.4 MGD contract for water from the North Jersey District Water Supply Commission (see Table 3.2 above), but also provides water to many municipalities in the Newark area. For such systems, more detailed evaluations are required to assess available capacity. Many of the larger water supply systems in central and northern New Jersey are interconnected. Some of these interconnections provide routine supplies based on contracts, while others are for emergency supplies when droughts or system failures such as broken lines temporarily damage one system's ability to provide supplies to its customers.

Table 3.6 High Growth Municipalities Dependent on Surface Water Supplies in Northern New Jersey

Municipality Name	2010 Pop	2035 Pop	Mun. % Growth 2010-2035	Growth 2010-2035 (% of Region)	Surface Water Source	System % of Region Growth	2012 System Surplus (MGD)
East Brunswick twp	47,512	63,450	33.5%	1.3%	NJWSA (Raritan)	13.6%	59.98
North Brunswick twp	40,742	46,590	14.4%	0.5%	NJWSA (Raritan)		
New Brunswick city	55,181	73,150	32.6%	**1.5%**	New Brunswick & NJWSA (Raritan)		
Elizabeth city	124,969	155,610	24.5%	**2.5%**	NJ American (Raritan)		
South Brunswick twp	43,417	58,970	35.8%	1.3%	NJ American (Raritan)		
Hillsborough twp	38,303	50,970	33.1%	1.0%	NJ American (Raritan)		
Franklin twp	62,300	72,400	16.2%	0.8%	NJ American (Raritan)		
Plainsboro twp	22,999	31,150	35.4%	0.7%	NJ American (Raritan)		
Plainfield city	49,808	56,810	14.1%	0.6%	NJ American (Raritan)		
Piscataway twp	56,044	62,230	11.0%	0.5%	NJ American (Raritan)		
Linden city	40,499	46,070	13.8%	0.5%	NJ American (Raritan)		
Cranbury twp	3,857	8,790	127.9%	0.4%	NJ American (Raritan)		
Somerville boro	12,098	16,670	37.8%	0.4%	NJ American (Raritan)		
Edison twp	99,967	119,140	19.2%	**1.6%**	NJ American (Raritan) & Middlesex Water		
Woodbridge twp	99,585	117,940	18.4%	**1.5%**	Middlesex Water	3.6%	24.64
Highland Park boro	13,982	18,410	31.7%	0.4%	Middlesex Water		
Old Bridge twp	65,375	75,490	15.5%	0.8%	GW & Middlesex Water		
Sayreville boro	42,704	53,940	26.3%	0.9%	GW & Middlesex Water		
Jersey City city	247,597	327,500	32.3%	**6.6%**	United Water (Jersey City)	9.1%	12.16
Bayonne city	63,024	86,740	37.6%	**2.0%**	United Water (Jersey City)		
Lyndhurst twp	20,554	26,800	30.4%	0.5%	United Water (Jersey City)		
Paterson city	146,199	187,790	28.4%	**3.4%**	PVWC	7.2%	10.58
Passaic city	69,781	90,200	29.3%	**1.7%**	PVWC		
Clifton city	84,136	98,820	17.5%	1.2%	PVWC		

Table 3.6 High Growth Municipalities Dependent on Surface Water Supplies in Northern New Jersey

Municipality Name	2010 Pop	2035 Pop	Mun. % Growth 2010-2035	Growth 2010-2035 (% of Region)	Surface Water Source	System % of Region Growth	2012 System Surplus (MGD)
Harrison town	13,620	18,990	39.4%	0.4%	PVWC & Kearny (NJDWSC)		
Garfield city	30,487	35,760	17.3%	0.4%	GW & PVWC		
Hackensack city	43,010	55,370	28.7%	1.0%	United Water (Hackensack)	5.0%	39.55
North Bergen twp	60,773	71,300	17.3%	0.9%	United Water (Hackensack)		
Union City city	66,455	75,400	13.5%	0.7%	United Water (Hackensack)		
Fort Lee boro	35,345	42,860	21.3%	0.6%	United Water (Hackensack)		
Secaucus town	16,264	23,350	43.6%	0.6%	United Water (Hackensack)		
Teaneck twp	39,776	44,740	12.5%	0.4%	United Water (Hackensack)		
Weehawken twp	12,554	17,220	37.2%	0.4%	United Water (Hackensack)		
Paramus boro	26,342	30,740	16.7%	0.4%	United Water (Hackensack)		
Newark city	277,140	322,190	16.3%	**3.7%**	Newark	3.7%	0.41
Asbury Park city	16,116	22,790	41.4%	0.6%	NJ American (Coastal North)	3.1%	7.53
Long Branch city	30,719	36,320	18.2%	0.5%	NJ American (Coastal North)		
Neptune twp	27,935	33,470	19.8%	0.5%	NJ American (Coastal North)		
Middletown twp	66,522	71,580	7.6%	0.4%	NJ American (Coastal North)		
Howell twp	51,075	65,790	28.8%	1.2%	NJ American (Lakewood)		
Wayne twp	54,717	67,130	22.7%	1.0%	NJDWSC Customer	2.6%	58.41
Bloomfield twp	47,315	54,890	16.0%	0.6%	NJDWSC Customer		
Montclair twp	37,669	44,630	18.5%	0.6%	NJDWSC Customer		
Kearny town	40,684	45,350	11.5%	0.4%	NJDWSC Customer		
Toms River twp	91,239	117,540	28.8%	**2.2%**	United Water (Toms River) & NJ American (Ocean)	2.2%	7.86
Irvington twp	53,926	67,570	25.3%	1.1%	NJ American (Short Hills)	2.2%	8.31
Union twp	56,642	63,460	12.0%	0.6%	NJ American (Short Hills)		
City of Orange twp	30,134	36,590	21.4%	0.5%	NJ American (Short Hills)		
Brick twp	75,072	96,610	28.7%	**1.8%**	Brick Twp MUA	1.8%	0.04
Newton town	7,997	12,400	55.1%	0.4%	Newton-Lake Morris	0.4%	0.56
Totals	**2,860,161**	**3,519,670**		**54.50%**		**2.20%**	**230.03**

These 50 high growth municipalities represent nearly 55% of the total projected regional growth through 2035. Of these, 44 are served by just seven surface water supply systems representing nearly 48% of the total projected regional growth: the **NJ Water Supply Authority: Raritan System**, which provides supplies to NJ American Water (Raritan), Middlesex Water, and the municipalities of East Brunswick, New Brunswick and North Brunswick; **United Water (Jersey City)**; **Passaic Valley Water Commission**; **United Water (Hackensack)**; **City of Newark**; **NJ American (Coastal North)**; and **North Jersey District Water Supply Commission** (which provides water by contract to Newark, PVWC and United Water-Hackensack, among others). Several other systems provide significant surface water supplies to high growth municipalities, but not at the same level as these seven.

In addition to these systems, there are 17 municipalities in the "high growth" category that rely on aquifer supplies primarily or entirely, listed in Table 3.7. Only two of these municipalities, Jackson and Berkeley Townships in Ocean County, represent 1.5% or more of the projected regional growth through 2035. While some of the 17 municipalities may have sufficient aquifer supplies, others may not. At this time, there is no consensus metric or threshold available to determine available water other than the firm capacity for these systems (see Appendix A). However, one municipality derives its supplies from an area known to have limited supplies, specifically East Orange from the Central Passaic Buried Valley Aquifer System. Further information on water availability is anticipated in the pending NJ Statewide Water Supply Plan.

Table 3.7 High-Growth Municipalities Dependent on Aquifers in Northern New Jersey

Municipality Name	2010 Pop	2035 Pop	Municipal % Growth 2010-2035	Growth 2010-2035 (% of Region)
Jackson twp	54,856	99,040	80.5%	**3.6%**
Berkeley twp	41,255	59,450	44.1%	**1.5%**
Perth Amboy city	50,814	67,950	33.7%	1.4%
Manchester twp	43,070	59,740	38.7%	1.4%
East Orange city	64,270	79,830	24.2%	1.3%
Little Egg Harbor twp	20,065	31,900	59.0%	1.0%
Lacey twp	27,644	38,590	39.6%	0.9%
Monroe twp	39,132	48,900	25.0%	0.8%
Manalapan twp	38,872	47,630	22.5%	0.7%
Ocean twp	8,332	16,770	101.3%	0.7%
Stafford twp	26,535	34,130	28.6%	0.6%
Barnegat twp	20,936	28,110	34.3%	0.6%
Wantage twp	11,358	18,000	58.5%	0.5%
Plumsted twp	8,421	14,000	66.3%	0.5%
Andover twp	6,319	11,270	78.4%	0.4%
Frankford twp	5,565	10,130	82.0%	0.4%
Vernon twp	23,943	28,230	17.9%	0.4%
Totals	**491,387**	**693,670**		**16.70%**

3.3.2.2. Stressed systems and systems with significant capacity.

Table 3.8 shows the aggregate population increases of high-growth municipalities within the largest systems from Table 3.6 (comprising nearly 48% of total regional projected growth), which is then translated into estimated demands (combined Residential, Industrial, Commercial) using two different per capita use rates: 130 gpcd, representing the statewide average; and 100 gpcd, representing a low industrial component and more aggressive conservation.

Table 3.8 Estimated Additional Potable Water Demands Through 2035 for High-Growth Municipalities Within the Seven Largest Surface Water Supply Systems

Surface Water Source	System % of Region Growth	2012 System Surplus (MGD)	Pop Growth	Demand at 130 gpcd (MGD)	Demand at 100 gpcd (MGD)
NJWSA (Raritan) – including NJ American (Raritan)	13.6%	59.98	164,304	21.36	16.43
Middlesex Water	3.6%	24.64	44,134	5.74	4.41
United Water (Jersey City)	9.1%	12.16	109,865	**14.28**	10.99
PVWC	7.2%	10.58	87,337	**11.35**	8.73
United Water-NJ (Hackensack)	5.0%	39.55	60,461	7.86	6.05
Newark	3.7%	0.41	45,050	**5.86**	**4.51**
NJ American (Coastal North)	3.1%	7.53	37,583	4.89	3.76
NJDWSC Customers	2.6%	58.41	31,615	4.11	3.16
Totals	**47.90%**	**213.26**	**580,349**	**75.45**	**58.04**

Shown in bold red are those projected demands from high-growth municipalities that exceed the estimated 2012 System Surplus from Table 3.6. Two examples (Jersey City and PVWC) only exceed the system surplus if per capita demands are 130 gpcd, but not if a lower per capita demand is used. In both cases, careful residential, commercial, business and industrial water conservation may keep demands within the available supply, though demands from lower-growth municipalities must be considered. Only Newark shows projected demands exceeding system surplus in both scenarios. However, as noted above, the actual available capacity for Newark is complicated by its contracts to provide water as compared to its contract to purchase water as a major customer of the North Jersey District Water Supply Commission. Also, if NJDWSC receives NJDEP approval of its safe yield increase to 190 MGD, Newark (and for that matter PVWC) may be able to contract for additional supplies, offsetting any deficit. United Water (Hackensack) is also a partner with NJDWSC and could contract for additional supplies. Jersey City, though not currently a NJDWSC customer, has an interconnection with the other systems through the Great Notch Interconnection, and so could potentially look to NJDWSC or its customers for additional supply. Finally, the NJWSA Raritan System has a significant current surplus that could be “wheeled” through Newark to supply the Passaic/Hackensack systems. Essentially, Newark would use some Raritan water through a direct interconnection, and then would sell water either from its Pequannock system or its NJDWSC contract to other systems. The northern New Jersey area has a significant level of flexibility regarding water supplies due to existing or planned interconnections and customer relationships. The primary obstacles are financial rather than regulatory.

Some of the aquifer-based water systems listed in the section above could face constraints on their ability to gain additional water allocations, as many aquifers are reaching or have reached their limits. Details on this part of the analysis require information from the pending NJ Statewide Water Supply Plan, on Net Water Availability for the state’s watersheds.

3.3.2.3. Systems with high water losses

No authoritative evaluation of system water losses is currently available. The international consensus is that a simple comparison of water withdrawn to water billed, the “unaccounted-for water,” is not adequate for calculating water losses. The problems with this simple metric are many. Much “unaccounted-for water” is actually known, such as hydrant flushing, firefighting and so on – the water may not be billed, but its use is understood and appropriate. Second, water systems differ considerably, with some having relatively few connections per volume sold and others have a much greater number of connections. Each customer connection is a potential failure point, which affects the amount of water that will be lost. The International Water Association and the American Water Works Association have collaborated on a new approach for water loss accounting (AWWA Manual 36). NJDEP has been reviewing the applicability of this method to New Jersey and may propose regulations shifting to its use. Doing so will provide a much more nuanced understanding of the amount of “lost water” that can be recovered through better asset management. In the absence of State regulations, independent action by water purveyors to use AWWA Manual 36 would be beneficial.

3.3.2.4. Systems with high drinking water quality violations

Based on information provided by NJDEP, none of the seven major surface water supply systems has had high drinking water quality violations from 2010 through 2012. What violations are noted are for the Passaic Valley Water Commission, with one instance of a high lead level and one instance of a coliform violation. The high-growth municipalities with ground water supplies also show few violations within this period, primarily again for coliform and total lead. NJDEP provides public information on drinking water quality violations. While each violation is a matter for concern, none of the violations on record indicate systemic failure that would affect development or redevelopment potential.

3.3.3. Key factors likely to influence future trends and the region's ability to address needs and disparities

The financial agreements necessary to wheel Raritan System water to the north have been long delayed, and likely will occur only when conditions require them so that a PCWS system in the northern areas can avoid turning away customers. A major increase in the NJDWSC safe yield could delay consideration of such transfers for a significant period. Two issues could pose significant constraints for further demands in some parts of the region.

3.3.3.1. Water availability

As discussed previously, the definition and methodology for water availability is changing as scientific research provides a more certain understanding of how stream flow changes affect aquatic ecosystems. This issue is not entirely new to New Jersey – approval of the Manasquan Reservoir in the 1980's required extensive studies to prove that withdrawals from the river would not harm the Barnegat Bay. However, application of the Ecological Limits of Hydrologic Alteration (ELOHA) concept to shallow aquifers and to northern New Jersey's reservoirs could result in significant constraints on further water development. The Water Supply Management Act limits NJDEP's ability to reduce current withdrawals: a Water Supply Critical Area must be declared by the Commissioner and an alternative water supply must be provided. Therefore, any impacts of the evolving water availability concepts will affect future uses and will occur over time. Aggressive water conservation can reduce per capita uses in a way that could allow for both future demands and protection of ecological needs in many areas, but not all.

3.3.3.2. Costs of deferred maintenance

No authoritative figures are available regarding the total costs of deferred maintenance, but anecdotal and individual system evidence indicates that they will be high. Newark has released estimates of over $500 million in deferred maintenance costs for its sewer and water supply systems. NJ American provided information indicating that at then-current rates (2011) of replacement, their lines would have a 500-year replacement cycle, though recent Board of Public Utility decisions to allow Distribution System Improvement Charges (DSIC) should increase the pace of action for investor-owned systems. Other systems are just starting to get a handle on their costs. Regardless of the total costs, the costs of not taking action include emergency repairs at much higher cost, plus service disruptions, undermining of streets and buildings, etc., as has been seen many times in recent years, including three major breaks during a two-week period in early 2013 within the region. To the deferred maintenance costs must also be added the upcoming costs of system improvements to meet public health requirements and address increasing demands, and further needs to improve system resilience in the face of increased flood frequency and height, coastal storm surges, power losses, etc. Deferred maintenance costs will harm the ability of water supply utilities to address other emerging needs. The issue of asset management has been highlighted by the NJ Clean Water Council and Water Supply Advisory Council (NJCWC/WSAC, 2010) over the last six years and is starting to gain traction at the State level, with ongoing discussions among NJDEP, NJDCA and the BPU.

3.3.4. Challenges and Opportunities

The largest challenges for PCWS systems will be ensuring that they maintain the capacity and capability to provide high quality potable water on an uninterrupted basis, in response to both existing needs and future demands. The increased peak summer demands for lawn irrigation and pools stress system capacity, while deferred maintenance increases the risks of system failure at various scales. At the same time, an increasing awareness of ecological needs will limit the ability of utilities to place further stresses on shallow aquifers, and better science regarding confined aquifers may increase constraints on those systems as well. Many aquifers along the coast and within inland watersheds are fully utilized or overstressed, and new allocations from those aquifers will be rare and difficult. Water supply planning will be necessary to reduce or eliminate deficits in several key areas. Finally, some facilities are at risk for flooding, which must be addressed.

As has been true since the 1980's, significant attention must be paid to the Passaic and Hackensack River reservoir systems, as they are highly interdependent, interconnected and stressed during severe droughts. Both the Newark and Jersey City systems need more in-depth evaluation, and the Hackensack system of United Water-NJ has always been drought sensitive. Fortunately, surface water supplies in the northern New Jersey region are well placed to provide alternative water supplies for growth areas that are within or contiguous to the existing service areas. The NJWSA Raritan System has potential for new supplies exceeding 100 MGD, which can be used in that basin, northern Monmouth County or the Passaic and Hackensack river areas. These areas comprise most of the high-growth municipalities, except for Ocean County. Perhaps as importantly, aggressive water conservation by the surface water supply systems can reduce ecosystem stresses and create capacity to address future demands.

3.4. Public Sewerage Systems

Public sewerage systems collect sewage from residential, commercial, business and industrial properties, deliver the sewage to a treatment plant, treat the sewage to meet regulatory requirements for disposal, and then discharge the treated effluent to ground or surface waters. Those sewage treatment plants in the Together North Jersey region that discharge to ground water are generally small in size. As discussed previously, relatively few public sewer systems are owned by private or investor-owned companies, and these are generally small. Each sewage treatment plant is regulated by NJDEP through the NJPDES program. Collection systems are subject to NJDEP regulation requiring construction permits (called Treatment Works Approvals), and must ensure that no discharges occur from sanitary sewers. Both programs apply regardless of system ownership. Combined sewers are regulated in a different fashion, and are all government-owned.

3.4.1. Key patterns and trends

3.4.1.1. Sewage treatment plants and capacity

New Jersey's urbanized areas are served by a few very large sewage treatment plants (including one of the five largest in the country – Passaic Valley Sewerage Commissioners) and a much larger number of relatively small facilities. Of the 56 facilities in northern New Jersey with a design capacity of 1 MGD or more (see Appendix C), the 15 treatment facilities in Table 3.9 have a total design capacity of 15 MGD or more.

Table 3.9 Public Sewer Utilities and General Service Areas, Northern New Jersey

NJPDES Permit Number	Facility Name	Design or Permitted Flow (MGD)	County of Discharge Location	General Service Area (Counties)
NJ0021016	Passaic Valley Sewerage Commissioners (PVSC)	330.00	Essex	Southern Bergen, Essex, southern Hudson, northern Union
NJ0020141	Middlesex County Utility Authority (MCUA)	147.00	Middlesex	Middlesex, southeastern Somerset, southwestern Union
NJ0020028	Bergen County Utilities Authority (BCUA) Main STP	75.00	Bergen	Eastern Bergen
NJ0024741	Joint Meeting of Essex and Union Counties	75.00	Union	Southern Essex, northern Union
NJ0024643	Rahway Valley Sewerage Authority (RVSA)	40.00	Union	Southeast Union

Table 3.9 Public Sewer Utilities and General Service Areas, Northern New Jersey

NJPDES Permit Number	Facility Name	Design or Permitted Flow (MGD)	County of Discharge Location	General Service Area (Counties)
NJ0024708	**Bayshore Regional Sewerage Authority**	16.00	Monmouth	Northern Monmouth
NJ0025356	**Middletown Sewerage Authority (TOMSA)**	10.80	Monmouth	Northern Monmouth
NJ0028142	Ocean County Utilities Authority (OCUA)-Northern WPCF	32.00	Ocean	Northern Ocean
NJ0029408	Ocean County Utilities Authority (OCUA)-Central WPCF	32.00	Ocean	Central Ocean
NJ0024864	Somerset Raritan Valley Sewerage Authority (SRVRSA)	21.30	Somerset	Somerset
NJ0026085	North Hudson Sewerage Authority-Adams Street WTP	20.80	Hudson	Northeastern Hudson
NJ0026018	Ocean County Utilities Authority (OCUA)-Southern WPCF	20.00	Ocean	Southern Ocean
NJ0024953	Linden Roselle Sewerage Authority	17.00	Union	Southeast Union
NJ0024813	Northwest Bergen County Utility Authority (NBCUA)	16.80	Bergen	Western Bergen
NJ0024970	Parsippany-Troy Hills Twp	16.00	Morris	Central Morris
Total		**869.7**		

The two facilities in **bold** discharge their effluent through the Monmouth County Bayshore Outfall Authority, which is not a treatment system.[18] Almost all of these larger facilities discharge to the ocean or tidal waters, with the exceptions of SRVRSA, NBCUA and Parsippany-Troy Hills. The top five facilities are all in the urban northeast, not the Shore counties. Figure 3.23 gives a sense of perspective, showing all 56 facilities by design capacity.

[18] MCBOA does not provide sewage treatment, but rather pumps treated effluent to the ocean from the two regional sewerage authorities, each of which treats their sewage prior to sending it to MCBOA.

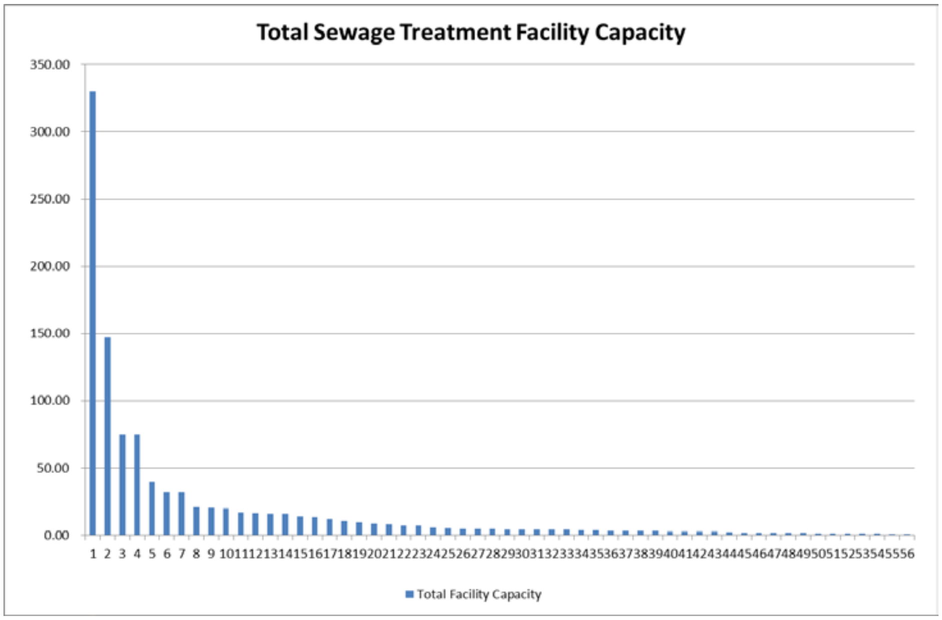

Figure 3.23 Total Sewage Treatment Facility Capacity (based on NJDEP data, 2012)

Total design capacity for all facilities is 1,055.8 MGD, and for the 15 largest facilities is 869.7 MGD (82% of the total). Estimates for New Jersey as a whole are that discharges to the ocean and estuaries comprise roughly 80 percent of all sewage flows. For the northern New Jersey region, ocean and estuary discharges comprise 83.7% of total design capacity.

However, much of the design capacity has already been committed to existing flows. There are two methods used to measure such commitments, as discussed in Chapter 2. The NJDEP Capacity Assurance Program and the Highlands Regional Master Plan both compare design capacity to the maximum three-month flow (MAX3MO, expressed as an average in MGD) over recent years. The NJDEP wastewater management planning program uses annual average flows, also in MGD. To provide a clear sense of how both metrics apply, Table 3.10 shows all sewage treatment facilities with at least 2 MGD available capacity using the MAX3MO method (see Appendix C for a complete listing):

Table 3.10 Available Capacity for Major Sewerage Facilities of Northern New Jersey

NJPDES Permit Number	Facility Name	County	Design or Permitted Flow (MGD)	2011 Available Capacity: MAX3MO Flows (MGD)	2011 Available Capacity: Annual Avg Flows (MGD)
NJ0021016	Passaic Valley Sewerage Commissioners (PVSC)	Essex	330.00	30.00	54.50
NJ0026018	Ocean County Utilities Authority (OCUA)-Southern WPCF	Ocean	20.00	11.10	12.78
NJ0028142	Ocean County Utilities Authority (OCUA)-Northern WPCF	Ocean	32.00	8.03	9.06
NJ0029408	Ocean County Utilities Authority (OCUA)-Central WPCF	Ocean	32.00	7.47	10.53
NJ0024708	Bayshore Regional Sewerage Authority	Monmouth	16.00	6.52	7.39
NJ0026085	North Hudson Sewerage Authority-Adams	Hudson	20.80	5.83	7.01

Table 3.10 Available Capacity for Major Sewerage Facilities of Northern New Jersey

NJPDES Permit Number	Facility Name	County	Design or Permitted Flow (MGD)	2011 Available Capacity: MAX3MO Flows (MGD)	2011 Available Capacity: Annual Avg Flows (MGD)
	Street WTP				
NJ0024643	Rahway Valley Sewerage Authority	Union	40.00	3.83	7.77
NJ0024562	South Monmouth Regional STP	Monmouth	9.10	2.70	3.53
NJ0024872	TNSA Sewerage Treatment Plant (Neptune Township)	Monmouth	8.50	2.64	3.20
NJ0028002	Wayne Twp, Mountain View STP	Passaic	13.50	2.39	4.52
NJ0024902	Hanover Sewerage Authority WTP	Morris	4.61	2.08	2.38
NJ0024520	Township of Ocean Sewerage Authority (TOSA)	Monmouth	7.50	2.07	2.71
NJ0025356	Middletown Sewerage Authority (TOMSA)	Monmouth	10.80	2.07	3.10
			544.81	**86.73**	**128.48**

A key point is that except for PVSC, the next four facilities are located in Ocean and Monmouth Counties. Also worth noting is that although PVSC has an available capacity (using the MAX3MO approach) of 30 MGD, which is larger than the total capacity of most other treatment plants in the state, that amount is less than 10 percent of their total capacity. Even that amount needs to be seen in light of the major CSO events common to the PVSC service area, which raises questions about actual capacity in the sewer trunk lines that contribute to PVSC flows. Several of the largest facilities from Table 3.9 drop off the list entirely, most notably MCUA, BCUA, Joint Meeting of Essex and Union Counties, Rahway, and SRVRSA, all of which have design capacities of greater than 20 MGD. Again using the MAX3MO values, the total distribution of all facilities (with the largest negative capacity being BCUA) is as follows in Figure 3.24 (see Appendix C for a complete listing of facilities):

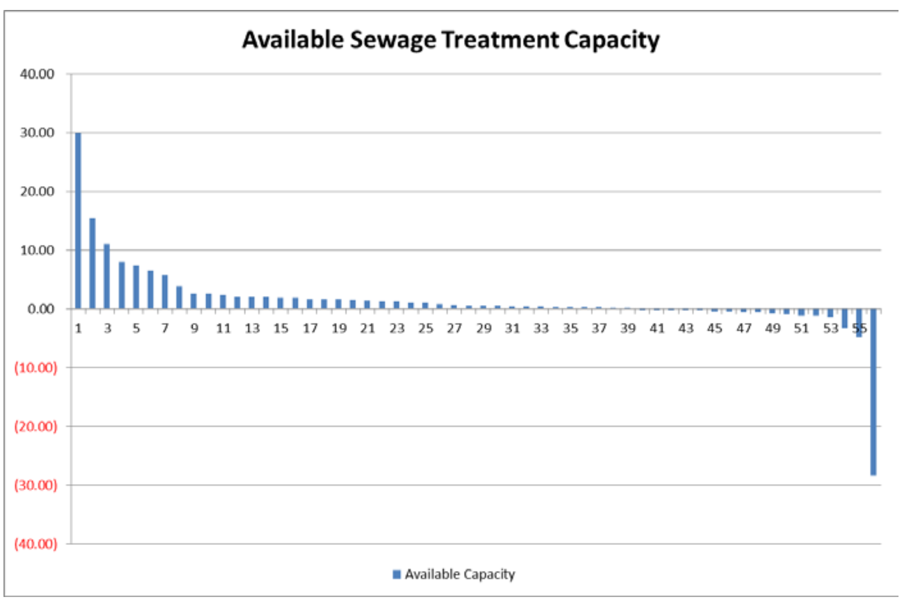

Figure 3.24 Available Sewage Treatment Capacity (MAX3MO approach) (based on NJDEP data, 2012)

Total available capacity for all facilities using MAX3MO is 109.9 MGD (86.73 MGD from the major facilities), but using annual average flows is 195.68 MGD (128.48 MGD from the major facilities). These values for all facilities represent 10.4% and 18.5%, respectively, of the 1,055.8 MGD in total design capacity. It is important to note that in nearly all cases, design capacity and sewage flows are not regulatory effluent permit limits but rather serve as planning and program indicators. Therefore, the values provided above are indicators of system stress rather than specific limits to growth. The actual limits may be higher or lower depending on facility design, operation and maintenance. However, they are the best available information for determining capacity limitations that might affect growth within the region.

No single metric is most appropriate for assessing system stress across all systems. For combined sewer systems, daily flows may be the most critical as these determine when CSO events occur. For most other facilities, the monthly or MAX3MO flows may be the best indication of system stress, depending on the extent to which the system can equalize (smooth out) peak flows. Likewise, environmental impacts are likely to be most critical during the growing season, when warm temperatures and lower average flows heighten ecosystem stress. For facilities receiving sewage that derives from aquifers, summer flows may be most critical for surficial aquifers (as a measure of ecosystem stress) while annual or multi-year flows may be most critical for confined aquifers (as an indication of the potential for potential saltwater infiltration). However, in general the MAX3MO is most appropriate for a regional evaluation of this type.

3.4.1.2. Sewage flow variations

Wastewater flows vary from month to month and year to year, in response to the gain and loss of customers, customer water use patterns, I&I (Inflow and Infiltration, a measure of water that gains access to sewer lines from non-sewer sources), and in some areas stormwater flows in combined sewers. The following table shows the MAX3MO and Annual Average flows for the sewer facilities with design flows of greater than 30 MGD, to provide a sense of flow variations, with the bold numbers indicating the highest year for each flow metric:

Table 3.11 Maximum Three-Month Average Flows and Annual Average Flows for Major Sewerage Facilities of Northern New Jersey, 2009-2011 (bold indicating maximum year for each metric)

NJPDES Permit Number	Facility Name	2009 MAX3MO v Annual (MGD)	2010 MAX3MO v Annual (MGD)	2011 MAX3MO v Annual (MGD)
NJ0021016	Passaic Valley Sewerage Commissioners (PVSC)	256.667/ 236.667	287.333/ 233.750	**300.000/ 275.500**
NJ0020141	Middlesex County Utility Authority (MCUA)	131.653/ 118.112	**152.293**/ 114.436	151.743/ **133.880**
NJ0020028	Bergen County Utilities Authority (BCUA) Main STP	85.785/ 78.769	**103.494**/ 78.198	103.272/ **92.676**
NJ0024741	Joint Meeting of Essex and Union Counties (Joint Meeting)	64.926/ 57.919	**76.351**/ 56.833	76.084/ **66.259**
NJ0024643	Rahway Valley Sewerage Authority (RVSA)	31.200/ 28.425	33.600/ 27.483	**36.167/ 32.233**
NJ0028142	Ocean County Utilities Authority (OCUA)- Northern WPCF	23.147/ 22.338	**28.117/ 23.483**	23.973/ 22.940
NJ0029408	Ocean County Utilities Authority (OCUA)-Central WPCF	24.167/ 21.825	**24.967/ 22.483**	24.533/ 21.475

Several of the facilities have their highest MAX3MO flows in different years from their highest annual average flows (perhaps indicating a year with a major wet period, causing more I&I, that was otherwise normal or dry), while others match years. PVSC and RVSA have contributing areas with CSOs, while the Ocean County facilities do not and those of MCUA are limited to Perth Amboy (see below).

3.4.1.3. Relationship between water demands and wastewater generation

Sewage is generated from three broad sources: customers, I&I, and stormwater influx to combined systems. Infiltration rates are influenced by ground water levels; very wet seasons increase water levels such that infiltration increases significantly. Inflow is dependent on (often illicit) input from sources such as basement sumps. In both cases, deferral of maintenance will tend to result in increased I&I, while routine programmed maintenance will tend to reduce I&I. Stormwater influx to combined sewers depends highly on precipitation events and to a certain extent (as seen with Superstorm Sandy), system flooding.

Customer flows will tend to be fairly constant across the months – the primary reason for peaks in customer water supply demand is for outdoor water uses, which should not generate sewage. Therefore, new building codes that require efficient appliances and plumbing can achieve routine reductions in sewer demand from residential, commercial and office building customers. On the other hand, new water-using devices such as on-line HVAC humidifiers can increase demands. Industrial flows are highly dependent on the manufacturing process involved, which over the last several decades has significantly reduced as water-dependent manufacturing has either ceased or become more water efficient. Customer-generated sewage is a critical factor for public sewer systems, as customers generate all the revenue for the utility. I&I and stormwater within combined sewers can't be billed directly, and therefore the costs of conveying and treating these waters are added to the customer rates.[19]

Unfortunately, many of the public sewer systems have service areas that draw potable water supplies from more than one source, and vice versa. This lack of contiguity complicates efforts to coordinate water conservation efforts that will benefit both the PCWS system and the public sewer system.

3.4.1.4. Sewer service areas

The extension of sewer service to areas that previously lacked service is controlled by NJDEP through the adoption of wastewater management plans with sewer service areas, pursuant to the Water Quality Management Planning rules. As discussed in Chapter 2, NJDEP is currently in the process of reviewing and approving revised sewer service area mapping for all of New Jersey (see www.nj.gov/dep/wqmp). Development proposals reliant on sewer extensions not allowed by NJDEP regulations will not be viable. Several wastewater management plans were recently adopted for Highlands municipalities working under Highlands RMP conformance, and a future sewer service area map for Somerset County was adopted through the statewide NJDEP process. Completion of the new sewer service area maps is expected in 2013.

Sewer service area mapping is not a significant management issue for many of the largest public sewerage systems, as they already are serving the maximum area possible for their systems. For these facilities, the critical issue will be increased demand within the existing service areas. However, for other facilities such as the Ocean County Utilities Authority facilities (e.g., in Jackson Township) and some of the Middlesex County Utilities Authority municipalities, designation of future sewer service areas will be a major factor in growth potential.

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[19] An interesting legal and operational question is raised by this issue. Once stormwater enters a combined sewer, it is no longer stormwater but becomes part of the sewage. Therefore, a bifurcated rate structure may be possible that separately assesses costs for sanitary sewage and stormwater-derived sewage may be an option for CSO communities, avoiding issues of stormwater utility authorization.

The proper designation of sewer service areas is important for a variety of reasons. First, they can be used to prohibit dense development within environmentally sensitive areas. Second, they establish a priority for use of limited sewerage capacity. Third, they can encourage efficient use of land for development, avoiding situations where the density of development on sewers is less cost-effective. Low-density sewerage means that the costs of maintaining each mile of sewer line is imposed on fewer customers than in more densely developed areas, resulting in higher sewer charges. One cause of the existing suburban sewer rates in New Jersey is the relatively low customer density (connections per linear mile of line). All of those pipelines will require major maintenance or replacement over time, a cost that rarely if ever was factored into zoning and development decisions.

3.4.1.5. Stressed systems based on CAP status and effluent quality violations

NJDEP provided information regarding public sewer systems in northern New Jersey that were subject to the Capacity Assurance Program as of mid-2012. These treatment plants have reached or exceeded 80% of their design flow. For each a Capacity Assurance Plan must be submitted to and accepted by the NJDEP, meaning that NJDEP believes additional flows can be accepted without violation of NJPDES permit limits. None of the plants in Middlesex, Union, and Warren are under the CAP Program. Of these facilities, only the first two (BCUA and PVSC) are among the largest fifteen.

Table 3.12 Capacity Assurance Program – Northern New Jersey Facilities as of August 2012 (NJDEP, 2012)

County	Facility (NJPDES #)
Bergen County	Bergen County UA (NJ0020028)
Essex County	Passaic Valley Sewerage Commissioners (PVSC) NJ0024490
Essex County	Verona Township STP (NJ0024490)
Essex County	Township of Livingston (NJ0024511)
Hudson County	North Bergen-Woodcliff STP (NJ0029084) (delisted, May 2013)
Hunterdon County	Raritan Township MUA (NJ0022047)
Hunterdon County	Frenchtown STP (NJ 0029831)
Hunterdon County	Delaware Township MUA (NJ0027561) (delisted, May 2013)
Morris County	Chatham Twp. STP (NJ0020290)
Morris County	Chester Borough STP (NJ0054101)
Morris County	Long Hill Twp STP (NJ0024465)
Morris County	Mendham Borough STP (NJ0021334)
Morris County	Rockaway Valley Regional SA (NJ0022349)
Morris County	Roxbury Twp. Ajax Terrace STP (NJ0022675)
Morris County	Schooley's Mountain STP- Washington Twp (NJ0023493)
Morris County	White Rock Lake STP- Jefferson Twp (NJ0026867)
Passaic County	Wanaque Valley Regional Sewerage Authority (NJ0053759)
Somerset County	Bernard Twp SA- Harrison Brook STP (0022845)
Somerset County	Warren Twp Stage I & II STP (NJ0022489)
Somerset County	Hackettstown MUA (NJ0021369)
Sussex County	Town of Newton (NJ0020184)
Monmouth County	Township of Ocean SA (NJ0024520)
Monmouth County	Borough of Allentown (NJ0020206)

Effluent quality for all treatment plants is regulated by NJDEP using a combination of technology based standards for parameters that are in conformance with the Surface Water Quality Standards for the receiving water, and water quality based effluent limits (WQBELs) for water quality parameters that are in violation of the SWQS for the receiving water, where a discharge contributes to the violation and technology-based effluent limits are not sufficient to achieve compliance. These WQBELs may be created for a specific discharge, or derived from an adopted Total Maximum Daily Load (TMDL) for that parameter (see discussion in Section 3.2, Water Quality and Watershed Integrity, for more details). The Clean Water Enforcement Act requires routine inspections and monitoring of effluent, and imposes significant fines where non-compliance is confirmed. Operators of sewage treatment plants have been subject to these requirements for over a decade, resulting in more attention to effluent quality than in the past. The more critical issues pertain to SWQS violations for which TMDLs and WQBELs have not yet been developed (see Section 3.2 for discussion of water quality issues).

3.4.1.6. Combined Sewer Systems and Overflows

As discussed in Section 3.2 on Water Quality and Watershed Integrity, New Jersey sewers in the oldest urban areas were built at a time when it was accepted practice to transmit both sewage and stormwater away from the cities, without treatment. Once treatment plants were established, it was deemed too difficult in most cases to retrofit the collection system and separate the lines (though some areas such as New Brunswick did so more recently). However, the treatment plants were never built to handle all of the sewage transmitted by the collection systems during significant storms, resulting in “bypasses” to avoid damaging the facilities. In addition, many of the collection systems themselves are not capable of transmitting the full flows during such storms, resulting in Combined Sewer Overflows (CSOs). The bypasses and CSOs result in considerable contamination of the receiving waters (including pathogens as a primarily concern but also including many other contaminants). These waters are not just the estuaries of the New Jersey/New York harbor, but also freshwaters such as the Elizabeth, Hackensack, Passaic and Rahway Rivers, as shown in Figure 3.25 for Paterson. Table 3.13 and Figure 3.26 provide a listing of CSOs and show their approximate locations in northern New Jersey, respectively:

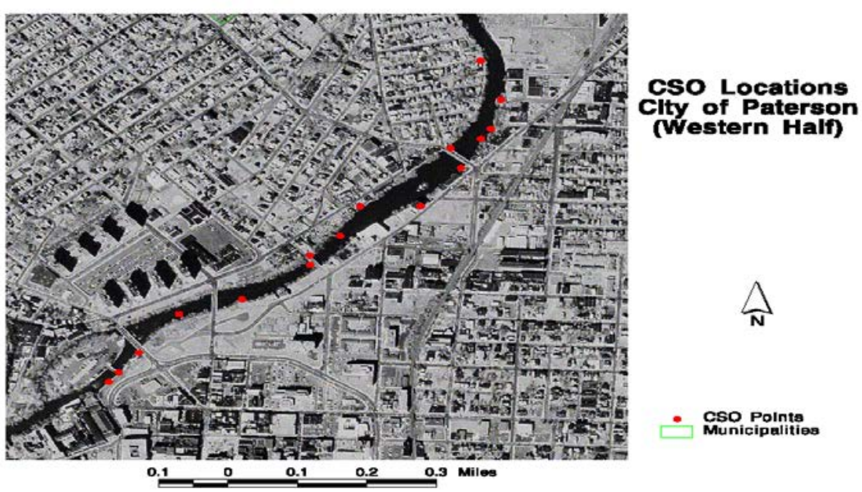

Figure 3.25 CSO Locations in the City of Paterson (NJDEP, 2010)

Table 3.13 Combined Sewer Overflow Points by Municipality (Northern New Jersey) (NJDEP, 2013)

Local Government Unit (Total Number of CSO Points)	Receiving Water Bodies
Bayonne, City of (30)	Kill van Kull
	Upper New York Bay
	Newark Bay
East Newark Borough (1)	Passaic River

Table 3.13 Combined Sewer Overflow Points by Municipality (Northern New Jersey) (NJDEP, 2013)

Local Government Unit (Total Number of CSO Points)	Receiving Water Bodies
Elizabeth, City of (28)	Peripheral Ditch
	Elizabeth River
	Arthur Kill
	Newark Bay
Fort Lee Borough (2)	Hudson River
Guttenberg (1)	Hudson River
Hackensack, City of (2)	Hackensack River
Harrison, Town of (7)	Passaic River
Hoboken (7)	Hudson River
Jersey City Sewerage Authority (21)	Newark Bay
	Penhorn Creek
	Hackensack River
	Hudson River
Kearny, Town of (5)	Passaic River
	Frank's Creek
Newark, City of (17)	Second River
	Passaic River
	Peripheral Ditch
North Bergen Township (10)	Cromakill Creek
	Bellman's Creek
	Paunpeck Creek
	Penhorn Creek
	Hudson River
Paterson, City of (24)	Passaic River
Perth Amboy, City of (16)	Raritan River
	Arthur Kill (Crane Creek)
Ridgefield Park Village (6)	Hackensack River
Union City (1)	Hudson River
Weehawken (2)	Hudson River
West New York MUA (2)	Hudson River
REGIONAL TOTAL	**182**

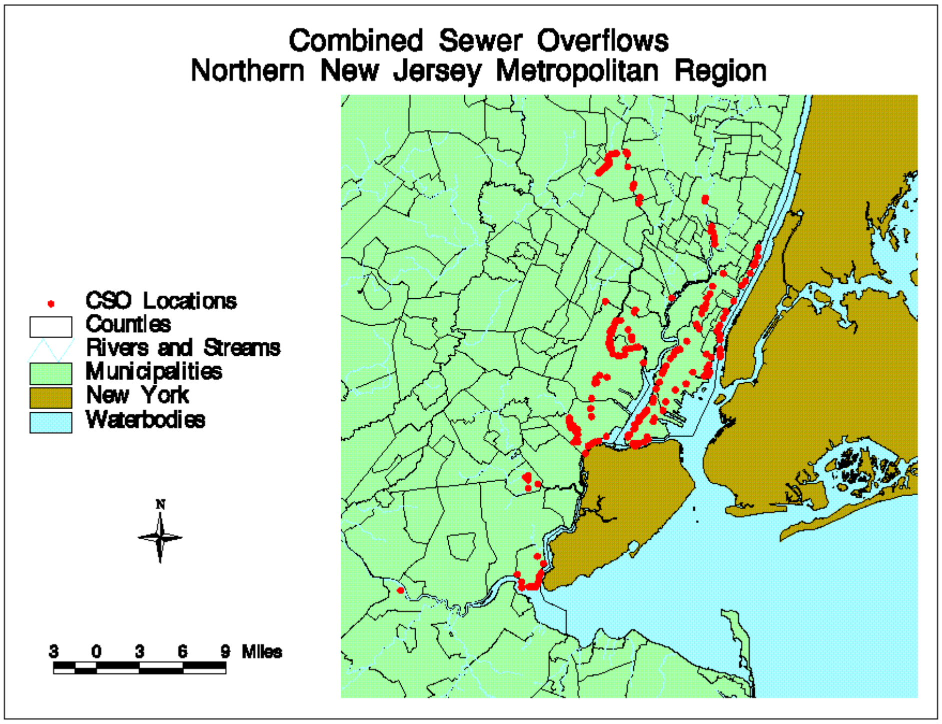

Figure 3.26 CSO Discharge Locations in Northeastern New Jersey (NJDEP, 2010)

No public database is currently available that provides the number and severity of CSO events per year for each facility. Each affected public sewer system has been developing relevant data, some of which is available within individual reports. Along with these data, an estimate of CSO volumes as a percentage of annual flows and as net volumes (indicators of CSO severity) would provide valuable metrics for assessing system and regional trends over time.

As discussed in Section 3.2, federal CSO policies have evolved over time, with early work on implementation of "nine minimum elements" for CSO controls, which are:

1. **Proper operation and maintenance**
2. **Maximum use of collection system for storage**
3. **Review of pretreatment requirements**
4. **Maximization of flow to POTW for treatment**
5. **Prohibition of CSOs during dry weather**
6. **Control of solids and floatables** (mostly completed or under construction)
7. **Pollution prevention**
8. **Public notification**
9. **Monitoring of CSO impacts and efficacy of controls**

NJDEP has been working with CSO communities to accomplish CSO controls in phases over a period of years. NJDEP initially used a "general permit" approach to implement the nine minimum elements for all CSOs in New Jersey, which has resulted in closure of many CSO points and solids/floatable controls on nearly all remaining CSOs. While draft Long Term Control Plans (LTCPs) were begun, they have not progressed to completion in any New Jersey community.

Two recent actions have occurred, one by USEPA and the other by NJDEP. USEPA has taken actions to enforce the nine minimum elements through administrative orders. Jersey City and Perth Amboy signed settlement agreements with USEPA in 2011 and 2012, which address compliance with these provisions.[20] In 2013, NJDEP initiated a new regulatory effort to achieve development and adoption of LTCPs for all 21 municipalities and nine treatment facilities associated with CSOs. These individual NJPDES CSO permits incorporate an approach similar to that of Philadelphia and New York for a combination of "green" and "gray" design solutions, along with other actions. NJDEP released the draft permits for the Camden area in April 2013 and anticipates release of draft permits for all municipalities and facilities in 2013, with final permits being issued in 2014 and 2014.

The anticipated costs for addressing pollutant impacts from CSOs are anything but trivial. Philadelphia alone is committing over $2 billion ($1.2 billion in present value terms) to their long term CSO control plan, which has USEPA approval. New York City is also committing major funding.

As discussed in section 3.2.4.3, planning and regulatory action are moving toward long term control plans based on modeling of stormwater generation and CSO impacts, identification of cost-effective control measures, and implementation. As with Philadelphia, New York City, Syracuse/Onondaga County and other metropolitan areas, current efforts are looking at both methods to reduce the amount of stormwater getting into the combined sewers (e.g., stormwater diversion, infiltration, green roofs) and necessary "gray infrastructure" methods to address the combined flows that cannot be avoided. Techniques investigated by NJDEP regarding the latter included: disinfection of CSO discharges to address the pathogen contamination (costs in excess of $2 billion statewide); maximization of storage capacity within the collection system prior to flow into the treatment plants; deep tunnels (as were selected by Chicago to address their CSO issues); and separation of sewers and consolidation of CSO points (preliminary estimates exceeded $6 billion statewide). Preliminary cost estimates from NJDEP indicate that disinfection may be the least capital intensive approach on a statewide basis. However, there are numerous technical and regulatory issues that must be addressed to determine whether this approach is both feasible and sufficient. NJDEP has been working with Bayonne MUA as a northern New Jersey CSO/WWTP facility to investigate these issues.

[20] The Jersey City settlement requires repair sewer lines and other work totaling approximately $52 million (http://www.justice.gov/opa/pr/2011/July/11-enrd-940.html). The Perth Amboy settlement requires repair of sewer lines and development of a CSO pollution prevention plan, at a cost of roughly $5.4 million (http://yosemite.epa.gov/opa/admpress.nsf/0/452629A43C7CA07285257A150066A2B0).

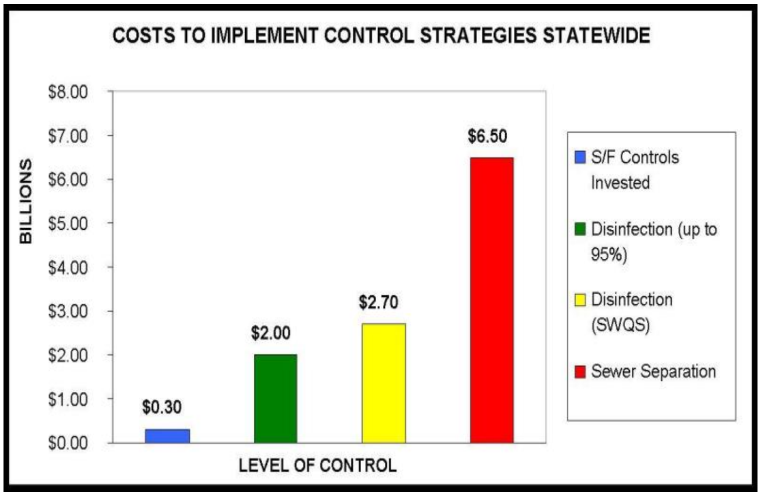

Figure 3.27 Costs to Implement CSO Control Strategies Statewide (NJDEP, 2010)

3.4.1.7. Key issues: Aging infrastructure; Infiltration and Inflow

Another major issue is aging infrastructure. Historic urban areas in some cases have original collection systems in place, over 100 years old. Even suburban areas are aging – what were once thought of as the newly developed areas were in many cases built in the 1960's or soon after and are approaching 40-50 years of age. Public pressure to keep rates low has a perverse result – deferred maintenance that will result in future system breaks and emergency repairs at great cost. The results include increased I&I rates, which stress the collection system and increase the total volume of sewage to be treated. Both impacts have costs, which place further financial stress on the utility and can result in more deferral of planned maintenance. In the absence of effective asset management, systems could reach a point where only major expenditures will prevent ongoing degradation of the sewerage system. These issues are of greatest concern for collection systems, as the treatment plants are routinely inspected and face fines if effluent limits are not met.

3.4.2. Needs and disparities for Priority Systems

One way of assessing stresses for future needs is to compare projected population increases within sewer system service areas. For this purpose, the NJTPA projections to 2035 were analyzed to identify each municipality comprising at least 0.4% of the region's population growth from 2010 to 2035. A total of 67 municipalities are in this set, out of 384 municipalities in the region. The breakdown in number of municipalities is as follows (See Appendix B for a complete listing):

Table 3.14 Number of Municipalities by Share of Projected Regional Growth through 2035 (based on NJTPA projections)

Percent of Regional Growth	# of Municipalities
>3.0	4
2<3	3
1<2	18
0.8-0.9	6
0.6-0.7	13
0.4-0.5	23

These municipalities were then examined regarding their public sewer systems. Nearly all of the high-growth municipalities are within the service areas of the largest public sewer systems.

3.4.2.1. Systems with apparent capacity for growth

As discussed above and shown in Table 3.10, based on the MAX3MO method a number of systems appear to have significant capacity for additional sewage flows, while others (such as MCUA) apparently do not. However, some issues need to be addressed to determine whether this potentially available capacity can actually be realized. Some facilities may have water supply constraints, others may require treatment upgrades to address TMDL requirements, and PVSC has major CSO issues. Appendix D addresses these issues for all public sewer systems.

Table 3.15 Available Capacity and Potential Capacity Issues for Major Sewerage Treatment Plants in Northern New Jersey

NJPDES Permit Number	Facility Name	2011 Available Capacity: MAX3MO (MGD)	Potential Issues
NJ0021016	Passaic Valley Sewerage Commissioners (PVSC)	30.00	CSO controls, Potential NY/NJ Harbor TMDL
NJ0026018	Ocean County Utilities Authority (OCUA)-Southern WPCF	11.10	Net Water Availability (TBD from pending NJSWSP)
NJ0028142	Ocean County Utilities Authority (OCUA)-Northern WPCF	8.03	Net Water Availability (TBD from pending NJSWSP)
NJ0029408	Ocean County Utilities Authority (OCUA)-Central WPCF	7.47	Net Water Availability (TBD from pending NJSWSP)
NJ0024708	Bayshore Regional Sewerage Authority	6.52	Water Supply Critical Area #1
NJ0026085	North Hudson Sewerage Authority-Adams Street WTP	5.83	CSO controls, Potential NY/NJ Harbor TMDL
NJ0024643	Rahway Valley Sewerage Authority	3.83	CSO controls, Potential NY/NJ Harbor TMDL
NJ0024562	South Monmouth Regional STP	2.70	
NJ0024872	TNSA Sewerage Treatment Plant (Neptune Township)	2.64	
NJ0028002	Wayne Twp, Mountain View STP	2.39	Passaic River Phosphorus TMDL
NJ0024902	Hanover Sewerage Authority WTP	2.08	Passaic River Phosphorus TMDL
NJ0024520	Township of Ocean Sewerage Authority (TOSA)	2.07	
NJ0025356	Middletown Sewerage Authority (TOMSA)	2.07	Water Supply Critical Area #1

3.4.2.2. Growth projections and capacity

Table 3.16 shows the high-growth municipalities (with those over 1.5% of the regional total shown in bold) and the relevant public sewer systems. The municipalities are grouped by public sewer system. Only four are not served by any public sewer systems, as shown at the bottom of the table, though some high-growth municipalities may be only partly served by public sewers. The three right-hand columns are of particular interest, as they show the aggregated percentage of projected regional growth represented by the high-growth municipalities for each system, the system surplus or deficit using MAX3MO (as discussed previously) for the systems representing at least 1.4% of the regional projected growth through 2035, and an estimated demand based on per capita sewage flows of 75 gpcd. It is important to note that the total projected regional growth within these systems will be higher, as there are many municipalities with regional growth shares of less than 0.4% (see Appendix B for a complete listing).

Table 3.16 Sewer Service Demand Contributions of High-Growth Municipalities in Northern New Jersey

Municipality	2010 Pop	2035 Pop	Growth 2010-2035 (% of Region)	Sewage Treatment Provider	System % of Region Growth	2011 Available Capacity Based on MAX3MO (MGD)	Demand at 75 gpcd (in MGD)
Garfield city	30487	35760	0.4%	PVSC	22.7%	30.00	20.60
Bloomfield twp	47315	54890	0.6%	PVSC			
Montclair twp	37669	44630	0.6%	PVSC			
Newark city	277140	322190	**3.7%**	PVSC			
Bayonne city	63024	86740	**2.0%**	PVSC			
Harrison town	13620	18990	0.4%	PVSC			
Jersey City	247597	327500	**6.6%**	PVSC			
Kearny town	40684	45350	0.4%	PVSC			
North Bergen twp	60773	71300	0.9%	PVSC			
Union City	66455	75400	0.7%	PVSC			
Clifton city	84136	98820	1.2%	PVSC			
Passaic city	69781	90200	**1.7%**	PVSC			
Paterson city	146199	187790	**3.4%**	PVSC			
Cranbury twp	3857	8790	0.4%	MCUA	14.3%	-4.74	13.03
East Brunswick twp	47512	63450	**1.3%**	MCUA			
Edison twp	99967	119140	**1.6%**	MCUA			
Highland Park boro	13982	18410	0.4%	MCUA			
Monroe township	39132	48900	0.8%	MCUA			
New Brunswick city	55181	73150	**1.5%**	MCUA			
North Brunswick twp	40742	46590	0.5%	MCUA			
Old Bridge twp	65375	75490	0.8%	MCUA			
Perth Amboy city	50814	67950	1.4%	MCUA			
Piscataway twp	56044	62230	0.5%	MCUA			
Sayreville boro	42704	53940	0.9%	MCUA			
South Brunswick twp	43417	58970	1.3%	MCUA			
Woodbridge twp	99585	117940	**1.5%**	MCUA			
Franklin twp	62300	72400	0.8%	MCUA			
Plainfield city	49808	56810	0.6%	MCUA			
Barnegat twp	20936	28110	0.6%	OCUA-Central	7.2%	7.47	6.58
Berkeley twp	41255	59450	**1.5%**	OCUA-Central			
Lacey twp	27644	38590	0.9%	OCUA-Central			
Manchester twp	43070	59740	1.4%	OCUA-Central			
Ocean twp	8332	16770	0.7%	OCUA-Central			
Toms River twp	91239	117540	**2.2%**	OCUA-Central			
City of Orange twp	30134	36590	0.5%	Joint Mtg of Essex & Union	6.0%	-1.08	5.48
Irvington twp	53926	67570	1.1%	Joint Mtg of Essex & Union			
Union twp	56642	63460	0.6%	Joint Mtg of Essex & Union			
East Orange city	64270	79830	1.3%	Joint Mtg of Essex & Union/ PVSC			
Elizabeth city	124969	155610	**2.5%**	Joint Mtg of Essex			

Table 3.16 Sewer Service Demand Contributions of High-Growth Municipalities in Northern New Jersey

Municipality	2010 Pop	2035 Pop	Growth 2010-2035 (% of Region)	Sewage Treatment Provider	System % of Region Growth	2011 Available Capacity Based on MAX3MO (MGD)	Demand at 75 gpcd (in MGD)
				& Union/ PVSC			
Brick twp	75072	96610	**1.8%**	OCUA-Northern	5.4%	8.03	4.93
Jackson twp	54856	99040	**3.6%**	OCUA-Northern			
Fort Lee boro	35345	42860	0.6%	BCUA	2.9%	-28.27	2.66
Hackensack city	43010	55370	1.0%	BCUA			
Lyndhurst twp	20554	26800	0.5%	BCUA			
Paramus boro	26342	30740	0.4%	BCUA			
Teaneck twp	39776	44740	0.4%	BCUA			
Little Egg Harbor twp	20065	31900	1.0%	OCUA-Southern	1.6%	11.10	1.46
Stafford twp	26535	34130	0.6%	OCUA-Southern			
Hillsborough twp	38303	50970	1.0%	SRVSA	1.4%	-0.77	1.29
Somerville boro	12098	16670	0.4%	SRVSA			
Howell twp	51075	65790	1.2%	Southern Monmouth RSA	1.2%		1.10
Wayne twp	54717	67130	1.0%	Wayne	1.0%		0.93
Manalapan twp	38872	47630	0.7%	Western Monmouth UA	0.7%		0.66
Plainsboro twp	22999	31150	0.7%	Stony Brook RSA/ United Water Princeton Meadows	0.7%		0.61
Secaucus town	16264	23350	0.6%	Secaucus	0.6%		0.53
Asbury Park city	16116	22790	0.6%	Asbury Park STP	0.6%		0.50
Linden city	40499	46070	0.5%	Linden Roselle SA	0.5%		0.42
Long Branch city	30719	36320	0.5%	Long Branch SA	0.5%		0.42
Neptune twp	27935	33470	0.5%	Township of Neptune SA	0.5%		0.42
Middletown twp	66522	71580	0.4%	Township of Middletown SA	0.4%		0.38
Weehawken twp	12554	17220	0.4%	North Hudson SA	0.4%		0.35
Newton town	7997	12400	0.4%	Newton WWTP	0.4%		0.33
Vernon twp	23943	28230	0.4%	Sussex County MUA	0.4%		0.32
Plumsted twp	8421	14000	0.5%	N/A	0.5%		
Andover twp	6319	11270	0.4%	N/A	0.4%		
Frankford twp	5565	10130	0.4%	N/A	0.4%		
Wantage twp	11358	18000	0.5%	N/A	0.5%		
Totals	**3351548**	**4213340**	**71.20%**		**71.20%**		**63.0**

As seen in Table 3.16, there are several systems with high-growth municipalities but a capacity deficit based on MAX3MO flows. These systems will need more detailed evaluation to determine the extent to which the system capacity may constrain future development and redevelopment activities. It is important to note that capacity can be gained through infrastructure improvements (such as I&I reductions), water conservation, and redevelopment that results in a net reduction of water use. The need for CSO reductions in affected systems is also a major issue.

3.4.2.3. Capacity issues for CSO systems

A significant question that New Jersey has not really addressed is whether it is appropriate to view systems with CSOs as having any capacity at all. The problem is that each additional volume of routine sewage in the system equates to both an increased gallon of combined sewer discharges and an increased frequency of CSO events, as the collection system will fill that much faster. Redevelopment that results in reduced sewage flows avoids this problem, but most redevelopment results in additional flows. Policy will be needed regarding new flows, such as requirements for mitigation measures that reduce CSO volumes even as sewage flows increase. The mitigation measures could be on-site or off-site, and often would be able to use "green infrastructure" technology, stormwater reuse and other means of sequestering stormwater from the sewer systems.

3.4.3. Key factors likely to influence future trends and the region's ability to address needs and disparities

Three major issues exist for public sewer systems, in addition to net capacity, that can greatly affect the sustainability of systems in the decades to come.

3.4.3.1. CSO compliance requirements

The national experience is clear – CSO reductions to achieve Clean Water Act objectives are very costly. Some measures have concomitant benefits, such as the major redevelopment activity along the Chicago River and the anticipated neighborhood "greening" and land value increases anticipated through the New York City and Philadelphia programs. However, many of the benefits will accrue to private landowners and only indirectly to cities (through an enhanced tax base), and even increased property taxes will not benefit the public sewer systems, which are dependent on revenue from sewer rates, not property taxes. Therefore, the likelihood of major rate increases to address CSOs must be anticipated in the cities and systems with the most CSO discharge points: Bayonne, Elizabeth, Jersey City, Harrison, Kearny, Newark, North Bergen, Paterson, Perth Amboy, and the North Hudson Sewerage Authority area. Some of these are large cities and others are much smaller relative to the number of outfalls. The region can expect the costs to be major, though spread out over as much as 20 years or more. No system has a long-term CSO control plan or settlement agreement equivalent to those of Philadelphia.

3.4.3.2. Nutrient standards

The Passaic River Nutrient TMDL is the only major nutrient TMDL that has been adopted to date by NJDEP. A Raritan Basin nutrient TMDL model has been developed but has not received final approval from NJDEP to serve as the basis for a formal TMDL. The basic purpose of the Passaic River TMDL is to reduce nutrient (primarily phosphorus) loads in the river so as to protect water supplies from the effects of eutrophication, such as taste and odor problems or toxicity from cyanobacteria (aka blue-green algae), certain types of green algae, and other organisms. Upon full implementation of the TMDL, certain Passaic River Basin dischargers will face additional treatment and operational requirements that may increase capital and operating costs. Some of these same public sewer systems will face constraints on treatment plant construction due to their location with the Passaic River Basin flood plains. Similar issues may arise in the Raritan Basin. Nutrient issues have been identified in other waters, including the Barnegat Bay and the Delaware Bay near Salem County. Nutrient issues in the NY/NJ Harbor Estuary complex also are of concern. At this time, issues of the Barnegat Bay are known to be primarily nonpoint source in origin, while the Harbor Estuary has a mix of point and nonpoint sources. The Delaware Bay is affected by pollutant loads from Delaware River Basin above the head of tide, point and nonpoint source discharges to the tidal river upstream of the main bay, and by a variety of nonpoint and point sources into and near the bay itself.

3.4.3.3. Costs of deferred maintenance

As with water supply systems, no authoritative figures are available regarding the total costs of deferred maintenance for sewer systems, but anecdotal and individual system evidence indicates that they will be high. Newark has released estimates of over $500 million in deferred maintenance costs for its sewer and water supply system. Other systems are just starting to get a handle on their costs. Regardless of the total costs, the costs of not taking action include emergency repairs at much higher cost, plus service disruptions, as has been seen many times in recent years. To the deferred maintenance costs must also be added the upcoming costs of system improvements to meet CSO and TMDL requirements and to address increasing demands. Deferred maintenance costs will harm the ability of public sewer systems to address other emerging needs.

An additional cost will be related to protecting wastewater systems from the effects of rising sea level and the attendant increases in storm damages. Public sewers in urbanized areas of this region, as with stormwater systems, are essentially all dependent on the gravity flow of sewage to the treatment plant. As such, the collection systems, pumping stations and treatment plants tend to be in the lowest possible locations to maximize the benefit of gravity. Therefore, they are located in the most vulnerable places. The effects of Superstorm Sandy are instructive, having completely flooded and knocked out the PVSC treatment plant (in the Ironbound section of Newark), a critical pumping station to the MCUA treatment plant (which itself is located on higher ground), and many pumps along the barrier islands. Sewer collection lines along the barrier islands were damaged and in some cases filled with sand and debris. In addition to storm repairs, systems will face costs associated with redesigning and reconstructing their systems to reduce the risk of catastrophic system failure due to extreme weather events, flooding, storm surge and sea level rise.

3.4.4. Challenges and Opportunities

Public sewer systems play a fundamental role in support of existing and potential concentrated development in the northern New Jersey region. The major challenges are three. First, many systems are aging and must receive concentrated investment over many years to reach a sustainable condition that can be maintained with the lowest lifecycle costs. The issue has been ignored in both good times and bad, seemingly because no time is “good enough” to raise rates significantly. However, the long term result is that rates will be raised anyway, and possibly higher, to address frequent emergency repairs. These systems face a real possibility that they will be conducting emergency repairs at the same time that they try to bring the entire system up to satisfactory condition.

Second, major costs should be anticipated for environmental issues long studied but not managed, such as CSO controls, nutrient TMDLs, the loss of potential water supplies due to the common practice of “use once and discharge to the ocean,” etc. As noted earlier in this section, roughly 80% of all treated wastewater discharges are to the ocean and estuaries, providing no opportunity for reuse or ecological benefits.

Third, the service areas and governance for public sewage systems are very often disconnected from those of public water systems, public stormwater systems, and municipalities that control development (see Appendix B for listings regarding high growth municipalities in the region). For instance, in much of Bergen County, the water supply is provided by United Water-NJ, an investor-owned utility. Wastewater service is provided largely by municipalities connected to the Bergen County Utility Authority or the Northwest Bergen County Utility Authority. Stormwater services are provided by municipalities, or by individual property owners for non-public facilities. Middlesex and Monmouth Counties have similar situations. This fragmented, disjointed condition will make large-scale viable solutions much more difficult to identify and implement. The difference between New Jersey and its neighbors – New York City and Philadelphia – is stark. Those two cities have an enviable situation where all three utilities are revenue-generating enterprises controlled by the same entity (the city) that governs land use, the transportation system, etc. Philadelphia is noted for its cross-departmental efforts to manage water issues. New Jersey is highly unlikely to ever reach that level of contiguity in system management.

The key opportunity comes from a simple fact – without adequate water utility systems, the economy of northern New Jersey cannot thrive. Water supply, wastewater and stormwater systems must be in place, with sufficient capacity, managed in a manner that ensures quality services at the lowest lifecycle costs, or all other efforts will ultimately fail. The absence of a negative (systems that aren't badly failing yet) doesn't maximize the potential benefits of having good water utility systems. Many places in this and other countries have recognized and benefited from the amenity value of water. When damaged rivers, streams, ponds and lakes are replaced by attractive waters with good quality, the tendency is for land values to jump significantly as the water amenities attract development. Boston and Baltimore harbors, the Chicago River and New Jersey's "Gold Coast" along with other examples show the potential that comes from water quality and ecological improvements.

3.5. Public Stormwater Systems

As with public water supply and wastewater systems, public stormwater systems generally are comprised of those components that are not within purely private property. Collection and treatment components within specific developments tend to be private, while the collection and discharge systems within streets and highways and their rights-of-way and those within public property are government-owned. Some private developments have stormwater systems that never intersect with a public stormwater system – stormwater is discharged to surface waters directly. In areas with combined sewers, the stormwater collection systems are also the sewer collection systems, and they run to the sewage treatment plant but are punctuated by periodic CSO outfall points at or along streams or tidal waters. In areas with separate stormwater systems (aka Municipal Separate Stormwater Systems, or MS4s), the collection systems generally do not aggregate flows from large areas, but rather collect stormwater from relatively small catchment areas and then discharge into fresh or tidal waters. Any one municipality can have hundreds or even thousands of stormwater outfalls.

Unfortunately, no standardized, compiled mapping of stormwater systems or even outfalls exists across the Together North Jersey region. Components of a system do exist. For instance, under municipal stormwater permits, each municipality with an MS4 was required to create and maintain an inventory of stormwater outfalls. These maps were required to use a tax map or similar map, but unfortunately Geographic Information System (GIS) mapping was <u>not</u> required. Other agencies, for instance the Freehold Soil Conservation District, have mapped (using GPS and GIS) and evaluated stormwater basins with their jurisdiction to identify possible problems with mosquito vector control, system failure, etc. In the 1990's under the Sewage Infrastructure Improvement Act, 94 municipalities along the Atlantic Coast attempted to map all stormwater and sewer lines and determine whether and where water in one might flow to another. These maps were provided to NJDEP in hard-copy format, regardless of their original hand or digital development. Few if any used GIS, and again the results were not compiled. Finally, studies have been conducted by NJDEP and others in specific areas to identify stormwater outfalls and the related collection systems, as part of a program to relate water quality effects to specific outfalls, groups of outfalls, types of land uses, etc. However, these studies cover only a small part of the total state.

A fundamental distinction between public stormwater systems and public water supply and sewer systems is that the stormwater systems have no direct revenue source. Many of the components were constructed by developers and ceded to the municipality, though many municipalities minimize the extent to which they accept ownership for stormwater systems that are not within public lands or rights-of-way. Therefore, there is even less incentive to maintain and improve public stormwater systems than is true for the other water utilities. While one statute would appear to allow creation of a fee-based municipal stormwater utility as part of the municipal government, it does not allow for a fee-based stormwater utility authority. This statute also has never been applied to stormwater management. Therefore, to the extent that municipalities engage in any maintenance of stormwater systems, the costs are part of the municipal budget and supported by the property tax, paid by those who create stormwater that affects public stormwater systems and by those who do not.

3.5.1. Key patterns and trends

The most fundamental pattern in public stormwater systems is that stormwater systems follow development and do not precede it. One major trend has been an evolution of stormwater management practices to more sophisticated objectives, and therefore more complex systems. A second major (and directly related) trend is a major reluctance on the part of municipalities to accept ownership of stormwater infrastructure wherever possible, as a way of minimizing public maintenance costs.

3.5.1.1. Conceptual shifts in regulatory approaches

Stormwater was for decades seen as a public nuisance that should be removed from properties and streets and discharged to the nearest water body in the shortest possible time. The result has been a significant reduction in the recharge of ground waters by stormwater, and a significant degradation of water quality and watershed integrity from polluted stormwater being discharged with no volume or velocity controls, both polluting the receiving waters and destroying stream channels.

The advent of improved modeling approaches and broader environmental programs resulted in a rethinking of this approach. The first steps involved controlling the rate and force of discharges, so that the peak rate of discharge was no higher than predevelopment peaks, and the discharge force was dissipated at the outfall to protect the stream channel. Stormwater basins (mostly detention, but some retention where a water amenity was desired) became the standard approach in suburban and exurban development. These basins also resulted in some sediment control (through settling) but in some cases exacerbated pollution problems from bacterial sources and thermal pollution. City stormwater systems had long-since been constructed and were not required to change, even upon redevelopment.

Further research and modeling, including several key studies in New Jersey, showed that a developed watershed where all discharges met the “no increase in discharge rate” requirement would still have stream flows that greatly exceeded natural flows. This impact is caused by the greatly increased volumes of stormwater flow from developed sites; the peak discharges are maintained much longer than natural, and the peaks therefore overlap in the stream and increase flooding and stream damage. This new work led to new standards (such as the original Residential Site Improvement Standards and related NJDEP stormwater management rules in the 1990’s) requiring that peak discharge rates be less than predevelopment peaks, with the extent of the reduction varying based on the severity of the storm.

Finally, stormwater experts recognized that water quality problems were still a significant issue and were caused both by stormwater system discharges and by reduced stream flow due to loss of recharge. In New Jersey, these concerns led to NJDEP stormwater requirements adopted in 2004 that new developments maintain predevelopment recharge rates, and achieve specific levels of nonpoint source pollutant control. As before, stormwater basins are constructed to manage runoff from a 100 year storm, while collection systems are generally sized to handle a 25 year storm. Again, different and far less stringent requirements apply to redevelopment in urban areas, though some rethinking of this issue is being forced by the CSO issue to see whether stormwater flows to the combined sewers can be reduced.

The net result of this evolving system of stormwater regulation is that development from early settlement through the 1970’s and into the 1980’s (the vast majority of existing development) has little or no control on stormwater discharges, development from around the 1980’s and 1990’s has some controls on discharge rates and velocities, and development approved after the new standards of 2004 has the most current controls. Modification of past systems is rare and primarily driven by local issues such as street flooding.

3.5.1.2. Beach closing trends

Beach closings in New Jersey became a major political scandal in the 1980's, resulting in Governor Kean's successful program to reduce ocean pollution. The closings were caused by a combination of factors: medical, other solid wastes, and debris ranging from small chunks of floatable materials to wharf sections, washing up into beach areas from the urban areas; poorly treated local sewage treatment plant discharges; sewage crossing into stormwater systems through line breaks and being discharged near the beaches; and stormwater discharges, most of which are to back bays rather than the ocean. Over time, each of these issues has been improved, with the possible exception of stormwater discharges into the back bays, though even those discharges benefitted from a reduction in sewage inflows. Numerous small sewage treatment plants that discharged to inland streams were eliminated and their flows consolidated to coastal discharges (which greatly improved water quality but had the concomitant effect of decreasing stream flows and preventing wastewater reuse). Coastal discharges were improved through treatment upgrades, and their beach impacts were reduced through extension of the outfall pipes. Programs with the U.S. Army Corps of Engineers to remove rotting waterfront structures in the NY/NJ Harbor were successful in reducing large debris, enforcement programs reduced medical wastes in ocean waters, and CSO controls for floatable and solid materials are being effective in reducing introduction of these materials into coastal waters. The result has been a significant improvement in the beach closing issue, with most remaining closings caused by stormwater discharges (NJDEP 2011). As such, these closings do not have a trend, per se, but rather correlate with the number of weather events that lead to significant runoff, which can change significantly from year to year. As noted in the NJDEP report, many beach closings are now precautionary, based on anticipated impacts from storm events, rather than from test results.

3.5.1.3. Nonpoint source (NPS) pollution trends

As discussed above in Section 3.2 on Water Quality and Watershed Integrity, nonpoint source pollution in suburban and exurban streams has been increasing over time as development increases in these areas. Most of the nonpoint pollutant load is brought to the streams by stormwater outfalls, though some results from direct runoff of stormwater or from erosion of the streams themselves. Major pollutants generally associated with stormwater include sodium and chloride from road salts, nutrients from fertilizers, sediment, pesticides, litter and road debris, and vehicle materials such as oil, grease and particulate solids. Also of concern but rarely discussed is the heat brought to streams by stormwater that has been heated on roads and in stormwater basins. Thermal pollution can make a stream uninhabitable by sensitive species such as trout in the coldwater, Category One streams of northwestern New Jersey.

The pollutant trends may be mitigated by ongoing shifts in policy. New Jersey passed a stringent law regarding the composition and application of lawn care fertilizers primarily to reduce nutrient contamination and eutrophication in Barnegat Bay, but the benefits should become evident in other waters also. Second, transportation agencies are slowing shifting some of their road salt use to brine applications, which can significantly reduce salt use without harming road safety.

3.5.2. Needs and disparities/existing and future conditions

Given the paucity of information available on stormwater systems, it is very difficult to assess needs for the future. Therefore, the primary need is for methods to evaluate current conditions. The first step is understanding what types of stormwater infrastructure were constructed where and when. Constructing this inventory for each stormwater line would require major funding and time. Therefore, a simplified approach is needed.

3.5.2.1. Method for assessing the stormwater infrastructure constructed by regulatory period

New Jersey has conducted a series of aerial photography surveys that show the land use and land cover of the entire state for the years 1986, 1995, 2002 and 2007 (with flights occurring generally in March to provide "leaf off" photographs with minimal snow cover). These photographs were then interpreted to create GIS-based Land Use/Land Cover data for each of these years in GIS. Comparisons provide useful data on the development that occurred between each set of photographs. Satellite images from intervening years can be used to identify when specific land uses occurred, relying on the next aerial photographic survey and Land Use/Land Cover data to identify the specific type of development.

The first step is to relate the Land Use/Land Cover data to changes in stormwater regulations over time. For instance, new requirements were first incorporated into the Residential Site Improvement Standards in 1996 and adopted into municipal requirements in 1997, between the 1995 and 2002 surveys. Most residential development that occurred in the period of 1995 through 1998 probably responded to pre-RSIS standards, based on prior municipal approvals. Commercial development would have been affected only if it occurred in Flood Hazard Areas, where equivalent standards were adopted by NJDEP, or if municipalities adopted the RSIS stormwater standards as applicable to all development. As noted above, NJDEP's Municipal Stormwater Regulations were adopted in 2004, and so by 2007 most new development would be responding to those rules.

Precise application of this approach is not feasible, as some developments are constructed years after their approval, and New Jersey has adopted several iterations of permit extension acts during poor markets that allowed development to maintain active approvals that otherwise would have lapsed. However, as a regional tool for broadly evaluating which developments are likely to have been regulated under specific types of stormwater regulations, the approach will be adequate. Municipalities can then check their records if there as a need for more specific analysis. The general purpose of this evaluation is to determine which systems are likely experiencing reduced integrity due to age and poor maintenance, and which systems are likely causing the most stream damage due to uncontrolled discharges.

Another check on the GIS-based information could come from State Soil Conservation Committee (SSCC) data on the number, affected acreage and (where available) density of development for which Soil Erosion and Sediment Control plans were approved, by year and municipality.

3.5.2.2. Understanding retrofit needs

The stormwater systems are vast, aging and not funded. Therefore, retrofit needs must be assessed based on priorities for redevelopment, water quality restoration, and watershed management needs. Key priorities would include:

- ***Waterfront areas***: As noted previously, water quality improvements in waterfront areas can foster major redevelopment activities on adjoining and nearby lands. People like water, and they like their water to be an amenity rather than a trash-filled mess. Stormwater improvements that will help increase urban amenity values can be highly cost-effective.
- ***Urban streams, especially in parks and other public areas***: Likewise, where urban residents and workers can have access to streams, the amenity value can be high if the streams aren't highly degraded by trash, erosion, obstructions and the like. Philadelphia is placing many stormwater and stream improvements in parks to both improve their stormwater system <u>and</u> enhance park values for their users. As with waterfront areas, neighboring lands can experience increased values and redevelopment potential.
- ***Suburban and urban ponds and lakes***: Ponds and lakes are a special case, as their waters flow too slowly to quickly move pollutants out of their waters. Stormwater outfalls to ponds and lakes and to streams just

above them can create long-lasting damage. Conversely, correction of these stormwater systems can provide long-lasting benefits.

3.5.3. Key factors likely to influence future trends and the region's ability to address needs and disparities

3.5.3.1. Urban stormwater standards

To date, NJDEP has been reluctant to apply some of the more recent stormwater standards particularly regarding water quality controls) to urban areas, in part due to the diversity of existing stormwater systems and redevelopment scenarios. However, over time it is quite possible that some approach will be developed that addresses stormwater retrofit needs in urban areas through redevelopment projects. The approach could be normative or it could be more qualitative, setting general guidelines within which municipalities and developers work. Evolution of the regulatory approaches could be driven by work in the CSO abatement field, or by other Clean Water Act needs that would be implemented through the municipal stormwater permit program.

3.5.3.2. TMDL implementation regarding NPS pollution from stormwater sources

One Clean Water Act driver for stormwater system enhancements is the Total Maximum Daily Load (TMDL) approach. Urban waters are frequently noncompliant with Surface Water Quality Standards. For saline waters, the primary issue is pathogen pollution that damages recreational uses of estuarine and coastal waters, including fishing and boating. For freshwaters, the primary issues tend to be pathogens, nutrients and reduced dissolved oxygen (caused by introduction of organic materials with a high Biological Oxygen Demand, or BOD). Sufficient research has been conducted to know that stormwater is a major means by which pollutants reach surface waters, and therefore retrofit and maintenance requirements could become a major approach for correcting the water quality problems. NJDEP has adopted many pathogen TMDLs that ostensibly require nonpoint source controls, but these TMDLs are not highly successful to date. Funding of controls remains a major issue, especially as no fee-based stormwater utilities exist in New Jersey.

3.5.3.3. Stormwater as a water resource

The most fundamental change that could affect the region is the ongoing shift from stormwater as a "waste" water with no value and significant costs, to stormwater as a valuable water resource usable for ground water recharge, maintenance of stream flow, reuse for everything from irrigation to building HVAC systems to water fountains, and as a park amenity in ponds, retention basins and water sculptures. To the extent that stormwater attains status as a public value, regulations will shift to provide more of that value. To the extent that stormwater management becomes a private sector value (as in Battery Park City in New York City), private sector design will take advantage of the potential values through improved design.

3.5.4. Challenges and Opportunities

The most fundamental challenge of stormwater is its status as a resource without a price and without a value. Unlike water resources that are managed as public resources (public goods), stormwater has been managed as a form of wastewater (a public "bad") but without the institutional structure that would provide for effective management even in that status. The challenge will be in migrating stormwater from public bad to public benefit, with a management approach that allows for incremental change regionally, but profound improvements locally.

3.6. Climate Change Implications for Water Resources and Water Utilities

Climate change poses a significant uncertainty facing New Jersey's water resources and utilities. Many of the direct effects of climate change on communities will involve heightened natural hazards, as a warmer atmosphere and oceans power both more numerous and powerful storms, on one hand, and more frequent and severe droughts, on the other. Climate change and natural hazards affect water resources. Storms and floods can damage dams for reservoirs and lakes. Droughts can greatly reduce stream flows, harming aquatic ecosystems in streams, rivers, lakes and estuaries. Industrial uses of surface waters, including cooling water for electric power generation, may be constrained. Reduced stream flows also can harm agriculture, which often uses surface waters for irrigation water and livestock. Some agricultural needs are provided by natural precipitation, but irrigated agriculture is the second largest water uses in the United States after electrical power generation, and the largest single consumptive water use (Kenny et al., 2009). Finally, reduced stream flows stress public water supplies and harm water quality, as less water is available to dilute both natural and anthropogenic pollutant loads (Sustainable Jersey, in review).

The New Jersey Climate Adaptation Alliance (2013) identifies the following significant potential issues for New Jersey regarding climate change:

Climate Impacts	*New Jersey Risks*
Heat and Drought	• Degraded infrastructure • Obsolete and aging infrastructure • Decreases in surface water supplies and groundwater recharge • Overall lower water levels in reservoirs • Greater variability in water levels
Water Quality Degradation	• Saltwater intrusion • Contamination from flooding due to erosion and contaminants from runoff or failure of low-lying treatment infrastructure
Extreme Weather Events and Flooding	• Damage to infrastructure from intense precipitation events or storm surge • Contamination of water resources from infrastructure failure • Physical damages and losses to public and private property from flooding
Resource Demand	• Limited capacity to meet demand • Potential contamination of protected aquifers limits available resources • Failure of aging infrastructure

Figure 3.28 New Jersey Impacts and Risk for Water Resources as a Result of Climate Change (NJCAA, 2013)

3.7. Conclusion

The current status of water resources (availability, quality and watershed integrity) and infrastructure (water supply, wastewater and stormwater) in northern New Jersey reflects directly the history of land development and land uses, the combination of local home rule tradition with the necessity of regional perspective and management, the evolution of scientific understanding and regulatory approach, and the necessity of expenditures as constrained by a desire for low costs. Our ground and surface waters are frequently polluted but in some areas better than they were 40 years ago. Watershed integrity is often damaged, with few improvements over time due to continuing land use pressures. Our water supply systems are extensive but fragmented, and have put considerable pressure on water resources to the point where some are clearly overextended. Our water supply, wastewater and stormwater infrastructure are aging and declining in most urban and older suburban areas, and will require extensive investment just to keep them working well, much less to improve them to address water quality and quantity needs for a sustainable region. The challenges are many, and require among other things a way to measure progress over time.

4. Linking Water Resources to Livability Principles and RPSD Long-term Outcomes

If northern New Jersey is to achieve long-term sustainability as a community, economy and environment, water resources and infrastructure must be sustainable as well. A first step is defining sustainability for water resources and infrastructure, with appropriate metrics and evaluation methods that can be used to determine progress over time, which are addressed in this chapter.

4.1. Water Sustainability Objectives

The focus of sustainability from the perspective of water uses and users is on aggregate demands; individual uses are considered "sustainable" only in a resource-based context. For instance, the use of water for sector needs such as agricultural demands cannot be determined "sustainable" without consideration of ecological, public health and industrial needs from the same water resources. Water needs such as for a single city also cannot be determined "sustainable" without consideration of those needs in a broader context, including consideration of economic effectiveness and equitable access.

Likewise, each aspect of water resources affects the others. Water supply infrastructure relies on water availability and provides the water flow that becomes public sewage and industrial wastewater. The development supported by water infrastructure benefits from but also can harm watershed integrity. Watershed integrity requires protection of water quality, proper management of development and its attendant water infrastructure, and water uses that do not exceed water availability. In turn, these five aspects of water resources affect the viability of the all individual water uses and users.

Therefore, sustainability regarding water resources is an inherently systems-based issue that requires simultaneous consideration of the following integrated concepts:

2 Watershed integrity, including water quality and flows to support ecosystem and environmental service values
3 Adequate and reliable water supply, wastewater and stormwater management to meet human and economic needs, efficiently provided at affordable prices, with acceptable environmental impacts
4 Maintenance of water amenity values to support quality of life and community vitality

In general, then, **sustainable development requires watersheds that exhibit or attain sufficient integrity to support human and ecological uses and needs, where water is: withdrawn from and returned to the environment in a manner that protects aquatic ecosystems and other uses; used at a rate and in a manner that provides for and protects both human and ecological needs; and managed where appropriate through water utilities that can provide affordable services while continually maintaining all necessary infrastructure.** Specifically, the following sustainable objectives are proposed:

a) Water Availability – ***Water availability provides for human needs in an equitable manner that may be maintained through foreseeable drought periods without significant harm to the integrity of aquatic ecosystems***.

   This definition has several major implications and underlying assumptions:

   - The focus of human use is on meeting needs (e.g., sufficient water for household use, sufficient water for crop production), not guaranteeing a specific rate, volume or allocation of water. Where the need may be met in a more efficient manner, it should be. Therefore, water conservation and efficient water delivery systems should be integrated in all areas, even where sufficient water is available at present. In other words, wasting water is unsustainable even where ample water currently exists, as there are always other valid needs such as ecosystems.

- A system of transparent, equitable distribution is necessary. For instance, the New Jersey water allocation process has a framework for assessing allocation needs, and gives priority to reasonable prior allocations. Unused allocations may be removed if there is no sufficient justification for maintaining them.
- Water supplies are generally ample in times of normal precipitation. New Jersey defines the "drought of record" as the planning target for surface and unconfined ground water supplies, as a period of high stress. It is assumed that strict conservation, well beyond normal water conservation measures, will be imposed at such times to ensure that aquifers and reservoir systems are not overstressed.
- Confined aquifers are addressed based on modeling of long-term trends in water pressure (the potentiometric surface) of each aquifer, to prevent contamination by saltwater intrusion and induced flows from other ground water units.
- The threshold for ecological harm varies depending on the ecosystems involved. More sensitive ecosystems (e.g., trout production waters, low pH Pinelands waters, calcareous fens) will have less tolerance for water impacts than other waters.

b) Self-Supplied Industrial and Agricultural Water Supply – ***Water supplies are available in sufficient quantity and quality to support efficient uses that sustain industry and agricultural productivity, within the limits of water availability.***

This definition has several major implications and underlying assumptions:

- Water uses for production purposes exist within the broader context of all demands on each specific water resource.
- Water demands for production purposes should be efficient to reduce competition with other uses and ecological needs.
- Production uses plus all other demands for water including ecological needs should not exceed water availability at any time, and specifically during dry periods and droughts.

c) Ground and Surface Water Quality – ***Ground and surface water quality support and protect reasonable human needs (e.g., public health and sanitation, agriculture, commerce and industry, recreation, aesthetic, spiritual) and natural ecosystem functions, in a manner that optimizes societal health and function***.

This definition has several major implications and underlying assumptions:

- Water quality standards are based on anticipated or designated water uses, such as drinking water, recreation, industry, agriculture and ecological integrity.
- Maintenance of higher quality waters is a fundamental aspect of water quality standards.
- Restoration of water quality for urban areas plays a significant role in optimizing societal health and function.
- Use of waters for effluent dilution is permissible only to the extent that it does not damage the integrity of water resources for designated uses or to maintain higher quality waters. Effluent discharge therefore is not a right, but a privilege that carries with it responsibilities.

d) <u>Watershed Integrity</u> – ***Watersheds are maintained or restored to a level of integrity in which: natural land cover supports dynamic hydrologic and geomorphic processes within their natural range of variation; habitat of sufficient size and connectivity supports native aquatic and riparian ecosystems and species; and water quality supports healthy biological communities.***

This definition has several major implications and underlying assumptions:

- Natural land cover is a fundamental component of each watershed, to support hydrologic processes such as recharge, stream base flow, flood attenuation and ecosystem support. Where natural cover no longer exists or is removed, replication of these hydrologic processes is needed.
- Natural land cover also is critical to support interconnected aquatic and riparian habitats and species. Where disconnected habitat exists or will be caused through development, action is needed to ensure continued connections or reconnect habitat.
- Natural land cover also is critical to support water quality for biological communities. Where pollutant loads exceed natural attenuation capacity, action is needed to mitigate pollution effects.

e) <u>Ecosystem Vitality and Biodiversity</u> – ***Water resources remain in natural water bodies in sufficient quantity and quality to support overall ecosystem vitality and biodiversity, such that aquatic ecosystems of each major watershed have or are restored to a level of integrity that supports a full complement of organisms, including rare, threatened and endangered species, aquatic species, and species reliant on aquatic ecosystems for a critical portion of their lifecycle.***

This definition has several major implications and underlying assumptions:

- Ecosystem vitality is a function of the relevant ecosystem, and the water needs of such ecosystems cannot be significantly altered without harming the ecosystems.
- Ecosystems, unlike human uses, are associated with specific environmental conditions, including watersheds. Therefore, maintaining ecological integrity is necessary in each major watershed, though specific areas of the watershed may be altered due to historic or appropriate new development.
- Restoration of ecosystem vitality is coequal in importance to maintenance of areas with higher ecosystem integrity where degradation is minimal or nonexistent.
- Species cannot be replaced. Some species are common within each watershed and throughout watersheds, but others are limited in range or populations and may become extirpated (eliminated from one portion of their range) or extinct if not protected. Sustainable communities maintain long-term viability of all natural species, though not necessarily in all parts of their natural range.
- Sustainability regarding water resources affects both species that are aquatic and those that depend on aquatic ecosystems. Both must be sustained.

f) <u>Water Supply Infrastructure</u> - ***Public water supply infrastructure has and will have sufficient capacity and reliability to meet customer needs with minimal service disruptions at sufficient quantity and quality (including peak demands and drought needs) at the lowest possible lifecycle cost, using water supplies that do not exceed sustainable levels of water availability***.

This definition has several major implications and underlying assumptions:

- A "public" utility is one that serves the public, and may be owned by a municipality, a municipal utility authority, an investor-owned corporation, or a private firm.
- Compliance with regulatory requirements for drinking water quality and system "firm capacity"[21] is a fundamental aspect of utility capacity.
- New Jersey waters are public trust resources managed by NJDEP on behalf of the public, through its authority to allocate water among various users. The utilities do not own the water, but rather own the right to distribute it. The ownership of the water supply utility is not relevant to water allocation; the end users, such as residents and businesses, are the primary beneficiaries.
- Utility net capacity may be increased through reduced leakage of the pipeline system (supply side conservation), reduced overall or peak consumer demand (demand side conservation), or development of addition supply within constraints of water availability.
- Future demands may be met by utility net capacity created by any of the above means.
- Asset maintenance is a critical aspect of water supply infrastructure sustainability. This concept responds directly to 2010 recommendations of the NJ Clean Water Council and Water Supply Advisory Council to the NJDEP, the NJ Department of Community Affairs and the NJ Board of Public Utilities.

g) Human Health and Welfare – ***Water supplies are available in sufficient quantity and quality to support efficient uses that sustain human health, sanitation and consumption from residences and businesses, and for recreational and outdoor uses, within the limits of water availability***.

This definition has several major implications and underlying assumptions:

- Water uses for human health and welfare exist within the broader context of all demands on each specific water resource.
- Water demands for human health and welfare should be efficient to reduce competition with other uses and ecological needs.
- Human health and welfare requires access to water supplies, which for urban areas requires effective and affordable water supply infrastructure.
- An implied hierarchy of uses exists, with demands for human health, sanitation and consumption having a higher priority than recreational and outdoor uses.
- Human health and welfare uses plus all other demands for water including ecological needs should not exceed water availability at any time, and specifically during dry periods and droughts.

h) Water Quality Infrastructure –
Public wastewater infrastructure has and will have sufficient capacity and reliability to collect and treat sewage of sufficient quantity and quality to meet customer needs with minimal service disruptions at the lowest possible lifecycle cost, while protecting public health and the environment.

Public stormwater infrastructure protects public health and safety and the waters of the State from flooding, contamination, recharge loss and surface water damages during normal operating conditions, with minimal service disruptions at the lowest possible lifecycle cost, while protecting public health and the environment.

These definitions have several major implications and underlying assumptions:

[21] As defined by NJDEP and discussed in Chapter 3, Section 3.3

- A "public" utility is one that serves the public, and may be owned by a municipality, a municipal utility authority, an investor-owned corporation, or a private firm.
- Compliance with regulatory requirements for effluent quality, pollutant loadings and effluent rate and volume is a fundamental aspect of utility capacity.
- Wastewater utility net capacity may be increased through reduced stormwater and ground water flows (i.e., Infiltration & Inflow) into the pipeline system, reduced consumer sewage creation (e.g., reduced indoor water use), diversion of stormwater from combined sewer systems (e.g., system separation, green technology, stormwater reuse), or development of additional collection system, treatment plant or flow equalization capacity.
- Future demands may be met by wastewater utility net capacity created by any of the above means.
- Stormwater utility systems will require significant modification to meet modern standards for stormwater management regarding rate and volume of flow, discharge quality and recharge.
- Asset maintenance is a critical aspect of water quality infrastructure sustainability. This concept responds directly to 2010 recommendations of the NJ Clean Water Council and Water Supply Advisory Council to the NJDEP, the NJ Department of Community Affairs and the NJ Board of Public Utilities.

4.2. The Costs of Failure

Where water resources are not managed in a sustainable fashion, society can expect to incur costs and economic inefficiencies including but not limited to the following:

5 <u>Insufficient Water for Users</u> – Unsustainable water withdrawals result in aquifer depletion, streams running dry, loss of wetlands, and draconian water restrictions during dry periods and droughts. Unaddressed competition issues for water may result also in essential and beneficial water uses going unmet due to economic competition or unwillingness on the part of existing users to relinquish allocations.

6 <u>Loss of Water Values</u> – Pollution of water resources degrades or destroys the use of those waters for potable water supplies, fish consumption, ecosystems, production uses, recreation, etc. Watershed degradation results in damaged water supplies (such as by sedimentation and eutrophication), flooding of developed lands, loss of essential habitat, and other damages.

7 <u>Economic Disruption</u> – The economic development potential of society is damaged by infrastructure failure, such as: loss of services and escalating infrastructure rates due to system failure and the resulting emergency repair and replacement costs; market failure (i.e., where essential and beneficial uses are either priced out of the market or artificially prevented from accessing available water resources, whether for households or production uses such as agriculture); and loss of water values such as recreational uses and flood damage attenuation. Economic disruption also occurs from inadequate infrastructure robustness and resiliency in the face of extreme weather events, as recently seen where otherwise undamaged areas lost economic value due to public sewer system failures.

8 <u>Social Disruption</u> – Developed nations are accustomed to ample water supplies in most times. Where supplies have failed or are imperiled, basic assumptions of the populace and the economic and political sectors are undermined. Social disruption can follow, whether evidenced through unrest, opposition to rationing measures or lawsuits. UNICEF (1999) notes "In the coming years, the challenge in the sector will be to promote and facilitate the management of water resources to achieve an equitable balance between competing consumers. …As communities acquire the tools and knowledge to manage local water resources, they will increasingly have a stronger voice in influencing factors and events outside of the community which

affects the community's water balance." A critical aspect of sustainable development is that water is allocated through a transparent process that ensures equitable access to resources and equitable protection from any negative effects of water use.

4.3. Linking Water Resources Outcomes to Sustainability Principles and Long-term Outcomes

Water resource sustainability must occur within the framework of broader sustainability principles and preferred outcomes.

4.3.1. Together North Jersey Principles and Long-term Outcomes

Desired long-term outcomes are being developed by the Together North Jersey project, based in part on input from the U.S. Department of Housing and Urban Development (HUD). They will be finalized based on input from the Livability and Environment project team members and the Standing Committee. HUD's "Core Planning Outcomes" include "Comprehensive integrated water, air and land use plans adopted by participating jurisdictions," which will be fully addressed through implementation of the following outcomes in State, regional, county and local planning. Table 4.1 provides a starting point related to issues of water resources and water infrastructure, as drawn from the Together North Jersey "Working List of Planning Goals, Objectives, Strategies & Indicators".

Table 4.1 Draft TNJ Planning Goals, Strategies & Indicators (version of 30 November 2012)

Goals, Objectives and Strategies	Potential Performance Indicators
1. Strengthen the region's economy	
b. Ensure infrastructure systems (transportation, water, sewer, power, telecommunications, etc.) remain in good repair and have adequate capacity to accommodate planned growth	•Proportion of infrastructure elements (all types) graded in a state of good repair •Number of water/wastewater infrastructure failures requiring emergency repair •Available wastewater/water supply capacity vs. projected demand
i. Make public investments in infrastructure that will attract industries and businesses	•ROI from infrastructure investments by different type (i.e., fix it first/state of good repair vs. new capacity, etc.)
c. Enhance economic resilience and increase regional self-sufficiency	
i. Increase infrastructure resilience to extreme weather events	•Miles of roadway and rail infrastructure located in surge and flood prone areas
ii. Reduce the number of housing units and business vulnerable to storm surge and flooding due to extreme weather events and sea level rise	•Proportion of housing units and business located in surge/flood prone areas
4. Enhance efficiency and conserve land	•Acres of agricultural and natural lands converted to development per new resident
5. Protect and enhance the environment	
c. *Reduce potential impacts of climate change and increase community resilience to extreme weather events*	•Change in impervious cover •Per capita water/wastewater demand
i. Restore flood plains to their natural function	•Acres of flood plains returned to natural function
d. Ensure water supply is apportioned to maintain both human consumption and to support healthy	•Extent and severity of drinking water quality violations

Table 4.1 Draft TNJ Planning Goals, Strategies & Indicators (version of 30 November 2012)

Goals, Objectives and Strategies	Potential Performance Indicators
aquatic ecosystems	
e. Improve water quality	•Number and location of impaired water bodies •Extent and severity of effluent violations •Beach closing days due to impaired water quality
f. *Direct development away from environmentally sensitive areas*	•Acres of wetlands converted to development
6. Address regional growth issues in a coordinated way	
a. Align existing plans, programs and regulations at all levels of government	Number of policies, plans, ordinances, statutes, regulations, etc. amended or enacted by State, county and municipal government entities to support implementation of sustainable development practices and the regional plan
b. Foster collaboration between federal, state, county and local governments to address regional growth issues	
c. Maintain up-to-date, coordinated local, regional and State functional plans that reflect these goals.	
d. Provide a regional framework for making decisions about capital investments, programs, regulations and major development applications	

4.3.2. Recommended Long-term Water Resources Outcomes

Based on the ideas presented in Section 4.1 and Table 4.1, the following water resource outcomes are recommended for consideration in the RPSD:

a) Water supply, wastewater and stormwater infrastructure are developed and managed to achieve optimum sustainable benefits at the lowest lifecycle costs, to support existing service areas, to support appropriate development and redevelopment with modern levels of service, and to protect environmental resources

b) Development and redevelopment are focused in areas with sustainable water supply and wastewater capacity, at densities that make efficient and cost-effective use of infrastructure capital and capacity

c) Development and redevelopment are designed and built, and developed areas are improved, such that water resources (e.g., streams, lakes, coastal waters, ground water) are protected and, to the extent feasible, restored regarding both flows and quality for functional human uses and ecologic integrity

d) Increased water supply and wastewater capacity is created where necessary for areas most suitable otherwise for sustainable development and communities

e) Water supply resources are protected and equitably apportioned for both human and ecological uses including clean drinking water and aquatic ecosystems

f) Water supplies are used efficiently to maximize capacity benefits and minimize lifecycle costs

g) Water quality improvements (such as investments in wastewater treatment plants and combined sewer systems) and protections are focused on critical resources, cost-effective results and phased benefits

h) Surface water bodies and riparian areas are ecologically functional, of sufficient quality to support active and passive recreational uses, and serve as quality open spaces

i) Development and redevelopment are designed and built, and developed areas are improved, such that flood damages are avoided and floodplains remain or become undeveloped

j) Agricultural uses of water and impacts on water quality are sustainable within the broader context of water availability within watersheds and aquifers

4.4. Metrics and Indicators for Future Assessment

Metrics can be defined as "standards of measurement by which efficiency, performance, progress, or quality of a plan, process, or product can be assessed." Indicators can be defined as "measures that relate actual performance (results achieved) to the desired or aimed-at objectives…." (www.businessdictionary.com) As such, metrics are not the standards for determining whether the current status represents success or failure, but the "yardsticks" by which current status are measured against such standards. Indicators can be seen as the interlocutors between current and desired conditions.

The proposed Water Sustainability Objectives introduced in Section 4.1 are deliberately stated in broad terms to support the recommended long term outcomes in Section 4.3. Each objective then requires metrics that can be used to measure current status and trends, and indicators for determining how the current status and trends relate to the Sustainability Objective. Metrics and indicators are intended to have the following characteristics:

Table 4.2 Criteria for Metrics and Indicators

Relevant: Indicators should be readily associated with the principles, goals and desired outcomes to be measured.
Understandable: Metrics/indicators should be easy to interpret, even by the community at large
Acceptable: Metrics/indicators should be acceptable to the agencies/ communities that will use them to track and measure progress.
Measureable: Data required to use the metric/indicator should be available or collectable at a reasonable cost. If any calculations are required, methods and tools to perform required calculations should be readily available.
Accurate: Data for the metric/indicator should be based on information of known quality and origin that allows for detailed comparisons. Use of the data should allow policy makers to draw correct conclusions when interpreting the data.
Sensitive: Data for the metrics/indicators should be able to detect a certain level of change when making comparison and should show trends over a reasonable period of time.
Appropriate: Data for the metric/indicator should be specified and used at the level of detail and/or aggregation necessary for what is to be measured. It is best if the data are flexible/ scalable to different levels of analysis.

Metrics and indicators are provided for consideration in this section. In most cases, data limitations make it impossible to fully measure current conditions against the proposed sustainability measures. The concept is to begin with either readily available or potentially feasible metrics, and then add to them over time. Table 4.3 provides recommended metrics and indicators that are considered relevant and timely for each proposed Water Sustainability Objective. Where multiple components of the sustainability objective are being addressed, the relevant component is noted in parentheses after specific indicators as appropriate.

Table 4.3 Proposed Sustainability Measures, Metrics and Indicators for Water Resources

Category	Proposed Sustainability Measures	Proposed Metrics	Proposed Indicators	Scale of Analysis	Availability and Period of Data
Water Availability	*Water availability provides for human needs in an equitable manner that may be maintained through foreseeable drought periods without significant harm to the integrity of aquatic ecosystems.*	•Water delivered from reservoir-based or – supported systems •Total and consumptive/ depletive water withdrawals and trends by watersheds (demand) •Ground Water Availability by watershed or subwatershed •Potentiometric surface (measured level of aquifer pressure) established for each confined aquifer of concern	•Safe Yields (reservoir systems) •Net Water Availability (surficial aquifers) •Saltwater/freshwater Interface (confined aquifers)	•Reservoir system or intake watershed •HUC14 subwatershed (Highlands Region), HUC11 watershed (statewide) •Regional aquifers, specifically in the PRM Aquifer System for northern New Jersey	•All major and many minor systems, various dates •Highlands NWA based on 2003 data; updates in pilot project areas •Statewide NWA based on 2009 data •Water Supply Critical Area #1 model, updated
Self-Supplied Industrial and Agricultural Water Supply	*Water supplies are available in sufficient quantity and quality to support efficient uses that sustain industry and agricultural productivity, within the limits of water availability.*	•Industrial total and consumptive/depletive withdrawals •Agricultural total and consumptive/depletive withdrawals •Agricultural consumptive water use per irrigated acre by crop type	•See Water Availability		
Ground and Surface Water Quality	*Ground and surface water quality support and protect reasonable human needs (e.g., public health and sanitation, agriculture,*	•Surface water quality and trends •Ground Water Classification Exception Areas (CEAs) •Nitrate Trends from the	•SWQS violations (current or projected) •GWQS violations (current)	• Statewide network, not all subwatersheds have monitoring data •Statewide by contaminated sites •Statewide point data	•Biennial assessment of data from routine monitoring network •Updated as new CEAs identified •Data from 2002 to

Table 4.3 Proposed Sustainability Measures, Metrics and Indicators for Water Resources

Category	Proposed Sustainability Measures	Proposed Metrics	Proposed Indicators	Scale of Analysis	Availability and Period of Data
	commerce and industry, recreation, aesthetic, spiritual) and natural ecosystem functions, in a manner that optimizes societal health and function.	Private Well Testing Act data			current, as residential property transfers occur
Watershed Integrity	*Watersheds are maintained or restored to a level of integrity in which: natural land cover supports dynamic hydrologic and geomorphic processes within their natural range of variation; habitat of sufficient size and connectivity supports native aquatic and riparian species; and water quality supports healthy biological communities.*	•Forest land cover •Wetlands land cover •Riparian area, natural and developed •% impervious surface •Developed floodplain areas	•Forest area trends and fragmentation by watershed (habitat integrity) •Wetlands acreage trends and fragmentation by watershed (habitat integrity) •Riparian area trends and fragmentation by watershed (habitat integrity) •% impervious surface and trends within riparian areas by watershed (habitat integrity and stormwater) •% impervious surface and trends by watershed (stormwater) •% of floodplain with structures (flood damage potential)	•Any scale from neighborhood to regional (all data types)	Statewide: •1986, 1995, 2002, 2007 Land Use/Land Cover based on aerial photo interpretation for all data types except flood plain delineations; •satellite remote sensory data for land cover; •NFIP Flood Insurance Rate Map delineations; •NJDEP floodprone area delineations
Ecosystem Vitality and Biodiversity	*Water resources remain in natural water bodies in*	•Presence of rare, threatened or endangered plant or animal species	•# rare, threatened or endangered plant or animal species by watershed	•Statewide by watershed	•Ongoing data acquisition, formalized starting in 1980's

Table 4.3 Proposed Sustainability Measures, Metrics and Indicators for Water Resources

Category	Proposed Sustainability Measures	Proposed Metrics	Proposed Indicators	Scale of Analysis	Availability and Period of Data
	sufficient quantity and quality to support overall ecosystem vitality and biodiversity, such that aquatic ecosystems of each major watershed have or are restored to a level of integrity that supports a full complement of organisms, including rare, threatened and endangered species, aquatic species, and species reliant on aquatic ecosystems for a critical portion of their lifecycle.	•Surface water quality for aquatic life criteria •Stream daily flows •Riparian area trends and fragmentation •Ambient Biological Monitoring Network (AMNET) and Fish Index of Biological Integrity (IBI) scores	(normalized by watershed size) & trends (biodiversity) •Surface water violations for aquatic life criteria (water quality) •Low flow (7Q10 and 7Q30) trends (aquatic ecosystem support) •Net Water Availability deficits (aquatic ecosystem support) •Riparian area trends and fragmentation (habitat integrity) •Aquatic Life Support (SWQS)	• See Ground and Surface Water Quality • Statewide network, not all subwatersheds have monitoring data •See Water Availability •See Watershed Integrity •See Ground and Surface Water Quality	• See Ground and Surface Water Quality •Varies by gaging station, many have decades of data • See Water Availability •See Watershed Integrity •See Ground and Surface Water Quality
Water Supply Infrastructure: Public Community Water Supply Systems	*Public water supply infrastructure has and will have sufficient capacity and reliability to meet customer needs with minimal service disruptions at sufficient quantity and quality (including peak demands and drought needs) at the lowest*	•Customer density •Delivered drinking water quality •Firm Capacity + Contracted Supplies •Peak monthly demands •Pipeline breaks	•Accounts per linear mile and per square mile served •Drinking Water Quality violations (reliability) •Net Available Capacity as Current and Projected Net Surplus/Deficit Analysis by PCWS system (capacity) •Pipeline network annual breaks per pipeline mile and trend by system (reliability)	•PCWS systems •All public water supply systems •PCWS systems •PCWS systems	•No State database. Ad hoc by PCWS system •Data from 1970's, routinely updated •Updated routinely •No State database. Ad hoc by PCWS system

Table 4.3 Proposed Sustainability Measures, Metrics and Indicators for Water Resources

Category	Proposed Sustainability Measures	Proposed Metrics	Proposed Indicators	Scale of Analysis	Availability and Period of Data
	possible lifecycle cost, using water supplies that do not exceed sustainable levels of water availability.	•Residential water use •Water rates per thousand gallons •Asset mgt reports and system budgets	•% Households exceeding 75 gpcd (demand efficiency) •Affordability as average system household cost relative to 1% of area median household income, by system (equity) •Comprehensive asset mgt plan implementation	•PCWS systems •PCWS systems •PCWS systems	• No State database. PCWS systems record for billing purposes •Census Bureau data on household income •Ad hoc by PCWS system
Human Health and Welfare	*Water supplies are available in sufficient quantity and quality to support efficient uses that sustain human health, sanitation and consumption from residences and businesses, and for recreational and outdoor uses, within the limits of water availability.*	•Enteric disease incidence per year from drinking water supplies •Disconnected residential customers •# Homeless persons •Bacterial concentrations in recreational waters	•# Enteric disease incidence (public health) •% of households with active access to potable water supply (access) •Recreational uses – see Water Quality	•Statewide •Any scale, municipal to statewide •See Water Quality	•Occurrence data NJ Department of Health tracking system •No State database. Use PCWS service areas and development data •See Water Quality
Water Quality Infrastructure	•*Public wastewater infrastructure has and will have sufficient capacity and reliability to collect and treat sewage of sufficient quantity and quality to*	**Wastewater**: •Customer density •Monthly, MAX3MO and annual average sewage flows •CSO volumes and discharge	 •Accounts per linear mile and per square mile served •Current and Projected Net Available Capacity (capacity, MAX3MO method) •CSO discharges as % annual	 •Public sewer system •Wastewater treatment facility •Public sewer system	 •No State database. Ad hoc by sewer system •Quarterly data •Not routinely

Table 4.3 Proposed Sustainability Measures, Metrics and Indicators for Water Resources

Category	Proposed Sustainability Measures	Proposed Metrics	Proposed Indicators	Scale of Analysis	Availability and Period of Data
	meet customer needs with minimal service disruptions at the lowest possible lifecycle cost, while protecting public health and the environment.	days	flow		monitored; estimates
		•Effluent quality	•Effluent quality violations and trends (reliability)	• Wastewater treatment facility	•Monthly or more frequent data
		•Sewerage rates per thousand gallons	•Affordability as average system household cost relative to 1.5% of area median household income, by system (equity)	•Public sewer system	• Census Bureau data on household income
	•Public stormwater infrastructure protects public health and safety and the waters of the State from flooding, contamination, recharge loss and surface water damages during normal operating conditions, with minimal service disruptions at the lowest possible lifecycle cost, while protecting public health and the environment.	•Infrastructure reliability	•Annual line breaks per mile	• Public sewer system	•Ad hoc by system
		•Reliability	•Comprehensive asset mgt plan implementation	• Public sewer system	•Ad hoc by system
		Stormwater:			
		•Development occurring prior to and after adoption of the original Residential Improvement Standards and the 2004 NJDEP Stormwater Rules, NJAC 7:8 (capacity and recharge potential)	•% of development with rate, velocity and treatment controls meeting current requirements	•Any scale, but mostly municipal or subwatershed	•1986, 1995, 2002, 2007 Land Use/Land Cover based on aerial photo interpretation •Satellite remote sensory data for land cover;
		•Beach closings (reliability)	•Trend of beach closings caused by stormwater discharges	•Ocean beaches, back bay beaches, fresh water beaches	•Summer data by beach for ocean and back bay; some health dept data
		•Recharge loss •Stream daily flows	•Stream baseflow as a percentage of annual flows	•Gaged drainage area, watershed or subwatershed	• Varies by gaging station, many have decades of data

4.4.1. Recommended Indicators for Water Availability

This discussion includes both the general water availability measure and the measure for self-supplied industrial and agricultural supplies. As discussed in Chapter 2, the Ecological Limits of Hydrologic Alteration (ELOHA) approach is emerging as a viable conceptual approach for determining water availability. However, no methodology currently exists that fully incorporates this approach in a manner applicable to all watersheds in a region, some of which lack flow monitoring data. Therefore, new methods are being developed that use the ELOHA concept as a guiding principle, but rely on other indicators for actual measurement of water availability. The recommended indicators below take the same approach, and are based on a combination of existing, emerging and research approaches in New Jersey, which is on the cutting edge in this field.

- **SAFE YIELDS** – Safe Yield is generally defined as the volume of water that can be routinely provided for human use by a surface water supply system during a repeat of the drought of record. In the past, passing flows were considered sufficient to protect downstream areas. Applying the ELOHA approach is feasible in New Jersey, as nearly every reservoir of significant storage has a flow monitoring station downstream of the outlet. Therefore, the following indicator is proposed, against which demands and contracts can be compared to determine whether a system is committing to supplies in excess of safe yield:

  Safe Yield is the volume of water that can be routinely provided by a surface water supply system during a repeat of the drought of record for human use, while ensuring downstream water flows sufficient to protect against ecological harm.

- **NET WATER AVAILABILITY** –The Highlands Council has adopted and NJDEP is set to propose use of the “Low Flow Margin” method, which defines Ground Water Capacity as the difference between the September median flow and the 7Q10 flow (i.e., lowest seven-day median flow with a ten year return period). This volume is then divided into two portions, one in support of aquatic ecosystems using in part the New Jersey equivalent of the ELOHA method, and the remainder to support human use. The latter volume is called Ground Water Availability. As such, Ground Water Availability is defined as the amount of consumptive and depletive water withdrawals that can be supported by surficial aquifers and related surface waters without degradation of aquatic ecosystems.

  Net Water Availability is simply Ground Water Availability minus current consumptive and depletive water uses, using a mass balance approach. The major difference between the Highlands and NJDEP methods is that the Highlands Council has multiple thresholds for Ground Water Availability based on watershed characteristics, with the most stringent threshold for sensitive watersheds (e.g., trout production waters, which require cool temperatures) and the least stringent threshold for watersheds with less sensitive streams. NJDEP currently is considering use of only one threshold, as a statewide average that does not distinguish between sensitive and less sensitive watersheds. The ELOHA approach clearly anticipates that thresholds will be based on the nature of the aquatic ecosystem being protected, and so in the long run a more nuanced approach is necessary in establishing Ground Water Availability, using multiple thresholds. Therefore, the following threshold is proposed, where a negative (or deficit) existing or projected Net Water Availability indicates an unsustainable stress on aquatic ecosystems:

Net Water Availability for a watershed or subwatershed is Ground Water Availability minus current or projected consumptive and depletive withdrawals from surficial aquifers and surface waters (other than reservoirs or streams augmented by reservoir releases). Ground Water Availability is that portion of Ground Water Capacity allowed for consumptive or depletive uses, based on thresholds that are protective of sensitive aquatic ecosystems where appropriate. Ground Water Capacity is based on the Low Flow Margin method, the difference between the September median flow and the 7Q10 flow for a watershed or subwatershed.

- **SALTWATER/FRESHWATER INTERFACE** – Confined aquifers exist in the Coastal Plain Physiographic Province, in Monmouth, Ocean and parts of Middlesex Counties within this region. In Monmouth and northern Ocean Counties, Water Supply Critical Area #1 was established to greatly restrict withdrawals, so as to prevent saltwater intrusion. The Saltwater/Freshwater Interface is a general location within the confined aquifer where water quality shifts from saline to very low salinity that is useable for potable water. A basic indicator for confined aquifer stress is as follows:

  The Saltwater/Freshwater Interface in a confined aquifer shall be stable or improving, and protected against a rate of withdrawal that causes saltwater intrusion or other harmful impacts that reduce the integrity of the aquifer.

4.4.1.1. Coverage and scale

Reservoir systems supply a large percentage of the population in northern New Jersey, primarily in the historic urban areas, first-ring suburbs and neighboring newer suburbs. Safe yield applies to these systems. Net Water Availability is an issue primarily in those areas where surficial (i.e., water table/unconfined or semi-confined) aquifers are a major source of water supply, including nearly all of the region except the most urbanized areas that are served by surface water supplies. Every county in the region except Hudson has at least some area dependent on surficial aquifers for a significant portion of their supply. As noted, the confined aquifers are limited to the Coastal Plain areas of the region, in Monmouth, Ocean and parts of Middlesex Counties, where they underlie surficial aquifers.

4.4.1.2. Availability, cost and reliability

- **SAFE YIELDS** – All major reservoir systems in New Jersey have approved safe yields. These were developed using the same general approach (though with varying sophistication), which among other components assumes that reservoir releases will remain unchanged from the requirements of the relevant water allocation permits or statutes. Data availability is high, and so the primary costs will be in modifying the models to apply the ELOHA approach. Where this approach has been implemented, the ELOHA approach usually requires consideration of watershed-specific objectives and a dialogue regarding safe yield effects relative to these objectives. Therefore, modification of safe yields to incorporate ecosystem protection requires a public process that is reflected in the modified model. Each system with a safe yield tracks both commitments and delivered water routinely.

- **NET WATER AVAILABILITY** – All large water withdrawals are tracked by NJDEP and are available in georeferenced data bases. Of these, data are considered less accurate for agriculture due to regulatory differences in reporting requirements. The stream flow data are available for some watersheds but not others; robust statistical models are used to estimate Ground

Water Availability for watersheds using all relevant and appropriate flow data. Water use trends by public water supply systems are relatively easy to project, as they follow population trends reasonably well. Water use trends by industry are much more difficult to project, as manufacturing techniques and facilities routinely change. However, available data show a downward trend except for electrical power generation, which mostly does not affect fresh waters. Agricultural water use trends are somewhat more readily projected, showing an upward trend, but data quality is not high. The major theoretical issue with Net Water Availability is that the ELOHA approach provides an indicator of aquatic ecosystem impacts, but not a direct causative relationship. However, the ELOHA approach is the closest available indicator that relies on available data rather than years of site-specific research that may or may not be regionally applicable. Therefore, application of this indicator has been implemented in the Highlands and is readily adapted from NJDEP work that should be released in 2013.

- **SALTWATER/FRESHWATER INTERFACE** – The capacity of most confined aquifers in New Jersey has been defined using models relying on local geological data and potentiometric surfaces, with a good to highly accurate location of the saltwater/freshwater interface. All large water withdrawals are tracked and available in georeferenced data bases. Application of this concept is ongoing and does not require alteration.

4.4.2. Recommended Indicators for Ground and Surface Water Quality, Watershed Integrity, and Ecosystem Vitality and Biodiversity

This discussion groups aspects of the three related sustainability measures that address different aspects of watersheds other than water availability and water infrastructure.

- **SURFACE WATER QUALITY STANDARDS (SWQS) VIOLATIONS** – NJDEP and its partners (local governments, health boards, non-governmental organizations, etc.) have developed a relatively robust surface water quality monitoring approach and network for physical, chemical and biological parameters. While the network certainly would benefit from being larger and more comprehensive, monitoring costs are significant and funding has been reduced over the last decades, not increased. This indicator compares the resulting surface water quality and biological monitoring data to the numerical and narrative SWQS standards – by watershed, in heavily urbanized areas, and in Category One (nondegradation) streams – to determine the extent to which potable water, recreational and ecological uses are supported or not supported, and trends where available.

- **GROUND WATER QUALITY STANDARDS (GWQS) VIOLATIONS** – Of the three general types of ground water monitoring data exist in New Jersey, the network for monitoring natural ground water quality is small and does not provide the basis for sustainability measures. The monitoring of contaminated sites does not comprise a formal "network" and the data are not compiled in a general database or assessed statistically. However, the data are used to determine Classification Exception Areas that violate the GWQS for industrial contaminants. These areas generally remain designated for extensive periods of time, due to the difficulty of removing such contaminants. The database of monitoring data from residential wells from the Private Well Testing Act is also not from a formal network but is aggregated and assessed routinely by NJDEP.

Based on the availability of ground water quality information, the use of GWQS Classification Exception Areas and the generalized data from the Private Well Testing Act program provide the most useful current indicators regarding GWQS violations.

- **WATERSHED INTEGRITY** – Specific normative metrics and indicators for watershed integrity have not been scientifically established, and therefore all relevant metrics and indicators are considered inferential regarding watershed integrity. The most commonly cited indicator is % Impervious Surface, based on research by the Center for Watershed Protection (see CWP, 2003) and others, with a general finding that above 10% a watershed will be significantly modified and degraded in quality, while above 25% the stream will be impaired. However, as noted in CWP publications, these values are general guides rather than explicit standards, and do not account for degradation caused by other factors such as wastewater discharges or agriculture. They also do not address the different sensitivities of some aquatic ecosystems such as those with very low pH (e.g., the Pinelands), very high pH (e.g., calcareous fens) or coldwater fisheries (e.g., trout). Research findings indicate significant variance from these general guides, both higher and lower, based on specific watershed characteristics. For this reason, most programs rely on multiple indicators of watershed integrity and a "weight of evidence" approach to assess watershed integrity. The following indicators are proposed here:

    - <u>Forest area trends and fragmentation by watershed</u> – This indicator is based on USGS research (see NJWSA 2002, Highlands Council 2008d) indicating that higher forest land cover correlates well with both increased water quality and stream flows, as forests provide good recharge, are not developed lands, and slow water movement to streams. Fragmentation of forests leads to degradation of habitat integrity, and therefore is a related aspect of this indicator.
    - <u>Wetlands acreage and fragmentation trends by watershed</u> – This indicator is a strong measure of habitat integrity and is also related to flood plain and riparian area integrity, both of which are important to stream health and minimization of flood damages.
    - <u>Riparian area trends and fragmentation by watershed</u> – This indicator is a measure of the integrity of aquatic habitat, as many species that inhabit or are routinely dependent upon aquatic areas depend on the surrounding riparian area to provide for food, nesting areas and hiding locations.
    - <u>% impervious surface and trends within riparian areas by watershed</u> – This indicator addresses both habitat integrity and stormwater. Impervious surfaces within riparian areas will contribute stormwater to the surface waters faster than development outside the riparian area.
    - <u>% impervious surface and trends by watershed</u> – This indicator is a means of assessing relative stormwater generation within a watershed or subwatershed. A more robust indicator would be "Effective Impervious Surface" (the portion of impervious surface that actually contributes flow to stormwater discharges, not including impervious surface that is disconnected from runoff systems), but this measure is data intensive and not feasible at the regional level.
    - <u>% of floodplain with structures</u> – This indicator is a means of assessing flood damage potential. Again, a superior indicator would actually assess the flood potential of each structure, but such an effort is not feasible at the regional level.

- **ECOSYSTEM VITALITY AND BIODIVERSITY** – As with watershed integrity, no generally accepted method or indicators capture all aspects of ecosystem vitality and biodiversity. There are scores of scientific approaches to biodiversity alone. Therefore, the following indicators are proposed as a starting point for aquatic ecosystems, as they rely on available data:

  - Rare, threatened or endangered plant or animal species by watershed – This indicator takes a simple approach of counting up the number of target species by watershed, and then normalizing the results so that large watersheds do not have a general advantage over small watersheds. High-integrity watersheds are likely to support more such species than low-integrity watersheds, as sensitive species in the latter are more likely to have been extirpated.
  - Surface water quality violations for aquatic life criteria – This indicator is discussed as part of the Surface Water Quality Standards indicator, above, based on violation or conformance regarding numerical criteria for aquatic life.
  - Aquatic Life Support (SWQS) – This indicator is discussed as part of the Surface Water Quality Standards indicator, above, based on support or non-support for aquatic life as a narrative standard.
  - Low flow (7Q10 and 7Q30) trends – This indicator provides a measure of whether extreme lows in stream flows (that support aquatic ecosystems during severe dry periods) are increasing, decreasing or remaining stable over time. A decreasing low flow would indicate an increase in ecosystem stress over time. Sudden increases in low flows would indicate a new routine importation of water to a stream that could alter ecosystems.
  - Net Water Availability deficits – This indicator is discussed as a Water Availability indicator, above. It provides a measure of stresses on the broader stream flow regime due to excessive consumptive and depletive water uses from within the watershed or subwatershed.
  - Riparian area trends and fragmentation – This indicator is discussed as a Watershed Integrity indicator, above.

4.4.2.1. Coverage and scale

All waters of the state are subject to requirements of the state Water Pollution Control Act and the Water Quality Planning Act, which in turn are the statutory basis for the ground and surface water quality standards, the pollutant discharge and cleanup programs, the watershed and wastewater management planning process, TMDLs, etc. As such, these indicators apply to the entire region. While in theory they are applicable at all scales, from site-specific to statewide, they generally are applied at the watershed or subwatershed scale for practicality of management.

4.4.2.2. Availability, cost and reliability

The indicators proposed for this group of sustainability measures are based on metrics and monitoring systems that already exist, and therefore additional costs should be relatively low as long as the various monitoring and assessment programs are maintained. However, given the funding reductions to these programs over the last 20 years or more, the continuity of these programs cannot be assured.

- **WATER QUALITY** – Surface water quality data are available for specific locations in most but not all large watersheds, and for relatively few subwatersheds. Some stations are sampled each year while others are sampled in rotation to provide more areal coverage over five year cycles. Biological monitoring data are available for more locations, but on five year cycles in most monitoring points. Some local organizations and agencies provide sampling data from periods not covered by NJDEP, providing a valuable addition to the data but only for specific locations. All significant wastewater effluent discharges are tracked and available in georeferenced data bases. Highly reliable ground water quality data are concentrated in contaminated areas, and sparse in others. Useful but less reliable ground water quality data are widely available from the Private Well Testing Act data set, but the specific locations for each result are confidential and by nature the data are more subject to sampler error.

- **WATERSHED INTEGRITY** – Various data sets are readily available regarding watershed integrity, especially regarding the periodic Land Use/Land Cover data (roughly every five years). See also Water Quality, Water Availability and Ecosystem Vitality and Biodiversity.

- **ECOSYSTEM VITALITY AND BIODIVERSITY** – Significant data sets are available to support statistical analysis of ecosystem vitality, but some watersheds entirely lack directly applicable stream flow data. Biodiversity data are routinely available for many but not most locations, and so viable habitat is often used as a surrogate, as in NJDEP's Landscape Project. The results are periodically reassessed to improve the accuracy and value of the assessment methodology. Many individual threatened and endangered species populations are routinely tracked to determine overall progress in protecting or increasing viability.

4.4.3. Recommended Indicators for Water Supply Infrastructure: Public Community Water Supply Systems, and Human Health and Welfare

This discussion groups aspects of the three related sustainability measures that address different aspects of watersheds other than water availability, water quality and watershed integrity.

- **ACCOUNTS PER LINEAR MILE AND SQUARE MILE SERVED** – Efficient water supply infrastructure systems will support development dense enough to ensure sufficient revenue for operations, maintenance and replacement of infrastructure, etc. Where densities are low, rates are likely to escalate as system costs will be reliant on an insufficient customer base. This indicator can be used to assess the customer density of the existing service area, but will be most useful when evaluating the appropriateness of service area extensions. For non-residential development, an "equivalent residential unit" flow can be developed for comparison purposes.

- **PCWS SYSTEM DRINKING WATER QUALITY VIOLATIONS –** NJDEP requires routine monitoring of the drinking water quality by all public water supply systems, including PCWS systems, pursuant to the Safe Drinking Water Act, and compiles the extent and severity of drinking water quality violations. This indicator assesses treatment and distribution system reliability, and focuses on actual quality violations, rather than on reporting or administrative violations.

- **CURRENT AND PROJECTED NET AVAILABLE CAPACITY BY PCWS SYSTEM** – This indicator assesses PCWS system capacity, expressed both as net MGD and as percent of total system capacity, defined as firm capacity plus contracted water supplies (i.e., water that is contracted for delivery to the PCWS system by another water purveyor) minus contracted water exports to other systems. NJDEP requires that systems not commit to the supply of water beyond their firm capacity and contracted supplies. The NJDEP Surplus/Deficit Analysis compares this measure of supply against peak monthly demands to determine current surplus/deficit, and adds commitments to determine net surplus/deficit. Current Net Available Capacity would use the current surplus/deficit. Future Net Available Capacity would assess the changes in future demands caused by population projections and add or subtract (as appropriate) from the Current Net Available Capacity.

- **PIPELINE SYSTEM ANNUAL BREAKS PER PIPELINE MILE AND TREND BY PCWS SYSTEM** – The Drinking Water Quality Standards apply to the quality of water delivered to the customer. There is no clear regulatory guidance for the continuity of that flow, though consumer warnings and "boil water" orders may be required in the case of a pipeline failure and very low water pressure events. This indicator assesses the frequency of known pipeline failures per pipeline mile, annually and trend. The trend information will provide a sense of whether the utility is falling behind in asset management, while the annual data will be useful in comparisons between utilities. These data apparently are not compiled by NJDEP, but may currently be tracked within utilities.

- **% HOUSEHOLDS EXCEEDING 75 GPCD** – Many if not most PCWS systems now track household water demand for billing purposes, though group meters are still used in many apartments where water is included in the rent or association fee. Where water demand data are available for households and can be compared to population for the smallest U.S. Census units, the per capita water use can be estimated. This indicator would compare the results across Census units to identify areas with higher or lower per capita demands, as a measure of demand efficiency. To avoid inappropriate comparisons between PCWS systems, residential demands should be disaggregated into summer and winter periods. The winter demands can be compared across PCWS systems. The summer demands can be used to create trends within individual PCWS systems to identify areas with excessive peak demands due to irrigation and other outdoor uses.

- **AFFORDABILITY AS AVERAGE HOUSEHOLD COST RELATIVE TO 1% OF MEDIAN HOUSEHOLD INCOME** – Given the importance of equity in sustainable development, affordability is a necessary indicator of water infrastructure sustainability. This indicator uses a common threshold for water supply affordability, at 1% of median household income for the relevant area, which is best determined at relatively small areas (i.e., municipal level, or even smaller for municipalities with significant household income differences among major neighborhoods or districts) to avoid blurring distinctions in incomes. This amount is compared to the average household cost for water supply within the same area. By defining this indicator as a percentage of median income, it becomes comparable across PCWS systems.

- **COMPREHENSIVE ASSET MANAGEMENT PLAN IMPLEMENTATION** – Reliability of systems go well beyond simple metrics such as annual line breaks. Asset management planning involves a wide range of activities, including: knowing the system (inventory); assessing the current status of the components; understanding which parts are most vulnerable and which are most critical; establishing and funding capital investment plans that keep up with system aging; employee capacity building and retention; and tracking results against the plan. Asset management plans have common components but are tailored to the type, size and age of each utility. Having a plan is irrelevant unless it is being implemented, so both aspects are part of this indicator.

- **# ENTERIC DISEASE INCIDENCE** – Enteric diseases caused by waterborne pathogens (e.g., dysentery, typhoid, cholera) were major killers prior to the advent of drinking water treatment around 1900. Now, they are relatively rare in the United States, and therefore an indicator of failure in a drinking water system (very rare for public systems, and perhaps somewhat more common for private wells) or in recreational water quality (somewhat rare). This indicator would track the total incidence of enteric diseases by year. Further evaluation is needed regarding whether this indicator can parsed out by source (e.g., drinking water, recreational water) and whether it can be brought to at least the county level, or will apply only at the regional or state level.

- **% OF HOUSEHOLDS WITH ACTIVE ACCESS TO POTABLE WATER SUPPLY** – Modern society simply expects that all families and individuals will have routine access to a potable water supply, either public or private. This indicator assesses the extent to which this is true, by looking at the number of unsupplied, inhabited residences and the number of homeless persons in a PCWS service area.

- **RECREATIONAL USES – SEE WATER QUALITY**

4.4.3.1. Coverage and scale

PCWS systems dominate the provision of water supply in New Jersey, and yet perhaps one-seventh of the state's population is served by private (domestic, on-site) wells for a single home. Therefore, the indicators for PCWS systems address all of the urbanized areas but not most of the exurban and rural areas. The same is true for the public health and welfare indicators to the extent that they are focused on PCWS systems. However, the enteric disease issue is broader, as incidences from private wells and recreational water uses will be included.

4.4.3.2. Availability, cost and reliability

The availability, cost and reliability of these indicators vary considerably. Some are readily implemented while others will require more research and may not be immediately viable.

- **WATER SUPPLY INFRASTRUCTURE** – No current, statewide or regional delineation of water supply service areas exists, though a GIS coverage has been developed for most of the Highlands Region. With service area delineations, it is feasible to assess customer density using Census data and dasymetric mapping, similar to the build-out analysis work by the Highlands Council. Delivered drinking water quality is routinely monitored and reported, as are instances of treatment failure and boil-water orders. Current Net Available Capacity is readily available from NJDEP. Future Net Available Capacity will require calculation of future demand scenarios, which in turn requires more detailed knowledge of service areas than currently available outside the Highlands Region. Residential water use trends are routinely projected, using population projections. The pending NJ Statewide Water Supply Plan has projections through 2025, while the RPSD project intends to use projections through 2040 (currently 2035 projections have been formally adopted). Utilities are increasingly able to provide water use data for specific categories of users, based on modern metering technology. Therefore, residential demands are available from billing systems within many but not all PCWS systems, and from most but not necessarily all household within the systems that do track demands by building. Census data are readily available, but only every 10 years, which will result in less confidence about the population related to household water demands in years just prior to the Census. Estimates are prepared more frequently based on other data sources. This issue relates to the customer density, per capita demand and affordability indicators. Pipeline breaks are compiled by many but not all utilities but are not available through any single data source.

- **HUMAN HEALTH AND WELFARE** – Human health and welfare has many different facets, so parsing out water resource-specific impacts is difficult. However, data are available regarding access to water supplies and may be available regarding immediate health effects from bacterial and prokaryotic contamination that cause enteric diseases. Recreation waters are routinely monitored during summer months, providing significant data on health threats from contamination.

4.4.4. Recommended Indicators for Water Quality Infrastructure: Public Sewer Systems

- **ACCOUNTS PER LINEAR MILE AND SQUARE MILE SERVED** – Efficient sewage infrastructure systems will support development dense enough to ensure sufficient revenue for operations, maintenance and replacement of infrastructure, etc. Where densities are low, rates are likely to escalate as system costs will be reliant on an insufficient customer base. This indicator can be used to assess the customer density of the existing service area, but will be most useful when evaluating the appropriateness of sewer service area extensions. For non-residential development, an "equivalent residential unit" flow can be developed for comparison purposes.

- **NET AVAILABLE CAPACITY (MAX3MO METHOD)** – This indicator assesses public sewer system capacity, expressed both as net MGD and as percent of design capacity. Current Net Available Capacity would subtract the maximum three-month (MAX3MO) flows (in the last three to five years) from the design flow. Future Net Available Capacity would assess the changes in future demands caused by population projections and add or subtract (as appropriate) from the Current Net Available Capacity. This indicator can also be used to assess trends, which may reflect new flows from development or redevelopment, reduced flows due to water conservation and industrial sector change, etc.

- **CSO DISCHARGES** – Combined Sewer Overflows are attracting more attention as one of the last major sources of pollutant discharges that is essentially uncontrolled. These indicators of CSO severity measure CSOs based on their percentage of annual sewage flows and as net volumes. The number of CSO days (a count of days in which CSO events occur) may also be useful, especially if normalized using the number of precipitation days that exceed some threshold, such as 0.5 inches of rainfall equivalency.

- **EFFLUENT QUALITY –** NJDEP requires routine monitoring of effluent quality by all public sewer systems, pursuant to the Water Pollution Control Act, and compiles the extent and severity of violations. This indicator assesses treatment system reliability and stresses, in two different ways. First, it focuses on actual quality violations, rather than on reporting or administrative violations. Second, it addresses effluent quality trends over time, which may reflect a variety of influences such as treatment improvements, raw effluent quality changes, reduced I&I (which increases raw sewage concentrations but may also increase treatment efficiency), or problems with treatment plant operation.

- **AFFORDABILITY AS AVERAGE HOUSEHOLD COST RELATIVE TO 1.5% OF MEDIAN HOUSEHOLD INCOME, BY SYSTEM** – Given the importance of equity in sustainable development, affordability is an important indicator of water infrastructure sustainability. This indicator uses a common threshold for water quality affordability, at 1.5% of median household income of a relevant area, which is best determined at relatively small areas (i.e., municipal or even smaller for municipalities with significant household income differences among major neighborhoods or districts) to avoid blurring distinctions in incomes. This amount is compared to the average household cost for sewer service within the same area. By applying this indicator as a percentage of median income, it becomes comparable across public sewer systems.

- **ANNUAL LINE BREAKS PER MILE –** This indicator provides a straightforward assessment of current asset condition. As wastewater lines age, breaks are caused by corrosion or other degradation of the line material, shifting of the ground, compaction, construction damage, joint leakages, under washing from water supply or stormwater line breaks, etc. This indicator has two components: annual comparison to industry benchmarks; and trends for the specific utility. An upward trend of a high break rate (relative to industry benchmarks) would be a very clear indication of a declining infrastructure.

- **COMPREHENSIVE ASSET MANAGEMENT PLAN IMPLEMENTATION** – Reliability of systems go well beyond simple metrics such as annual line breaks. Asset management planning involves a wide range of activities, including: knowing the system (inventory); assessing the current status of the components; understanding which parts are most vulnerable and which are most critical; establishing and funding capital investment plans that keep up with system aging; employee capacity building and retention; and tracking results against the plan. Asset management plans have common components but are tailored to the type, size and age of each utility. Having a plan is irrelevant unless it is being implemented, so both aspects are part of this indicator.

4.4.4.1. Coverage and scale

Public sewer systems dominate the treatment of wastewater in New Jersey, and yet many homes use septic systems in some suburban and most exurban and rural areas. Therefore, the indicators for public sewer systems address all of the urbanized areas and most of the population, but do not apply to most of the region’s total land area and a relatively small portion of the population.

4.4.4.2. Availability, cost and reliability

The availability, cost and reliability of these indicators vary considerably. Some are readily implemented while others will require more research and may not be immediately viable. NJDEP is in the process of delineating current and future sewer service areas, and a GIS coverage has been developed also for most of the Highlands Region. With service area delineations, it is feasible to assess customer density using Census data and dasymetric mapping, similar to the build-out analysis work by the Highlands Council. Sewer flows through treatment facilities are continuously monitored and reported as monthly averages, and so Current Net Available Capacity can be calculated readily. Future Net Available Capacity will require calculation of future demand scenarios, which is problematic as sewer flows from residential and other small sources are not metered, unlike residential water uses. Therefore, sewer demands are generally projected using population projections and a nominal per capita rate, such as 75 gpcd; winter residential water demand can be used as a surrogate measure for sewage flows, or multiple scenarios can be generated using varying per capita rates to test sensitivity to assumptions. CSO discharges are harder to monitor, and CSO events are not at all routine. Treated effluent quality is routinely monitored and reported for permitted wastewater treatment facilities, as are violations. Census data are readily available, but only every 10 years, which will result in less confidence about the population related to household sewage generation, and to household income per Census area, in years just prior to the Census, though estimates are available for the intervening years.

4.4.5. Recommended Indicators for Water Quality Infrastructure: Public Stormwater Systems

As discussed previously, there is very little regulation of existing public stormwater systems. While newer stormwater infrastructure is subject to ongoing operation, monitoring and maintenance requirements, there is no standardized reporting system at any level. Older systems are even less regulated. Therefore, the indicators used for public stormwater systems must start from a far less sophisticated level than is feasible for water supply and sewer systems.

- **% OF DEVELOPMENT WITH RATE, VELOCITY AND TREATMENT CONTROLS MEETING CURRENT REQUIREMENTS** – The first issue is the lack of knowledge regarding the systems we have in place. Because stormwater systems are rarely modified after construction, asset management planning (in the sense used for water supply and wastewater) is essentially unknown in New Jersey, and 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 NJDEP Stormwater Rules (NJAC 7:8) in 2004, for previously developed areas (only partial application of the rules required) and for greenfield development (full application of the rules required). This assessment will be divided between combined sewer areas and separate stormsewer areas.

- **TREND OF BEACH CLOSINGS CAUSED BY STORMWATER DISCHARGES** – This indicator will assess annual beach closings attributed to stormwater discharges. Normalization of the results using rainfall events over a certain size, such as 0.5 inches, may be appropriate. Initially, this indicator will apply to ocean and bay beaches monitored by NJDEP and local health departments. Public bathing beaches at parks in freshwater lakes and rivers can be added as data are compiled. Alternative indicators could be used, such as the number or percentage of recreation days lost. In the case of beach closings, the numbers have declined to the point where using an indicator of this sort will be more of a public call to action than the inverse – the number of beaches open to recreation or the percentage of beach days open.

- **STREAM BASEFLOW AS A PERCENTAGE OF ANNUAL FLOWS –** This indicator takes advantage of USGS research showing that the natural baseflow component (i.e., the portion not related to rainfall events) of stream flow is generally greater than 70 or 80%, but for urban streams can be less than 40% due to aquifer withdrawals, recharge losses, sewage effluent discharges, etc. Greater baseflow as a percentage of annual stream flow is a good indicator of a more natural, less stressed aquatic ecosystem.

4.4.5.1. Coverage and scale

The assessment of stormwater infrastructure relative to regulatory system is applicable regionally, as is the assessment of stream base flows. Bathing beach closures are primarily applicable to the Atlantic coastal counties, in this case Monmouth and Ocean. Relatively few public bathing beaches exist in freshwater systems; most bathing beaches associated with inland lakes are on private property such as summer camps and homeowner lake associations.

4.4.5.2. Availability, cost and reliability

Land Use/Land Cover data are readily available in GIS for the years 1995, 2002 and 2007 (with the addition of 2012 when available) and can be augmented by satellite data to assess when stormwater systems were constructed. Ocean and back bay beach closings are compiled by NJDEP with assessments of causes. Freshwater bathing beach data for public beaches could be compiled from the park owners. Stream flows are available for many waters, and baseflow separations have been conducted from the data. However, there are also many watersheds for which no stream monitoring stations exist. Statistical models have been used by USGS and NJDEP to generate base flow estimates for such streams, as in the U.S. Forest Service update report on the Highlands Region (USFS 2002). These assessments only need to be recalculated every five to ten years, as changes in the baseflow characteristics of a watershed will change fairly slowly.

4.5. Recommended Implementation Process and Responsibilities

To be useful, metrics and indicators must be readily available for use by planners and other professionals and especially by decision makers. In the fields of water resources and aquatic ecosystems, NJDEP is the major agency engaged in compilation and assessment of field data. Therefore, much of the burden for these metrics and indicators will rest with NJDEP, as it currently does. Other agencies such as the Highlands Council, Pinelands Commission and individual counties do not have the jurisdiction to develop regionally-applicable metrics and indicators, though they can develop versions of the ones recommended here for application to special purposes (as with the Highlands Council regarding Net Water Availability). Table 4.4 notes the proposed appropriate source for data in support of metrics, and then for assessment of the data to assess the status of each indicator. ***None of the proposed roles in Table 4.4 have been cleared with or accepted by the relevant agencies and should not be viewed as definitive or taken as assignments***.

4.6. Conclusion

The outcomes, metrics and indicators proposed in this chapter reflect the complexity of water availability, health, quality and infrastructure issues. They also reflect the pervasive nature of water issues; just as with the medium, the issues flow everywhere throughout our society and profoundly influence our sustainability in ways economic, environmental and social. Neglecting water resources as a fundamental component of sustainable development will greatly damage our potential for success.

Table 4.4 Proposed Responsibilities for Water Resource Metrics and Indicators (Tentative)

Category	Proposed Sustainability Measures	Proposed Metrics	Proposed Responsibility (Commitments to be determined)	Proposed Indicators	Proposed Responsibility (Commitments to be determined)
Water Availability	*Water availability provides for human needs in an equitable manner that may be maintained through foreseeable drought periods without significant harm to the integrity of aquatic ecosystems.*	•Water delivered from reservoir-based or –supported systems •Total and consumptive/ depletive water withdrawals and trends by watersheds (demand) •Ground Water Availability by watershed or subwatershed •Potentiometric surface (measured level of aquifer pressure) established for each confined aquifer of concern	•NJDEP •NJDEP •NJDEP/Highlands Council (for Highlands Region) •NJDEP/USGS	•Safe Yields (reservoir systems) •Net Water Availability (surficial aquifers) •Saltwater/freshwater Interface (confined aquifers)	•NJDEP •NJDEP/Highlands Council (for Highlands Region) •NJDEP/USGS
Self-Supplied Industrial and Agricultural Water Supply	*Water supplies are available in sufficient quantity and quality to support efficient uses that sustain industry and agricultural productivity, within the limits of water availability.*	•Industrial total and consumptive/depletive withdrawals •Agricultural total and consumptive/depletive withdrawals •Agricultural consumptive water use per irrigated acre by crop type	•NJDEP •NJDEP •NJDEP/Rutgers Cooperative Extension	•See Water Availability	
Ground and Surface Water Quality	*Ground and surface water quality support and protect reasonable human needs (e.g., public health and sanitation, agriculture,*	•Surface water quality and trends •Ground Water Classification Exception Areas (CEAs)	•NJDEP • NJDEP	•SWQS violations (current or projected) •GWQS violations (current)	• NJDEP • NJDEP

Table 4.4 Proposed Responsibilities for Water Resource Metrics and Indicators (Tentative)

Category	Proposed Sustainability Measures	Proposed Metrics	Proposed Responsibility (Commitments to be determined)	Proposed Indicators	Proposed Responsibility (Commitments to be determined)
	commerce and industry, recreation, aesthetic, spiritual) and natural ecosystem functions, in a manner that optimizes societal health and function.	•Nitrate Trends from the Private Well Testing Act data	• NJDEP		
Watershed Integrity	*Watersheds are maintained or restored to a level of integrity in which: natural land cover supports dynamic hydrologic and geomorphic processes within their natural range of variation; habitat of sufficient size and connectivity supports native aquatic and riparian species; and water quality supports healthy biological communities.*	•Forest land cover •Wetlands land cover •Riparian area, natural and developed •% impervious surface •Developed floodplain areas	•NJ Office of Information Technology (coordination) • NJ Office of Information Technology (coordination) • NJ Office of Information Technology (coordination) • NJ Office of Information Technology (coordination) • NJ Office of Information Technology (coordination)	•Forest area trends and fragmentation by watershed (habitat integrity) •Wetlands acreage trends and fragmentation by watershed (habitat integrity) •Riparian area trends and fragmentation by watershed (habitat integrity) •% impervious surface and trends within riparian areas by watershed (habitat integrity and stormwater) •% impervious surface and trends by watershed (stormwater) •% of floodplain with structures (flood damage potential)	•NJDEP •NJDEP •NJDEP •NJDEP •NJDEP •NJDEP
Ecosystem Vitality and Biodiversity	*Water resources remain in natural water bodies in sufficient quantity and*	•Presence of rare, threatened or endangered plant or animal species	•NJDEP	•# rare, threatened or endangered plant or animal species by watershed (normalized by watershed	•NJDEP

Table 4.4 Proposed Responsibilities for Water Resource Metrics and Indicators (Tentative)

Category	Proposed Sustainability Measures	Proposed Metrics	Proposed Responsibility (Commitments to be determined)	Proposed Indicators	Proposed Responsibility (Commitments to be determined)
	quality to support overall ecosystem vitality and biodiversity, such that aquatic ecosystems of each major watershed have or are restored to a level of integrity that supports a full complement of organisms, including rare, threatened and endangered species, aquatic species, and species reliant on aquatic ecosystems for a critical portion of their lifecycle.	•Surface water quality for aquatic life criteria •Stream daily flows •Riparian area trends and fragmentation •Ambient Biological Monitoring Network (AMNET) and Fish Index of Biological Integrity (IBI) scores	•NJDEP •USGS/NJDEP •NJDEP •NJDEP	size) & trends (biodiversity) •Surface water violations for aquatic life criteria (water quality) •Low flow (7Q10 and 7Q30) trends (aquatic ecosystem support) •Net Water Availability deficits (aquatic ecosystem support) •Riparian area trends and fragmentation (habitat integrity) •Aquatic Life Support (SWQS)	•NJDEP •NJDEP •NJDEP •NJDEP •NJDEP
Water Supply Infrastructure: Public Community Water Supply Systems	*Public water supply infrastructure has and will have sufficient capacity and reliability to meet customer needs with minimal service disruptions at sufficient quantity and quality (including peak demands and drought needs) at the lowest possible lifecycle cost,*	•Customer density •Delivered drinking water quality •Firm Capacity + Contracted Supplies •Peak monthly demands •Pipeline breaks •Residential water use	•NJDEP/PCWS systems •NJDEP •NJDEP •NJDEP •NJDEP/PCWS systems •NJDEP	•Accounts per linear mile and per square mile served •Drinking Water Quality violations (reliability) •Net Available Capacity as Current and Projected Net Surplus/Deficit Analysis by PCWS system (capacity) •Pipeline network annual breaks per pipeline mile and trend by system (reliability) •% Households exceeding 75	•NJDEP/PCWS systems •NJDEP •NJDEP •NJDEP/PCWS systems •NJDEP/PCWS systems

Table 4.4 Proposed Responsibilities for Water Resource Metrics and Indicators (Tentative)

Category	Proposed Sustainability Measures	Proposed Metrics	Proposed Responsibility (Commitments to be determined)	Proposed Indicators	Proposed Responsibility (Commitments to be determined)
	using water supplies that do not exceed sustainable levels of water availability.	•Water rates per thousand gallons • Asset mgt reports and system budgets	•NJDEP •NJDEP/PCWS systems	gpcd (demand efficiency) •Affordability as average system household cost relative to 1% of area median household income, by system (equity) •Comprehensive asset mgt plan implementation	•NJDEP •NJDEP/PCWS systems
Human Health and Welfare	*Water supplies are available in sufficient quantity and quality to support efficient uses that sustain human health, sanitation and consumption from residences and businesses, and for recreational and outdoor uses, within the limits of water availability.*	•Enteric disease incidence per year from drinking water supplies •Disconnected residential customers •# Homeless persons •Bacterial concentrations in recreational waters	•NJ Department of Health and Senior Services •NJDEP? •NJ DCA? •NJDEP	•# Enteric disease incidence (public health) •% of households with active access to potable water supply (access) •Recreational uses – see Water Quality	•NJ Department of Health and Senior Services •NJDEP?
Water Quality Infrastructure	*•Public wastewater infrastructure has and will have sufficient capacity and reliability to collect and treat sewage of sufficient quantity and quality to meet customer needs with minimal service*	**Wastewater**: •Customer density •Monthly, MAX3MO and annual average sewage flows •CSO volumes and discharge days •Effluent quality	•NJDEP/Sewer systems •NJDEP •NJDEP •NJDEP	•Accounts per linear mile and per square mile served •Current and Projected Net Available Capacity (capacity, MAX3MO method) •CSO discharges as % annual flow •Effluent quality violations	•NJDEP/Sewer systems •NJDEP •NJDEP •NJDEP

Table 4.4 Proposed Responsibilities for Water Resource Metrics and Indicators (Tentative)

Category	Proposed Sustainability Measures	Proposed Metrics	Proposed Responsibility (Commitments to be determined)	Proposed Indicators	Proposed Responsibility (Commitments to be determined)
	disruptions at the lowest possible lifecycle cost, while protecting public health and the environment.	•Sewerage rates per thousand gallons	•NJDEP	(reliability) •Affordability as average system household cost relative to 1.5% of area median household income, by system (equity)	•NJDEP
	•Public stormwater infrastructure protects public health and	•Infrastructure reliability • Asset mgt reports and system budgets	•NJDEP •NJDEP/Sewer systems	•Annual line breaks per mile •Comprehensive asset mgt plan implementation	•NJDEP/Sewer systems •NJDEP/Sewer systems
	safety and the waters	**Stormwater**:			
	of the State from flooding, contamination, recharge loss and surface water damages during normal operating	•Development occurring prior to and after adoption of the original Residential Improvement Standards and the 2004 NJDEP Stormwater Rules, NJAC 7:8 (capacity and recharge potential)	•NJDEP	•% of development with rate, velocity and treatment controls meeting current requirements	•NJDEP
	conditions, with minimal service disruptions at the	•Beach closings (reliability)	•NJDEP	•Trend of beach closings caused by stormwater discharges	•NJDEP
	lowest possible lifecycle cost, while protecting public health and the environment.	•Recharge loss •Stream daily flows	•NJDEP •NJDEP	•Stream baseflow as a percentage of annual flows	•NJDEP

5. References Cited or Used

Reference	Applicability
American Society of Civil Engineers. (2009). 2009 Report Card for America's Infrastructure. Reston, Virginia.	Overview and scorecard for categories of national infrastructure.
American Water Works Association. (2012). Buried No Longer: Confronting American's Water Infrastructure Challenge. Denver, Colorado.	Overview and cost estimates for addressing deferred and future water supply infrastructure costs.
Agriculture Water Subcommittee. (2006). Agricultural Water Needs to 2020: Submitted to the State Water Supply Advisory Council for Revisions to the New Jersey Water Supply Master Plan. Trenton, NJ	Summary and projection of agricultural water needs and acreage through 2020.
Beard, Leo R. (1966). Methods for Determination of Safe Yields and Compensation Water from Storage Reservoirs. U.S. Army Corps of Engineers, Davis, CA.	Technical methodology for standard approach to safe yield determinations using mass balance equations.
Center for Watershed Protection. (2003). Impacts of Impervious Cover on Aquatic Systems.	A comprehensive exploration of more than 225 multi-disciplinary studies documenting the hydrological, physical, water quality, and biological impacts of urbanization and its accompanying impervious cover.
Department for Communities and Local Government. (2009). The Water Efficiency Calculator for new dwellings. United Kingdom, London, England.	Guidance in support of United Kingdom water efficiency standards for new housing.
European Environment Agency. (2012). Towards efficient use of water resources in Europe. Stockholm, Sweden.	Overview discussion of water use efficiency in Europe.
Higgins, J. V., C. P. Konrad, A. Warner, and J. T. Hickey. (2011). A framework for monitoring, reporting and managing dam operations for environmental flows. Version 1.0. Sustainable Rivers Project measures working group.	Technical document in support of ELOHA application to U.S. Army Corps of Engineers dam operations.
Highlands Water Protection and Planning Council (Highlands Council). (2007a). Utility Capacity Technical Report. Chester, NJ.	• Compares 2003 peak monthly demands against firm capacity for all major public water supply systems in the Highlands Region, determines available capacity, and identifies systems with insufficient current capacity. • Compares peak three-month demands against design capacity for all major public wastewater supply systems in the Highlands Region, determines available capacity, and identifies systems with insufficient current

Reference	**Applicability**
	capacity.
Highlands Council. (2008a). Highlands Regional Master Plan. Chester, NJ.	Regional plan for management of development and watershed integrity.
Highlands Council. (2008b). Highlands Regional Build-Out Report. Chester, NJ.	• Compares 2003 wastewater flows plus build-out demands (based on the Highlands Regional Master Plan and available land) against existing available capacity for all major public wastewater supply systems in the Highlands Region and identifies systems with insufficient current capacity for the build-out demand. • Compares 2003 demands plus build-out demands (based on the Highlands Regional Master Plan and available land) against existing firm capacity for all major public water supply systems in the Highlands Region and identifies systems with insufficient current capacity for the build-out demand.
Highlands Council. (2008c). Water Resources Technical Report, Volume 2. Chester, NJ.	• Establishes regulatory thresholds for ground water availability using the Low Flow Margin of Safety method developed by the NJ Geological Survey. • Uses a threshold for ecologically sensitive watersheds based on the NJHAT methodology, of 5% of the Low Flow Margin (LFM). • Establishes a threshold of 20% for urbanized watersheds based on empiric evaluation, and an allocation of 10% LFM specifically for agricultural uses in the watersheds that use the 5% LFM threshold for general water demands.
Highlands Council. (2008d). Water Resources Technical Report, Volume 1. Chester, NJ.	• Assesses water quality in the region for ground and surface waters • Determines median nitrate concentrations by subwatershed
Howard, Guy, and Jamie Bartram. (2003). Domestic Water Quantity, Service Level and Health. World Health Organization. Geneva, Switzerland.	Technical report in support of WHO guidance for water supply availability in support of human health.
Hughes, James W., and Joseph J. Seneca. (2012). Reinventing the New Jersey Economy: New Metropolitan and Regional Employment Dynamics. Rutgers Regional Report, New Brunswick, NJ	Evaluation of shifting regional trends in the New Jersey area.

Reference	Applicability
Johnson Foundation Freshwater Summit. (2010). Charting New Waters: A Call to Action to Address U.S. Freshwater Challenges. The Johnson Foundation at Wingspread. Racine, Wisconsin.	Report, vision statement and call to action regarding freshwater resource management, from a workshop of high-level corporate, professional, non-government and government representatives
Kendy, Eloise, Colin Apse, and Kristen Blann. (2012). A Practical Guide to Environmental Flows for Policy and Planning With Nine Case Studies in the United States. The Nature Conservancy.	Guidance document for ELOHA with case studies, none of which make full use of the concept.
Kennen, Jonathan G., James A. Henriksen, and Steven P. Nieswand. (2007). Development of the Hydroecological Integrity Assessment Process for Determining Environmental Flows for New Jersey Streams. U.S. Geological Survey Scientific Investigations Report 2007-5206. West Trenton, NJ.	Establishes New Jersey Hydrologic Assessment Tool (NJHAT) methodology for applying the ELOHA (Ecological Limits of Hydrologic Alteration) approach to New Jersey streams. This methodology was later used by the Highlands Council and NJDEP to provide a basis for selecting ground water availability thresholds.
Kenny, J.F., Barber, N.L., Hutson, S.S., Linsey, K.S., Lovelace, J.K., and Maupin, M.A. (2009). Estimated use of water in the United States in 2005: U.S. Geological Survey Circular 1344, 52 p.	Summary report of state and national data on water withdrawals by category, developed every five years.
NJ Clean Water Council and Water Supply Advisory Council. (2010). Recommendations for Water Infrastructure Management and Financing. Trenton, NJ.	Recommendations to NJDEP, NJDCA and the BPU for action on asset management requirements for water supply, wastewater and stormwater utility systems.
New Jersey Climate Adaptation Alliance. (2013). Working Brief: A Summary of Climate Change Impacts and Preparedness Opportunities for the Water Resources Sector in New Jersey. Rutgers University, New Brunswick, NJ	Discussion of potential climate change impacts on water resources and utilities with application to New Jersey.
NJDEP. Surface Water Quality Standards, NJAC 7:9B	Establishes narrative and numerical standards for surface water quality, applicable to regulated pollutant sources through a wide variety of NJDEP programs including the NJ Pollutant Discharge Elimination System (NJPDES) rules at NJAC 7:14A.
NJDEP. Ground Water Quality Standards, NJAC 7:9C	Establishes narrative and numerical standards for ground water quality, applicable to regulated pollutant sources through a wide variety of NJDEP
NJDEP. (1996). New Jersey Statewide Water Supply Plan. Trenton, NJ.	• Recommends continued use of safe yields to assess the capacity of reservoir systems. • Assesses projected demand through 2040

Reference	Applicability
	against ground water availability (as defined above) and reservoir safe yields. • Recommends planning thresholds of ground water use for unconfined aquifers, at 10% of recharge for coastal aquifers and 20% of recharge for inland aquifers. • Provided estimates of how water demands on confined aquifers have modified aquifer recharge and inter-aquifer water movement.
NJDEP. (2008). Private Well Testing Act Program: Well Test Results for September 2002 – April 2007	Summary of results from over 50,000 wells
NJDEP. (2012a). 2010 Revised Final New Jersey Integrated Water Quality Monitoring and Assessment Report	Statewide assessment of physical, chemical and biological integrity of surface waters
NJDEP. (2012b). Draft 2012 Integrated Water Quality Monitoring and Assessment Overview	Statewide assessment of physical, chemical and biological integrity of surface waters
NJDEP. (2012c). Cooperative Coastal Monitoring Program: Summary Report for 2011	Overview and statistics regarding bathing beach closures on the ocean and back bays
NJDEP. (2012d). DGS10-3 New Jersey Water Transfer Model Withdrawal, Use, and Return Data Summaries (MS Access file)	Data on water withdrawals, consumptive uses and returns by HUC14 subwatershed
NJDEP. ((pending release). Draft New Jersey Statewide Water Supply Plan. Appendix 5. Trenton, NJ.	• Recommends continued use of safe yields to assess the capacity of reservoir systems. • Assesses projected demand through 2020 against ground water availability (as defined above), reservoir safe yields and current net capacity for public water supplies. • Establishes a planning threshold for ground water availability using the LFM approach, based on the average NJHAT results for New Jersey streams, of 25% LFM, for all areas other than the Highlands Region.
New Jersey Water Supply Authority. (2002). Surface Water Quality and Pollutant Loadings Technical Report. Clinton, NJ	Analysis of water quality status and trends, and contributing factors within the Raritan River Basin.
Poff, N. Leroy, Brian D. Richter, Angela H. Arthington, Stuart E. Bunn, Robert J. Naimans, Eloise Kendy, Mike Acreman, Colin Apse, Brian P. Bledsoe, Mary C. Freeman, James Henriksen, Robert B. Jacobson, Jonathan G. Kennen, David M. Merritt, Jay H. O'Keeffe, Julian D. Olden, Kevin Rogers, Rebecca E. Tharme and Andrew Warner. (2009). "The ecological limits of hydrologic alteration	Overview and argument for application of ELOHA concept by major researchers on this method.

Reference	Applicability
(ELOHA): a new framework for developing regional environmental flow standards." Freshwater Biology, doi:10.1111/j.1365-2427.2009.02204.x	
Reilly, Thomas E., Kevin F. Dennehy, William M. Alley, and William L. Cunningham. (2008). Ground-Water Availability in the United States. United States Geological Survey, Circular 1323, Reston, Virginia.	Program document establishing national approach for estimating ground water availability.
Roy, Sujoy B., Limin Chen, Evan Girvetz, Edwin P. Maurer, William B. Mills, and Thomas M. Grieb. (2010). Evaluating Sustainability of Projected Water Demands Under Future Climate Change Scenarios. Tetra Tech, Inc., Lafayette, California.	Estimation of water withdrawal stress on river basins, prepared for Natural Resource Defense Council, based on withdrawals relative to total stream flow.
Sustainable Jersey. (In review). Sustainability, Climate Change Adaptation, and Natural Hazards. The College of New Jersey, Ewing, NJ	Overview and discussion of sustainability issues, metrics and indicators
UNICEF. (1999). A Water Handbook. United Nations Children's Fund, New York, N.Y.	Overview of state-of-the-art programming for water management, protection and supply in support of UNICEF program implementation.
USEPA. (2002). The Clean Water and Drinking Water Gap Analysis. Washington, DC	Review and cost estimate for deferred and future capital costs regarding both water quality and water supply infrastructure.
USEPA. (2008). Effective Utility Management: A Primer for Water and Wastewater Utilities. Washington, DC.	Overview and general methodology for utility planning and implementation for improved utility operations.
USEPA. (2010a). Clean Water and Drinking Water Infrastructure Sustainability Policy.	Statement of policies and implementation actions to improve sustainability of water infrastructure.
USEPA. (2010b). Clean Watersheds Needs Survey: 2008 Report to Congress. Washington, DC	Provides estimates of New Jersey needs for public wastewater collection and treatment systems, stormwater management systems, and nonpoint source pollution control.
USEPA. (2012a). Planning for Sustainability: A Handbook for Water and Wastewater Utilities. EPA-832-R-12-001, Washington, DC.	Overview and general methodology for utility planning and implementation for improved sustainability of utility and operations.
USEPA. (2012b). Water Quality Assessment and TMDL Information, http://www.epa.gov/waters/ir/ (undated). Along with NJDEP 2010 Water Quality Inventory Report and Impaired Waters List.	Evaluate current surface water quality in fresh and saline water resources, identify waters that violate one or more standards, and track waters for which Total Maximum Daily Loads (i.e., water quality improvement plans) have been adopted by NJDEP and approved by USEPA. (Along with NJDEP 2010 Water Quality Inventory Report and Impaired Waters List.)

Reference	Applicability
USEPA. (2012c). Identifying and Protecting Healthy Watersheds: Concepts, Assessments, and Management Approaches. EPA 841-B-11-002, Washington, DC.	Systems approach to watershed management, based on evolving science and indicators.
US Forest Service. (2002). New York-New Jersey Highlands Regional Study: 2002 Update. Newtown Square, PA	Technical assessment of the Highlands Region of New York and New Jersey, with recommendations for management issues and approaches.
Veolia Water. (N.d.). Sustaining growth via water productivity: 2030/2050 scenarios.	Overview and discussion of modeling results in support of the Growing Blue program, applying an index of water stress to countries based on three growth scenarios and four water efficiency scenarios.
Watt, Martha K. (2000). A Hydrologic Primer for New Jersey Watershed Management. United States Geological Survey, Water-Resources Investigation Report 00-4140, West Trenton, NJ.	Overview of hydrology and hydrogeology of New Jersey.
Worstell, Carolyn. (2013). Green Infrastructure in the State of New Jersey: Statutory and Regulatory Barriers to Green Infrastructure Implementation. New Jersey Future, Trenton, NJ	Background report for consideration of recommendations for how to ensure broader use of green infrastructure approaches to stormwater management.

Appendix A. Public Community Water Supply Systems of Northern New Jersey with Firm Capacity Exceeding 1 MGD[22]

PWSID #	County	Name	Firm Capacity (MGD)	Allocation Limits (MGM)
2004002	Union	New Jersey American Water Company - Raritan System	251.500	6761.500
0238001	Bergen	United Water New Jersey - Haworth	194.500	4860.000
1613001	Passaic	N.J.D.W.S.C. - Wanaque North	173.000	4138.500
1605002	Passaic	Passaic Valley Water Commission	110.500	2325.000
0714001	Essex	Newark Water Department	105.010	1767.000
1225001	Middlesex	Middlesex Water Company	91.400	806.760
0906001	Hudson	Jersey City MUA	80.000	2635.000
1345001	Monmouth	New Jersey American Water Company - Coastal North	77.877	1838.860
0712001	Essex	New Jersey American Water Company - Short Hills	64.623	1113.000
1204001	Middlesex	East Brunswick Water Utility	32.500	N/A
1507005	Ocean	United Water Toms River	28.555	734.350
2004001	Union	Liberty Water Company	24.758	N/A
1214001	Middlesex	New Brunswick Water Department	20.000	310.000
1424001	Morris	Southeast Morris County MUA	16.640	360.000
0251001	Bergen	Ridgewood Water Department	15.766	403.000
1205001	Middlesex	New Jersey American Water Company - Edison	14.900	N/A
1219001	Middlesex	Sayreville Borough Water Department	14.500	285.000
1209002	Middlesex	Old Bridge Township MUA	14.360	222.500
1506001	Ocean	Brick Township MUA	13.763	650.000
1614001	Passaic	Wayne Township Division of Water	13.500	N/A
1429001	Morris	Parsippany - Troy Hills	12.601	280.000
1808001	Somerset	Franklin Township Department Public Works	12.500	N/A
0907001	Hudson	Kearny Town Water Department	11.250	N/A
0705001	Essex	East Orange Water Commission	11.000	341.000
1221004	Middlesex	South Brunswick Township Water Company	10.652	180.000
1326001	Monmouth	Gordons Corner Water Company	10.628	202.000
0901001	Hudson	Bayonne City Water Department	10.500	N/A
1328002	Monmouth	Marlboro Township MUA	10.456	120.000
1213002	Middlesex	Monroe Township Utility Department	10.080	359.170
1316001	Monmouth	Freehold Township Water Department	9.840	265.000
1339001	Monmouth	Shorelands Water Company	9.480	201.000
1530004	Ocean	Stafford Township MUA - Beach	9.060	175.000
1432001	Morris	Morris County MUA	8.496	218.000
0713001	Essex	Montclair Water Department	8.050	57.000
1215001	Middlesex	North Brunswick Water Department	8.000	N/A
1216001	Middlesex	Perth Amboy Department of Municipal Utilites	8.000	248.000
1511001	Ocean	Jackson Township MUA	7.582	265.500
0702001	Essex	Bloomfield Water Department	6.510	N/A
1507007	Ocean	NJ American Water Company - Ortley Beach System	6.500	N/A
0233001	Bergen	Mahwah Water Department	6.473	154.000
0217001	Bergen	Fair Lawn Water Department	6.437	108.900
0905001	Hudson	Hoboken Water Services	6.300	N/A

[22] Systems with Allocations Limits noted either as N/A or as less than 30 times their firm capacity are dependent on contracts with other water suppliers for all or part of their firm capacity.

PWSID #	County	Name	Firm Capacity (MGD)	Allocation Limits (MGM)
0717001	Essex	Orange Water Department	6.235	140.000
1352003	Monmouth	Wall Township Water Department	6.130	88.450
0239001	Bergen	North Arlington Water Department	6.000	N/A
1417001	Morris	Madison Water Department	5.904	108.500
2119001	Warren	Aqua New Jersey - Phillipsburg	5.901	182.650
0231001	Bergen	Lodi Water Department	5.730	N/A
0247001	Bergen	Park Ridge Water Department	5.595	128.000
1514002	Ocean	Lakewood Township MUA	5.566	188.840
0710001	Essex	Livingston Township Water Division	5.491	148.800
1533001	Ocean	Barnegat Township Water and Sewer Utilities	5.472	154.000
1516001	Ocean	Little Egg Harbor MUA	5.400	112.700
0716001	Essex	Nutley Water Department	5.250	N/A
0706001	Essex	Essex Fells Borough	5.220	155.000
1518004	Ocean	Manchester Township Water Utilities - Western	5.184	70.000
1518005	Ocean	Manchester Township Water Utility	5.011	145.000
0701001	Essex	Belleville Township Water Department	5.000	N/A
1517001	Ocean	Long Beach Township - Brant Beach	4.968	86.800
1421003	Morris	Montville Township MUA	4.744	103.000
1604001	Passaic	Hawthorne Borough Water Department	4.725	167.000
1918004	Sussex	Sparta Township Water-Lake Mohawk	4.594	N/A
1408001	Morris	Denville Township Water Department	4.456	77.000
1409001	Morris	Dover Water Commission	4.320	112.000
0221001	Bergen	Garfield City Water Department	4.186	105.000
2013001	Union	United Water Rahway	4.100	186.000
0220001	Bergen	United Water NJ-Franklin Lakes	4.080	47.500
0232001	Bergen	Lyndhurst Water Department	4.000	N/A
0719001	Essex	South Orange Water Department	4.000	17.850
1326004	Monmouth	United Water Company- Matchaponix System	4.000	224.300
1512001	Ocean	Lacey Township MUA	3.816	112.700
1431001	Morris	Pequannock Township Water Department	3.713	106.000
1524001	Ocean	Point Pleasant Water Department	3.518	90.000
0902001	Hudson	East Newark Borough Water Department	3.500	N/A
1605001	Passaic	NJ American Water Company - Little Falls	3.500	N/A
2108001	Warren	Hackettstown MUA w/Diamond Hill	3.312	123.700
0211001	Bergen	Elmwood Park Water Department	3.250	N/A
1526001	Ocean	Seaside Heights Water Department	3.168	72.000
1401001	Morris	Boonton Water Department	3.152	61.700
1322001	Monmouth	Keyport Water Department	3.144	27.000
1432003	Morris	Randolph Township Water Division	3.120	N/A
1330002	Monmouth	Aberdeen Township Water Department	3.000	N/A
1403001	Morris	Butler Water Department	3.000	124.000
1603001	Passaic	Manchester Utilities Authority	3.000	N/A
1612001	Passaic	Totowa Water Department	3.000	N/A
1005001	Hunterdon	Clinton Town Water Department	2.866	88.000
0257001	Bergen	Saddle Brook Water Department	2.850	N/A
1315001	Monmouth	Freehold Borough Water Department	2.800	61.300
0707001	Essex	Fairfield Township Water Department	2.750	N/A
1326002	Monmouth	Manalapan Township Water Department - Lambs	2.750	8.000

PWSID #	County	Name	Firm Capacity (MGD)	Allocation Limits (MGM)
		Lane/Knobb Hill		
1520001	Ocean	Ocean Township MUA - Pebble Beach	2.739	71.000
0704001	Essex	Cedar Grove	2.700	N/A
0721001	Essex	West Caldwell Township Water Department	2.700	N/A
1436002	Morris	Roxbury Water Company	2.685	55.000
1609001	Passaic	Pompton Lakes Water Department	2.671	60.000
1613002	Passaic	Wanaque Water Department	2.660	39.000
1611002	Passaic	Ringwood Borough Water Department	2.554	40.000
1435002	Morris	Rockaway Township Water Department	2.509	71.500
0265001	Bergen	Wallington Water Department	2.500	N/A
0242001	Bergen	Oakland Water Department	2.401	124.000
1207001	Middlesex	Highland Park Borough Water and Sewer Department	2.400	N/A
1329001	Monmouth	Matawan Borough Water Department	2.400	48.000
0720001	Essex	Verona Water Department	2.396	34.600
1439001	Morris	Wharton Water Department	2.390	40.300
1404001	Morris	Chatham Water Department	2.302	50.000
1411001	Morris	Florham Park Water Department	2.290	54.250
1616001	Passaic	Woodland Park Water Department	2.160	N/A
0904001	Hudson	Harrison Town Water Department	2.000	N/A
1416001	Morris	Lincoln Park Borough Water Department	2.000	N/A
2121001	Warren	New Jersey American Water Company - Washington	2.000	57.880
0248001	Bergen	Borough of Ramsey Board of Public Works	1.961	87.650
1319007	Monmouth	Parkway Water Company	1.923	32.800
1410001	Morris	East Hanover Township Water Department	1.800	72.300
1915001	Sussex	Newton Water and Sewer Utility	1.788	38.750
1340001	Monmouth	Red Bank Water Department	1.742	75.000
1327001	Monmouth	Manasquan Water Department	1.728	45.000
1504001	Ocean	Beachwood Borough	1.728	52.000
1505002	Ocean	Aqua New Jersey Eastern Division	1.620	48.000
1348001	Monmouth	Springlake Borough Water Department	1.600	30.000
1434001	Morris	Rockaway Borough Water Department	1.584	44.400
1531001	Ocean	Surf City Water Department	1.548	46.500
1321001	Monmouth	Keansburg Water and Sewer Department	1.512	52.240
1505004	Ocean	Berkeley Township MUA	1.512	65.000
1503001	Ocean	Beach Haven Water Department	1.500	50.000
1306001	Monmouth	Belmar Borough	1.464	50.000
0264001	Bergen	Waldwick Water Department	1.460	50.000
1515001	Ocean	Lavallette Water Department	1.440	30.000
1308001	Monmouth	Brielle Water Department	1.408	18.000
1427017	Morris	New Jersey Amercian Water Company - ITC	1.368	12.000
1414011	Morris	Jefferson Township Water Utility - Lake Hopatcong	1.306	21.000
1212001	Middlesex	Milltown Water Department	1.200	N/A
1344001	Monmouth	Sea Grit Water Department	1.155	17.600
1223001	Middlesex	South River Borough Water Department	1.152	56.000
1528001	Ocean	Ship Bottom Water Department	1.152	26.000
1501001	Ocean	Barnegat Light Water Department	1.116	26.500
1349001	Monmouth	Borough of Springlake Heights	1.100	20.000
1328003	Monmouth	Marlboro Psychiatric Hospital	1.080	13.000

PWSID #	County	Name	Firm Capacity (MGD)	Allocation Limits (MGM)
1425001	Morris	Mountain Lakes Water Department	1.074	30.000
0708001	Essex	Glen Ridge Water Department	1.057	N/A
1517002	Ocean	Long Beach Township - Holgate	1.037	14.700
0201001	Bergen	Allendale Water Department	1.034	24.000
1304001	Monmouth	Atlantic Highlands Water Department	1.008	24.000
1527001	Ocean	Seaside Park Water Department	1.008	34.000
1919001	Sussex	Stanhope Water Department	1.008	22.320
2101001	Warren	Allamuchy Township Water and Sewer	1.008	22.000
0703001	Essex	Caldwell Water Department	1.000	N/A
0715001	Essex	North Caldwell Water Department	1.000	N/A
1208001	Middlesex	NJ American Water Company - Jamesburg System	1.000	N/A
1422001	Morris	Sisters of Charity of St. Elizabeth	1.000	3.100
1433001	Morris	Riverdale Borough Water Department	1.000	10.270
1601001	Passaic	Bloomingdale Water Department	1.000	N/A

Appendix B. High-Growth Municipalities[23] of Northern New Jersey as a Percentage of Total Projected Regional Growth through 2035 (NJTPA Projections) with Associated Water Supply Source and Sewage Treatment System

County	Municipality	2010 Pop.	2035 Pop.	Municipal % Growth 2010-2035	Growth 2010-2035 (% of Region)	Water Supply Source (Surface Water PCWS System or Ground Water	Public Sewer Systems
Bergen	Fort Lee borough	35,345	42,860	21.3%	0.6%	United Water-NJ (Hackensack)	BCUA
Bergen	Garfield city	30,487	35,760	17.3%	0.4%	GW & PVWC	PVSC
Bergen	Hackensack city	43,010	55,370	28.7%	1.0%	United Water-NJ (Hackensack)	BCUA
Bergen	Lyndhurst township	20,554	26,800	30.4%	0.5%	United Water (Jersey City)	BCUA
Bergen	Paramus borough	26,342	30,740	16.7%	0.4%	United Water-NJ (Hackensack)	BCUA
Bergen	Teaneck township	39,776	44,740	12.5%	0.4%	United Water-NJ (Hackensack)	BCUA
Essex	Bloomfield township	47,315	54,890	16.0%	0.6%	NJDWSC Customer	PVSC
Essex	City of Orange township	30,134	36,590	21.4%	0.5%	NJ American (Short Hills)	Joint Mtg of Essex & Union
Essex	East Orange city	64,270	79,830	24.2%	1.3%	GW	Joint Mtg of Essex & Union/ PVSC
Essex	Irvington township	53,926	67,570	25.3%	1.1%	NJ American (Short Hills)	Joint Mtg of Essex & Union
Essex	Montclair township	37,669	44,630	18.5%	0.6%	NJDWSC Customer	PVSC
Essex	Newark city	277,140	322,190	16.3%	3.7%	Newark	PVSC
Hudson	Bayonne city	63,024	86,740	37.6%	2.0%	United Water (Jersey City)	PVSC
Hudson	Harrison town	13,620	18,990	39.4%	0.4%	PVWC & Kearny (NJDWSC)	PVSC
Hudson	Jersey City city	247,597	327,500	32.3%	6.6%	United Water (Jersey City)	PVSC
Hudson	Kearny town	40,684	45,350	11.5%	0.4%	NJDWSC Customer	PVSC
Hudson	North Bergen township	60,773	71,300	17.3%	0.9%	United Water-NJ (Hackensack)	PVSC
Hudson	Secaucus town	16,264	23,350	43.6%	0.6%	United Water-NJ	Secaucus

[23] High-growth municipalities have a projected growth that comprises at least 0.4% of the total regional projected growth through 2035

County	Municipality	2010 Pop.	2035 Pop.	Municipal % Growth 2010-2035	Growth 2010-2035 (% of Region)	Water Supply Source (Surface Water PCWS System or Ground Water	Public Sewer Systems
						(Hackensack)	
Hudson	Union City city	66,455	75,400	13.5%	0.7%	United Water-NJ (Hackensack)	PVSC
Hudson	Weehawken township	12,554	17,220	37.2%	0.4%	United Water-NJ (Hackensack)	North Hudson Sewerage Authority
Middlesex	Cranbury township	3,857	8,790	127.9%	0.4%	NJ American (Raritan)	MCUA
Middlesex	East Brunswick township	47,512	63,450	33.5%	1.3%	NJWSA (Raritan)	MCUA
Middlesex	Edison township	99,967	119,140	19.2%	1.6%	NJ American (Raritan) & Middlesex Water	MCUA
Middlesex	Highland Park borough	13,982	18,410	31.7%	0.4%	Middlesex Water	MCUA
Middlesex	Monroe township	39,132	48,900	25.0%	0.8%	GW	MCUA
Middlesex	New Brunswick city	55,181	73,150	32.6%	1.5%	New Brunswick & NJWSA (Raritan)	MCUA
Middlesex	North Brunswick township	40,742	46,590	14.4%	0.5%	NJWSA (Raritan)	MCUA
Middlesex	Old Bridge township	65,375	75,490	15.5%	0.8%	GW & Middlesex Water	MCUA
Middlesex	Perth Amboy city	50,814	67,950	33.7%	1.4%	GW	MCUA
Middlesex	Piscataway township	56,044	62,230	11.0%	0.5%	NJ American (Raritan)	MCUA
Middlesex	Plainsboro township	22,999	31,150	35.4%	0.7%	NJ American (Raritan)	Stony Brook RSA/United Water Princeton Meadows
Middlesex	Sayreville borough	42,704	53,940	26.3%	0.9%	GW/Middlesex Water	MCUA
Middlesex	South Brunswick township	43,417	58,970	35.8%	1.3%	NJ American (Raritan)	MCUA
Middlesex	Woodbridge township	99,585	117,940	18.4%	1.5%	Middlesex Water	MCUA
Monmouth	Asbury Park city	16,116	22,790	41.4%	0.6%	NJ American (Monmouth)	Asbury Park STP
Monmouth	Howell township	51,075	65,790	28.8%	1.2%	NJ American (Lakewood)	Southern Monmouth RSA
Monmouth	Long Branch city	30,719	36,320	18.2%	0.5%	NJ American (Monmouth)	Long Branch SA
Monmouth	Manalapan township	38,872	47,630	22.5%	0.7%	GW	Western Monmouth UA
Monmouth	Middletown township	66,522	71,580	7.6%	0.4%	NJ American (Monmouth)	Township of Middletown SA
Monmouth	Neptune township	27,935	33,470	19.8%	0.5%	NJ American (Monmouth)	Township of Neptune SA
Ocean	Barnegat township	20,936	28,110	34.3%	0.6%	GW	OCUA-Central
Ocean	Berkeley township	41,255	59,450	44.1%	1.5%	GW	OCUA-Central

County	Municipality	2010 Pop.	2035 Pop.	Municipal % Growth 2010-2035	Growth 2010-2035 (% of Region)	Water Supply Source (Surface Water PCWS System or Ground Water	Public Sewer Systems
Ocean	Brick township	75,072	96,610	28.7%	1.8%	Brick Twp MUA	OCUA-Northern
Ocean	Jackson township	54,856	99,040	80.5%	3.6%	GW	OCUA-Northern
Ocean	Lacey township	27,644	38,590	39.6%	0.9%	GW	OCUA-Central
Ocean	Little Egg Harbor township	20,065	31,900	59.0%	1.0%	GW	OCUA-Southern
Ocean	Manchester township	43,070	59,740	38.7%	1.4%	GW	OCUA-Central
Ocean	Ocean township	8,332	16,770	101.3%	0.7%	GW	OCUA-Central
Ocean	Plumsted township	8,421	14,000	66.3%	0.5%	GW	N/A
Ocean	Stafford township	26,535	34,130	28.6%	0.6%	GW	OCUA-Southern
Ocean	Toms River township	91,239	117,540	28.8%	2.2%	United Water-NJ (Toms River) & NJAWC (Ocean)	OCUA-Central
Passaic	Clifton city	84,136	98,820	17.5%	1.2%	PVWC	PVSC
Passaic	Passaic city	69,781	90,200	29.3%	1.7%	PVWC	PVSC
Passaic	Paterson city	146,199	187,790	28.4%	3.4%	PVWC	PVSC
Passaic	Wayne township	54,717	67,130	22.7%	1.0%	NJDWSC Customer	Wayne
Somerset	Franklin township	62,300	72,400	16.2%	0.8%	NJ American (Raritan)	MCUA
Somerset	Hillsborough township	38,303	50,970	33.1%	1.0%	NJ American (Raritan)	SRVSA
Somerset	Somerville borough	12,098	16,670	37.8%	0.4%	NJ American (Raritan)	SRVSA
Sussex	Andover township	6,319	11,270	78.4%	0.4%	GW	N/A
Sussex	Frankford township	5,565	10,130	82.0%	0.4%	GW	N/A
Sussex	Newton town	7,997	12,400	55.1%	0.4%	Newton-Lake Morris	Newton WWTP
Sussex	Vernon township	23,943	28,230	17.9%	0.4%	GW	Sussex County MUA
Sussex	Wantage township	11,358	18,000	58.5%	0.5%	GW	N/A
Union	Elizabeth city	124,969	155,610	24.5%	2.5%	NJ American (Raritan)	Joint Mtg of Essex & Union/PVSC
Union	Linden city	40,499	46,070	13.8%	0.5%	NJ American (Raritan)	Linden Roselle SA
Union	Plainfield city	49,808	56,810	14.1%	0.6%	NJ American (Raritan)	MCUA
Union	Union township	56,642	63,460	12.0%	0.6%	NJ American (Short Hills)	Joint Mtg of Essex & Union

Appendix C. Public Sewer Systems of Northern New Jersey with Total Capacity Exceeding 1 MGD

NJPDES Permit Number	Facility Name	County	Design or Permitted Flow (MGD)	2011 Available Capacity Based on MAX3MO Flows (MGD)	2011 Available Capacity Based on Annual Average Flows (MGD)	Outfall to River (R) or Ocean/ Estuary (O)
NJ0021016	Passaic Valley Sewerage Commissioners	Essex	330.00	30.00	54.50	O
NJ0020141	Middlesex County Utility Authority	Middlesex	147.00	(4.74)	13.12	O
NJ0020028	Bergen County Utilities Authority (BCUA) Main STP	Bergen	75.00	(28.27)	(17.68)	O
NJ0024741	Joint Meeting of Essex and Union Counties	Union	75.00	(1.08)	8.74	O
NJ0024643	Rahway Valley Sewerage Authority	Union	40.00	3.83	7.77	O
NJ0024694	Monmouth County Bayshore Outfall Authority	Monmouth	33.00	15.46	17.03	O
NJ0024708	Bayshore Regional Sewerage Authority	Monmouth	16.00	6.52	7.39	O
NJ0025356	Middletown Sewerage Authority (TOMSA)	Monmouth	10.80	2.07	3.10	O
NJ0028142	Ocean County Utilities Authority (OCUA)-Northern WPCF	Ocean	32.00	8.03	9.06	O
NJ0029408	Ocean County Utilities Authority (OCUA)-Central WPCF	Ocean	32.00	7.47	10.53	O
NJ0024864	Somerset Raritan Valley Sewerage Authority	Somerset	21.30	(0.77)	3.88	R
NJ0026085	North Hudson Sewerage Authority-Adams Street WTP, Hoboken	Hudson	20.80	5.83	7.01	O
NJ0026018	Ocean County Utilities Authority (OCUA)-Southern WPCF	Ocean	20.00	11.10	12.78	O
NJ0024953	Linden Roselle Sewerage Authority	Union	17.00	1.40	3.61	O
NJ0024813	Northwest Bergen County Utility Authority	Bergen	16.80	1.60	4.95	R
NJ0024970	Parsippany-Troy Hills Twp	Morris	16.00	(1.35)	0.17	R
NJ0026735	Two Rivers Water Reclamation Authority	Monmouth	13.83	1.70	3.16	O
NJ0028002	Wayne Twp, Mountain View STP	Passaic	13.50	2.39	4.52	R
NJ0022349	Rockaway Valley Regional Sewerage Authority	Morris	12.00	(1.11)	0.79	R
NJ0025321	North Hudson Sewerage Authority-West New York WTP	Hudson	10.00	(0.38)	0.06	O
NJ0024562	South Monmouth Regional STP	Monmouth	9.10	2.70	3.53	O
NJ0024872	TNSA Sewerage Treatment Plant (Neptune Township)	Monmouth	8.50	2.64	3.20	O
NJ0024520	Township of Ocean Sewerage Authority (TOSA)	Monmouth	7.50	2.07	2.71	O
NJ0029386	Two Bridges Sewerage Authority WTP	Morris	7.50	(3.20)	(0.79)	R
NJ0020591	Bergen County Utilities Authority (BCUA)-Edgewater	Bergen	6.00	1.93	2.33	O
NJ0024783	Long Branch Sewerage Authority	Monmouth	5.40	1.91	2.86	O
NJ0025038	Secaucus MUA	Hudson	5.12	0.67	1.35	R
NJ0024791	Ridgewood Village WPC Facility	Bergen	5.00	1.25	1.98	R

NJPDES Permit Number	Facility Name	County	Design or Permitted Flow (MGD)	2011 Available Capacity Based on MAX3MO Flows (MGD)	2011 Available Capacity Based on Annual Average Flows (MGD)	Outfall to River (R) or Ocean/ Estuary (O)
NJ0025496	Morristown Sewer Utility	Morris	4.80	1.65	2.04	R
NJ0024902	Hanover Sewerage Authority WTP	Morris	4.61	2.08	2.38	R
NJ0024511	Livingston Water Pollution Control Facility	Essex	4.60	0.35	0.88	R
NJ0020427	Caldwell Wastewater Treatment Plant	Essex	4.50	(0.93)	(0.10)	R
NJ0025241	Asbury Park Wastewater Treatment Plant	Monmouth	4.40	1.67	1.88	O
NJ0027821	Musconetcong Sewerage Authority	Morris	4.30	1.12	1.51	R
NJ0028436	Raritan Township MUA-Flemington	Hunterdon	3.85	NA	NA	R
NJ0022047	Raritan Township MUA STP	Hunterdon	3.80	(0.05)	0.51	R
NJ0024937	Madison-Chatham Joint Meeting-Molitor WPCF	Morris	3.50	0.55	0.94	R
NJ0024716	Phillipsburg Town STP	Warren	3.50	0.46	0.87	R
NJ0024911	Morris Township-Butterworth WPCF	Morris	3.30	1.36	1.64	R
NJ0021369	Hackettstown MUA	Morris	3.30	0.53	0.79	R
NJ0027961	Berkeley Heights WPCF	Union	3.10	1.09	1.43	R
NJ0053350	Sussex County MUA-Upper Wallkill Facility	Sussex	3.00	0.54	1.07	R
NJ0024490	Verona Township Wastewater Treatment Plant	Essex	3.00	0.42	1.79	R
NJ0029084	North Bergen MUA-Woodclilff STP	Hudson	2.91	(0.41)	(0.20)	O
NJ0022845	Bernards Township-Harrison Brook STP	Somerset	2.50	(0.55)	0.03	R
NJ0033995	Environmental Disposal Corp	Somerset	2.10	0.52	0.65	R
NJ0020389	Clinton Town Wastewater Treatment Plant	Hunterdon	2.03	0.36	0.53	R
NJ0025330	Cedar Grove STP	Essex	2.00	0.39	0.59	R
NJ0022675	Roxbury Township	Morris	2.00	(0.54)	(0.12)	R
NJ0024929	Morris Township-Woodland WPCF	Morris	2.00	0.83	0.95	R
NJ0024104	United Water-Princeton Meadows	Middlesex	1.64	0.25	0.58	R
NJ0020915	Lambertville Municipal Utility Authority	Hunterdon	1.50	0.27	0.47	R
NJ0025518	Florham Park Water Pollution Control Facility	Morris	1.40	0.37	0.46	R
NJ0020184	Newton Wastewater Treatment Plant	Sussex	1.40	(0.20)	0.07	R
NJ0053759	Wanaque Valley Regional Sewerage Authority	Passaic	1.25	(0.09)	0.05	R
NJ0023698	Pompton Lakes Borough MUA	Passaic	1.20	(0.01)	0.25	R
NJ0021113	Washington Borough Wastewater Treatment Plant	Warren	1.16	(0.03)	0.23	R

Appendix D. Water-related Constraints for High Growth Municipalities of Northern New Jersey

(a=known Net Water Availability, Water Supply Critical Area, or Water Allocation Permit Program Constraint for Aquifer Supply; b=Receiving Water Quality Constraint such as likely or existing TMDL or Nondegradation Designation for Receiving Water (PSS); c=Existing Net Available Capacity deficit (PCWS or PSS); d=Potential Future Net Available Capacity deficit (PCWS or PSS); e=CSO within system)

County	Municipality	Growth 2010-2035 (% of Region)[24]	Water Supply Source (Surface Water PCWS System or Local Aquifer)	Public Sewer Systems
Bergen	Fort Lee boro	0.6%	United Water-NJ (Hackensack)	BCUA – b,c,d,e
Bergen	Garfield city	0.4%	GW & PVWC – d	PVSC – b,e
Bergen	Hackensack city	1.0%	United Water-NJ (Hackensack)	BCUA – b,c,d,e
Bergen	Lyndhurst twp	0.5%	United Water (Jersey City) – d	BCUA – b,c,d,e
Bergen	Paramus boro	0.4%	United Water-NJ (Hackensack)	BCUA – b,c,d,e
Bergen	Teaneck twp	0.4%	United Water-NJ (Hackensack)	BCUA – b,c,d,e
Essex	Bloomfield twp	0.6%	NJDWSC Customer	PVSC – b,e
Essex	City of Orange twp	0.5%	NJ American (Short Hills w/ GW – a)	Joint Mtg of Essex & Union – b,c,d,e
Essex	East Orange city	1.3%	GW - a	Joint Mtg of Essex & Union – b,c,d,e/PVSC – b,e
Essex	Irvington twp	1.1%	NJ American (Short Hills w/ GW – a)	Joint Mtg of Essex & Union – b,c,d,e
Essex	Montclair twp	0.6%	NJDWSC Customer	PVSC – b,e
Essex	Newark city	3.7%	Newark – d	PVSC – b,e
Hudson	Bayonne city	2.0%	United Water (Jersey City) – d	PVSC – b,e
Hudson	Harrison town	0.4%	PVWC – d & Kearny (NJDWSC)	PVSC – b,e
Hudson	Jersey City city	6.6%	United Water (Jersey City) – d	PVSC – b,e
Hudson	Kearny town	0.4%	NJDWSC Customer	PVSC – b,e
Hudson	North Bergen twp	0.9%	United Water-NJ (Hackensack)	PVSC – b,e
Hudson	Secaucus town	0.6%	United Water-NJ (Hackensack)	Secaucus – b
Hudson	Union City city	0.7%	United Water-NJ (Hackensack)	PVSC – b,e
Hudson	Weehawken twp	0.4%	United Water-NJ (Hackensack)	North Hudson Sewerage Authority – b,e
Middlesex	Cranbury twp	0.4%	NJ American (Raritan)	MCUA – b,c,d,e

[24] See Appendix B for 2010 population, 2035 projected population, and municipal growth 2010-2035 as percent

County	Municipality	Growth 2010-2035 (% of Region)[24]	Water Supply Source (Surface Water PCWS System or Local Aquifer)	Public Sewer Systems
Middlesex	East Brunswick twp	1.3%	NJWSA (Raritan)	MCUA – b,c,d,e
Middlesex	Edison twp	1.6%	NJ American (Raritan) & Middlesex Water	MCUA – b,c,d,e
Middlesex	Highland Park boro	0.4%	Middlesex Water	MCUA – b,c,d,e
Middlesex	Monroe twp	0.8%	GW	MCUA – b,c,d,e
Middlesex	New Brunswick city	1.5%	New Brunswick & NJWSA (Raritan)	MCUA – b,c,d,e
Middlesex	North Brunswick twp	0.5%	NJWSA (Raritan)	MCUA – b,c,d,e
Middlesex	Old Bridge twp	0.8%	GW & Middlesex Water	MCUA – b,c,d,e
Middlesex	Perth Amboy city	1.4%	GW	MCUA – b,c,d,e
Middlesex	Piscataway twp	0.5%	NJ American (Raritan)	MCUA – b,c,d,e
Middlesex	Plainsboro twp	0.7%	NJ American (Raritan)	Stony Brook RSA – b/United Water Princeton Meadows – b
Middlesex	Sayreville boro	0.9%	GW/Middlesex Water	MCUA – b,c,d,e
Middlesex	South Brunswick twp	1.3%	NJ American (Raritan)	MCUA – b,c,d,e
Middlesex	Woodbridge twp	1.5%	Middlesex Water	MCUA – b,c,d,e
Monmouth	Asbury Park city	0.6%	NJ American (Monmouth)	Asbury Park STP
Monmouth	Howell twp	1.2%	NJ American (Lakewood)	Southern Monmouth RSA
Monmouth	Long Branch city	0.5%	NJ American (Monmouth)	Long Branch SA
Monmouth	Manalapan twp	0.7%	GW – a	Western Monmouth UA – b
Monmouth	Middletown twp	0.4%	NJ American (Monmouth)	Township of Middletown SA
Monmouth	Neptune twp	0.5%	NJ American (Monmouth)	Township of Neptune SA
Ocean	Barnegat twp	0.6%	GW	OCUA-Central
Ocean	Berkeley twp	1.5%	GW	OCUA-Central
Ocean	Brick twp	1.8%	Brick Twp MUA (w/ GW – a)	OCUA-Northern
Ocean	Jackson twp	3.6%	GW	OCUA-Northern
Ocean	Lacey twp	0.9%	GW	OCUA-Central
Ocean	Little Egg Harbor twp	1.0%	GW	OCUA-Southern
Ocean	Manchester twp	1.4%	GW	OCUA-Central
Ocean	Ocean twp	0.7%	GW	OCUA-Central
Ocean	Plumsted twp	0.5%	GW	N/A
Ocean	Stafford twp	0.6%	GW	OCUA-Southern
Ocean	Toms River twp	2.2%	United Water-NJ (Toms River) & NJ American	OCUA-Central

County	Municipality	Growth 2010-2035 (% of Region)[24]	Water Supply Source (Surface Water PCWS System or Local Aquifer)	Public Sewer Systems
			(Ocean)	
Passaic	Clifton city	1.2%	PVWC – d	PVSC – b,e
Passaic	Passaic city	1.7%	PVWC – d	PVSC – b,e
Passaic	Paterson city	3.4%	PVWC – d	PVSC – b,e
Passaic	Wayne twp	1.0%	NJDWSC Customer	Wayne – b
Somerset	Franklin twp	0.8%	NJ American (Raritan)	MCUA – b,c,d,e
Somerset	Hillsborough twp	1.0%	NJ American (Raritan)	SRVSA – b,c,d
Somerset	Somerville boro	0.4%	NJ American (Raritan)	SRVSA – b,c,d
Sussex	Andover twp	0.4%	GW	N/A
Sussex	Frankford twp	0.4%	GW	N/A
Sussex	Newton town	0.4%	Newton-Lake Morris – d	Newton WWTP
Sussex	Vernon twp	0.4%	GW	Sussex County MUA
Sussex	Wantage twp	0.5%	GW	N/A
Union	Elizabeth city	2.5%	NJ American (Raritan)	Joint Mtg of Essex & Union – b,c,d,e/PVSC – b,e
Union	Linden city	0.5%	NJ American (Raritan)	Linden Roselle SA – b
Union	Plainfield city	0.6%	NJ American (Raritan)	MCUA – b,c,d,e
Union	Union twp	0.6%	NJ American (Short Hills w/ GW – a)	Joint Mtg of Essex & Union – b,c,d,e