New Jersey Coastal Plain Aquifer

Support Document

Atlantic, Burlington, Camden, Cape May, Cumberland, Gloucester, Mercer, Middlesex, Monmouth, Ocean, and Salem Counties New Jersey
May 1988

I. Introduction

A. Statement of Section 1424 (e)

The Safe Drinking Water Act (SDWA), Public Law 93-523, of December 16, 1974 contains a provision in Section 1424(e), which states that:

> If the Administrator determines, on his own initiative or upon petition, that an area has an aquifer which is the sole or principal drinking water source for the area and which, if contaminated, would create significant hazard to public health, he shall publish notice of that determination in the Federal Register. After the publication of any such notice, no commitment for Federal financial assistance (through a grant, contract, loan guarantee, or otherwise) may be entered into for any project which the Administrator determines may contaminate such aquifer through a recharge zone so as to create a significant hazard to public health, but a commitment for Federal financial assistance may, if authorized under another provision of law, be entered into to plan or design the project to assure that it will not so contaminate the aquifer.

This section allows for the specific designation of areas which are dependent upon ground water supplies. Following designation, the review process will ensure that federal agencies will not commit funds toward projects which may contaminate these ground water supplies.

B. Receipt of Petition

On December 4, 1978 the Environmental Defense Fund, Inc. and Sierra Club New Jersey Chapter petitioned the U.S. Environmental Protection Agency (EPA) Administrator to determine that the Counties of Monmouth, Burlington, Ocean, Camden, Gloucester, Atlantic, Salem, Cumberland, Cape May and portions of Mercer and Middlesex Counties, New Jersey, constitute an area whose aquifer system is "the sole or principal drinking water source for the area and which, if contaminated, would create a significant hazard to public health".

C. Area of Consideration

The area of the New Jersey Coastal Plain Aquifer System includes the area for the Counties of Monmouth, Burlington, Ocean, Camden, Gloucester, Atlantic, Salem, Cumberland, Cape May and portions of Mercer and Middlesex Counties, New Jersey. Pursuant to section 1424(e), Federally assisted projects proposed for construction in the New Jersey Coastal Plain Area and the project review area within portions of its streamflow source zone will be subject to EPA review.

The streamflow source zone for the New Jersey Coastal Plain Aquifer System includes upstream portions of the Delaware River Basin in the States of Delaware (New Castle County), New Jersey (Mercer-part, Hunterdon-part, Sussex-part, and Warren Counties), New York (Delaware, Orange, Sullivan and Ulster Counties), and Pennsylvania (Berks-part, Bucks, Carbon-part, Chester-part, Delaware, Lackawanna-part, Lancaster, Lehigh, Luzerne-part, Monroe, Montgomery, Northampton, Philadelphia, Pike, Schuykill and Wayne Counties).

The project review area includes that portion of the streamflow source zone which lies within two miles of the Delaware River in the States of New Jersey (in Mercer, Hunterdon, Sussex and Warren Counties), Delaware (in New Castle County), Pennsylvania (in Delaware, Philadelphia, Bucks, Monroe, Northampton, Pike and Wayne Counties) and New York (in Delaware, Orange and Sullivan Counties).

D. Topography

The New Jersey Coastal Plain is part of the Atlantic Plain physiographic province. The Coastal Plain physiographic province lies along the Atlantic and Gulf Coasts from Long Island to Mexico and contains one of the most prolific system of aquifers in the country. The area petitioned by the Environmental Defense Fund, Inc. and the Sierra Club New Jersey Chapter is the New Jersey Coastal Plain Aquifer System, which is located between the Delaware River and Bay, the Atlantic Coast, Staten Island and a belt of more rugged, generally higher terrain called the Piedmont province. A Fall Line, extending northeast along the Delaware River and through Mercer and Middlesex counties, separates the Coastal Plain from the Appalachian Highlands. The Fall Line separates areas with major differences in topography, geology, and hydrology.

The New Jersey Coastal Plain Aquifer System, lying southeast of the Fall Line, covers about 4,200 square miles. More than half of the land area is below an altitude of fifty feet (50') above sea level (NGVD). The area is largely surrounded by salty or brackish water and is bounded by the Delaware River on the west, Delaware Bay on the south, the Atlantic Ocean on the east, and Raritan Bay on the north.

The land surface is divided into drainage basins. A drainage basin is an area that contributes runoff to a stream and its tributaries. A drainage divide marks the topographic boundary between adjacent drainage basins. A major stream divide in the Coastal Plain of New Jersey separates streams flowing to the Delaware River and the Atlantic Ocean.

II. Hydrogeology

A. Geologic Framework

The following physiographic and hydrogeologic descriptions are excerpted from the United States Geological Survey (USGS) Report on the New Jersey Coastal Plain Area (Vowinkel and Foster, 1981). The New Jersey Coastal Plain is underlain by a wedge shaped mass of unconsolidated sediments composed of clay, silt, sand and gravel. The wedge thins to a featheredge along the Fall Line and attains a thickness of over six-thousand feet (6,000') at the tip of Cape May County, New Jersey. These sediments range in age from Cretaceous to Holocene and can be classified as continental, coastal or marine deposits. The Cretaceous and Tertiary age sediments generally strike on a northeast-southwest direction and dip gently to the southeast from ten to sixty feet (10 - 60') per mile. The overlying Quaternary deposits, where present, are basically flat lying. The unconsolidated Coastal Plain deposits, are unconformably underlain by a Pre-Cretaceous basement bedrock complex, which consists primarily of Precambrian and early Paleozoic age rocks. Locally, along the Fall Line in Mercer and Middlesex Counties, Triassic age rocks underlie the unconsolidated sediments.

Potomac Raritan Magothy aquifer system is divided into two aquifers. They are the Farrington aquifer and the Old Bridge aquifer. These aquifers are both upper Cretaceous in age and would be stratigraphically equivalent to the Raritan and Magothy formations, respectively.

B. Geologic Setting (Major Aquifers and Confining Units)

The wedge of sediment comprises one interrelated aquifer system that includes several aquifers and confining units. These sediments range in age from Cretaceous to Holocene and can be classified as continental, coastal or marine deposits. In general, aquifers and confining units in the Coastal Plain Aquifer System correspond to the geologic formations presented in Table 1. However, the boundaries of the aquifers and confining beds may not be the same as the geologic formations for the following reasons: (1) the formations may change in physical character from place to place and may act as an aquifer in one area or a confining bed in another; (2) some formations are divided into several aquifers and confining beds; and (3) adjacent

formations may form a single aquifer or confining bed.

There are five major aquifers in the New Jersey Coastal Plain Aquifer System. They are the Potomac-Raritan-Magothy aquifer system, Englishtown aquifer, Wenonah-Mount Laurel aquifer, lower "800 foot" sand aquifer of the Kirkwood Formation and the Kirkwood-Cohansey aquifer. The major aquifers and their respective confining units are described in ascending order from the bedrock surface.

Overlying the consolidated rocks of the bedrock is the Potomac-Raritan-Magothy aquifer system. This wedgeshaped mass of sediments of Cretaceous age is composed of alternating layers of clay, silt, sand, and gravel. These deposits range in thickness from a featheredge along the Fall Line to more than 4,100 feet beneath Cape May County. The Potomac-Raritan-Magothy aquifer system is exposed in a narrow outcrop along the Fall Line and the Delaware River. The aquifer is confined except in outcrop areas by the underlying crystalline rocks and the overlying Merchantville-Woodbury confining unit. In the northern part of the Coastal Plain, the Potomac-Raritan-Magothy aquifer system is divided into two aquifers. They are the Farrington aquifer (mainly Raritan age) and the Old Bridge aquifer (Magothy age).

The Merchantville Formation and Woodbury Clay form a major confining unit throughout most of the Coastal Plain of New Jersey. Although their permeability is very low, the Merchantville-Woodbury confining unit can transmit significant quantities of water when sizeable differences in potentiometric head exist between overlying and underlying aquifers.

The Englishtown aquifer overlies the Merchantville and Woodbury confining unit in the central and northern parts of the Coastal Plain. The aquifer is a significant source of water for Ocean and Monmouth Counties. In northern and eastern Ocean County, the Englishtown aquifer can be subdivided into two waterbearing sands. Upper and lower units of quartz sand with thin interbeds of dark sandy silt are separated by a thick sequence of sandy and clayey lignitic silt (Nichols, 1977).

The Marshalltown Formation overlies the Englishtown sand in most of the Coastal Plain but overlies the Woodbury Clay in much of Salem County. The formation has a maximum thickness of thirty feet (30'). Because the Marshalltown Formation is thin and contains some slightly to moderately permeable beds, it acts as a leaky confining bed.

Although the Wenonah Formation and Mount Laurel Sand are distinct lithologic units, they are hydraulically connected and together form the Wenonah-Mount Laurel aquifer. The Mount Laurel Sand, a coarser sandunit than the Wenonah Formation, is the major component of the aquifer. The combined thickness of the Wenonah Formation and Mount Laurel Sand in outcrop is as much as one hundred feet (100'). In the subsurface they range in thickness from forty feet (40') to slightly more than two hundred feet (200') (Nemickas, 1976). The Wenonah-Mount Laurel aquifer is an important water producing aquifer in the northern and western parts of the Coastal Plain.

Overlying the Wenonah-Mount Laurel aquifer is a confining unit that comprises several geologic units. The confining unit consists of the Navesink Formation, Red Bank Sand, Tinton Sand, Hornerstown Sand, Vincentown Formation, Manasquan Formation, Shark River Marl, Piney Point Formation and the basal clay of the Kirkwood Formation. Some of these geologic units may act as aquifers on a local basis.

The Kirkwood Formation includes several waterbearing units. The major Kirkwood aquifer is the principal artesian aquifer within the Kirkwood Formation, also known as the Atlantic City "800 foot" sand (Barksdale and others, 1936). The Kirkwood "800 foot" sand aquifer extends along the Atlantic Coast from Cape May to Barnegat Light and some distance inland. In Cape May and Cumberland Counties, the upper artesian aquifer of the Kirkwood Formation is defined as the Rio Grande waterbearing zone (Gill, 1962). This aquifer is productive only locally in Cape May County. Along the coast north of Barnegat Light and inland from the coast in Ocean, Burlington, AtIantic, and the western part of Cumberland Counties, the sands of the upper part of the Kirkwood Formation are hydraulically connected to the overlying Cohansey Sand.

The Cohansey Sand is typically a lightcolored quartzose sand with lenses of silt and clay. The Cohansey Sand is exposed throughout most of the outer part of the Coastal Plain and attains a maximum thickness of about two hundred fifty feet (250'). Ground water in the Cohansey aquifer occurs generally under watertable conditions except Cape May County, where the aquifer is confined. Inland from the coast and in the northern part of Ocean County, the upper part of the Kirkwood Formation is in hydraulic connection with the Cohansey Sand and they act as a single aquifer.

C. Ground Water Hydrology

Man has modified the natural equilibrium of the New Jersey Coastal Plain Aquifer System by increasing the rate of outflow from the system to the ocean. One major effect of the increased outflow of water is a regional decline in ground water levels. This decline in potentiometric head (the level to which water will rise under a given pressure with respect to aknown datum) within the aquifers may change the direction of ground water flow and cause induced recharge and/or saltwater encroachment into the system. Significant regional waterlevel declines have occurred in the Potomac-Raritan-Magothy aquifer system, Englishtown aquifer, Wenonah-Mount Laurel aquifer and the "800 foot" sand aquifer of the Kirkwood Formation. Ground water withdrawals from the Potomac-Raritan-Magothy aquifer system have resulted in ground water level declines of 1.5 to 2.5 feet per year from 1966 to 1976 (Luzier, 1980). These declines in head are causing a reversal in the direction of ground water flow near pumping centers. Model studies have indicated that about forty three percent (43%) of the total inflow to the Potomac-Raritan-Magothy aquifer system in 1973 was induced recharge from the Delaware River (Luzier, 1980). Saline water in the Delaware River Estuary threatens water quality in the aquifers along Salem and Gloucester Counties. sustained increases in the rate of withdrawal from the Potomac-Raritan-Magothy and in the consumptive uses of Delaware River water portends continued and increased movement of inferior quality water into the aquifer.

The head reductions in the Potomac-Raritan-Magothy aquifer system have also increased leakage from the overlying Englishtown and Wenonah-Mount Laurel aquifers through the Merchantville Formation Woodbury Clay confining unit. In model simulation, approximately thirty percent (30%) of the recharge to the Potomac-Raritan-Magothy aquifer system in 1973 was due to leakage from overlying aquifers (Luzier, 1980).

Withdrawal of water from the Englishtown aquifer has had a marked effect on the water level in the overlying Wenonah-Mount

Laurel aquifer. Decline in head in the Englishtown aquifer from 1959 to 1970 was 8 to 12 ft/yr over a large area. As a consequence of this change in head, increased quantities of water apparently leak from the Wenonah-Mount Laurel aquifer, through the confining layers, and into the Englishtown aquifer (Nichols, 1977).

Since the recharge from precipitation and induced infiltration is insufficient to replace ground water in heavily pumped areas close to the saltwater-freshwater interface, the interface can advance toward pumping centers.

1. Recharge

The Delaware River and Estuary, Sandy Hook Bay, the Atlantic Coast and the older, harder rocks of the Piedmont province constitute the recharge boundaries of the New Jersey Coastal Plain aquifers. These hydrographicfeatures represent the interfaces across which water either moves into or out of the ground water reservoir. Natural recharge occurs primarily through direct precipitation on the outcrop area of the geologic formations. A smaller component of natural recharge to the deeper layers of the system occurs by vertical leakage from the upper layers. This accounts for a small percentage of the total amount of recharge; however, over a large area and a long period of time the amount of water transmitted can be significant.

Natural recharge to the New Jersey Coastal Plain Area occurs primarily through direct precipitation on the outcrop area of the geologic formations. Based primarily on estimates of ground water contributing to streamflow and basin runoff, several estimates of ground water recharge in the Coastal Plain have been made. In the outcrop areas of the Potomac - Raritan - Magothy aquifer system, where it is unconfined, recharge to the aquifer is about twelve (12) inches per year (in/yr). In the outcrop area of the Farrington aquifer, the recharge to ground water is twelve (12) in/yr. Recharge ranges from twelve to twenty (12 - 20) in/yr in the outcrop of the Old Bridge aquifer.

Another component of natural recharge to deep, confined aquifers is primarily by vertical leakage from the upper layers. Only a small percentage of the water within the unconfined ground water system leaks to the confined aquifers; but over a large area and a long period of time, the amount of water transmitted can be significant (Vowinkel & Foster, 1981).

2. Discharge

The New Jersey Coastal Plain Aquifer discharges to the surface through streams, springs and evapotranspiration. Many streams ultimately flow into bays or directly into the ocean. Development of the ground water reservoir as a water supply source constitutes another discharge component which today accounts for a significant portion of discharge from the overall system. In certain areas (e.g., along the Delaware River) heavy pumping has caused a reversal in the normal discharge from the aquifer (Raritan-Magothy) such that the surface stream (Delaware River) now recharges the aquifer. This phenomenon implies that, in addition to the New Jersey Coastal Plain Area, the Delaware River Basin within Delaware, New Jersey, Pennsylvania and New York must be regarded as a streamflow source zone (an upstream headwaters area which drains into a recharge zone), which flows into the Coastal Plain Area.

3. Streamflow Source Zone

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D. Ground Water Quality

Fresh, uncontaminated ground water in the New Jersey Coastal Plain is low in dissolved solids (generally less than 150 milligrams per liter (mg/l). Calcium and bicarbonate are usually dominant ions in solution with smaller amounts of sodium, potassium, magnesium sulfate and chloride. Locally, concentrations of iron and manganese present a problem near the water table because the ground water tends to have a low pH. These waters are treated to make them palatable. Historically, no significant quantities of heavy metals, pesticides, organics or coliform bacteria have been found in the artesian aquifers. Except for specific parameters (e.g. iron) and contamination incidents, water quality in the artesian ground water system meets or exceeds Federal and State drinking water standards. The quality of ground water in the outcrop area, on the other hand, is variable, being largely determined by local conditions at the land surface.

A large part of the Potomac-Raritan-Magothy aquifer system in the southern Coastal Plain of New Jersey contains salty ground water with chloride concentrations ranging from less than 250 to as high as 27,000 mg/L (Luzier, 1980). The concentrations of chloride increase with depth as well as toward the ocean.

E. Designated Areas

The proposed Sole Source Aquifer designation areas for the New Jersey Coastal Plain Aquifer System are defined within the Counties of Monmouth, Burlington, Ocean, Cumberland and Cape May, and portions of Mercer and Middlesex Counties, New Jersey, and that portion of the streamflow source zonewhich lies within two miles of the Delaware River in the States of New Jersey (in Mercer, Hunterdon, Sussex and Warren Counties), Delaware (in New Castle County), Pennsylvania (in Delaware, Philadelphia, Bucks, Monroe, Northampton, Pike and Wayne Counties) and New York (in Delaware, Orange and Sullivan

Counties). Outside the New Jersey Coastal Plain Area and further than two miles from the Delaware River in the streamflow source zone, only those Federally assisted proposed projects requiring the preparation of an Environmental Impact Statement will be reviewed. The two-mile limit for the project review area along the Delaware River is based on the climate and hydrologic setting of the area.

F. Ground Water Use

Ground water use for public supply in the Coastal Plain area, was about 250 million gallons per day (MGD) in 1978. Use of surface water for public supply in this same area amounts to 79 MGD. Of the estimated 400 MGD withdrawn from the Coastal Plain aquifer system in 1978, approximately seventy-five percent (75%) was used for drinking water purposes to serve 2.3 million people.

Estimates for industrial and commercial consumption of ground water range from 75 MGD (USGS, 1978) to 97 MGD (NJ Water Supply Master Plan, WSMP, 1976). Agriculture is also a major consumer of ground water, pumping anywhere from 11 MGD (USGS, 1978) to 50 MGD (NJWSMP, 1976).

No accurate tally of domestic consumption in the Coastal Plain Area is available; however, the New Jersey Water Supply Master Plan estimates that as much as 40 MGD of ground water was pumped to private households.

The PotomacRaritanMagothy aquifer system is the most widely used aquifer in the Coastal Plain, but it is not the primary source of drinking water for every county. The Cohansey and Kirkwood aquifers are the primary sources of ground water in Atlantic, Cape May and Cumberland County. In these counties, the Potomac-Raritan-Magothy aquifer contains saltwater. The Englishtown and Wenonah-Mount Laurel aquifers are productive mainly in the northern and central counties of the Coastal Plain.

III. Susceptibility to Contamination

The New Jersey Coastal Plain Aquifer System is susceptible to contamination across several interfaces. In the outcrop areas, the water table conditions and the highly permeable nature of the soil, with its low attenuation capability, facilitate the movement of contaminants from the land surface into the system. Significant pollution sources include septic tanks, landfills, chemical spills and dumping, chemical storage leaks, industrial waste lagoons, highway deicing and agricultural chemicals. These sources have immediate local impacts as well as long term cumulative impacts as they progress through to the lower system.

EPA has identified roughly 150 hazardous waste disposal sites within the New Jersey Coastal Plain area which have the potential for contaminating the environment.

Municipal Land Disposal

Municipal land disposal sites frequently are discovered to contain other than municipal wastes. One example is Jackson Township, Ocean County. The Township disposal site has been found to be leaching chlorinated industrial solvents and other toxic organic chemicals into the aquifer that serves private drinking water wells of more than 100 homes in a nearby development. A second site is the Price Landfill in Pleasantville, New Jersey. The contamination emanating from this site does threaten the Atlantic City water supply.

Pipelines and Storage Tanks

Pipelines and tanks which carry and store petroleum products and other chemicals are subject to accidental rupture, external corrosion, and structural failure from a wide variety of causes. In the Pinelands, there are fourteen (14) storage tanks which are required to have Federal and/or State permits because of their size. Approximately 13.9 million gallons are stored in these facilities, and additional amounts are transferred through them.

Industrial Waste Lagoons

Industrial waste lagoons are constructed for the primary purpose of providing temporary storage of waste materials. Seven industrial lagoons have been identified in the Pinelands, and three have been linked to contaminated wells (New Jersey Pinelands Comprehensive Management Plan, 1980).

Hazardous Waste Sites

The lower Delaware along the TriCounty and Salem County area is highly industrialized, densely populated and contains a concentration of hazardous waste sites as well as an assortment of treatment, storage and disposal facilities. The potential for pointsource contamination of ground andsurface water quality is therefore greater in this area.

Fertilizer

In the Pinelands, there is increasing evidence to support an association between fertilizer use and nitrate in ground water. For example, high ground water nitrate levels possibly stemming from agricultural fertilization has been noted in Winslow Township. (New Jersey Pinelands Comprehensive Management Plan)

Hydraulic Gradient Variability Across Confining Units

Contamination across the confining units is another mechanism through which the Coastal Plain aquifer system is susceptible to contamination. Significant hydraulic gradients and variabilities in the integrity of these units has facilitated the migration of pollutants from one formation into another in South Brunswick (Geraghty and Miller, 1979)

Salt Water Encroachment

The Coastal Plain aquifers are also susceptible to contamination by saltwater encroachment. A large part of the Potomac-Raritan-Magothy aquifer system in the southern Coastal Plain of New Jersey contains saline ground water. m e concentrations of chloride increase with depth as well as distance toward the ocean. According to Luzier (1980), head reductions caused by withdrawal of ground water near the saltwater interface are more than sufficient to cause the slow migration of the saltwater toward pumping centers.

Lateral Salt Water Intrusion

Lateral saltwater intrusion is occurring in a part of the Old Bridge aquifer in the vicinity of Keyport and Union Beach Boroughs in Monmouth County, NJ. The reduction in water levels has caused a reversal in the direction of ground water flow in the Old Bridge aquifer. Prior to development, water in the aquifer flowed into Raritan Bay; however, saltwater is now flowing inland from the submerged (exposed) outcrop of the aquifer beneath Raritan Bay. As previously discussed, saltwater contamination is a threat to the Potomac-Raritan-Magothy Aquifer along the Delaware River.

In summary, problems in the New Jersey Coastal Plain Aquifer System revolve around rapid migration of contaminants as a result of the predominantly permeable hydrogeology. This poses an immediate threat to existing water supplies, as in the case of the Price Landfill, or may result in a more chronic contamination of the large interrelated aquifers.

IV. Alternative Sources of Drinking Water

The New Jersey Coastal Plain Aquifer System area is heavily dependent upon the ground water system for its drinking water supply. The many streams throughout the area might be considered alternative supplies; however, the streams are not as readily accessible to everyone as is ground water. Since the ground water has historically been the primary source of supply, considerable cost would be associated with tapping, treating and distributing this surface resource as an alternative supply. Most importantly, the close interrelationship between the ground water system and quality and baseflow of the streams precludes stream resource as a viable longterm alternative in the event of ground water contamination. The Delaware River may be considered an alternative source of supply for portions of the area; however, existing competitive uses severely limit the availability of additional water for drinking purposes.

In the event of contamination, it is possible to relocate drinking water wells to different depths and, in some portions of the Coastal Plain, to different formations. Deeper wells inevitably incur higher costs for drilling, piping and pumping. As evidenced in the discussions on ground water movement and susceptibility to contamination, the practical lifetime of this alternative can be limited and very costly.

Desalinization is also an alternative source of drinking water for the Coastal and Bay areas; however, conversion of saltwater requires considerable energy and the economic constraints make desalinization an impractical alternative.

Since the ground water resources of the New Jersey Coastal Plain Aquifer System are vast in magnitude and distribution, no alternative sources of water supply are considered viable.

V. Summary

Based upon the information presented, the New Jersey Coastal Plain Aquifer System, as defined in this document, meet the technical requirements for Sole Source Aquifer designation. More than fifty percent (50%) of the drinking water for the aquifer service areas is supplied by the aquifer system. In addition, there are no economically feasible alternative drinking water sources which could replace the aquifer systems. Therefore, it is recommended that the New Jersey Coastal Plain Aquifer System be designated a Sole Source Aquifer. This will provide an additional review of ground water protection measures, incorporating state and local measures whenever possible, for only those projects which request Federal financial assistance.

The Coastal Plain Aquifer System of New Jersey is an interrelated hydrologic system which responds to natural and manmade stresses. The wedge of unconsolidated sediments underlying the Coastal Plain Aquifer System of New Jersey is comprised of a series of hydrologic units that have varying thickness, lateral extent, and waterbearing characteristics. Some of the units act as aquifers, while others act as confining beds. Previous to development by wells, the groundwater system is in a state of dynamic equilibrium.

Withdrawal of ground water by wells is a stress superimposed on a previously balanced groundwater system. The response of an aquifer to pumping stresses may result in an increase in recharge to the aquifer, a decrease in the natural discharge, a loss of storage within the aquifer, or a combination of these effects. Also, the response of an aquifer to stress may extend beyond the limits of the aquifer being evaluated.

The following findings, which are the basis for the determination:

(1.) The New Jersey Coastal Plain Area depends upon the under-lying Coastal Plain Aquifer System for seventy-five percent (75%) or more of its drinking water to serve 3 million people.

(2.) Data show that the formations of the New Jersey Coastal Plain Area are hydrologically inter-connected such that they respond collectively as an interrelated aquifer system.

(3.) If the aquifer were to become contaminated, exposure of the persons served by the system would constitute a significant hazard to public health.

(4.) Alternative supplies capable of providing fifty (50) percent or more of the drinking water to the designated area are not

available at similar economic costs.

VI. Selected References

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VII. Tables

Table 1. Characteristics of the New Jersey Coastal Plain Aquifer System

System	Formation	Thickness	Lithology
Quaternary	Alluvial & Cape May Formation	80'	Sand, silt, black mud
Tertiary	Pennsauken & Bridgeton Formation	200'	Sand, quartz, light-colored clayey, pebbly, glauconite
	Beacon Hill Formation	40'	Gravel, quartz, light-colored sandy
	Cohansey Sand	250'	Sand, quartz, light-colored, medium to coarse-grained, pebbly; local clay beds
	Kirkwood Formation	780'	Sand, quartz, gray to tan, very fine- to medium-grained, micaceous
	Piney Point Formation	220'	Sand, quartz and glauconite, fine- to coarse-grained
	Shark River Marl	140' ?	Sand, quartz and glauconite, gray, brown, and green, fine- to coarse-grained, clayey and green silty and sandy clay
	Manasquan Formation	180'	Sand, quartz and glauconite, gray, brown, and green, fine- to coarse-grained, clayey and green silty and sandy clay
	Vincentown Formation	100'	Sand, quartz, gray and green, fine- to coarse-grained, glauconitic, and brown clayey, very fossiliferous, glauconite and quartz calcarenite
	Hornerstown Sand	35'	Sand, glauconite, green, medium- to coarse-grained, clayey
Cretaceous	Tinton Sand	25'	Sand, quartz, and glauconite, brown and gray, fine- to coarse grained, clayey, micaceous
	Red Band Sand	150'	Sand, quartz, and glauconite, brown and gray, fine- to coarse grained, clayey, micaceous
	Navesink Formation	50'	Sand, glauconite, and quartz, green, black and brown, medium- to coarse grained, clayey
	Mount Laurel Sand / Wenonah Formation	220'	Sand, quartz, brown and gray, fine- to coarse-grained, glauconitic
	Marshalltown Formation	30'	Sand, quartz, and glauconite, gray and black, very fine- to medium-grained, very clayey
	Englishtown Formation	220'	Sand, quartz, tan and gray, fine- to medium-grained; local clay beds
	Woodbury Clay / Merchantville Formation	325'	Clay, gray and black, micaceous, glauconitic, silty
	Magothy - Rariton - Potomac Formations	4100'	Sand, quartz, light-gray, fine- to coarse-grained, pebbly, arkosic, dark-gray lignitic clay/red, white and varigated clay/alternating clay, silt, sand and gravel
Pre-Cretaceous	Pre-Cretaceous Unconsolidated rocks and Wissahickon Formation	?	Precambrian and lower Paleozoic crystalline rocks, metamorphic schist and gneiss; locally Triassic basalt, sandstone, and shale

Table 2. Total Drinking Water Pumped from the New Jersey Coastal Plain Area

	(Million Gallons per day)			
County	**USGS (a)**	**208 Plan (b)**	**NJWSMP ©**	**Est. Private Use ©**
Atlantic	20.1	28.5	17.7	4.4
Burlington	30.5	25.5	32.4	4.7
Camden	67.5	66.7	70.3	2.4
Cape May	10.9	9.0	11.3	2.5
Cumberland	14.2	13.5	13.5	4.2
Gloucester	16.6	15.0	16.0	4.0
Mercer	7.2	6.5	4.5	1.5
Middlesex	24.7	25.8	24.1	1.5
Monmouth	26.0	28.6	28.6	4.2
Ocean	29.6	28.5	29.5	3.1

Salem	2.8	3.0	3.0	2.2
TOTAL	**251.0**	**251.0**	**251.0**	**39.6**

Sources of information:
(a) USGS Report on the NJ Coastal Plain Area; Database: 1978.
(b) Respective Water Quality Management Plans; database: 1970-75.
© New Jersey Water Supply Master Plan; database: 1976.

Table 3. Major Ground Water Withdrawals from the Coastal Plain Area

	(Million Gallons per day)					
County	**PRM**	**E**	**W-M**	**K**	**K-C**	**Other**
Atlantic	---	---	---	9.12	16.75	0.30
Burlington	38.96	0.49	1.14	---	0.36	---
Camden	69.57	0.76	0.88	---	0.04	0.98
Cape May	---	---	---	5.36	0.38	0.56
Cumberland	---	---	---	0.80	20.12	0.45
Gloucester	25.19	---	0.02	---	1.76	---
Mercer	8.12	---	---	---	---	---
Middlesex	49.38	---	---	---	---	---
Monmouth	21.60	6.25	1.31	---	1.14	0.31
Ocean	11.53	4.59	0.03	4.22	12.50	4.84
Salem	6.10	---	1.32	---	1.86	0.82
TOTAL	**230.45**	**12.09**	**4.70**	**19.50**	**60.92**	**8.26**

PRM = Potomac-Raritan-Magothy
W = Englishtown
WM = Wenonah-Mount Laurel
K = Kirkwood
KC = Kirkwood-Cohansey
Source: Vonwinkle and Foster, 1981.

Table 4. Population within Coastal Plain Aquifer System

County	**1985**	**2000**	**Change**
Atlantic	226,800	277,400	50,600
Burlington	372,900	471,900	99,000
Camden	482,600	555,900	73,300
Cape May	85,500	91,600	6,100
Cumberland	135,100	142,600	7,500
Gloucester	206,300	269,100	62,800
Mercer	100,330	111,602	11,272
Middlesex	256,440	302,840	46,400
Monmouth	515,700	588,200	72,500
Ocean	370,100	447,300	77,200
Salem	66,500	6,100	2,600
TOTAL	**2,818,270**	**3,327,542**	**509,272**

VIII. Figures

Coastal Plain Figures