THE ECOLOGICAL IMPLICATIONS OF EXPORTING WATER FROM THE COHANSEY AQUIFER

Proceedings Of A Technical Advisory Committee Meeting On The Issue Of Pumping Cohansey Water To Meet The Water Supply Needs Of The Metropolitan Camden Area, May 30, 1984

STATE OF NEW JERSEY · PINELANDS COMMISSION

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Prepared By The Staff Of
The New Jersey Pinelands Commission

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NEW JERSEY PINELANDS COMMISSION
P.O. Box 7, New Lisbon, NJ 08064

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EXECUTIVE SUMMARY

A technical advisory committee, comprised of scientists with Pinelands research experience, was convened by the Pinelands Commission to discuss issues associated with the exportation of water from the Cohansey aquifer. This meeting was called in response to the identification of the Cohansey by the New Jersey Department of Environmental Protection as a potential source of water for the metropolitan Camden area.

Several issues associated with water exportation (a form of water mining) were identified. These concerned regional and local changes in water quality, water table level, and salinity regimes, and related changes in Pinelands and coastal bay communities and ecosystems. Preemptive use of the region's water resources was also identified, *i.e.*, needs generated from outside the region affecting the availability of the resource for local agricultural, residential, industrial, and commercial uses.

The cumulative ecological and cultural impacts associated with water exportation can be significant. A majority of the committee concluded that pumping the Cohansey to meet Camden's water supply needs is therefore not a viable alternative. Should the State continue to pursue this alternative, extensive study of the impacts which it may generate must be conducted.

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INTRODUCTION

Ninety-eight percent of Camden County's total estimated water demand of 97 mgd is supplied by the Potomac-Raritan-Magothy Formation (PRM). Over-pumping of this aquifer has resulted in the formation of a large cone of depression in Camden County and adjacent areas which is causing a deterioration of ground water quality. Sources of contamination, which include organic compounds and saltwater, are waste disposal sites and inducement of contaminated and saline water into the PRM from the Delaware River. This contamination has created a water supply problem in the metropolitan Camden area which is made worse by an unmet water supply need estimated at 15 mgd by the Statewide Water Supply Master Plan (1, 2).

The Department of Environmental Protection, Division of Water Resources is currently conducting a study to identify environmentally and economically feasible alternatives to accommodate the water supply needs of the affected area. Several alternatives are being considered by the Department, including:

a. interconnections between currently separate water systems;
b. the proposed Delanco intake from the Delaware River for use as a new surface water supply;
c. conjunctive use of surface water and ground water (surface water, probably from Delanco, being used during wet years and groundwater being used during dry years);
d. developing new well fields in the PRM outcrop area to the northeast;
e. developing new well fields in the Mount Laurel-Wenonah aquifers;
f. purchasing Philadelphia water;
g. relocating existing well fields in other portions of the PRM located further inland; and
h. developing new well fields in the Cohansey-Kirkwood aquifer.

The last alternative is of special interest to the Pinelands Commission because of the potential for significant impacts to the Pinelands, a unique ecological area and the country's first National Reserve.

On May 30, 1984, Commission staff convened a meeting among a group of scientists and Department representatives to identify and discuss (a) the issues which may be associated with the export of water from the Cohansey and (b) the steps required to address these issues. The major objectives of this meeting were to share with the Department the insights and experience of the invited scientists, all of whom have conducted research in the Pinelands and possess an expertise in some area of Pinelands ecology, and to present in a timely fashion those important ecological concerns which should be assessed by the Department. A draft paper that summarized the results of this meeting was prepared by Commission staff and distributed among the invited scientists for their review. This final report incorporates the comments received during this review period. All written comments on the draft paper are included in the appendix to this report.

REGIONAL PERSPECTIVE

The ecological implications of exporting water from the Cohansey aquifer must be given thoughtful consideration. Perspectives vary on the actual impact of removing large quantities of water from the formation. It has been reported that the Cohansey can be extensively developed as a water supply source for Camden County (3). Contrary to this viewpoint, it has also been suggested that any removal of water from this formation may seriously harm the Pinelands system (4).

Concern regarding the exportation of water from the Pinelands is reflected in state legislation and regulation. The New Jersey Pinelands Comprehensive Management Plan (N.J.A.C. 7:50-6.86) prohibits the exportation of water from Pinelands counties except for that which occurs from natural surface and ground water flows. State legislation (N.J.A.C. 58:1A-7.1) prohibits the exportation of surface and ground water beyond more than ten miles from the boundary of the Pinelands National Reserve. Furthermore, the Pinelands Commission is on record as opposing any consideration regarding the exportation of water from the Cohansey aquifer (5).

Before exportation of water is given serious consideration, it is imperative that a thorough environmental analysis be conducted to determine the negative impacts which may be generated by a water exportation proposal. Because of the complex nature of Pinelands hydrology, which includes both local and regional flow patterns, such an environmental assessment must measure the effects of water exportation on a regional scale (i.e., throughout the Cohansey and systems dependent on the aquifer) and on a local level (i.e., within a sub-watershed). This requirement is supported by a report (6) prepared for the Commission in 1980 by a group of scientists convened by Rutgers University. It describes the ecological effects of development-induced water level changes in the Pinelands and emphasizes the importance of examining these changes in terms of their scale (i.e., regional/interregional changes, area wide changes, local changes and site specific changes). Additionally, any assessment must address the cumulative effects which may result from both existing and future water supply demands generated within and outside the boundaries of the Cohansey.

The Kirkwood and Cohansey formations are the principal sources of water used to supply domestic, irrigation, and industrial needs in the Pinelands. The Cohansey is used at an estimated rate of 98 mgd within and outside the region, while the Kirkwood is pumped in areas which are predominantly outside the Pinelands. Based on a review of water usage data for the seven Pinelands counties, the Pinelands Commission concluded that the methods used to determine pumpage underestimate the quantity of groundwater actually used, and that if fully utilized the water usage approvals already granted could have an impact on the Pinelands ecosystem (7).

All groundwater usage is depletive to some degree, even when recharge is conducted on-site. For example, irrigation water usage in the Pinelands has been estimated to be 15.5 mgd, a value which does not include potentially large amounts of grandfathered rights (8). Considering that about thirty-seven percent* of total annual precipitation in the Pinelands is lost through evaporation and transpiration (9), the amount of irrigation water lost through these pathways may be significant. Other losses, such as those associated with the use of sewers, also occur. In 1980, the Pinelands Commission estimated that the average flow from existing sewerage systems in the Pinelands (includes systems located adjacent to the region but serving parts of it) was 74.82 mgd. The total design capacity of these systems was estimated to be 155.88 mgd. (10). The cumulative effects of all types of water usage within the Pinelands are compounded by needs generated outside the region. In 1981, for example, the Commission approved the installation of nine wells (needed to replace wells affected by a toxic waste site) within the Pinelands area of Atlantic County. These wells, capable of pumping 15 mgd, will provide water for Atlantic City, an area located outside the Pinelands.

Exportation of water from the Cohansey results in localized effects similar to those caused by some forms of water usage within the boundaries of the formation. A significant difference is that exportation results in the complete removal of water from the system. Exportation of water not only has ecological impacts, but is also preemptive, precluding the use of this resource within the region or reducing that which is available for local agricultural, industrial and residential needs.

The impact of water exportation is of course dependent on the quantity removed. Neither preferred alternatives nor the quantities to be derived from new sources have yet been identified by the Department of Environmental Protection and any pumpage figures presented in discussion must be considered speculative. By presenting several assumptions regarding pumpage, however, a perspective may be obtained. As previously noted, Camden County obtains nearly 100 mgd of water from the PRM, and the unmet need of the metropolitan

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*Evaporative losses associated with irrigation may actually be higher (as much as 50% loss from evaporation and transpiration).

Camden area has been estimated to be 15 mgd. For the purpose of the following discussion, it will be assumed that between 1-15 mgd (a conservative estimate) will be pumped and exported from the Cohansey. The significance of even this seemingly low pumpage, representing from 1-15% of Camden County's total estimated water demand, is apparent when reviewed relative to the Pinelands hydrology.

In the Pinelands infiltration represents about forty-five percent (20.05 inches/yr) of total precipitation (45 inches per year) (11). This translates to a ground water recharge rate of approximately 544,400 gallons/acre/yr. A pumpage of 1-15 mgd represents the total average recharge occurring over 670-10,057 acres. This observation becomes important when compared to the size of the headwater-stream basins of the Nescochague Creek and the Sleeper Branch drainage systems, two probable pumpage areas. The average size of these headwater basins, which are listed below, is approximately 3,000 acres. Water mining of 1-15 mgd represent a significant reduction in the water yield of these systems. The higher pumping level would totally deplete the average annual contribution from precipitation in several of these basins.

STREAM	BASIN SIZE (acres)	ESTIMATED INFILTRATION (million gallons per day)
Gun Branch	2,800	4.18
Clark Branch	2,100	3.13
Price Branch	1,700	2.54
Wildcat Branch	1,400	2.09
Cooper Branch	1,300	1.94
Hays Mill Creek	4,700	7.01
Pump Branch	7,200	10.74
Blue Anchor Branch	3,700	5.52
Total	24,900	37.15

The ecological implications of removing even minor quantities of water from the Cohansey or the Pinelands are numerous. Exporting millions of gallons per day presents serious concerns. The following sections review significant issues regarding impacts to the coastal estuaries and alterations in the ground water level and water quality.

WATER TABLE ALTERATION

The Pinelands are characterized by a gently undulating, sandy terrain lying mainly between 50-150 ft above sea level (12) and a water table which is generally close to the surface of the land, ranging in depth from 0-70 ft (13). A seasonal-high water table of four feet or less occurs over extensive areas of the Pinelands. For example, nearly forty-five percent of the land in Ocean County, a county which is almost entirely within the ecological boundaries of the Pinelands, falls in this category (14). The proximity of the water table to the surface exerts a tremendous effect on the distribution and abundance of the characteristic Pinelands plant and animal communities. Activities, such as water pumpage and exportation, which cause a drop in the water table can therefore adversely impact the Pinelands ecosystem.

Water table changes can affect both upland and lowland habitats. The roots of many upland plants are in direct contact with the water table. This is especially true in areas where the water table is within 5-10 ft of the surface. Lowering the water table can exert considerable stress on these plants, affecting entire communities. The local and regional impact of ground water withdrawal on Pinelands wetlands is a special concern. Hydrologic factors are the principle determinant of wetlands function and structure, and alteration of the natural hydrology can result in detrimental impacts to these invaluable resources (15). The narrow depth to seasonal high water table range (0-18 inches) within which wetlands generally occur increases the potential for adverse impacts associated with an alteration of the natural hydrology. It has been suggested that changing a wetland water table by only 10-20 cm (4-8 in) over a growing season could contribute to changes in wetland composition and structure (16). Pitch pine lowlands, a transitional wetland vegetation type which occupies the drier end of the wetland soil continuum, may be especially susceptible to slight changes in water table resulting from groundwater withdrawal (17). A regional effect of altering the water table may be the loss of areas of pine lowland habitat.

Pumpage induced changes in wetland water tables are dependent on several factors, including well depth and distribution and amount of pumpage. An aquifer test involving the pumping of approximately 1.5 mgd for 12 days from a well located adjacent to the Mullica River and screened between 71-81 ft from the surface was conducted in 1970 (18). The test resulted in the drying up of swamps on both sides of the river after about six days of pumping. Placement of wells in upland areas may reduce the localized impact to wetlands, but the effect will not be eliminated. Groundwater discharge accounts for an average of eighty-nine percent of total annual stream discharge (19). Although a portion of the groundwater discharge follows a regional pathway, approximately eighty-five percent of infiltrated precipitation discharges to local streams, generally by way of associated wetlands (20-21). The impact to wetlands must therefore be measured on a sub-basin level. As previously noted, even limited pumpage can have a significant effect on the hydrologic budget of minor stream basins.

A general estimate of the anticipated water-table drawdown in the vicinity of a well or well-field site can be calculated, and a scenario, albeit a simplistic one, describing the effects of this withdrawal can be presented (refer to Appendix I for methodology). Fifteen widely spaced wells, each capable of pumping 720 gpm, can provide the projected 15 mgd water supply need. The significant part of the cone of depression for each well would be approximately 2.50 to 3.25 square miles. A water table lowering of 2 feet or more would occur within this area. These values are based on the assumption that the cone of depression will encounter a recharge boundary (a stream or wetland) within 8000 feet and stabilize at this point. Water will then be induced from this recharge boundary. In the long-term the flow of a stream or swamp can be totally diverted if it is much less than the pumpage of the adjacent well. By extrapolating, it is estimated that the cumulative impact of pumping fifteen wells will result in a significant lowering of the water table (2 feet or more) over 37.5 to 48.8 square miles. This lowering would be a net reduction that would be superimposed on naturally occurring fluctuations.

A reduction in water-table can have many other effects on wetland habitats, including a greater incident of late frost, warmer summer soil temperatures, and greater potential for wildfire (22), along with loss of Sphagnum ground cover, altered soil chemistry and changes in decomposition and nutrient cycling processes. Changes in wetlands habitats will affect those wildlife and plant species dependent on them. This is especially true for many threatened or endangered species, the majority of which are dependent on wetlands as their primary habitats. The endangered Pine Barrens treefrog, for example, breeds in ephemeral ponds which can be eliminated by slight changes in water table. The Pine Barrens gentian, an endangered plant species inhabiting transitional wetland areas, is another example of a species which may also be adversely affected.

WATER QUALITY DEGRADATION

Preservation of the Pinelands ecosystem is dependent on the maintenance of the acid and nutrient poor surface and ground waters which characterize the region (23, 24, 25). The ecological processes which regulate water quality can be disrupted by water exportation, resulting in the degradation of these critical water resources. Several of these processes and pumpage related impacts are briefly reviewed in this section. This review principally addresses pH and nitrogen, two of the most biologically important parameters.

Because most streamflow in the Pinelands is derived from a water table aquifer, ground and surface water quality are quite similar, and changes in the composition of the former are reflected in the latter. The characteristics of Pinelands soils minimize their ability to prevent the movement of inorganic pollutants to the ground water. The principle mechanism for reducing concentrations of these contaminants is dilution. This is especially true for nitrate-nitrogen, ammonia-nitrogen, and phosphorus (26). Removal of ground water from the system will reduce the effectiveness of dilution as an attenuating mechanism, increasing the potential for the introduction of excess nutrients and other contaminants to wetlands and surface waters. Pumpage induced changes in streamflow will also compound the impact of both point and non-point discharge of contaminants to surface waters.

Ground water discharge and streamflow affect water quality in several other ways. Drainage from swamps adds acidity to streams, thus maintaining low pH levels (27). It has been suggested that the increased acidity is the result of several processes. Suspended iron appears to increase with increased stream flow and the oxidation and hydrolysis of the introduced iron may reduce the pH of the receiving waters (28, 29, 30). Humic acids and, to a lesser degree, carbon dioxide produced in swamps and transported to streams in discharged ground water also contribute to reducing surface water pH, and *Sphagnum* moss and peat found in swamps are able to absorb bases and release hydrogen ions (31). All of these mechanisms which regulate the pH of surface waters are dependent on the flushing of swamps, a phenomenon which is definitely affected by pumpage induced variations in water yield. These pH regulating mechanisms will also be affected by the water-table related wetland impacts which have been previously described.

Pinelands wetlands also play an important role in attenuating introduced nutrients. Much of the exchange of nutrients between ground water and streams occurs in wetlands. These areas may, under certain conditions, buffer the effects of upstream development (32). A reduction in water table or flow can affect the ability of wetlands to provide this important function. Differences in the type of stream flow, <u>i.e.</u>, dispersed flow through wetlands vs. channel flow, may also affect the nutrient attentuation role of wetlands (33). A reduction in discharge will result in less overflow to wetlands, and, therefore, less contact time between swamps and nutrient-laden water.

Wetland soils in the Pinelands contain appreciable amounts of organic matter which serve as a sink for introduced contaminants such as excessive nutrients. Oxidation of this organic matter resulting from a reduction in water table would eliminate this role. Nutrients, stored in the organic matter, would also be released to surface waters and wetlands.

THE ESTUARY

The relatively constant flow of nutrient poor water from the Pinelands has a major controlling and stabilizing effect on the coastal bays located along the region's eastern boundary. The hydrologic relationship between the Mullica River and the Great Bay estuary is especially critical (34). Changes in the quality and quantity of freshwater flowing to Great Bay can have profound effects on what is generally considered to be the most ecologically valuable estuary in New Jersey.

Exportation of water from the Pinelands will definitely result in lowered river flows. This can have pronounced effects on the salinity gradients of surrounding estuaries, causing upriver extensions of saline water (35). The distribution of salt is a critical ecological factor for certain estuarine organisms, especially the economically important American oyster. An increase in salinity in the Mullica River oyster grounds would permit the upriver movement of oyster predators, such as starfish and oyster drills, which are kept from the oyster seed beds by low salinity (36, 37). The upper reaches of the estuary are also known to be important nursery areas for many fish species. As with the oyster seed beds, the value of these areas as nursery grounds may be due to the low salinity which separates predators from larval fish (38, 39).

It has been suggested that primary production in bays and inlets may also be susceptible to variations in river flow (40), and that the impact of discharge related changes in the productivity of planktonic organisms can extend to higher trophic levels in the estuarine food chain. Because the relationship between productivity and river flow has not been adequately investigated, further study is required to determine the ecological implications of altering the existing hydrologic regime.

It must be realized that any withdrawal from the Mullica River Basin will have some effect on the generally "pristine" conditions of Great Bay. It has been suggested that an average of 118 mgd can be withdrawn from the entire 517 square mile (330,880 acres) Mullica Basin while maintaining the necessary salinity regime in the Great Bay Estuary (41, 42). This value was derived by using a conjunctive-use model which assumed that water would be withdrawn at a uniform rate. Although this figure provides some basis for evaluating the impact of water exportation, it should be reviewed within the context from which it was presented. Most notably, the only environmental effect considered in the analysis was a change in salinity. Withdrawing an average of 118 mgd from the Mullica River Basin would result in the maintenance of minimum monthly river flows, an artificial and potentially disruptive regime. Additionally, further research is needed on both the biological validity of salinity standards and the effect of water management practices on salinity gradients in the estuary (43). It should also be noted that the siting of water withdrawal in the basin was unspecified, and problems associated with such sitings were not addressed.

Estimates of the relative magnitude of withdrawal related changes in discharge may provide a basis from which to review the significance of water pumpage. Low-flow discharges for the Mullica River Basin are reported as 305.9 mgd (7 day/2 year low-flow) and 205.5 mgd (7 day/10 year low-flow) (44). The former approximates average baseflow while the latter is representative of drought conditions. The 118 mgd withdrawal rate represents a significant part of this discharge, comprising thirty-nine percent of the 7 day/2 year low-flow discharge and fifty-seven percent of the 7 day/10 year low-flow discharge. Exporting 15 mgd from the Mullica Basin would result in a five percent and seven percent reduction in average baseflow and drought condition baseflow, respectively. Perspectives on the effects of removing seemingly minor amounts of water vary. The actual significance of these values must be viewed within several contexts. First, one source will be entirely responsible for this withdrawal. Secondly, from an ecological perspective such a reduction may represent a significant change in a system which is so dependent on river flow. Finally, the impacts of this withdrawal will be compounded by existing and future withdrawals which individually may be considered minor. Once again the regional, cumulative effects of water exportation must be considered.

SUMMARY AND CONCLUSION

Protection of the quality and quantity of the Cohansey's water resources is critical to the preservation of the Pinelands. The abundant "pristine" waters of the region are the ecosystem's first and major defense against the impacts associated with existing and future development. From a scientific perspective, it must be concluded that there will be a definite change in this unique ecosystem if millions of gallons per day are removed from the Cohansey.

Two factors must be weighed in dealing with the issue of water exportation. The first is the public water supply needs and an account of the strategies which are available to meet these needs. The second is the ecological impacts associated with accommodating this need by mining water from the Cohansey. The public benefits of each factor must then be compared before a final decision is made.

Several issues were raised by the advisory committee. These were related to pumpage-induced changes in water quality, water-table, and regional and local surface and ground water flow patterns and the ecological implications of these changes. It is the conclusion of the majority of the committee that because of the potentially adverse cumulative effects of removing water from the Cohansey, exportation of water from the aquifer is not a viable alternative for meeting the water supply needs of the metropolitan Camden area. If the State ultimately decides to pursue this alternative, an intensive study program is mandatory. Detailed modeling, accompanied by extensive field investigations, is needed before the State can embark on a project to remove water from the internationally significant aquifer on which the Pinelands region is dependent. These impacts must be measured on both a local and a regional level. It can not be automatically assumed that any area of the Pinelands is expendable.

FOOTNOTES

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APPENDIX - DRAFT REVIEW COMMENTS

Reviewer	Exhibit
James Durand, Ph.D.	A
Joan Ehrenfeld, Ph.D.	B
Ralph E. Good, Ph.D.	C
Robert Hordon, Ph.D.	D
Mark Morgan, Ph.D.	E
George Nieswand, Ph.D.	F
Edward Rhodehamel	G
Beryl Robichaud, Ph.D.	H
Patrick Leahy	I
Anthony Navoy	I

THE STATE UNIVERSITY OF NEW JERSEY
RUTGERS

Department of Biology
Camden College of Arts and Sciences • Camden • New Jersey 08102 • 609/757-6142

A

SEP 04 1984

August 30, 1984

Mr. Terrence D. Moore
Executive Director
Pinelands Commission
P.O. Box 7
New Lisbon

Dear Mr. Moore:

I have only a short comment on the draft statement on the Ecological Implications of Exporting Water from the Cohansey Aquifer.

I think you are right in viewing this question on a regional scale. It is of utmost importance to realize that all of the New Jersey coastal bays derive their fresh water stocks from the New Jersey Pine Barrens drainage. In particular, the Mullica River - Great Bay estuary is supplied by the Pinelands. Any change in Pinelands water quality or quantity may affect the ecology of the coastal bays and plans that affect water quality/quantity should be examined carefully.

With reference to the last paragraph, The Estuary, of the draft statement, I think it is important to point out that in the study referred to (Durand and Granstrom) the siting of water withdrawal in the basin was unspecified. The withdrawal was calculated for the basin as a whole. Additional problems could be encountered in the actual siting of wells. Furthermore, the river flow levels recommended for ecological protection would most likely be violated at times in order to maintain scheduled water removal.

I point out the danger that once water removal schedules are put into effect, they become the governing force. The ecological considerations tend to be neglected to second place. Therefore, I stress again that priorities must be clear in the beginning and must be adhered to. In this case, the priority is non-degradation of water supply.

Sincerely,

James B. Durand
Rutgers Marine Field Station

JBD/ts

THE STATE UNIVERSITY OF NEW JERSEY
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Center for Coastal and Environmental Studies
Doolittle Hall · New Brunswick · New Jersey 08903 · 201/932-3738

SEP 06 1984 **B**

September 5, 1984

Mr. Terrence D. Moore
Executive Director
The Pinelands Commission
P.O. Box 7
New Lisbon, NJ 08064

Dear Mr. Moore:

Thank you for sending me the summary paper on the Cohansey water withdrawal issue. I found the paper to be an effective summary of the issues raised at the meeting of May 30, 1984. I fully support the conclusion that exportation of water from the Cohansey aquifer is not a viable alternative.

I have only a few specific comments on the paper:

p. 5: The higher (15 mgd) pumping rate would deplete infiltration from all, not several, of the basins. It should also be pointed out that even the lowest rate (1 mgd) would deplete 25-50% of the infiltration of 5 of the 8 sub-basins. Can the reduced flow in these two affected streams be related to the total flow of the Mullica?

p. 7, last ¶: Other important changes in wetland habitats would include change in the redox conditions in wetland soils, with concurrent changes in the chemistry and solubility of multivalent cations and heavy metals, changes in decomposition and nutrient cycling processes, and loss of _Sphagnum_ ground cover. Also, it should be stressed that many rare and endangered species could be affected -- not just the treefrog and gentian.

It should also be pointed out that many of the upland plants are phreatophytes, especially where the water table is within 5-10' of the surface. Lowering of the water table in those upland areas could impose considerable stress on plants that have been growing with root contact with the water table. Thus, water table alteration effects may not be confined to the wetlands.

It could also be expected that a major regional effect of water table lowering wold be loss of pine lowland habitat, since it could be expected that the pine lowland-upland boundary would shift streamward in response to the hydrological change. Since protection of wetland habitat is a prime goal of the Management Plan, this is a further argument against permitting export of Pinelands water.

p. 12, last ¶: I suggest that if the State decides to pursue this alternative, the Commission should demand not only intensive study of impacts, but intensive study of methods of mitigating or preventing impacts through the design, placement and pattern of utilization of the wells. Furthermore, the Commission should request that before this alternative be considered further by DEP, sufficient evidence should be presented demonstrating to the Commission's satisfaction that none of the other alternatives are feasible.

I hope these comments will be useful to you in preparing a final draft.

Sincerely yours,

Joan G. Ehrenfeld, Ph.D.

dr/wp

C

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OCT 4 1984

Reply to:
Biology Department
Camden, NJ 08102

October 2, 1984

Mr. Terrence D. Moore, Executive Director
The Pinelands Commission
PO Box 7
New Lisbon, NJ 08064

Dear Terry:

I have reviewed the staff report entitled "The Ecological Implications of Exporting Water from the Cohansey Aquifer" which summarizes the discussions of the May 30 meeting of a technical advisory committee. As you know I attended this meeting, but was unable to be present for the afternoon session.

The Executive Summary and Summary and Conclusions sections properly point out that cumulative ecological impacts associated with water exportation can be significant and if exportation is to be considered further a massive field study of the impacts must be undertaken.

There are several suggestions I can recommend for the report text.

1. page 1 line 7, include not includes
2. page 7 line 4, incidence not incident
3. page 8 para. 2 line 6, groundwater used as 2 words elsewhere in report
4. same paragraph line 9, phosphorus
5. footnote 42 is not clearly identified in References section which I believe is the NSF supported conference on Pinelands problems referenced as:
   Good, R.E., ed. 1982. Ecological Solutions to Environmental Management Concerns in the Pinelands National Reserve. Center for Coastal and Envirionmental Studies, Rutgers University, New Brunswick, NJ 47p.

   Several other sections of the same report are also relevant to this issue.

Please let me know if I can provide additional assistance on this issue.

Sincerely,

Ralph E. Good
Division Director

REG/kpc

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Faculty of Professional Studies · School of Urban and Regional Policy · Department of Geography
Lucy Stone Hall · Kilmer Campus · New Brunswick · New Jersey 08903 · 201/932-4103

OCT 2 1984

D

September 27, 1984

Terrence D. Moore
Executive Director
The Pinelands Commission
P.O. Box 7
New Lisbon, NJ 08064

Dear Terry:

Thank you for the opportunity to participate in the TAC meeting re: Cohansey water exports to the Camden area. The 8/7/84 draft document is well written and carefully enumerates all of the various issues pertaining to the maintainance of the Pinelands ecosystems with regard to water. At the least, extensive study of the pertinent aquifers and impacts associated with major pumping is a reasonable request from the Commission. In this context, I wonder if Harold Meisler of the USGS office in Trenton (609-989-2005) has been contacted by your staff. He was the former District Chief for New Jersey and has been working on coastal plain aquifers in the-Mid-Atlantic region for the past several years.

In short, I am in general agreement with the statements contained in your draft 8/7/84 report entitled "The Ecological Implications of Exporting Water from the Cohansey Aquifer."

Very truly yours,

Robert M. Hordon
Associate Professor

RMH:f

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OCT 4 1984 E

September 28, 1984

Mr. Terrence Moore
Executive Director
Pinelands Commission
P.O. Box 7
New Lisbon, NJ 08066

Dear Mr. Moore,

I have read the report of our meeting on "The ecological implications of exporting water from the cohansay aquifer" and believe that it fairly reflects the issues and concerns brought up at the meeting. I have communicated comments on minor technical details directly to Mr. Robert Zampella.

Sincerely,

Mark D. Morgan

Mark D. Morgan, Ph.D.

F

THE STATE UNIVERSITY OF NEW JERSEY
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Cook College • New Jersey Agricultural Experiment Station
P.O. Box 231 • New Brunswick • New Jersey 08903 • 201/932-9447
Office of the Dean and Director

September 28, 1984

OCT 5 1984

Terrence D. Moore
Executive Director
The Pinelands Commission
P. O. Box 7
New Lisbon, New Jersey 08064

Dear Terry:

Please excuse the excessive delay in responding to your letter of August 13, requesting comments on the staff summary paper on "The Ecological Implications of Exporting Water from the Cohansey Aquifer." As you know, things continue to run at a hectic pace for me. Nonetheless, I have reviewed the paper on two occasions and feel that it is a reasonable presentation of the concerns that must be considered vis-à-vis any proposal to export water from the region. I would offer the following general comments:

- "It is never the last straw that breaks the camel's back, but, rather, the first." Translation: It will not be the last million gallons of water exported from the Pinelands that will do irreparable harm, but, rather, the precedent set by exporting the first million, though the impact of the first million may go unnoticed.

- "The problem is one of incrementalism." Translation: It is not the exportation of any particular million gallons of water that will do damage, but, rather, the cummulative impact of the total exported.

- Any exportation of water from the Pinelands will, obviously, preempt the use of that water within the region, whether it be for development, agriculture or the maintenance of ecosystem.

I would concur with the summary and conclusion presented in the staff paper, especially that, "if the State ultimately decides to pursue this alternative, an intensive study program is mandatory."

I trust that the above comments will be of some use. Let me know if I can be of further assistance.

Sincerely yours,

George H. Nieswand
Acting Dean and Director

cc: Robert A. Zampella

EDWARD C. RHODEHAMEL
14621 Baugh[illegible] Dr[illegible]
Centreville, Virginia 2[illegible]
(703) 830-2849

G

SEP 26 1984

September 20, 1984

The Pinelands Commission
P.O. Box 7
New Lisbon, New Jersey 08064

Dear Director Moore,

Setforth below are my comments.

Comments by E. C. Rhodehamel regarding draft of: "Proceedings of a Technical Advisory Committee held May 30, 1984 on Ecological Implications of Exporting Water from the aquifer in the Cohansey-Kirkwood formations."

General Comment:

In general, the report is good; in most cases properly and adequately (strongly) worded; and pertinent, instructive, and useful examples are presented to hammer home the catena of problems that will develop from such a water-mining regimen.

However, nothing was said about the undesirable precedent that would be set by the initiation of such a pumping regimen. It is left up to the reader to make this mental jump from the single opening statement of paragraph 3, page 6. I think the thrust of the report would be enhanced by such a statement delivered in both the Executive Summary and in the Summary and Conclusion sections.

Beyond this I have several specific comments as setforth below.

Point (1)

Executive Summary
Paragraph 1, line 4.
Comment: The word "exportations" per se does not provide the full connotation needed - that it is, by it's "one-crop nature," a form of "water mining" - a term that strikes at the very heart of this manner of water use. Therefore I would add after the words "exportation of water" "(considered by its one-crop nature a form of mining)" from the Cohansey.....

Point (2)

Page 4, lines 3-7, re: Evapotranspiration losses as being approximately a 37% rateable of water losses from irrigation activities. Comment: Use of the 37% value as the probable rateable of evapotranspiration (ET) that might occur from irrigation activities (overwhelmingly aerial spraying practices used in the Pinelands) is, in my opinion, too low. Under such irrigation practice the aerial parts of the crop, for example blueberries, is wetted. As such, evaporation (E) of the intercepted water on these aerial parts may account for as much as 13 percent more water loss. Thus, a 50 % loss from ET should be cited.

Point (3)

Page 4, last paragraph, line 1.
Comment: Suggest inserting "about" before the "forty-five"... Your 20.05 inches ÷ 45 inches = 44.5%+ or "about" 45%. Actually 45% = 20.25 inches, and 50.8 cm ÷ 114.3 cm = 44.4% or "about" 45% if using actual numbers cited in my table 11, page 163 of reference.

Point (4)

As above, line 4.
Comment: 20.25" (45% of 45 inches) = 351,895,104 g/mi^2/yr. and when ÷ 640 acres = 549,836 g/acre/yr. If 20.05 inches is used then 348,245,821 g/mi^2/yr. ÷ 640 acres produces 544,134 g/acre/yr.
My figures above are based on 27,878,400 ft /mi^2 = 208,530,432 g/mi^2/ft of water depth. Seemingly there are some inconsistencies here as well as some need to round off the numbers to hundred or thousand gallon units. This is especially true when one looks at the rounding off used in the table page 5. I suggest you recheck your numbers, for example (e.g.) the 45% of 45 inches. 20.25 inches/yr (1.6875 ft of depth) or 20.05 per year (44.4%) (1.67 ft of depth per year), apparently is your 544,515 g/acre/yr value and my 544,105 g/acre/yr. Then after all is cleared - round the accepted numbers off in the proper engineering manner. Thus, e.g., 544,515 (if correct) could be rounded to 544,500 g/acre/yr or even 545, 000 g/acre/yr.

SEP 26 1984

Point (5)

Page 4, last paragraph, 5th, 4th, 3rd, and last line from bottom.
Comment: For more clarity the following:
5th line: State ".....headwater [-] stream basins [within] the...."
4th line: State ".....Branch [drainage] systems, ..."
3rd line: State ".....size of these [headwater] basins, ..."
last line: State "[Water] mining [of] 1-15 mgd...."

Page 5, line 1: State "yield of these two [drainage] systems." The use of the more specific identification of hydrologic units (names/terms) helps to guide the reader to an understanding of the significance of this important example.

Respectfully submitted,

Edward C. Rhodehamel

H

September 10, 1984

Dear Terry,

I believe that the August 1984 draft of the proceedings on the meeting on the issue of pumping Cohansey water to meet Camden water supply needs summarizes well the particular impacts that pumping will have on water table alteration, water quality alteration, and the estuary.

I found shortchanged in the report a translation of these impacts on the total resources of the Pinelands. As you will recall, in 1980 a group of scientists acting as a technical advisory resource prepared for the Commission a report which defined the essential character of the Pinelands natural environment, identified impacts that may cause change in this environment, and recommended management actions to ensure the continued viability of the essential character of the Pinelands as mandated by legislation. The conclusion of this group was that changes in water levels with accompanying changes in water quality would have a dramatic effect on the character of the Pinelands.

The present landscape, a mosaic of upland and wetland habitats with diverse vegetation types that sometimes merge through wide transition zones of mixed composition or separate by abrupt and visible demarcations of boundaries, would be markedly changed by the alteration of water tables. Also, the composition of both representative and unique natural communities would be altered and many of the unusual plant and animal species that are found in the Pinelands lowlands would be destroyed. All these changes would alter significantly the essential character of the Pinelands. Much more about this was said in our meeting and probably should be said in the report.

Sincerely,

United States Department of the Interior

GEOLOGICAL SURVEY

Water Resources Division
Room 418, Federal Building
402 East State Street
Trenton, New Jersey 08608

September 13, 1984

SEP 14 1984

Mr. Terrence D. Moore
Executive Director
The Pinelands Commission
P.O. Box 7
New Lisbon, New Jersey 08064

Dear Mr. Moore,

We wish to thank you for the opportunity to attend and participate in the Commission's Technical Advisory Committee Meeting on the Issue of Pumping Cohansey Aquifer Water to Meet the Water Supply Needs of the Metropolitan Camden Area held on May 30, 1984. Such meetings are valuable tools to use in the multi-disciplined problem of protecting New Jersey's Pinelands.

We have some criticisms to voice, pertaining to the general conclusions drawn in your staff's proceedings of the meeting. The summary of the document concluded that:

> "It is the conclusion of the committee that because of the potentially adverse cumulative affects of removing water from the Cohansey, exportation of water from the aquifer is not a viable alternative for meeting the water supply needs of the metropolitan Camden area."

This conclusion is neither supported by the proceedings document nor by the discussion at the meeting. What was established at the meeting were various ecological impacts that may be expected due to hypothetical decline of ground-water levels. The actual magnitude and frequency of ground-water level decline was not quantitatively discussed. Without such quantification, the intensity and total area that would be significantly effected by ground-water level decline remains highly speculative, and thus, the realization of the discussed detrimental ecological impacts is also highly speculative.

The area-wide effect of withdrawals on water-table aquifer systems is difficult to assess without a large amount of field data. However, generalizing from a hydrogeologic perspective, the impact of pumping a water-table aquifer system, such as the Cohansey, will be focused on three areas:

1.) The effect of drawdown of the water table at the immediate well or well field site.

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2.) The effect of pumping on the discharge of the nearest significant streams or swamp (recharge boundaries).

3.) The effect of diminished streamflow downstream of the pinelands.

In order to assess these effects, a few assumptions can yield some "ballpark" estimates of the magnitude and extent of water-table declines due to pumpage. I have summarized these estimates in the following paragraphs. Please refer to the appendix for the basis of these estimates.

A rough estimate of the anticipated water-table drawdown in the immediate vicinity of a well or well-field site can be calculated. Assuming that wells individually pump 720 gpm, to meet the proposed 15 mgd demand, the size of the significant part of the cone of depression for each well would be approximately between $2^1/_2$ and $3^1/_4$ square miles. Inside of this area drawdown would be two feet or more. This is based on the assumption that the cone of depression will stabilize at a radius of 8,000 feet for a one-foot drawdown due to the proximity of a recharge boundary. The magnitude of two feet of water level change is not significantly different than the seasonal variation of three to six feet typical of Cohansey wells in the area.

As pumpage occurs in the Cohansey and a cone of depression extends outward from the well, a recharge boundary (ie: stream or swamp) will probably be encountered. Water is then induced to flow from the boundary to the well. In order to estimate the amount of water that would be diverted from the stream or swamp, by necessity, one must be specific as to location and prevailing hydrogeologic parameters. This detail is, of course, beyond the scope of this discussion. However, the long-term behavior of stream depletion by wells can be generalized. After a period of steady pumpage, very roughly about a year for a hypothetical Cohansey well, induced infiltration from streams or swamps comprises most of the discharge of a well. The ramification of this is that after continued pumping, a stream or swamp could be totally diverted if its flow is much less than the discharge of the nearby well and if it is the only or primary recharge boundary.

The effect of pumping 15 mgd upon streamflow from the pinelands into Great Bay and Great Egg Harbor Bay is not significant. The pumpage would diminish the total baseflow of the Mullica and Great Egg Harbor rivers by less than 4 percent and in

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periods of extreme low flow would diminish streamflow by less than 6 percent (assumming an equitable distribution of pumpage between the two basins).

The greatest concern about the effect of Cohansey pumpage upon the pinelands should be focused upon induced streamflow infiltration. Before any quantitative assessment of ecological impact can be made, the magnitude and extent of induced streamflow infiltration must be investigated in detail through field studies. Unfortunately, this is not within the scope of tasks that Camp Dresser and McKee have been given for its water supply feasibility study for the Camden area. Because the potential of pumpage from the Cohansey to meet Camden area's water supply needs is a water management alternative, an investigation of this critical aspect of induced streamflow infiltration at a test site in the pinelands is needed in order to provide the necessary background data and interpretation to aid in water management decisions and associated ecological impact estimations.

Sincerely,

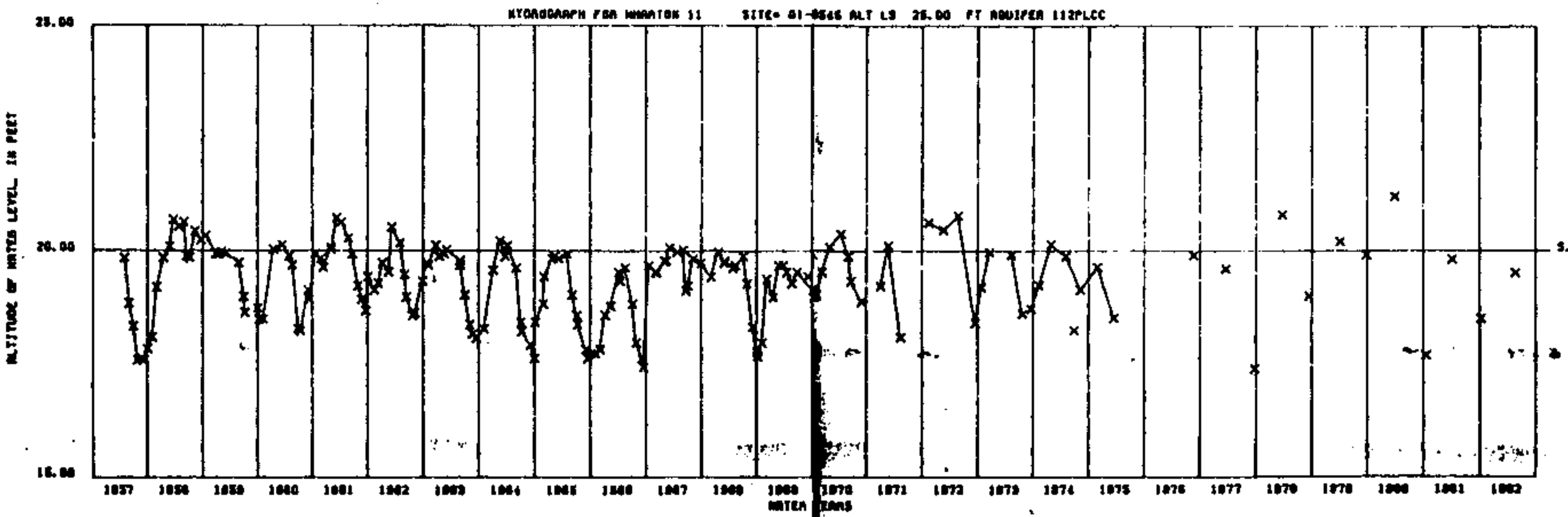
Anthony S. Navoy
Hydrologist

P. Patrick Leahy
Supervisory Hydrologist

Enclosures

CC: District Chief, USGS, WRD, Trenton, NJ

WELL 010545



8

WELL DEPTH 23. FEET

Figure 5 -- Hydrograph of Well 010545

SEP 14 1984

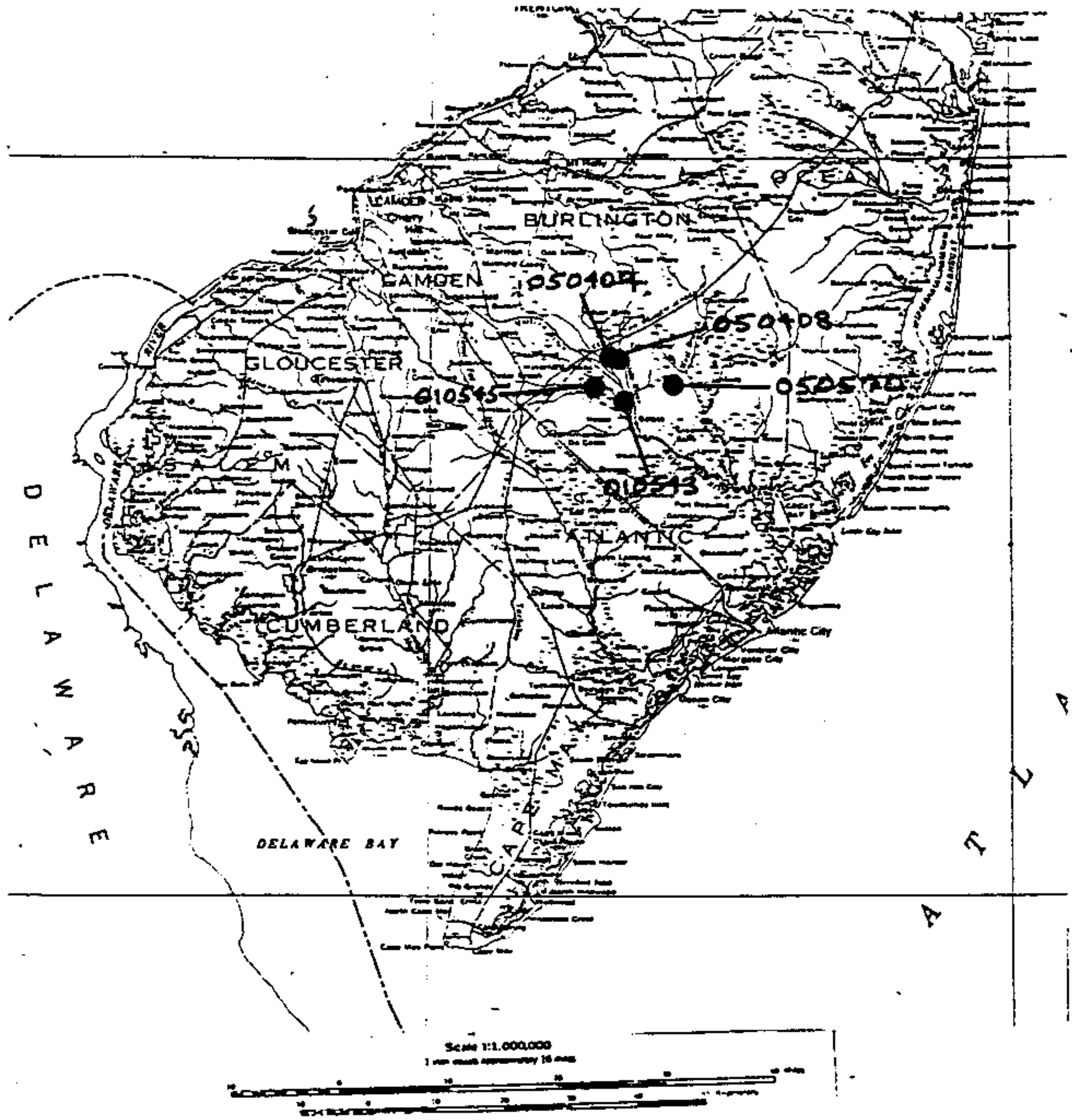


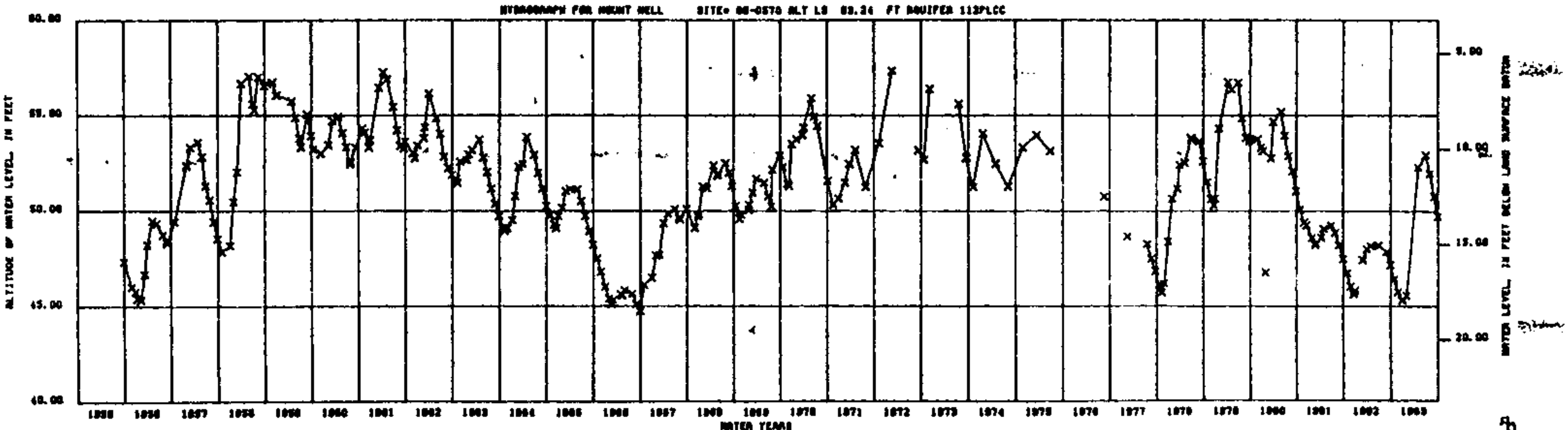
Figure 6 -- Location of Cohansey Aquifer system observation wells.

APPENDIX -- DETAILED DISCUSSION

DRAWDOWN IN THE IMMEDIATE VICINITY OF THE PUMPED WELL: The drawdown caused by a particular well or well field can be calculated. In order to assess impact, the area effected by a water-table deline of one foot or more can be determined. A simple Theis calculation will give an easy "ballpark estimate" of drawdown in a water table type well as long as the drawdown is not a significant portion of total saturated thickness of the aquifer, assumming that the well is fully-penetrating and without accounting for localized recharge or recharge boundaries (a good reference for this type of calculation is Walton, 1970). Using hydrogeologic parameters established by Rhodehamel (1979), a transmissivity of between 10,000 and 20,000 feet squared per day and a storage coefficient of 0.001, as representative of the Cohansey, the location and time of arrival of one foot of drawdown due to pumping can be determined. For the sake of the example, let us assume that the projected 15 mgd water supply need will be met by 15 ~~20~~ widely-spaced Cohansey wells located throughout the headwater areas of the Mullica and Great Egg Harbor rivers. This would require that each well pump at a rate of 720 gpm, a realistic amount. The cone of depression from the pumped well would cause one foot or greater drawdowns at 8,000 feet in approximately 24 days with at transmissivity of 20,000 feet squared per day and approximately 5 days with a transmissivity of 10,000 feet squared per day. In the pinelands, the cone of depression of a water-table well will probably hit a significant recharge boundary within 8,000 feet. At that point, in a simplistic sense, further enlargement of the cone of depression will cease and water will then be induced from the recharge boundary. It would then be reasonable to assume that effects of this postulated cone of depression will result in a drawdown of two feet or greater over an area of $2^{1}/_{2}$ to $3^{1}/_{4}$ square miles. Examining hydrographs of observation wells in the pinelands (figures 1 to 5), the annual variation in ground-water levels is approximately 3 to 6 feet. The part of the cone of depression that has a drawdown of two feet or less would not be significant relative to the annual variation. The locations of these observation wells are shown in figure 6.

THE EFFECT OF PUMPING ON THE NEAREST SIGNIFICANT RECHARGE BOUNDARY: A generalized estimation of the rate and volume of induced infiltration from a reacharge boundary can be calculated using curves developed by Jenkins (1968). Using the same hydrogeologic parameters as above (T = 10,000 or 20,000 cubic feet per day, S = .001, and 8,000-foot radius from well to recharge boundary), the axes of figure 7 have been scaled to the problem at hand. Following the rate or volume curves, it can be seen that between approximately 3.4 and 15 days, depending on transmissivity, 50 percent of the well discharge or volume will be derived from induced infiltration. After approximately 320 days to $1^{3}/_{4}$ years, depending on transmissivity, 90 percent of the well discharge will be derived from induced infiltration. Estimates of this kind are based upon four important simplifying assumptions:

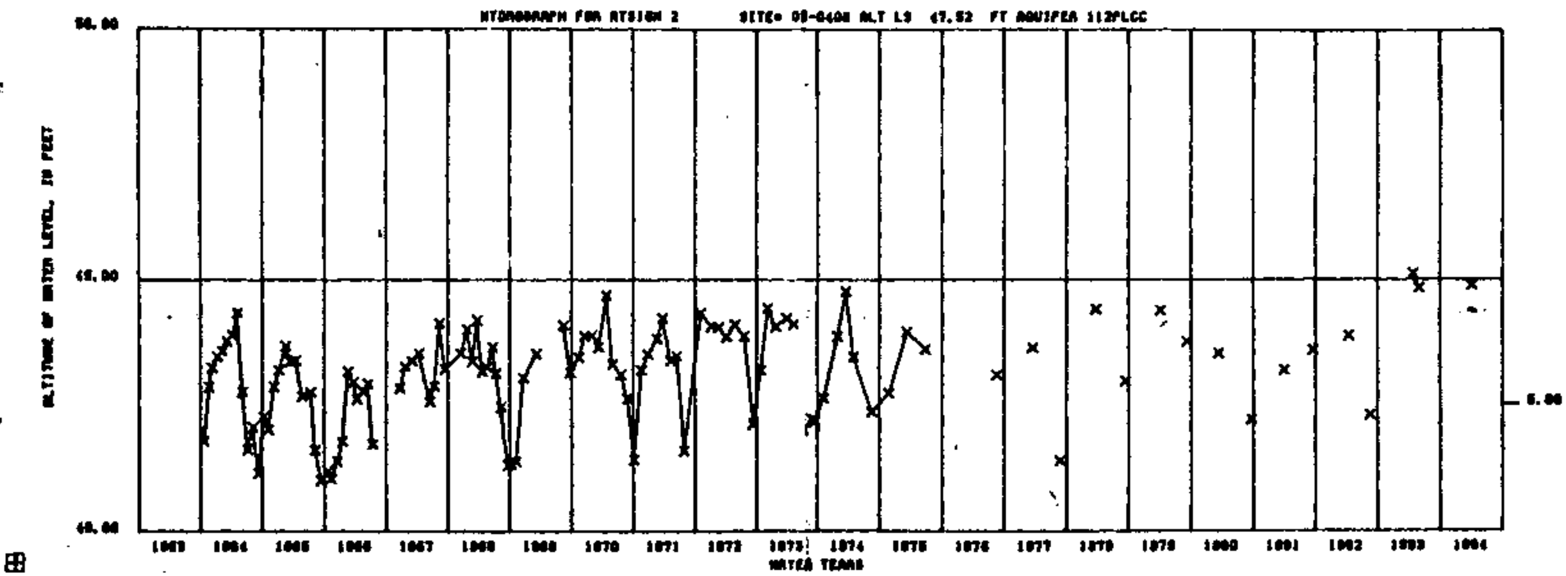
WELL 050570



WELL DEPTH 25. FEET

Figure 1 -- Hydrograph of WEL 050570.

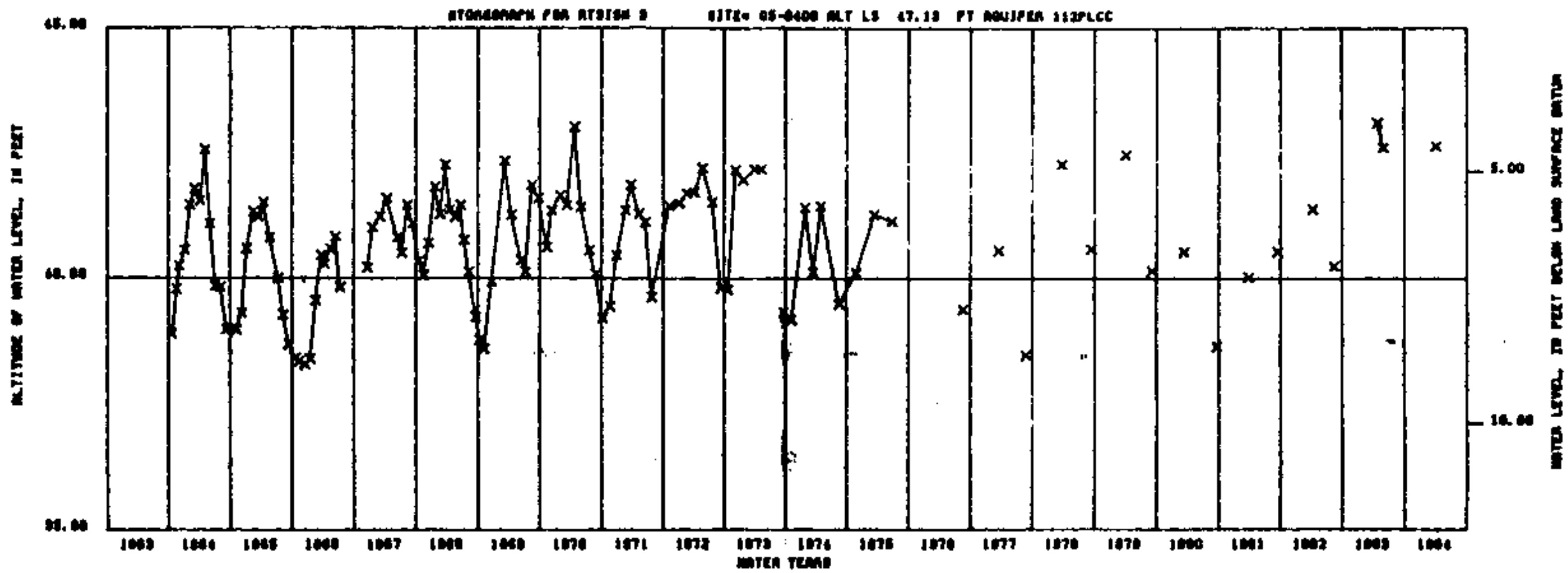
WELL 050408



WELL DEPTH 65. FEET
SCREENED INTERVAL 63.-65 FEET

Figure 2 -- Hydrograph of WELL 050408

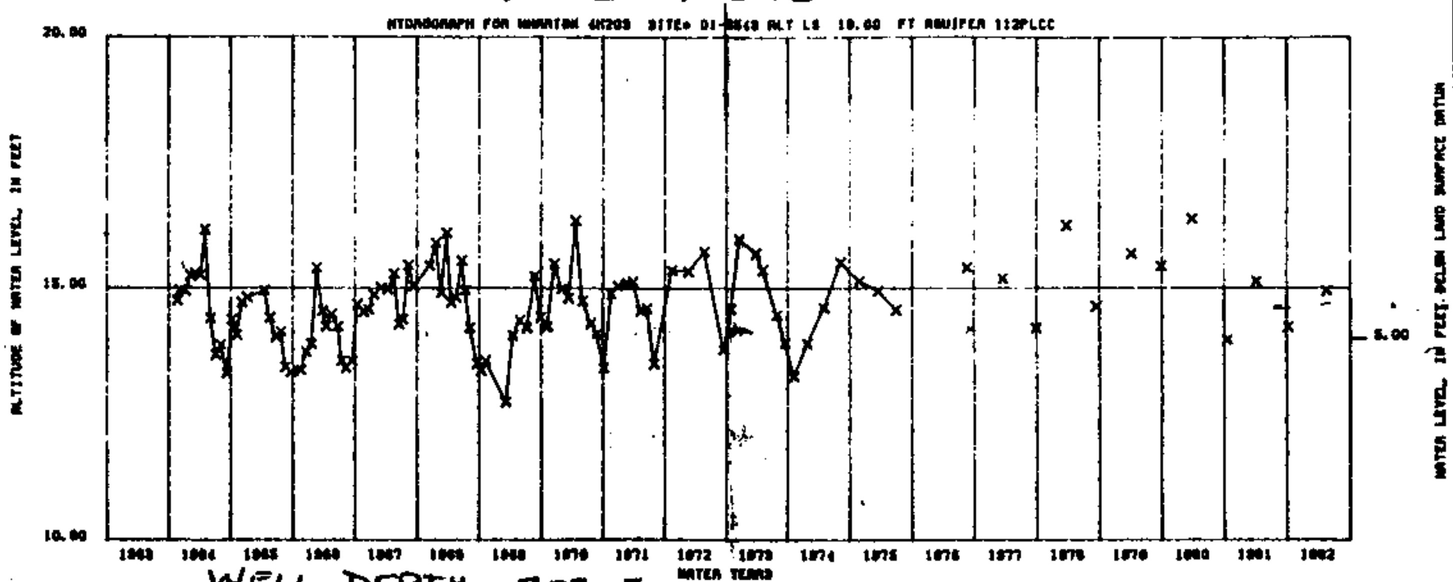
WELL 050409



WELL DEPTH = 17. FEET
SCREENED INTERVAL 14.-17. FEET

Figure 3 -- Hydrograph of WELL 050409

WELL 010543



WELL DEPTH 202. FEET

SCREENED INTERVAL 196. - 202. FEET

Figure 4 -- Hydrograph of WELL 010543

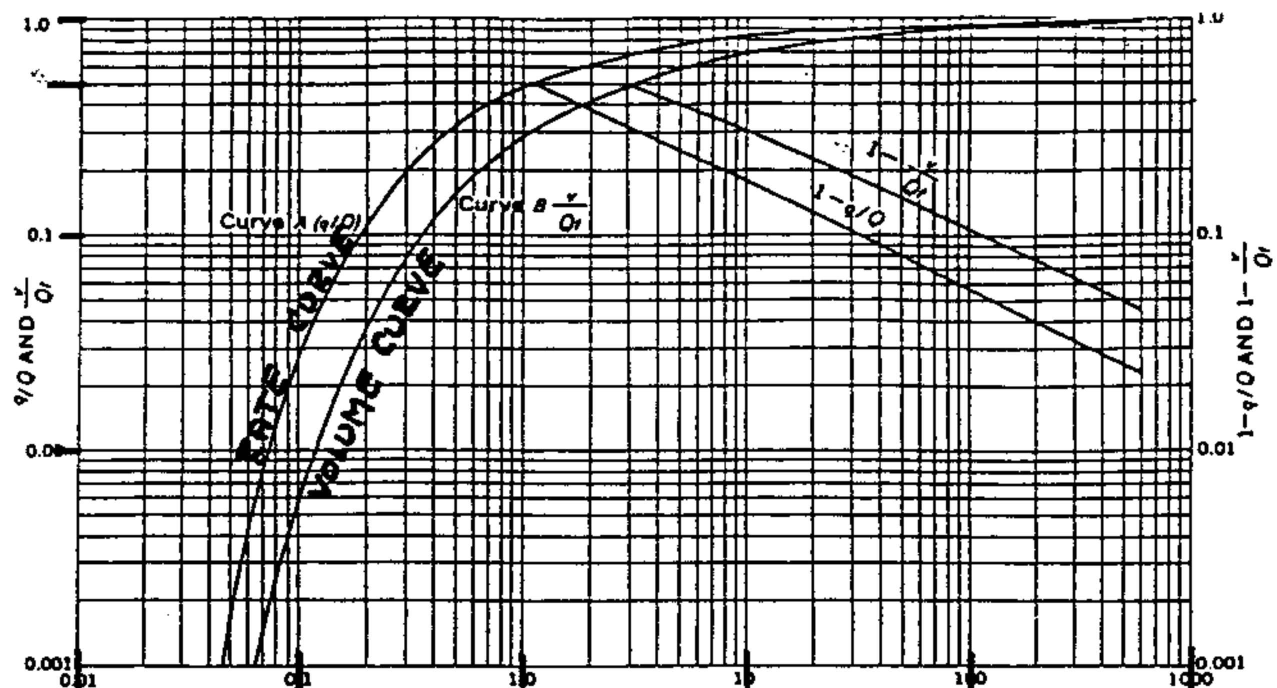
TABLE 1. -- LOW-FLOW DISCHARGES
(from Gillespie and Schopp, 1982)

	7 day/2 year low-flow	7 day/10 year low-flow
Mullica River Drainage		
Mullica R. near Batsto	46.4 mgd	23.2 mgd
Sleeper Br. at Batsto	2.5	1.2
Nescochague Ck. at Pleasant Mills	35.6	23.2
Batsto R. at Batsto	80.5	65.0
Landing Ck. at Egg Harbor City	3.7	1.7
West Br. Wading R. near Jenkins	61.8	38.7
Oswego R. at Harrisville	49.5	34.0
East Br. Bass R. at New Gretna	17.0	13.3
West Br. Bass R. at New Gretna	8.8	6.2
Total	305.8	205.5
Great Egg Harbor River Drainage		
Great Egg Harbor R. at Folsum	49.5	34.0
Penny Pot Str. near Folsum	1.2	0.6
Babcock Ck. at Mays Landing	7.3	4.3
Tuckahoe R. at head of river (1)	20.1	17.0
Total	78.1	55.9
Total	383.9 mgd	261.4 mgd

Note:

(1) The Tackahoe River is not part of the Great Egg Harbor River Drainage but it does contribute a substancial ammount of fresh water to Great Egg Harbor Bay.

FIGURE 7--Computation of Streamdepletion by WELL PUMPAGE (After JENKINS, 1968)



ⓐ T=20,000	46 min	7.7 hrs	3.2 days t/sdf	32	320	8.77 yrs
ⓑ T=10,000	(1.54 hrs)	(15)	(6.4 days)	(64)	(1.75 yrs)	(17.5)

TIME

t = time (days). V = Volume depleted from stream (ft³)

Q_t = Total volume pumped at time t (ft³) Q = Discharge (ft³/day), TOTAL

q = Depletion rate (ft³/day)

sdf = streamdepletion factor = $a^2 S/T$

a = Distance from stream to well (Ft) ⟶ 8000 ft

S = Aquifer storage coefficient ⟶ .001

T = Aquifer Transmissivity (Ft²/day)

ⓐ T = 20000 ft²/day Sdf = $(8000)^2(.001)/(20{,}000)$ = 3.20

ⓑ T = 10,000 ft²/day Sdf = $(8000)^2(.001)/(10000)$ = 6.40

t/Sdf	t ⓐ T=20000	t ⓑ T=10000
0.01	46 min	1.54 hrs
0.1	7.7 hrs	15
1.0	3.2 days	6.4 days
10	32	64
100	320	1.75 yrs
1000	8.77 yrs	17.5 yrs

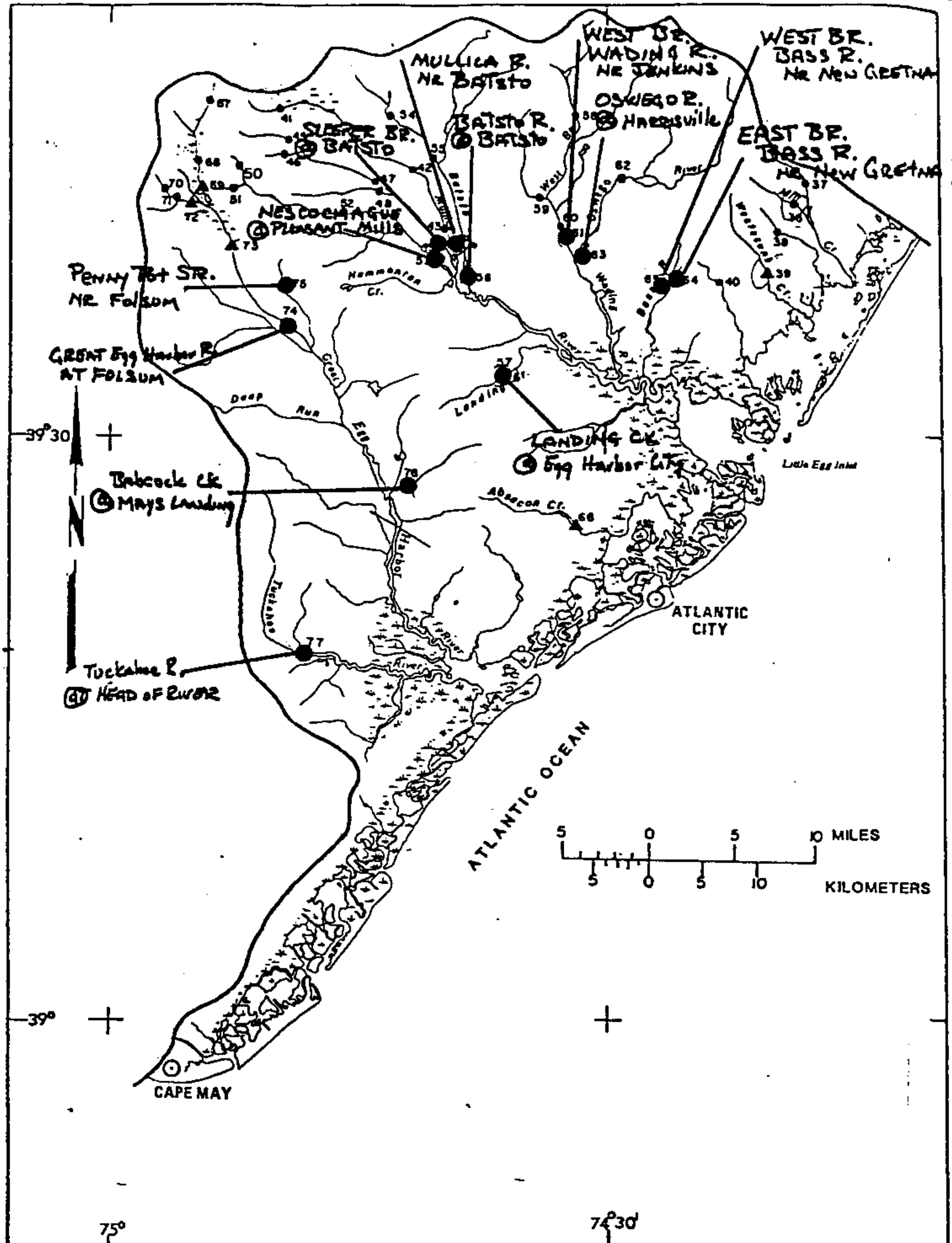


FIGURE 8 --LOCATION OF LOW-FLOW DATA SITES (MODIFIED FROM Gillespie AND Schopp, 1982).

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