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Cranbury

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A Report on Cranbury, Mt. Laurel II &
water ~~re~~resources
- W/Monmouth County groundwater report

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I. INTRODUCTION

The Stony Brook-Millstone Watersheds Association has brought to the attention of the parties to this litigation and the Court its concern that crucial environmental matters may not be given appropriate consideration in the rezoning of Cranbury and other action that may be required as a result of this case. By order dated October 29, 1984, Judge Serpentelli ruled that the Association may submit its "concerns to the master without intervention at this time."

In formulating these comments, the Executive Director of the Association discussed Cranbury's groundwater recharge requirement and its other environmental problems in detail with the following independent experts: William Kruse, Environmental Division Director, Middlesex County Planning Board; Bud Chavooshian, Land Use Specialist, Cook College; Ernest Hardin, Director of the D.E.P. Water Allocation Section; Bob Canace, N.J. Geologic Survey; Arthur Honeywell, Project Specialist Water Supply and Watersheds Management Section, D.E.P.; Steven Noble, Specialist Water Supply and Watersheds Management Section, D.E.P.; George Farlekas, Chief Geohydrologist, Study Section, United States Geologic Survey; and Anne Kruger, Coordinator, New Jersey Water Resources Coalition.

In addition to submitting our concerns to the master, we are sending copies of this report to the Cranbury Township Committee, and other parties in the litigation.

Cranbury Township sits on top of aquifer recharge areas of the most heavily used groundwater system in New Jersey -- the Raritan-Magothy aquifers. Improper development in Cranbury could deprive many thousands of present and future Cranbury residents and others of the safe water that they now take for granted. Therefore, Cranbury's land use regulation must incorporate an aquifer recharge strategy for its Mount Laurel development and all other major development which:

(a) Maintains the proportion of precipitation which is recharged to the groundwater;

(b) Maintains or decreases groundwater withdrawals;

(c) Maintains the amount of waste water recharged to groundwater;

(d) Adopts suitable stream corridor management requirements.

We set forth in this report specific measures to accomplish these objectives. These measures should be applied in determining the specific sites for Mount Laurel housing and all development in Cranbury; in determining the specific portion of each site that are suitable for construction; and in determining the intensity of development that can be accommodated there.

II. MOUNT LAUREL II ZONING MUST PROTECT THE ENVIRONMENT

As Judge Serpentelli noted in Orga Greenhouses v. Colts Neck Township, 192N.J.Super.599,:

> The court (in Mount Laurel II) repeatedly recognized the importance of environmental and planning concerns. Mount Laurel II stands as a champion of environmental and planning causes.

Judge Serpentelli adds in footnote 68: "We emphasize here that our concern for protection of the environment is a strong one and that we intend nothing in this opinion to result in environmentally harmful consequences. This opinion explicity recognizes "the clear obligation to preserve open space and prime agricultural land."

The Supreme Court clearly requires these environmental factors to be given full weight not only in determing each municipality's fair share of low and moderate income housing but also in deciding the precise location and type of housing construction for Mount Laurel housing and in revising land use regulation for the rest of the community, so the final outcome of the Mount Laurel process will achieve both the housing and the other objectives of the Constitution. The opinion notes that:

> The specific location of such housing will of course continue to depend on sound municipal land use planning.
>
> ... once a community has satisfied its fair share obligation, the Mount Laurel doctrine will not restrict other measures, including large lot and open space zoning, that would maintain its beauty and communal character.

The Mount Laurel II decision itself specifically held that these factors must be applied in determing appropriate zoning in the Chester and Clinton cases.

The Supreme Court's opinion, like the opinion of Judge Serpentelli in this case, relies heavily on the State Development Guide Plan (SDGP), as issued in 1980. Justice Wilentz states:

> We believe that the use of the Development Guide Plan, and the confinement of all Mount Laurel litigation to a small group of judges, selected by the Chief Justice with the approval of the court, will tend to serve that purpose.

The Chief Justice made the following statement to back up the use of the SDGP: "The primary function of the State Development Guide Plan is to determine where growth, including residential growth, should be encouraged or discouraged." Since most of Cranbury falls into what the SDGP defines as a growth area, the following goals of the SDGP have particular relevance:

> Goal I -- A suitable balance between conservation and growth in New Jersey with space for both the conservation of agricultural land and critical environmental areas and for residential and economic growth.
>
> Goal II- The conservation of areas characterized by prime agricultural soils, public open space, steep slopes, wetlands and water supply resources.

The SDGP recommends that water supplies should "be protected from extensive development to protect quality and yield." We have a situation in portions of Monmouth and Ocean Counties where we have saline intrusion into aquifers and where the groundwater levels have been drawn down 220 feet in some cases. Cranbury sits atop the primary aquifer recharge area for this groundwater supply.

There are many approaches to protecting aquifer recharge areas. In the SDGP's Guidelines for Planning this statement about protecting steep slopes is made:

> Steep slopes and wetlands serve important functions in flood control and water resources protection. Development in such areas is possible, although site preparation and construction cost may be high. However, there are environmental costs. The State's undeveloped hillsides protect the quality of water flowing into water supply storage areas. The vegetation on steep slopes serves to retard the flow of stormwater run-off and soil erosion and, thereby, flooding in river valleys.

The SDGP makes the following statement on wetlands protection:

> Wetlands are important areas for retarding storm water run-off and for protecting water supply resources. They also serve as important fish and wildlife habitats.

The SDGP makes a causal argument for the protection of surface and groundwater resources. It is evident that the Mount Laurel II decision for Cranbury is not intended to affect adversely necessary protection of the water resources of the municipality. This report addresses the impacts of adding 408 units of low income housing and 408 units of moderate income housing to the Borough of Cranbury, as ordered by Judge Serpentelli under the Mount Laurel II decision, upon its water resources. We recommend ways that Cranbury Township by enacting appropriate ordinances and other means can protect its significant environmental resources while meeting its Mount Laurel II obligations.

III. CRANBURY'S WATER RESOURCES MUST BE PRESERVED

A. Aquifer Recharge and Water Supply

1. The Regional Nature of Water Supply --

People need water. To live in Cranbury, people, regardless of income, must have adequate supplies of fresh water. It is the environment in which people live that supplies them with fresh water. This environment must be protected so that people can continue to live.

Water supplies start as precipitation, rain and snow, which has been largely cleansed of other substances by the processes of evaporation, and condensation or freezing. What happens to storm water as it falls on land determines how much of this water will be available and clean enough for human use. In most places there are three different types of land, for each of which the water resource protection objectives are different. These are:

* Stream corridors, including flood plains, wetlands, lakes or ponds, and needed buffer/ecotone land;
* Aquifer recharge areas without significant discharge of water;
* Uplands with thin soils and relatively impermeable subsurfaces.

Generally, uplands with thin soils are least susceptible to damage from development, and careful building thereon need not impair the movement of storm water so that it is available for water supply. Extensive building upon the other two, stream corridors/wetlands and aquifer recharge areas, should be avoided if possible. However, in Cranbury this is not possible.

Cranbury contains no uplands with thin soils and relatively impermeable subsurfaces. Therefore, there are only two types of "water resource land" in Cranbury. Both of them require high degrees of protection. Stream corridors/wetlands are discussed in section III.B. The need for protecting aquifer recharge areas is given here.

Much of the upland areas in Cranbury lie atop the aquifer members of the Raritan-Magothy formation. The surface soils are permeable so that water can infiltrate directly into a Raritan-Magothy aquifer. Geology maps indicate that Merchantville and Woodbury clays, which are aquitards, also lie beneath Cranbury. However, studies of the surface soils [1,2] and geology [3] in this area indicate that a thick layer of quarternary materials lies atop the clays. This is unconsolidated, porous soil which forms an aquifer itself, and which transmits water to the lower aquifers. About 28% of the land area of Cranbury Township is stream corridors/wetlands. The remaining land, about 72%, is all **Aquifer Recharge Area.**

Most of the water used in Cranbury is groundwater. Without aquifer recharge areas, even in the humid climate of New Jersey, there would be little water supply for human use. This would be an arid land with the rain rushing out to the ocean. About half the people in New Jersey use surface water that comes from reservoirs and rivers, but it was mostly ground water before it became surface water. The other half of the population uses ground water directly. To see how the usable portion of storm water becomes ground water, look at a water budget for an area which is very similar in geology and precipitation to Cranbury.

The Manasquan River watershed, located in parts of Monmouth and Ocean Counties, is atop water table (unconfined) aquifers. Beneath the watershed and the water table aquifers are thick clays which separate the water table aquifers from the confined aquifers, including the Raritan-Magothy formations. (See Figure 1. and Appendix A.) The watershed is not highly developed, and withdrawals of water from the water table aquifers are not significant. (See Figure 2.) Thus the Manasquan watershed is in a limited development state. The water budget for the watershed was estimated for the study for the Manasquan Reservoir System. [4]

ESTIMATED LONG-TERM WATER BALANCE
MANASQUAN BASIN AREA

		Inches of water per year
Water Input	Precipitation	45
Water Losses	Interception	5.8
	Evaporation from Undrained Depressions	0.9
	Evapotranspiration (vegetation, soil and groundwater)	15.5
	Total Water Losses	22.2
Runoff	Surface Runoff	8.9
	Base Flow	13.5
	Total Water Yield	22.4
Subsurface Outflow	Subsurface Outflow in Kirkwood Aquifer	0.4

Precipitation is renovated water, whose quality has been improved by the evaporation-condensation processes. Although people do reuse water, its quality is usually not as good as that of rain or melted snow. This water balance indicates that water losses, which are almost half of precipitation, are not available for use by people. Surface runoff, the water that moves rapidly downstream during and after storms, is also not available for use by people, unless it is trapped in a surface storage area, such as a reservoir or pond. Base flow is storm water which percolates into the ground during and after storms or as snow melts. It is first ground water, and then it gradually discharges into streams to maintain their flow during dry weather. This is water that is available for use, because it is stored in the ground. The subsurface outflow, or groundwater flow, into the ocean is necessary to keep salt water from intruding into the freshwater aquifers. Thus, the maximum water yield from this watershed which is conceptually available for human usage is 22.4 inches of water per year when the mean precipitation is 45 inches per year. However, for many reasons this degree of usage would be very expensive, both environmentally and economically, and would damage the ecologic functioning of the watershed. In planning for the Manasquan Reservoir System, the "dependable" yield of the Manasquan River watershed has been determined by the New Jersey Water Supply Authority to be 10.9 inches of water per year. [5]

This amount of water, 10.9 inches per year, is a realistic maximum amount of water that can be taken from the ground and/or surface waters of the basin, used consumptively/ depletively by people in the watershed and exported from the watershed. If the recharge of water in the basin is not decreased, then using 10.9 inches of water per year from the basin would dry up streams in drought, and cause ground and surface water to become more degraded in quality, but it should not cause significant declines in the amount of water in storage in the aquifers. Many people would consider dried up streams, with consequent damage to ecosystem vitality, such as the death of fish, and more degradation of water supplies as undesirable. However, in order to supply water to as many people as possible in Monmouth and Ocean Counties, the New Jersey Water Supply Authority is willing to call 10.9 inches of water per year a "dependable" or "safe" yield.

The problem in Monmouth and Ocean Counties is that water resources have been overused and abused beyond an environmentally "dependable" yield. Water deficits in Monmouth and Ocean Counties and other parts of New Jersey have present-day impacts on Cranbury and implications on water resource/land use planning for Cranbury. Let us examine these in order to understand the many water-related problems that Cranbury faces.

Most of the water used in Monmouth and Ocean counties is ground water, and between half and three-quarters of that water is pumped from the Raritan-Magothy aquifer system. Since at least the early sixties "dependable" yields have been exceeded, and the mining of ground water has occurred at an ever quickening pace as the rate of development has spiraled. A booklet, Groundwater: What Is Happening beneath Monmouth County and Northern Ocean County?, tells the story. (See Appendix A.) [8] The last page illustrates the magnitude of the problem in the Raritan-Magothy aquifer. If the aquifer system were adequately recharged, then the potentiometric surface, that is the height to which water rises in a well because of the pressure upon it, would be above sea level at all points on the map. At every point east of the heavy contour line, which is sea level, the potentiometric surface is below sea level. In the Freehold area it is more than fifty feet below sea level. The hydrograph of a well tapping the Raritan-Magothy formation shows that the groundwater level has not been above sea level since 1953 and that in 1983 it was about 50 feet below sea level. (See Figure 3. [9]) Drawdown in the Englishtown aquifer is worse with the nadir of one cone of depression at more than 250 feet below sea level. ("Cone of depression" is explained in Appendix A.) Furthermore, salt water is intruding into some of the aquifers along the coast, aquifers where the water was once fresh.

This area of the state is growing rapidly. In order to supply the area with water the Manasquan Reservoir is being planned. The desired yield of the reservoir is 35 mgd. However, even if the reservoir were usable today, there would not be enough water without pumping water from the aquifers. (See Figure 4. [10])

To continue mining water from the aquifers would be unwise. It would cause increasing salinization of the aquifers near the coast, and compaction of the aquifer sands, resulting in land subsidence (as has happened often in Florida and elsewhere), earthquake, and loss of aquifer water storage capacity further inland. To allow the aquifers beneath Monmouth and Ocean Counties to recover, two actions should be taken. One is to cease pumpage from the depleted, confined aquifers beneath the counties. (Even with the Manasquan Reservoir and water conservation measures in place, in order to stop pumping it will probably be necessary to import water from the Raritan River basin.) The other is to allow the recharge areas to function well so that water can fill the voids in the aquifers as rapidly as possible.

The problem with recharging the Raritan-Magothy and Englishtown aquifers is that the aquifer recharge areas are not in Monmouth or Ocean Counties, but in Middlesex County. (An aquifer, like housing, serves a broad region.) The water that is being pumped out of the Raritan-Magothy aquifer beneath the Freehold area rained on land in Cranbury, Plainsboro, South Brunswick, or Monroe many years ago. Thus, for the sake of people far away in other counties, the aquifer recharge areas of Cranbury must be protected.

Distressed water systems in other parts of New Jersey also have a potential for having an impact upon Cranbury's water resources. In the area around Atlantic City the Kirkwood aquifer is over-drafted. The recharge area for this section of the aquifer is not known, but part of it is likely to be in the Pinelands. The delicate ecosystem of the Pinelands is controlled by its groundwater. The present intent of the State and federal governments is to preserve the ecology of the Pinelands. The ecology would be altered if large amounts of Pinelands groundwater were used by Atlantic City. Thus, Atlantic City is likely to look towards the Delaware River basin for its future supplies of water.

Groundwater in the Raritan-Magothy has been extensively over-drafted in the area around Camden. Under natural flow conditions the Raritan-Magothy supplies base flow for the Delaware River in its lower reaches. Today much of the flow has been reversed. The Delaware River is recharging the aquifer. To allow the aquifer to recover, the Delaware River is the obvious source for replacement water. At present New Jersey is entitled to remove 100 mgd from the basin, which is allocated to flow through the Delaware & Raritan Canal into the Raritan River basin. The Delaware River system is already under severe stresses from many sources. In the future, when the Atlantic City and Camden areas are withdrawing more than a 100 mgd from the river, the Raritan River basin could lose its 100 mgd diversion right.

The most used system in New Jersey is the Passaic River Basin, which supplies water to densely populated northeastern New Jersey. [11] The New Jersey Statewide Water Supply Master Plan said that region I, which includes both the Passaic and Raritan basins, had a 55 mgd deficit in 1976 under drought conditions. [12] This deficit was in the Passaic basin, and there was a surplus of 80 mgd in the Raritan River basin. [13] More recent studies have indicated that demand is less than projected in the Passaic River basin. [14] However, they also indicate that the basin, upon completion of the Wanaque South/Monksville project, will have developed its potential for making water available for human use to almost the maximum extent practicable. Studies of several proposals for new surface storage facilities showed that the safe yield of the basin could only be increased by 8 mgd at the most, and that any such project would be very expensive. As the basin will be developed, the area above Little Falls of 762 square miles will have a "safe" yield, under drought conditions, of 369 mgd. This is a "safe" yield of 10.2 inches of water per year. [15] The hydrologic system of the Passaic River basin above Little Falls is extremely stressed, as indicated by the excessive flooding under relatively mild storm conditions three times in 1984. The water supply system is also not desirable because much of the water available at Little Falls has already been used and degraded one or more times before it is picked up, treated, and piped to the populous areas in Essex and Hudson Counties. The upland portions of the basin are developing rapidly, so conditions can only deteriorate. Elizabethtown Water Company has a pipe line up into the Newark area which can carry over 20 mgd from the Raritan Basin to the Passaic. That pipe line is likely to be used more extensively in the future. Thus the Passaic River basin with 10.2 inches per year "safe" yield probably represents the maximum practicable development of water supplies. Unless present trends are reversed, that the basin will need to import water in the near future, and that water will come from the Raritan River basin.

Cranbury is in the Raritan River basin. It is in the headwaters of the Millstone River. Both the headwater regions and the lower Raritan are developing rapidly, and groundwater resources throughout the basin are becoming stressed. One example is Pennington. It now gets its water from the ground, but it may be forced to bring in water from the Elizabethtown Water Company. Although the Raritan system now has a theoretical surplus of about 70 mgd available from Spruce Run and Round Valley Reservoirs [16], demands for water before the year 2000 will probably reduce the surplus to a deficit. These demands will come from the following regions:

* Atlantic basins, such as Monmouth and Ocean Counties, and Atlantic City;
* Lower Delaware, including the area around Camden, which could eliminate 100 mgd diversion right from Delaware River basin;
* Passaic River basin;
* Raritan River basin itself.

All the major water systems in New Jersey are now under stressed conditions, and the growth trends in the state will inevitably exaccerbate these stresses.

In the implementation of Mount Laurel II directives, the affects upon the limited groundwater supplies of the local region and of the state as a whole must be seriously considered. To do so is complicated, difficult, but necessary. It requires an estimate of "dependable" yield from all geohydrologic systems in the state. Then the estimated usable water resources should be apportioned among human uses in an equitable way.

As a "quick and dirty" method of making these estimates, let us suggest the following:

* Assume that the maximum "dependable" yield from any hydrologic system in New Jersey is 10 inches of water per year. The base flow yield from the Manasquan basin is 13.5 inches per year. The "dependable" yield is 10.9 inches per year. The "safe" yield from the Passaic basin is 10.2 inches per year. The Manasquan basin has limited development. The Passaic is over developed. The geology of the Manasquan basin is quite different from that of the Passaic basin, but the water yields are similar. Given these data, we feel that 10 inches of water per year is a reasonable assumption for the state of New Jersey.
* Assume that half of the area of New Jersey will not be developed for water supplies. This undeveloped area includes the coastal wetlands, the inland wetlands, the surface water, the Pine Barrens, ecotone areas to protect these areas, and lands that should be left in their natural state. Half of the area of New Jersey is 3760 square miles.
* Multiply these two numbers together and convert units. This gives a "maximum dependable yield for human uses" of 1,791 mgd for all human uses in the state.
* Calculate the average amount of water available per person. The population of the state in 1980 from preliminary census data was

7,364,823. The average share of this amount of water was 243 gallons per day per person for all uses including industrial and agricultural. * Note that because so much water is used in New Jersey, the water used is not all freshwater direct from precipitation. Much of it is reused/recycled water, such as waste water from a septic system which moves through the ground, into a stream and then into a reservoir. Reused water is degraded water, but in New Jersey many people must use recycled water. With recycling of water we count only depletive uses as uses. Depletive or consumptive uses include those which evaporate water into the air or export water out of the area of concern. It is depletive uses of which we will be speaking further. Thus, 1,791 mgd is the postulated "maximum dependable yield for depletive human uses" in New Jersey.

To illustrate the concept, let us apply this type of analysis to Cranbury. The population of Cranbury in 1980 was 1,927. If we assume that a good allocation policy would be to allow each person presently living in New Jersey to have his/her fair share of water be allocated to the municipality in which he/she lives, then Cranbury's fair share of water would be 0.469 mgd. If we further assume that all the people moving into the low and moderate income housing move into Cranbury from other places in New Jersey, then Cranbury's fair share of water would increase. If we assume the average occupancy of each unit is 4 people, and the 816 required units were built, then Cranbury's population would increase by 3,264 (1.7 times the present population, which does not include the population increase due to additional housing resulting from the implementation of Mount Laurel II). Then Cranbury's fair share of water would be 1.26 mgd.

However, Cranbury appears to be now using more water than either "fair share." The water allocation rights in Cranbury are presently as follows:

User	Source of Water	Maximum Diversion
Municipality	Groundwater	0.40 mgd
Industry	Groundwater	0.97 mgd
Agriculture	Groundwater	2.31 mgd
	Streams	18.74 mgd
	Ponds	9.21 mgd
		=========
Total		31.63 mgd

Data is not available to estimate the depletive use in Cranbury. What follows is a conservative guess, which illustrates the concept of depletive use accounting:

User	Source of Water	Depletive Usage
Municipality	Groundwater	0.13 mgd
Industry	Groundwater	0.87 mgd
Agriculture	Groundwater	0.14 mgd
	Streams	1.17 mgd
	Ponds	0.29 mgd
		========
Total		2.60 mgd

The reliability of such an analysis may be questioned, but, in fact, we know that groundwater withdrawals in Cranbury are exceeding the dependable yield of the Raritan-Magothy aquifer. This is documented by United States Geological Survey data which show that water table elevations in Cranbury have dropped from 7 to 12 feet in the past ten years. [17]

Our obvious conclusion is that Cranbury must recharge its aquifers in order to have water supplies in the future. Our recommendations on how to do this within the constraints of the Mount Laurel II decision follow in section III.A.2.

2. Proposals for Regulations to Protect Aquifer Recharge and Water Supplies --

Cranbury is now over-using water supplies available to it, and is not protecting its aquifer recharge areas. The water supply problems in Cranbury, when looked at from a regional and statewide perspective, are already severe. Drastic and rapid action is needed to keep them getting worse, even with the present population. The Mount Laurel II decision requires Cranbury to more than triple its population. These people will require water supplies and waste water treatment. Furthermore, the housing mandated will cover over a significant proportion of Cranbury's aquifer recharge areas. Unless this development is properly managed, the recharge of water to the underlying aquifers will be greatly reduced. The impervious coverage of 816 units of low and moderate income housing alone has the potential to reduce recharge by about 60,000 gallons per day. That is enough water to supply 1,000 people adequately. The most important problems that **must be addressed** in the revision of regulations and zoning pursuant to the Mount Laurel II decision are the following:

* Supplying the growing population of Cranbury with sufficient supplies of water;
* Renovating the waste water produced;
* Assuring that adequate supplies of water are available for people in future generations.

And all these problems must be solved at costs affordable to this and future generations, both in Cranbury and throughout New Jersey.

We urge that the minimum effort that Cranbury makes be to maintain the "status quo", to allow no deterioration in present groundwater resource conditions. The present policy of the State of New Jersey is to permit no additional diversion allocations from groundwaters of the coastal plain aquifers, and to reduce those allocations which are not being utilized. [18] (Cranbury's municipal diversion allocation may be reduced from 12 million gallons per month, i.e. 0.4 mgd.) Our recommendation goes beyond this policy. However, without maintaining present groundwater resource conditions, Cranbury Township will be unable to meet its various obligations in the future.

To conserve present groundwater resource conditions the amount of water going into the ground has to remain the same or increase, and the amount of water withdrawn from the ground has to remain the same or decrease. For a given amount of precipitation, the change in the volume of water recharged to the ground, be it either precipitation water or waste water, minus the volume of water taken out of the ground must be equal to or greater than zero. To achieve this necessary "status quo" of the groundwater, the following objectives are needed:

(1) **To maintain the proportion of precipitation which is recharged to ground water each year.**
(2) **To maintain the amount of waste water recharged to the groundwater.**
(3) **To maintain or decrease groundwater withdrawal rates.**

How Cranbury can achieve these objectives through changes in policies and ordinances is described in the following sections.

a. Objective: To maintain the proportion of precipitation which is recharged to ground water each year.

Four approaches to regulating groundwater recharge are discussed here. These are the following:

i. Storm Water Management;
ii. Reduction in Impervious Coverage;
iii. Augmentation of Recharge;
iv. Clustering.

i. Storm Water Management:

Water which recharges an aquifer is storm water. Recharge to groundwater should be primarily regulated by a performance standard which requires the following:

> The volume of surface runoff per storm event from a site or other contiguous area shall be no greater after development than before development.

The township's ordinance (150-86) reads as follows in part:

> Flood and erosion control:
> The flood and erosion standard for detention shall require that volumes and rates be controlled so that, after development, the site shall generate no greater peak runoff from the site prior to development, for a two-year, 10-year and 100-year storm considered individually.

This ordinance is not adequate, because peak runoff is the controlling factor. If just the peak runoff is controlled, the post-development volume of runoff leaving a site is usually much greater than that pre-development, because it only controls the amount of water leaving a site at one point in time. The proposed performance standard regulates the runoff over the entire time of a storm event from the first rain drop hitting the ground until the last trickle has run off. The volume of water recharging the aquifers with this requirement will be about the same as it has been. The engineering calculations are more difficult, but that may encourage people to study the problem, to use common sense instead of juggling numbers.

ii. Reduction in Impervious Cover:

There are numerous ways in developing a site by which impervious cover, which blocks water from recharging the groundwater, can be reduced at lower cost. For instance, Cranbury's ordinance has called for parking spaces of 9' width and 18-1/2' length. The design standards of the Watersheds Association call for large car spaces not to exceed 8'6" in width by 17' in length, and small car spaces not to exceed 7'6" in width and 15' in length. [19] This change would reduce the space, paving, and recharge augmentation required for large cars by 15% and for small cars by 48% and even more when car stalls are not angled at 90 degrees. We also recommend the Drachman System of parking lot stripping. [20]

Curbings create cover which is often unneeded and which causes storm water runoff to pond instead of flowing in sheets. Sheet flow can more readily percolate into the ground because it causes a thinner film of water covering a larger area. Curbings with gaps are also useful. We recommend a minimum of curbings.

Cranbury's current ordinance for sidewalks has a 5' minimum width requirements. We recommend a minimum width of 4'. In many developments we would recommend no sidewalks, or sidewalks only on one side of the street.

Also suggested is the use of porous paving for parking areas, driveways, and other surfaces which are not extensively used. Looking at such details will not only save water, but also money and the aesthetic appeal of the development. Green grass is much more pleasant to look at and walk on than concrete or macadam.

Limitation on the percentage of impervious coverage allowed is essential, if maintenance of the amount of water recharged to the ground is to be achievable. With too much coverage it becomes either too impractical and costly, or else impossible to recharge all the water that should not run off an area. Even the expensive method of pumping water back into the ground can be impossible, if there is more water to recharge than the aquifer around the well can receive.

The Lower Raritan/Middlesex County Water Resources Management Program has recommended coverage, or impervious surface requirements, for land uses. [21] A comparison of the Middlesex County recommendations with the current Cranbury regulations follows:

		Maximum (Impervious Surface) Requirements	
Zone		Middlesex County	Cranbury
PUD		20%	40%
A-100		20%	No requirements
R-LI	Residence - Light Impact	20%	No requirements except for open space: 10% wooded areas and land other than in flood-ways, wetlands, channels, or retention basins; 15% active recreation.
R-LD,	Residence-Low Density	20%	No requirements
PD-MD	Planned Development Medium Density	20%	40%
PD-HD	Planned Development - High Density	20%	40%
OR	Office & Research	25-40%	Professional offices....50%; Corporate office park...50%; Conference hotel/motel..50%; Area & bulk.............50%.
C-H	Commercial - Highway	25-40%	60%
C-V	Commercial - Village	25-40%	No requirements
I-LI	Industrial - Light Impact	25-40%	Professional offices....50% Planned indus. parks.....50%

		Area & bulk........... 50%
I-Industrial Zone	25-40	50%

We strongly advocate that the coverage regulations be changed to allow no more impervious surfacing than recommended by Middlesex County.

iii. Augmentation of Recharge

Any additional coverage of the land after development, as compared to before development, with both residential and non-residential uses, requires that positive steps be taken to increase the recharge of storm water where the ground is not covered. The Middlesex County document lists various mechanisms by which the runoff from impervious surfaces can be trapped and allowed to infiltrate to groundwater. [22] These include:

* Retention/recharge basins;
* Injection wells;
* Dry wells;
* Trenches or swales;
* Rooftop detention;
* Subsurface drainfields;
* Porous pavement;
* Porous blankets.

These techniques, and other useful mechanisms for recharging water are explained further elsewhere. [23,24]

There is some mention in the townships's current ordinance on Soil Protection (150-69) of the means that should be taken to manage storm water "to facilitate groundwater." But there is an underlying question on how the detention basins are to be managed so that it keeps recharging groundwater. Besides the initial design and construction of recharge mechanism, there is the on-going need for maintenance. In some cases a regional/shared infiltration basins or other mechanism may be practical. Although the primary method of regulating groundwater recharge is the performance standard, i.e. no increase in the volume of runoff..., the municipality needs to consider how it will manage this program of building and maintaining sufficient recharge mechanisms so that the present proportion of precipitation entering groundwater is not reduced as development occurs.

iv. Clustering

An important means of reducing coverage and cost is clustering. We advise that clustering be encouraged in all residential zoning districts. Clustering should be required when a conventional, non-cluster development would adversely affect environmentally sensitive areas of a tract, remove excessive areas of land from agricultural use, or run contrary to the municipal land use plan for open space linkages and park space. [25]

For all major developments we recommend that 40% of the land be set aside for common open space. The definition of "common open space" excludes any streets, driveways, parking lots, school sites, club houses, indoor recreational facilities, house lots, private yards, and land owned by a utility authority. Cranbury's recent cluster ordinance contains this definition of "common open space":

> An open space area within or related to a site designed as a development that is available for the use of all residents or occupants thereof. Common open space may contain such complementary structures and improvements as are necessary and appropriate for the use or enjoyment of residents, occupants and owners of the development.

This should be changed because it negates a primary purpose of open space which is to retain recharge areas. Our definition of "impervious surface" is "the building coverage plus the areas of all impervious surfaces on a site, such as parking areas, driveways, service areas, streets, walkways, patios and plazas, expressed as a percentage of the total lot area."

Cranbury allows 15% of open space to be used for active recreation areas, such as trails, bikeways, playgrounds, play lots, tennis courts, or swimming pools. Such land uses either require impervious surfaces, or else compact the soild so water can not percolate through it. In order to maintain recharge such areas should not be classified as "open space". Cranbury Township has a minimum open space requirment of 30% for both cluster housing and PUD. This is not enough to provide adequate recharge without great expense. To meet the objective of maintaining recharge, the present regulations on clustering must be amended.

b. **Objective: To maintain the amount of waste water recharged to the groundwater.**

Used water is either depleted water or degraded water. Depleted water is lost water. It is lost either by eventual evaporation into the air, or by export out of the system of concern. Depletion is also called consumption. The system of concern here is the Cranbury water resource system. Degraded water is used water that has picked up heat or soluble materials, when it was used, but which is still liquid water. Liquid used water is often called waste water.

In Cranbury now all of the municipal and industrial water and part of the agricultural water used is pumped out of the ground. Furthermore, much of the water used for agriculture from ponds and streams is water that seeped out of the ground into the ponds and streams in dry weather, so it is also groundwater. At the present time some of that used water is returned to the groundwater in a degraded condition from septic systems, over-watering of yards, golf courses and agricultural fields, and possibly seepage pits and lagoons.

Note that even the extra water sprinkled on lawns is degraded by dissolving fertilizers, pesticides, and other soluble matter as it percolates into the ground. Storm water which recharges can also be degraded. One notorious example of this is leachate from landfills. However, if the water is not over-loaded with degrading materisals, then the soil with its microorganisms, plants and animals may renovate the water. This happens in a well functioning septic system. Though even in the best designed system of soil renovation of water more salts are present in the renovated water than in rain water.

It was nice when there was so much freshwater to go around that waste water, or treated waste water, could be dumped downstream or into the ocean. However, there are insufficient water supplies so that water needs to be recycled, and recycled with care so that the ground water does not become polluted.

With the Mount Laurel II decision the domestic use of water will increase, and consequently the production of sewage will increase. To maintain the recharge of waste water to the ground, we recommend that Cranbury adopt the following policies:

(1) **That no additional waste water be pumped to the Middlesex County Utilities Authority for treatment at its Sayreville plant and discharge into Raritan Bay.**

About 0.1 mgd of sewage was piped from Cranbury to the MCUA treatment plant in Sayreville in 1983. [26] Because this water is discharged into Raritan Bay it can not be reused, and therefore is lost water. In the future every effort should be made to use waste water to recharge the ground water in Cranbury.

(2) **Establish a program to provide for the maintenance of existing on-site septic systems and other alternative waste water treatment systems.**

Cranbury should consider starting a program for the management of on-site waste water treatment areas, such as that of East Brunswick.

(3) **Encourage the use of low water or waterless systems for the treatment of human wastes.**

Transporting 0.5% human wastes in 99.5% water to some distant sewage treatment plant is not the only way to treat human wastes. Consider composting toilets and other means that use less water. Such methods could even be used in large housing developments.

(4) **Encourage the reuse of gray water.**

Gray water, the waste water from baths and washing clothes and dishes, if stored, can be reused in gardens and to flush toilets.

(5) **Build a sewage treatment plant in Cranbury relatively close to large new developments whose effluent will recharge the groundwater by spray irrigation, or overland flow for irrigation.**

Some of the upland recharge areas in Cranbury should be ideal for such a treatment system. The Monroe Municipal Utilities Authority operates such a facility in the Forsgate area.

(6) **Prohibit any new waste water treatment facilities from discharging directly into streams or other surface water bodies.**

The Middlesex County Planning Board, Environmental Division, is adopting the following policy: [27]

> Discharge to surface waters:
> A direct discharge to surface waters is not recommended in the Lower Raritan area. Water quality problems from existing point source discharges and runoff make additional discharges, even from advances levels of treatment undesirable. This is especially true for the Millstone River and its tributaries.

Besides causing water quality problems, direct discharges to surface waters are rapidly moved downstream, exported out of Cranbury.

(7) **Encourage industry to conserve and reuse the water it uses.**

Two industries in town have ground water diversion permits totalling 0.97 mgd. None of the water that they withdraw is returned to the ground. It is either evaporated or discharged to surface water as regulated by a NJPDES permit. This causes a large loss of water for municipality.

If these methods of maintaining the recharge of wastewater to the groundwater are all implemented, then the amount of wastewater recharged should increase significantly. For further ideas there are references listed in the bibliography. [28,29]

c. Objective: To maintain or decrease groundwater withdrawal rates.

In order to allow no deterioration in the present groundwater resource, it is, of course, essential that no more water than at present be pumped from the ground. In order for Mount Laurel II housing to be built, extra water supplies will likely be needed. In order for an equilibrium between available water supplies, and water demands to be achieved, water conservation measures, or demand management, must be a predominant component in the whole water supply strategy for Cranbury. These are the approaches to decreasing groundwater withdrawals which we shall examine:

(a) Limit pumpage;
(b) Build new surface water supplies;
(c) Import surface water supplies;
(d) Conserve water.

(a) Limit pumpage.

The State will not permit any new wells drawing over 100,000 gallons per day. However, smaller wells can be built without the State's permission. We urge that Cranbury institute a ban on all new wells.

(b) Build new surface water supplies.

Any use of surface water which would decrease the dry weather base flow of a stream would be counter to the objective sought. Base flow comes from groundwater. To use it, instead of allowing it to flow downstream, would change for the worse the downstream ecosystems and the pollution in the Millstone River. However, storm water that runs off into streams is lost water unless it is caught in a surface reservoir or other storage system. This surface runoff water may be caught by flood skimming, or by piping roof and pavement runoff into cisterns. In semi-arid lands catching and storing storm water for water use is commonplace. Technologies available ought to be usable in Cranbury, especially for agricultural use.

(c) Import surface water supplies.

Surface water can be imported from surface water supplies via the Elizabethtown Water Company. The company now has rights to enough water to supply Cranbury. However, we strongly advise that Cranbury carefully consider the disadvantages to using water from Elizabethtown. These disadvantages include the following:

* Poorer water quality.
  The water is collected from over a large catchment area and carries many different compounds. Although the company has one of the best treatment facilities in New Jersey, it still does not remove all of these materials. Furthermore, the water has to be moved long distances from the treatment plant to Cranbury. In this process heavy chlorination is required to keep the water bacteriologically safe, but chlorination forms toxic chemical compounds in the water. Also, dirty or leaky pipes can introduce new contamination.
* Cost.
  Elizabethtown water is more costly than groundwater, and its cost will rise as demand increases.

* Future availability.
As pointed out in section III. A., demand for water from the Elizabethtown Water Company is likely to increase very rapidly in the near future. At some future time, probably before the year 2000, the company will not have enough water to supply all its customers. It is likely to discontinue service to its distant customers first, such as Cranbury.

Thus, importation of water is the least desirable method mentioned here.

(d) **Conserve water.**

It is imperative that Cranbury carry out an aggressive program to conserve water. Only by major reduction in demand can the municipality achieve both maintenance of the current groundwater resources and livable, affordable housing for low and moderate income people. There are numerous references on how to conserve water, such as those listed in the bibliography. [30, 31, 32]. The New Jersey Department of Environmental Protection has an Office of Water Conservation, which should be contacted for aid. Municipal ordinances should be amended to make aspects of water demand management mandatory. Requirements for plumbing fixtures in new development is a type of conservation measure which can be made obligatory. We advise that regulation of plumbing fixtures be of the performance standard type, because if a toilet does not flush the first time, then more water is used to get it to flush. Most important, however, is to make water conservation a community project so everyone starts thinking of ways that they can use less water.

We encourage the people of Cranbury to make saving water the "in" thing to do. We wish them well in their efforts to solve their piece of the water crisis in New Jersey. The Stony Brook-Millstone Watersheds Association is here to help in these efforts.

B. Stream Corridors and Wetlands

Four streams flow through Cranbury: the Upper Millstone River, Cranbury Brook, Cedar Brook and Shallow Brook. It is universally acknowledged that streams must be protected not only from the damage that will beset property owners who move too close to the flood line, but to the stream itself in maintaining an ecological balance.

Unfortunately the State's Flood Hazard Statutues do not sufficiently protect the landowners from floods. The D.E.P. regulations for the flood way and flood fringe currently allow development to occur, although some conformance to D.E.P. standards must be met.

We recently conducted a study of stream corridor protection as a means of measuring how 18 municipalities in our own watersheds were zoning their land (33). I have appended an excerpt of our plan to underscore the significance of protecting undisturbed elements within the stream corridor, a legal explanation justifying the ability of township to appropriately zone as stream corridors, an explanation of the program we recommend to Cranbury, and an explanation of the benefits that will come to Cranbury Township by following the procedures we recommend [Appendix B].

The management objectives we recommended were: floodplain protection, slopes exceeding 12% should be protected, protection for wet soils identified either by the Soil Conservation Service or the U.S. Fish and Wildlife Service, preservation of a 100' buffer area to protect our larger streams where neither wet soils or steep slopes are found, and a set-aside of 25-50' on our intermittent streams.

We chose to protect wet soils for a variety of reasons. They help stabilize water supplies by replenishing groundwater during dry periods. They help maintain stable flows in associated streams. They minimize the effect of erosion by acting as siltation basins. They may function as groundwater recharge areas. They serve as a habitat for plants which filter of stream water of excess quantities of nitrogen and phosphorus-two nutrients that can lead to the eutrophication of our surface waters. They provide suitable sites for commercially valuable waterfowl and fish. They serve as productive areas for silvaculture and agriculture. They provide excellent habitats for many varieties of nongame plant and animals. They help dissipate the energy from floods and serve as water storage areas. And they can serve as open space, recreation, educational and aesthetic resources (34-38).

Likewise, near-stream vegetation is important in stablizing moisture condtions, in controlling erosion, and in intercepting overland stormwater runoff. Scientists give great credit to trees and shrubs in their capacity to absorb stormwater runoff. In our region, by a process known as evapotranspiration, plants return to the air 50-60% of the rain which falls to the ground (39).

The benefits of trees in providing shading from heat and light should not be ignored. As we reported in our publication:

> The effects of elevated stream temperatures on an ecosytem are often dramatic. Increased temperatures reduce the dissolved oxygen hold-

> ing capacity of streams, thereby adversely affecting organisms which require high oxygen levels. Warm water hastens the conservsion of nutrients to a form which can be more readily assimilated by nuisance organisms such as bacteria and algae.

We have used as our setback distance for water resource protection a distance which closely approximates what the Soil Conservation Service recommends (a distance of 100') for a buffer strip in municipal watersheds and critical areas (40). This is also what the the California Resources Council recommends for a setback distance for streams that flow through more natural settings (41).

Cranbury's current ordinance does not, in our estimation, provide for adequate stream corridor protection. Cranbury's ordinance lists under its Natural Landscape Areas Along Water Courses:

> No building or parking areas shall be located within 200' of the center line of any stream or within the 100-year floodway. Such area be deemed to be part of any required landscaped buffer area.

I understand the Township Planner is currently rewording the draft ordinance to read the 100-year flood plain. From our standpoint this is not sufficient. These requirements fail to:

(a) protect the slopes exceeding 12% from development

(b) protect wet soil areas from development. Such wet soils help maintain stable flows in associated streams. Many of these fluvial wet soils are found beyond the 100 year flood plain. We conducted a wet soils inventory last year using information available to us from the U.S. Fish and Wildlife Service of Stony Brook and the Upper Millstone and Lower Millstone River (10). We found that in the Township of Cranbury roughly 2,035 acres of land consisted of wet soils (submergent vegetation, scrub-shrub vegetation, submergent vegetation, bottom land forest or deep water areas.) This figure represents about 24% of the total acreage in the Township. It is not altogether clear on Cranbury's current ordinance exactly into what category wetlands might fall. While they are not allowed to be used in the calculation of 10% open space, they are not specifically prohibited from being built upon unless they fall within the floodway or floodfringe boundary, regulated by the Department of Environmental Protection.

CONCLUSION

The Stony Brook Millstone Watersheds Assocation is anxious to assist Cranbury Township in its efforts to consider the regional ramifications of groundwater withdrawals and the needs for a recharge management plan. Our studies clearly show that our needs can be met if everyone. including Mount Laurel II litigants, work together for the benefit of all.

APPENDIX A

GROUNDWATER

WHAT IS HAPPENING BENEATH MONMOUTH COUNTY ?

MANASQUAN RESERVOIR SYSTEM

NEW JERSEY WATER SUPPLY AUTHORITY

Metcalf & Eddy, Inc.
Woodward-Clyde Consultants
New Jersey First, Inc.
Holt & Ross, Inc.
Arthur Young & Company

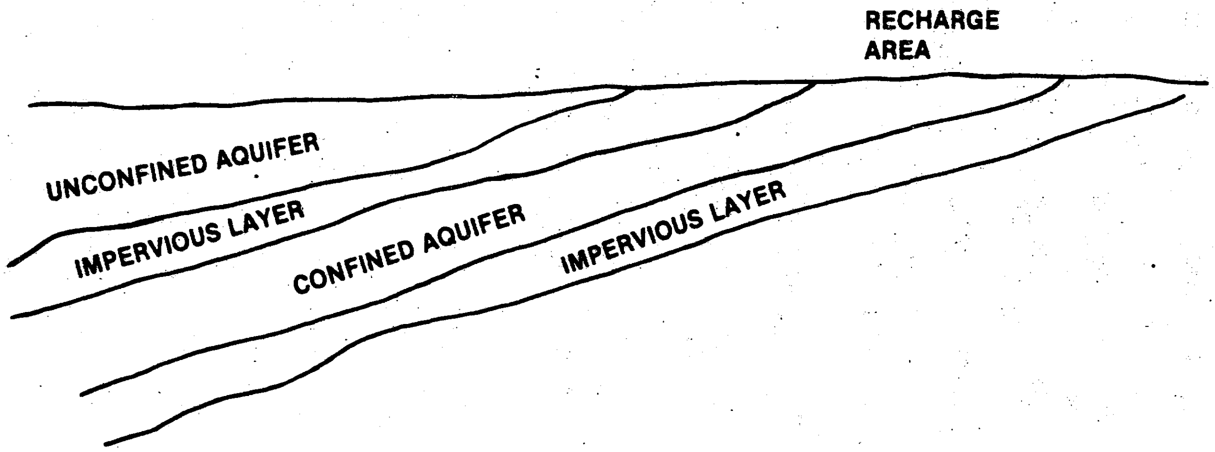
INTRODUCTION

The purpose of this report is to give a basic understanding of the aquifers that lie beneath the Monmouth County area and what happens to these aquifers as water is withdrawn from them. This report will use illustrations to show:

- o What aquifers are;
- o How they store water;
- o What happens when water is withdrawn from them.

This report also shows the effect that withdrawal of large amounts of water is having on one of the major aquifers, the Englishtown aquifer, that serves the Monmouth-Ocean County area.

Typical geometry of a confined aquifer



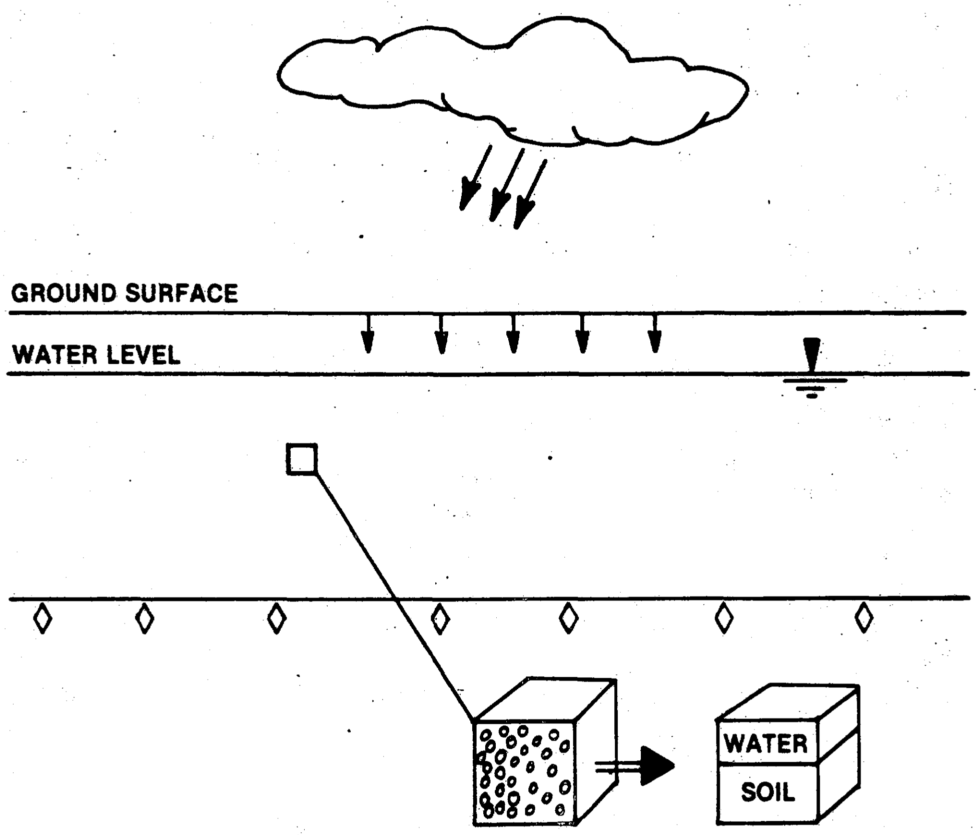
Aquifers are nothing more than underground reservoirs which store water that seeps below ground after it rains. Aquifers come in two types: "confined" and "unconfined."

Unconfined aquifers are those that lie on the surface and are often referred to as the "water table." They are sandy, gravelly deposits that contain water. This water can sometimes be reached by shallow wells and often appears in holes dug in these deposits.

Confined aquifers typically start at a point on the surface and slope downward, reaching very deep underground. They are layers of soil that contain water and are usually sandwiched between other layers of soil, such as clay, that are relatively impermeable — that is, water passes through them very slowly, if at all.

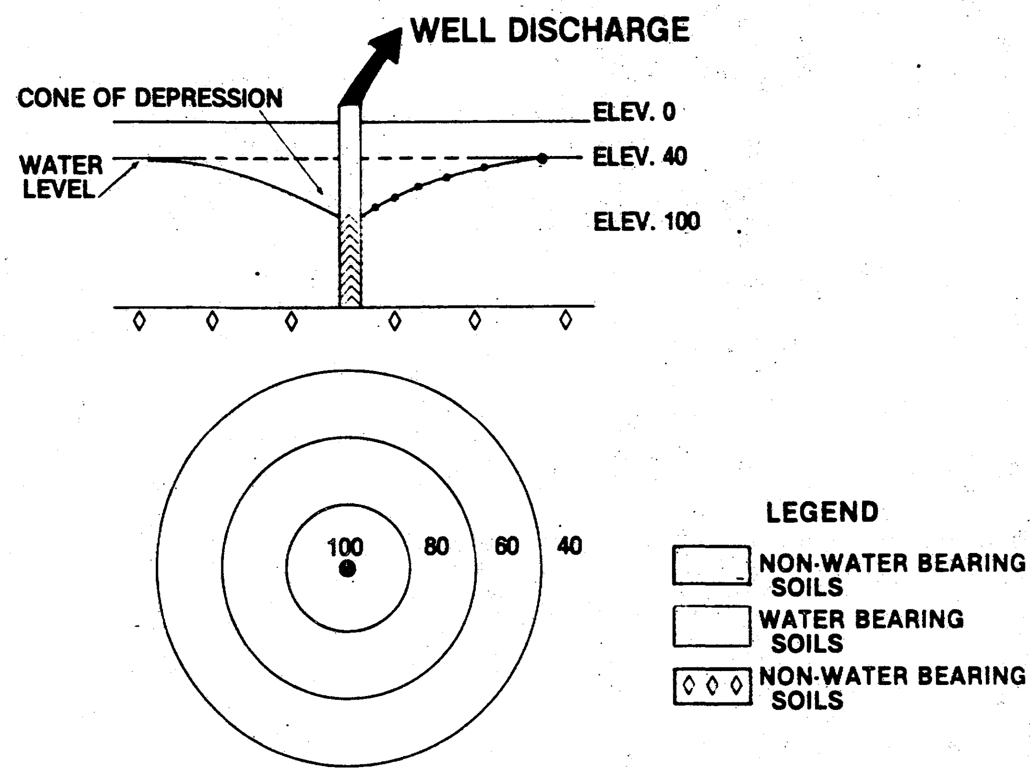
Aquifers receive most of their water from rainfall. Unconfined aquifers receive their rainwater over large, widespread areas. Confined aquifers, on the other hand, can only receive water at those points of limited area where they emerge from the ground. These natural "recharge" areas, as they are called, usually occur as strips of ground that typically cross township and county boundaries.

Storage of rainfall in underground reservoirs



When rainfall enters the surface aquifers, or the recharge areas of confined aquifers, it percolates downward as far as necessary to fill the lower areas in the aquifer that have no water. Thus, if a block of aquifer soil was examined, it would be found to consist of a mixture of soil and water.

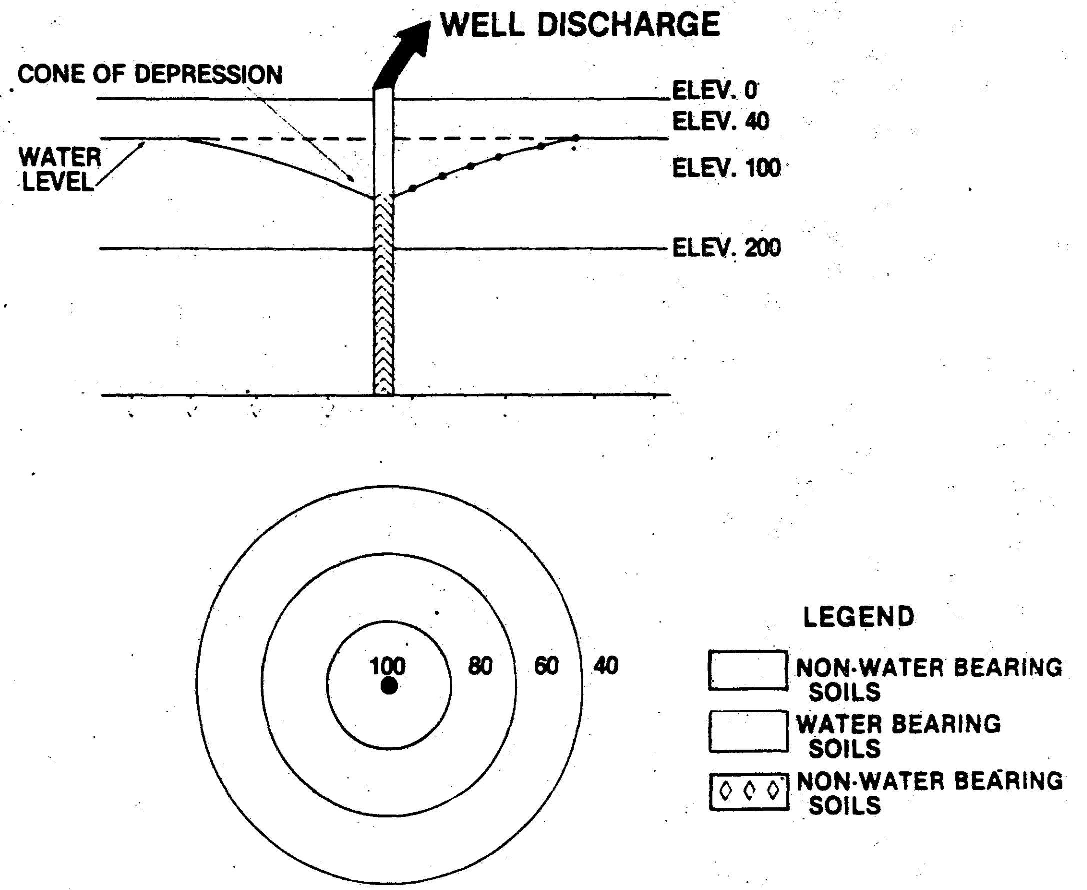
Pumping from a water table aquifer



This picture shows what happens when water is removed from a surface aquifer. As water is drawn from the well, other water moves through the earth as nature attempts to refill the zone from which water was removed. The well's operation causes the water table to decline not only in the vicinity of the well, but in adjacent areas as well. The level of decline falls off as the distrance from the well increases.

If an unused well was located next to the working well, its water level would be affected by the operation of the working well. A series of inactive wells could be used to measure this effect of the working well. When these levels are measured and plotted on a graph, they would produce a picture like the one on this page. The plotted water levels would look like a cone. In fact, they are called "cones of depression." Lines of constant water level — which actually occur as a series of concentric circles — can also be plotted on a map to show the extent of those cones of depression.

Pumping from a confined aquifer



The picture above shows what happens when water is removed from confined aquifers — the ones that are typically located deep underground. These aquifers often contain water that is under pressure, especially when they are tapped deep in the ground, far from the place where they are recharged by rainfall. In those cases, this hydrostatic pressure can actually raise the water level above the top of the soil layer that contains the water.

As in the previous illustration, the water drawn from the area around the well is replaced by water that moves to refill the space from which the water was removed; water then moves to replace that water, and so on. As a result, the water level declines near the well and throughout the rest of the aquifer, with the levels of greatest decline occurring closest to the active well.

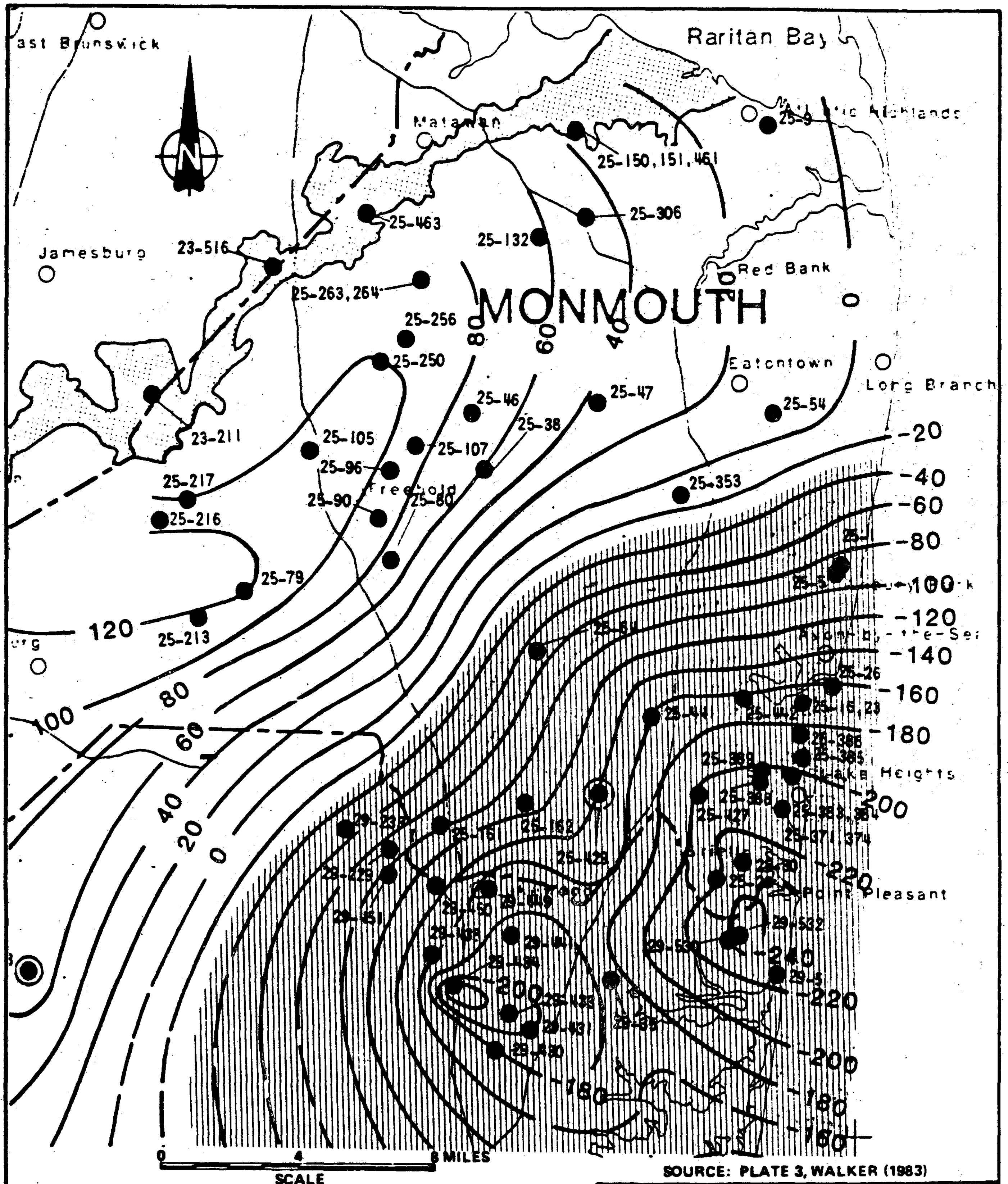
Here again, an unused well adjacent to an active well would be affected by the working well. If several of these idle wells were present, they could be used to plot and map the varying water levels and the locations of the rings of constant water level in the aquifer. By doing this, the plots would show where the cones of depression are.

In fact, this is the method used by the United States Geologic Survey (USGS) to measure water levels and map the rings of constant water level in aquifers. There are numerous wells in Monmouth County and Ocean County that are used to measure water levels in the aquifers that lie beneath this region. This water level information is collected and mapped every five years.

The following maps show rings of equal water level in one of the aquifers that lies beneath the Monmouth-Ocean area — the Englishtown aquifer. This is one of the more heavily used aquifers in the region. The map shows that in 1978, water levels in this aquifer in the Point Pleasant area were more than 240 feet below sea level. The ring that represents a water level of 100 feet below sea level runs from Asbury Park to a location south of Freehold Township. The ring that represents the aquifer water level at sea level runs from Eatontown through Freehold Township and into Jackson Township in Ocean County.

When aquifer water levels are lowered to the extent shown by these USGS maps, they become vulnerable to contamination. This contamination can come from the water that moves into the aquifer from its recharge area or it can come in the form of salt water that enters the aquifers from the ocean. In addition, as water levels decline, wells run out of water and must either be drilled deeper or be moved further inland, where water levels are not as depressed.

This has already been happening in Monmouth County, where some communities along the coast are finding that the chloride levels (a measure of the amount of salt in the water) are increasing on a regular basis. In fact, some communities have had to move their wells inland to escape the salt water that is entering their underground water supplies. Other communities in Monmouth County have had to drill deeper wells, and in some cases have even had to change aquifers, in order to find enough water to meet their present water needs.



SOURCE: PLATE 3, WALKER (1983)

KEY:

OUTCROP AREA OF THE ENGLISHTOWN FORMATION

—20— POTENTIOMETRIC CONTOUR, SHOWS ELEVATION IN FEET AT WHICH WATER WOULD HAVE STOOD IN TIGHTLY CASED WELLS (NATIONAL GEODETIC VERTICAL DATUM OF 1929)

5-259 OBSERVATION WELL AND NUMBER SHOWN IN TABLE 4 AND FIGURE 6 OF WALKER (1983)

29-449 DATA POINT AND NUMBER SHOWN IN TABLE 4 OF WALKER (1983)

MANASQUAN RESERVOIR SYSTEM

NEW JERSEY WATER SUPPLY AUTHORITY

POTENTIOMETRIC SURFACE OF THE ENGLISHTOWN AQUIFER, 1978

DR BY	CH'D BY	DATE	SCALE	PLATE NO
CIG	AM	6/19/84		2-G

APPENDIX B

Chapter One

Stream Corridor Protection

LEGAL UNDERPINNINGS

of

STREAM CORRIDOR PROTECTION

The regulations of land bordering water ways, inevitably involve some limit setting on the rights of property owners to the full use and enjoyment of his property. Consequently, questions have arisen as to the legal defensibility of stream corridor or even flood plain protection. By examining court action involving flood plain and wetlands protection it is possible to gain a clearer understanding of the actual basis for judicial decision making.

Underlying Issues in Flood Plain Protection

When municipalities have been challenged in court on the legitimacy of flood plain ordinances, judicial decisions will consider several factors. Where ordinances have been upheld - municipalities have been given clear, delegated authority from the state, the adopted regulations are viewed as serving legitimate police power objectives, the regulations are reasonable and generally precise in their wording, they do not discriminate against similarily situated landowners, and they do not deprive a property owner of the reasonable use of his property. Generally, it is the absence of more than one of these characteristics that results in the overturning of a local ordinance.

The courts have recognized a public purpose in flood plain protection beyond that of protecting individuals from self-inflicted property damage due to their occupancy of the flood plain. In Kraiser vs. Zoning Hearing Board of Horsham Township (1979) the Pennsylvania Commonwealth Court upheld a local Zoning Board denial of a variance for development of duplex housing within a 100-year flood plain. The court stated that buildings would "increase flood height and conceivably increase the hazard to the inhabitants of other buildings both on and away from the zoned area."

Court decisions involving flood plain ordinances can be categorized by the era in which they were rendered. Prior to the 1970's courts took a narrow view of local restrictions on flood plain development. Ordinances which prohibited encroachments in the floodway were upheld, but any limit setting on development in the flood fringe was likely to result in the invalidation of the ordinance. In one state, a flood plain ordinance which allowed marinas, boat houses, parks, farmland and wildlife but little else was struck done. In another state, the construction of multi-family housing on flood prone land was given court approval.

As the burden to society of flood plain development has become better appreciated, courts have taken a more protective approach to flood plain occupancy. Today, there is a trend toward permitting buffer zones adjacent to flood plain lands and totally excluding residential, commercial and industrial uses from flood plain areas. The Supreme Court of Washington (Maple Leaf Investors, Inc. vs. State Dept. of Ecology (1977) prohibited construction of single family homes within a flood control zone while the Supreme Court of Iowa (Young Plumbing and Heating Co. vs. Iowa Natural Resources Council (1979), upheld flood plain protection because of a state regulation which prohibits encroachment within a floodway.

In Krahl vs. Nine Mile Creek Watershed District, the Minnesota Supreme Court sustained floodway regulations which limited encroachment to 20% of the total flood area to preserve the flood storage capacity of the flood plain. In Subura of New England, Inc. vs. Board of Appeals of Canton, the Massachusetts Supreme Court sustained flood plain and floodway regulations designed to protect flood storage. Here the court took into account the potential for cumulative impacts of flood plain construction. The Massachusetts Supreme Court in Turnpike Realty vs. Town of Dedham (1973) upheld a flood plain zoning district which restricted a parcel to open space uses such as woodland, wetland, greenland, agricultural, horticultural, or recreational use even though the landowner argued that the land was valued at $431,000 before the ordinance took effect and $35,000 after regulation and gave evidence that several hills were included within the flood plain district.

In Turner vs. County of Del Norte (1971), a California court upheld a flood plain zoning ordinance which prohibited single family dwellings from being placed in a severely flooded area. The ordinance permitted recreational and agricultural activity and seasonal camping. Similarly, in S. Kemble Fisher Realty Trust vs. Board of Appeals of Concord, a Massachusetts court upheld regulations which restricted property in Concord to open space conservancy uses. A New York court in Dur-Bar Realty Co. vs. City of Utica sustained local regulations which designated a flood plain area with uses limited to farming and agriculture, parks, golf courses, athletic fields, disposal facilities, landfill operations and marinas.

In New Jersey, the protection of more than just flood plain land has been likewise upheld. In Usdin vs. Department of Environmental Protection of New Jersey, the court prohibited construction on land identified only as "flooding for years." The judge denied the plaintiff's argument that the restrictions on development constituted a taking without compensation even though the land had not been formally designated as flood fringe. In a statement having clear implications for stream corridor features protection, the court observed "that the township's police powers to protect and preserve the public health, safety and welfare included protection of environment as well as ecological values."

In fact courts are supporting ordinances which seek the protection of natural features which may be located outside the flood plain because of the public water supply benefits and recreation and scenic opportunities they provide. In Perlay vs. North Carolina, the United States Supreme Court upheld the regulation of forestry operations within 400 feet of a watershed. "The regulations provided a buffer zone for operations which through erosion and other factors damage the water supply."

A landmark decision by the Supreme Court of Wisconsin in 1972 (Just vs. Marientte County) upheld a county shoreland zoning ordinance restricting development within 1000 feet of navigable lakes, ponds or flowage, and 300 feet from a navigable river or stream on the basis that a property owner had no inherent right to destroy the natural suitability of the land. The court specifically noted the "...interrelationship of the wetlands, and swamps, and the natural environments of shorelands to the purity of the water and to such natural resources as navigation, fishing and scenic beauty."

In a case with direct implications for New Jersey, the Georgia Supreme Court in Pope vs. Atlanta (1978) held that a permit program for development in a stream corridor (land within 2,000 feet of the river and the 50 year flood plain) was valid. Uses within 150' of the river and on the 50 year flood plain were limited to those which are not harmful to the water and land resources of the stream corridor, do not significantly impede the natural flow of flood waters, and will not result in significant land erosion, stream bank erosion, siltation or water pollution.

Similarly a New Hampshire court in Patenavde ve. Town of Mereaith (1978) upheld a local ordinance which prohibited subdivision of lake-front wetland property, and a Massachusetts court in Lovequist vs. Conservation Commission of the Town of Dennis (1979) prohibited the filling of a wetland area because of proven negative impacts to the groundwater supply associated with the building of a new roadway.

Legal Aspects of Wetlands Zoning

Although the body of legal evidence is not as extensive on wetlands statutes as it is for flood plains, enough cases have been decided to give a sense of judicial opinion. Provided that the perceived values of wetlands are carefully spelled out, zoning laws that restrict activities in or around wetlands are likely to be upheld in a court of law. The key word is restrict, since the outright prohibition of all activities may be perceived as a taking of the right of the landowner to the reasonable use of land.

The Association of New Jersey Environmental Commissions in its review of wetlands statutes observed that ordinances can be overturned by a court of law if they: are based on a lack of sufficient factual data and are therefore unreasonable; fail to utilize the valid police powers; impose undue restraint upon private property; or discriminate against a particular landowner. On the other hand courts have sustained wetlands ordinances whose objectives are to prevent flood damage, control water pollution, or protect water supplies.

Among the most heatedly discussed aspect of wetlands and flood plain zoning, is the taking issue. Overly restrictive regulations which prevent a landowner from realizing the value of his property were considered by plaintiffs as a taking of property rights without just compensation. In an exhaustive review of more recent court decisions one author observed that when the taking issue has arisen, ordinances have been invalidated when a landowner has been deprived of the reasonable use or economic benefits of his property.[43] No standards for determining reasonable use has been established. We have already seen in Turnpike Realty vs. Dedham that claims of a 10 fold reduction of property value due to flood plain restrictions were held not to be a taking due to other considerations.

It is significant that during rhe 1970's only two court decisions struck down local ordinances based solely on the taking issue. In Sturdy Homes, Inc. vs. Township of Redford, a Michigan court found regulations to be confiscatory because no evidence of flooding in the regulated area had been presented. In American National Bank and Trust Company of Chicago vs. Willaged Winfield, an Illinois court found that local ordinances which limited residents on flood plain land to single family houses were unreasonable. In this particular case, 70% of the 32 acre parcel was within the flood plain. The cost of adding fill would have cost $4,192 - $12,577 an acre, while at the same time the land was worth only $6,000 an acre for single family use. While ruling against the restrictions in the limited case the court supported the concept of regulations to protect open space, aquifer recharge and flood storage.

New Jersey's courts have upheld wetlands protection statutes in those limited instances when they have been enacted. In Loveladies Property vs. Roab, the court ruled that adoption of an ordinance and the mapping of wetlands are the appropriate prerequisites for requiring a permit from a landowner. The court was firm that ordinances could not discriminate against landowners in the same situation. In Morris County Land Improvement Co. vs. Parsippany-Troy Hills Township, a local ordinance was declared invalid because it discriminated against upstream landowners. New Jersey's own coastal Wetlands Act has been upheld as a legitimate exercise of the government's right to protect its own resources without taking from property owners their rights to development (American Dredging Co. vs. State of New Jersey.

To date, courts across the country have not invalidated any of the basic requirements of the National Flood Insurance Program. The right to delineate the floodway and flood fringe area under the equal conveyance system, the prohibition of new structures and fill in the floodway, and the construction of residential buildings above the 100 year flood level have been sustained. Recent trends show a willingness to support restrictions on the building of structures outside the floodway, even when flood mitigation is not the sole or primary objective. The issue of reasonable use, alluded to earlier, may well be encompassed by teh use of cluster ordinances which allow the development potential of most riparian lands when densities are adjusted elsewhere on the property.

Municipal Authority to Protect Stream Corridors

The Home Rule Act, N.J.S.A. 40:48-1 et seq. of 1917 invests every municipality with broad police powers, enabling them to adopt ordinances considered necessary and proper to promote public health, safety and welfare. Such provisions, however, may not be contrary to the laws of New Jersey or the federal government. In Hudson Circle Servicenter, Inc. vs. Kearney, courts affirmed the delegation of police power as stated in the Constitution.

Stringent regulations on particular land uses that impair the environment have been validated in courts of law. In Dock Watch Hollow Quarry Pit vs. Township of Warren the strict regulation of quarry operation was upheld, with the court commenting:

> ...The Supreme Court has recognized that the protection of public health through the preservation of the environment is a valid, and indeed primary objective of the police power. Huron Portland Cement Co. vs. Detroit, 362 U.S. 440, 442, 80S, Ct. 813, 815 YL. Ed. 2d 852, 855 (1960). Today it cannot possibly be questioned that the preservation of the environment and the protection of ecological values are, without more, sufficient to warrant an exercise of this power...

(For further information see Middlesex, Somerset, Mercer Regional Study Council, Sourland Ground Water Study, 1983.

Municipal governments have been likewise given broad powers and discretion to adopt zoning ordinances limiting and restricting building structures according to the nature and extent of their intended use and that of the land.

Under the Municipal Land Use Law, Chapter 291, Laws of N.J. 1975, municipalities have been given broad powers to protect natural resource features of significance. Of the specific purposes of the act, four would be at least partially achieved by a stream corridor protection program:

- To provide adequate light, air, and open space;

- To provide sufficient space in appropriate locations for a variety of agricultural, residential, recreational, industrial uses and open space, in order to meet the needs of all New Jersey citizens, both public and private, according to their respective environmental requirements
- To promote the conservation of open space and valuable natural resources and to prevent urban sprawl and degredation of the environment through improper use of land;
- To encourage coordination of the various public and private procedures and activities shaping aldn development with a view of lessening the cost of such development and to the more efficient use of land.

The centerpiece of the local planning process is the municipal master plan. The land use element of the plan lays the foundation for the legally binding provisions of zoning and site plan ordinances. The Land Use Act identifies several stream corridor features (eg. topography, soils, water supply, drinage, flood plains, marshes and woodlands) as central to the planning process. Section 40:55D - 38 of the Municipal Land Use Act requires that provisions be made: for water supply, drainage, shade trees and sewerage facilities; the set aside of open space. Furthermore, site plan ordinances (40:55D - 41) must set forth provisions relating to preservation of existing natural resources on the site. The natural resources can include provisions for stream corridors or their component parts.

In sum, a review of case law and existing state statutes clearly indicates an intent to protect sensitive land features bordering streams. Municipalities have the delegated authority to exercise police power to protect flood plains and to restrict development on other sensitive lands provided that the regulations are applied fairly and evenly.

How municipalities choose to accomplish this, is a matter that planning boards would do well to consider in site plan ordinances. While the net density of a particular building lot is often established by the availability of utilities and general constraints of the land's capacity to support growth, there are techniques available to apportion the same net density onto a smaller portion of the lot, thereby preserving natural resource features of significance. This can be accomplished through the use of cluster housing or by relaxing maximum height limitations established for the township.

ORDINANCE GUIDELINES

STREAM CORRIDOR DEFINITION

OBJECTIVES: To protect property from flooding, to reduce land development impacts on stream water quality and flows, and to provide recreation and wildlife migration corridors, management areas for perennial and intermittent streams are proposed (see Figure 3).

PERENNIAL STREAM CORRIDOR

1. Flood Plains

The stream corridor should include as a minimum the land now inundated or likely to be inundated by the flood of 100 year frequency. It includes the flood way and the New Jersey Flood Hazard Area and the encroachment lines of undelineated streams. Where the flood plain extends beyond the limits of the stream buffer area (defined below), then the full extent of the flood plain should be included in the stream buffer areas and the required setbacks should be measured from the edge of the flood plain.

2. Stream buffer area

This component of the corridor is comprised of lands whose disturbance would likely adversely impact the annual flow regime or water quality of a stream. Included are:

a. Wet soil areas

Soils having a seasonally high water table within a foot of the surface and located contiguous to a permanently flowing stream or contiguous to other wet soils which are hydrologically connected with a permanently flowing stream. The extent of these soils is indicated on Soil Conservation Service maps, but must be confirmed through field investigation (see accompanying chart).

The U. S. Fish and Wildlife Service definition of wetland may be substituted for wet soils in defining the buffer area. The wetlands have at least one of three attributes:

(1) at least periodically, the land supports predominantly hydrophytes or
(2) the land substrate is predominantly undrained hydric soil or
(3) the substrate is non-soil and is saturated with water or covered by shallow water at sometime during the growing season. (See Classification of Wetlands and Deepwater Habitats of the United States, U. S. Fish and Wildlife Service, 1979.)

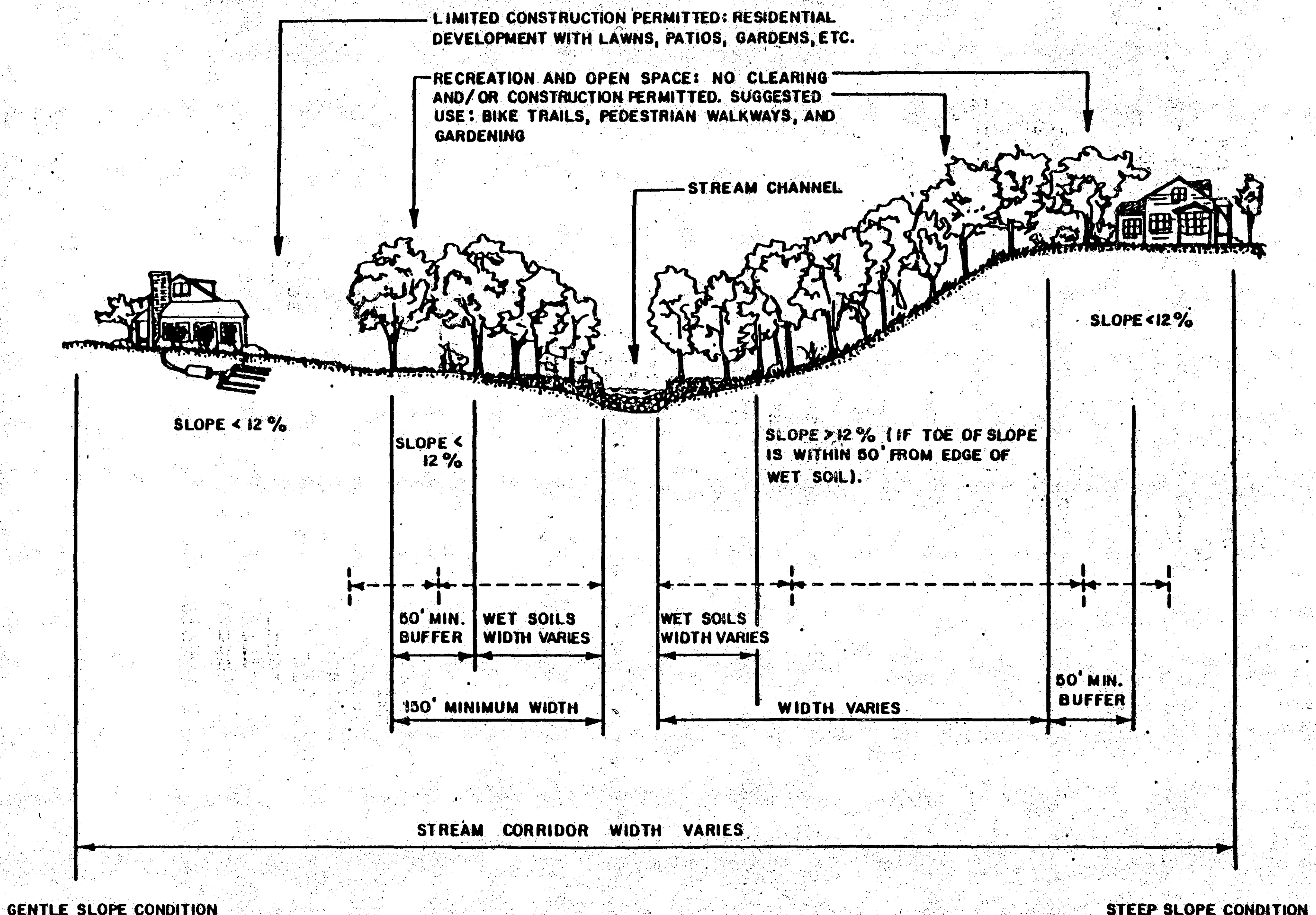


Figure 3. The Stream Corridor Management Area

b. <u>Slopes of 12% or greater</u>

Land whose slope exhibits a change in elevation greater than 12% of the corresponding distance through the slope and where the toe of the slope lies within 50 feet of the stream channel bank, the flood plain or contiguous wet soils/wetlands. The protection area for slopes shall be the greater of...

(1) A distance of 100' from the toe of slopes having a consistently average slope of 12% or greater or
(2) A distance of 50' beyond the first point in which the average slope is less than 12% for the distance of 25 or more feet.

c. <u>Riparian Lands Set Back</u>

For streams which are not immediately bounded by a well defined flood plain, by wet soils or by slopes of 12% or more, the following vegetated setbacks shall apply -

(1) one hundred feet (100') from the channel bank for purposes of protecting water quality from erosion and overland flow, nutrient runoff and septic tank effluent
(2) one hundred fifty (150') feet from the channel bank for providing water quality benefits, usable recreation and wildlife corridors
(3) 50' vegetated buffers shall be preserved around all riparian wet soil or wetland areas to control land runoff and mitigate the entry of nutrients and toxic substances.

INTERMITTENT STREAM CORRIDORS

Intermittent stream corridors are areas including and surrounding surface water drainage channels which are characterized as having seasonal, rather than perennial, stream flows. The extent of these swales or ephemeral stream corridors is the greater of:

a. the outer boundary of alluvial soils or alluvium plus contiguous slopes of 12% or more (but extending a distance not to exceed 50' from the toe of the slope)

b. 25' or more on either side of the stream channel

"WET SOILS" OF STUDY AREA COUNTIES

NAME	SYMBOL	LOCATION[a] (county)	DEPTH TO SEASONALLY HIGH WATER TABLE
Abbottstown	AbA AbB	H, Me, S	½ - 1½
Adelphia	AdA, AdB, AeB	Mo	½ - 4
Alluvial	Ae, Ad, Ae 240[b]	H, Me, Mi	1 - 1½
Amwell	AmB, AmC, AnB, AnC	S	1 - 4
Atsion	At 9736	Mi, Mo	0 - 1
Berryland	9746	Mi	0
Bowmansville	Bt	H, Me, S	0 - 1
Califon	CaB, CaB	H, S	½ - 2½
Chalfont	CdB, CdC, CeB CeC, CeE	H, Me, S	½ - 1½
Cokesbury	CpB	H, S	0 - 1
Colemantown	Cm	Mo	0 - 1
Croton	CrA	H, S	0 - 1
Doylestown	DgA, DgB, DgBa, DgC, DgCa	Me	0 - 1
Dragston	DwB	Me	1 - 1½
Dunellen variant	Dw	S	½ - 4
Elkton	Ek, En 9831	Mi, Mo, S	0 - 1
Fallsington	Fa, Fb, Fd 9433,	Me, Mi, Mo	0 - 1
Fluvaquents	9431		
Fluvaquents	Fl	Mo, S	0 - 1
Lamington	La	S	0 - 1
Lansdowne	LbA, LbB	H, S	½ - 2½
Lawrenceville	LeA, LeB, LaB_2 Ld_2	S	1 - 2½
Lehigh	LhB, LhC	H, Me, S	½ - 4
Lenoir	Lk	Me	1 - 1½
Marsh	Fl	Mi	0
Mount Lucas	MoB, MpC, MuB	H, Me, S	½ - 4
Muck	M646M	Mi	
Othello	Ot	Me	0 - 1
Parsippany	Ph	S	0
Parsippany variant	Pk	S	0
Plummer	Pu, Pv	Me	0 - 1
Portsmouth	Pw	Me	0
Rartian	RbA	H, S	½ - 3
Pocomoke	9443	Mi	0
Reaville	ReA, ReB, ReB_2, ReC_2	H, Me, S	½ - 3
Reaville wet variant		H, Me	0 - 1
Rowland	RO	H, Me, S	1 - 3
Shrewsburg	Sn, So	Mo	0 - 4
Turbotville	TuB	H	½ - 1½
Udifluvants & Ochrepts	Ud	S	1 - 5
Watchung	Wa	S	½ - 1½

[a]H=Hunterdon, Me=Mercer, Mi=Middlesex, Mo=Montgomery, S=Somerset
[b]Alpha numeric symbols apply to Middlesex County soils

GUIDELINES

STREAM CORRIDOR OBJECTIVES

1. To prevent the erection of structures of land subject to seasonal or periodic flooding so as not to endanger the health, safety or welfare of the occupants thereof, or of the public generally, or so as to burden the public with costs resulting from unwise individual choices of land use.
2. To retain the natural storage capacity of the watershed.
3. To protect, preserve, and maintain the water table and water recharge areas within the municipality so as to preserve present and potential water supplies for the publics' health and safety.
4. To minimize danger to public health by protecting the quality and quantity of surface and subsurface water supplies adjacent to and underlying stream corridor areas and promoting safe and sanitary drainage.
5. To permit only those uses which can be appropriately located in the stream corridor which will neither impede the flow and storage of flood waters, nor cause accelerated erosion, soil failure, accelerated seepage or other conditions which may create a danger to life and/or property at, above, or below their locations along the stream corridor.
6. To prevent inappropriate development in order to avoid potential dangers for human usage caused by erosion, stream siltation, soil failture leading to structural collaspe or damage and/or unsanitary conditions of associated hazards.
7. To assume the continuation of the natural flow pattern of watercourses within the municipality, in order to provide adequate and safe floodwater storage capacity to protect person and property against the hazards of flood inundation.
8. To maintain undisturbed the ecological balance between those natural system elements, including wildlife, vegetation and marine life, dependent upon watercourses, steep slopes and wetlands.
9. To protect other municipalities within the same watershed from the impact of improper stream corridor development and the consequent increased potential for flooding.
10. To maintain a framework of stream corridors of high quality for public access within close proximity to neighborhood and population centers.

11. To protect areas of importance to the preservation of significant ecological systems, retain contrast in the landscape and provide natural buffer zones between incompatible land uses.

12. To maintain and encourage the improvement of environmental qualities including beauty, recreational opportunity, plant and animal life, scenic, and other natural values.

13. To preserve areas of unique, scientific, or historic interest and to retain areas with special significance for scientific study, ecological research, and conservation or nature education.

14. To permit only those uses in stream corridor areas that are compatible with the preservation of existing natural features, including vegetation cover, by restricting the grading of steep slopes.

15. To prevent development that would cause excessive erosion, result in reduction in the water carrying capacity of the watercourses which flow through or around the municipality and in so doing increase flood crests and flood hazards within the municipality and in adjacent upstream and downstream communities.

16. To maintain a framework of environmental corridors of high quality for public access close to neighborhood and population centers.

17. To retain sites for beneficial water uses such as flood control, water supply, wildlife habitat, and recreation.

18. To protect areas of importance to the preservation of significant ecological systems and to retain contrast in the landscape and provide buffer zones between incompatible land uses.

19. To maintain and encourage the improvement of environmental qualities including beauty, recreational opportunity, plant and animal life, scenic and other natural values.

20. To preserve areas of unique, scientific, or historic interest and to retain areas with special significance for scientific study, ecological research, conservation or nature education.

ORDINANCE GUIDELINES

Land Uses Within Stream Corridor Protection Zone

Permitted Uses:

1. Cultivation and farming (including truck gardening and harvesting of any wild crops such as marsh hay, ferns, moss, berries or wild rice) according to best management practices of the Soil Conservation Service or the State Soil Conservation Committee.
2. Pasture and controlled grazing of animals according to recognized soil conservation practices.
3. Outdoor plant nursery, vineyards, and orchards according to recognized soil conservation practices.
4. Wildlife sanctuary, woodland preserve, and arboretum exclusive of facilities subject to damage by flooding.
5. Game farms, fish hatcheries, or hunting and fishing reserves, operated for the protection and propagation of wildlife, but excluding enclosed structures.
6. Forestry, lumbering and reforestation according to recognized natural resources conservation practices of the New Jersey Forest Society.
7. Structures, buildings, retaining walls associated with flood retention, water supply impoundments, culverts or bridges.

Prohibited Uses:

1. New construction or replacement of free standing structures, buildings and retaining walls not in the public interest.
2. On-site sewage disposal systems.
3. Any solid or liquid waste or refuse disposal including sanitary landfills, transfer stations and wastewater lagoons.
4. Junk yards, commercial and industrial storage facilities and the open storage of vehicles and materials.

5. Barns, stables, feedlots, barnyards, dry lots, poultry, buildings, and farm waste disposal facilities.

Conditional Uses:

1. Recreational use, whether open to the public or restricted to private membership, such as parks, camps, picnic areas, golf courses, fishing areas, hiking, bicyle and bridle trails, sport or boating clubs, not to include enclosed structures, except toilet facilities, but permitting piers, docks, floats, or enclosed shelters usually found in developed outdoor recreational areas. Any toilet facilities requiring water should be connected to public water and sewerage systems.

2. Sewage treatment plants, outlet installations for sewerage treatment plants and sewage pumping stations with the approval of the Township Engineer, the appropriate utility authority and the New Jersey Department of Environmental Protection when accompanied by documentation as to the necessity for locating within the stream corridor.

3. Private or public water supply wells provided with a sanitary seal, flood proofed water treatment facilities, or pumping facilities, when approved by the Township Engineer and the New Jersey Department of Environmental Protection.

4. Quarrying, excavating, digging, dredging or grading when incidental to permitted structures or uses including stream cleaning, and stream rehabilitation work undertaken to improve hydraulics or to protect public health.

5. Dams, culverts and bridges upon formal approval in the appropriate municipal, county and state agencies having such authority.

6. Sanitary or storm sewers and impoundment basins, approved by the Township Engineer, the New Jersey Department of Environmental Protection and/or the Delaware and Raritan Canal Commission.

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6. Sanitary or storm sewers and impoundment basins, approved by the Township Engineer, the New Jersey Department of Environmental Protection and/or the Delaware and Raritan Canal Commission.

7. The riparian lands setback gives each municipality more of an equal share in protecting the one resource which links all municipalities together. The lands set aside during additional recreation facilities to each community. The protection policies work to the good of the commonly shared aquatic ecosystem.

8. For the first time, inland wetlands and headwaters areas, two long neglected sensitive resources, will be provided some protection.

9. By using a corridor concept which permits variability due to the presence of sensitive resource features, the limitations of fixed width setbacks can be overcome. The fixed width setbacks currently in use do not provide complete protection of the Millstone River floodplain whose total width may vary from 100' to 1'000' in Piedmont streams, up to 1,000' in the Upper Millstone and up to 2,000' in the lower Millstone River.

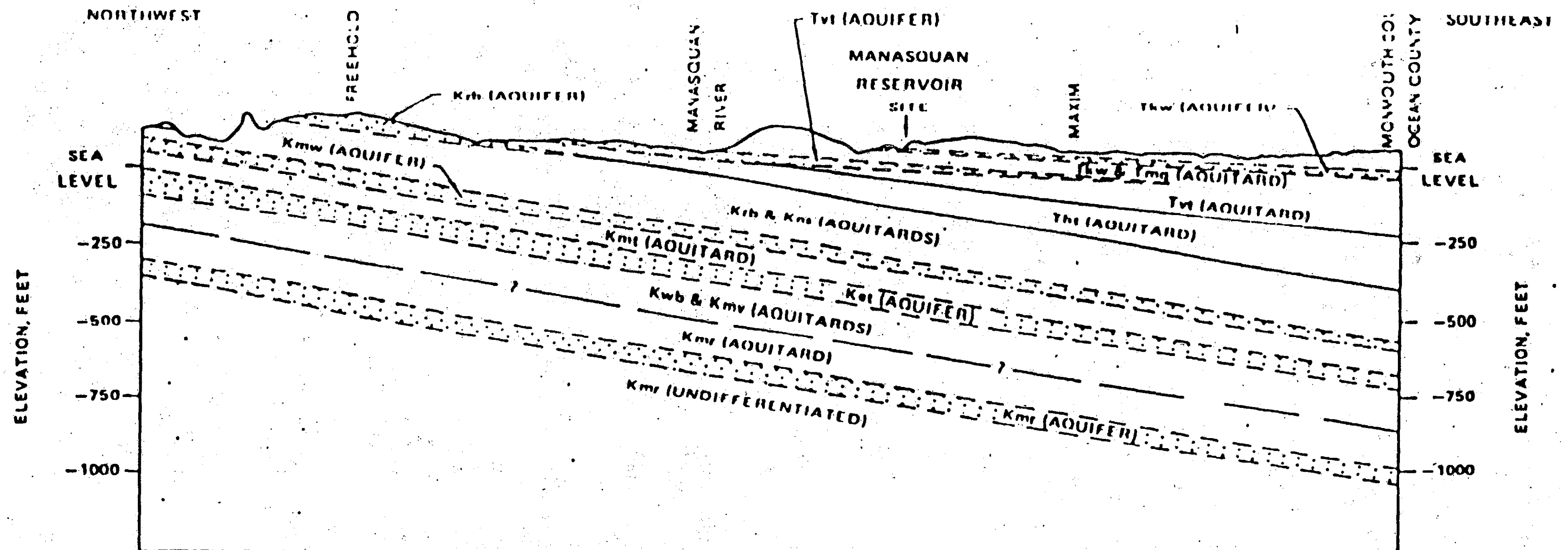


FIGURE 1

KEY:

[symbol]	AQUIFER ZONE
Tkw	KIRKWOOD FORMATION
Tmq	MANASQUAN FORMATION
Tvt	VINCENTOWN FORMATION
Tht	HORNERSTOWN FORMATION
Krb	RED BANK SAND
Kns	NAVESINK FORMATION
Kmw	MT. LAUREL SAND AND WENONAH FORMATION
Kmt	MARSHALLTOWN FORMATION
Ket	ENGLISHTOWN FORMATION
Kwb	WOODBURY CLAY
Kmv	MERCHANTVILLE FORMATION
Kmr	MAGOTHY AND RARITAN FORMATIONS

NOTES:

1. ADAPTED FROM FIGURE 6 OF JABLONSKI, L.A. (1968)
2. LOCATION OF CROSS SECTION SHOWN ON FIGURE 2-A

0 1 2 3 4 5 MILES
SCALE

MANASQUAN RESERVOIR SYSTEM

NEW JERSEY WATER SUPPLY AUTHORITY

HYDROGEOLOGIC CROSS SECTION FROM FREEHOLD TO OCEAN COUNTY LINE

CIG | AM | 6/18/84 | 2-B

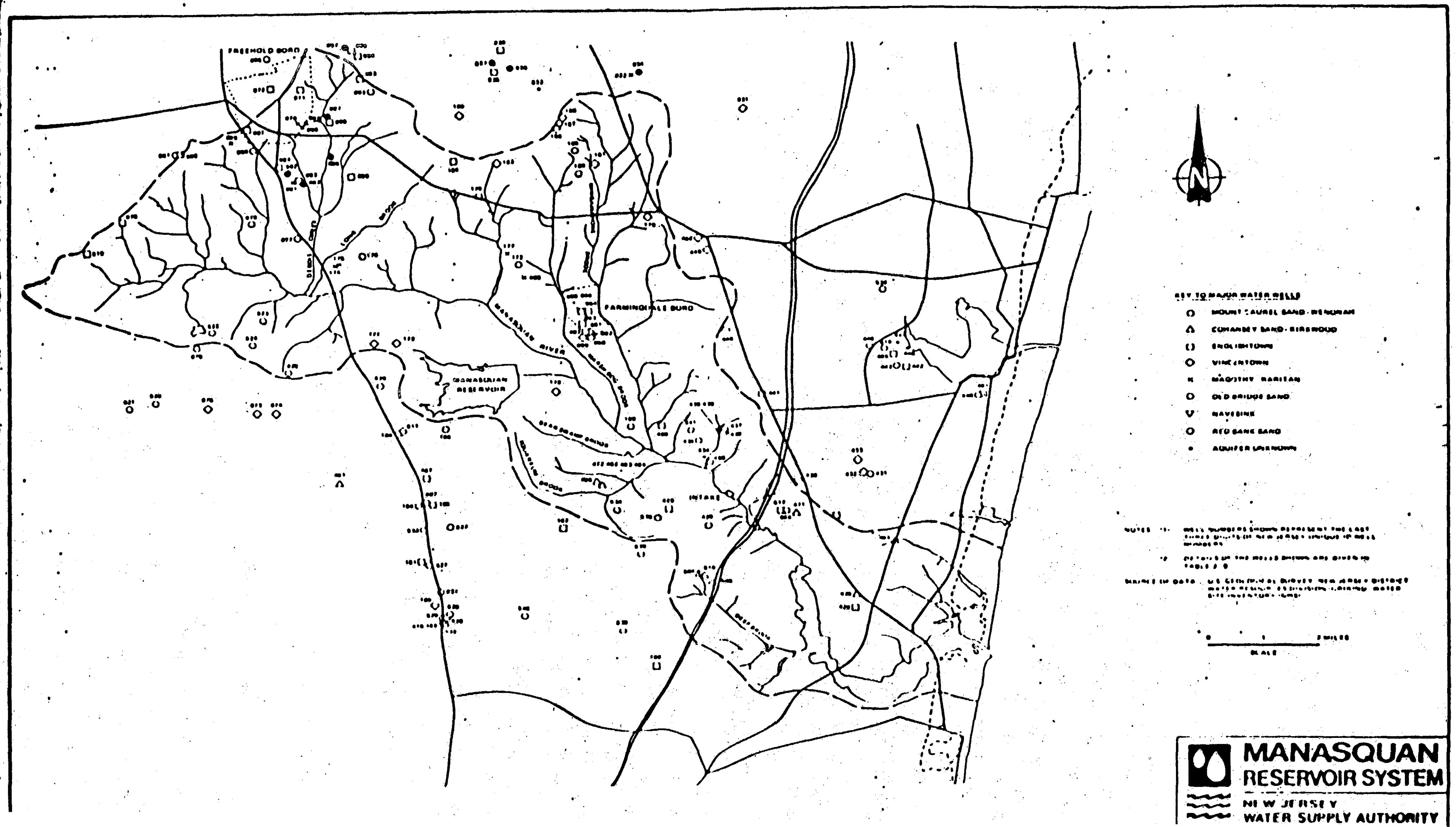
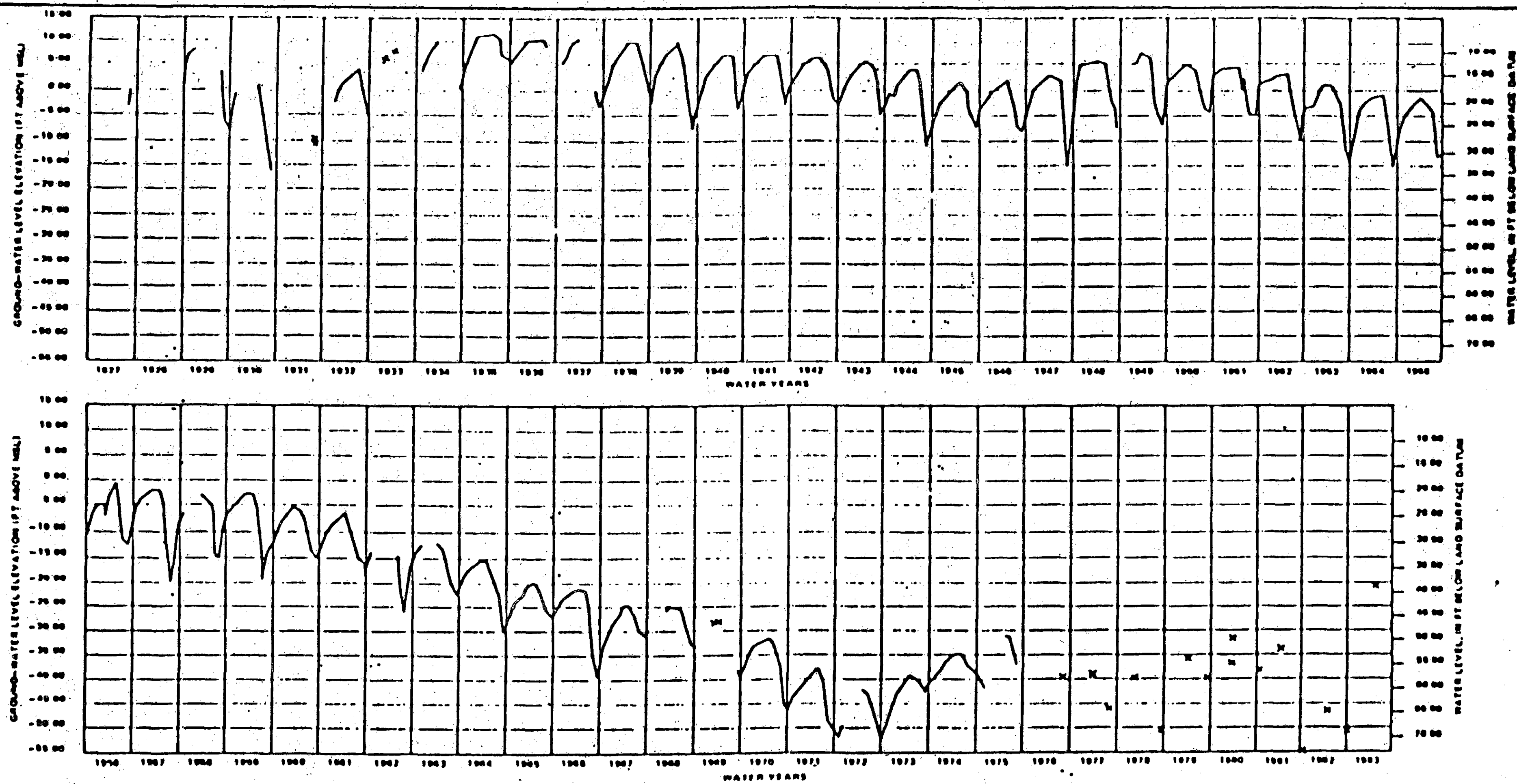

FREEHOLD BORO
FARMINGDALE BORO
MANASQUAN RESERVOIR
MANASQUAN RIVER
INTAKE
N
KEY TO MAJOR WATER WELLS
MOUNT LAUREL SAND-WENONAH
COHANSEY SAND-KIRKWOOD
ENGLISHTOWN
VINCENTOWN
MAGOTHY RARITAN
OLD BRIDGE SAND
NAVESINK
RED BANK SAND
AQUIFER UNKNOWN
SCALE
MANASQUAN
RESERVOIR SYSTEM
NEW JERSEY
WATER SUPPLY AUTHORITY

FIGURE 3



NOTES: (1) HYDROGRAPH PROVIDED BY THE U.S. GEOLOGICAL SURVEY, NEW JERSEY DISTRICT, WATER RESOURCES DIVISION
(2) WELL TAPS THE MAGOTHY - RARITAN AQUIFER SYSTEM AND IS LOCATED IN WHITESVILLE, NJ, APPROXIMATELY 3 MILES ENE OF FARMINGDALE, NJ
(3) WATER YEARS EXTEND FROM OCTOBER 1st OF THE PREVIOUS CALENDAR YEAR TO SEPT. 30th OF THE INDICATED YEAR

KEY: X = WATER LEVELS MEASURED AT WIDELY-SPACED INTERVALS

MANASQUAN RESERVOIR SYSTEM

NEW JERSEY WATER SUPPLY AUTHORITY

HYDROGRAPH OF MAGOTHY - RARITAN WELL

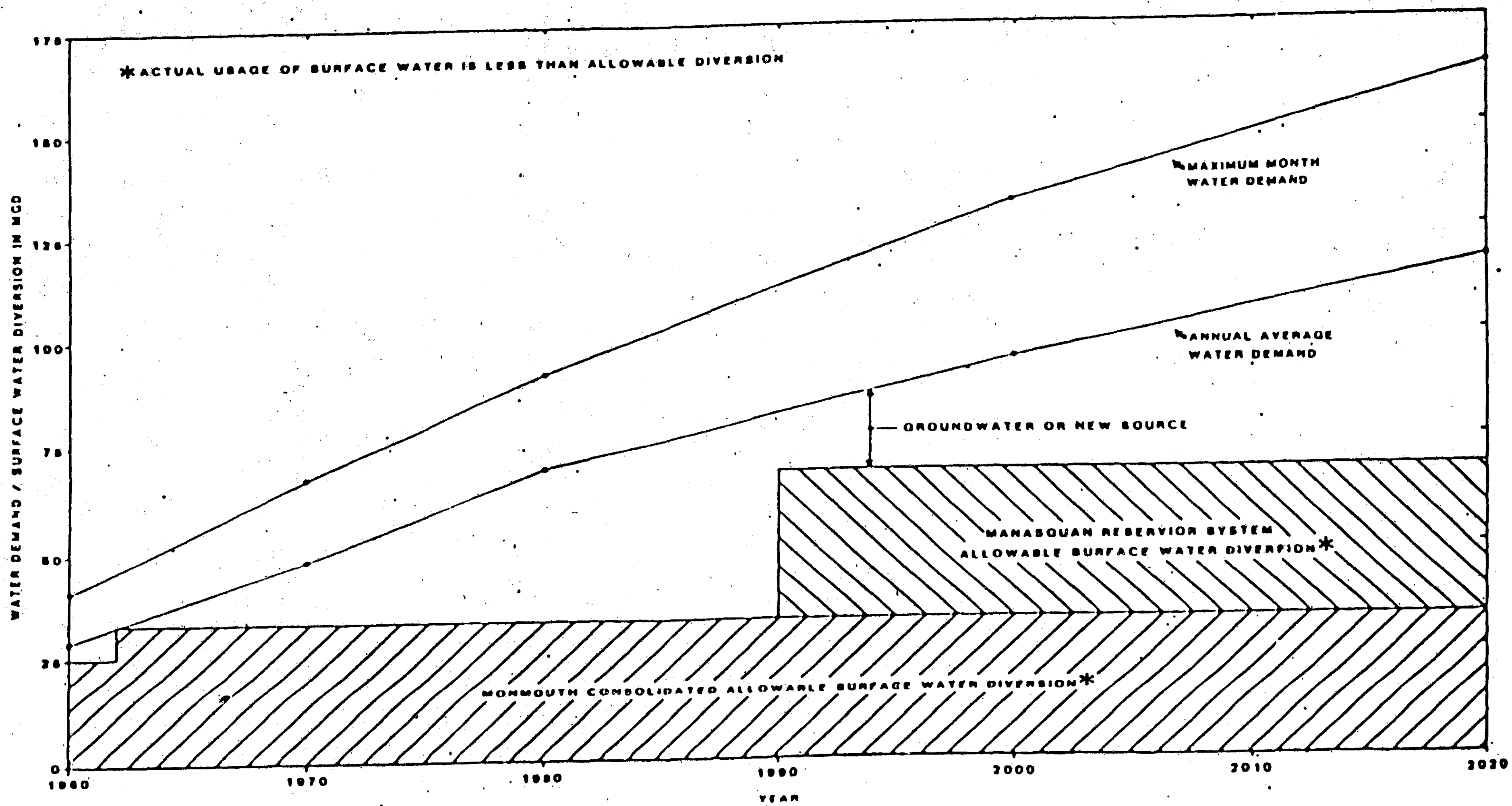


FIGURE 6 WATER DEMANDS AND SURFACE WATER DIVERSIONS

FIGURE 4