## 1.16 WMA 6 - WATER SUPPLY AVAILABILITY

### Introduction

The hydrologic cycle (see Figure 1.16.1) describes the natural movement of water from the atmosphere to the Earth's surface and into surface and ground water systems. The simplified "natural" water budget equation can be written as:

$P = I + ET + R$ where;

$P$ = precipitation
$I$ = infiltration below root level
$ET$ = evapotranspiration
$R$= direct surface runoff

Managing water supply availability on a watershed basis requires that the water budget equation is expressed to account in more detail for "artificial" or man-made withdrawals of surface and ground water from the natural system, changes in storage of surface and groundwater reservoirs, and also the disposition of wastewater (effluent) (see Figure 1.16.2). Simplified, on an annualized basis, the modified water budget can be written as:

$$P + I_{GW} + I_{IW} + I_{SS} + I_{GS} = ET + O_{SW} + O_{GW} + O_C + O_D + O_{SS} + O_{GS}$$ where;

$P$ = precipitation
$I_{GW}$ = regional groundwater flow into the watershed
$I_{IW}$ = imported water supply
$I_{SS}$ = decreased surface water storage, i.e., lowering reservoirs, draining wetlands.
$I_{GS}$ = decreased groundwater storage by depleting or mining groundwater

$ET$ = evaporation from all surfaces plus plant transpiration
$O_{SW}$ = total streamflow leaving the watershed
$O_{GW}$ = groundwater flow out of the watershed
$O_C$ = within watershed consumptive uses (excluding ET)
$O_D$ = depletive use (transfer out of the watershed)
$O_{SS}$ = increased surface water storage, i.e., raising reservoir levels, flooding wetlands
$O_{GS}$ = increased groundwater storage, i.e., artificial recharge, recharge enhancement

The purpose of this task is to characterize the water supply-side artificial modifications to the water budget to characterize water supply availability related to the Watershed Management Area (WMA). The characterization and assessment contained herein provide baseline information and references on water supply availability for ongoing watershed planning. This information is relevant to the future development of the water budget for the Passaic Basin, to be undertaken by NJDEP.

## Background

To ensure that New Jersey would be able to meet projected future water needs, the Water Supply Management Act and the Water Supply Bond Act (Bond Fund) were approved in 1981. These acts provided a management framework and a $350 million source of funding to evaluate existing water supply and plan accordingly for future growth. In 1982, NJDEP adopted the first New Jersey Statewide Water Supply Master Plan (NJSWSP), as required by the Water Supply Management Act. In 1996, the NJSWSP was completely revised and updated to replace the 1982 Plan.

To improve the NJDEP's ability to characterize and assess water supply availability, the 1996 Plan divides the state into twenty-three Regional Water Resource Planning Areas based upon watersheds. These watershed-planning areas are somewhat different in size and delineation than the current WMA's adopted by the State.

The NJSWSP and supporting documentation is a statewide characterization and assessment of water supply availability, and a substantial amount of the information in this report is drawn from these documents.

## Concepts

There are several concepts related to water supply availability that will be presented throughout this report. An explanation of these concepts and the definitions of frequently used terms are as follows:

- **Diversion –** is the removal of either groundwater or surface water from the natural hydrologic cycle. The NJDEP Bureau of Water Allocation is responsible for granting the privilege to a person to divert over 100,000 gallons per day (gpd) of water for any purpose other than agricultural or horticultural use. The NJDEP maintains extensive databases on water usage. The ability to use full diversions is typically related to satisfying other criteria (e.g., surface water diversion can be limited based upon requirements to maintain a certain stream flow past the diversion – **passing flow**).
- **Depletive Water Use –** "surface or ground water withdrawn from a selected watershed and discharged in another watershed. Also referred by others as **out-of-basin transfers** (or inter-basin transfers) and wastewater and water exportations, depletive use has become a significant issue in New Jersey over the last several years as competition for water has increased."[1]
- **Safe Yield From Surface Sources –** means the yield maintainable by a water system continuously throughout a repetition of the most severe drought of record, after compliance with requirements of maintaining minimum passing flows, assuming no significant changes in upstream or upbasin depletive withdrawals.

- **Minimum Passing Flow –** surface water diversions are limited by requirements to maintain a certain stream flow, or passing flow, downstream of the water intake. The New Jersey Department's Bureau of Water Allocation has set these passing flow requirements. Where not specified, statutory minimum passing flow is calculated as 125,000 gallons per square mile of contributing upstream-unappropriated watershed for public water supplies.
- **Dependable Yield of Subsurface Sources –** means that yield of water from a subsurface source or sources available continuously during projected future conditions, including a repetition of the most severe drought of record, without creating undesirable effects. Undesirable effects may include adverse impact on other wells of a depth of 50 feet or more, increased risk of introducing or spreading saline water or polluted water in the aquifer or unacceptable reduction of surface flow of streams. Estimating dependable yield of subsurface sources is a complex undertaking, and for planning purposes is typically established as a percentage of the estimated groundwater recharge (i.e., natural or artificial recharge)

## Characterization of Water Supply Availability in WMA 6

### Types of Diversions and Diversion Summary

The NJDEP Bureau of Water Allocation is responsible for approving requested diversions, and maintains an extensive database of existing withdrawals of water from natural sources. This effort is a balancing act of providing approvals for the benefit of potential users, but at the same time insuring that new diversions do not adversely impact existing users or adversely impact the existing ecosystem.

The New Jersey Geological Survey (NJGS) has extensively researched the Bureau of Water Allocation's database to develop summaries of water diversion based upon different types of use classifications[4]. The NJGS has indicated that there are known errors of assigning diversions to specific watersheds based upon: inaccurate location information; and combined withdrawals from different geographic locations provided as a single location. However, for general planning purposes, the diversion summary is very useful in assessing how water is used within the watershed.

The general use classifications are: public supply; agriculture; irrigation; power generation; mining; industrial; and commercial. Table 1.16.1 (see following pages; use codes are on the fourth page of the table) is a summary of specific water users and total water used, and is given as the average daily withdrawal in millions of gallons per year (MGY) in the time period between 1990 and 2000. The following table indicates percentage of water withdrawn by use group:

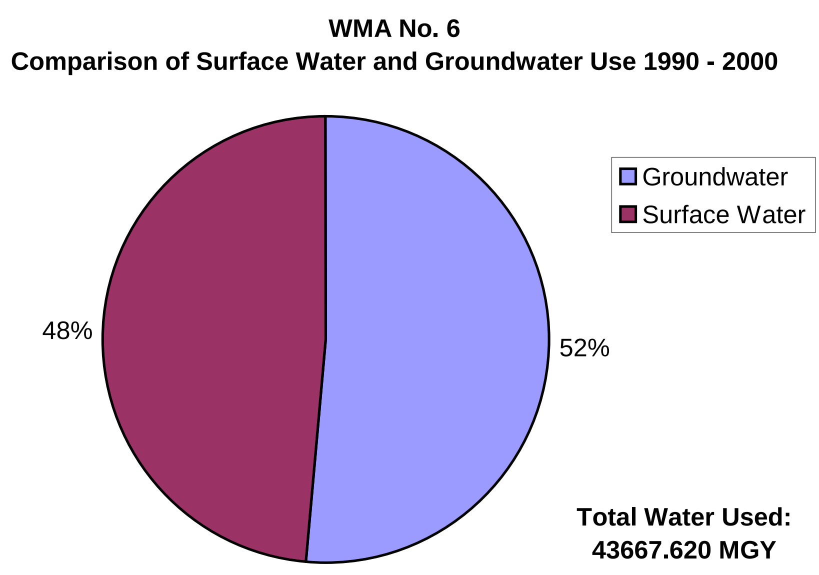
**Table 1.16.2**
**Summary of Average Annual Withdrawals 1990 –2000**
**By Use Group (WMA 6)**

| WMA 6: User Groups | Amount (MGY) | Percent |
|---|---|---|
| Power Generation | 0 | 0 |
| Mining | 121.644 | 0.279 |
| Industrial | 1285.7873 | 2.944 |
| Commercial | 42.531 | 0.097 |
| Public Supply | 42006.442 | 96.196 |
| Irrigation | 206.858 | 0.474 |
| Agricultural | 4.358 | 0.010 |
| **Total** | **43667.620** | |

Table 1.16.2 indicates that over 96 percent of the water withdrawn within WMA 6 (42,000 MGY average), was used for potable water supply purposes. On Table 1.16.1 the records indicate that private home wells have used an average of 1858 MGY between 1990 and 2000. The private home well records was compiled by NJGS using 1990 Census Data that includes information on the number of persons with private water system. A usage of 75 gpd was applied per person and the value was extrapolated proportionately based upon current populations.

### Comparison of Groundwater and Surface Water Diversion

The following chart provides a comparison of groundwater and surface water diversions, on average for the period between 1990 and 2000:



### Potable Water Users and Sources

Diversion of raw water for potable water use is a large component of water diversion within a watershed, and therefore, has a significant impact on watershed planning. Potable water use has additional complexities related to impacts of inter-basin transfers and depletive use on watersheds, diversion rights, and impacts on other water users. The following information characterizes these users and their sources for both surface water and groundwater diversions. The majority of information on water sources was taken from the 1996 New Jersey Statewide Water Supply Plan (NJSWSP) – Task 2 Report "Water Supply Baseline Data Development and Analyses".

#### Surface Water Sources

WMA 6 is comprised of the following subwatersheds (based upon Hydrologic Unit Code Group 11):

| Subwatershed | Area (sq. miles) |
|---|---|
| Whippany River | 70 |
| Passaic River | 154 |
| Rockaway River | 137 |
| Totals | 361 |

It is noted that the Passaic River and Rockaway River subwatersheds are currently used for major surface water supplies. The Clyde Potts Reservoir in the upper portion of the Whippany River subwatershed is an additional supply of surface water in WMA 6.

The following information is specific to those sources and users within the watershed:

- **Boonton Reservoir System –** The 8.1 BG **Boonton Reservoir** is owned by the City of Jersey City, and is filled by the **Rockaway River** and main tributaries (Beaver Brook, Green Pond Brook, and Stony Brook) within a drainage basin of over approximately 119 square miles. The **Splitrock Reservoir** which holds approximately 3.4 BG is part of the reservoir system. The reservoir system and watershed has a safe yield of 56.8 MGD.

- **Clyde Potts Reservoir –** This 400 million-gallon reservoir, maintained by SMCMUA, is located in Mendham Township, and is filled by a small adjacent watershed of Harmony Brook within the Whippany River watershed. This watershed and reservoir has a safe yield of 2 MGD.

- **Passaic River Basin –** The Passaic River supply is used by the New Jersey-American Water Company at their Canoe Brook Water Treatment Plant located in Millburn Township. The Water Company is permitted to divert 11 MGD from

Canoe Brook. The Passaic River diversion is limited to the months of October through May, and also by a minimum passing flow of 75 MGD.

Although the Passaic Valley Water Commission (PVWC) does not have any water intakes physically located within WMA 6, they have a main intake located in WMA 4 just downstream of the WMA 6 and WMA 3 watershed area delineations. PVWC draws approximately 50 MGD from the Passaic River Basin (only a small portion of this water is from runoff within WMA 4), and, therefore, is very dependent upon watershed planning decisions within WMA 6 and WMA 3.

Water supply is provided to WMA 6 via the WaterSource Project through which PVWC transfers finished water from its Little Falls Water Treatment Plant (in WMA 4) upstream to WMA 6. Additional supply is also provided to WMA 6 through interconnections between the New Jersey-American Water System in WMA 6 and the Elizabethtown Water Company in WMAs 7 and 9.

- **Taylortown (Stony Brook) Reservoir –** The Town of Boonton Water Department owns and operates Taylortown Reservoir. Taylortown Reservoir is located north of Boonton in Montville Township. The reservoir has a safe yield of 1.5 MGD, and the allocation is 0.7 MGD.

### Evaluation of Surface Water Use for Potable Supply

Table 1.16.3 provides a summary of important statistical information for the various surface water users in WMA 6:

**Table 1.16.3**
**Summary Statistics on Surface Water Diversion**

| Purveyor | Location | Safe Yield (MGD) | Allocation (MGD) | Diversion Avg. 1990-1999 (MGD) | Diversion Avg 1999 (MGD) | Reservoir Capacity (BG) | Drainage Area (sq. mi.) | Min. Passing Flow (MGD) | Interbasin Transfer (MGD) | Depletive Use (MGD) |
|---|---|---|---|---|---|---|---|---|---|---|
| NJAWC | Canoe Brook WTP - Passaic River | 11 | 11 | 6.2 | 7.3 | 3.1 | 114 | 75 | 24 (1) | 0 |
| Jersey City | Boonton Reservoir System | 56.8 | | 47.8 | 50.9 | 8.1 | 119 | 7 | -48 | 48 |
| SMCMUA | Clyde Potts Reservoir | 2.0 | 4 | 0.8 | 0.3 | 0.4 | <2 | | +2 (2) | 0 |
| Town of Boonton | Taylortown Reservoir | 1.5 | 0.7 | 0.85 | 0.4 | 0.7 | | | 0 | 0 |
| | Totals | 71.3 | | 55.65 | 58.9 | | | | -22 | |

(1) Approximately 12 MGD from Elizabethtown Water Company and 12 MGD from PVWC
(2) From NJAWC, originating at NJDWSC and/or PVWC

**Review of Passing Flow Requirements**

Minimum passing flow requirements for water purveyors are established in NJAC 7:19-4.6 (e), with the following purveyors specified in WMA 6:

**Table 1.16.4**
**Passing Flows**

| Purveyor | Gaging Station | Passing Flow (Cu. Ft./Sec) |
|---|---|---|
| City of Jersey City | Boonton Reservoir | 10.83 |
| New Jersey-American Water Company | Passaic River at Chatham | 116 |
| | Canoe Brook near Summit | 2.12 |
| | Passaic River near Millington | 10.7 |

The code indicates that where passing flow is not specified, it will be fixed by the Department based on an amount equal to the average daily flow for the driest month from records, or in lieu thereof, 125,000 gallons for each square mile of unappropriated watershed above the point of diversion (in addition to flows from any appropriated watershed above the point of diversion).

The code also indicates (NJAC 7:19-4.6 (d), 1) that fees will be paid by purveyors at a minimum charge of $1.00 per million gallons for each million gallons below the passing flow requirement, when the purveyor is diverting water. The maximum charge of $10.00 per million gallons shall apply on those days when the passing flow below the point of diversion is zero.

**Groundwater Sources**

Detailed information of the groundwater sources (aquifers) for WMA 6 is presented in Section 1.8 of this report. Section 1.8 also provides information of the anticipated yield from these aquifers, ranging from poor producing to prolific groundwater, as well as surface water, sources.

Table 1.16.1 provides a summary of the average usage of groundwater, by user, within WMA 6.

**Evaluation of Groundwater Availability for Potable Supply**

In general, groundwater sources are developed for use locally within a watershed. There are instances where regional water purveyors will produce groundwater that is transmitted over longer distances for consumption outside of the local area. The Morris County Municipal Utilities Authority (MCMUA) is an example of a regional water purveyor using groundwater sources. MCMUA has 8 wells located in WMA No. 8 that produce an annual average of approximately 5 MGD. These wells provide small amounts of supply to: Denville; Parsipanny – Troy Hills; Randolph; SMCMUA; Mine Hill;

Roxbury; Jefferson; Mt. Arlington; and NJAWC. Based upon the close proximity of these wells to WMA 6, and considering that aquifer dynamics are not generally confined to watershed boundaries determined by surface topography, this inter-basin transfer can be considered of minor immediate significance.

From available reference material, it was determined that NJGS uses at least two methods for calculating the availability of groundwater within a geographic region (e.g. watershed). Both approaches first estimate groundwater recharge in the area, and then calculate water availability as a percentage of recharge.

In the NJSWSP – Task 2 Report "Water Supply Baseline Data Development and Analyses, the groundwater availability calculation was based upon NJGS' methodology of estimating recharge based upon a recharge rate per physiographic province. In WMA 6 these physiographic provinces and their estimated recharge rates from the NJSWSP are as follows:

| Physiographic Province | Annual Average Recharge (inches) |
|---|---|
| Highlands | 18 |
| Piedmont (Newark Basin) – glaciated | 15 |
| Piedmont (Newark Basin) – unglaciated | 10 |

For the NJSWSP, the State was divided into Regional Water Resource Planning Areas (RWRPA). WMA 6 and WMA 3 were combined in this report as a single planning area designated RWRPA No. 4. It was estimated in this study, that the recharge and available groundwater in RWRPA No. 4 were 471 MGD and 94 MGD, respectively (based on available groundwater as 20 percent of recharge).

Using available GIS datasets, the groundwater recharge and availability was recalculated specific to WMA 6 as follows:

| Physiographic Province | Annual Average Recharge (inches) | Geographic Area (sq. miles) | Average Daily Recharge (MGD) | Available Water (MGD) |
|---|---|---|---|---|
| Highlands | 18 | 166 | 142 | 28.5 |
| Piedmont (glaciated) | 15 | 144 | 102 | 20.6 |
| Piedmont (unglaciated) | 10 | 50 | 24 | 4.8 |
| Totals | | 360 | 268 | 53.6 |

Comparing the available groundwater estimate of 53.6 MGD to the withdrawal calculated by NJGS, from actual water allocation data and private well estimates from census data, of 62.2 MGD indicates a deficit of groundwater supplies in WMA 6. The NJGS has completed detailed studies of the buried valley aquifer systems in WMA 6. Concerns regarding intensive over use of these aquifers in southwestern Essex County and southeastern Morris County provided the impetus for importing water from WMA 4 via the previously mentioned WaterSource Project.

The second methodology for determining groundwater availability as supported by NJGS[5], calculates groundwater recharge based upon land use and soils types. This methodology may yield more significant answers since more specific criteria are used.

Groundwater availability can also be estimated based on trending the water levels in the aquifers during pumping and non-pumping conditions. The Bureau of Water Allocation maintains a database on these levels. The Water Supply Management Act (NJAC 7:19-6.3 (b) 1.) states "A progressive reduction in the potentiometric surface of an aquifer will be considered presumptive evidence that the dependable yield of a subsurface source is less than current withdrawals, subject to acceptable evidence to the contrary."

## Assessment of Water Availability

### Adequacy of Current Supplies for Current Demands

A summary of current surface water and groundwater demands compared to surface water supply capacity and estimates of groundwater availability are provided in the following table:

**Table 1.16.5**
**Surface Supply and Demands Comparison**

| Water System | Available Surface Supply (MGD) | Current Surface Demand (MGD) | Surface Supply/Deficit (MGD) | Estimated Ground Supply (MGD) | Current Ground Demand (MGD) | Ground Supply/Deficit (MGD) |
|---|---|---|---|---|---|---|
| | | | | | | |
| NJAWC | 11 | 7 | +4 | | | |
| SMCMUA | 2 | 0.5 | +1.5 | | | |
| Jersey City | 57 | 50 | +7 | | | |
| Boonton | 1.5 | 0.9 | +0.6 | | | |
| | | | | | | |
| All Groundwater Systems | | | | 54 | 62 | -8 |

The table indicates that current surface supplies are capable of providing supply, however, there is limited spare surface water supply capacity. The groundwater availability estimating criteria used by NJGS and adopted by the NJSWSP indicate a current deficit of groundwater supplies in WMA 6. Since the estimates are based upon a very general methodology for estimating groundwater supply, much more investigation is required to improve this determination. As mentioned in the previous sections of this report, there are alternate methods for estimating groundwater availability that can be employed.

### Adequacy of Current Supplies for Future Demands

Future demands can be estimated based upon population projections. In the NJSWSP Task 3 Report – Development and Projection of Water Demands and Comparison to Net Available Water, population projections were provided by Regional Water Resource Planning Area (RWRPA). The Rutgers University, Center for Urban Policy Research (CUPR) is cited as a source of population projections.

WMA 6 and WMA 3 combine to form RWRPA No. 4, and the population projections for RWRPA No. 4 were estimated by NJSWSP as follows:

| RWRPA | Year 2000 | 2005 | 2010 | 2020 | 2030 | 2040 |
|---|---|---|---|---|---|---|
| No. 4 | 693,013 | 698,327 | 703,627 | 711,587 | 720,378 | 729,360 |

This table indicates a moderate growth of approximately 5.2 percent increase in population in the next 40 years.

Population projections recently developed by the New Jersey Department of Labor, Division of Labor Market & Demographic Research as part of the department's economic and demographic projections series, indicate the following population growth within Morris County

**Table 1.16.6**
**Population Forecast (New Jersey Department of Labor)**

| County | Est. 1998 | 2005 | 2008 | 2010 | 2015 |
|---|---|---|---|---|---|
| Morris | 470,700 | 500,500 | 512,500 | 520,600 | 545,500 |

This indicates a much more dramatic increase in population with WMA 6 of almost 16 percent by the Year 2015.

It is noted that these population estimates do not account for water needs for the City of Jersey City.

### Proposed Projects to Provide Additional Water

The NJSWSP recommended consideration of capital projects such as new interconnections within the region and with adjacent management areas (such as the Raritan Basin), sharing a Hudson River project with New York City (if initiated), increasing the size of existing storage facilities, constructing new storage facilities (including ASR systems in buried valley aquifers), and direct and indirect wastewater re-use. Among the management initiatives to be evaluated are programs aimed at modifying demand and improving operations, such as water conservation, improved drought rule curves, depletive use reduction programs, and improved coordination among presently interconnected purveyors. In addition, it was recommended that a detailed simulation model be developed of the Passaic and Hackensack Rivers that evaluates the region's storage facilities' capability to withstand various drought conditions and changing demand scenarios. The model would include a means for assessing groundwater diversions and wastewater flows in the region in order to properly model available water resources[5].

**Conclusions**

The majority of surface water utilized for water supply developed within WMA 6 is utilized for out-of-basin purposes. This includes the Boonton Reservoir System that provides the City of Jersey City with approximately 50 MGD. In addition, stream flow passed through WMA 6 supports downstream environmental flow and water supply allocation requirements.

The characterization and assessment indicated that surface water supplies have almost been maximized, and projected growth (both in and out of the basin) would require additional infrastructure projects or alternative water sources.

The groundwater characterization and assessment indicates a variety of groundwater sources that vary from low producing to prolific. Comparing current and projected groundwater withdrawals to estimated groundwater availability, there is evidence to suggest a growing groundwater deficit. This is an area that requires significantly more investigation and improved methods of estimating groundwater availability and evaluating the interrelationship between groundwater and surface water availability.

**Planning Issues**

The NJSWSP Task 4 Report - Preliminary Development of Water Supply Initiatives (Chapter 5)[7] includes a section on issues related to the RWRPA's. The task report provides an excellent summarization of these issues, and should be referred to for additional information. A summary of these issues and their magnitude of importance, as indicated in the Task Report, is provided in the following table:

**Table 1.16.7**
**NJSWSP - SIGNIFICANT PLANNING ISSUES FOR RWRPA NO. 4**

| ISSUES | IMPORTANCE | EXISTING PROBLEM | POTENTIAL PROBLEM |
|---|---|---|---|
| Supply Contamination & Treatment Requirements | High | Medium | High |
| Salt Water Intrusion | Low | Low | Low |
| Protection & Augmentation of Aquifer Recharge | High | High | High |
| Impacts of Utilization of Shallow Aquifers | High | Medium | High |
| Baseflow Reductions to Reservoir Streams or Waterways | Medium | Low | High |
| Low Flow Augmentation | Medium | Low | Low |
| Passing Flow Requirements | High | Low | High |
| Depletive Use | High | High | High |
| Strict Enforcement of the Municipal Land Use Law | Low | Medium | Medium |
| Demographics | Low | Low | Low |
| Facility Sources | Medium | Medium | Medium |
| Source Over-Allocation | High | Medium | High |
| Regionalization | High | Low | High |
| Deficit Quantification | High | High | High |

The information contained in the table is generally consistent with information provided in this report.

Additional issues of concern that should be addressed in the watershed planning process include:

- Surface water system yields are dependent upon groundwater systems for baseflow to the streams and this must be considered when planning new groundwater sources to determine their impact on surface water systems. New groundwater sources also impact adjacent, existing groundwater sources.

- Innovation in the form of engineered environmental solutions must be reviewed. For example, direct groundwater recharge using wastewater treatment plant effluent must be evaluated. Direct groundwater recharge must be evaluated considering the impact to downstream purveyors, both in terms of quantity of water and quality of water. Innovation through using "gray water" wastewater treatment plant effluent as a source of irrigation within the watershed (e.g., golf courses).

- The methodology for determining future groundwater availability through estimates of recharge needs continued refinement.

- New developments must be engineered to minimize adverse impacts to groundwater and surface water systems. New developments that require additional water sources at the same time reduce available water by increasing impervious area in the watershed and channeling stormwater runoff directly to streams instead of allowing natural recharge.

- The information that has been collected by various agencies that is useful to watershed planning must be continuously refined. For example, the Bureau of Water Allocation database must be updated with accurate coordinate locations of water withdrawals so this information can be incorporated into GIS analysis. This will also require that some permits that cover more than one geographic location be separated into the required individual permits. Furthermore, the Bureau should enforce reporting of withdrawals from the individual sources, and not as "combined" withdrawals that cover all withdrawals contained in the permit.

- GIS has become a very effective tool for watershed planning. Additional efforts are required to develop sophisticated GIS watershed models specific and calibrated to the individual watersheds.

**References**

[1] N.P. Zripko, A. Hasan, NJDEP, Depletive Water Use Project for Regional Water Resource Planning Areas of New Jersey, July, 1994

[2] N.J. Geological Survey Digital Geodata Series DGS01-2, September 2001

[3] N.J. Geological Survey Report GSR-32 (Charles and others, 1993)

[4] NJIT, R. Dresnack, E. Golub, F. Salek, Safe Yield Study of Proposed Project to Provide Addtional Water to Northeast New Jersey, July 1984

[5] New Jersey Department of Environmental Protection, 1996. New Jersey Statewide Water Supply Plan – with Appendices and Task Reports