BEFORE THE PUBLIC SERVICE COMMISSION

OF THE STATE OF DELAWARE

IN THE MATTER OF THE COMMISSION'S INVESTIGATION OF THE WATER SUPPLY AVAILABLE TO COMMISSION REGULATED WATER UTILITIES DURING THE DROUGHT OF 2002 (OPENED NOVEMBER 19, 2002)	)))))	PSC DOCKET NO. 323-02

ORDER NO. 6374

This 16th day of March, 2004, the Commission determines and Orders the following:

1. During the prolonged drought of 2002, questions were raised in the public press whether one, or both, of the two non-municipal water utilities[1] serving northern New Castle County had made reasonable provisions to ensure that they had adequate water supply available to them during such a dry spell. To determine the validity of such allegations, the Commission opened this proceeding and directed its Staff to investigate and report whether the two jurisdictional water utilities did, or did not, have adequate supply available to them during the 2002 drought. PSC Order No. 6068 (Nov. 19, 2002). The inquiry was to have both backward and forward-looking facets: it was first to look back to determine what supply was actually available to the utilities in 2002 and then suggest what might be needed – on a going forward basis - to ensure that adequate supply is available to meet future demand in the area. Id. at ¶¶ 4-6.

[1]Artesian Water Company, Inc. ("Artesian") and United Water Delaware Inc. ("UWD") are the two water utilities serving northern New Castle County that are subject to this Commission's regulatory jurisdiction.

2. At the Commission's meeting on February 9, 2004, Staff submitted a final Report setting forth the results of its investigation. See "Investigation of Water Supply Availability in Northern New Castle County, Delaware During the Drought of 2002," Final Report (Feb. 2004) ("Staff Report").[2] As to the drought of 2002, the Staff Report's bottom line is that the earlier allegations of inadequate supply lacked factual basis. The Staff Report says that the two Commission-jurisdictional utilities had, or had access to, adequate supply during the drought period.[3] Artesian and UWD have reviewed the Staff Report's findings and conclusions concerning the supply available to them during the 2002 drought. Neither has suggested that the final Staff Report makes any material errors related to their past performance. Consequently, the Commission does not believe that there is any reason to continue this investigation as it relates to the utilities' capabilities to meet demand during the year 2002. The Report is now available to those who, in 2002, posed questions whether one or both of these utilities were adequately positioned.

3. The investigation launched by Order No. 6068 also had a forward-looking component: to explore what should be done to ensure

[2]Staff's Report was prepared using the consultative services of the Parsons Infrastructure and Technology Group. The Commission considered an earlier draft of Staff's Report at its meeting on December 23, 2003. At that time, the Commission also heard presentations by Staff, the two affected utilities, and the Division of the Public Advocate. The Public Advocate also submitted his own "Final Report." See "Final Report Prepared for the Delaware Division of the Public Advocate" (Howard J. Woods, Jr. & Assocs., LLC, (Dec. 15, 2003). The Staff Report, in its final version, emerged after some further discussions between these participants.

[3]See, e.g., Staff Report at ES-5 to ES-6 (Artesian), ES-8 to ES-9 (UWD).

reasonably adequate supply will indeed be available during future periods of drought in the drought-sensitive area of northern New Castle County. PSC Order 6068 at ¶¶ 5-6. The Staff Report provides several insights and recommendations concerning what might assist in assuring such adequate future supply.[4] However, the Commission finds that it is not necessary for the Commission to now undertake any further proceedings to determine whether it is appropriate to translate those insights and recommendations into enforceable regulatory directives. After the Commission entered Order No. 6068, the General Assembly and the Governor enacted the "Water Self-Supply Sufficiency Act of 2003."[5] That Act sets up an obligation, beginning in the year 2006, for each of these jurisdictional water utilities to certify to this Commission, on a regular periodic basis, that it has available adequate supply (even during specifically defined drought conditions) to meet demand in northern New Castle County.[6] Under the Act, if the Commission might eventually find that a jurisdictional water utility will not have adequate supply available, the Commission can then direct that utility to develop new sources and, until it does so, withhold permission for further expansions by that utility.[7] The Commission believes that the provisions of the Act lifts the

[4]For example, see Staff Report at ES-2 through ES-5, ES-7 to ES-8 (Artesian), ES-10 to ES-11 (UWD).

[5]74 Del. Laws ch. 179 (July 8, 2003), codified as 26 Del. C. §§ 1401-1408 (2003 Supp.).

[6]See 26 Del. C. § 1404(a)(2), (d) (2003 Supp.).

[7]See 26 Del. C. § 1404(i) (2003 Supp.). This authority is available only after the utility has had the opportunity to procure additional supply for use during the projected year. See 26 Del. C. § 1404(f)-(h) (2003 Supp.) (discussing Commission review of a utility's adequate supply certification).

imperative for this Commission to now adopt in this proceeding its own forward-looking directives related to future water supply for northern New Castle County.

4. The Commission recognizes that the first certification under the Act, although to be filed in 2006, will apply to demand and available supply for a "projected year" several years thereafter. However, the Commission believes - given the Staff Report's conclusion that Artesian and UWD had adequate supply available in 2002 - that there is a reasonable probability that such adequacy will prevail until the first projected year. Indeed, the fact that an officer of each utility will have to certify to adequate supply in 2006 provides some assurance that these utilities will soon (if they are not doing so now) be examining their supply resources to make sure they are capable of meeting even the most voluminous demand over the upcoming years. Of course, if facts later emerge that a shortfall in supply looms during this "interim" period, the Commission stands ready to intervene (prior to the Act's first projected year) to make sure these utilities meet their present statutory obligation to provide sufficient and adequate utility services.

5. The Commission also recognizes that it will likely be called upon to interpret, and implement,[8] several of the provisions in the Act. In fact, the Staff Report identifies one such interpretive dispute that might arise. See Staff Report at 4.7.1 at pp. 4-14. However, the Commission need not resolve such interpretive questions

[8] See 26 Del. C. § 1408 (2003 Supp.).

now. In fact, some may be more appropriately addressed in a rule-making procedure to implement the details of the Act's provisions.

6. The Commission does not formally adopt the Staff Report and, therefore, does not make its findings legally binding. However, this does not mean that the Staff Report should be ignored. The Commission believes that the Staff Report provides a thoughtful appraisal – both backward and forward-looking – concerning the crucial issue of how to ensure adequate water supply for northern New Castle County. Its insights and recommendations should be carefully considered by the utilities and others involved in ensuring such supply. Moreover, the Staff Report provides a good contextual platform for considering questions that might arise in future proceedings.

Now, therefore, **IT IS ORDERED:**

1. That, for the reasons set forth in the Body of this Order, the Commission acknowledges the Report entitled "*Investigation of Water Supply Availability in Northern New Castle County, Delaware During the Drought of 2002"* submitted by Staff on February 9, 2004. A copy of such Report shall be filed with the original of this Order.

2. That, for the reasons set forth in the Body of this Order, the investigation instituted by PSC Order No. 6068 (Nov. 19, 2002) is hereby terminated. This docket is closed.

3. That the Commission reserves the jurisdiction and authority to enter such further Orders in this matter as may be deemed necessary or proper.

BY ORDER OF THE COMMISSION:

/s/ Arnetta McRae
Chair

/s/ Joshua M. Twilley
Vice Chair

/s/ Joann T. Conaway
Commissioner

/s/ Donald J. Puglisi
Commissioner

/s/ Jaymes B. Lester
Commissioner

ATTEST:

/s/ Karen J. Nickerson
Secretary

INVESTIGATION OF WATER SUPPLY AVAILABILITY IN NORTHERN NEW CASTLE COUNTY, DELAWARE DURING THE DROUGHT OF 2002

FINAL REPORT

Prepared for:

DELAWARE
PUBLIC SERVICE COMMISSION

Prepared by:

Parsons

February 2004

EXECUTIVE SUMMARY

During much of 2001 and 2002, drought conditions prevailed throughout the mid-Atlantic region of the U.S. Based on meteorological and hydrologic conditions, a new "drought-of-record" was established in some areas, including the area of New Castle County, Delaware north of the Chesapeake & Delaware Canal. Beginning in mid-2001, significant precipitation deficits began to accumulate throughout northern New Castle County (NNCC), ultimately reaching an accumulated deficit of 12.73 inches at the New Castle County Airport for the period October 2001 through September 2002 – the lowest annual precipitation since record-keeping began in 1894. During this period, the Delaware Geological Survey's Water Conditions Index for NNCC showed record low indices during 6 of 14 months over the period from August 2001 through September 2002. The region's primary source of surface water supply, Brandywine Creek, exhibited record low daily flow averages for the months of July, August, and September 2002. An all-time record low flow of 21 million gallons (mg) was observed on Brandywine Creek at Wilmington on August 23, 2002. Analyses conducted on behalf of the Delaware Water Supply Coordinating Council (WSSC) indicate that low-flow conditions on Brandywine Creek during 2002 were statistically a 100-year event, which means these conditions have a 1 percent chance of recurrence in a given year. Similar record or near-record low flow conditions were also observed on other streams in NNCC (*i.e.*, White Clay Creek and the Christina River).

On March 5, 2002, Delaware Governor Ruth Ann Minner declared a statewide Drought Warning and urged water users to voluntarily adopt water conservation practices. At the recommendation of the Governor's Drought Advisory Committee, Governor Minner declared a Drought Emergency for NNCC on August 2, 2002, imposing mandatory restrictions on certain water uses (*e.g.*, lawn watering, car washing, *etc.*). With improving hydrologic conditions, the Governor rescinded the Drought Emergency for NNCC on October 11, 2002. The statewide drought warning was terminated in January 2003.

At the conclusion of the drought of 2002, the Delaware Public Service Commission (DPSC) issued Order No. 6068 (PSC Docket No. 323-02) initiating an investigation focused on determining the amount of water supply that was available to the Artesian Water Company, Inc. (Artesian), and United Water Delaware Inc., (United) to meet customer water demands: (a) during the drought period from March 5, 2002 to October 11, 2002 (the drought period); and (b) over the next 5 years. Subsequently, the DPSC contracted with Parsons to conduct an investigation of the adequacy of water supplies available for use by Artesian and United within their service areas in Northern New Castle County (NNCC), Delaware. The scope of the investigation included consideration of both current and future water supply conditions and requirements and was also intended to confirm that the two utilities complied with their responsibilities during the drought of 2002 and that they have the ability to "provide

efficient, sufficient and adequate" supply for customers within NNCC during future drought conditions.

The key findings, conclusions, and recommendations of the Parsons project team are presented below.

Regional Water Supply Planning in NNCC

The information reviewed for this investigation clearly demonstrates that the NNCC region was well prepared for the drought of 2002, having learned important lessons from previous droughts in 1995 and 1999 and having taken action to develop or make available additional water supplies and to further improve regional water supply security. With new water supplies slated to come online by the summer of 2004 (*e.g.*, the City of Newark's new reservoir), the region appears to be even better prepared to cope with a future recurrence of severe drought conditions.

The NNCC area has made major advances in regional water supply planning and in development of additional water supplies since 1999. Under the auspices of the WSCC, major water suppliers in the region have or will soon complete projects that will increase the amount of water available during drought conditions by nearly 1.1 billion gallons (bg). Over a 75-day drought period, this represents approximately 14.6 million gallons per day (mgd) of new supply capacity. Additional projects are under consideration that will further increase supply by 471 to 1,020 mg (6.3 to 13.6 mgd).

Additionally, recently enacted legislation – the Water Supply Self-Sufficiency Act of 2003 (HB 118) – establishes new requirements to ensure that water utilities in NNCC "…have adequate supplies of water available, even in times of drought, to meet the present and future needs of this State on a continuing and sustainable basis." Key provisions of the new law include:

- Investor-owned and larger municipal water utilities are required to adopt conservation-oriented water rate structures for residential customers, at a minimum, by 2005.
- By July 1, 2006 and every 3 years thereafter, each NNCC utility is required to submit a water conservation plan for the following 3-year period.
- By July 1, 2006 and every 3 years thereafter, each NNCC water utility is required to certify that it has water supply sources sufficient to meet or exceed projected demand for its service area for the following 3-year period.
- Utilities are required to establish equitable bulk wholesale rates for inter-utility water purchases and each utility is required to provide water, if it has excess capacity, to a drought-sensitive area if necessary.

- Beginning in 2009, NNCC water utilities must certify "…that none of its sources of supply for use during a drought of record are reliant on contracts with out-of-state water authorities or utilities, except for minimum purchase obligations under purchase-water contracts in existence on April 1, 2003 between Delaware water utilities and non-Delaware providers."

Overall, the Parsons project team has been impressed by the high degree of cooperation that has evolved among NNCC water suppliers and with the level of support that has been provided for regional water supply planning. Parsons review of the products of the Governor's Water Supply Task Force and the WSCC, combined with information gleaned from meetings with many of the principals involved in the planning process, strongly supports a conclusion that the regional water planning process for NNCC is based on technically sound analytical methods and assumptions.

The Parsons project team's recommendations for future regional water supply planning follow.

Water Demand Projections

With regard to water demand projections for NNCC, it is recommended that the WSSC consider:

- Extending the planning horizon to 2030;
- The long-term effects of continuing decreases in per capita water use resulting from efficiency improvements in plumbing fixtures and appliances, demographic trends (*e.g.,* smaller household sizes), and housing trends (*e.g.,* more multi-family units, smaller lot sizes); and
- Development of alternative demand scenarios based on different growth rates (*e.g.*, low, high, and "most likely").

Water Supply Availability Estimates

Regarding water supply availability estimates, the WSCC should:

- Re-evaluate current estimates (20.0 mgd) of the amount of groundwater available to Artesian from existing facilities over an extended period (*i.e.*, for 75 consecutive days during a repeat of a drought-of-record);
- Evaluate the long-term sustainability of current rates of groundwater withdrawals in NNCC once the new groundwater availability model is completed;

- Assess the effects of the Water Supply Self-Sufficiency Act of 2003 on the amount of water supply that is available to Artesian from the Chester Water Authority during drought conditions; and
- Once proposed, re-evaluate the amount of water supply available to United from White Clay Creek during drought conditions under a new operating plan for the Tidal Capture Structure.

Water Supply Options

The Parsons project team's recommendations regarding NNCC water supply options include:

Hoopes Reservoir - The Parsons project team believes that additional modeling analyses of strategies for optimization of the water supply yield of Hoopes Reservoir will likely support a conclusion that the project can provide additional supplies without increasing either storage or diversion capacity. Accordingly, it is recommended that further evaluation of physical modifications to Hoopes Reservoir to increase water storage and/or pumping capacity be postponed pending the outcome of DRBC action on a new operating plan for United's Tidal Capture Structure on White Clay Creek. While the amount of flow augmentation required under a modified operating plan for the Tidal Capture Structure has not been determined at this time, it appears likely the amount will be significantly less than the 500 mg the City of Wilmington has committed to other NNCC utilities in its current operating plan for the Hoopes Reservoir. However, the amount may exceed the 200 mg specified in United's current contract with Wilmington. If further analysis reveals a need for flow augmentation in excess of 200 mg during drought, it is recommended that United seek to amend its contract with Wilmington to increase the amount of water reserved for stream flow augmentation from Hoopes Reservoir.

The Parsons project team recognizes that the Hoopes Reservoir is the key to long-term water supply security in NNCC. Should water demands in the region increase substantially or should minimum flow standards be established for Brandywine Creek, or both, modification of the existing pumping capacity and/or increasing the storage volume of Hoopes Reservoir should then be considered "A

List" priority options. It is likely that further analyses of reservoir operations will shed light on the timing and sequencing of future physical modifications to the project when and if conditions warrant. Accordingly, it is recommended that the WSCC sponsor additional modeling studies to evaluate supply optimization strategies for Hoopes Reservoir. Specifically, it is recommended that modeling analyses be performed in four steps:

Step 1: Conduct additional modeling analyses of the reservoir to determine how much additional water can be supplied from the project during a repeat of drought-of-record conditions without increasing pumping or storage capacity. In addition to the simulations performed by the WRA, probabilistic modeling methods should be applied to assess the risks associated with varying levels of increased releases from the reservoir.

Step 2: Conduct modeling analyses using both statistical and probabilistic methods, to determine how to optimize "scalping" of flows from Brandywine Creek and thereby increase the yield of Hoopes Reservoir with modifications to diversion facilities (*e.g.,* increased pumping capacity, variable pumping).

Step 3: Conduct modeling analyses to determine how to optimize the yield of Hoopes Reservoir with increased storage by raising the elevation of the conservation pool in 1-foot increments from 1 to 5 feet.

Step 4: Conduct modeling analyses to determine how to optimize the yield of Hoopes Reservoir both by modifying diversion facilities and by increasing reservoir storage.

Water Conservation – It is recommended that analyses be performed to determine how much additional water conservation could be reasonably achieved through utility-sponsored programs to encourage early replacement of older non-conserving plumbing fixtures and appliances. Such an analysis should quantify the water savings associated with various incentive and/or regulatory strategies and identify the direct and indirect costs of each approach. The analysis should also consider the merits of program implementation strategies at a regional scale. For example, a toilet replacement rebate program could be implemented region-wide by a single entity with funding provided by each participating utility proportionate to its level of participation.

Water Reuse – It is recommended that the WSCC include direct non-potable reuse as a "B List" strategy for further evaluation, at least at a reconnaissance level. The general concept is to use appropriately treated wastewater as a substitute for fresh or potable water supplies for certain uses (*e.g.*, cooling water,

industrial process water, irrigation of golf courses). It is noted that both the City of Wilmington and United supply significant quantities of potable water to commercial and industrial users. It is likely that a significant amount of this demand is associated with "end-uses" that do not require a potable-grade water supply. Accordingly, there is likely to be significant technical potential to increase the effective water supply of NNCC through direct non-potable reuse. Importantly, direct non-potable reuse can also reduce demand on potable water production and distribution facilities, which may extend the capacity of existing facilities for future growth.

Additional Groundwater Development - It is recommended that additional groundwater development in NNCC be deferred pending the completion of modeling analyses of the long-term effects of current rates of groundwater withdrawals.

Artesian Water Company

The Artesian Water Company Artesian currently serves nearly 65,000 customers in a service area that encompasses approximately 100 square miles of NNCC. During 2002, Artesian delivered approximately 6 billion gallons of water in NNCC. At present, approximately 80 percent of Artesian's annual water demand is from self-supplied groundwater, which is produced from 48 wells in 17 well fields in NNCC. Artesian also has 13 interconnections with other water suppliers, which allows it to access surface water supplies, as well as additional groundwater supplies. Artesian currently purchases significant amounts of water from the Chester Water Authority, the City of Wilmington, and the New Castle Municipal Services Commission.

Based on information reviewed for this investigation, the Parsons Project Team concludes that Artesian had sufficient water supply from self-supplied sources (groundwater and ASR) and from water purchases from the Chester Water Authority, the City of Wilmington, and the New Castle MSC to meet customer water demands throughout the 2002 drought period. Daily water production records for the period June through August 2002 demonstrate that average monthly demands on the Artesian system were below the WSCC's estimate of Artesian's currently available water supply of 25.7 mgd (average for maximum month). Furthermore, it appears that Artesian likely would not have had difficulty meeting higher water demand levels that would have occurred had voluntary and mandatory water use restrictions not been in effect.

It is apparent, however, that with curtailment of water deliveries from Chester Water Authority during late July and through August 2002, water purchases from the City of Wilmington and the New Castle MSC took on added importance. This is noteworthy inasmuch as the current WSCC water supply estimates for Artesian do not include

supply from these sources. In recent communication between Artesian and the DPSC, Artesian indicates that it considers 0.7 mgd from the New Castle MSC as a component of its available peak month average day supply. However, Artesian does not consider water purchases from the City of Wilmington as part of its available supply during peak periods even though it obtained significant amounts of water from this source throughout the drought period.

In addition, data provided by Artesian supports a conclusion that it did not experience any undue problems maintaining adequate storage of finished or treated water during the drought period. It was noted by Artesian that no customer complaints of low water pressure were received during the drought period.

Other findings, conclusions, and recommendations with regard to Artesian's performance during the drought of 2002 and with regard to current and future water supply requirements are presented below.

Ability to Meet "Unrestrained" Peak Demands

Based on the WSCC's estimates of Artesian's available water supply from groundwater (20.0 mgd) and ASR (1.7 mgd), it appears it could easily have met an "unrestrained" maximum month demand condition (*i.e.,* 25.0 mgd), provided that supplemental water supplies of approximately 3.3 mgd were available throughout the peak demand period through Artesian's interconnections with other utilities. During the 2002 drought period, Artesian maintained 12 interconnections with other NNCC water utilities and one interconnection with an out-of-state water supplier. Combined, these interconnections gave Artesian the ability to purchase approximately 14 mgd during peak demand periods. Up to 11.0 mgd can be obtained under Artesian's existing agreements with the Chester Water Authority (6.0 mgd) and the City of Wilmington (5.0 mgd). However, water deliveries from both of these suppliers are subject to full or partial curtailment during emergency conditions. During late July and through August 2002, Artesian's water purchases from Chester Water Authority were reduced to approximately 2.0 mgd to comply with mandatory pro rata curtailments imposed on all Authority customers. Accordingly, under an unrestrained peak demand scenario with only 2.0 mgd available from the Authority, Artesian would still have had approximately 10 mgd of supplemental peaking capacity through its interconnections with other utilities. The only scenario under which Artesian would have had a problem satisfying unrestrained peak demands would be the simultaneous curtailment of all water deliveries from the Authority and curtailment of all water deliveries from the City of Wilmington. Given the very high degree

of reliability of the City of Wilmington's water supplies, this is considered to be a very unlikely scenario.

Water Demand Projections

In light of the observed effects of voluntary water conservation during the 2002 drought period and the potential for continued growth in Artesian's customer base and water demands, it appears prudent to re-evaluate the WSCC's demand projections for Artesian. It is therefore recommended that projections for maximum month demand on the Artesian system be re-evaluated and revised if appropriate to reflect: 1) an updated estimate of current "unrestrained" maximum month water demand; and 2) alternative growth scenarios through 2020.

Water Supply Availability

The water supply availability estimates adopted by the WSCC in its Fifth Report indicate that Artesian's current water supply from all sources is 25.7 mgd – 20 mgd from groundwater, 4.0 mgd from Chester Water Authority, and 1.7 mgd from ASR. Based on the data and information reviewed during this investigation, it appears these estimates should be re-evaluated and adjusted, if appropriate, to reflect: 1) a lower estimate of the amount of groundwater that can be produced on a sustained basis over a 75-day drought period; and 2) new State statutory limits on the amount of water supply that Artesian can consider as available from the Chester Water Authority during a repeat of drought-of-record conditions.

Water Supply Options

The Parsons project team concurs with Artesian's overall approach to water supply development and management, that is, to expand conjunctive management and use of groundwater and surface water resources. Current plans have Artesian developing an additional 2.0 mgd (150 mg for 75 days) of ASR capacity, which will require the company to purchase 375 mg/year of surface water under its existing contracts with the City of Wilmington and Chester Water Authority.

Assuming the WSCC's current water supply and demand analysis for Artesian is accurate, the amount of additional ASR capacity proposed by Artesian will provide sufficient water supply

(25.7 mgd) to meet projected maximum month water demands through the current planning period (27.1 mgd in 2020). However, if the current water supply availability estimate for groundwater is reduced, the potential additional yield from ASR may only serve to offset that reduction. Furthermore, if the current estimate of water supply availability is also reduced by as much as 2.0 mgd to reflect reduced availability of water from Chester Water Authority beginning in 2009, Artesian will show deficits of 2.3 mgd in 2010 and 3.4 mgd in 2020. Also, if re-evaluation of the WSCC water demand projections for Artesian results in higher projections for 2010 and 2020, the projected deficits will be even larger.

Should the recommended re-evaluation of the water supply and demand analysis for Artesian result in projected water supply deficits, it would appear that Artesian has several potentially viable options for increasing its available water supply including:

- Additional water conservation;
- Additional groundwater development, if modeling analyses indicate that additional supplies are available within NNCC; and
- Additional purchases of treated water from other NNCC utilities.

United Water Delaware

United currently provides water service to about 35,000 customers (105,000 people) within a 55 square mile service area in NNCC. During 2002, total water demand on the United system was approximately 7.5 billion gallons (20.5 mgd). Approximately 49 percent of this demand is for residential and commercial uses and 40 percent is for industrial uses.

United's primary source of water supply is from the White Clay Creek, from which it has the capacity to divert and treat up to 30.0 mgd. United also operates a smaller water plant (6.0 mgd capacity) on the Christina River. In addition, United operates a well at the Christina WTP with a capacity of approximately 0.25 mgd. Groundwater from this well is withdrawn as needed and blended with surface water from the Christina WTP to reduce chloride concentrations.

During low flow periods, the quality of United's water supply from White Clay Creek is prone to increasing chloride concentrations due to upstream migration of tidally-influenced brackish water. The engineered solution was development of a Tidal Capture Structure (TCS), which consists of an expandable water-filled bladder that inflates at peak high tide to impound and hold the tidally supplied fresh water. During low flow periods, the inflatable bladder is operated twice daily at high tide, which maintains the depth of water at the Stanton WTP intake. It has been estimated that the operation of the TCS provides a firm supply of approximately 14.0 mgd to the Stanton WTP (7.0 mgd for each tidal cycle). In addition, the TCS can be operated in a fashion to control the migration of high chloride water from the downstream incoming tidal prism.

United also has existing agreements with the City of Wilmington for the purchase of both raw and treated water. Raw water is supplied from the Hoopes Reservoir to augment flows in White Clay Creek during low flow periods. Treated water is provided through existing interconnections with the City of Wilmington. United also has the ability to obtain treated water from the Chester Water Authority through its interconnections with a sister company, United Water Bethel in southeastern Pennsylvania.

Based on information reviewed for this investigation, the Parsons project team concludes that United had sufficient water supply from self-supplied sources and from purchases of both raw and treated water from the City of Wilmington to meet customer water demands throughout the 2002 drought period. Daily water production

records for the period June through August 2002 demonstrate that average monthly demands on the United system were below the WSCC's estimate of United's currently available water supply of 26.0 mgd (average for maximum month) under a "no flow standard" scenario for White Clay Creek.

Furthermore, it appears that United likely would have been able to meet higher water demand levels that would have occurred had voluntary and mandatory water use restrictions not been in effect. If for example demand on the United system had been 5 percent higher on average during July 2002 (the maximum month for 2002) average monthly demand would have been approximately 26.4 mgd, or about 0.4 mgd greater than the WSCC's estimate of United's available water supply. Satisfying this additional demand would have required United to purchase somewhat greater amounts of raw water from Hoopes Reservoir or from existing treated water interconnections with the City of Wilmington and the Chester Water Authority. This should not have posed a problem as the existing agreements with these water suppliers would have allowed United to obtain the additional supplies required to meet unrestrained maximum month water demands.

Information and data provided by United also support the conclusion that the company did not experience any undue problems maintaining adequate storage of finished or treated water during the drought period. The data indicate that treated water storage volumes exhibited fluctuations normally expected during the summer months when daily water demands reach peak levels. There were no reports of low water pressure or major equipment failures during the drought period.

Other findings, conclusions, and recommendations with regard to United's performance during the drought of 2002 and with regard to current and future water supply requirements are presented below.

Ability to Meet "Unrestrained" Peak Demands

Based on the WSCC's estimates of United's available water supply from surface water sources (26.0 mgd), it appears that United would not have had a problem meeting an "unrestrained" peak demand condition of approximately 29.0 mgd, provided that supplemental water supplies of approximately 3.0 mgd were available through United's existing interconnections with other utilities. During the 2002 drought period, United maintained three interconnections with other NNCC water utilities and one interconnection with an out-of-state water supplier (Chester Water Authority). Combined, these interconnections gave United the ability to purchase approximately 5.0 mgd during peak demand periods - up to 0.5 mgd directly from the Authority, up to 1.5 mgd from the Authority through United's

interconnection with United Water Bethel, and up to 3.0 mgd from the City of Wilmington.

Water Demand Projections

During the drought of 2002, United's actual maximum month (July 2002) demand was 25.1 mgd. However, this amount includes wholesale water sales to the City of Newark which averaged 1.8 mgd during July 2002. As the City of Newark will soon discontinue water purchases from United once the City's new reservoir is operational, the average demand on the United system for July 2002 can be reduced by 1.8 mgd to 23.3 mgd. If one then assumes that a 5 percent reduction in water demand occurred as a result of voluntary water conservation, then United's average demand for July 2002 would have been approximately 24.5 mgd or about 2 percent higher than the WSCC estimate of current maximum-month demand. While this maximum month demand level is well below the WSCC estimate of available water supply (26.0 mgd) under a "no minimum stream flow" scenario, the Parsons project team believes it would be prudent for United and/or the WSCC to re-evaluate projections of United's unrestrained maximum month demands.

Water Supply Availability

Under current regulatory conditions, United has adequate water supply available to meet all water demands during drought conditions from both self-supplied sources and through contractual purchases. Had United not been able to obtain a waiver of the pass-by requirement at the TCS, it would have needed approximately 586 mg of water from Hoopes Reservoir during 2002. While this amount is in excess of the 200 mg reserved by United, analyses indicate that the reservoir could have supplied this amount without undue risk of shortage. Reservoir releases of this volume of water would require agreement by the City of Wilmington to modify the current operating plan for Hoopes Reservoir and agreement to amend its current contract with United. However, it appears likely that modification

of the DRBC pass-by requirement as proposed by United will obviate the need for changes in either the reservoir operating plan or the existing contract.

If, however, minimum stream flow standards are established for Brandywine Creek at Wilmington, United will not be able to obtain enough water from Hoopes Reservoir to meet its needs and meet the current pass-by requirement at the TCS. If a 7Q50 standard were established for Brandywine Creek, the City of Wilmington would only be able to supply about 64 percent of United's total stream flow augmentation requirement. Under a 7Q10 standard for Brandywine Creek, the City of Wilmington would not be able to supply any water to United from Hoopes Reservoir and it would also experience a significant shortage.

Water Supply Options

United is currently in the process of developing a new TCS operating plan based on an approach that focuses on chloride management and avoidance of ecological damage that might be caused by de-watering White Clay Creek below the TCS. Considering the available ecological information, the Parsons project team considers this to be a reasonable approach and serious consideration should be given to modifying the DRBC pass-by requirement accordingly. Modification of the TCS Operating Plan to reflect the new approach would likely give United most of the 20 mgd supply shown for Scenario 1 in the WSCC's current supply and demand analysis. Under these conditions, United's existing agreement with Wilmington to purchase up to 200 mg from Hoopes Reservoir for augmentation of flows in White Clay Creek should be adequate for the foreseeable future, both for chloride management and for protection of ecological resources downstream of the TCS.

Although still in the planning stage, United plans to locate and develop an ASR well in its River Road service area just north of the C&D Canal. If feasible, the proposed project will store and recover approximately 225 mg per year of surface water by the year 2004, which would provide up to 3.0 mgd of additional water supply to United during drought. Given that there are "excess" flows in White Clay Creek during most of a typical year, the Parsons project team is supportive of United's plans to develop ASR facilities to optimize the use of this surplus water supply.

During the drought of 2002, United's agreements with the City of Wilmington for both finished water and raw water were essential to United's ability to meet all of the demands on its system. Since Wilmington proved to be a reliable source of treated water supply during the drought, United has undertaken projects aimed at improving its interconnections with the City. In addition, United is seeking further interconnections that will allow United to purchase up to 10 mgd of treated water from Wilmington. Also, United is discussing the possibility of an interconnection with Delaware City. The connection would allow two-way water transfers, but could only provide minimal support to United during times of

drought. The Parsons project team concurs with United's stated intent to increase purchases of treated water from other utilities.

It is recommended that an assessment of the potential costs and benefits of a more aggressive water conservation program be performed to determine the amount of additional water savings that could be achieved realistically within United's service area. The analysis should consider likely customer participation rates and the direct and indirect (reduced water sales) costs of program implementation. As noted previously, consideration should also be given to assessing the efficacy of regional program implementation strategies for replacement of older non-conserving plumbing fixtures and appliances.

Currently, approximately 40 percent of United's demand is from commercial and industrial users. Consequently, it is likely that significant amounts of that demand are for non-potable uses, such as process water used in manufacturing and cooling water. It is therefore recommended that direct non-potable reuse be evaluated, at least at a reconnaissance level, as a future water supply option for United.

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ACRONYMS AND ABBREVIATIONS

Artesian	Artesian Water Company, Inc.
ASR	Aquifer storage and recovery
AWWA	American Water Works Association
BCCE	*bis* (2-chloroethyl) ether
bg	Billion gallons
C&D	Chesapeake & Delaware
DAC	Drought Advisory Committee
DDNREC	Delaware Department of Natural Resources and Environmental Control
DPSC	Delaware Public Service Commission
DRBC	Delaware River Basin Commission
EDR	Electrodialysis reversal
gpcd	gallons per capita per day
gpd/ft.	Gallons per day per foot
gpm	Gallons per minute
HB	House bill
mg	Million gallons
mgd	Million gallons per day
MSC	Municipal Services Commission
NNCC	Northern New Castle County
ppb	Parts per billion
ppm	Parts per million
RO	Reverse osmosis
TCS	Tidal capture structure
the Authority	Chester Water Authority
the Task Force	Governor’s Water Supply Task Force
United	United Water Delaware
WRA	Water Resources Agency
WSCC	Water supply coordinating council
WTP	Water treatment plant

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SECTION 1
INTRODUCTION

1.1 PURPOSE AND SCOPE

Following the drought of 2002 that affected much of the mid-Atlantic region of the United States, including all of Delaware, the Delaware Public Service Commission (DPSC) issued Order No. 6068 (PSC Docket No. 323-02) on November 19, 2002 to initiate an investigation focused on determining the water supply available to Artesian Water Company, Inc. (Artesian), and United Water Delaware Inc., (United) to meet customer water demands: (a) during the drought period from March 5, 2002 to October 11, 2002 (the drought period); and (b) over the next 5 years. Subsequently, the DPSC contracted with Parsons to conduct an investigation of the adequacy of water supplies available for use by Artesian and United within their service areas in Northern New Castle County (NNCC), Delaware. The scope of the investigation included consideration of both current and future water supply conditions and requirements and was also intended to confirm that the two utilities complied with their responsibilities during the drought of 2002 and that they have the ability to "provide efficient, sufficient and adequate" supply for customers within NNCC during future drought conditions.
The specific elements of the scope of work for the project were to:

2 Determine what volume of water supply was actually available to each utility during the drought period from its own "in house" sources, whether such sources were subsurface wells, surface water diversion and capture, or pre-existing water purchase agreements with other entities;

3 Ascertain what other volume of supply (and from what sources) was utilized by, or available to, each utility to meet shortfalls during the drought period;

4 Determine what other sources were potentially available to supply water to each utility during the period, even if such supply was not contractually obligated to supply that particular utility. This analysis was to measure "available" supply against actual demand for water service during the drought period and, because such actual demand might have been depressed due to mandatory water use restrictions, should also develop facts focusing on adequacy of the available supply to meet demand had those water restrictions not been imposed;

5 Develop facts surrounding the cost to each utility of procuring additional supplies from non "in-house" sources;

6 Develop facts reflecting: (a) expected demand for water supply from Artesian and United in the NNCC area for the next 5 years; and (b) the supply which will be available to each of those utilities to meet the forecasted demand for that future period;

7 Provide the DPSC an appraisal of what happened during the year 2002 and provide views on what further steps, if any, the DPSC might require of the two utilities to ensure that they fulfill the statutory obligation (26 Del. C. Section 308 (b)) to provide efficient, sufficient, and adequate water utility services;

8 Provide the DPSC with an assessment concerning their ability to weather a drought in the next 5 years and meet their statutory obligation; and

9 Other such issues that may be identified by further review by Parsons project team.

1.2 APPROACH

In conducting the investigation, the Parsons project team worked closely with DPSC staff and personnel from the Delaware Department of Natural Resources and Environmental Control (DNREC). Initially, the Parsons project team was provided with documents prepared and submitted by Artesian and United in response to DPSC Order No. 6068, Exhibit A. Parsons was also given documents prepared and submitted by Artesian and United in response to a data request made by the Division of the Public Advocate dated February 20, 2003.
During the period July 15-17, 2003, the Parsons project team participated in meetings with representatives of the following agencies:

- Delaware Public Service Commission;
- The Division of the Public Advocate;
- Delaware Department of Natural Resources and Environmental Control;
- Governor's Water Supply Coordinating Council for New Castle County;
- Water Coordinator for New Castle County and the Water Resources Agency at the University of Delaware; and
- Delaware Geological Survey

Subsequently, the Parsons project team met individually with representatives of four of the six water utilities that serve NNCC - Artesian, United, the City of Wilmington Public Works Department, and the City of Newark Water and Waste Water Department. While Artesian and United were the focus of the investigation, cities of Wilmington and Newark were contacted because of their current and potential future role as water suppliers to Artesian and United. The City of New Castle Municipal Services Commission, which supplies water to Artesian, was also contacted.[9]
A list of the individuals contacted for this investigation is provided in Appendix A.

1.3 ORGANIZATION OF THE REPORT

Section 2 of this report presents background information on the area of interest for this investigation (northern New Castle County, DE) including brief descriptions of the major water utilities that serve the area, an overview of drought conditions in the region during 2002, a description of the surface and groundwater resources of the region, and an overview of milestones in State and local response to

[9] The sixth water utility in NNNC -Delaware City - was not contacted for this investigation. Delaware City does not sell or obtain water from other NNCC utilities.

the drought. Section 3 presents an overview of regional water supply planning activities in the study area since 1999. Sections 4 and 5 provide the Parsons project team's assessment of the performance of Artesian Water Company and United Water Delaware during the drought of 2002 and an assessment of the adequacy of water supplies currently available to each utility.

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SECTION 2
THE DROUGHT OF 2002

The phases of drought follow a predictable sequence. Drought begins with "meteorological drought," defined as a prolonged period of below normal precipitation. Over time, as meteorological drought conditions persist, "hydrologic drought" becomes apparent as stream flows and groundwater levels decline. Lacking replenishment, hydrologic drought may become a "water supply drought," in which the amount of water available for socioeconomic uses becomes increasingly limited. Water supply drought is typically characterized both by declining water supply and by increasing water demand. Ultimately, meteorological conditions return to normal or above normal conditions, surface and groundwater resources recover, and water supplies are replenished, marking the end of the drought. This is the pattern that emerged throughout much of the mid-Atlantic region of United States during 2001 and 2002 and it describes the general progression of the record-setting drought that occurred in NNCC during 2001-2002.

As a prelude to discussions of regional water supply planning in NNCC and discussions of the performance of Artesian Water Company and United Water Delaware, this section presents a brief description of the study area and the six water utilities that provide water service within NNCC. It then provides a brief overview of meteorological conditions in the region during the drought period, generally describes the water resources within or available to the region, and describes how those resources were affected by drought during 2002. Finally, this section provides an overview of the chronology of key events relating to management of the drought by the State of Delaware and the major water suppliers in the NNCC region.

2.1 DESCRIPTION OF THE STUDY AREA

Delaware is the second smallest of the United States and is known as the "First State" for being the first state to ratify the U.S. Constitution. Delaware is located south of Pennsylvania, bordered on the east by the Delaware River and Bay and the Atlantic Ocean, and on the west by Maryland. New Castle County, one of three counties in Delaware, is in the northernmost portion of the state, with a land area of 437 square miles and a current population of approximately 500,265. New Castle County is bordered by Pennsylvania to the north, approximately 40 miles of the Delaware River to the east, Maryland to the west, and Kent County, Delaware to the south. Northern New Castle County, the area of interest for this investigation, is that portion of New Castle County that is north of the Chesapeake & Delaware (C&D) Canal. Figure 2.1 shows the location of NNCC in relation to the State of Delaware.

Delaware and New Castle County have experienced significant population growth over the past 30 years. Since 1970, the

population of the State has increased 43 percent, from 548,104 to 783,600 in 2000. For that same period, the population of New Castle County grew from 385,856 to 500,265, an increase of nearly 30 percent. By 2030, the population of the state is projected to increase by nearly 32 percent to 1,032,974.[10] Over that same period, the population of New Castle County is expected to increase by approximately 19 percent to 594,839. Approximately 480,000 or 96 percent of the current population of New Castle County resides in the area north of the C&D Canal. The population of NNCC is projected to increase to approximately 513,000 by 2020.

Six water utilities – two private investor-owned utilities and four owned by the municipalities they serve - provide water service in NNCC. While each utility is operated independently, there currently are 25 interconnections between the NNCC water utilities that enable water to be bought and sold among the utilities and provide a high degree of reliability during drought and other emergencies.[11] The service areas of the six water utilities in NNCC are depicted in Figure 2.2 and each are briefly described below.

2.1.1 Artesian Water Company

Artesian Water Company has been in operation since 1905, and is the oldest and largest investor-owned water utility in the State of Delaware. Statewide, Artesian serves nearly 70,000 customers or approximately 220,000 people. At present, nearly 65,000 Artesian customers are located within the company's 100 square mile service area in NNCC (see Figure 2.2)[12].

During 2002, Artesian provided nearly 7.2 billion gallons (bg) of water to its customers in NNCC, which represents an average daily demand of 19.72 million gallons (mg). For planning purposes, the Delaware Water Supply Coordinating Council (WSCC) has estimated Artesian's maximum-month average daily demand to be 24.0 mg per day (mgd). During 2002, maximum-month average daily demand was 23.0 mgd in July. Artesian reports that its historic maximum-day water demand is 27.99 mgd (August 9, 2001)[13] and, during 2002, maximum-day demand reached 26.3 mgd on June 19th.[14]

Artesian currently obtains approximately 80 percent of its water supply in NNCC from self-supplied groundwater sources. The remaining 20 percent is obtained through purchases of treated surface water from the Chester Water Authority, the City of Wilmington, and purchases of groundwater from the New Castle Municipal Services Commission. The water purchased from Chester

[10] Delaware Population Consortium, *Population Projection Series,* September 23, 2003

[11] Delaware Water Supply Coordinating Council, *Fifth Report to the Governor and the General Assembly*, January 17, 2003.

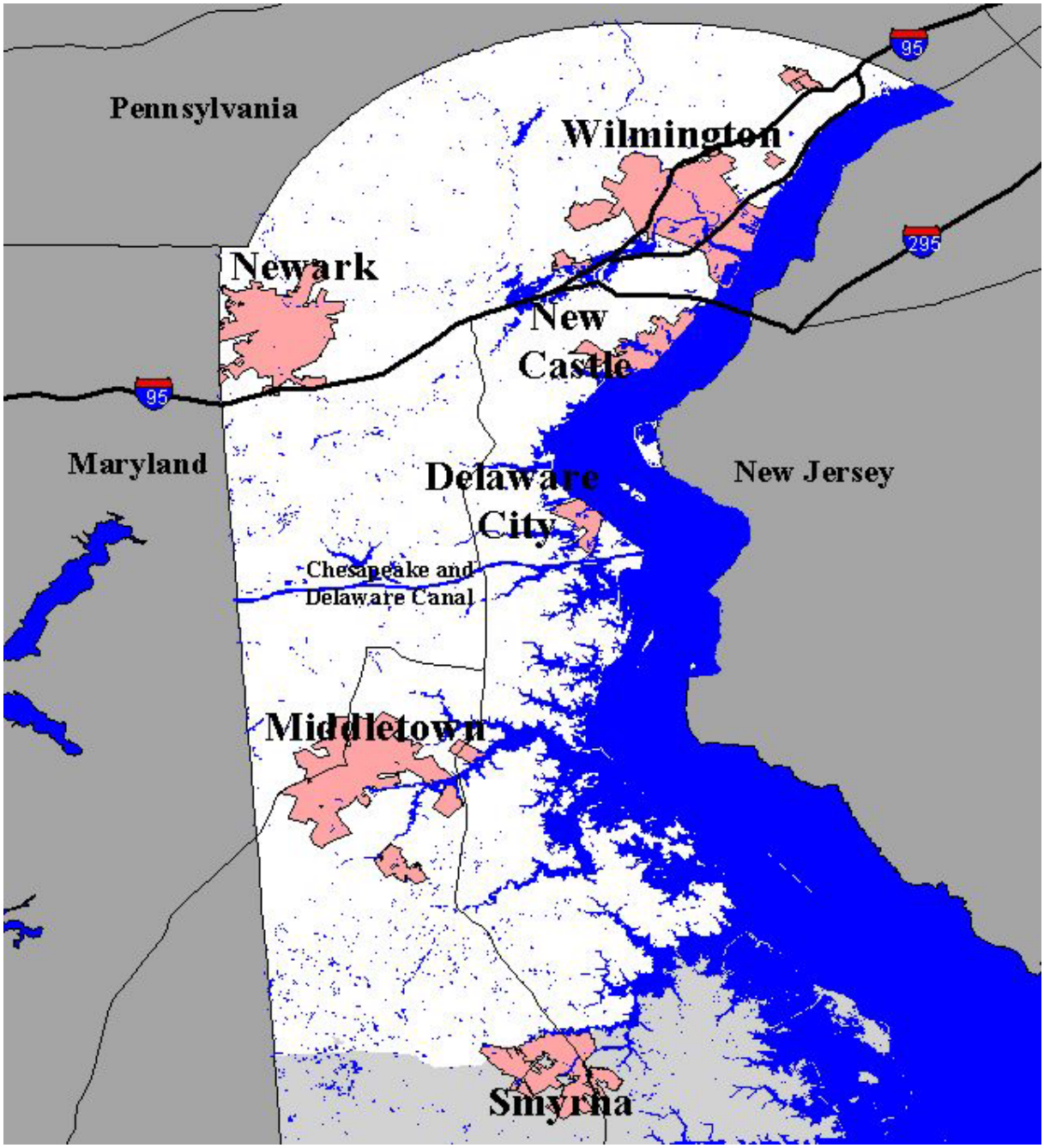
[12] Artesian Water Company Response to Questions from Parsons, Bruce P. Kraeuter, September 12, 2003.

[13] Personal communication with Bruce P. Kaeuter on January 7, 2004.

[14] Delaware Water Supply Coordinating Council, *Fifth Report to the Governor and the General Assembly*, January 17, 2003.

Water Authority is an interbasin transfer from the Susquehanna River Basin.

Figure 2.1 New Castle County, DE



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Artesian's water distribution system in NNCC consists of approximately 800 miles of pipeline of varying size. The system also includes usable water storage of approximately 22 mg.[15] Additional information about the Artesian Water Company is presented in Section 4.

2.1.2 United Water Delaware

United Water Delaware, Inc. was incorporated as an investor-owned water utility in 1933. United currently provides water service to approximately 35,000 customers or roughly 105,000 people in the NNCC area (see Figure 2.2)[16]. United's service area in NNCC consists of three non-contiguous areas that are physically interconnected and managed and regulated as a single service area.

During 2002, United delivered approximately 7.65 bg of water to its customers in NNCC[17]. Average daily demand was approximately 21.0 mgd. Maximum-day water demand in 2002 was 28.9 mgd (including 2.0 mgd of water provided on that day to the City of Newark) and occurred on July 10th. For planning purposes, the WSCC has estimated that United's maximum-month average day demands are 24.0 mgd. During July 2002, average daily demand on the United system was 25.1 mgd or 23.3 mgd excluding average daily water sales of 1.8 mgd to the City of Newark[18].

Nearly all of United's water supply comes from surface water sources. Its principal water source is White Clay Creek, from which the company diverts water to its Stanton Water Treatment Plant (WTP), which has a capacity of 30 mgd. United also operates a smaller WTP (6.0 mgd capacity) that diverts water from Smally's Pond on the Christina River. In addition, the company operates a single groundwater well adjacent to the Christina River that has a production capacity of 0.25 mgd. Water produced from this well is blended with water from the Christina WTP to reduce chloride levels through dilution[19].

[15] Artesian Water Company Response to PSC Order No. 6068, Bruce P. Kraeuter, January 31, 2003.
[16] United Water Delaware/United Water Bethel website. http://www.unitedwater.com/uwde
[17] United Water Delaware Response to PSC Order no. 6068, undated.
[18] Delaware Water Supply Coordinating Council, *Fifth Report to the Governor and the General Assembly*, January 17, 2003.
[19] United Water Delaware Response to PSC Order no. 6068, undated.

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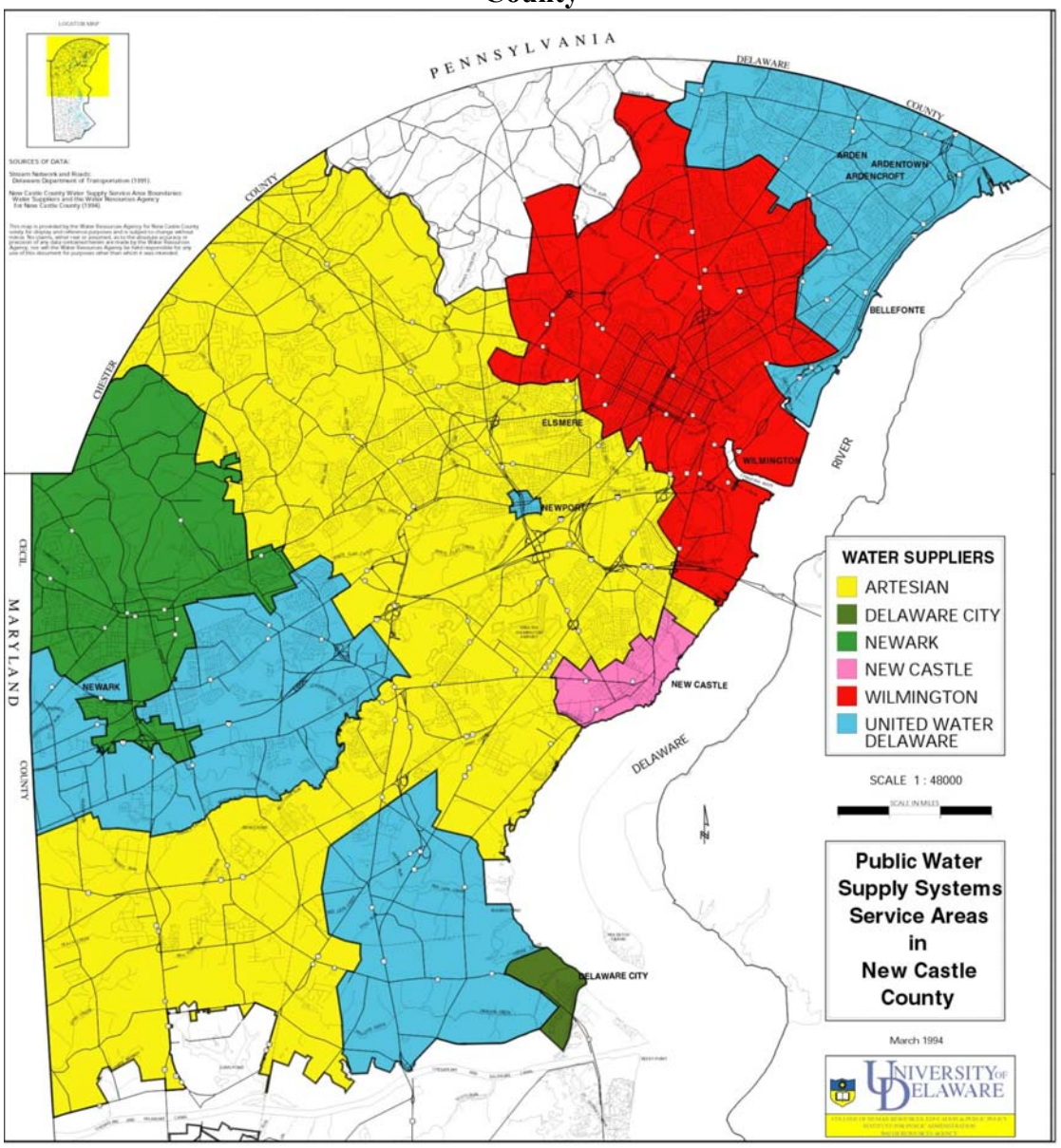
Figure 2.2 Public Water Supply System Service Areas in Northern New Castle County



Approximately 95 percent of United's annual water demand is from self-supplied sources. The balance is obtained through purchases of treated surface water from Chester Water Authority, which is delivered through a direct interconnection and through an interconnection with United Water Bethel in southeastern Pennsylvania, and through purchases of both raw and treated surface water supply from the City of Wilmington. Raw water purchased from Wilmington is provided for augmentation of flows in White Clay Creek at the Stanton WTP through releases to Red Clay Creek from Hoopes Reservoir. United also purchases treated surface water supplies from the City of Wilmington, primarily to serve the northernmost portion of its service area. Under peak demand conditions, United

also sells as much as 2.7 mgd of treated water to the City of Newark. However, these water sales will

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soon be discontinued once the City of Newark completes a new 317 mg off-channel reservoir at its water treatment plant on White Clay Creek.
United's water distribution system includes 509 miles of water mains and 18 storage tanks with a capacity of approximately 31 mg[20]. Additional information about United Water Delaware is provided in Section 5.

2.1.3 City of Wilmington

The City of Wilmington, through its Public Works Department, owns both water and wastewater utility systems. The City operates the water utility, but the wastewater treatment facility is operated by a contractor. The City's water utility provides service to over 38,000 water customers or approximately 140,000 people in the city and its suburbs[21]. During 2002, the City of Wilmington supplied approximately 8.4 bg or an average daily demand of about 23.1 mgd. Of this amount, the City sold 291.83 mg of treated water to Artesian and 7.97 mg of treated water to United. The WSCC estimates that the City's current maximum-month average day water demand is 30.3 mgd. However, actual maximum-month average day demand during July 2002 was 25.5 mgd and, excluding water supplied to Artesian Water Company, Wilmington's maximum-month average daily water demand during July 2002 was 24.2 mgd. Maximum-day demand during 2002 was 30.6 mgd on July 24th, which included 1.3 mgd supplied to Artesian Water Company[22].
In terms of water supply, the City of Wilmington is entirely self-sufficient and obtains all its water supply from Brandywine Creek. The City has the capacity to divert up to 56.0 mgd from Brandywine Creek and has two surface WTPs with a combined capacity of approximately 45.0 mgd[23]. The City also owns the Hoopes Reservoir, which has a usable storage capacity of approximately 1.8 bg. In addition to providing a reserve water supply for the City, directly or indirectly Hoopes Reservoir also provides a back-up water supply source for much of NNCC. As noted above, under a contract with United, the City releases raw water from the reservoir to augment flows in White Clay Creek. The City also sells treated water to both Artesian and United, and indirectly to the Cities of Newark and New Castle to the extent that these systems are interconnected with Artesian and United.

2.1.4 City of Newark

[20] United Water Delaware/United Water Bethel website. http://www.unitedwater.com/uwde
[21] City of Wilmington, DE, *Water Works.* Newsletter published by the City of Wilmington , Department of Public Works – Water Division, Spring 2003.
[22] Delaware Water Supply Coordinating Council, *Fifth Report to the Governor and the General Assembly*, January 17, 2003.
[23] Personal communication with Sean Duffy and Matt Demo, Water Division Director, Department of Public Works, City of Wilmington, DE. August 28, 2003.

The City of Newark currently serves approximately 10,000 water customers and a population of approximately 26,000 people. Included is the University of Delaware, which represents about 40 percent of the City's annual water demand[24]. Current annual water demands are approximately 1.4 bg and average daily demand is approximately 3.8 mgd. For planning purposes, the WSCC estimates the City's current maximum-month average daily demand to be 4.5 mgd. During 2002, the City's average daily demand during July was 4.3 mgd. Maximum-day demand during 2002 was 5.0 mgd on both July 10th and August 2nd. At present, the City has three primary sources of water supply – surface water from White Clay Creek with 3.0 mgd of water treatment capacity, groundwater from 10 wells (3.8 mgd), and water purchased from United Water Delaware (up to 2.7 mgd). By the summer of 2004, Newark is expected to complete a new off-channel storage reservoir with a capacity of 317 mg. This reservoir will provide a back-up supply for the City's surface WTP and allow the City to become completely self-sufficient. Accordingly, the City will soon discontinue water purchases from United Water Delaware[25].

2.1.5 City of New Castle

The City of New Castle, Delaware owns and operates a water utility through its Municipal Services Commission (MSC). The MSC serves approximately 2,080 water customers that are billed quarterly (mostly residential) and 63 water customers that are billed monthly (mostly commercial). Average day water demand is approximately 0.4 mgd and peak day demand is approximately 0.5 mgd.

The MSC's water supply is from groundwater produced from two wells. The WSCC estimates that the MSC has 2.0 mgd of water supply available on a sustained basis during drought.

The New Castle MSC also provides water on a wholesale basis to the Artesian Water Company through a two-way interconnection which allows transfers of approximately 1.0 mgd. During July and August 2002, Artesian purchased approximately 0.6 mgd from the MSC. According to representatives of the New Castle MSC, this was the first time in about a decade that Artesian required water in significant quantities. MSC representatives confirm that they have the capability to supply Artesian approximately 0.7 mgd on a sustained basis during drought conditions.[26]

2.1.6 Delaware City

Delaware City operates a small municipal water utility that serves approximately 300 customers. The utility can produce

[24] Personal communication with Joe Dombrowski, Director of Water and Waste Water, City of Newark, DE. August 29, 2003.
[25] *Ibid.*
[26] Personal communication with Chip Patterson, New Castle Municipal Services Commission, October 27, 2003.

approximately 0.5 mgd of groundwater. As noted previously, Delaware City was not contacted for this investigation as the City's water utility neither sells or purchases water from other NNCC water utilities.

2.2 METEOROLOGICAL CONDITIONS

The 2001-2002 "meteorological drought" in NNCC began in mid-2001 when a significant precipitation deficit began to accumulate over a large area of the mid-Atlantic region including NNCC. The cumulative precipitation deficit reached 15.51 inches for the period July 1, 2001 through September 30, 2002 at the City of Wilmington. For the 2002 "water year" (October 2001 through September 2002), precipitation was 28.33 inches or 69 percent of normal at New Castle County Airport, the lowest since record keeping began in 1894. At the Porter Reservoir in Wilmington, precipitation was 34.28 inches or 74 percent of normal[27].

The region began to emerge from meteorological drought conditions during the last 4 months of 2002. Precipitation at the New Castle County Airport was 140 percent of normal for that period and 147 percent of normal at the Porter Reservoir in Wilmington[28]. Above average precipitation has been recorded throughout much of 2003.

2.3 HYDROLOGIC CONDITIONS

It has since been determined that the meteorological drought of 2001-2002 created a new hydrologic "drought-of-record" in NNCC. Analysis of stream flow data for Brandywine Creek at Chadds Ford indicates that low-flow conditions during 2002 were statistically a 100-year drought[29] (see Figure 2.3). In addition, the Delaware Geological Survey's Water Conditions Index showed record low indices during 6 of 14 months over the period from August 2001 through September 2002 (see Figure 2.4). This index was developed to provide an overall gauge of water conditions in NNCC and includes measures of precipitation, shallow groundwater levels, flows in Brandywine Creek, and the population of NNCC. Since October 2002, the index has been in the normal or above normal range.

A description of the surface and groundwater resources currently available to NNCC follows.

2.3.1 Surface Water Sources

[27] *Delaware Water Supply Coordinating Council, Fifth Report to the Governor and the General Assembly, January 17, 2003.*
[28] *Ibid.*
[29] *Ibid*

The primary surface water sources in NNCC are the Brandywine Creek, the White Clay Creek and its tributary Red Clay Creek, and the Christina River. Surface water is also supplied to NNCC through a transfer from the Susquehanna River Basin. Each of these sources is briefly described below.

Brandywine Creek

Brandywine Creek is a major tributary of the Delaware River. Its watershed covers approximately 325 square miles, with over 300 square miles in southeastern Pennsylvania. Brandywine Creek is the City of Wilmington's sole source of water supply and provides supplemental water supply to both Artesian and United through the City of Wilmington.

Figure 2.5 shows stream flow conditions on Brandywine Creek at Wilmington from October 2001 through December 2002. The annual daily mean stream flow of 109 mgd on Brandywine Creek at Wilmington during the 2002 water year was the lowest since record keeping began in 1947. Record low monthly median flows occurred on Brandywine Creek at Wilmington during February 2002 and record low average daily stream flows of about 50 mgd were established on Brandywine Creek during July, August, and September 2002. The previous record low monthly median flows was about 70 mgd, set in 1957. Record daily low flows were also recorded during 2002, and an all-time record low flow of 21 mg occurred on August 23, 2002[30]. During August and September 2002, there were 25 days during which daily stream flow in Brandywine Creek was below 34 mg, the previous record low for a single day, established in 1995[31].

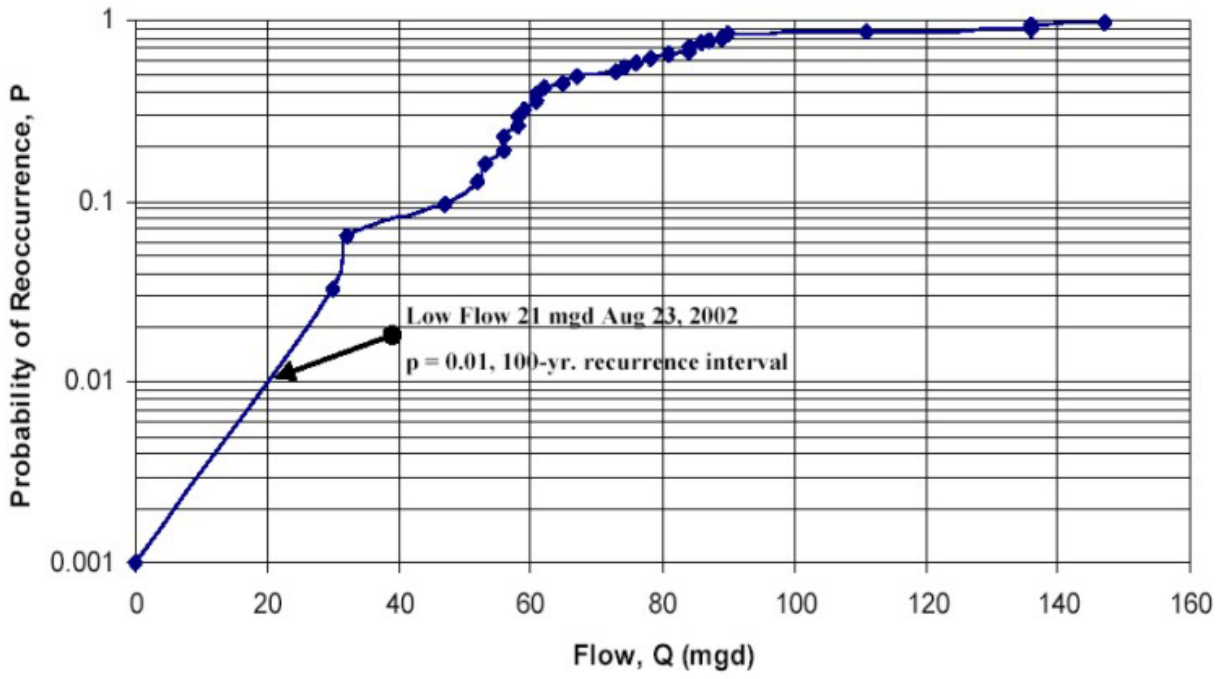

Figure 2.3 Estimate of Low Flow Recurrence Interval with the Weibull Distribution Brandywine Creek at Chadds Ford – 1972-2001

[30] *Ibid.*
[31] *Ibid.*

Figure 2.4 Delaware Geological Survey's Water Conditions Index 1998 – 2002

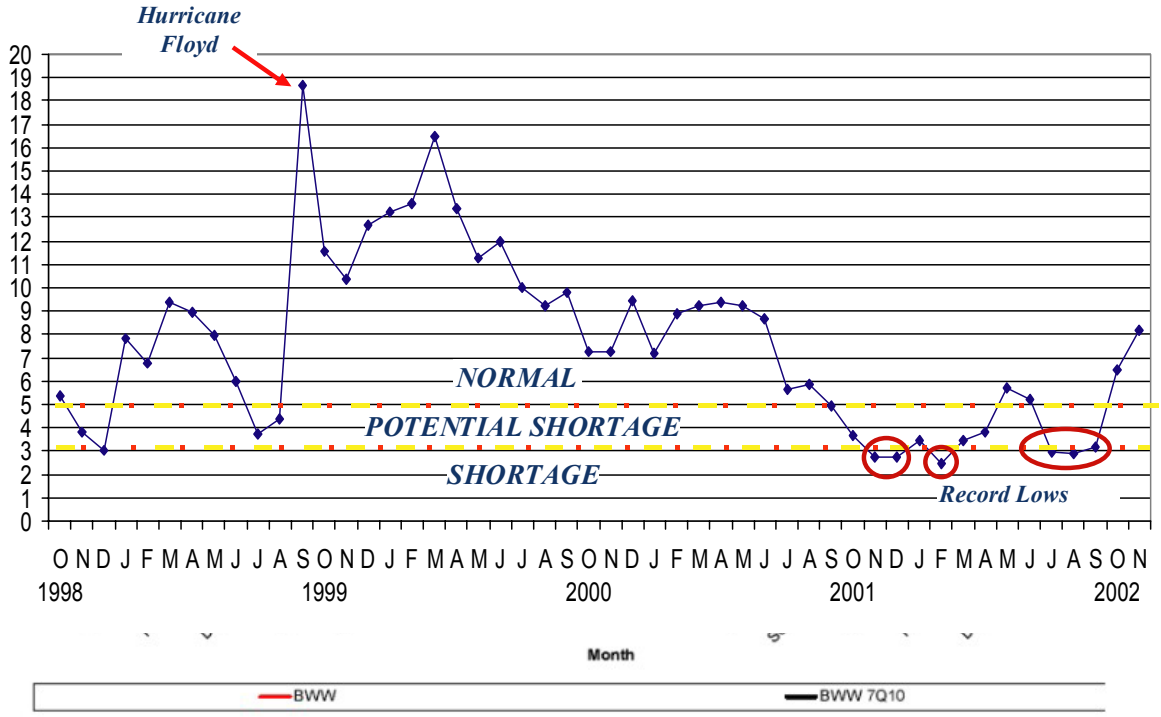

Figure 2.5 Brandywine Creek at Wilmington Streamflow Data October 2001-December 2002

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Hoopes Reservoir, located on Red Clay Creek, was built by the City of Wilmington in 1932. The reservoir has a total storage capacity of approximately 2.0 bg and a usable storage capacity of approximately 1.8 bg. Water stored in Hoopes Reservoir is diverted from Brandywine Creek and then pumped to the reservoir. The City's capacity to divert water to the reservoir is 25 mgd. The City has historically used water from the reservoir as a back-up water supply when the quality of water in Brandywine Creek is poor (*e.g.*, high turbidity) and during low stream flow periods. During such conditions, water is conveyed via pipeline from the reservoir to the City's Porter Lake and WTP[32]. The reservoir can also be used to augment flows in White Clay Creek through direct releases to Red Clay Creek. Water was used from the reservoir during the droughts of 1995 and 1999, as well as during 2002.

During the drought period, releases of raw water from Hoopes Reservoir to augment flows in White Clay Creek began on July 31, 2002, in amounts ranging from 1.2 to 7.0 mgd and were required intermittently through September 26, 2002[33]. Releases were made under terms of an agreement between the City of Wilmington and United and were required to ensure that water produced at United's Stanton WTP stayed within State drinking water standards for chlorides. Through the drought period, 178 mg was released from the reservoir for stream flow augmentation. In addition, intermittently over a 9-day period from August 14th to August 22nd, 91 mg were released from the reservoir to the City's Porter WTP[34].

At the time releases from the reservoir began, the level of Hoopes Reservoir was 2 feet below its full conservation storage level. During the release period, the level of the reservoir dropped an additional 4 feet to 82 percent of its capacity. On August 23, 2002, remaining usable storage in the reservoir was approximately 1.47 bg. By comparison, during the drought of 1995, the water level in Hoopes Reservoir was drawn down 8 feet to approximately 74 percent of its capacity[35]. Flows in Brandywine Creek increased significantly in early September 2002, which allowed the City of Wilmington to begin refilling Hoopes Reservoir. The reservoir reached 100 percent capacity on October 11 and has remained full since. Figure 2.6 shows actual level of the reservoir from July 2002 through November of 2002, as well as reservoir levels during the same period in 1995 and 1999.

White Clay Creek

White Clay Creek is another important source of surface water supply for NNCC. The White Clay Creek watershed covers approximately

[32] Personal communication with Sean Duffy and Matt Demo, Water Division Director, Department of Public Works, City of Wilmington, DE. August 28, 2003.

[33] Delaware Water Supply Coordinating Council, *Fifth Report to the Governor and the General Assembly*, January 17, 2003.

[34] *Ibid.*

[35] *Ibid.*

107 square miles, with 62 square miles located within Pennsylvania and 45 square miles located in NNCC. The stream flows from southeastern Pennsylvania to NNCC and eventually joins the Christina River. On October 24, 2000, portions of White Clay Creek received National Park Service designation as a wild and scenic river under the National Wild and Scenic River Act.
During the 2001-2002 water year, median monthly flows in White Clay Creek, measured at the Stanton WTP, were at record or near-record levels for 7 out of 12 months[36] (see Figure 2.7). The lowest stream flow at Stanton was 11 mgd, recorded on August 21 and again on September 12, 2002. At Newark, the lowest flow rate on White Clay Creek was 2.0 mgd, which occurred on August 15, 2002 (see Figure 2.8).

Christina River

The Christina River is also a source of surface water supply for United, which can divert and treat up to 6.0 mgd of flow at Smalley's Pond. The Christina River encompasses a 78 square mile watershed. Forty-five square miles of the watershed are located within NNCC, 8 square miles are within Maryland, and only 2 square miles are in Pennsylvania. Record or near-record monthly mean stream flows were recorded on the Christina River for 4 of 12 months during 2002 (see Figure 2.9).

Water Supply Available to NNCC from the Susquehanna River Basin

NNCC receives approximately 5 percent of its water supply from the Susquehanna River Basin through the Chester Water Authority (the Authority). The Authority, formed in 1939, supplies treated surface water to public water systems and industries in southeastern Pennsylvania and NNCC through interconnections with Artesian and United. The Authority owns and operates the Octoraro Reservoir, as well as a surface WTP, both with a permitted capacity of 60 mgd. The reservoir derives half of its yield (30 mgd) from the Octoraro Creek watershed and half is from diversions from the Conowingo Pool on the Susquehanna River. The reservoir, located near Oxford, PA, has a usable storage capacity of approximately 1.7 bg. On average, the Authority supplies approximately 34 mgd to its customers[37].
Drought-of-record conditions also prevailed on Octoraro Creek during 2002. From May 25, 2002 to August 23, 2002, the level of Octoraro Reservoir went from full to 42 percent of its capacity (840 mg remaining), the lowest level in the 51-year history of the project (see Figure 2.10). During this period, the Authority had to fully utilize its permitted diversion from the Susquehanna River and also activate an emergency interconnection with the Philadelphia Suburban Water Company, which was used from late August to mid-September.

[36] Delaware Geological Survey, Monthly Mean Stream Flows October 1, 2001 – September 30, 2002.
[37] Personal communication with Bob Naef, General Manager, Chester Water Authority, September 4, 2003.

Figure 2.6 Hoopes Reservoir Water Level
July 2002-November 2002

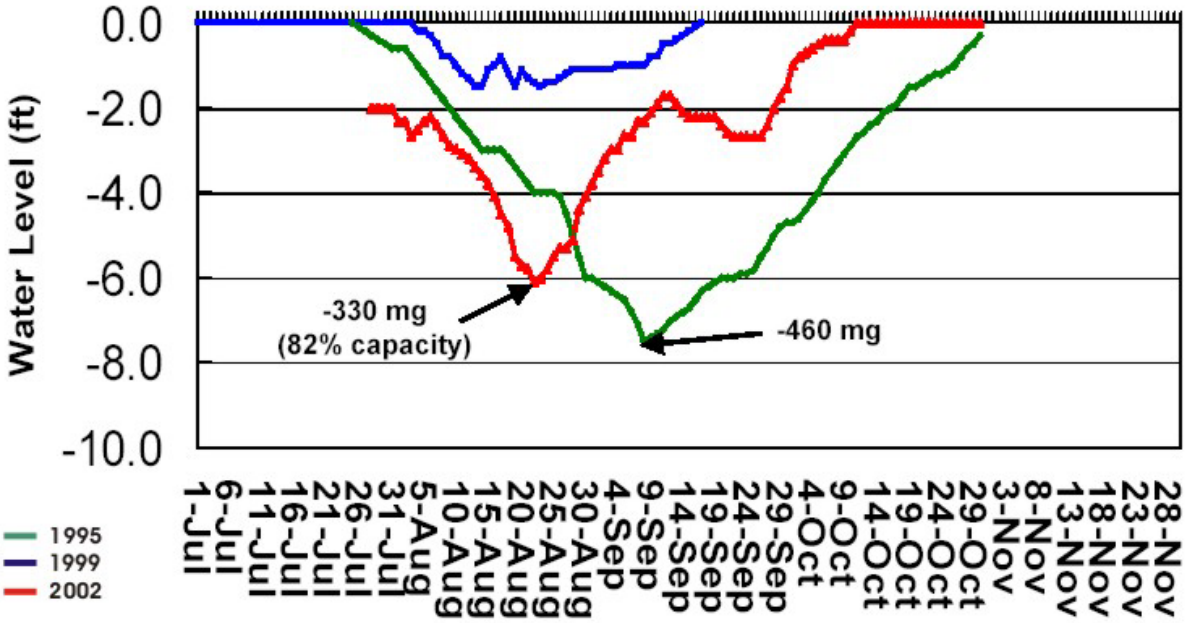

Figure 2.7 White Clay Creek at Stanton Streamflow Data
October 2001-December 2002

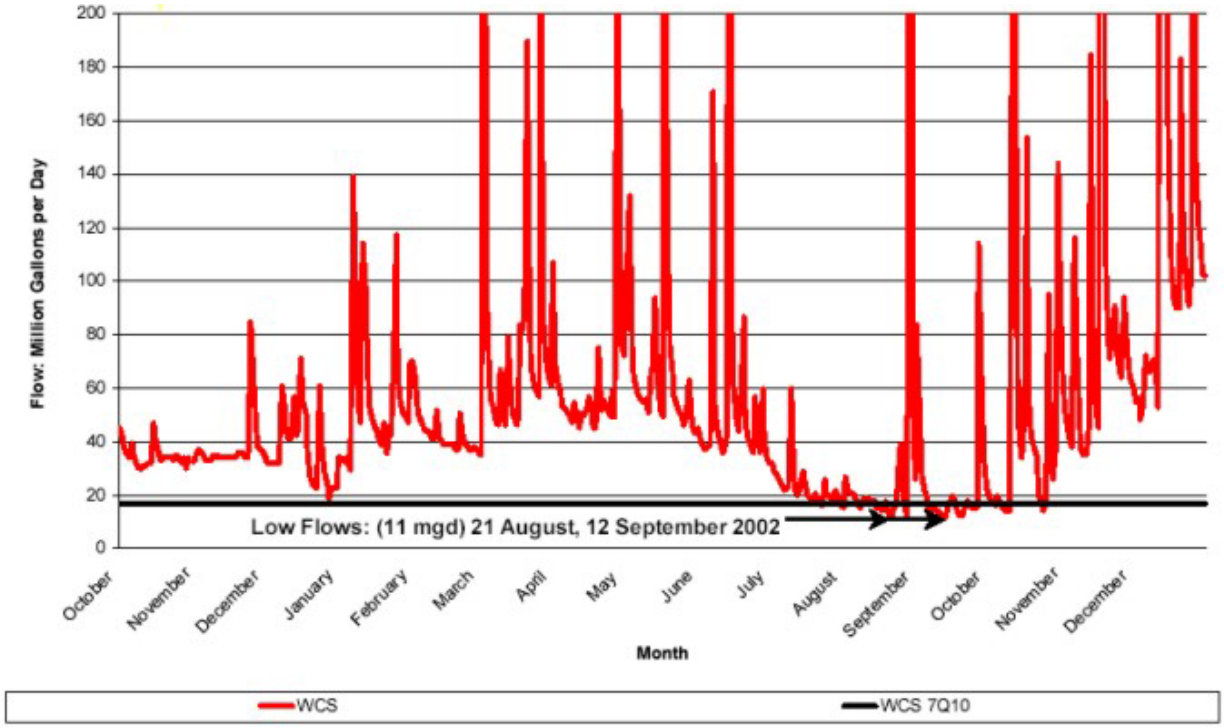

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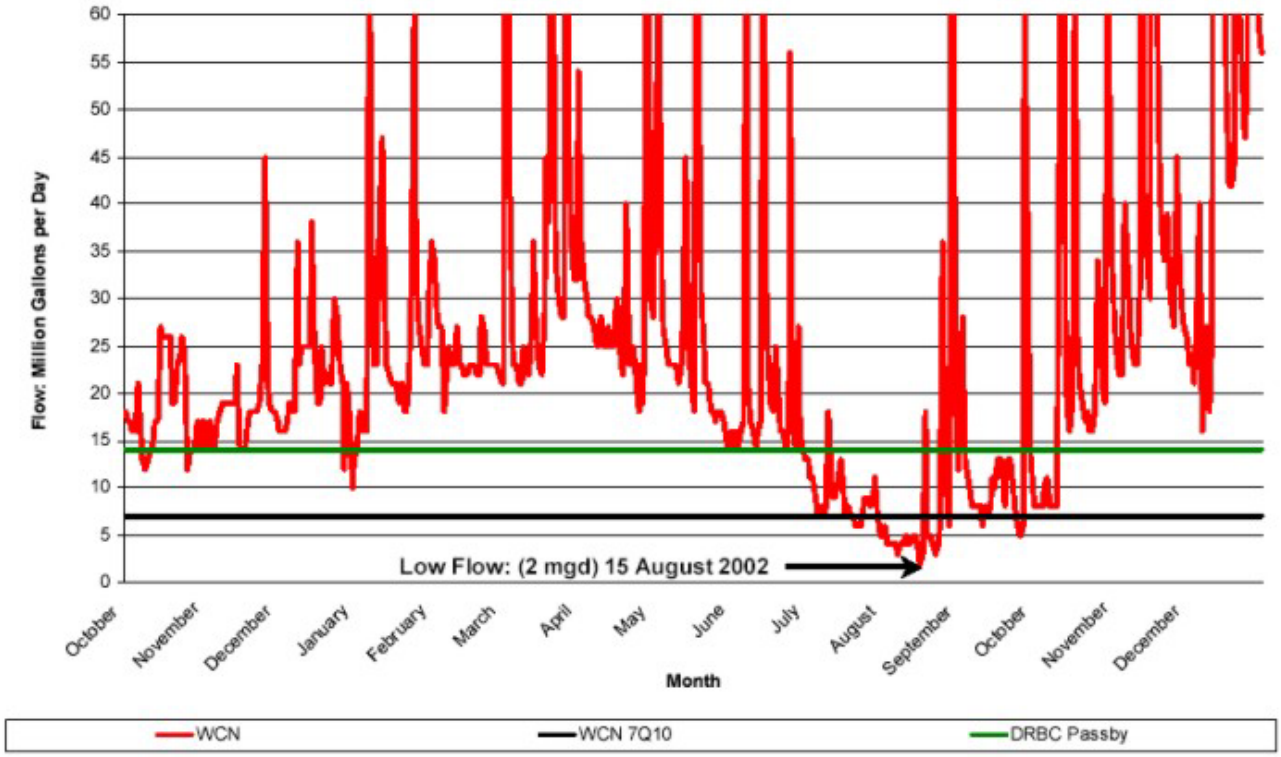
Figure 2.8 White Clay Creek at Newark Streamflow Data October 2001-December 2002



On August 12, 2002, the Authority requested a 20 percent reduction in water deliveries to its customers and subsequently requested additional reductions on August 14, 2002. Prior to these requests, demand averaged approximately 40 mgd. Afterward, demand dropped to approximately 32 mgd[38]. By November 2002, water storage in Octoraro Reservoir reached 100 percent and the Authority terminated its request for curtailment of water deliveries.

Following the drought, the Authority commissioned a study to evaluate the yield of the Octoraro Reservoir and to evaluate options for increasing water supply. Analyses indicate that 2002 established a new drought-of-record on Octoraro Creek and that the yield of Octoraro Reservoir is less than previously thought. Options for water supply augmentation that are under consideration include development of raw water supplies from the Delaware River for industrial use, development of potable water supplies from the Delaware River, groundwater development, and increasing diversions from the Susquehanna River. The Authority is also considering adoption of an inverted (*i.e.*, increasing block) water rate structure to encourage water conservation. It is expected that the Authority's water supply study will be completed by the end of 2003[39].

[38] *Ibid.*
[39] *Ibid.*

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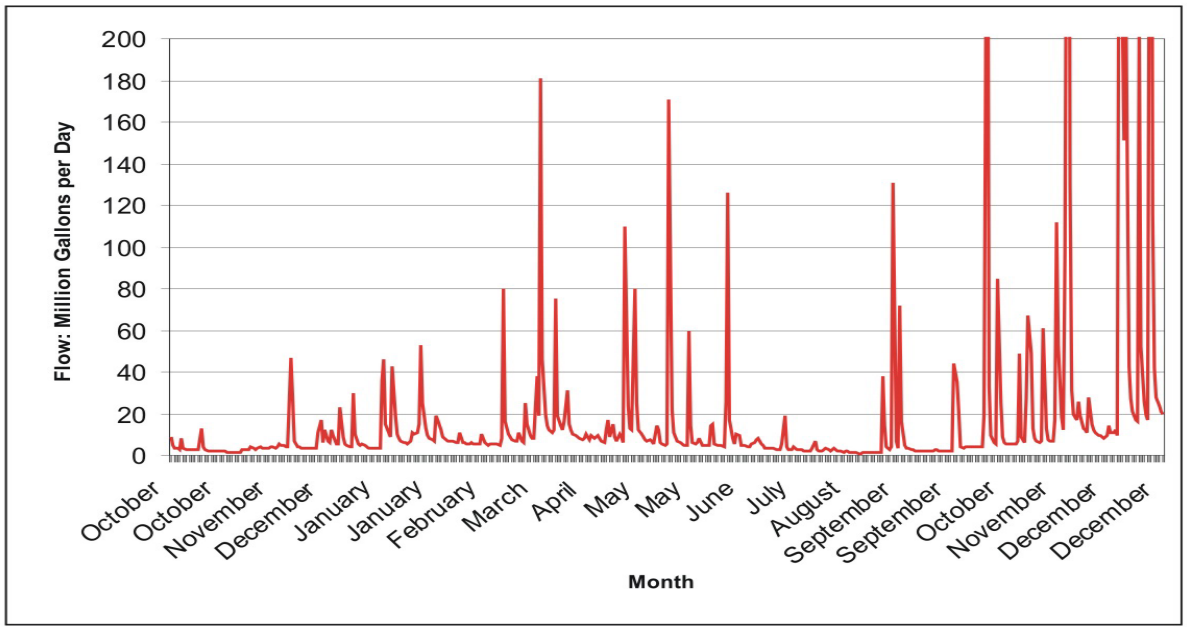
Figure 2.9 Christina River at Coochs Bridge Streamflow Data October 2001-December 2002



2.3.2 Groundwater

Groundwater occurs throughout NNCC and in some areas provides a substantial and reliable source of public water supply. Below is a discussion of the groundwater resources of NNCC.

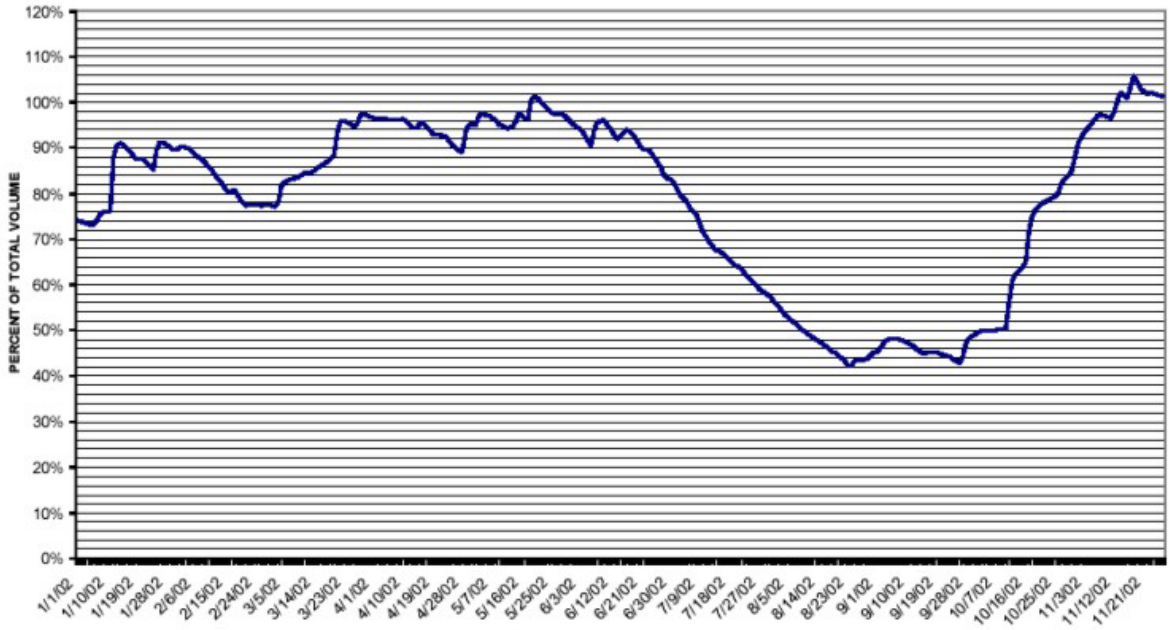
Physiography of NNCC

As shown on Figure 2.10, NNCC is located within both the Appalachian Piedmont Province and the Coastal Plain Province of Delaware. The Piedmont Province of Delaware consists of gently rolling hills comprised of highly deformed and metamorphosed metasedimentary, metaigneous, and igneous rocks. These rocks reportedly cover approximately 82 square miles of the northern portion of New Castle County. The rocks have been divided into two major northeast-southwest trending belts of contrasting lithologies. One belt is located in the northeast portion of New Castle County and underlies the City of Wilmington[40]. This belt contains rocks comprising the Wilmington Complex, which is primarily composed of gabbro, gneiss, and metagabbro. The second belt underlies the northwestern portion of NNCC and is comprised of pre-Cambrian age basement rocks known as Baltimore Gneiss, the Glenarm Group and the Wissahickon Formation. The Glenarm Group contains the Setters and Cockeysville Formations.

[40] Plank, Margaret O; Schenck, William S. and Srogi, LeeAnn; Bedrock Geology of the Piedmont of Delaware and Adjacent Pennsylvania, Delaware Geological Survey, Report of Investigations No. 59, 2000.

The Cockeysville Formation is an important source of groundwater in the area.
The southern boundary of the Piedmont Province forms the northern limit of the Coastal Plain Province of Delaware. This boundary between the Coastal Plain and Piedmont is commonly referred to as the Fall Line. The rocks of the Piedmont Province extend eastward across the county and are overlain by younger Coastal Plain sediments. The Coastal Plain Province consists of a series of silts, sands, and clays that generally dip toward the southeast. Successively younger units dip less steeply and were originally thought to thicken in the down dip direction. The sediments are erodable and form low nearly flat plains and broad shallow valleys. The Coastal Plain Province within NNCC consists primarily of the Cretaceous Age Potomac Formation. Near the C&D Canal, the Potomac Formation is overlain by Magothy and several formations of the Matawan Group. These formations are overlain by quaternary age material that includes the Columbia Formation and recent sediments.

Figure 2.10 Octoraro Reservoir Water Level
January 2002-November 2002



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Geology/Hydrogeology of NNCC

In general, the geology of NNCC consists of crystalline rock in the northern portion of the area overlain by much younger Cretaceous age sediments (see Figure 2.11). The crystalline rocks have been studied in detail (Plank, Schenck, Srogi 2000) and have been divided into numerous geologic units. These divisions were based on geochemical data, which allowed grouping by trace element concentrations, and by geochronology using (define) U-Pb dating techniques. As previously indicated, the Cockeysville Formation is an important source of groundwater in NNCC; details pertaining to the formation follow. The remaining geologic units have limited groundwater yield potentials and are not described herein.

The Cockeysville Marble is a lithostratigraphic unit that correlates with marbles exposed in Cockeysville, Maryland. The unit consists of pure, coarsely crystalline dolomite marble with minor calcite marble and calc-schists[41]. The dolomite marble consists of greater than 90 percent dolomite with calcite. Cockeysville Marble is found on the sides of the Hockessin-Yorklyn and Avondale anticlines and in Pleasant Hill Valley. Due to faulting, it is highly unlikely that the Cockeysville marbles in the Hockessin Yorklyn areas are hydrology connected to the marbles in the Pleasant Hill area. The total area underlain by the formation is reported to be 1.2 square miles.

The formation is reportedly easily eroded and exposures of the marble are reportedly non-existent in Delaware. Being a carbonate rock, problems associated with karst terrain, such as the formation of sinkholes can be expected and have been recorded. The thickness of overlying residual soils, weathered from the parent rock range from several to greater than 150 feet. The thickness of the formation is estimated to vary from 400 to 800 feet. The geologic data also indicate that foliations trend N45°E, which is parallel to the regional strike, and dip to the southeast at angles ranging from 30 to 45 degrees.

[41] *Ibid.*

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Figure 2.12 Geologic Map New Castle County

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Hydrogeologically, the movement of water through the Cockeysville Formation is dependent on secondary porosity or the movement of water through secondary openings such as joints and fractures. Being a carbonate rock these openings are typically enlarged due to dissolution of the carbonate materials and large quantities of groundwater can be expected from wells that penetrate these solution channels. The Cockeysville Formation is considered to be the most productive aquifer in the Delaware Piedmont.
Yields for domestic wells typically range from 3 to 40 gallons per minute (gpm) and nondomestic well yields are reported to range from 50 to 2000 gpm[42]. Reported transmissivity values range from 940 to 6,820 ft^2/day. Storativity values based on observation well data range from 4x10-2 to 8x10-5. Specific capacity of these wells ranged from 0.09 to 12.5 (gal/min/ft) with a mean value of 0.89 (gal/min/ft). The wide variation of values indicates a wide variability of the water transmitting and storage capacity of the aquifer[43].

Recharge to the aquifer is reported to occur from three sources: infiltration of precipitation, infiltration of stream water, and some flow of groundwater from adjacent Piedmont geologic units into the Cockeysville aquifer. Water level data from the aquifer suggest that portions of the aquifer are stressed and that average water level declines of 30 feet have taken place during the period 1950 to 1990. Further, groundwater budgets for the stressed part of the aquifer indicate that even during wet years, recharge may be less than the withdrawal and water is removed from storage.[44] Based on the water level declines and groundwater budget analyses, it is reported that continued residential and commercial development of the aquifer could threaten the water supply capability of the aquifer.[45] However, Artesian maintains approximately 30 years of water level data for its wells in the Cockeysville aquifer and the company claims the data shows that water levels have been relatively constant over the period.[46] This would suggest that the existing regulatory limits on groundwater withdrawals from this source are having their intended effect.
The lower Cretaceaous age Potomac Formation directly overlies the crystalline basement rocks and is the major source of groundwater in NNCC. The formation consists of red, gray, purple, yellow, and white frequently lignitic silts and clays containing interbedded

[42] Werkheiser, William H.; Geohydrology of the Hockessin Area With Emphasis On The Cockeysville
[43] *Ibid.*
[44] Werkheiser, William, H. "Geohydrology of the Hockessin Area with Emphasis on the Cockeysville Aquifer"; Bulletin No. 19 Delaware Geological Survey, 1995, Pg 46.

[45] *Ibid*, Pg 47.
[46] Personal communication with Bruce P. Kraeuter, January 7, 2004.

white, gray, and rust brown quartz sands and some gravel[47]. The thickness of the formation increases to the southeast in the range of 600 to 700 feet near the C&D Canal. Over most of NNCC, younger Columbia Formation sediments unconformably overlie the Potomac Formation. Near the C&D Canal, upper Cretaceous materials directly overlie the Potomac Formation.

The Potomac Formation is described as containing individual sand bodies that were deposited in stream channels and are subsequently elongate and tabular and not sheet like[48]. Attempts to correlate individual sand beds across the entire aquifer proved unsuccessful and two hydrologic zones were described. These zones were labeled the upper hydrologic zone and the lower hydrologic zone. Previous investigators had divided the formation into three aquifer zones with intervening confining beds. These aquifers, within the Potomac Formation, were described as the Upper, Middle and Lower aquifers and were separated by confining layers that consisted primarily of silts and clays.

Hydrogeologically, the movement of water through the three hydrologic zones comprising the Potomac Formation is a function of the primary permeability and porosity of the aquifer. Reported transmissivity values for the Potomac aquifer range from 4,700 to 12,300 gallons per day per foot. (gpd/ft) for the lower aquifer and from 4,100 to 7,500 gpd/ft for the upper aquifer. Storativity values varied from 1.1x10-4 to 3.0x10-4 for the lower aquifer and from 1.7x10-4 to 6.0x10-5 for the upper aquifer. The low storativity values suggest both aquifers are confined. However, vertical leakage through the confining layers is thought to be occurring. This leakage is based on vertical permeabilities in the range of 2.0x10-3 to 7.0x10-4 gpd/ft^2. Based on their studies, Sundstrom and Picket concluded that the available supply of the Potomac for all of New Castle County was in the range of 18 to 23 mgd above what was already being withdrawn[49].

In 1984 the Potomac Formation was modeled using a three-aquifer system[50]. The model extended from the border of the Piedmont Province to a southern limit below the towns of Middletown and Odessa and was based on a variety of transmissivity and storativity data for three aquifer zones within the Potomac Formation. These data indicated the upper zone had the lowest transmissivity and the lower zone had the highest transmissivity. It also assumed that all three hydrologic zones had subcrop areas that received

[47] Sundstrom, R.W. and Pickett, T.E., The Availability of Ground Water in New Castle County Delaware, University of Delaware Water Resources Center, 1971.

[48] *Ibid.*

[49] Sundstrom, R.W. and Pickett, T.E., The Availability of Ground Water in New Castle County Delaware, University of Delaware Water Resources Center, 1971.

[50] Martin, Mary M.; Simulated Ground-Water Flow in the Potomac Aquifers, New Castle County, Delaware, U.S. Geological Survey, Water-Resources Investigation Report 84-4007, 1984.

direct recharge from the overlying unconfined aquifer. It should be noted that recent studies by the Delaware Geological Survey indicate that the three permeable zones of the Potomac dip gently to the southeast with generally sandy fluvial facies at the base of the formation lapping onto a south dipping basement unconformity. The consequence of this interpretation is that only the top aquifer has a sub-crop area that receives recharge from the water table (surficial aquifer) and the lower aquifer receives limited recharge. The Martin model was calibrated by comparing calculated heads and head changes to observed data. The calibrated model was used to evaluate changes in water levels resulting from several scenarios of future pumpage. One scenario was based on expected increases in pumping in eastern Delaware (*i.e.,* Northern New Castle County) for the period 1980 to 2005. The model predicted a decline of 40 feet in the lower aquifer and declines of about 5 feet in the upper and middle aquifers.

Near the C&D Canal, sediments of the Magothy Formation and Matawan Group overlie the Potomac Formation. Both are not considered to be important sources of groundwater supply for NNCC. In the remaining portion of the Coastal Plain province in NNCC, the Columbia Formation and more recent quaternary sediments unconformably overlie the Potomac.

The Columbia Formation consists of orange, tan, and yellow medium to coarse sands and gravel that are Pleistocene in age[51]. The sediments were deposited by Pleistocene streams, which formed a system of straight channels in the area north of the C&D Canal. The mapped thickness of the formation, including more recent quaternary deposits, varies across the study area. Along most of the Fall Line and northward in the Piedmont Province, the formation is not present. South of Newark and north of New Castle, the Columbia formation has a thickness of 40 to 60 feet.

Comprising the surficial geologic unit in the area, the Columbia Formation and other quaternary materials form the water table (unconfined) aquifer in the study area. Because it is the water table aquifer, it provides base flow to streams and was originally thought to provide recharge to the Potomac confined aquifers in the subcrop areas. The previously described study by the Delaware Geological Survey now suggests that only the top aquifer zone has a subcrop area that receives recharge.

Published data indicate that transmissivity of the aquifer is extremely variable because of the wide range in thickness and permeability of the sands that compose the aquifer.

2.4 STATE DROUGHT RESPONSE

Under Delaware State law, the Governor is the sole authority for declaration of Drought Warnings and Drought Emergencies through

[51] Sundstrom, R.W. and Pickett, T.E., The Availability of Ground Water in New Castle County Delaware, University of Delaware Water Resources Center, 1971.

Executive Order. In considering whether to initiate or terminate State drought response measures, including voluntary water conservation and mandatory water use restrictions, the Governor is advised by a Drought Advisory Committee (DAC), which makes its recommendations based on meteorological and hydrologic conditions within Delaware. Representation on the DAC includes:

- Governor's Chief of Staff
- Secretary of the Department of Natural Resources and Environmental Control
- Secretary of Department of Public Safety
- Chairman of the Public Service Commission
- Director of the Delaware Geological Survey
- State Fire Marshall
- Secretary of the Department of Agriculture
- Secretary of the Department of Health and Social Services.

During the drought of 2002, the DAC provided recommendations that led to the declaration of a statewide Drought Warning by Governor Minner on March 5, 2002 (Executive Order No. 29). Under the Drought Warning, Delawareans were requested to voluntarily adopt water conservation practices. Due to worsening conditions in NNCC, on August 2, 2002, Governor Minner issued Executive Order No. 32, which declared a Drought Emergency for NNCC. Under Drought Emergency, restrictions were placed on certain water uses (*e.g.*, landscape irrigation, non-commercial car washing). On October 11, 2002, in response to improving meteorological and hydrological conditions, the Governor terminated the Drought Emergency and reinstated a Drought Warning Condition. Upon the recommendation of the DAC, the Drought Warning was terminated on January 15, 2003.

A chronology of key events and corresponding actions taken to manage the drought of 2002 within NNCC follows[52]:

- November 15, 2001 - 250 parts per million (ppm) chloride line within a half mile of the Stanton WTP intake on White Clay Creek.
- February 28, 2002 - Record low monthly mean flows observed at Delaware Geologic Survey (DGS) gages along the Brandywine Creek at Wilmington, White Clay Creek near Newark, and Red Clay Creek at Stanton.
- March 5, 2002 - Governor Minner declares Drought Warning with voluntary water use restrictions throughout Delaware.
- June 6 - Newark curtails withdrawals from White Clay Creek as flow is below the DRBC 14 mgd minimum flow requirement.
- July 4 - Public water demand in NNCC exceeds 80 mgd.
- July 8 – United implements chloride monitoring plan for White Clay Creek to determine stream flow augmentation needs.

[52] Water Supply Coordinating Council, *Fifth Report to the Governor and General Assembly*, January 17, 2003.

- July 12 – United commences operation of well at Christina WTP to blend with surface water for chloride dilution.
- July 18 – flow in Brandywine Creek at Wilmington below 49 mgd (7Q10). Governor's DAC urges voluntary 10 percent reduction in water demand by Delawareans.
- July 31 - Wilmington begins releases from Hoopes Reservoir to Red Clay Creek to augment flows in White Clay Creek at United's Stanton WTP.
- August 2, 2002 - Governor Minner declares Drought Emergency in NNCC with goal of reducing water demand to less than 70 mgd through mandatory water use restrictions.
- August 4 - Raw water chloride levels in White Clay Creek at United's Stanton WTP increase to 250 ppm.
- August 5- United requests waiver of DRBC pass-by requirement at the Stanton Tidal Capture Structure.
- August 6 – United commences treated water purchases from the City of Wilmington.
- August 9 - Public water demand declines below 70 mgd in northern Delaware.
- August 12 – flow in Brandywine Creek at Chadds Ford declines to less than 27 mgd; lowest on record for 91 year period-of-record. Chester Water Authority requests 20 percent reduction in water deliveries to its customers, including Artesian and United. DRBC approves waiver of minimum stream flow requirement at the Tidal Capture Structure on White Clay Creek.
- August 20 - Chester Water Authority requests further reduction in water deliveries to slow decline in Octoraro Reservoir water levels.
- August 23 – flow in Brandywine Creek at Wilmington at 21 mgd; the lowest stream flow on record.
- August 23 - Hoopes Reservoir at minus 6 feet below capacity, leaving 1,470 mg or 82 percent available.
- September 2 - Labor Day rains. Flows in Brandywine Creek above 119 mgd. Wilmington begins refilling Hoopes Reservoir.
- September 6 - Public water demand in NNCC decreases to below 60 mgd.
- October 4 - Remnants of Tropical Storm Isidore help replenish water supplies in the Christina Basin.
- October 10 - Hoopes Reservoir at 100 percent capacity.
- October 11, 2002 - Governor Minner terminates Drought Emergency in NNCC. Drought Warning remains in effect statewide.
- December 31 - Precipitation at the Wilmington Porter Reservoir for October, November, and December totals 17.52 inches or 7.11 inches above normal for the period.
- January 15, 2003 – Governor Minner terminates Drought Warning.

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SECTION 3
REGIONAL WATER SUPPLY PLANNING IN NORTHERN NEW CASTLE COUNTY

Regional water planning in NNCC dates to the late 1960s with the establishment of the New Castle County Water and Sewer Management Office. During the early 1970s, a regional water quality planning initiative was started with grant funding from the U.S. Environmental Protection Agency under Section 208 of the Federal Clean Water Act. Participants in the regional water quality planning program included the cities of Newark and Wilmington and New Castle County. In 1977, the county's water-related programs were combined under a Policy Board to form the Water Resources Agency (WRA) of New Castle County. Voting membership on the Policy Board included representatives from New Castle County, the cities of Newark and Wilmington, and the Governor. Over time, the responsibilities of the WRA broadened too include regional water supply planning. During the late 1990s, the WRA became a program of the Institute for Public Administration (IPA), a research center within the College of Human Services, Education, and Public Policy (CHEP) at the University of Delaware. It has since played a key role as the Water Coordinator for NNCC.

3.1 DELAWARE WATER SUPPLY COORDINATING COUNCIL

- During a declared drought emergency in the summer of 1999, Governor Carper convened a Water Supply Task Force for NNCC. The Task Force was directed to evaluate the effects of the 1999 drought, update water supply and demand analyses for NNCC, and recommend measures to increase the supply of water available to NNCC during droughts. Membership on the Task Force included representatives of State, regional, and county government and the five public and investor-owned water purveyors that serve the area north of the C&D Canal. The members are:
- Governor's Chief of Staff
- City of Wilmington
- Delaware Department of Natural Resources and Environmental Control
- New Castle Board of Water & Light
- Delaware Division of Public Health
- City of Newark
- Delaware River Basin Commission
- United Water Delaware
- New Castle County
- Artesian Water Company, Inc.
- Water Resources Agency at the University of Delaware
- Delaware Geological Survey

On December 2, 1999, the Water Supply Task Force adopted its report. The report, which included recommended measures to develop additional water supplies for NNCC, also recommended that the Governor appoint a Temporary Water Coordinator and establish the Delaware Water Supply Coordinating Council (WSCC). Acting on the Task Force's recommendations, Governor Carper issued Executive Order No. 74 on December 30, 1999. This Order established the WSCC and appointed the Water Resources Agency at the University of Delaware as the Temporary Water Coordinator for New Castle County. The principal responsibility of the Temporary Water Coordinator was to monitor the implementation of water supply projects recommended by the Water Supply Task Force.

Both the WSCC and the Temporary Water Coordinator were given statutory authorization in House Bill (HB) 549, which was signed by Governor Carper in July 2000. The purpose of the WSCC, as stated in HB549, is "…to work cooperatively with the Temporary Water Coordinator for New Castle County to implement short-term water supply enhancement projects. Additional duties of the Council shall consist of performing the following specific functions:

1. "To provide technical input in conducting hydraulic field tests and/or modeling to optimize and expand the intra-county interconnections to convey water from suppliers with excess capacity to suppliers in need of additional water to meet peak demands;
2. "To work with water utilities to develop cooperative market based cost and capacity agreements for the purchase of water supplies during drought and other times emphasizing the need for providers with supply deficiencies to enter agreements which assure adequate supply to customers;
3. "To provide technical input to the recently authorized U. S. Army Corps of Engineers Groundwater Availability Study for northern New Castle County; and
4. "To examine appropriate utilization of all water supply sources located in both northern and southern New Castle County."

The membership of the WSCC is defined in HB549 and includes representatives from the following governmental and private sector entities and non-governmental organizations:

- Office of the Governor (represented by the Governor's Chief of Staff)
- Delaware Department of Natural Resources & Environmental Control (Chair)
- Delaware Department of Public Safety
- Delaware Department of Agriculture
- Public Service Commission
- Delaware Emergency Management Agency
- Delaware Geological Survey
- Delaware Division of Public Health

- Public Advocate
- Delaware River Basin Commission
- New Castle County
- Artesian Water Company
- City of Newark
- City of Wilmington
- New Castle Board of Water and Light (now Municipal Services Commission)
- Tidewater Utilities, Inc.
- United Water Delaware
- New Castle County Chamber of Commerce
- Delaware State Chamber of Commerce
- Delaware Nursery and Landscape Association
- Delaware Professional Grounds Management Society
- Delaware State Golf Association
- Delaware Nature Society
- Coalition for Natural Stream Valleys
- New Castle County Civic League

HB549 further provided that staff support for the WSCC is to be provided by the DNREC, the DGS, and the Water Resources Agency (WRA) of the University of Delaware. Together, these agencies were directed to prepare semi-annual reports to the Governor and the General Assembly summarizing the progress of the WSCC and the status of the water supply projects recommended by the Governor's Water Supply Task Force (the Task Force). To date, the WSCC has submitted five reports.

3.2 1999 WATER PLAN FOR NORTHERN NEW CASTLE COUNTY

In addition to various "institutional recommendations" (*e.g.*, creation of the WSCC), the report of the Task Force presented a 20-year water supply plan for NNCC. The water plan included two key elements: 1) a water supply and demand analysis for NNCC; and 2) recommended near-term and long-term measures to increase the water supply available to the region. Each of these elements is summarized below.

3.2.1 Water Supply and Demand Analysis

For planning purposes, the Task Force developed three water supply scenarios based on differing assumptions with regard to minimum stream flow requirements during drought-of-record conditions, which

was then defined as a 60-day event based on conditions experienced in 1963. The three scenarios[53] are:

- Scenario 1 - no minimum stream flows would be required on Brandywine Creek at Wilmington or on White Clay Creek at Stanton.
- Scenario 2 - no minimum flow requirement on Brandywine Creek and a 7Q10[54] stream flow standard at the Tidal Capture Structure at White Clay Creek, which is equal to minimum stream flow of 17.2 mgd. This scenario represented the existing regulatory condition imposed by the Delaware River Basin Commission (DRBC) for the operation of Tidal Capture Structure by United.
- Scenario 3B - assumed a 7Q10 minimum stream flow standard for both Brandywine Creek and White Clay Creek. This represented a potential future regulatory condition and the most restrictive scenario in terms of water supply availability.

On the demand side of the analysis, the Task Force adopted projections for NNCC that reflect "unrestrained" (*i.e.*, no water use restrictions) maximum month demands for the five NNCC water utilities. Projections were provided for 2000, 2010, and 2020 and were derived from projections prepared by Merna Hurd in 1998 on behalf of DNREC[55].

The comparison of estimated available water supply to projected demand is presented in Table 3.1. As indicated, under Scenario 1, the NNCC region was projected to have surplus supplies through the planning period, while shortages were projected through the planning period for Scenario 2 and Scenario 3B.

3.2.2 Recommended Water Supply Measures

The Task Force adopted the most conservative of the three water supply/demand scenarios (Scenario 3) as the basis for regional water supply planning. In doing so, the Task Force implicitly established a goal to augment the region's water supplies by an amount sufficient to eliminate the projected 17 mgd (1,020 mg) deficit in 2020. A total of 15 water supply augmentation options were identified and evaluated and ultimately reduced to an "A List" and "B List" of recommended water supply projects. The "A List" represented projects that could be implemented in a relatively short time frame (1-3 years) and which had a sponsor committed to implementation of each project. The "B List" included longer-term options that would require additional analysis. Each list is presented in the tables below.

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[53] A fourth scenario - 3A – was also defined and assumed a 7Q50 for Brandywine Creek and a 7Q10 stream flow standard for White Clay Creek at Stanton. This scenario was used in analyses of Hoopes Reservoir operations but was not included as a supply/demand scenario for planning purposes.

[54] 7Q10 refers to a seven-day low stream flow period with an expected recurrence of once every 10 years.

[55] Delaware Department of Natural Resources and Environmental Control, *Water Demand Trends & Future Water Needs, New Castle County, Delaware.* Prepared by Merna Hurd, January 1998.

Table 3.1 Water Supply and Demand Analysis – 1999

	2000				2010				2020			
	Supply	**Demand**	**Surplus/Deficit**		**Supply**	**Demand**	**Surplus/Deficit**		**Supply**	**Demand**	**Surplus/Deficit**	
Scenario 1	93 mgd	86 mgd	+7 mgd	+420 mg	93 mgd	88 mgd	+5 mgd	+300 mg	93 mgd	90 mgd	+3 mgd	+180 mg
Scenario 2	85 mgd	86 mgd	-1 mgd	-60 mg	85 mgd	88 mgd	-3 mgd	-180 mg	85 mgd	90 mgd	-5 mgd	-300 mg
Scenario 3B	73 mgd	86 mgd	-13 mgd	-780 mg	73 mgd	88 mgd	-15 mgd	-900 mg	73 mgd	90 mgd	-17 mgd	-1020 mg

Table 3.2 Water Supply Task Force "A List" - 1999

Project	Millions of Gallons	Millions of Gallons/Day
Newark Reservoir	200 mg	3 mgd
Hoopes Reservoir Deep Storage	500 mg	8 mgd
United Water Delaware Storage Lagoon	25 mg	1 mgd
Artesian Water Co. New Wells North of C&D Canal	120 mg	2 mgd
Newark South Wellfield Iron Treatment Plant	60 mg	1 mgd
Artesian Water Co. ASR	300 mg	5 mgd
Total	1,205 mg	20 mg

Table 3.3 Water Supply Task Force "B List" - 1999

Project	Millions of Gallons	Millions of Gallons/Day
Increase CWA to AWC Interconnection	180 mg	3 mgd
Increase Hoopes Reservoir Storage	300 mg	5 mgd
UWD Bread and Cheese Island Reservoir	500 mg	8 mgd
Artesian Water Co. C&D Canal Pipeline	300 mg	5 mgd
Philadelphia to Delaware Pipeline	1,200 mg	20 mgd
Total	2,480 mg	41 mgd

Table 3.4 Water Supply and Demand Analysis – 2003

	2000				2010				2020			
	Supply	Demand	Surplus/Deficit		Supply	Demand	Surplus/Deficit		Supply	Demand	Surplus/Deficit	
Scenario 1	103.5 mgd	83.3 mgd	+20.2 mgd	+1,515 mg	103.5 mgd	86.3 mgd	+17.2 mgd	+1,290 mg	103.5 mgd	88 mgd	+15.5 mgd	+1,162 mg
Scenario 2	97.5 mgd	83.3 mgd	+14.2 mgd	+1,065 mg	97.5 mgd	86.3 mgd	+11.2 mgd	+840 mg	97.5 mgd	88 mgd	+9.5 mgd	+712 mg
Scenario 3A	84.5 mgd	83.3 mgd	+1.2 mgd	+90 mg	84.5 mgd	86.3 mgd	-1.8 mgd	-135 mg	84.5 mgd	88 mgd	-3.5 mgd	-262 mg
Scenario 3B	82.0 mgd	83.3 mgd	-1.3 mgd	-97 mg	82.0 mgd	86.3 mgd	-4.3 mgd	-322 mg	82.0 mgd	88 mgd	-6.0	-450 mg

3.3 2003 WATER PLAN FOR NORTHERN NEW CASTLE COUNTY

In January 2003 the WSCC submitted its fifth report to the Governor and General Assembly. The report includes a re-evaluation of the 1999 water supply and demand analysis and a new A List and B List of recommended projects. Reevaluation of the water supply and demand analysis was necessary both to update water supply estimates to account for the additional water supplies made available since 1999 and to consider impacts of the drought of 2002. Following the drought, the WRA and DGS analyzed meteorological and hydrologic records and determined that 2002 was a new drought-of-record for the region. Whereas the previous drought-of-record was considered to be a 60-day event, the new drought-of-record is a 75-day period. Consequently, the previous estimates of the amount of water supply available during drought-of-record conditions had to be updated to reflect the more severe conditions that actually occurred during 2002.

NNCC made substantial progress toward its 1999 goal of increasing the amount of water supply available to the region by 1,205 mg (20 mgd). By the end of 2002, 720 mg of additional supply, or 60 percent of the 1999 goal, was in service and available to NNCC water users. Table 3.5 presents the current status of the NNCC water supply projects recommended by the Governor's Task Force in 1999.

Table 3.5 NNCC Water Supply Projects Projected for Completion by 2004

Recommended "A List" Project	Targeted Capacity	Capacity as of December 2002	Status
Newark Reservoir	200 mg (3 mgd)	-0-	317 mg reservoir scheduled for completion summer 2004
Hoopes Reservoir	500 mg (8 mgd)	500 mg (8 mgd)	Complete – current operating plan provides 500 mg for use by other utilities
New Artesian Water Co. Wells	120 mg (2 mgd)	100 mg (2 mgd)	Additional 0.4 mgd in service by end of 2003
Newark Iron Treatment Plant	60 mg (1 mgd)	-0-	Scheduled for completion by the end of 2003
AWC Aquifer Storage & Recovery	300 mg (5 mgd)	120 mg (2 mg)	120 mg pumped from ASR facilities during 2002 drought
Total	1,180 mg (19 mgd)	720 mg (12 mgd)	

Note: The proposed 25 mg storage lagoon for United Water, which was included on the 1999 "A List", was eliminated from further consideration. United determined that the project was not justified in terms of water supply yield versus cost. Also, the Newark Reservoir was originally scheduled for completion by the end of 2003. Weather conditions have delayed completion of the project until the summer of 2004.

3.3.1 Re-Evaluation of Water Supply and Demand

Once again, for the 2003 water supply plan the WSCC adopted several water supply availability scenarios with differing assumptions regarding minimum stream flow standards:

- Scenario 1 – Drought Emergency - No minimum stream flow standard along Brandywine Creek and White Clay Creek.
- Scenario 2 – Existing Regulatory Condition – No 7Q10 along Brandywine Creek but 7Q10 along White Clay Creek.
- Scenario 3A – Future Regulatory Condition – 7Q50 in effect on Brandywine Creek and 7Q10 in effect along White Clay Creek.
- Scenario 3B – Future Regulatory Condition - 7Q10 in effect for both Brandywine Creek and White Clay Creek.

The WSCC also continued to use the water demand projections adopted in 1999 by the Task Force. However, adjustments were made to reflect the discontinuation of water sales from United to the City of Newark once the City's new reservoir is in service.
The updated water supply and demand analysis is presented in Table 3.4.

3.3.2 Updates "A" and "B" Lists

For planning purposes, the WSCC adopted both Scenarios 3A and 3B as a conservative "worst case" scenario based on the assumption that a minimum stream flow standard of 7Q50 or 7Q10 could be imposed on Brandywine Creek at some time during the 20-year planning period. Accordingly, after accounting for the additional water supplies brought on-line since 1999 and considering the impacts of the drought of 2002, the WSCC now forecasts a water supply deficit ranging from 262 mg to 450 mg in the year 2020.
To close the projected gap, the WSCC adopted a new "A List" and "B List" in January 2003 as shown in Tables 3.6 and 3.7, respectively. It should be noted that some projects identified on the 1999 "A" and "B" lists were removed from the new lists by the WSCC based on the results of engineering and economic analyses of project feasibility.

Table 3.6 Water Supply Task Force "A List" -2003

Project	Millions Gallons	Millions Gallons/Day
Increase Storage in Hoopes Reservoir:		
Raise water level by 1 foot	60 mg	0.8 mgd
Raise water level by 2 feet	128 mg	1.7 mgd
Raise water level by 3 feet	203 mg	2.7 mgd
Raise water level by 4 feet	285 mg	3.8 mgd
Raise water level by 5 feet	375 mg	5.0 mgd
Increase Hoopes Pump Station Capacity:		
a. Expand Brandywine pump (12 mgd)	108 mg	1.4 mgd
b. Increase Wills pump station (4 mgd)	36 mg	0.5 mgd
c. New Red Clay Creek pump station (24 mgd)	96 mg	1.3 mgd
d. New pipe/pumps to Hoopes Reservoir (30 mgd)	270 mg	3.6 mgd

AWC Aquifer Storage and Recovery	150 mg	2.0 mgd
United Aquifer Storage and Recovery	225 mg	3.0 mgd
Modification of United Tidal Capture Structure Operating Plan	TBD	TBD

Table 3.7 Water Supply Task Force "B List" - 2003

Project	Millions of Gallons	Millions of Gallons/Day
Philadelphia to Delaware Pipeline	1,200 mg	20 mgd
Brandywine Creek Flow Augmentation: River Water Recycling Scenario	2,025-4,050 mg	25-50 mgd
Brandywine Creek Flow Augmentation: Wastewater Recycling Scenario	2,025-4,050 mg	25-50 mgd
Desalination at White Clay Creek Stanton WTP	TBD	TBD

3.4 NEW STATE LEGISLATION

Two legislative initiatives passed by the Delaware General Assembly and signed by Governor Minner in 2003 directly affect water supply planning and management in NNCC. Each is described below.

3.4.1 House Bill 118 – The Water Supply Self-Sufficiency Act of 2003

In July 2003 Governor Minner signed HB118, the Water Supply Self-Sufficiency Act of 2003. This new law establishes a goal of water supply self-sufficiency for NNCC and includes several key provisions including:

- Investor-owned and larger municipal water utilities are required to adopt conservation-oriented water rate structures for residential customers, at a minimum, by 2005.
- By July 1, 2006 and every 3 years thereafter, each NNCC utility is required to submit a water conservation plan for the following 3-year period. Water conservation plans for the investor-owned water utilities are to be submitted to the DPSC for review while water conservation plans for municipal water utilities are to be submitted to the WSCC for review.
- By July 1, 2006 and every 3 years thereafter, each NNCC water utility is required to certify that it has water supply sources sufficient to meet or exceed projected demand for its service area for the following 3-year period. The certifications of investor-owned utilities are to be submitted to the DPSC for review while certifications of municipal utilities are to be submitted for review to the WSCC.
- Utilities are required to establish equitable bulk wholesale rates for inter-utility water purchases and to provide water, if it has excess capacity, to a drought-sensitive area if necessary.
- Beginning in 2009, NNCC water utilities must certify "…that none of its sources of supply for use during a drought of record are reliant on contracts with out-of-state water authorities or utilities, except for minimum purchase obligations under purchase-water contracts in existence on April 1, 2003 between Delaware water utilities and non-Delaware providers."

3.4.2 House Bill 203

In August 2003, Governor Minner signed HB203, which amends the statute (HB549) establishing the WSCC. HB203 reauthorizes the WSCC through January 1, 2010, expands the membership of the WSCC to provide statewide representation, and eliminates the position of Temporary Water Coordinator for New Castle County. The new mandate of the WSCC is:

> "…to work cooperatively with WRA, DGS, DNREC, and DPH to achieve water supply self sufficiency in northern New Castle County by 2010, and to develop and publish water supply plans for southern New Castle County, Kent County, and Sussex County. These plans shall identify and describe uses, localities, or areas where water supply issues exist, and identify and describe localities, or areas where future water supply issues may occur. These areas and uses should include, but not be limited to Middletown-Odessa-Townsend, Dover and central Kent County, Coastal Sussex County and agricultural irrigation uses. These plans shall contain an estimate of existing and future public and private water supplies and water demands through 2025. Private demands shall take into account, to the maximum extent practicable, all domestic, industrial, and irrigation uses. Additional duties of the Council shall consist of performing the following specific functions:
>
> (1) To provide technical input in conducting hydraulic field tests and/or modeling to optimize and expand, where appropriate, water utility connections;
> (2) To work with water utilities to develop cost and capacity agreements subject to approval by the applicable rate-setting authority for the purchase of water supplies during drought and other times emphasizing the need for providers with supply deficiencies to enter agreements which assure adequate supply to customers; and
> (3) To conclude the authorized U. S. Army Corps of Engineers Groundwater Availability Study for northern New Castle County and provide technical support on any groundwater availability studies as deemed necessary by the WSCC."

3.5 FINDINGS AND CONCLUSIONS

All of the many individuals and organizations involved in the work of the Task Force and the WSCC are to be commended for having had the foresight and wherewithal to undertake regional water supply planning and coordinated water resources management. The record reviewed for this investigation clearly demonstrates that the region was well prepared for the drought of 2002, having learned important

lessons from previous droughts in 1995 and 1999 and having taken action to develop or make available additional water supplies and to further improve regional water supply security. With new water supplies slated to come online by the end of 2003 (*e.g.*, the City of Newark's new reservoir), the region appears to be even better prepared to cope with a future recurrence of severe drought conditions.

Overall, the Parsons project team has been impressed by the high degree of cooperation that has evolved among NNCC water suppliers and with the level of support that has been provided for regional water supply planning. The region's recent accomplishments in water resources planning and management speak for themselves. Parsons review of the products of the Water Supply Task Force and the WSCC, combined with information gleaned from meetings with many of the principals involved in the planning process, strongly supports a conclusion that the regional water planning process for NNCC is based on technically sound analytical methods and assumptions. There are, however, a few issues that should be considered in future updates of the region's water supply plan.

3.5.1 Water Demand Projections

As discussed elsewhere in this report, the WSCC's current water demand projections for Artesian and United should be re-evaluated and adjusted if appropriate. It is noted that current maximum month average demands for both utilities, if adjusted to reflect unrestrained demand conditions (i.e., demands without voluntary or mandatory water use restrictions), appear to be higher than the current WSCC projections of maximum month demand. Also, the WSCC projections for Artesian need to be re-evaluated in light of recent growth trends and prospects for continued growth of Artesian's NNCC customer base and water demands. In re-evaluating water demand projections, it is also recommended that the WSCC also consider:

- Extending the planning horizon to 2030;
- The long-term effects of continuing decreases in per capita water use resulting from efficiency improvements in plumbing fixtures and appliances, demographic trends (*e.g.,* smaller household sizes), and housing trends (*e.g.,* more multi-family units, smaller lot sizes); and
- Development of alternative demand scenarios based on different growth rates (*e.g.*, low, high, and "most likely").

3.5.2 Water Supply Availability Estimates

As noted in Section 4, concerns were expressed by representatives of DNREC, the Delaware Geological Survey, and the Water Resources Agency about the WSCC's current estimates of water supply availability for Artesian. It is therefore recommended that those estimates be re-evaluated and adjusted if warranted.. A particular concern is whether Artesian can produce 20.0 mgd from its current groundwater production facilities over an extended period, for

example, for 75 consecutive days during a repeat of a drought-of-record. A definitive answer to this question will require additional analyses beyond the scope of this investigation.
There are also unanswered questions with regard to the long-term sustainability of current rates of groundwater withdrawals in NNCC, questions that cannot be addressed until the new Army Corps of Engineers' groundwater model is completed in about 1 year. Once the model is completed, it is recommended that simulations be performed to evaluate the long-term effects of current rates of groundwater withdrawals in NNCC and the effects of various scenarios for increased withdrawals. Of particular interest is determining if there are areas within NNCC where additional groundwater supplies can be developed without jeopardizing the long-term sustainability of the resource in terms of both quantity and quality. Pending such analyses, it is recommended that further groundwater development in NNCC be deferred.
The Water Supply Self-Sufficiency Act of 2003 (HB118) also places new restrictions on the amount of water supply that NNCC water utilities can count on from out-of-state sources. Specifically, beginning in 2009, the new law will limit the amount of water from the Chester Water Authority that Artesian can include in its certification of water supply availability. At present, the WSCC's estimate of the amount of water available to Artesian from Chester Water Authority is 4.0 mgd. A literal reading of the new statutory restriction on out-of-state water purchases would appear to limit Artesian to 2.0 mgd of supply from the Chester Water Authority during drought. The statute has no impact on the amount of water available to United as it is not currently included in contractual water purchases from Chester Water Authority as a supply source during drought.
Taken together, concerns about Artesian's existing groundwater supplies and the impacts of new statutory restrictions on out-of-state water purchases lead Parsons to recommend that the WSCC re-evaluate these components of its current estimates of water supply availability. Additionally, if and when a new Operating Plan for United's Tidal Capture Structure is approved by the DRBC, it will also be necessary for the WSCC to revise its planning scenarios and water supply availability estimates for United.

3.5.3 Water Supply Options

Recommendations regarding NNCC water supply options are presented below.

Hoopes Reservoir

As shown in Table 3.6, the WSCC's current "A List" of recommended water supply projects includes several options for modifying diversion (a.k.a. pumping) facilities for diversions from Brandywine Creek to Hoopes Reservoir and several options for increasing the storage capacity of the reservoir. While such options should remain under active consideration, the Parsons project team does not

believe capital investments to increase water supply from Hoopes Reservoir are warranted at this time. Specifically, further action on increasing the supply of water from Hoopes Reservoir should be postponed pending the outcome of DRBC action on a new operating plan for United's Tidal Capture Structure on White Clay Creek. As noted in Section 5, United is expected to propose a new operating plan that, if approved by DRBC, will significantly lessen the amount of water United will require from Hoopes Reservoir for augmentation of flows in White Clay Creek during drought. The Parsons project team holds the opinion that the approach United intends to propose in the new operating plan is technically feasible and will provide adequate protection of environmental resources. While the amount of flow augmentation required under a modified operating plan for the Tidal Capture Structure has not been determined at this time, it appears likely the amount will be significantly less than the 500 mg the City of Wilmington has committed to other NNCC utilities in its current operating plan for the Hoopes Reservoir. However, the amount may exceed the 200 mg specified in United's current contract with Wilmington. If further analysis reveals a need for flow augmentation in excess of 200 mg during drought, it is recommended that United seek to amend its contract with Wilmington to increase the amount of water available to it from Hoopes Reservoir.

If, however, the current minimum stream flow requirement at the Tidal Capture Structure is not modified, and absent imposition of a minimum stream flow standard on Brandywine Creek, it also appears likely that Hoopes Reservoir can fully satisfy United's requirements without increasing the capacity of the reservoir. Reservoir simulations performed by the WRA indicate that had the current flow standard for White Clay Creek been in effect throughout the drought of 2002, United would have required 586 mg in releases from Hoopes Reservoir. Combined with the City of Wilmington's needs (91 mg), Hoopes Reservoir would only have been drawn down to 74 percent of its capacity. This analysis strongly suggests that the reservoir, with its current pumping and storage capacity, could supply significantly greater quantities of water during a repeat of drought-of-record conditions without creating an unacceptable risk of shortage. However, this scenario would require modification of the City of Wilmington's current operating plan for Hoopes Reservoir and amendment of the existing contract between United and Wilmington.

The Parsons project team recognizes that the Hoopes Reservoir is the key to long-term water supply security in NNCC. Should water demands in the region increase substantially or should minimum flow standards be established for Brandywine Creek, or both, modification of the existing pumping capacity and/or increasing the storage volume of Hoopes Reservoir should be considered priority water supply augmentation strategies. However, the Parsons project team recommends that the WSCC sponsor additional studies to evaluate supply optimization strategies for Hoopes Reservoir. Specifically, it is recommended that modeling analyses be performed in four steps:

- Step 1: Conduct additional modeling analyses of the reservoir to determine how much water can be supplied from the project during a repeat of drought-of-record conditions without increasing pumping or storage capacity. In addition to the simulations performed by the WRA, probabilistic modeling methods should be applied to assess the risks associated with varying levels of increased releases from the reservoir.
- Step 2: Conduct modeling analyses using both statistical and probabilistic methods, to determine how to optimize "scalping" of flows from Brandywine Creek and thereby increase the yield of Hoopes Reservoir with modifications to diversion facilities (*e.g.,* increased pumping capacity, variable pumping).
- Step 3: Conduct modeling analyses to determine how to optimize the yield of Hoopes Reservoir with increased storage by raising the elevation of the conservation pool in 1-foot increments from 1 to 5 feet.
- Step 4: Conduct modeling analyses to determine how to optimize the yield of Hoopes Reservoir both by modifying diversion facilities and by increasing reservoir storage.

At the risk of pre-judging the outcome of the recommended modeling analyses of Hoopes Reservoir, the Parsons project team believes the analysis will support the conclusion that the project can provide additional supplies without modification of the diversion or storage facilities. It is likely the analyses will also shed light on the timing and sequencing of future modifications to the project when demand conditions warrant (*e.g.*, modification of diversion facilities versus increasing storage).

Water Conservation

Sections 4 and 5 of this report include recommendations that analyses be performed to determine how much additional water conservation could be reasonably achieved through utility-sponsored programs to encourage early replacement of non-conserving plumbing fixtures and appliances. Such an analysis would quantify the water savings associated with various incentive and/or regulatory strategies and identify the direct and indirect costs of each approach. The Parsons project team sees potential for economies of scale and reduced program implementation costs through a regional approach. For example, a toilet replacement rebate program could be implemented region-wide by a single entity with funding provided by each participating utility proportionate to its level of participation. Accordingly, it is recommended that the WSCC consider sponsoring the necessary water conservation cost-benefit analysis and evaluate the merits of regional program implementation strategies.

Water Reuse

The WSCC's "B List" of recommended water supply projects includes the concept of augmentation of flows in Brandywine Creek during low flow conditions using either "recycled" river water from the Delaware River or "recycled" wastewater treated to tertiary

standards. While these concepts may have merit if and when a minimum stream flow standard is implemented for Brandywine Creek, other strategies for direct beneficial reuse of "reclaimed" water (treated effluent) should also be considered. The general concept is to use appropriately treated wastewater as a substitute for fresh or potable water supplies for certain uses. It is noted that both the City of Wilmington and United supply significant quantities of potable water to commercial and industrial users. It is likely that some of this demand is associated with "end-uses" that do not require a potable-grade water supply (*e.g.*, cooling water, industrial process water, irrigation of golf courses). Accordingly, there is likely to be some potential to increase the effective water supply of NNCC through direct non-potable reuse. Importantly, direct non-potable reuse can also reduce demand on potable water production and distribution facilities, which may extend the capacity of existing facilities for future growth.
It is recognized, however, that there are several potentially significant impediments to direct non-potable reuse in NNCC. Cost is often prohibitive as direct non-potable reuse often requires enhanced treatment of wastewater to meet end user requirements, as well as construction, operation, and maintenance of reclaimed water storage, transmission, and distribution facilities. In addition to cost, there may be other impediments such as regulatory constraints, public acceptance, and institutional concerns (*e.g.*, separation of potable water utility and wastewater utility functions). It is nonetheless recommended that the WSCC include direct non-potable reuse as a "B List" strategy for further evaluation, at least at a reconnaissance level.

Additional Groundwater Development

As indicated above, it is recommended that additional groundwater development in NNCC be deferred pending the completion of modeling analyses of the long-term effects of current rates of groundwater withdrawals. Additional groundwater development in NNCC should only be considered if it can be demonstrated that current rates of groundwater withdrawals can be sustained. Additionally, any additional groundwater development should be directed to areas within NNCC where modeling analyses indicate that such development can occur without adversely affecting existing groundwater withdrawals.

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SECTION 4
ARTESIAN WATER COMPANY

The Artesian Water Company was formed in 1905 by William Taylor, a developer and homebuilder in the Wilmington area. The company was formed as a result of the City of Wilmington's denial of water utility services to the Richardson Park Subdivision. During the post-World War II housing boom, Artesian grew through the acquisition and consolidation of numerous small subdivision-scale water systems, which have since been interconnected allowing the transmission of potable water throughout the Artesian service area. Artesian is the water utility subsidiary of Artesian Resources and is the oldest and largest public water utility in Delaware[56].

4.1 SERVICE AREA AND CUSTOMER BASE

Artesian serves a large area (approximately 100 square miles) of NNCC (see Figure 2.2). It also serves areas of New Castle County south of the C&D Canal and operates water systems in Sussex and Kent counties, Delaware. Statewide, Artesian serves approximately 69,155 customers representing approximately 220,000 people, which is approximately 27 percent of the State's total population[57].
As of July 31, 2003, Artesian served 64,781 customers in NNCC, which is 93.7 percent of its total customer base. The breakdown by type of customer follows:

Residential	60,325	93.1%
Commercial	3,614	5.6%
Industrial	16	0.02%
Other	826	1.3%
Total	**64,781**[58]	

Artesian has and continues to experience sustained growth in its customer base (see Table 4.1). Since 1990, Artesian reports a system-wide increase in metered customers approximating 37 percent[59]. More recently, over the past 5 years (1997-2002), Artesian reports a system-wide increase of 14.8 percent in metered customers, representing an average annual rate of growth of 2.81 percent.

4.2 WATER DEMAND

Table 4.1 presents system-wide water demands for the period 1990 to 2002, during which annual water demand increased by 28 percent. For

[56] Artesian Water Company website. www.artesianwater.com
[57] *Ibid*
[58] *Ibid*
[59] Artesian Water Company Response to Questions from Parsons, Bruce P. Kraeuter, September 12, 2003.

the 5-year period from 1997 to 2002, annual water demand increased by approximately 8.5 percent, representing an average annual rate of growth of 1.65 percent[60].

Table 4.1 Annual Water Demand 1990-2002

Year	Number of Metered Customers	Annual Demand (in mg)	Average Daily Demand (in mgd)	Percent Increase in Average Day Demand
1990	49,568	5,016.2	15,453,509	
1991	50,865	5,311.5	16,556,911	7.14%
1992	52,014	5,325.3	16,960,710	2.43%
1993	53,599	5,437.4	17,559,161	3.53%
1994	55,097	5,622.7	17,825,523	1.52%
1995	56,672	5,616.1	17,976,332	0.08%
1996	57,934	5,416.7	17,538,893	-2.43%
1997	59,218	5,879.5	18,184,800	3.68%
1998	60,688	5,950.7	18,463,736	1.53%
1999	62,621	6,138.1	18,515,480	0.28%
2000	64,902	6,048.3	18,799,840	1.54%
2001	66,173	6,573.7	19,708,712	4.83%
2002	68,010	6,388.0	19,721,167	0.06%

Source: Artesian Response to Questions from Parsons, Bruce P. Kraeuter, September 12, 2003.

If one assumes that residential and commercial water demand on the Artesian system in NNCC are proportionate to the number of customers that it serves in NNCC, and that all industrial demands are within its NNCC service area, then average day water demand during 2002 by type of customer in Artesian's NNCC service area was:

Table 4.2 Estimated Water Demand in NNCC Supplied by Artesian

Customer Class	% of Customers in NNCC	Total Water Demand in 2002 – All Customers	Estimated Water Demand in NNCC
Residential	93.45%	3,627 mg	3,389 mg
Commercial	97.10%	2,167 mg	2,104 mg
Industrial	100.00%	221 mg	221 mg
Other	95.38%	373 mg	355 mg
Total		6,388 mg	6,069 mg

Demands on the Artesian system exhibit typical seasonal fluctuations with the highest demands occurring during the summer months when landscape irrigation and other discretionary water uses (*e.g.*, car washing) are greatest. July is typically the month with the highest average day demand. The WSCC's current (2003) maximum month water

[60] *Ibid*

demand estimate for Artesian is 24.0 mgd. Artesian has experienced maximum day demands of 27.99 mgd[61]. Maximum day demand on the Artesian system during 2002 was considerably lower at 26.3 mgd on July 4th, which clearly reflects the effects of voluntary water conservation measures associated with the declared Drought Warning that was in effect at the time.

4.3 WATER SUPPLY SOURCES

Artesian's primary source of water supply for its NNCC service area is groundwater. At present, approximately 80 percent of Artesian's annual water demand is from self-supplied groundwater, which is produced from 48 wells in 17 well fields within NNCC. Artesian also has 13 interconnections with other water suppliers, which allows it to access surface water supplies, as well as additional groundwater supplies. A brief description of each of Artesian's major sources of water supply follows.

4.3.1 Groundwater

Artesian's production wells in NNCC derive their water supply yield from the Piedmont Cockeysville Formation (eight wells), the Upper and Lower Aquifers in the Potomac Formation (35 wells) and the Quaternary age Columbia Formation (six wells). The wells range in depth from the land surface from 72 to 419 feet and the pumping capacities range from 100 to 1,100 gpm. The average pumping rate for Artesian's well is approximately 380 gpm.

Withdrawal allocations are required from both the DNREC for all wells producing more than 50,000 gpd (35 gpm) and from the DRBC for all wells producing more than 100,000 gpd (70 gpm). DNREC allocation permits specify a maximum pumping rate and a maximum drawdown. For each well field, DNREC also specifies a maximum daily, monthly (30 days) and yearly withdrawal amounts. DRBC specifies a maximum 30-day withdrawal that coincides with the DNREC limit.

It is noted that three of Artesian's well fields are not under the jurisdiction of the DRBC. These well fields are the Chesapeake City Road (11.19 mg), the Eastern States (38.5 mg), and the Old County Road (95.04 mg) well fields. Accordingly, DRBC's allocations to Artesian are 593.06 mg of groundwater withdrawal over 30-days while the cumulative 30-day allocation granted by DNREC is 745.948 mg.

Under DNREC permits, the maximum allowable 24-hour withdrawal from all wells operated by Artesian in NNCC is 24.49 mg. However, Artesian reports that its peak month operating capacity is 23.34 mgd and that its annual average groundwater production

[61] *Ibid*

capacity is 15.6 mgd. Artesian also states that its wells and well fields pump at rates less than the pumping limits established in the DNREC allocation permits. They indicate this is due to the following;

- Total pumpage may not exceed permit limits.
- The water level drawdown of wells may not exceed permit limits.
- The wells are pumped only to the extent required to satisfy demand[62].

Artesian provided information for each well showing the maximum drawdown level, pumping water levels, maximum pumping rate in gpm, and actual flow rate in gpm. The review of this information indicates that Artesian is in compliance with the allocation criteria. However, in several cases, such as the charts for Glendale Well #5, Fairwinds Well #5, Jefferson Farms Well #1, Hockessin Well #4, or Eastern States Well #1, the allowable drawdown is at or near the limit while the actual pumping rates are from 100 to 500 gpm below the maximum permitted rate. Artesian has indicated that they have reduced groundwater withdrawals in these areas to maintain compliance with allocation limits and thereby prevent undue stress on the resource.

4.3.2 Aquifer Storage and Recovery

Aquifer storage and recovery (ASR) involves injection of surface water or groundwater into an aquifer for storage and subsequent extraction from the same well. Water stored in the aquifer may come from a variety of sources and may be subjected to varying degrees of treatment prior to storage and following recovery. Most ASR applications for water utilities typically involve underground injection of treated drinking water through a dual purpose well. The water is temporarily stored in the vicinity of the injection well in a suitable aquifer. As it is needed, the stored water is recovered through the same well and pumped into the water distribution system, typically with some additional treatment (*e.g.*, chlorination) to comply with water quality standards.
The benefit of ASR is that it allows for optimization of water treatment facilities and enables water utilities to meet periodic peak water demands without having to oversize other water production, storage, and distribution facilities. ASR can also increase the amount of water supply available during a drought to the extent that surplus water from other sources, particularly surface water, can be stored or banked during off-peak periods to meet demands during drought.

[62] Artesian Water Company Response to PSC Order No. 6068, Bruce P. Kraeuter, January 31, 2003.

Reportedly, annual operating costs for an ASR facility are often somewhat higher than the cost of utilizing conventional water sources. However, when comparing capital cost per unit of new capacity, development of an ASR system may be less costly than development of other water supply and treatment alternatives. At present, Artesian operates two ASR wells – one located in the company's Fairwinds Well Field and one in the Llangollen Well Field. The Fairwinds well is screened in the Lower Potomac aquifer. The well produces approximately 100 gpm and produces groundwater with a high iron content. As reported by Artesian, during 2001 the Fairwinds well was used to store approximately 7.8 mg while approximately 7.7 mg was recovered from the well. Because the well was used as a groundwater supply source for the entire year, no water was placed in storage in the Fairwinds well during 2002 Also, because of the limited storage rate at this facility, Artesian now intends to use this well only as a production well.

Artesian's other ASR well is located in the Llangollen River Road well field and is screened in the Upper Potomac Aquifer. According to DNREC staff, the water stored in the Llangollen ASR well is from groundwater produced from other wells within the Llangollen Well Field. Treatment includes fluoridation and chlorination. Artesian estimates the size of the aquifer storage zone by testing for fluorides in observation wells.

Artesian's Llangollen ASR well has the capacity to withdraw water at a rate of 1,100 to 1,200 gpm. However, by agreement with DNREC, Artesian has reduced the withdrawal (recovery) rate to approximately 800 gpm to correspond to the rate that water is injected (stored). Artesian reports that in addition to its water supply benefits, the Llangollen ASR well has also created a barrier to the migration of groundwater with higher chloride levels towards the Llangollen well field. It is reported that one well in the Llangollen field once showed elevated chloride levels when operated at a high pumping rate (1,400-1,500 gpm). The Llangollen field is also vulnerable to contamination. During the summer of 2000, bis (2 chloroethyl) ether (BCEE) was detected in Llangollen Well Field water. By late October 2000 when the BCEE concentration exceeded the U.S. Environmental Protection Agency's action level of 0.96 parts per billion (ppb), Artesian voluntarily took both the production wells and the ASR well at Llangollen temporarily out of service while a granular activated carbon treatment system was installed. This facility became operational by the end of December 2000. Although little information is provided in any of the reports with regard to the source of the BCEE, DNREC staff have indicated

that the source is the Delaware Sand and Gravel Landfill, which is listed as a Federal Superfund site. Fortunately, this contamination incident and its remediation at the Llangollen Well Field occurred during a non-drought demand period.

To date, Artesian has been operating its ASR facilities under annual operating permits, which have allowed limited production so that data on the performance of the facilities can be collected and analyzed. It is expected that DNREC will soon issue an underground injection permit and groundwater withdrawal permits for these wells and that the DRBC will issue groundwater withdrawal permits.

Artesian hopes to obtain an additional 2.0 mgd of reliable water supply from ASR. At present, Artesian is investigating the feasibility of ASR at a site within the company's Artisan Village Well Field, which also produces groundwater from the Upper Potomac Aquifer. The ASR well at this site will reportedly store and recover water from different sands within the Potomac Formation. To date, water quality testing indicates the presence of iron. Reportedly there are no chloride issues.

Artesian reports that during 2001, 118.5 mg was stored and 113.7 mg was recovered from the Llangollen well. During 2002, approximately 126 mg was stored and 122 mg was recovered. The WSCC's water supply estimates for Artesian show a firm supply from ASR of 1.7 mgd. However, by prior agreement between Artesian and DNREC, ASR supplied only 1.1 mgd on average during the drought of 2002. Artesian reports that approximately 120 mg was stored in early 2003 and it anticipates that approximately 90 mg will be recovered to meet demands during the summer of 2003.

Two concerns have been voiced about Artesian's ASR strategy. The first is that water stored in the Llangollen ASR well is actually produced from other wells within the Llangollen well field. The concern is that taking groundwater from one part of the formation and storing it in another may not provide a net gain in Artesian's reliable water supply. However, Artesian contends that its purchases of surface water during off-peak periods is in excess of its demands and therefore provides a system-wide surplus that can be "banked" through ASR. The records reviewed for this investigation support the company's contention insofar as a system-wide water balance does indicates that Artesian is purchasing sufficient quantities of surface water during the off-peak aquifer storage period.

A second concern is that the sites selected by Artesian for ASR may not be in the best locations in terms of both recharge and recovery potential. It is noted that the new groundwater model being developed by the Army Corps of Engineers for DNREC may show other more suitable areas for ASR within NNCC. For example, because a certain amount of stored water cannot be recovered – estimates are 7 percent of the water stored in the aquifer remains in the aquifer - it may be better to site ASR facilities in areas where over-pumping has occurred so some long-term replenishment of the aquifer will occur.

Despite these concerns Artesian is confident it will be able to meet its future goal of having 3.7 mgd available from ASR during drought conditions. Provided Artesian identifies and develops suitable sites for ASR and provided it purchases surface or groundwater water supplies in excess of system demand, the Parsons project team generally concurs with Artesian's ASR strategy.

4.3.3 Water Purchases from Other Suppliers

As indicated, approximately 20 percent of the current annual demand on the Artesian system is supplied from surface and groundwater purchased from other water suppliers. Artesian currently maintains nine "active" interconnections and four "emergency" interconnections with other water suppliers. Artesian's wholesale water purchases are from the Chester Water Authority, the City of Wilmington, and the New Castle Municipal Services Commission. Each of these sources of supply are briefly described below.

Chester Water Authority

Artesian has a longstanding contractual relationship with Chester Water Authority to purchase treated water from the Authority through an interconnection in the northwestern portion of Artesian's service area near the Pennsylvania-Delaware state line. In addition to providing a reliable source of water supply, Artesian reports that the location of its interconnection with the Authority in the portion of its service area with the highest elevation provides water distribution benefits by enabling water transfers by gravity to lower elevations within Artesian's NNCC service area[63].
The term of the current agreement is through December 31, 2021 with an option to extend the term through 2047. The contract provides that Artesian will purchase a minimum of 3.0 mgd or 1,095 mg per year. It further stipulates that Artesian is to purchase a minimum of 2.0 mgd and that it may purchase up to 6.0 mgd during peak demand periods. The WSCC's current estimate of the supply available to Artesian during drought is 4.0 mgd.

It is noted, however, that the existing contract between Artesian and the Authority includes a clause that allows the Authority to curtail water deliveries provided that such curtailments are imposed on all of the Authority's customers on an equal or pro rata basis. During the drought of 2002, Artesian has stated that it initially attempted to use as much water as possible from the Authority during the winter and spring in order to conserve their Piedmont groundwater supplies. As the drought progressed, Artesian stated that it began to voluntarily reduce its purchases of water from the Authority in anticipation of mandatory curtailments. On August 12, 2002, the Authority officially requested its customers to reduce water purchases by 20 percent. The Authority also temporarily suspended its minimum purchase requirements, which gave Artesian further incentive to reduce its water purchases from the

[63] Personal communication with Bruce P. Kaeuter, August 21, 2003.

Authority. During June and July 2002, Artesian's purchases of water from the Authority averaged 3.3 mgd and 2.8 mgd, respectively, and decreased to an average of 1.8 mgd during August and 0.7 mgd during September 2002. By November 2002, water supply conditions in the Octoraro Reservoir had returned to normal, and effective December 23, 2002 the Authority rescinded its waiver of minimum purchase requirements.

City of Wilmington

Artesian has had a contractual relationship with the City of Wilmington since 1986 for wholesale water purchases through an interconnection to the City's water distribution system at Maryland Avenue. The agreement stipulates that Artesian is to purchase a minimum of 200 mg/year and may purchase up to 3.0 mgd on a sustained basis and an additional 2.0 mgd on an interruptible basis during peak demand periods. The contract had an initial term of 10 years with automatic renewal for additional terms of 5 years unless either party gives notice of termination at least 6 months prior to the end of a renewal term. The current renewal term expires in 2006. The contract also includes a provision that allows the City of Wilmington to partially or fully curtail water deliveries to Artesian in the event of an emergency condition, as determined by the City.

While Artesian has consistently purchased water from Wilmington in excess of its minimum annual requirement (*e.g.*, approximately 292 mg during 2002), Artesian does not currently consider any water supply as being available from the City during drought or peak demand periods[64]. Artesian has stated it intends to rely on water purchases from the City, particularly during the winter months, as a source of excess water supply for its aquifer storage and recovery facilities[65]. However, the record indicates that Artesian did require significant amounts of water from the City of Wilmington during the 2002 peak demand period. Artesian's average daily water purchases from the City of Wilmington for the period from June 2002 through August 2002 were:

June 0.5 mgd

July 1.3 mgd

August 1.2 mgd

The amount of water purchased by Artesian from the City of Wilmington during the 2002 peak demand period suggests that Artesian should consider water purchases from the City of Wilmington as a supplemental source of supply during drought.

New Castle Municipal Services Commission

During July and August of 2002, Artesian began making bulk purchases of water from the New Castle Municipal Services Commission (MSC),

[64] Artesian Water Company Response to PSC Order No. 6068, Bruce P. Kraeuter, January 31, 2003.
[65] Personal communication with Bruce P. Kaeuter, August 21, 2003.

which, according to the WSCC's Fifth Report, has a current maximum month supply surplus of approximately 1.5 mgd. New Castle MSC's source of supply is groundwater from the Potomac Aquifer. During the 2002 drought period, Artesian purchased, on average, 0.6 mgd of water from New Castle MSC and a total of nearly 40 mg. Artesian's contract with the New Castle MSC does not specify any minimum or maximum purchase amounts and it provides for automatic renewal in five year increments unless one party or the other terminates the agreement. At present, the WSCC's water supply estimates for Artesian do not include supply provided to Artesian from the New Castle MSC. However, Artesian has stated that it considers 0.7 mgd of supply from New Castle MSC in its estimates of total available peak month average day supply[66].

4.4 WATER DISTRIBUTION AND STORAGE

Artesian maintains an extensive water distribution system consisting of approximately 800 miles of pipeline that range in size from 2 inches in diameter to 24 inches in diameter. The distribution system also has more than 3,000 fire hydrants. Artesian currently has 20 water storage tanks at locations throughout its NNCC service area. Combined, these tanks have a storage capacity of approximately 35 mg. Approximately 22 mg is available for use while the remainder is required to maintain a minimum water pressure of 25 psi within the water distribution system.
Artesian reports that it has no plans to construct additional ground or elevated water storage tanks and that it has no plans for additional interconnections with neighboring water utilities. Artesian does note that it plans to construct at least two additional ASR wells in NNCC[67]. In addition, Artesian is planning to interconnect its service areas in New Castle County north and south of the C&D Canal by constructing new water transmission facilities that will cross beneath the C&D Canal. Artesian states that this project is intended to improve overall system reliability and that its purpose is not to provide additional groundwater supply to NNCC from its well fields south of the C&D Canal[68].

4.5 WATER CONSERVATION

Information provided by Artesian supports a conclusion that water demand per service connection "…has generally declined at a rate in excess of 1 percent per year since 1994."[69] Of note is that this trend of declining water demand has allowed Artesian to accommodate

[66] Artesian Water Company Response to PSC Order No. 6068, Bruce P. Kraeuter, P.E., January 31, 2003.
[67] Artesian Water Company Response to Questions from Parsons, Bruce P. Kraeuter, September 12, 2003.
[68] Statements by Bruce P. Kraeuter at the Water Supply Coordination Council meeting of July 16, 2003.

[69] *Ibid*

some of its recent growth without corresponding levels of investment in additional water supplies. Artesian cites both the adoption of national plumbing fixture efficiency standards in 1993 and its adoption of a conservation-oriented water rate structure (inclining block) in 1992 as factors that have contributed to decreasing water demand[70]. Artesian also reports that it maintains "unaccounted for" water at less than 9 percent of total water production, which is exceptional considering the geographic extent of Artesian's service area and water distribution system.

Additionally, Artesian maintains an active consumer education program on water conservation, which includes:

- A quarterly newsletter distributed to all customers. The spring 2003 issue was focused on residential indoor and outdoor water use and conservation.
- A water conservation display in the lobby of its offices.
- Free brochures and other water conservation information that is available to Artesian's customers in the lobby of its offices or upon request.
- Displays at community events (*e.g.*, the Wilmington Flower Festival).
- Programs for schools, clubs, and summer camps.
- During the early 1990s, Artesian offered rebates to its customers for purchase and installation of ultra-low volume toilets.

4.6 PERFORMANCE DURING THE DROUGHT OF 2002 – FINDINGS AND CONCLUSIONS

Based on information reviewed for this investigation, the Parsons project team concludes that Artesian had sufficient water supply from self-supplied sources (groundwater and ASR) and from water purchases from the Chester Water Authority, from the City of Wilmington, and from the New Castle MSC to meet customer water demands throughout the 2002 drought period. Daily water production records for the period June through August 2002 demonstrate that average monthly demands on the Artesian system were below the WSCC's estimate of Artesian's currently available water supply of 25.7 mgd (average for maximum month). Furthermore, it appears that Artesian likely would not have had difficulty meeting higher water demand levels that would have occurred had voluntary and mandatory water use restrictions not been in effect. For example, if demand on the Artesian system had been 9 percent higher on average during July 2002 (the maximum month for 2002) average monthly demand would have been approximately 25.1 mgd, or about 0.7 mgd less than the WSCC's estimate of Artesian's available water supply.

It is apparent, however, that with curtailment of water deliveries from Chester Water Authority during late July and through August 2002, Artesian's ability to purchase water from the City of Wilmington and the New Castle MSC took on added importance. This is noteworthy inasmuch as the current WSCC water supply estimates for

[70] *Ibid*

Artesian do not include supply from these sources. In recent communication between Artesian and the DPSC, Artesian indicates that it now considers 0.7 mgd from the New Castle MSC as a component of its available peak month average day supply. However, Artesian does not consider water purchases from the City of Wilmington as part of its available supply during peak periods even though it obtained significant amounts of water from Wilmington throughout the 2002 peak demand period. If a drought of similar magnitude were to occur in the near future, it would seem that Artesian will likely require significant amounts of water from the City of Wilmington to meet customer water demands during peak periods[71].

In addition, data provided by Artesian supports a conclusion that it did not experience any undue problems maintaining adequate storage of finished or treated water during the drought period. It was noted by Artesian that no significant equipment outages occurred and no customer complaints of low water pressure were received during the drought period.

Other findings, conclusions, and recommendations with regard to Artesian's performance during the drought of 2002 and with regard to current and future water supply requirements are presented below.

4.6.1 Effects of Voluntary and Mandatory Water Use Restrictions

A review of water production data for Artesian during the drought period indicates that voluntary water conservation measures significantly reduced water demands on the Artesian system during the drought of 2002. Documents submitted by Artesian note that water demands during May and June of 2002 were approximately 9 percent lower than demands reported for the same period during 2001[72]. This level of demand reduction is confirmed by comparing average water demands for the region as a whole for July 2002 with average water demands for July 1999, also a drought period. That comparison indicates that overall regional water demand was approximately 9 percent lower in July 2002 than in July 1999, without considering the effects of growth over the 3-year period. Furthermore, it appears that imposition of mandatory water use restrictions also resulted in a significant decrease in water demand on the Artesian system. For the 2-week period immediately prior to (July 19-August 1) and immediately following imposition of mandatory water use restrictions(August 2-15), average demand on the Artesian system declined by 1.4 mgd or approximately 6 percent. Moreover, a comparison of average daily water demand during July 2002 (23.0 mgd) with average daily demands during August 2002 (19.8 mgd) indicates a decrease of 3.2 mgd or nearly 14 percent. Unquestionably, some of the reduction in water demand from July to August can be attributed to other factors (*e.g.*, moderating temperatures, precipitation) but

[71] Artesian Water Company Response to Questions DPA 8 and 9, Bruce P. Kraeuter, May 14, 2003.

[72] Artesian Water Company Response to PSC Order No. 6068, Bruce P. Kraeuter, P.E., January 31, 2003.

the magnitude of the decrease suggests that imposition of mandatory water use restrictions had the desired outcome.

4.6.2 Ability to Meet "Unrestrained" Peak Demands

While the record clearly demonstrates that Artesian was able to meet all customer water demands during the drought period, including peak daily demands, an important question is whether Artesian would have been able to meet peak demands over an extended period had voluntary and mandatory water use restrictions not been in effect. If, for example, demands had been 9 percent higher on average during July 2002, average day demand for the month would have been approximately 25.0 mgd. Based on the WSCC's estimates of Artesian's available water supply from groundwater (20.0 mgd) and ASR (1.7 mgd), it appears that Artesian could have easily met this "unrestrained" peak demand condition, provided that supplemental water supplies of approximately 3.3 mgd were available through Artesian's interconnections with other utilities.

During the 2002 drought period, Artesian maintained 12 interconnections with other NNCC water utilities and one interconnection with an out-of-state water supplier. Combined, these interconnections gave Artesian the ability to purchase approximately 14 mgd during peak demand periods. Up to 11.0 mgd can be obtained under Artesian's existing agreements with the Chester Water Authority (6.0 mgd) and the City of Wilmington (5.0 mgd). However, water deliveries from both of these suppliers are subject to full or partial curtailment during emergency conditions. During late July, Artesian voluntarily reduced water purchases from Chester Water Authority in advance of mandatory pro rata curtailments, which were imposed on all Authority customers during August 2002. Even with such curtailments, , Artesian still had approximately 10 mgd of treated water supply capacity available through its interconnections with other utilities. The only scenario under which Artesian might have had a problem satisfying unrestrained peak demands would be the simultaneous curtailment of all water deliveries from the Authority and curtailment of all water deliveries from the City of Wilmington. Given that full curtailment of water deliveries from Chester Water Authority did not occur during 2002, it appears that Artesian can meet its current projected maximum month water demand of 25.0 mgd without relying on supplemental water purchases from the City of Wilmington, provided that 20.0 mgd is available from self-supplied groundwater, 1.7 mgd is available from ASR, 0.7 mgd is available from New Castle, 0.4 mgd is available from a new well field that will be in service by the summer of 2004, and that 2.4 to 3.0 mgd is available from Chester Water Authority Water Demand Projections.

The water demand projections adopted by the WSCC for Artesian indicate current maximum month demands of approximately 24.0 mgd, which is projected to increase to 26.0 mgd in 2010 and 27.1 mgd in 2020. During the drought of 2002, Artesian's actual maximum month (July 2002) demand was 23.0 mgd, which at face value suggests that

the WSCC's estimate of Artesian's current maximum month demand is valid and provides a reasonable margin of safety. However, in light of the observed effects of voluntary water conservation during the 2002 drought period and the potential for continued growth in Artesian's customer base and water demands, it appears prudent to re-evaluate the WSCC's demand projections for Artesian.

As noted previously, information submitted by Artesian suggests that voluntary water conservation reduced demands by 9 percent during May and June 2002[73]. Assuming a comparable reduction in demand occurred in July 2002, the "unrestrained" average monthly demand on the Artesian system would have been approximately 25.1 mgd, or 4.5 percent higher than the current WSCC estimate of maximum month demand for Artesian.

Artesian has also experienced significant and sustained growth in its customer base and water demands since 1990. Since 1990, Artesian reports a system-wide increase in metered customers of approximately 37 percent and an increase of nearly 28 percent in annual water demand. Over the past 5 years (1997-2002), Artesian reports an increase of nearly 15 percent in metered customers and an increase in water demand of more than 8 percent. For that period, the average annual rate of growth in the number of customers and water demand is 2.81 percent and 1.65 percent, respectively.

If one assumes that Artesian's current "unrestrained" maximum month demand is 25.1 mgd and that growth in average maximum month water demand will continue at a conservative rate of 1.0 percent per year, Artesian's projected maximum month demand over the next 5 years would be:

2004	***2005***	***2006***	***2007***	***2008***
25.4 mgd	***25.6 mgd***	***25.9 mgd***	***26.1 mgd***	***26.4 mgd***

Extrapolating this projection to 2020, Artesian's projected maximum month water demand would be 26.9 mgd in 2010 and 29.7 mgd in 2020. This would represent average maximum month water demands that are 0.9 mgd or approximately 3.5 percent greater than the current WSCC projection for 2010 and 2.6 mgd, or approximately 9.6 percent greater than the current WSCC forecast for 2020. It is unclear, however, whether a 1.0 percent annual growth rate could be sustained within Artesian's service area through the planning period. It has been suggested that the Artesian service will be substantially built-out by 2010, which would reduce the rate of growth in customers and water demand thereafter. In any event, consistent with the WSCC policy to plan for worst-case conditions, it is recommended that projections for maximum month demand on the Artesian system be re-evaluated and revised if appropriate to reflect: 1) an updated estimate of current "unrestrained" maximum month water demand; and 2) alternative growth scenarios through 2020.

[73] Artesian Water Company Response to PSC Order No. 6068, Bruce P. Kraeuter, January 31, 2003.

4.6.3 Water Supply Availability

The water supply availability estimates adopted by the WSCC in its Fifth Report indicate that Artesian's current water supply from all sources is 25.7 mgd – 20 mgd from groundwater, 4.0 mgd from Chester Water Authority, and 1.7 mgd from ASR. Based on the data and information reviewed during this investigation, it appears these estimates should be re-evaluated and adjusted, if appropriate, to reflect: 1) a lower estimate of the amount of groundwater that can be produced on a sustained basis over a 75-day drought period; and 2) new State statutory limits on the amount of water supply that Artesian can consider as available from the Chester Water Authority during a repeat of drought-of-record conditions. These issues are further discussed below.

4.7 GROUNDWATER

Data and other information reviewed for this investigation suggest that Artesian's groundwater supply sources are not significantly impacted by drought conditions and are therefore highly reliable. Most of Artesian's groundwater is produced from confined aquifers that are not significantly influenced by relatively short-duration decreases in precipitation or stream flows. The reliability of Artesian's groundwater sources is further enhanced through conjunctive use of surface water through interconnections with other utilities. This allows Artesian to rest its well fields during low demand periods (*e.g.*, winter and spring) when surface water supplies are typically abundant. Aquifer storage and recovery further enhance this reliability by enabling Artesian to store water underground for subsequent use during peak demand periods.

Despite the inherent reliability of Artesian's groundwater sources, valid questions exist with respect to the amount of groundwater Artesian can produce during an extended peak demand period. Artesian states that the current peak production capacity of its wellfields is 23.34 mgd and that it can produce 20.0 mgd on a sustained basis through a repeat of a 75-day drought-of-record. This assertion is reflected in the WSCC's current water availability estimates for Artesian. However, several individuals interviewed for this investigation expressed doubts about the validity of this estimate and suggested that 18.0 mgd is a better "ballpark" estimate of Artesian's reliable groundwater supply during drought. While this lower estimate cannot be confirmed in this investigation, there is circumstantial evidence that suggests a lower value may be appropriate.

An indication that Artesian's reliable supply from its groundwater sources may be lower than 20.0 mgd is the fact that groundwater production was significantly and consistently below 20.0 mgd throughout the 2002 drought period. For example, Artesian's average production from groundwater sources was 16.4 mgd during June 2002, 17.2 mgd during July 2002, and 15.4 mgd during August 2002.

Furthermore, Artesian's groundwater production exceeded 20.0 mgd on only 1 day during June 2002 (23.3 mgd on June 19, 2002). In addition, during the peak demand period of July 4-11th, Artesian's maximum production from its wellfields was 19.0 mgd and the average for the period was 17.7 mgd. Given that Artesian's groundwater supplies are most likely the utility's least expensive water sources, one can question why Artesian did not fully utilize its stated groundwater production capacity of 20.0 mgd during peak demand periods, rather than purchasing significant quantities of water from other utilities.

A partial explanation is that Artesian's contract with Chester Water Authority requires a minimum delivery of 2.0 mgd, which was suspended after the Authority imposed mandatory pro rata curtailments of water deliveries. Also, the locations of Artesian's active interconnections with the Chester Water Authority and the City of Wilmington provide some hydraulic benefits in water distribution. However, it is noted that the amount of water obtained from the Authority was reduced to approximately 2.0 mgd and that no water was obtained from the City of Wilmington on numerous days during the drought period. Again, one might expect that Artesian would have an economic incentive to maximize groundwater production at an average of 20.0 mgd if it is able, in fact, to sustain pumping at that level without violating drawdown limits in its water allocation permits.

Given these concerns, it is recommended that the current WSCC estimate of the amount of groundwater available on a sustained basis during drought conditions be re-evaluated and adjusted if appropriate.

4.7.1 Water Supply Available from Chester Water Authority

Enactment of the Water Supply Self Sufficiency Act of 2002 (HB118) will require re-evaluation of the amount of water that is available to Artesian from Chester Water Authority during drought conditions. As discussed in Section 3.4.1, beginning in 2009, this new statute limits the amount of water from out-of-state sources that NNCC utilities can certify as being available during a drought to the minimum purchase amounts stated in existing contracts. The 4.0 mgd of supply that is shown in WSCC estimates as available to Artesian from Chester Water Authority will therefore need to be adjusted beginning in 2009. Artesian's existing contract with the Authority specifies a minimum purchase amount of 3.0 mgd on an annual basis and a daily minimum of 2.0 mg. Artesian's interpretation of the effect of HB118 is that it will limit the amount of water that it can certify as available from Chester Water Authority to 3.0 mgd. However, staff of the Public Service Commission and DNREC believe the new statutory requirement could be interpreted to set the limit at 2.0 mgd. Additionally, for drought planning purposes, PSC and DNREC staff believe it may be prudent to further reduce the minimum by 20 percent to reflect the actual 20 percent reduction imposed by Chester Water Authority during the

drought of 2002. In any case, these differing interpretations will need to be addressed and resolved by the PSC for the 2009 certification of Artesian's water supply availability.

4.7.2 Water Supply Options

The WSCC's most recent "A List" of recommended water supply options for NNCC includes development of an additional 2.0 mgd (150 mg for 75 days) of ASR capacity by Artesian. However, Artesian has indicated that the amount of additional yield that will be available from ASR is an "educated estimate" subject to revision (either increase or decrease) based on the outcome of current investigations at two potential ASR sites. Artesian also notes that its most aggressive estimates for ASR would require it to purchase 375 mg/year of surface water and that its existing contracts for purchase of surface water supplies from the City of Wilmington and Chester Water Authority "…are more than adequate to meet Artesian's anticipated storage requirements.[74]" The Parsons project team concurs with this conclusion provided Artesian's current water purchase agreement with the City of Wilmington is extended when its current term expires in 2006. The Parsons project team also concurs with Artesian's overall approach to water supply development and management, which is to expand conjunctive management and use of groundwater and surface water resources.

Assuming the WSCC's current water supply and demand analysis for Artesian is accurate, the amount of additional ASR capacity proposed by Artesian will provide sufficient water supply (25.7 mgd) to meet projected maximum month water demands in 2020 (27.1 mgd). However, if the current water supply availability estimate for groundwater is reduced by as much as 2.0 mgd (see previous discussion), the potential additional yield from ASR will only serve to offset that reduction. And if the current estimate of water supply availability is further reduced by 2.0 mgd to reflect reduced availability of water from Chester Water Authority beginning in 2009, Artesian will show deficits of 2.3 mgd in 2010 and 3.4 mgd in 2020. Furthermore, if re-evaluation of the WSCC water demand forecast for Artesian results in higher projections for 2010 and 2020, the projected deficits will be even larger.

Should the recommended re-evaluation of the water supply and demand analysis for Artesian result in projected water supply deficits, it would appear that Artesian has several potentially viable options for increasing its available water supply including:

- Additional water conservation;
- Additional groundwater development; and
- Additional purchases of treated water from other NNCC utilities.

Each of these options is briefly discussed below.

[74] *Ibid.*

Additional Water Conservation

While Artesian's efforts to promote and encourage water conservation through customer education, its conservation-oriented water rate structure, and water loss control are commendable, it is likely that significant additional reductions in customer water demand are both technically and economically achievable. Of particular note is the potential to achieve significant and lasting reductions in residential and commercial indoor water demands through accelerated replacement of old non-conserving plumbing fixtures and appliances. Water utilities throughout the U.S. have tested and proven the efficacy of various types of incentive programs for early replacement of non-conserving toilets, showerheads, and water-using household appliances (*e.g.*, dishwashers and clothes washers). The most common form of incentives have been direct cash rebates to consumers who purchase and install fixtures and appliances that conform to prescribed water efficiency standards.

The potential water savings associated with replacement of non-conserving plumbing fixtures and appliances is significant. A 1999 study sponsored by the American Water Works Association (AWWA) and the AWWA Research Foundation reports that indoor water use in older non-conserving homes averages 72.5 gallons per capita per day (gpcd) and that indoor water use in newer homes equipped with water-conserving plumbing fixtures and appliances averages 49.6 gpcd[75]. This represents an observed savings of 22.9 gpcd or a nearly 32.9 percent reduction in indoor water use. To illustrate the potential water savings at a utility system scale, consider that upgrading the efficiency of 20,000 older homes with an average occupancy of 2.5 persons would reduce water demand by approximately 1.145 mgd.

An assessment of the potential costs and benefits of a more aggressive water conservation program targeted at Artesian's residential (and perhaps commercial) customers is beyond the scope of this analysis. It is recommended, however, that such an analysis be performed to determine the amount of additional water savings that could be realistically achieved, considering likely costumer participation rates and considering the direct and indirect (reduced water sales) costs. Consideration should be given to assessing the efficacy of a regional program in cooperation with other NNCC water utilities.

Additional Groundwater Development

Artesian has stated its belief that "…some additional quantity of water can be withdrawn from the Potomac Aquifer without jeopardizing long-term availability of supply from the aquifer.[76]" The new U.S. Army Corps of Engineers' groundwater availability model for the

[75]American Water Works Association and the American Water Works Association Research Foundation, *Residential End Uses of Water Study*, 1999.

[76] Artesian Water Company Response to Questions from Parsons, Bruce P. Kraeuter, September 12, 2003.

Potomac Aquifer in NNCC should provide insight into whether there are areas within NNCC where additional groundwater can be developed without adversely affecting the long-term sustainability of the resource at a regional scale. If that turns out to be the case, then Artesian should undertake more detailed investigations to more definitively determine groundwater availability within such "target" areas. However, pending the completion of the new groundwater model and its use to assess groundwater availability, it is recommended that Artesian defer plans to develop additional groundwater supplies.

Additional Purchases of Treated Water

The Parsons project team believes that the City of Wilmington has the potential to become an even more significant wholesale provider of treated water to other NNCC water utilities. Specifically, it is the opinion of the Parsons project team that the Hoopes Reservoir is a significantly under-utilized asset that provides a very high degree of water supply reliability and assurance to the City and potentially to other utilities in the region. Wilmington Public Works Department personnel have acknowledged this potential and have expressed the City's willingness to consider a long-term agreement with Artesian to provide a guaranteed supply of treated water[77]. However, City personnel have stressed that the financial terms of such an agreement would have to recognize the inherent value of Hoopes Reservoir as a back-up source for the City of Wilmington and for any wholesale customers receiving a guaranteed supply from the City.

If re-evaluation of the water supply and demand analysis for Artesian indicates a need for additional water supplies, or if other proposed or potential water supply options do not prove to be feasible, it is recommended that Artesian consider amendment of its existing water supply agreement with the City of Wilmington to provide for a guaranteed minimum supply of water through a repeat of drought-of-record conditions.

[77] Personal communication with Sean Duffy on August 28, 2003 and with Kash Srinivasan on September 11 2003.

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SECTION 5
UNITED WATER DELAWARE

United Water Delaware, formerly Wilmington Suburban Water, was incorporated in 1933. Following incorporation, the company purchased several small water systems including the Delaware Water Supply Company, Arden Water Company, New Castle County Water Company, and the Delaware Water Corporation. In 1972 the DPSC approved a merger between these small systems to form one operating entity with physically interconnected facilities. In 1994, Wilmington Suburban Water merged with United Water Resources to become United Water Delaware. United Water Resources, based in Harrington Park, New Jersey, is the second largest investor-owned water services company in the United States.[78]

5.1 SERVICE AREA AND CUSTOMER BASE

United provides water service to about 105,000 people within NNCC. The company provides potable water in three non-contiguous but interconnected areas that cover approximately 55 square miles (see Figure 2.1). United provides domestic, commercial, and industrial water service and public/private fire protection in the NNCC area, including: Brandywine, New Castle, Pencader, Red Lion, White Clay Hundred, and the St. Georges Hundred.
As of July 31, 2003, United served 35,012 customers in NNCC. The breakdown by type of customer follows[79]:

Residential	39,910	91.1%
Commercial	2,574	7.3%
Industrial	68	0.02%
Other	487	1.4%
Total	**35,012**	

United has and continues to experience sustained growth in its customer base (see Table 5.1). Since 1990, United reports a system-wide increase in metered customers of approximately 23 percent from 28,447 in 1990 to 35,012 in 2002. Most of this growth has been in residential customers, increasing 23.1 percent from 25,920 in 1990 to 31,901 in 2002. United has been adding 300 to 400 new customers per year, mostly residential, with most of the growth occurring in the southern portion of its service area[80].

5.2 WATER DEMAND

Table 5.1 presents system-wide water demands for the period 1990 to 2002. While the number of customers served by United has increased,

[78] United Water Delaware website: http://www.unitedwater.com/uwde/
[79] Record of meeting with UWD representatives, 8/29/2003
[80] *Ibid*

total annual water demand has decreased by 5 percent over that period.

Table 5.1 Annual Water Demand 1990-2002

Year	Number of Metered Customers	Annual Demand (in millions of gallons)	Average Daily Demand (in millions of gallons per day)	Percent Increase in Average Day Demand
1990	28,447	7,895	25.1	
1991	28,924	8,284	25.4	1.2%
1992	29,491	7,925	24.1	-5.1%
1993	30,237	7,321	22.2	-7.9%
1994	30.661	7,442	23.4	5.4%
1995	31,128	7,418	21.8	-7.3%
1996	31,683	7,239	20.8	-4.6%
1997	32,269	7,097	20.5	-1.5%
1998	32,783	7,401	21.2	3.4%
1999	33,549	7,126	20.5	-3.3%
2000	34,177	6,929	19.9	-2.9%
2001	34,602	7,635	20.8	4.5%
2002	35,012	7,495	21.2	1.9%

Source: United Water Delaware Response to Questions from Parsons, August 29, 2003

During 2002, average day water demand by customer type in United's NNCC service area was:

Customer Class	Average Daily Water Demand in 2002	Percentage of Demand
Residential	5.49 mgd	25.9
Commercial	4.58 mgd	22.9
Industrial	8.61 mgd	40.6
Public	0.13 mgd	0.6
Resale	0.21 mgd	10.0
Total	21.2 mgd[81]	

Demands on the United system exhibit typical seasonal fluctuations with the highest demands occurring during the summer

[81] *Ibid*

months when landscape irrigation and other discretionary water uses (*e.g.*, car washing) are greatest. July is typically the month with the highest average day demand. The WSCC's current (2003) estimate of maximum month water demand estimate for United is 24.0 mgd.

5.3 WATER SUPPLY SOURCES

United's primary source of water supply for its NNCC service area is surface water from Stanton WTP, which has a 30 mgd capacity. The Stanton WTP is a state-of-the-art facility, which draws water from White Clay Creek. It is the only surface water treatment facility in the United States utilizing a very particular upflow clarification process along with the standard multimedia filtration process. The facility intake is located on a lower reach of White Clay Creek.

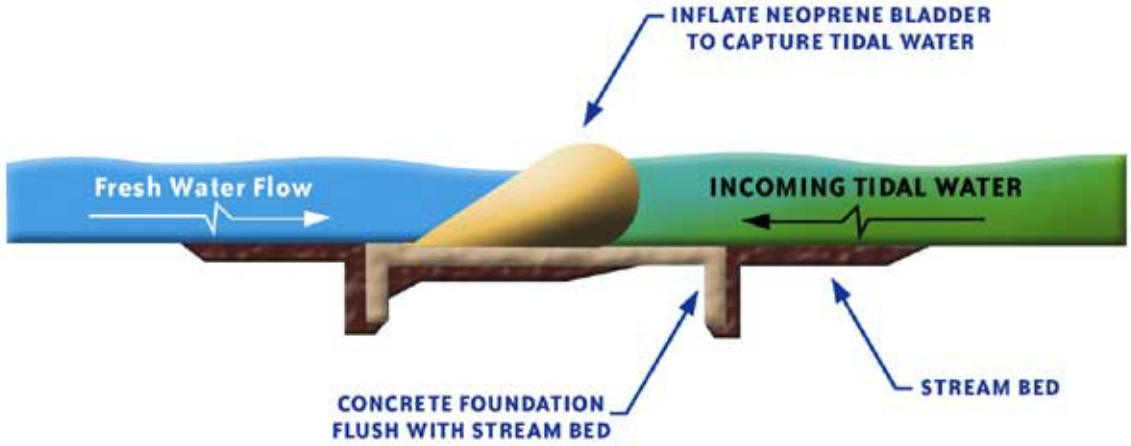
United also operates a smaller water plant on the Christina River. The Christina WTP provides some water to the United southern distribution system and has a capacity of 6 mgd. The Christina WTP uses conventional treatment, multimedia filtration, and sodium hypochlorite to disinfect the surface water from the Christina River. United also has a well at the Christina WTP with a capacity of approximately 0.25 mgd. Groundwater from this well is withdrawn as needed and blended with surface water from the Christina WTP to reduce chloride concentrations.

5.3.1 Tidal Capture Structure

In the mid-1990's United was confronted with the possibility of continuing water shortages in northern Delaware. In response, United sought to develop a more reliable water source for its Stanton WTP. United hired Duffield Associates to determine how to increase the reliable intake of raw water from the White Clay Creek without disturbing the stream's ecosystem. The solution entailed use of the large quantity of water available during the twice-daily flood of fresh water pushed up White Clay Creek by the semidiurnal tide.

The engineered solution was development of a Tidal Capture Structure (TCS), which consists of an expandable water-filled bladder that inflates at peak high tide to impound and hold the tidally supplied fresh water. The inflatable bladder is operated twice daily at high tide, which maintains the depth of water at the Stanton WTP intake. It has been estimated that the operation of the TCS provides a firm supply of approximately 14.0 mgd to the Stanton WTP (7.0 mgd for each tidal cycle). In addition, the TCS can be operated in a fashion to control the migration of high chloride water from the downstream incoming tidal prism. Figure 5.1 is a cross sectional profile of the TCS.

Figure 5.1 Cross-Sectional Profile of United Tidal Capture Structure



The inflatable neoprene bladder is anchored to a concrete foundation built into the streambed. On the right bank of White Clay Creek, adjacent to the concrete foundation, is a by-pass structure consisting of a gated flume. The bypass structure, shown in Figure 5.2 , allows water to be diverted around the inflated bladder and is currently used to maintain the 17.2 mgd instream flow requirement.
The facilities are located on White Clay Creek above its confluence with the Christina River. The TCS is utilized during periods of drought when the salt front from Delaware Bay moves upstream. Because the intake area is very low and flat, in the absence of the TCS, salt water would intrude as far as 7 miles upstream. During the 1960s, before the rubber dam was constructed, sand bags were laid across the creek bed to prevent salt intrusion during drought. At the time, it was thought that a permanent structure could not be erected because the area is prone to flooding.

5.3.2 Hoopes Water Agreement

Hoopes Reservoir is a manmade water storage reservoir located between the Brandywine Creek and Red Clay Creek north of the City of Wilmington. The reservoir was built in 1932 and is wholly owned by the City of Wilmington. The reservoir is supplied from Brandywine Creek from City of Wilmington pumps and has a capacity of approximately 2.0 bg, of which 1.8 bg is available for use. By policy, the City has made 500 mg available from the reservoir to other NNCC water suppliers and has recently indicated a willingness to consider reservations of larger quantities of water from the reservoir.[82]

[82] Personal communication with Sean Duffy, Water Division Director, Public Works Department, City of Wilmington, August 28, 2003. Personal communication with Kash Srinivasan, Commissioner, Public Works Department, City of Wilmington, September 11, 2003.

Figure 5.2 Tidal Capture Structure Bypass Structure

During the 2002 drought, United relied on releases from Hoopes Reservoir to augment flows in White Clay Creek primarily to control salinity levels at the Stanton WTP. A total of 178 mg of water were released from Hoopes Reservoir on 35 days during the drought with a median release rate of 5.0 mgd. In August 2002, United and the City of Wilmington entered into a new agreement governing releases from the reservoir. In addition, United has stated its willingness to cooperate with the City on further efforts to evaluate the feasibility of raising the level of the Hoopes Reservoir to provide additional storage.

Following the drought of 1999 United developed and implemented a chloride monitoring program that involves daily water quality sampling for chlorides downstream of the TCS during periods of low flow in White Clay Creek. This allows United to make informed decisions regarding the timing and amounts of raw water releases from Hoopes Reservoir to maintain chloride levels below drinking water quality standards. It is noted that United's chloride monitoring program led to apparent improvements in stream flow management during the drought of 2002.

5.3.3 Purchases from Other Suppliers

United maintains a network of system interconnections with adjacent water utilities. United has wholesale purchase agreements in place

with Chester Water Authority and with the City of Wilmington. Both are capable of providing limited quantities of finished water to United. Although the Authority historically has had the greater capacity of excess supply, the relatively high tariff rates have made this option economically unattractive for United. In addition, since the Authority is an out of state supplier, this contract is affected by the recent HB118, the Water Supply Self-Sufficiency Act of 2003. During the drought of 2002 these interconnects accounted for less than 5 percent of the United supply.

United also maintains interconnections with Artesian. In the past attempts to reach agreement on a wholesale water purchase contract have been unsuccessful. However, both utilities have mutually agreed to allow established tariff rates to be utilized should emergency transfers become necessary. It is also noted that the Water Supply Self-Sufficiency Act of 2003 requires utilities in NNCC to establish equitable bulk wholesale water rates and to provide water to other utilities in need if there is surplus capacity. It also empowers the DPSC to set wholesale water rates and to order regulated water utilities to interconnect and sell water at wholesale rates approved by the DPSC.

5.4 WATER DISTRIBUTION AND STORAGE

United maintains an extensive water distribution system consisting of approximately 509 miles of pipeline. The distribution system also has more than 1,900 fire hydrants. United currently has 17 water storage tanks at locations throughout its NNCC service area. In addition, United has one in-ground reservoir for water storage. Combined, these facilities have a storage capacity of approximately 31 mg.

5.5 WATER CONSERVATION

As noted above, since 1990 water demand on the United system has decreased by approximately 5 percent. However, over the same period the number of customers has increased by 23 percent with the largest growth in residential customers. Most of the reduction in water demand is attributed to reduced demand by United's industrial water customers, which account for approximately 40 percent of total annual water demand. Of note is that this decline in overall water demand has allowed United to accommodate growth in residential and commercial water demands without corresponding levels of investment in additional water supplies or infrastructure.

United currently maintains an active consumer education program on water conservation with information posted on their website. United also provides water saver kits and brochures on water conservation upon request. In addition United has an active program for leak detection, pipe replacement, and meter testing and replacement. During 2002, unaccounted-for water was approximately 10 percent of total annual water production.

At present, United does not employ conservation-oriented water rates. For residential, commercial, and public uses, United charges a uniform rate per 1,000 gallons. United also charges a uniform rate for water sales to other utilities and has a declining block rate structure for its industrial customers. Recently enacted State legislation – HB118 – requires NNCC water utilities to adopt conservation-oriented water rates for residential customers, at a minimum, by January 1, 2005. At this time, United has not determined whether it will adopt an increasing block rate structure or a seasonal rate structure and it has not determined whether conservation rates will be applied to non-residential customers.

5.6 PERFORMANCE DURING THE DROUGHT OF 2002 – FINDINGS AND CONCLUSIONS

Based on information reviewed for this investigation, the Parsons project team concludes that United had sufficient water supply from self-supplied sources and from purchases of both raw and treated water from the City of Wilmington to meet customer water demands throughout the 2002 drought period. Daily water production records for the period June through August 2002 demonstrate that average monthly demands on the United system were below the WSCC's estimate of United's currently available water supply of 26.0 mgd (average for maximum month) under a "no flow standard" scenario for White Clay Creek.

Furthermore, it appears that United likely would have been able to meet higher water demand levels that would have occurred had voluntary and mandatory water use restrictions not been in effect. If for example demand on the United system had been 5 percent higher on average during July 2002 (the maximum month for 2002) average monthly demand would have been approximately 26.4 mgd, or about 0.4 mgd greater than the WSCC's estimate of United's available water supply. Satisfying this additional demand would have required United to purchase somewhat greater amounts of raw water from Hoopes Reservoir or from existing treated water interconnections with the City of Wilmington and the Chester Water Authority. This should not have posed a problem as the existing agreements with these water suppliers would have allowed United to obtain the additional supplies required to meet unrestrained maximum month water demands. Under a scenario in which United would not have been able to obtain any water from Chester Water Authority during the period from July-September 2002, and assuming unrestrained water demands (5 percent higher than actual) and no increase in production from self-supplied sources, United would have needed to purchase an additional 111 mg from the City of Wilmington. Under water purchase agreements in effect at the time, United could have obtained approximately 23 mg of this additional requirement through releases of raw water from Hoopes Reservoir, bringing total releases to 200 mg. The balance (88 mg) could have been obtained through additional releases from Hoopes Reservoir by agreement with the City of Wilmington. Alternatively, United could have obtained the entire amount through

additional purchases of treated water from the City of Wilmington, provided the City agreed to make additional releases. As a practical matter, the relatively small amounts that would have been required on a daily basis to replace water from Chester Water Authority would likely have been met through purchases of treated water from Wilmington.

Information and data provided by United also support the conclusion that the company did not experience any undue problems maintaining adequate storage of finished or treated water during the drought period. The data indicate that treated water storage volumes exhibited fluctuations normally expected during the summer months when daily water demands reach peak levels. There were no reports of low water pressure or major equipment failures during the drought period.

5.6.1 Effects of Voluntary and Mandatory Water Use Restrictions

A review of water demand data for United during the drought period presents an uncertain picture regarding the effects of voluntary water conservation measures. A simple comparison of average monthly demands for the May through July 2002 period with the same period during 2001 indicates that average daily water demands were 0.74 mgd (3.6 percent) higher in 2002. A similar result is obtained by comparing demands for July 2002 with demands for July 2001. By contrast, as noted elsewhere in this report, a comparison of average maximum month water demands in July 2002 for the NNCC region as a whole with average water demands for July 1999, which was also a drought period, indicates that overall regional water demand was approximately 9 percent lower in July 2002. Given the apparent discrepancy, a more thorough analysis of the effects of voluntary water conservation on United's water demands during the 2002 drought period is warranted. Such an analysis should focus on more detailed comparisons of billing records to evaluate water demand by customer class to identify any factors that might explain the apparent lack of customer response to requests for voluntary water conservation. For example, since a large portion of the demand on the United system is from industrial customers, increases in industrial demand might have occurred due to economic factors (*e.g.*, increased production activity by one or more industrial customers).

It appears, however, that imposition of mandatory water use restrictions did result in an observable decrease in water demand on the United system. For the period during which mandatory water use restrictions were in effect (August 2-October 11, 2002), average water demands were approximately 1.0 mgd or 4.7 percent lower than during the same period in 2001.[83] Also, average daily demands on the United system during August 2002 were 1.3 mgd (5.2 percent) lower than average daily demands during July 2002. Further evidence of the effectiveness of mandatory water use restrictions is provided by

[83] Letter from Howard J. Woods, Jr. to G. Arthur Padmore, Public Advocate, Delaware Division of the Public Advocate, March 27, 2003.

comparing average daily water demands for August 2002 with average daily water demands for the same period in 2001. That comparison shows a 0.8 mgd (3.6 percent) decrease in demand during August 2002. However, for the 2-week period immediately prior to (July 19-August 1) and immediately following imposition of mandatory water use restrictions (August 2-15), average demand on the United system declined by only 0.2 mgd or approximately 0.8 percent.

5.6.2 Ability to Meet "Unrestrained" Peak Demands

While the record clearly demonstrates that United was able to meet all customer water demands during the 2002 drought period, including peak daily demands, an important question is whether United would have been able to meet peak demands had voluntary and mandatory water use restrictions not been in effect. It is noted that demands on the United system reached or exceeded 26.0 mgd – the WSCC's estimate of supply available to United to meet average maximum month demands - on 20 days during 2002. For a 4-day period from July 9th through July 12th, demand on the United system averaged 27.6 mgd. If one assumes that voluntary water use restrictions had the effect of reducing peak demands on the United system by 5 percent, "unrestrained" peak demands over the 4-day period would have averaged 29.0 mgd.

Based on the WSCC's estimates of United's available water supply from surface water sources (26.0 mgd), it appears that United would not have had a problem meeting an "unrestrained" peak demand condition (*i.e.*, 29.0 mgd), provided that supplemental water supplies of approximately 3.0 mgd were available through United's existing interconnections with other utilities. During the 2002 drought period, United maintained three interconnections with other NNCC water utilities and one interconnection with an out-of-state water supplier (Chester Water Authority). Combined, these interconnections gave United the ability to purchase approximately 5.0 mgd during peak demand periods - up to 0.5 mgd directly from the Authority, up to 1.5 mgd from the Authority through United's interconnection with United Water Bethel, and up to 3.0 mgd from the City of Wilmington. However, water deliveries from both Wilmington and the Authority are subject to full or partial curtailment during emergency conditions. During August 2002, United's water purchases from the Authority (directly or indirectly through United Water Bethel) were reduced in response to requests from the Authority, initially by approximately 20 percent and ultimately by approximately 80 percent. Accordingly, under a scenario of unrestrained peak demands with no supply available from the Authority, United would have had to rely solely on additional purchases of raw and/or treated water from the City of Wilmington. As previously noted, the additional supplies would have been available under the terms of existing agreements between United and the City of Wilmington.

5.6.3 Water Demand Projections

The water demand projections adopted by the WSCC for United indicate current maximum month demands of approximately 24.0 mgd, which is projected to increase only slightly to 24.1 mgd in 2010 and 24.4 mgd in 2020. United's service area is reported to be substantially built-out and, while United has experienced growth in the number of customers it serves, overall water demands have declined significantly since 1990. For example, total water production for the period 1990 through 1992 averaged approximately 9.1 billion gallons (bg) per year. By comparison, during the period from 2000 through 2002, average demand was approximately 7.7 bg, a decrease of about 15 percent since the early 1990s. This decrease in overall water demand on the United system is reported to have been caused by decreases in industrial water use over the period.
During the drought of 2002, United's actual maximum month (July 2002) demand was 25.1 mgd. However, this amount includes wholesale water sales to the City of Newark which averaged 1.8 mgd during July 2002. As the City of Newark will soon discontinue water purchases from United once the City's new reservoir is operational, the average demand on the United system for July 2002 can be reduced by 1.8 mgd to 23.3 mgd. If one then assumes that a 5 percent reduction in water demand occurred as a result of voluntary water conservation, then United's average demand for July 2002 would have been approximately 24.5 mgd or about 2 percent higher than the WSCC estimate of current maximum-month demand. While this maximum month demand level is well below the WSCC estimate of available water supply (26.0 mgd) under a "no minimum stream flow" scenario, the Parsons project team believes it would be prudent for United and/or the WSCC to re-evaluate projections of United's unrestrained maximum month demands.

5.6.4 Water Supply Availability

As mentioned previously, the water supply at the Stanton WTP is greatly affected by the operation of the TCS. When the TCS was constructed in 1997, its intended purpose was not to control chlorides but to capture tidal flows. However, during the drought of 1999 elevated chlorides emerged as a problem. United found that it could operate the TCS to prevent chlorides from entering the Stanton WTP intake. United maintains that use of the TCS during the drought actually protects many thousands of feet of stream above the TCS from excessive salt intrusion. Without the barrier, salt water would migrate well past the Stanton WTP intake and harm the fresh water species residing there. United's current operating plan for the TCS consists of four operating conditions, defined by the natural stream flow rate and United's pumping demand. The operating plan is summarized below:

United Water Delaware TCS Operating Plan

Stage 1: Stream flow equal to or greater than 47.2 mgd, which represents the Q7-10 flow of 17.2 mgd plus the plant capacity of 30 mgd. In this condition, which is estimated to occur an average of

307 days per year, the TCS would not be operated because the natural stream flow would be sufficient to meet the maximum plant demand and satisfy the pass-by requirement.

Stage 2: Stream flow less than 47.2 mgd, but greater than or equal to 17.2 mgd, which is estimated to occur an average of 51 days per year. This stage has two parts, 2A and 2B, as follows: Stage 2A occurs when the stream flow is greater than or equal to the sum of the actual plant demand plus the Q7-10 flow, but still less than 47.2 mgd. In this stage, the TCS would also not be operated since the stream flow, while less than 47.2 mgd, would still be sufficient to meet the plant demand and the pass-by requirement. Stage 2B occurs when the stream flow is less than the sum of the plant demand plus the Q7-10 flow. During Stage 2B, the TCS would be in operation twice daily and the Q7-10 flow (17.2 mgd) would be bypassed around the TCS.

Stage 3: Stream flow less than 17.2 mgd, but greater than or equal to 7.2 mgd. In this condition, which is estimated to occur an average of seven days per year, the TCS would be in operation twice daily and the natural stream flow would be bypassed around the TCS.

Stage 4: Stream flow less than 7.2 mgd. In this condition, the TCS would be in operation twice daily, and the natural stream flow, supplemented with water from the TCS storage pool, would be bypassed around the TCS at a rate of 7.2 mgd. This bypass flow rate represents a 25 percent enhancement of the historic 1-day low flow in White Clay creek of 5.8 mgd.

Twice daily, United personnel will telephone two existing USGS stream gages (Red Clay Creek at Woodale and White Clay Creek near Newark) to determine flow by extrapolation at the Stanton WTP. The plant operators will review the plant pumping records for the past 24-hour period to determine the average pump rate which will then be added to the Q7-10 flow of 17.2 mgd, and the sum will be compared to the extrapolated stream flow to determine the operating stage.

As noted previously, United obtained regulatory relief from minimum stream flow requirements imposed by the DRBC in its approval of the operating permit for the TCS. DRBC's temporary suspension of the pass-by requirement (17.2 mgd) enabled United to meet its demands largely from self-supplied sources backed-up by releases from Hoopes Reservoir. An important question is whether United would have been able to meet customer demands during 2002 if the DRBC had not suspended the pass-by requirement. An analysis performed on behalf of the WSCC by the Water Resources Agency indicates that adequate water supplies were potentially available to United from the Hoopes Reservoir. The analysis was conducted for four scenarios.[84]

Scenario 1 – Drought Emergency with no Pass-by Requirements

The first scenario analyzed was a drought emergency with both record low stream flows, as occurred during 2002, and maximum monthly demands with no pass-by requirements on either White Clay Creek or Brandywine Creek. This was essentially the condition that existed

[84] Delaware Water Supply Coordinating Council, *Fifth Report to the Governor and the General Assembly*, January 17, 2003.

during 2002 with the waiver of DRBC minimum flow requirements for White Clay Creek. As occurred during 2002, United had to rely upon releases of raw water from Hoopes reservoir, but those releases were well within the amount that the City of Wilmington had agreed to provide to United. For future projections of demand, United shows a small surplus of supply under these conditions.

Scenario 2 – Existing Conditions and Current Regulatory Restrictions

Analysis indicates that a total of 586 mg would have been needed from the Hoopes Reservoir to satisfy United's requirements and meet the current DRBC pass-by requirement. This amount of water exceeds both the amount that the City of Wilmington has agreed to provide to other utilities from the reservoir (500 mg) and the amount of water from the Hoopes Reservoir guaranteed to United under agreements that were in effect at the time (200 mg). Accordingly, the City of Wilmington would have had to agree to both modify its operating plan for Hoopes Reservoir to allow more than 500 mg to be released for United and the City would have had to agree to provide releases from Hoopes Reservoir in excess of the 200 mg allowed under the existing agreement with United.
It is important to note that the WRA's simulations of Hoopes Reservoir operations indicate that had releases been necessary to meet the stream flow standard at United's TCS, combined with releases required to supplement the City's supplies (91 mgd), the reservoir would only have been drawn down to 74 percent of its capacity. This provides an indication that the Hoopes Reservoir could provide substantially more water to other NNCC water utilities without creating an undue risk of shortage for the City of Wilmington.

Scenarios 3A and 3B – Future Conditions with Pass-by Requirements for both Brandywine and White Clay Creeks

These two scenarios investigated the effects of a pass-by requirement on Brandywine Creek in addition to the pass-by requirement on White Clay Creek. For Scenario 3A, the pass-by requirement of Brandywine Creek is the 7Q50 flow of 38 mgd, while for Scenario 3B the Brandywine pass-by requirement is increased to the 7Q10 flow of 49 mgd. In both these scenarios, the City of Wilmington has to rely much more heavily on Hoopes Reservoir releases to meet the City's demands during periods when the flows in Brandywine Creek are not sufficient to meet both the City's demands and the hypothetical pass-by requirements. This increased demand on the Hoopes Reservoir by the City of Wilmington in turn limits the availability of water from Hoopes Reservoir to United, resulting in a much larger supply deficit for United. Under Scenario 3A, the City of Wilmington would be able to meet all requirements but it would only be able to satisfy about 64 percent of United's needs (373 mg out of a requirement of 586 mg). Under Scenario 3B, the City of Wilmington would have experienced a shortfall of

approximately 254 mg and would not have been able to supply any of United's need.

5.7 WATER SUPPLY OPTIONS

5.7.1 Modification of the Operating Plan for the Tidal Capture Structure

On August 12, 2002 the DRBC granted a waiver of the pass-by restrictions at the TCS. One of the conditions of the waiver was that United was to develop a new operating plan for the TCS during times of low flow to avoid the need for future waivers. As a part of the development of the new operating plan, United was further instructed to undertake an "assessment of instream flow needs based upon a scientifically sound instream flow study to begin at the soonest practicable time". United hired Duffield and Associates, Inc. to undertake the study and the report entitled *Instream Flow Needs Fish Community Sampling Under Severe Drought Conditions in the Tidal Portion of White Clay Creek,* was produced in October 2002. The key conclusion presented in the report is that even under extreme low-flow conditions where no flow was by-passing the TCS, White Clay Creek below the TCS was able to maintain a healthy ecological community with diverse and appropriate fauna. The clear implication of this finding is that the current DRBC pass-by requirement on White Clay Creek is not necessary to protect the ecological health of this reach of the creek. In addition, during the course of this investigation the Parsons project team was unable to document an ecological basis or scientific rationale to justify the current 17.2 mgd pass-by requirement.

United is currently in the process of developing a new TCS operating plan based on an approach that focuses on chloride management and avoidance of ecological damage that might be caused by de-watering White Clay Creek below the TCS. Considering the available ecological information, the Parsons project team considers this to be a reasonable approach and serious consideration should be given to modifying the DRBC pass-by requirement accordingly. Modification of the TCS Operating Plan to reflect the new approach would likely give United most of the 20 mgd supply shown for Scenario 1 in the WSCC's current supply and demand analysis. Under these conditions, United's existing agreement with Wilmington to purchase up to 200 mg from Hoopes Reservoir for augmentation of flows in White Clay Creek should be adequate for the foreseeable future for both chloride management and protection of ecological resources downstream of the TCS.

5.7.2 Aquifer Storage and Recovery

Recognizing that they have surface water available during off-peak periods, United is evaluating future use of ASR technology. This will allow the conjunctive management of surface water and groundwater.

Although still in the planning stage, United's plans are to locate and develop an ASR well in its River Road service area just north of the C&D Canal. The Potomac Formation underlies this area and the Magothy Formation and Matawan Group overlie the Potomac Formation. The Magothy and Matawan are not considered important sources of groundwater supply for NNCC but could be utilized for ASR storage as well as the Potomac Formation. If feasible, the current plan is to store and recover approximately 225 mg per year of surface water by the year 2004, which would provide up to 3.0 mgd of additional water supply to United during drought. Given that there are "excess" flows in White Clay Creek during most of a typical year, the Parsons project team is supportive of United's plans to develop ASR facilities to optimize the use of this surplus water supply.

5.7.3 Additional Purchases of Treated Water

During the drought of 2002, United's agreements with the City of Wilmington for both finished water and raw water were essential to meeting all of United's water demands. Since Wilmington proved to be a reliable source of treated water supply during the drought, United has undertaken projects aimed at improving its interconnections with the City. In addition, United is continuing to review the feasibility and cost-effectiveness of additional interconnections with the City as part of its overall water supply planning. United is also discussing the possibility of an interconnection with Delaware City. The connection would allow

two-way water transfers, but could only provide minimal support to United during times of drought. The Parsons project team concurs with United's stated intent to increase purchases of treated water from other utilities.

5.7.4 Desalination

As required as a condition of receiving the waiver from DRBC for the pass-by requirements at the TCS, United has completed an evaluation of desalination as a water supply option. The evaluation, conducted by HDR Engineering, Inc., concludes that:

- "Neither reverse osmosis (RO) and electrodialysis reversal (EDR) is particularly suitable to treat water at the Stanton Plant site.
- The desalination equipment would only be needed for 75 days every 6 years.
- The cost of the water treated by either process would be excessively high."[85]

In addition, without relaxation of the DRBC pass-by requirement at the TCS, there may be many days during a future 75-day period when diversions to a desalination facility would not be possible. However, with relaxation of the pass-by restriction as discussed above, the desalination process would be unnecessary. While there may be other issues in the future that make desalination feasible, the Parsons project team concurs with the HDR conclusions – desalination it is not an appropriate approach to drought management for United.

5.7.5 Additional Water Conservation

While United's efforts to promote and encourage water conservation through customer education and water loss control are to be commended, it is likely that significant additional reductions in customer water demand are both technically and economically achievable. Some of that potential may be realized through the implementation of a conservation-oriented water rate structure, which United will be required to adopt by January 1, 2005 to comply with the Water Supply Self-Sufficiency Act of 2003 (HB118). However, the degree to which water rates will reduce future water demands on the United system is dependent upon a number of factors, including the type of rate structure, the strength of the conservation signal provided by the rate structure (*e.g.*, the degree to which the rate structure penalizes excessive water use), and the applicability of the rate structure to different customer classes.

[85] HDR Engineering, Inc., *Stanton WTP Desalination Feasibility Study*, January 2003.

It is noted that United has only recently entered into discussions with DPSC staff on modification of its current rate structure and at this time it has not determined which type of conservation-oriented rate structure it will adopt (*e.g.*, inclining block rate structure or seasonal rate structure). United also has not determined whether conservation rates will apply only to its residential customers, required by HB118, or whether such rates will also apply to commercial and/or industrial customers. The Parsons project team notes that widely accepted industry practices for the allocation of costs of water utility service to different customer classes often leads to justification for declining block or uniform commodity rates for large water users, particularly those that exhibit little seasonal variation in water demand.

Also of note is the potential to achieve significant and lasting reductions in residential and commercial indoor water demands through accelerated replacement of non-conserving plumbing fixtures and appliances. Water utilities throughout the U.S. have tested and proven the efficacy of various types of incentive programs for early replacement of non-conserving toilets, showerheads, and water-using household appliances (*e.g.*, dishwashers and washing machines). The most common form of incentives has been direct cash rebates, sometimes in the form of discounts on water bills, to consumers who purchase and install fixtures and/or appliances that conform to prescribed water efficiency standards.

The potential water savings associated with replacement of non-conserving plumbing fixtures and appliances is significant. A 1999 study sponsored by the AWWA and the AWWA Research Foundation reports that indoor water use in older non-conserving homes (general those built prior to about 1980) averages 72.5 gallons gpcd and that indoor water use in newer homes (those built since the adoption of national water efficiency standards) equipped with water-conserving plumbing fixtures and appliances average 49.6 gpcd.[86] This represents an observed savings of 22.9 gpcd or a nearly 32 percent reduction in indoor water use. To illustrate the potential water savings at a utility system scale, consider that upgrading the efficiency of 20,000 older homes with an average occupancy of 2.5 persons would reduce water demand by approximately 1.145 mgd. An assessment of the potential costs and benefits of a more aggressive water conservation program targeted at United's residential (and perhaps commercial) customers is beyond the scope of this analysis. It is recommended, however, that such an analysis be performed to determine the amount of additional water savings that could be realistically achieved, considering likely costumer participation rates, and the direct and indirect (reduced water sales) costs to United. The analysis should include consideration of effects and benefits on the volume of wastewater flows. Consideration should also be given to assessing the efficacy of a regional program in cooperation with other NNCC water utilities.

[86] American Water Works Association and the American Water Works Association Research Foundation, *Residential End Uses of Water Study*, 1999.

5.7.6 Direct Non-Potable Reuse

Currently, approximately 40 percent of United's demand is from commercial and industrial users. Consequently, it is likely that significant amounts of that demand are for non-potable uses, such as process water used in manufacturing and cooling water. Some of this demand could potentially be met through direct reuse of wastewater effluent. However, any reuse strategy in NNCC would require the providers of wastewater utility services (Wilmington and New Castle County) to provide effluent, either directly or through facilities, such as parallel non-potable water transmission lines, developed by United. While reuse might significantly reduce demands on the United system, that decrease in demand would also represent a significant loss of revenue to United. As a result, if direct non-potable reuse were to be considered as a strategy, it would need to be considered at a regional level.

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APPENDIX

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