



**Net Water Availability for HUC14  
02040105110030, Upper Delaware River (UDRV)  
tributaries (Route 22 to Buckhorn Creek)**

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RMP Update No. NWA\_UPD001\_091214

December 2009

Governor Jon S. Corzine

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# **RMP UPDATE NO. NWA\_UPD001\_091214**

## **Net Water Availability for HUC14 02040105110030,**

### **Upper Delaware River (UDRV) tributaries**

#### **(Route 22 to Buckhorn Creek)**

## **Overview of RMP Updates**

The Highlands Regional Master Plan (RMP) authorizes factual updates to the RMP, as follows:

**Policy 6G1:** To develop a program for RMP Updates for all substantive components of the RMP, based upon the receipt of new, corrected or updated factual information and verification by the Highlands Council, when and where necessary to improve the accuracy of the RMP.

**Policy 2A1:** To identify and periodically update net water availability and water deficits as a factor in the Land Use Capability Water Availability Map.

Chapter 6 of the RMP provides more detail regarding the intention of RMP Updates, as follows:

Subsequent to receipt of the RMP information and assistance regarding its use, municipalities and counties will assist the Council by examining the information used in the LUCM Series and other elements of the RMP and recommending RMP Updates as needed. Of specific interest will be updates on the following information:

- Development or other land use changes that have occurred and development proposals that have been built subsequent to the Land Use Land Cover aerial photography used in the LUCM Series (currently 2002) or are eligible for Highlands Act exemptions under Policy 7F1;
- Updates and corrections to the Existing Areas Served for both public community water supply systems and public wastewater treatment systems;
- Additional lands preserved for natural resource preservation, parks and recreational open space, historic preservation, farmland preservation, etc.;
- Modifications to stream and flood hazard delineation maps, including both additions and corrections to stream corridor locations;
- Jurisdictional wetlands and transition areas for which NJDEP has provided an updated Letter of Interpretation (LOI);
- Topographic mapping that will enable a more precise delineation of steep slopes;
- Additional NJDEP certified vernal pools, and proposed modifications to vernal pool buffers based on the criteria in the Goals, Policies, and Objectives and discussed in the *Critical Habitat Conservation and Management Program*;
- Modifications to critical habitat boundaries for rare, threatened and endangered wildlife species based on site-specific analyses using methods in Highlands Council guidance;
- Updates regarding transportation facilities that significantly alter the opportunity for multi-modal transportation connections and use; and
- Updates to water withdrawal, water use, and wastewater discharge volumes and locations that would result in a modification of the Water Availability values for HUC14 subwatersheds affecting the municipality, including information that results in recalculation of consumptive and depletive water uses for any subwatershed. In addition, information may be provided regarding specific contracts or rights to utility capacity by municipality, service

area or contracted uses (e.g., committed but unconnected users) that will allow for more specific utility capacity determinations by municipality.

Proposed RMP Updates will be verified for accuracy by the Highlands Council and used to determine whether changes in any of the LUCM Series are appropriate. See the RMP *Updates Program* and the *Map Adjustments Program* for additional information.

The Highlands Council may also identify the need for RMP Updates on its own initiative. RMP Updates are approved by the Executive Director of the Highlands Council, with notification to affected municipalities and public notice.

## **Proposed RMP Update**

The RMP Update addressed in this document specifically responds to the RMP priority for “Updates to water withdrawal, water use, and wastewater discharge volumes and locations that would result in a modification of the Water Availability values for HUC14 subwatersheds...”

The Highlands Council identified the potential need for an RMP Update regarding the Net Water Availability for HUC14 subwatershed 02040105110030, which is named “Upper Delaware River (UDRV) tributaries (Route 22 to Buckhorn Creek).” This subwatershed is identified in the RMP as being a Current Deficit Area, with a Net Water Availability of -5.746 MGD, as calculated using the methods described in the Highlands Council’s Water Resources Technical Report, Volume 2. This deficit is largely associated with three public supply wells owned by Aqua America (Aqua-NJ, Phillipsburg Division, PWSID 2119001) that are located within the subwatershed’s boundaries but directly adjacent to the Delaware River. These wells provide potable water supplies (maximum monthly water allocation of 178 million gallons per month, MGM, or 5.74 million gallons per day, MGD) to Phillipsburg Town and neighboring municipalities, with much of the water use being considered depletive because the water (in the form of wastewater) is discharged outside of the source subwatershed.

The critical question is whether these three high-capacity municipal water supply wells are primarily diverting water in direct hydrologic communication with the surface waters of the Delaware River, rather than ground water from the subwatershed in which they are physically located (HUC14 02040105110030), to the extent that the wells should not be considered as a consumptive or depletive water use for that HUC14 subwatershed. If so, the Net Water Availability for the subwatershed would be recalculated as an RMP Update.

## **Highlands Council Evaluation**

The Highlands Council conducted a detailed evaluation of the Aqua America wells at River Road in Lopatcong Township, New Jersey (see Appendix A). Specifically, the three wells and their respective well permit numbers are Well A (24-06549), Well C (24-06548), and Well D (24-06547). They are permitted under NJ water allocation permit number 5125X. The full evaluation is appended to this RMP Update. The New Jersey Department of Environmental Protection provided a courtesy review of this evaluation and concurs with the results.

## **Highlands Council Conclusion**

The Aqua America wells at River Road in Lopatcong Township, New Jersey, are highly dependent on the Delaware River as a source of flow, and should have a negligible effect on ground water flows to streams within HUC14 02040105110030. As such, withdrawals from the Aqua America

wells should not be assessed as consumptive or depletive water uses against the Ground Water Availability for this HUC14 subwatershed, but rather should be considered as non-Highlands Region water supply sources.

Based on this analysis, the demand for the three Aqua America public supply wells should be excluded from the total demand HUC14 subwatershed 02040105110030. These three wells are the only public supply wells in the subwatershed, though other ground water withdrawals exist in the same HUC14 subwatershed.

The current RMP analysis assigns a Net Water Availability of -5.746 MGD (a deficit) when the three wells are drawing from Ground Water Availability. Based on this RMP Update, the Net Water Availability for HUC14 02040105110030 would be recalculated as -0.154 MGD (still a deficit). Because the subwatershed remains in deficit, the Conditional Water Availability remains at 0.012 MGD (1% of LFM).

## **Approved RMP Update**

The Executive Director of the Highlands Council has approved the following RMP Update:

Net Water Availability

HUC14 02040105110030

-0.154 MGD

## Appendix A

### Highlands Council Staff Analysis

#### Highlands RMP Update: Net Water Availability for HUC14 02040105110030 Analysis of Aqua America Wells, Lopatcong Township, New Jersey September 2009

The Highlands Water Protection and Planning Council's (Highland Council) staff assessed whether three high capacity municipal water supply wells are primarily diverting water in direct hydrologic communication with the surface waters of the Delaware River, rather than ground water from the subwatershed in which they are located (HUC14 02040105110030), to the extent that the wells should not be considered as a consumptive or depletive water use for that HUC14 subwatershed. The wells are owned and operated by Aqua America, Inc. and supply water to the Town of Phillipsburg and neighboring municipalities. They are located along River Road in Lopatcong Township, Warren County in very close proximity to the Delaware River as shown below. As discussed below, the wells are supplied by flow from the Delaware River, and should not be considered a consumptive or depletive water use from the HUC14 02040105110030.



To begin, Highland's Council staff contacted the following entities to gather information concerning the operation of these wells and their potential influence from the Delaware River:

- The New Jersey Department of Environmental Protection Bureau of Water Allocation (NJDEP BWA) to obtain well records and monthly allocation diversion reports;
- The New Jersey Geological Survey (NJGS) to obtain any available hydrogeologic data;
- The NJDEP Bureau of Safe Drinking Water (NJDEP BSDW) for information about water treatment requirements and any available technical reports and;
- Aqua America, Inc for any available documentation, pumping test data, etc.

From the NJDEP BWA, Highlands Council staff was able to obtain well permit information for two Aqua America wells: 24-06548 (Well C) and 24-06549 (Well A). No well permit data were available for well 24-06547 (Well D). The NJGS did not have any specific information concerning these wells; however, the NJDEP BSDW was able to provide a March 2003 report by Hatch Mott MacDonald submitted in support of a Filtration Avoidance Wavier request. Aqua America supplied a letter from the NJDEP's Bureau of Safe Drinking Water (NJDEP BSDW) documenting that the NJDEP BSDW designated the wells as being under the direct influence of surface water (dated February 6, 1998). Staff also reviewed NJDEP's I-Map and geologic I-Map ([http://njgin.state.nj.us/dep/DEP\\_iMapNJGeology/viewer.htm](http://njgin.state.nj.us/dep/DEP_iMapNJGeology/viewer.htm)) and completed an Internet search for any other documentation concerning these wells. The results of this research are discussed below.

Discussion

The NJDEP I-Map data indicate that these wells are situated in HUC14 subwatershed number 2040105110030 identified as the Upper Delaware River tributaries (Route 22 to Buckhorn Creek). Well records retrieved from the NJDEP I-Maps indicate that wells 24-06547 (Well D) and 24-06548 (Well C) were completed April and February of 1967 respectively and that well 24-06549 (Well A) was completed in December of 1966. All three wells were drilled and installed by Layne Christensen, Inc., a drilling company specializing in the construction of high capacity water wells. NJDEP I-Map well details are summarized in the table below:

**Summary of construction details of Aqua America Wells, 24-06547 (Well D), 24-6548 (Well C) and 24-06549 (Well A) obtained from NJDEP I-Map**

Well Permit Number	Well Identification	Completion Date	Total Depth (feet)	Screened Interval (ftbgs)		Casing and Screen diameter (inches)	Geologic Formation	Pumping Rate (gpm)
				Top	Bottom			
24-06547	D	4/2/1967	65.67	45.67	65.67	20	Stratified drift	1,388
24-06548	C	2/27/1967	82	61	82	20	Stratified drift	2,100
24-06549	A	12/27/1966	87	65	85	20	Stratified drift	2,100

Well construction details, well pump test data and boring logs for wells 24-06548 (Well C) and 24-06549 (Well A) were reviewed from permits received from the NJDEP's Bureau of Water Allocation. No well construction details, well pump test data, or boring logs were available from the Bureau of Water Allocation for well 24-06547 (Well D). The data for wells 24-06548 (Well C) and 24-06549 (Well A) are summarized in the table below:

**Summary of Aqua America wells: 24-06548 (Well C) and 24-06549 (Well A) construction details and well pumping test data from NJDEP Bureau of Water Allocation well records.**

Construction Details:		
Well Identification Number:	24-06548 (Well C)	24-06549 (Well A)
Date installed:	11/07/1966	12/27/1966
Owner at time of installation:	Peoples Water Company (1966)	
Driller:	Layne New York Co, Inc	
Total Depth:	82 feet below land surface (ftbls)	85 fbls
Well Diameter:	20-inch	
Type of Well:	unconsolidated "sand & gravel"	

Screen Type:	20-inch bronze wire wrap 15.0 slot; screen length 20-feet	
Screen Interval:	61 ftbls to 81 ftbls(+1ft tail piece)	65 ftbls to 85 ftbls
Initial Well Pumping Test Data:		
Well Identification Number:	24-06548 (Well C)	24-06549 (Well A)
Yield (Q):	3,500 gpm	3,002 gpm
Static water level:	21 ftbls (February 1967)	16 ftbls (December 1966)
Pumping level:	35 ftbls, (February 1967)	46 ftbls (December 1966)
Drawdown:	14 ft (February 1967)	30 ft (December 1966)
Specific Capacity:	250 gpm/ft	100 gpm/ft
Completion Formation:	Unconsolidated material [Quaternary Alluvium (QAL)]	

Based on a review of available well records it appears that all three wells were drilled and installed (completed) into quaternary alluvium (QAL) material that makes up the narrow floodplain and riverbed of the Delaware River. According to the Layne Christensen boring logs of 24-06548 (Well C) and 24-06549 (Well A), it appears that these QAL deposits are at least 82 to 87 feet thick. The boring log of well 24-06548 (Well C) also indicates that ledge rock was encountered at a depth of 81 ftbls (feet below land surface); however, the type of rock encountered or its competency is unknown. Therefore, we can assume that the top of competent bedrock was not encountered and lies at depths below 87 feet.

According to the NJDEP Bureau of Water Allocation (BWA) well records, wells 24-06548 (Well C) and well 24-06549 (Well A) were reported to have yields of 3,500 gpm and 3,002 gpm respectively. However, NJ-I-Map well data report a yield of 2,100 gpm for both wells. A pumping rate of 2,100 gpm represents a more realistic yield than the higher rates reported on the BWA records. The higher rates are probably reflective of the well's initial "shake down" testing to check the well's pump and mechanical systems and to determine the well's maximum pumping rate. It is common practice to set a well's pumping rate below its maximum in order to reduce pumping costs and for long term maintenance purposes.

Using the yield and drawdown data from the BWA and NJDEP I-Map well records, we can estimate the specific capacity of these wells. Knowledge of a well's specific capacity is useful in determining a well's overall productivity and is useful in evaluating an aquifer's hydrogeologic characteristics. Simply put, specific capacity expressed as gallons per minute per foot of draw down (gpm/ft) is the rate of discharge of water from a well divided by the drawdown of the water level within the well, and can be calculated by using the equation below:

$$\text{Specific Capacity} = Q/\Delta s \quad (\text{equation 1})$$

where:

Q: pumping rate measured in gallons per minute (gpm)

$\Delta s$ : draw down measure in feet

(after, Driscoll, 1989)

From equation 1, specific capacities were estimated for wells 24-06548 (Well C) and 24-06549 (Well A) by using the yield data from the BWA records and the NJDEP I-Map records. Because the drawdown data were not reported on the NJDEP I-Map records, the BWA drawdown data were used for calculating specific capacity for both data sets.

#### Specific Capacity Estimates of Aqua America wells: 24-06548 (Well C) and 24-06549 (Well A)

Well	24-06548 (Well C)		24-06549 (Well A)	
	BWA	NJDEP I-Map	BWA	NJDEP I-Map
Yield (Q):	3,500 gpm	2,100 gpm	3,002 gpm	2,100 gpm
Specific Capacity:	250 gpm/ft	150 gpm/ft	100 gpm/ft	70 gpm/ft

As shown in the table above, wells 24-06548 (Well C) and 24-06549 (Well A) have reasonably high specific capacities. This is most likely due to the nature of the material the wells are completed in and their construction, specifically their well screen. According to NJDEP BWA records, each well was constructed

with a 20-inch diameter screen, twenty feet in length. The screen's brass composition, large slot size (15-slot) and wire wrap construction is typical of well screen designed for high capacity pumping.

As recorded on the NJDEP BWA and NJDEP I-Map records, the wells are completed into QAL deposits along the banks of the Delaware River. QAL deposits have the capacity to "pass through" or transmit very large quantities of water due to their unconsolidated mixture of sands and gravels and their poorly sorted nature. The ability of an aquifer to transmit quantities of water is referred to as Transmissivity (T) and can be estimated by using the equation below;

$$T=264(Q/\Delta s) \quad (\text{equation 2})$$

where:

- T: Transmissivity expressed as gallons per day per foot
- 264: Constant
- Q: pumping rate measured in gallons per minute (gpm)
- $\Delta s$ : draw down measure in feet

(after, Driscoll, 1989)

From equation 2, Transmissivities were estimated for wells 24-06548 (Well C) and 24-06549 (Well A) by using the specific capacities estimated for each well and are shown in the table below.

**Transmissivity Estimates of Aqua America wells: 24-06548 (Well C) and 24-06549 (Well A)**

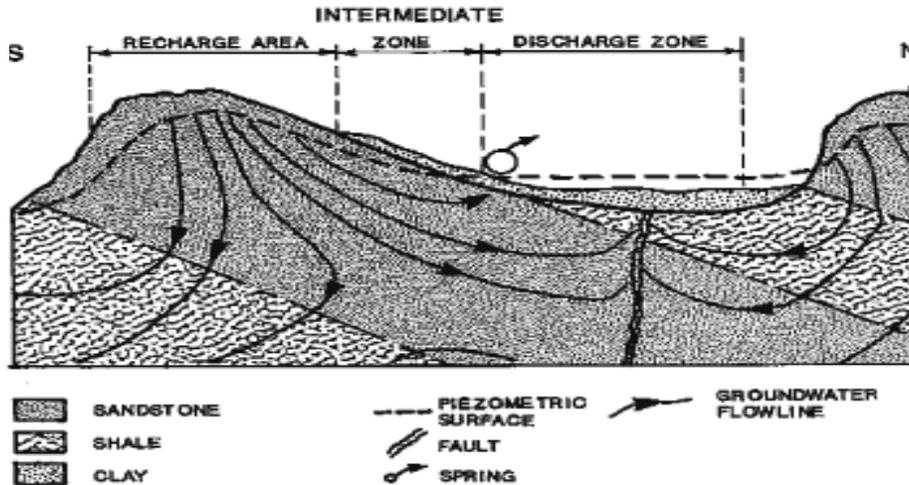
Well	24-06548 (Well C)		24-06549 (Well A)	
	BWA	NJDEP I-Map	BWA	NJDEP I-Map
Specific Capacity (gpm/ft):	250	150	100	70
Transmissivity (gpd/ft) :	66,000	39,600	26,400	18,480

As shown in the table above, the estimated Transmissivity values for the QAL sediments in which the wells are completed, ranges from approximately 66,000 gpd/ft to approximately 18,480 gpd/ft. This indicates that the QAL sediments along the banks of the Delaware are capable of transmitting vast quantities of ground water.

In February, 1998, the NJDEP BSDW concluded that the Aqua America wells were using ground water under the direct influence of surface water (GWUDI). This determination was based on the assessment that the Aqua America wells are physically "pulling in" surface water from the Delaware River through the underlying QAL sediments directly into the wells. Therefore, the NJDEP BSDW requires that water from these wells must meet specific water-quality criteria and must be treated in a manner similar to water from surface-water intakes ([www.nj.gov/dep/swap/reports/sw\\_no3.pdf](http://www.nj.gov/dep/swap/reports/sw_no3.pdf)). In this case, the well water is treated by chlorination and ultra-violet radiation for protozoan inactivation by Aqua America, Inc.

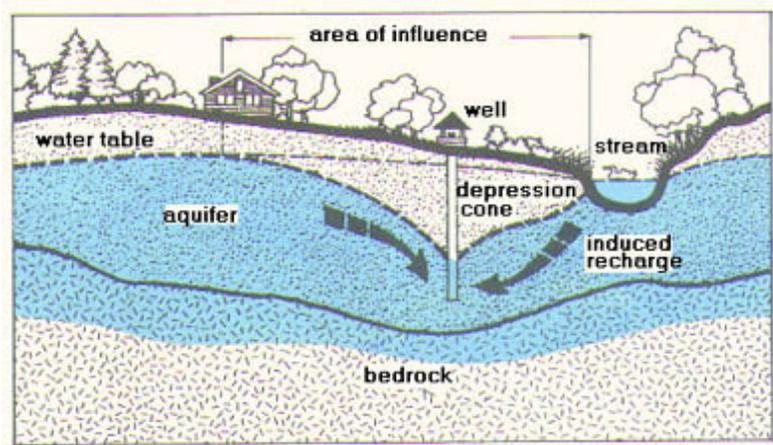
The physical "pulling in" of surface water into the underlying aquifer is referred to as "induced recharge" and is the result of the creation of a physical connection between the surface water body and the underlying aquifer. This physical connection can be either direct or indirect and is caused by the reversal of the pre-existing ground water flow towards the pumping well by a change of the ground water gradient as described below.

Before pumping or pre-development of the aquifer system, ground water flow into and out of the aquifer is considered to be in equilibrium or a "steady state condition." That is to say, over the long term the volume of water flowing into the aquifer from ground water, stream water, and other inputs such as rainfall infiltration and river discharge is equal to the outputs such as discharge to lakes and wetlands, and evapotranspiration as shown below. Within this system, surface water and ground water levels may fluctuate from year to year but remain relatively stable over the long term. This indicates that there are no stresses occurring in the aquifer system to change the overall equilibrium over the long term.



When ground water extraction is introduced, the equilibrium or the steady state of the aquifer system is disrupted. This is due to the presence of a new form of discharge that decreases the volume of water once available to maintain the original ground water flow regime. This deficit stresses the aquifer system; the aquifer system must respond by moving to a new equilibrium. One such manifestation of this shift in equilibrium is induced recharge or stream flow depletion as shown below.

How an aquifer system moves towards a new equilibrium in response to a stress such as ground water pumpage is a function of its lithology, geologic structure and the hydrogeologic characteristics of the material making up the aquifer, specifically the hydraulic conductivity. Hydraulic conductivity (K) is defined as the capacity of a porous medium to transmit water and is expressed as gallons per day per square feet [gpd/ft<sup>2</sup> (Driscoll, 1989)]. It can be estimated by using the following equation:



$$K=T/b \qquad \text{(equation 3)}$$

where:

T: Transmissivity expressed as gallons per day per foot

b: Saturated thickness of the aquifer (from static water level to bottom of screen interval)

(after, Driscoll, 1989)

The hydraulic conductivity of a material is dependent upon the size, shape and interconnectivity of the material's pore spaces in unconsolidated materials and the size and character of the fractures, crevices and solution cavities of consolidated materials. For example, deposits of silt, clay and glacial till, due to their minimal number or lack of pore spaces, have very low hydraulic conductivity values that can range from single to tens of gallons per day per foot squared (gpd/ft<sup>2</sup>). Because of the lower hydraulic conductivity values of silt, clay and glacial till, the movement of water through these materials is slow to non-existent. In contrast, the QAL sediments in which the Aqua America wells are completed have hydraulic conductivity values orders of magnitude higher. This is because these deposits consist of a poorly sorted unconsolidated mixture of sands and gravels that are very porous thus allowing water to easily pass through them. The table

below summarizes the range of estimated hydraulic conductivity values for the Aqua America wells produced by using equation 3.

**Hydraulic Conductivity Estimates of Aqua America wells: 24-06548 (Well C) and 24-06549 (Well A)**

Well	24-06548 (Well C)		24-06549 (Well A)	
Estimated Transmissivity (gpd/ft):	66,000	39,600	26,400	18,480
Total Depth:	82 ftbls		85 ftbls	
Static water level:	21 ftbls		16 ftbls	
Estimated Saturated Thickness:	61 feet		69	
Estimated Hydraulic Conductivity:	1,082 gpd/ft <sup>2</sup>	639 gpd/ft <sup>2</sup>	383 gpd/ft <sup>2</sup>	268 gpd/ft <sup>2</sup>

The estimated hydraulic conductivity values shown above indicate that ground water can move easily through the QAL sediments. The variability of these values is attributable to the heterogeneous nature that is typical of fluvio-glacial derived material (Driscoll, 1989 and Freeze and Cherry, 1979).

High capacity municipal water supply wells such as the Aqua America wells have the ability to draw water from a significant portion of an aquifer, within the zone of capture, and affect ground water flow paths within a somewhat different aquifer area called the zone of influence. The result is that the water coming from the well will be a mixture of water from a significant area, with the area increasing proportionally with pumping rates and time. A well's zone of influence can be estimated over time by using the volumetric flow equation as shown below:

$$r_o = \sqrt{Q/t/4524 \eta H} \tag{equation 4}$$

where:

- r<sub>o</sub>: radius of influence or zone of influence in feet
- Q: is discharge rate in cubic feet per day (ft<sup>3</sup>/d)
- t: pumping time in minute
- η: porosity of unconsolidated material or effective porosity of consolidated material
- H: screened or open hole interval of well

(after, Lee, Shun, 2007)

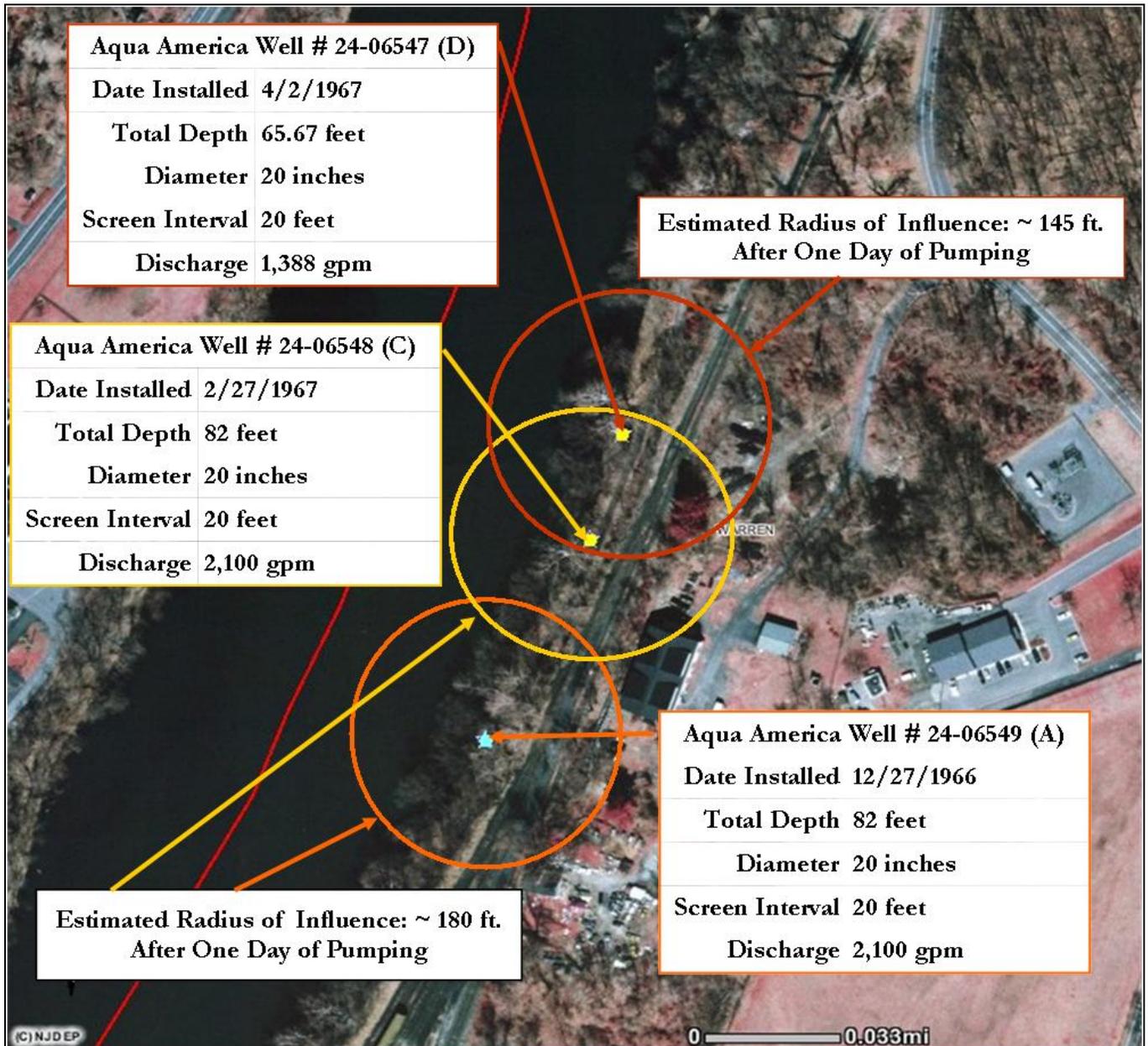
To show the expansion of the zone of influence over time for the Aqua America wells, the Volumetric Flow equation was used to determine the zone of influence for 1-day, 3-days, 60-days and 365-days of continuous pumping. These results are summarized in the table below:

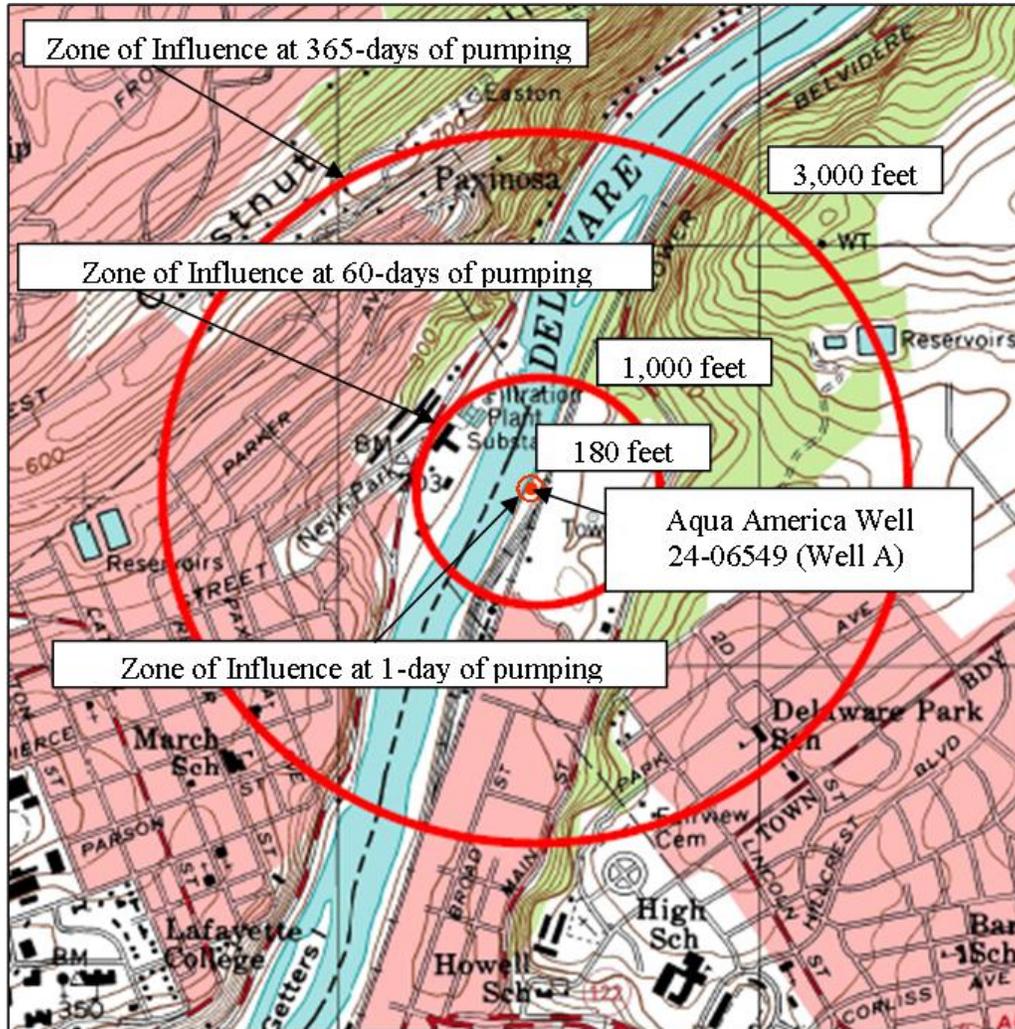
<b>Estimated Zone of Influence Using the Volumetric Flow Equation</b>			
Well Identification Number:	24-06548 (Well C)	24-06549 (Well A)	24-06547 (Well D)
Screened Interval:	20.00	20 feet	
Discharge (gpm):	2,100	404,278.07 ft <sup>3</sup> /day	
	1,388	267,208.56 ft <sup>3</sup> /day	
Time (days):	1.00	1,440.00 minutes	
Porosity (η):	0.20	0.20 (unitless)	(after, Driscoll, 1989)
Zone of Influence at:	1-day	179.36 ft	145.82 ft
	3-days	310.66 ft	252.57 ft
	60-days	1,389.33 ft	1,129.51 ft
	365-days	3,426.70 ft	2,785.87 ft

As tabulated above, the zone of influence for wells 24-06548 (Well C) and 24-06549 (Well A) at one and three days of continuous pumping range from approximately 180 feet to just over 300 feet, respectively. Aqua America well 24-06547 (Well D) has a slightly smaller zone of influence for the one and three day time period of 145 feet and 252 feet. As shown in the figure below, the zone of influence for all three wells clearly extends out into the Delaware River at the one and three day continuous pumping period. In actual practice,

water supply wells are not pumped continuously; instead they are pumped in cycles that are reflective of the water system's needs. However, it is common industry practice to pump wells continuously for one to three day periods in order to perform well performance testing and aquifer stress testing. Given the proximity of the wells to the Delaware River, the well construction details, and the hydrogeologic characteristics of the QAL sediments, we can assume that the zone of influence at the one and three day time period do intersect with, and therefore the wells do draw in surface water from the Delaware River. This supports the NJDEP BSDW's 1998 finding the wells are under direct influence of surface water.

Despite the cyclic pumping of a high capacity municipal well, the effects from pumping, or more specifically, the zone of influence caused by the pumping, will increase over time until the aquifer's recharge rate equals its discharge rate and a new equilibrium is established. This is illustrated by the figure below that shows the zone of influence for well 24-06549 (Well A) at just over 1,300 feet after 60-days and at just over 3,400 feet at 365-days (1-year).





As shown in the figure above, the zone of influence at the 60-day interval is wholly contained within the Delaware River's basin and encompasses its flood plains on either side, each composed of QAL sediments. This suggests that the wells are influencing and are drawing water across the entire width of the Delaware River. However, the zone of influence at the one year interval extends far out across the boundaries of the Delaware River basin and into the surrounding bedrock. This suggests that the wells are drawing water from the surrounding bedrock; however, this is not the case. In reality, a zone of influence does not extend out equally in all directions from a well – differences in geology and hydrogeologic parameters strongly affect the shape and size of a wells zone of influence. For example, we have demonstrated that the Aqua America wells were installed at shallow depths in QAL material along the banks of the Delaware River, which are thick and highly transmissive and can yield vast quantities of water. In contrast, wells completed into the carbonate bedrock aquifers which underlie the QAL sediments and Delaware River are completed at average depths of approximately 500 feet and produce yields of approximately 500 gpm or less. This indicates that the bedrock underlying the QAL material should act as a boundary, limiting the flow of ground water across it. Based on this assumption, the zone of influence for the Aqua America wells would likely be more of an ellipse following QAL material deposited along the banks of the Delaware River. The zone of influence will normally follow preferentially the materials of highest Transmissivity.

Based on the information above, all evidence supports the New Jersey Department of Environmental Protection's Bureau of Safe Drinking Water 1998 designation that the Aqua America wells are under the direct influence of surface water based upon the following supporting information:

- The wells are located along River Road in Lopatcong Township, Warren County in very close proximity to the Delaware River
- All three wells were drilled and installed into quaternary alluvium (QAL) material adjacent to the Delaware River as unconsolidated wells at relatively shallow depths ranging from 65 fbls to 85 fbls.
- According to the Layne Christensen, Inc. boring logs, the wells were not installed into bedrock.
- Each well was equipped with 20-inch diameter large slot size (15-slot) wire wrap screen of brass composition, typical of well screen designed for high capacity pumping.
- The NJDEP's Bureau of Safe Drinking Water issued a determination that the wells are under the direct influence of surface water.
- Estimates of the QAL material's Transmissivity and hydraulic conductivity indicate that the sediments are highly transmissive and are capable of producing large quantities of water.
- The QAL sediments form the narrow flood plain and river bed of the Delaware River; the unconsolidated and poorly sorted nature of these sediments indicates that they are in direct hydrologic communication with the river.
- Estimates of the zone of influence for all three wells intersect with, and do draw in surface water from the Delaware River.

### Conclusion

The Aqua America wells at River Road in Lopatcong Township, New Jersey, are highly dependent on the Delaware River as a source of flow, and should have a negligible effect on ground water flows to streams within HUC14 02040105110030. As such, withdrawals from the Aqua America wells should not be assessed as consumptive or depletive water uses regarding the Ground Water Availability for this HUC14 subwatershed, but rather should be considered as non-Highlands Region water supply sources.

Based on this analysis, the demands for the three Aqua America public supply wells should be excluded from the total demand HUC14 subwatershed 02040105110030. These three wells are the only public supply wells in the subwatershed, though other ground water withdrawals exist in the same HUC14 subwatershed.

The current RMP analysis assigns a net water availability of -5.746 MGD (a deficit) when the three wells are drawing from Ground Water Availability. Based on this evaluation, the net water availability for HUC14 02040105110030 would be recalculated to be -0.154 MGD (still a deficit). Because the subwatershed remains in deficit, the Conditional Water Availability remains at 0.012 MGD (1% of LFM).

### References

Driscoll, F.G., 1989, Groundwater and wells, Johnson Filtration Systems, Inc, St. Paul, Minnesota  
Freeze, R.A, Cherry J.A., 1979, Groundwater, Prentice Hall, Englewood Cliffs, New Jersey  
Lee, C.C., Shun DarLin, 2007 Handbook of Environmental Calculations, McGraw-Hill, pp 236-239