Eastern Panhandle Conservation District
Morgan County Rural Water Committee
West Virginia Conservation Agency
USDA Natural Resources Conservation Service

Assessment and Plan Development

Volume 1 of 2

Morgan County
Water Resources Study

February 2007

GANNETT FLEMING
Fairfax, Virginia

MORGAN COUNTY WATER RESOURCES STUDY

VOLUME 1 OF 2 - ASSESSMENT AND PLAN DEVELOPMENT

VOLUME 2 OF 2 - WATER RESOURCES PLAN

MORGAN COUNTY WATER RESOURCES STUDY

VOLUME 1 OF 2

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LIST OF ABBREVIATIONS

Agencies & Organizations		
AWWA	-	American Water Works Association
EPCD	-	Eastern Panhandle Conservation District
GF	-	Gannett Fleming, Inc.
MCC	-	Morgan County Commission
MCRWC	-	Morgan County Rural Water Committee
NRCS	-	United States Department of Agriculture, Natural Resource Conservation Service
OEHS	-	West Virginia Bureau for Public Health – Office of Environmental Health Services
PSD	-	Public Service District
USEPA	-	United States Environmental Protection Agency
USGS	-	United States Geologic Survey
VA	-	Commonwealth of Virginia
WV	-	State of West Virginia
WVCA	-	West Virginia Conservation Agency
WVDEP	-	West Virginia Department of Environmental Protection
WVDHHR	-	West Virginia Department of Health and Human Resources
WVDNR	-	West Virginia Department of Natural Resources
WVGES	-	West Virginia Geological and Economic Survey
WVU	-	West Virginia University

Common Engineering Terms		
ADD	-	Average Daily Demand
cfs	-	Cubic Feet per Second
cfsm	-	Cubic Feet per Second per Square Mile
CM	-	Construction Management
DI	-	Ductile Iron (pipe)
DIP	-	Ductile Iron Pipe
EDC	-	Endocrine Disruptor Compounds
gpcd	-	Gallons per Capita per Day
gpd	-	Gallons per Day
gpm	-	Gallons per Minute
l.f.	-	Linear Feet
MGD	-	Million Gallons per Day
O&M	-	Operation and Maintenance
PDD	-	Peak Daily Demand
PRV	-	Pressure Reducing Valve
psi	-	Pounds per Square Inch
WTP	-	Water Treatment Plant

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1.0 INTRODUCTION

The Morgan County Water Resources Study is being prepared under the leadership of the Eastern Panhandle Conservation District (EPCD) and the Morgan County Rural Water Committee (MCRWC). The MCRWC is comprised of representatives from water service systems, concerned citizens, and representatives of local, State, and Federal agencies interested in the water resources of Morgan County. The MCRWC has been assisted by the West Virginia Conservation Agency (WVCA) and the United States Department of Agriculture Natural Resources Conservation Service (NRCS). This group of agencies and groups will be referred to as the "Project Team" in this document.

The EPCD commissioned Gannett Fleming, Inc. (GF) to provide consulting services in order to develop the Morgan County Water Resources Study. The ultimate goal of the Morgan County Water Resources Study, which will be completed in two phases, is to identify and develop a drinking water project plan for the identified "Priority Area" of Morgan County that will satisfy drinking water demands within the designated area over a 25-year planning period. The study is comprised of the following phases of work activities, identified in the previously referenced agreement between the EPCD and GF:

Phase I: Collection of available data relating to population projections in Morgan County, water consumption, and raw water sources; projecting water demands to determine the required water supply quantity; surface water and groundwater quantity assessments to identify potential sources that can satisfy the projected water demands; water quality analyses of the identified water sources to determine an approximate level of treatment required to produce potable drinking water; and the development of the potential water sources for the areas served by the study, including conceptual cost estimates, in order to grade the options and assist the Project Team in selecting a preferred water supply plan for Morgan County.

The findings of the Phase I investigations are included in this Volume 1.

Phase II: Develop the preferred alternative and include water distribution and storage facilities to service the identified areas of Morgan County in the study; potential system interconnections; and fire service needs. Estimates of project cost and user fees for the 25-year planning period will be developed and project phases identified in Phase II of the Morgan County Water Resources Study.

The findings of the Phase II investigations are included in Volume 2.

1.1 Objectives

The primary purpose of this assessment is to develop a recommended water supply plan that will serve as a guidance document for designing and constructing a public water supply system that provides a safe and reliable source of high quality drinking water in the designated Priority Area in Morgan County for as many residents as practical.

Multiple raw water concepts were considered for each region of the Priority Area. These concepts were then evaluated and either eliminated from future consideration or developed further in order to be presented to the Project Team for selection of the preferred alternative. The preferred alternative selected by the Project Team was advanced to Phase II.

1.2 Summary of Study Area

The Morgan County Water Resources Study identifies a Priority Area within Morgan County that is the focus of the study. The Priority Area consists of the Route 522 corridor (both north and south of the Town of Berkeley Springs), the Route 9 corridor that extends east from the Town of Berkeley Springs to the Morgan County/Berkeley County border, and the Town of Great Cacapon.

The Priority Area was developed such that the existing Berkeley Springs Water Works system is located outside of the Priority Area and will not be included in the Morgan County Water Resources Study.

1.3 Data Collection and Evaluation

1.3.1 Data Sources

Data relevant to the soil and geologic conditions; population, economic settings, and planned development; water supply; water quality; and water systems in Morgan County was obtained from a multitude of Federal, State and local sources. Through various data collection activities, numerous records, reports, files, studies, inventories, and other available information were collected and compiled.

1.3.2 Development of General Data Index

As information was collected, a description of the data and source was prepared, a reference number was assigned, and a General Data Index was created. The General Data Index can be found in Appendix A of this report.

2.0 PROJECTION OF WATER DEMANDS

2.1 Background

Water demand projections for the Priority Area were generated based on information collected from the Project Team, as well as preliminary population projections contained in the County's Comprehensive Plan, which was being completed at the time of this study.

2.2 Priority Area Population Projections

The following sections explain the logic and assumptions used to estimate the population that is to be served by the new public water supply in the Priority Area.

2.2.1 Determine 2005 Morgan County Population

Due to the lack of reliable information that would indicate the current (2005) population of the Priority Area, it was necessary to start by determining the current population of Morgan County. EPCD and MCRWC informed GF that the County was developing a Comprehensive Plan and suggested that GF contact that consultant who was working on the Comprehensive Plan in order to obtain some preliminary population projections. Based on the information received from the consultant developing the Comprehensive Plan, the ***2005 population of Morgan County was estimated to be 17,232 people***.

2.2.2 Estimate 2005 Priority Area Population

In order to go from the entire Morgan County population to the Priority Area population, it was necessary to determine the percentage of the population living within the designated Priority Area. The U.S. Census Bureau website contains a breakdown of the 2000 Morgan County population based on County subdivisions. Figure 1 is a copy of the website indicating the County subdivisions and their respective populations according to the 2000 U.S. Census.

The Priority Area has been identified by EPCD and the MCRWC as the Route 522 corridor and the Route 9 corridor east of the Town of Bath, minus the Town of Bath (Berkeley Springs) but including the Town of Great Cacapon. As seen in Figure 1, Subdivisions 2 and 4 are very similar to the Priority Area, therefore, these two subdivisions are assumed to represent the Priority Area. While a portion of the Priority Area that is located in Subdivision 3 is missing from this assumption, there is additional land area included in Subdivision 2 that is believed to compensate for this omission.

The combined population of Subdivisions 2 and 4 from the 2000 U.S. Census was 7,222 people. However, the Town of Bath (2000 U.S. Census pop. = 663) appears to be included in the combined areas of Subdivisions 2 and 4. In order to be as accurate as possible, the population of the Town of Bath shall be subtracted from the populations of Subdivisions 2 and 4.

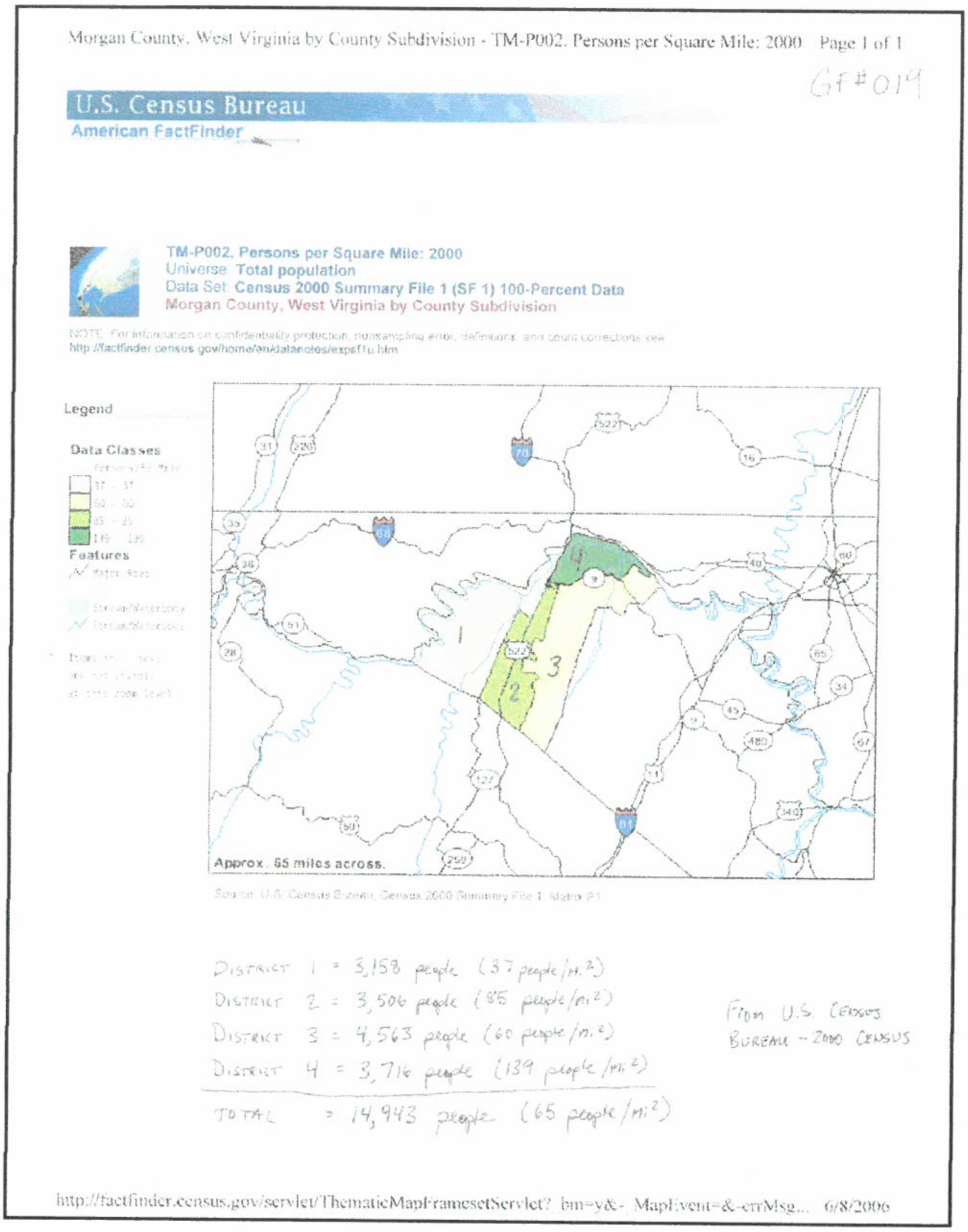

Figure 1: Morgan County Census Subdivisions and Populations from 2000 Census (Taken from U.S. Census Bureau Website)

Another omission from the assumption that Subdivisions 2 and 4 constitute the Priority Area is that the Town of Great Cacapon is not included in either subdivision. The 2000 U.S. Census did not provide a population estimate for the Town of Great Cacapon. However, the MCRWC was able to provide GF with the number of current sanitary sewer connections in the town. There are currently 145 sanitary sewer connections in the Town of Great Cacapon.

Assuming that there are 2.5 people per connection, the current population in the Town of Great Cacapon is approximately 363 people.

Therefore, the 2000 Priority Area population was assumed to be equal to 7,222 people – 663 people + 363 people = 6,922 people. This population estimate represents 46.32% of the Morgan County population in the year 2000.

Due to the short time span between 2000 and 2005, Gannett Fleming assumed that the Morgan County population distribution was the same in 2005 as it was in 2000. Therefore, 46.32% of the 2005 Morgan County population would be residing in the Priority Area. This results in a ***2005 Priority Area population of approximately 7,982 people***.

2.2.3 Estimate Morgan County Population in the Year 2030

GF again utilized the information received from consultant developing the Morgan County Comprehensive Plan to determine the appropriate 2030 Morgan County population estimate. The Comprehensive Plan contained "Low Growth" and "High Growth" scenarios for predicting the Morgan County Population out to the year 2025. GF used a linear regression analysis to determine the "Low" and "High" population projections for Morgan County in the year 2030. These values were 24,882 people and 41,457 people, respectively.

Per a directive from the MCRWC, Gannett Fleming selected a 2030 Morgan County population that was 75% of the difference between the "Low" and "High" projections. This resulted in a ***2030 Morgan County population of approximately 37,313 people***.

2.2.4 Estimate County Wide Population Increase Between 2005 and 2030

Based on the information gathered and calculated to this point, it appears that the ***Morgan County population will increase by approximately 20,081 people*** (37,313 people – 17,232 people) between the years 2005 and 2030.

2.2.5 Assume 75% of County Wide Population Increase Occurs in Priority Area

Based on engineering judgment that dictates people will likely move to an area with economic growth and infrastructure (e.g. water) availability, it is assumed that 75% of the Morgan County population increase between the years 2005 and 2030 will occur within the Priority Area. Therefore, the ***Priority Area population will increase by approximately 15,061 people by the year 2030***.

2.2.6 Projected 2030 Priority Area Population

The 2030 Priority Area population in the year 2030 will be the sum of the current population (7,982 people) and the projected population increase (15,061 people). Therefore, the projected ***2030 Priority Area population will be approximately 23,043 people***.

2.2.7 Assume 50% of Priority Area Population Will Be Served by the New Water System

Sound engineering judgment dictates that the typical percentage of service connections in a water system is approximately 75%. In a rural setting such as the Priority Area, it can be assumed that only 50% of the projected 2030 population will be connected to the new water system. This assumption is further supported by the fact that current residences in the Priority Area will not be required to convert to the new public water supply, thus allowing many to remain on their own private wells. It can also be assumed that some new permanent and seasonal homes built in the Priority Area over the next 25 years may elect to drill private wells.

Therefore, it can be assumed that ***the new water system will be serving a population of approximately 11,521 people*** in the Priority Area in the year 2030.

2.3 Priority Area Water Demand Projections

There are four components that collectively represent the projected water demands of the Priority Area. These components are residential consumption, commercial use consumption, industrial use consumption, and unaccounted for water losses. The following sections discuss the logic and assumptions made in order to estimate the projected water demands of the Priority Area in the year 2030.

2.3.1 Estimate Residential Water Consumption in Priority Area (2030)

To determine the average daily consumption in the Priority Area, Gannett Fleming reviewed available data from the American Water Works Association (AWWA) and from the Town of Bath. AWWA data indicates that the average U.S. water consumption is 74 gallons per capita per day (gpcd), while the Town of Bath has an average consumption of 123 gpcd. GF has selected 100 gpcd to be used for this study.

Therefore, the ***estimated residential water consumption in the Priority Area in the year 2030 is 1,152,100 gallons per day*** **(gpd)**.

2.3.2 Estimated 2030 Commercial Use Water Consumption in Priority Area

The Town of Bath data indicates that the current ratio of residential water consumption to commercial water consumption is 13:1. This means that there is 13 times more water consumed by residential customers than commercial customers. GF has assumed that this ratio is representative of the residential/commercial distribution that will be seen in the Priority Area over the next 25 years. Therefore, the ***estimated commercial water consumption in the Priority Area in the year 2030 is 88,626 gpd*** (1,152,138 gpd * 1/13).

2.3.3 Estimated 2030 Industrial Water Consumption in Priority Area

In order to estimate the 2030 industrial water consumption in the Priority Area, Gannett Fleming assumed that by the year 2030 there will be 15 industrial users in the Priority Area. Assuming that the Route 522 Industrial Park well yield data of 60 gallons per minute (gpm) is indicative of a typical industrial user, than each industrial user will consume approximately 28,800 gpd, assuming an 8-hour workday. Therefore, the ***estimated industrial water consumption in the Priority Area in the year 2030 is 432,000 gpd*** (28,800 gallons/day * 15 industrial users).

2.3.4 Total 2030 Priority Area Water Consumption

The total 2030 Priority Area water consumption is equal to the sum of the residential, commercial and industrial consumptions. Therefore, the ***total 2030 Priority Area water consumption is equal to 1,672,763 gpd***.

2.3.5 Unaccounted For Water Allowance

For a new system, it is customary to assume that there will be some unaccounted for water losses in the system. The AWWA Leak Detection and Accountability Committee recommended in 1996 that 10% unaccounted for water be used as a benchmark. Therefore, for this study, GF has selected a ***10% unaccounted for water allowance***.

2.3.6 Total 2030 Water Demand Projection for Priority Area

The total 2030 water demand projection for the Priority Area is the sum of the total 2030 Priority Area water consumption and the unaccounted for water allowance. Because the unaccounted for water allowance represents 10% of the demand, the total 2030 water demand projection for the Priority Area can be determined by dividing the total sum of the consumptions by 0.90. Therefore, the ***total 2030 water demand projection for the Priority Area is equal to 1,858,581 gpd***, or approximately 1.86 million gallons per day (MGD). This value will represent the average daily demand (ADD) for the Priority Area and will be used for sizing various water system facilities discussed in the Morgan County Water Resources Study.

2.3.7 2030 Priority Area Peak Daily Demand

A typical peaking factor of 1.5 has been applied to the ADD to determine the peak daily demand (PDD) that will occur in the Priority Area in the year 2030. The ***2030 PDD for the Priority Area is 2,787,872 gpd***, or approximately 2.79 MGD. This value will be used for sizing various water system facilities discussed in the Morgan County Water Resources Study.

2.4 Projected Water Demand Distribution

The MCRWC supplied GF with an estimated distribution of the projected water demands within the Priority Area, as seen in Figure 2. The majority (65%) of the demands will be located along the Route 522 corridor that extends from the Town of Bath south to the County border, which will be referred to as the "South" region of the Priority Area. The Route 9 corridor that extends from the Town of Bath east to the Morgan County border will contain approximately 30% of the future projected water demands and will be referred to as the "North" region of the Priority Area. The remaining 5% has been attributed to the Town of Great Cacapon, which will be referred to as the "Great Cacapon" region of the Priority Area in this study.

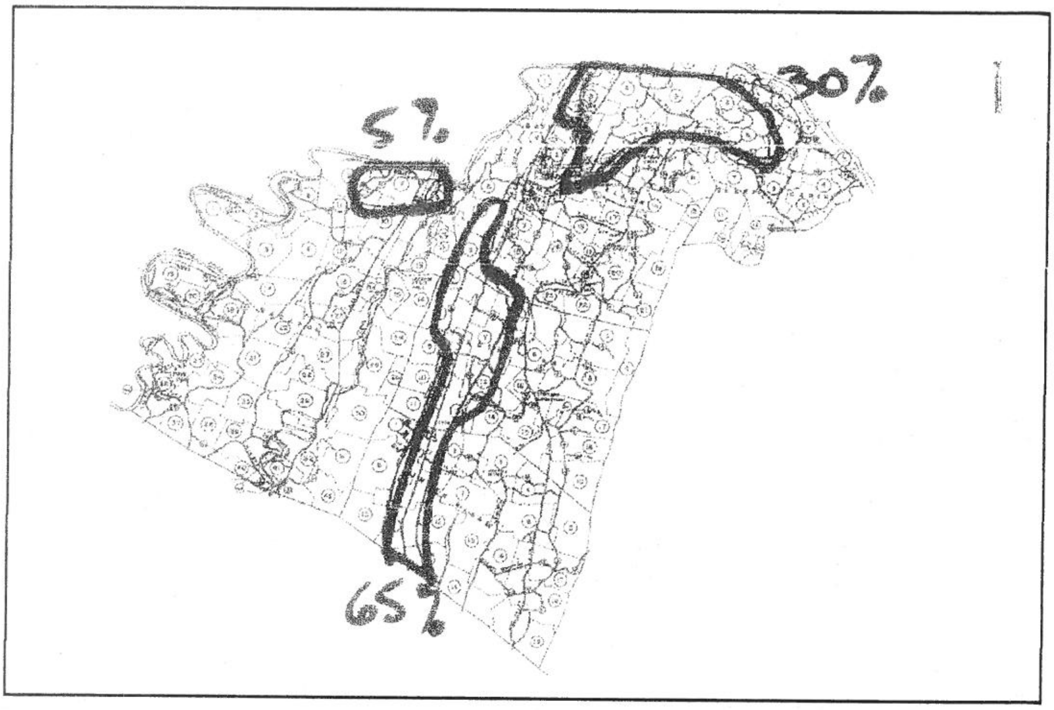

Figure 2: Distribution of Projected Water Demands Within the Priority Area

Based on the percentage distributions, Table 1 summarizes the projected water demands for the three Priority Area regions:

Table 1: Summary of Projected Water Demands in the Three Priority Area Regions

Priority Area Region	Estimated Demand Percentage	Average Daily Demand (ADD)	Peak Daily Demand (PDD)
South	65%	1.21 MGD	1.81 MGD
North	30%	0.56 MGD	0.84 MGD
Great Cacapon	5%	0.09 MGD	0.14 MGD

3.0 SURFACE WATER SOURCE OPTIONS

3.1 Study Approach

Surface water sources evaluated in this study include existing impoundments, new river intakes, new reservoir development, new pumped storage reservoirs, purchasing water from a nearby utility and the conversion of an existing sand mine into a reservoir. Springs were not included in the surface water study and are addressed in the evaluation of groundwater sources. The study area for locating new river intakes, new reservoir development and pumped storage sites was limited to Morgan County. The study area for identifying existing impoundments and purchasing water from a nearby utility was extended outside of Morgan County, to Berkeley County and Hancock, Maryland, respectively.

Since the cost, effort, and lead time needed to develop a surface water source is significant, it was assumed that any surface water option considered should be capable of providing the entire projected water demand deficit of 1.86 MGD. A collection of multiple small surface water sources was not considered.

3.2 Study Limitations

The identification of potential surface water sources was based on available mapping and published data. No field verification, environmental or subsurface investigations were performed. Cost estimates were prepared at a planning level of detail. The assessment of environmental impacts and permit requirements are based on experience with similar projects. Water quality, treatment and transmission were not considered at this time.

3.3 Surface Water Source Evaluations

3.3.1 Minimum Requirements for a Surface Water Source

For this study, in order for a surface water source to be viable it is assumed that it must be able to provide a safe yield of at least 1.86 MGD. In order for a river intake to be viable, it is assumed that it must be able to provide for a peak day of 1.5 times the safe yield, or approximately 2.79 MGD. These requirements imply that the facility for withdrawal at a river intake must be sized for up to 2.79 MGD or that an impoundment has sufficient storage and refill capacity to sustain a constant withdrawal of 1.86 MGD without running out of water. River intakes and impoundments must therefore have a reliable history of hydrologic data that demonstrates their ability to meet this requirement.

USGS Stream Gaging stations provide daily streamflow measurements over long periods of record at selected gage sites and are a valuable source of hydrologic information. When there is no stream gaging station within the same watershed, streamflow records from other nearby watersheds can be correlated and transposed to the watershed being evaluated, provided the watersheds and streamflow characteristics are similar.

Several long-term USGS stream gaging stations are available within or near Morgan County, West Virginia. They include three on the Potomac River, one on the Cacapon River, Opequon Creek and Back Creek. There is also a short-term gaging station with a period of record less than three years outside of Morgan County on Waites Run near Wardensville. Summary statistics for the aforementioned USGS stream gages are presented in Table 2.

3.3.2 Existing Impoundments

Guidelines published by the West Virginia Department of Health stipulate:

"The quantity of water at the source shall be adequate to meet the maximum projected water demand of the service area as shown by calculations based on the extreme drought of record; shall provide a reasonable surplus for anticipated growth; shall be adequate to compensate for all losses such as silting, evaporation, seepage, etc.; shall be adequate to provide ample water for other legal users of the source; shall not exceed a rate of withdrawal that is more than ten percent of the minimum available flow in a stream; and shall provide ***a minimum six (6) months storage*** *based on average daily demand for all drainage basins, natural lakes and artificial reservoirs or impoundments."*

A review of the stream gaging station data in Table 2 and of *"River Basin Bulletin 3"* suggests that the average runoff per square mile of drainage area for watersheds within and near Morgan County ranges between 0.7 and 1.0 cfs. Therefore, assuming the watersheds within or near Morgan County have similar runoff characteristics, in order for a surface water impoundment to provide a safe yield of 1.86 MGD (2.8 cfs), it must have a drainage area greater than approximately 3.3 square miles. That is, the average runoff must be greater than the safe yield. Making allowances for evaporation, seepage, conservation releases, sedimentation, dead storage, and back-to-back droughts, the minimum contributing drainage area of an impoundment should be at least 4 square miles to provide a safe yield of 1.86 MGD. Impoundments with smaller drainage areas should not be considered, as they would not be able to provide the required safe yield.

In addition to having adequate drainage area, the impoundment must also have sufficient storage capacity to augment low flows during a drought event. As stipulated in the West Virginia Department of Health guidelines, at least six (6) months of storage must be provided. Factoring in storage to account for evaporation, sedimentation, seepage, conservation releases and dead storage, the minimum reservoir storage requirement for a 1.86 MGD water supply reservoir is approximately 1,000 acre-feet.

An examination of existing impoundments located within Morgan County shows that none have storage volumes within the required range with drainage areas greater than 4 square miles. The closest existing impoundment that meets these minimum requirements is Sleepy Creek Lake located along the eastern border of Morgan County in Berkeley County.

Sleepy Creek Lake is created by an earthfill dam constructed in 1962 by the West Virginia Department of Natural Resources, Division of Wildlife Resources. The dam is 38 feet high, 1,100 feet long and stores 2,460 acre-feet of water at normal pool. The surface area of the impoundment is 205 acres at elevation 1,086 feet. The impoundment is located on the 23,000 acre Sleepy Creek Wildlife Management Area which lies within both Morgan and

Berkeley Counties. The lake has a maximum depth of 26 feet and an average depth of 9 feet. The drainage area upstream of the lake is approximately 9.1 square miles.

Based on the above reservoir characteristics and results of several safe yield studies recently completed by Gannett Fleming on similar water supply impoundments in West Virginia, Sleepy Creek Lake should be able to supply the predicted deficit of 1.86 MGD. A detailed safe yield study was performed for Elkwater Fork Reservoir in September 2004. Elkwater Fork Reservoir is a water supply project currently under construction by the West Virginia Natural Resources Conservation Service (NRCS) and consists of a 125-foot high roller-compacted concrete gravity dam located in Randolph County, West Virginia. The reservoir created by the dam has an 8.4 square mile drainage area and a total reservoir storage capacity of 2,035 acre feet. The safe yield study was performed using both West Virginia Department of Health criteria and simulating the worst drought of record (1930 drought event). The safe yield of Elkwater Fork Reservoir was computed to be 2.5 MGD. Using the Elkwater Fork project as a relative indication of the safe yield available from Sleepy Creek Lake and making adjustments based on drainage area and storage capacity, the estimated safe yield available from Sleepy Creek Lake is approximately 3.0 MGD.

Use of Sleepy Creek Lake as a water supply source would require an agreement with the owner, the West Virginia Department of Natural Resources, Division of Wildlife Resources (WVDNR). Modifications to the dam may be required to facilitate water withdrawals. If the WVDNR is unwilling to reallocate some of the existing recreation storage for water supply, Sleepy Creek Dam and its appurtenances could be modified/raised to provide additional storage. This could result in a win-win situation for both parties. The WVDNR would obtain a larger reservoir that could provide expanded recreation benefits, and the EPCD would obtain an economical surface water supply as compared to developing a new damsite. The environmental impacts and permit requirements associated with expanding Sleepy Creek Lake would also be less than for developing a new reservoir. Since the surface area of the existing impoundment is approximately 205 acres, the normal pool of the reservoir would need to be raised at least 5 feet to provide the needed additional storage.

If reallocating a portion of the existing reservoir storage is not possible and raising the dam is determined to be feasible, the construction costs associated with this alternative cannot be determined until the project features have been defined and the condition of the dam assessed. For planning purposes, a cost to raise the dam 5 feet could range between $1 and $4 million. This cost estimate does not include the cost for raw or treated water transmission mains and water treatment facilities.

Upon discussions between the Morgan County Rural Water Committee and the owners of Sleepy Creek Lake, it has been determined that the lake is not an option for serving water to the Morgan County Priority Area. Therefore, Sleepy Creek Lake will not be considered in future work to determine a practical alternative for providing water to the Priority Area.

3.3.3 New River Intake

This surface water supply source consists of a new raw water intake and pumping station along either the Cacapon River or the Potomac River. Figure 1 illustrates potential river intake locations along the Cacapon and Potomac Rivers. A new river intake on the Potomac River appears to be the preferred location as the Potomac River has significantly greater drainage area and better access points for a pipeline to the intake. However, since the Potomac River is on the state border between West Virginia and Maryland, there may be some additional permitting coordination associated with this option. A suitable location should be available for a river intake that would not require the construction of an intake dam. It is anticipated that the river intake would need to be equipped with screens that would preclude entrainment of aquatic life, particularly anadromous species like American Shad and bypass floating debris like leaves.

Daily river flow data spanning extended time periods are typically required to reliably predict low flow statistics for use in selecting the maximum withdrawal rates. Over 70 years of USGS stream gage records for both rivers are available. Information pertaining to the USGS stream gage data for the Cacapon and Potomac rivers is summarized in Table 2.

The gaging stations have substantially complete daily average streamflow records covering the worst drought of record (1966 drought) that resulted in the lowest instantaneous flows recorded in both rivers from 1895 to the present. Summary statistics for the stream gaging stations presented in Table 2 taken from the 2005 Annual USGS Water Resources Data Reports for West Virginia and Maryland are presented in Appendix B.

Low-flow at a river intake is generally characterized by how often a threshold discharge rate for a specific duration of time, is experienced. Annual gaging station data is normally analyzed to predict the probability of experiencing minimum flows for various durations.

Seven day, 10-year low flow (7Q10) values were obtained for the USGS gages in Table 2 using the Log-Pearson Type III Duration-Frequency Analysis computer program DURFREQ and comparing with published values. The streamflow data used in the DURFREQ program was limited to the period from 1928 to 1999. The published values were based on streamflow data prior to 1983. A copy of the published low-flow statistics for gaging stations is presented in Appendix B. Summary output from the DURFREQ analysis is also presented in Appendix B.

The maximum allowable withdrawal rate at each river intake was determined assuming it is equal to 10 percent of the 7Q10 low-flow discharge. The resulting maximum allowable withdrawal rate on the Cacapon River and the Potomac River were computed to be 4.1 MGD and 23.4 MGD, respectively. The minimum instantaneous low-flows recorded for the Cacapon and Potomac Rivers are well above these values and are also presented in Table 2. A river intake is therefore a viable surface water alternative for the EPCD to consider from these two river sources. Other rivers and creeks that flow through Morgan County do not have sufficient yield to satisfy the needed demand. In fact, the flow in the other streams in Morgan County are expected to fall well below 1.86 MGD during extreme droughts because of their relatively small contributing drainage areas.

It should be noted that the net impact of withdrawals from the Potomac River would be negligible since most of the water would be returned to the river in the form of treated wastewater (minus consumptive use). A reasonable estimate of consumptive use for this system is 20 percent.

Based on construction costs for similar projects, a planning-level range of costs to construct a river intake and pumping station on the Potomac River is between $500,000 and $2 million. This cost estimate does not include the cost for raw or treated water transmission mains and water treatment facilities.

3.3.4 New Reservoir Development

New reservoir development involves construction of a new dam on a stream with a drainage area greater than 3 square miles to produce a reservoir with a storage volume of at least 1,000 acre-feet. Additional storage may be needed for dead storage, water quality, conservation releases or other reasons. Additional storage could also be provided if the project is expanded to include other purposes such as flood control, recreation, irrigation or combinations of these.

The current climate for constructing new dams is not favorable. In order for this alternative to be selected it must also be demonstrated that it is the least environmentally damaging most practicable alternative. This is often not the case with the construction of new dams due to the significant loss of wetlands and stream habitat within the reservoir area and the availability of other alternatives with less environmental impacts. Costs associated with new dam construction and mitigation of environmental impacts may also be large when compared with other alternatives.

A total of 11 potential new conventional reservoir sites were initially identified within Morgan County using 1:24,000 scale USGS topographic maps. The sites were based primarily on suitable topography and engineering judgment. The topographic maps depict areas of commercial and residential development, as well as significant infrastructure features. Some of the maps have not been revised since the late 1970s and may not accurately indicate present conditions regarding industrial and residential development. This initial site selection was guided by the following general considerations:

1. In general, streams within Morgan County were studied for significant valley contractions with steep valley side slopes. This topographic condition is most favorable for a damsite as it minimizes dam construction costs. Similarly, it is desirable for the valley immediately upstream of the damsite to expand or widen, and for the stream to branch into several forks to maximize reservoir storage capacity.
2. Sites that would result in inundation of major roadways, rail lines, or significant development were avoided.
3. Existing access to the damsite is desirable. When more than one damsite appeared to be viable on a tributary, consideration was given to selecting the damsite nearest to an existing access road.

4. Drainage basins with areas greater than 4 square miles were targeted to create a reservoir with enough storage capacity to make the project viable.

A listing of the potential reservoir/dam sites located within Morgan County along with basic site information is presented in Table 3. The drainage areas and Northing and Easting coordinates at each damsite were obtained using Watershed Modeling System (WMS) software. The locations of all 11 of the damsites identified are shown on Exhibit 1.

The 11 reservoir/dam sites were screened using USGS 7.5 minute topographic maps and a USGS digital elevation model (DEM) of the watershed. Hydrologic data such as drainage area, and valley elevation at each site was obtained using Watershed Modeling System (WMS) GIS tools. Using the DEM of the watershed, WMS automatically delineates watershed boundaries for a damsite or outlet point. The site data obtained using the WMS-GIS tools was manually verified using the USGS 1:24,000 scale quadrangle maps. Watershed delineations upstream of each damsite are presented in Appendix B.

The principal criteria used to screen the damsites included identification of significant conflicts with existing cultural resources, assessing vehicle access to the site, and the size of the drainage area upstream of the dam. Significant conflicts included identifying paved roads, railroads, industrial and residential developments, existing dams and lakes, and major utilities that would be adversely impacted by the dam and reservoir.

The longer the distance between the reservoir and the water treatment plant and the service area, the greater the cost for the pipeline. Because the pipeline can represent a significant project cost, a site that is relatively close to the service area is most desirable. Vehicle access to the site was evaluated using the 1:24,000 mapping that shows primary and secondary roads, and some jeep trails. A site with a primary road in close proximity to the damsite is an important consideration as it reduces the cost of constructing access roads to the site, and normally provides a corridor for electric power and other utilities. Sites that have no road access, and are distant from any type of road, would incur substantial costs to construct an access road as well as other utilities. The size of the drainage area was considered because larger drainage areas generally have greater adverse environmental impacts. To minimize adverse environmental impacts, sites with small drainage areas (but large enough to provide the required safe yield) were favored above sites with large drainage areas.

Recreation potential was estimated by evaluating the access around the perimeter of the reservoir, the surface area and configuration of the reservoir, and the proximity of the site to nearby communities and parks.

The 11 reservoir/dam sites were screened based on contributing drainage area, site access, impacts to cultural resources, proximity to the planned service area, and development/disturbances within the watershed. From this screening, only one damsite has a drainage area greater than 4 square miles. It is located near the northern end of the County and is Damsite No. 6 on Meadow Branch of Sleepy Creek. Damsite No. 6 is therefore the only conventional damsite that would be able to satisfy the entire 1.86 MGD projected demand deficit.

The remaining 10 damsites can satisfy a portion of the projected demand deficit but would need to be combined with another source to provide the entire projected demand deficit. Of the remaining damsites, the next overall best conventional reservoir sites are Damsite No. 4 on Dry Run and Damsite No. 5 on Swim Run. These sites have drainage areas of 3.3 and 2.9 square miles, respectively, and may provide a safe yield between 1.6 MGD and 1.0 MGD depending on the actual watershed runoff conditions.

The remaining damsites were not selected for further consideration primarily because of inadequate drainage area and/or watershed development.

Reservoir stage-area-storage relationships were developed for Damsite Nos. 4, 5 and 6. Based on this information, the depth of the reservoir at these sites would need to be at least 55 feet in order to provide approximately 1,000 acre-feet of storage. The corresponding minimum dam height would need to be between 60 and 70 feet in order to provide freeboard for the spillway(s).

The primary costs associated with developing a new reservoir include the construction of a dam and appurtenances, purchase of land and easements, and mitigation of environmental impacts. Other costs include reservoir clearing, new access roads, and can include relocation of utilities, roads and other facilities. Table 4 presents actual construction costs for nine recent new dam projects constructed in West Virginia, Virginia and Pennsylvania based on actual bid information. Theses costs were escalated to 2006 price levels for comparison. It should be noted that these costs represent the costs for constructing the dam and do not include costs for environmental mitigation or other project features. For planning purposes, the cost of developing a new water supply reservoir capable of providing a 1.86 MGD safe yield is estimated to range between $7 million and $16 million. This cost estimate does not include the cost for raw or treated water transmission mains and water treatment facilities.

3.3.5 New Pumped Storage Projects

This alternative consists of developing a single pumped-storage reservoir capable of satisfying the projected demand. The development of pumped storage reservoirs, or water harvesting using off-stream storage, has gained greater acceptance as an alternative to conventional surface water impoundments on waterways where adverse environmental impacts may be significant. In a pumped storage project, the watershed area upstream of the dam is not solely relied upon to provide source water. Rather, water to fill and maintain the reservoir is pumped from a nearby surface water source and stored in the reservoir until it is required to augment the water supply during a drought. An advantage of pumped storage projects is that dam construction on high quality streams with significant drainage areas can be avoided by using smaller valleys, located along the main river, that only contain intermittent flow. In some cases, the dam and especially the appurtenant facilities such as the spillway and outlet works can be comparatively smaller and less costly, because flood runoff for the spillway design storm is not as great.

Operating a pumped storage facility would involve pumping water from a river intake on the Potomac River, Cacapon River, or another large stream to an off-stream man-made reservoir. System components for a pumped storage facility include a river intake, pumping station, raw water pipeline and a dam. The reservoir would be filled to maximum storage capacity during seasonal periods of relatively high river flows.

Two pumped storage reservoir sites were identified within Morgan County along the Potomac River. These sites do not have sufficient drainage area to refill by themselves and therefore require source water from the Potomac River to refill. The two sites are shown on Exhibit 1.

Because the Potomac River has an abundance of source water even during severe drought events, and the amount of source water needed is relatively small, a pumped storage facility does not appear to be required. That is, an intake on the Potomac River alone can provide all of the water needed during all river flow conditions without the need to rely on stored water. A planning-level cost estimate for a pumped storage facility was therefore not developed.

3.3.6 Water Purchase From Hancock, Maryland

According to the "Washington County Water and Sewer Infrastructure Commission Final Report" dated June 16, 2006, the Hancock, Maryland WTP is a groundwater treatment facility located in the Oriskany Formation and has a permitted withdrawal capacity of 300,000 gallons/day. The report also mentions the Town's desire to increase the withdrawal rate to 500,000 gallons/day.

Based on the fact even the increased capacity of 500,000 gallons/day would not be enough to serve both Hancock and the Priority Area, as well as the fact that the Priority Area can be served by groundwater wells in Morgan County, this option is eliminated from further consideration.

3.3.7 US Silica Sand Mine

In response to a citizen's question, the Project Team asked Gannett Fleming to evaluate the feasibility of converting a sand mine at the US Silica facility into a surface water reservoir for a potable water supply. The US Silica facility is located along Route 522 north of the Town of Berkeley Springs.

During the MCRWC meeting in which the Project Team asked Gannett Fleming to further research this option, the Project Team informed Gannett Fleming that there was some notion that the sand mine had become connected to a spring and required constant pumping in order to keep it operational.

Gannett Fleming contacted the facility and spoke with a US Silica representative regarding the status of the sand mine. The facility requires the use of approximately 5,000 gpm of water in its daily operations. The 5,000 gpm flows around the process "loop", with 4,000 gpm being recycled for reuse. The facility has a permit to withdraw 1,000 gpm of water from Warm Springs Run for use in the process loop. Therefore, 1,000 gpm of water is removed from the process loop and discharged to a tailings basin in order for the tailings (mostly clays and other fine particles that are not useful to the facility) to settle out before the 1,000 gpm of water is retuned to Warm Springs Run.

The sand mine that was investigated for this study is an abandoned quarry that is now being used as the tailings basin at the US Silica facility and will remain in operation as a tailings basin until approximately the year 2014 or 2015. In addition to acting as the tailings basin, the sand mine is also being used as a site to deposit backfill or overburden from the active quarry. Located in the sand mine is a limestone filtration dike that acts as a permeable barrier. This dike divides the sand mine into two sections – the south and north sections. The south section is where the overburden is deposited and the process water with tailings is discharged to for settling. To aid in the settling process, a coagulant is added to the south section of the sand mine. After the water is filtered through the limestone dike, it flows into the north section, where it is then pumped back into Warm Springs Run. In order to prevent the water in the sand mine from overtopping the filtration dike, the facility often pumps out more water than the 1,000 gpm discharged into the sand mine due to precipitation. According to the Water Use Study conducted by the facility for the West Virginia Department of Environmental Protection (WVDEP), the pump curves support the idea that the only water flowing into the sand mine are the process waters (approximately 1,000 gpm) and precipitation/surface runoff. Therefore, it appears that little or no groundwater via springs is contributing to the sand mine.

The US Silica representative explained that since a portion of the sand mine is being filled in with sedimentation and backfill of overburden, there will only be approximately 22,000,000 gallons worth of storage available when the sand mine is removed from service. As discussed in Section 2.4 of this report, the projected ADD for the North region of the Priority Area in the year 2030 is 0.56 MGD. Based on WV regulations discussed in this section of the report, a reservoir is required to contain 6 months worth of storage based on the ADD. Therefore, any reservoir that would be used to serve the North region would need to contain 100,800,000 gallons of useable storage. Based on the US Silica estimation of 22,000,000 gallons of storage eventually being available in the sand mine, the sand mine would contain approximately 20% of the volume required for the North region.

Based on these findings, it was determined that the sand mine would not be advanced further as a raw water source option.

Table 2: Summary of USGS Gaging Station Data In or Near Morgan County, West Virginia

Gage Number	Name	Drainage Area (Mi^2)	Years of Record	Average Runoff (CFSM)	Streamflow In CFS		
					Average	7Q10	Instantaneous Minimum
01610000	Potomac River at Paw Paw	3,129	68 (1938-2006)	1.09	3,412	234[1]	164 (Sept. 10, 1966)
01610400	Waites Run near Wardensville	12.6	4 (2002-2006)	1.75	22.1	-	Unknown
01611500	Cacapon River near Great Cacapon	675	83 (1922-2006)	0.88	594	41[1]	26 (Sept. 11, 1966)
01613000	Potomac River at Hancock	4,090	74 (1932-2006)	1.03	4,224	283[1]	180 (Oct. 4, 1932)
01613020	Warm Springs No. 3 (Detention)	0.45	2 (2004-2006)	-	-	-	-
01614000	Back Creek near Jones Springs	235	(1928-2006)[4]	0.84	198	3.6[3]	0.90 (Aug. 6, 1930)
01616500	Opequon Creek near Martinsburg	273	59 (1947-2006)	0.90	247	34.1[2]	25 (Oct. 25, 1947)
01618000	Potomac River at Shepherdstown	5,929	76 (1928-2004)	1.03	6,123	423[1]	170 (Aug. 1, 1966)

Notes:

(1) Computed using DURFREQ computer program

(2) Reported in *"Low-Flow Characteristics of Streams in West Virginia"*, USGS (1989)

(3) 7Q10 computed using a linear adjustment based on contributing drainage area from values reported in *"Low-Flow Characteristics of Streams in West Virginia"*, USGS (1989)

(4) Gage record from 1928-1931, 1938-1975, and 2004-2006.

Table 3: Potential Reservoir/Dam Sites Within Morgan County

ID No.	Fig. 1 ID No.	Stream Name	Reservoir Type	Northing (meters)	Easting (meters)	Elevation (Feet)	Drainage Area (Mi^2)	Comments
1	3	Dry Run	Conventional	4396073.6	742815.6	442	3.62	Drainage Area too small
2	1	Stoney Run	Pumped Storage	4396884.7	744659.6	410	1.47	Drainage Area too small
3	2	Unnamed Trib. to Potomac River	Pumped Storage	4396275.2	746619.5	406	0.94	Drainage Area too small
4	4	Dry Run	Conventional	4395220.2	742525.5	469	3.32	Drainage Area too small
5	5	Swim Run	Conventional	4392932.3	744719.5	522	2.95	Drainage Area too small
6	6	Meadow Branch of Sleepy Creek	Conventional	4388099.9	747678.2	815	17.73	Favorable Site
7	7	Mountain Run	Conventional	4385144.7	742171.3	721	3.79	Development occurring in watershed
8	8	Unnamed Trib. to Sleepy Creek	Conventional	4382867.0	740231.9	590	1.85	Drainage Area too small
9	9	Unnamed Trib. to Sleepy Creek	Conventional	4380876.0	737081.4	638	3.83	Possible development/roads
10	10	Unnamed Trib. to Middle Fork Sleepy Creek	Conventional	4372942.2	736510.8	756	1.13	Drainage Area too small
11	11	Unnamed Trib. to Middle Fork Sleepy Creek	Conventional	4370923.9	735673.2	797	0.67	Drainage Area too small
12	12	Cherry Run	Conventional	4387154.4	751339.5	502	3.63	On Morgan County/Berkeley County border
13	13	Breakneck Run	Conventional	4371488.4	731105.3	891	2.71	Upstream of existing fish hatchery

Table 4: Recent New Water Supply Dam Construction Costs for Projects in West Virginia, Virginia and Pennsylvania

Name	Year Bid	Height (Feet)	Crest Length (Feet)	Drainage Area (Mi^2)	Storage Capacity (Acre-Feet)	Volume (CY)		Safe Yield (MGD)	Construction Cost (Millions)	
						RCC	Fill		Year Built	Escalated to 2006
Siegrist Dam, PA	1991	125	575	11.3	3,640	85,000	-	4.9	$14	$27
Lost River 4, WV	1993	89	1,600	32.4	605*	-	1,134,000	1.6	$5.8	$10
Lost River 27, WV	1995	75	950	3.75	67*	-	345,000	-	$3.7	$6.1
Penn Forest Dam, PA	1998	180	2,100		19,700	370,000	-	11	$65	$99
Hughes River Dam, WV	1999	86	950	90.7	3,716*	85,500	-	-	$17	$26
Hunting Run Dam, VA	2000	89	2,400	7.0	9,365	140,000	-	8.0**	$28.5	$42
Lost River 10, WV	2002	83.3	760	6.7	602*	-	382,000	0.69	$5.9	$8.3
Lyman Run Dam, PA	2004	52	1.150	18	-	16,000	240,000	-	$16.8	$22
Elkwater Fork Dam, WV	2006	123	650	8.4	1,814	132,000	-	2.5	$32	$32

* Does not include flood control storage which is the primary purpose of this dam
** Pumped Storage Project

4.0 GROUNDWATER SOURCE OPTIONS

4.1 Objective

The objective of this evaluation is to examine the feasibility of developing groundwater sources to provide a 2030 average daily demand projection of 1.86 MGD and a peak demand of 2.79 MGD. Based on projected growth and development patterns, the anticipated demand is distributed in three areas: (1) the Great Cacapon region, which consists of the Town of Great Cacapon; (2) the North region that includes an area extended eastward along the Potomac River toward the Berkeley County line and (3) the South region, which is an elongated area extending from Berkeley Springs along the Route 522 corridor to the southern boundary of the County. Approximately 5 percent, 30 percent and 65 percent of the demand is attributable to Great Cacapon, North, and South regions, respectively. Table 5 enumerates the magnitude of average and peak demand allocated to the demand areas:

Table 5: Summary of Priority Area Average and Peak Daily Demands in MGD and GPM

Priority Area Region	Percentage of Demand	Average Demand (MGD)	Average Demand (GPM)	Peak Demand (MGD)	Peak Demand (GPM)
Great Cacapon	5%	0.09	65	0.14	97
North	30%	0.56	388	0.84	581
South	65%	1.21	840	1.81	1,259
SUM	*100%*	*1.86*	*1,293*	*2.79*	*1,937*

The specific goal of this evaluation is to describe the differing hydrogeologic characteristics of each of the demand areas with the objective of assessing the capability of the various bedrock aquifers to provide water to meet the projected demands. It is anticipated, due to the broad geographic distribution of demand, that physically distinct operationally independent groundwater based public water supply systems may be required. Groundwater sources of supply offer the favorable characteristic of being able to supply decentralized demand centers with generally smaller capital investment in conveyance infrastructure and in regard to phased resource development. However, it is realistic to plan for multiple well sources of supply for a variety of reasons.

4.2 Study Approach

In this groundwater resource evaluation, we have relied on previously published studies and mapping and have not conducted field reconnaissance, site specific evaluation of geologic structures, water budget analyses or subsurface investigations to reach our conclusions. A list of references from which we have obtained information about the study area is included at the end of Section 4 of this report.

It is worthwhile noting that despite the existence of a number of geologic studies for Morgan County, information specifically focused on groundwater appears fairly limited. It is anticipated that ongoing work being conducted in Morgan County by both West Virginia

University (WVU) and the United States Geological Survey (USGS) will make significant contributions in the future. The regional scale of significant works such as that of Kozar and Mathes (2001); a statewide study, and differing stratigraphic nomenclature present some difficulties. These difficulties should be overcome in the future as exploration for sources of water advances within targeted areas.

We have also relied on previous and ongoing groundwater development experiences in our evaluation. Project hydrogeologic staff responsible for work on this project has directed many successful groundwater development projects for public and industrial water supply in adjacent States and have conducted a variety of source water evaluations in West Virginia. The overwhelming majority of these groundwater development experiences are from fractured bedrock settings such as conditions anticipated in Morgan County.

4.3 Setting

According to Kulander et al (1995), Morgan County, West Virginia is situated in the Valley and Ridge Physiographic province. This province covers most of the eastern panhandle of the State where the rock formations and major structural elements all trend northeast. It is characterized by a series of long, narrow mountains, primarily composed of resistant sandstone, with intervening valleys composed of less resistant shale and some carbonate rocks.

4.4 Stratigraphy

Rocks exposed in Morgan County range in age from the Ordovician Oswego Sandstone to the Mississippian Purslane Sandstone (Lessing et al 1997). The following table (Table 6) is modified from Donovan et al (2006) and shows the Silurian through Mississippian stratigraphic nomenclature.

According to Donovan et al (2006), the stratigraphy of the Cacapon Mountain anticline extends from Devonian shales (Brallier, Harrell, Mahantango, Marcellus, and Needmore formations) down-section through the lower Devonian and the Silurian rocks of the region. The anticline's margins are marked by the prominent Oriskany sandstone (Devonian), which forms Warm Springs Ridge and Tonoloway Ridge. Younger Devonian rocks lie outside the Oriskany with respect to the anticlinal axis, and younger Silurian rocks lie inside the Oriskany outcrops.

At the base of the Oriskany lies the Helderberg limestone, which occurs on the back (west) side of Warm Springs Ridge from near its crest to the base of the ridge slope on the interior of the anticline. The Helderberg is not included as a map unit on the state geologic map of Cardwell et al. (1968), but is lumped with the Oriskany, due to limited exposure. By contrast, mapping of Kulander et al. (1995) includes the Helderberg with the underlying Silurian Tonoloway limestone and Wills Creek shale as "Devonian-Silurian carbonates". These distinctions are important because the Silurian-Devonian carbonates comprise the most significant bedrock aquifer in Morgan County.

The source of digital geologic base mapping for this study is the West Virginia GIS Data Clearinghouse. According to the clearinghouse the following process was used to develop the digital base map: In 1968 the West Virginia Geological and Economic Survey (WVGES) published a State Geologic Map (Cardwell et al. (1968)). The topographic base was compiled from Army Map Service 1:250,000 scale map sheets. In 1998 the WV Division of Environmental Protection (WVDEP) scanned the hardcopy geologic maps at 300 dpi, 8-bit color, and then georeferenced them. Rock unit boundaries were digitized off the images and attributed by WVDEP. The USGS-Water Resources Division later revised the attributes of large water bodies and rereferenced the datum to NAD83.

As noted above, Cardwell et al. (1968) mapped the Helderberg differently than Kulander et al. (1995), the refinement of which may be required in the future if groundwater development occurs from the Silurian-Devonian carbonates. Additionally, further refinement of the Chemung Formation may become important because it contains several lithologic types with varying intrinsic hydrologic properties. Specifically, the finer grained portions of the Chemung are not anticipated to offer the same water yielding characteristics as coarser grained portions of the formation.

The USGS no longer uses the Chemung nomenclature, having replaced it with the Greenland Gap Group that included two formations; the lower is the Scherr Formation and the upper is the Foreknobs Formation. Southworth et al (2001) maps the northern portion of Morgan County along the Potomac River using Foreknobs nomenclature.

Table 6: Stratigraphic Nomenclature for Morgan County, WV

Period	Series	Kulander, Lessing et al. (1995a, 1995b, 1995c)	USGS GEOLEX		Approx. thickness (ft.)
Mississipian	Osagean	Pinkerton ss			1,150
		Myers sh. Little Mountain ss			1,200 100
	Kinderhookian	Hedges sh.			190
		Pursiane ss.			450-550
		Rockwell Fm.			600-700
Devonian	Bradfordian	Hampshire Fm.			3,600-4,000
	Chataquan	Chemung Fm.	Greenland Gap Group	Foreknobs Formation	1,700-2,100
				Scherr Formation	
		Brallier-Harrel Fms.			1,600-1,900
	Senecan	Mahantango Fm.			1,800-2,400
		Marcellus-Needmore sh.			300-400
	Ulsterian	Oriskany ss.			200-300
		Heiderberg gp.			400-550
Silurian	Cayugan	Tonoloway ls.			300-400
		Willis Creek Fm.			350-450
		Bloomsburg Fm.			25-40
	Niagaran	McKenzie Fm.			175-225
		Keefer ss.			20-30
		Rose Hill Fm.			400-450
	Albion	Tuscarora ss.			150-250

4.5 Aquifer Characteristics

Kozar and Mathes (2001) estimated the transmissivity for aquifers throughout West Virginia. Transmissivity is defined as the rate at which water is transmitted though a unit width of an aquifer under a unit hydraulic gradient. It is equal to the hydraulic conductivity multiplied by the aquifer thickness. According to Freeze and Cherry (1979) transmissivities greater than 0.16 feet squared per second (576 feet squared per day) represent good aquifers for exploration.

Kozar and Mathes (2001) used three sources of data to develop these estimates. First, published data from existing hydrogeologic reports were tabulated and organized by aquifer. Second, estimates of transmissivity were made from specific-capacity data stored in the USGS National Water Information System (NWIS) ground-water site inventory (GWSI) database. Additional aquifer test and specific-capacity data were obtained from the West Virginia Bureau for Public Health - Office of Environmental Health Services (OEHS) files maintained for public ground-water supplies. Kozar and Mathes (2001) also provides estimates of groundwater recharge that were made by analysis of stream-flow data using USGS software and hydrograph separation methods. Specific-capacity data were obtained from the U.S. Geological Survey National Water Information System database and from files of the OEHS. The data were used to estimate transmissivity for aquifers located throughout West Virginia. In addition, literature was reviewed to obtain previously published estimates of storage coefficient and (or) specific yield for aquifers within the State. The storage-coefficient and (or) specific-yield data are needed to make estimates of transmissivity from specific-capacity data. Based on studies completed by Kozar and Mathes (2001), the following table (Table 7) presents the properties of the bedrock aquifers present in Morgan County.

Table 7: Statistical Summary of Specific Capacity and Transmissivity Data for Hydrogeological Units in Morgan County, WV (from Kozar and Mathes, 2001)

Hydrogeologic Unit (Aquifer)	Map Symbol	Specific Capacity (gpm/ft)				Transmissivity (ft2/d)			
		median value	minimum value	maximum value	number of sites	median value	minimum value	maximum value	number of sites
Maccrady Formation and Pocono Group	**Mp**	**0.83**	**0.17**	**8.67**	**7**	**210**	**33**	**2,300**	**7**
Hampshire Formation	Dhs	0.31	0.01	12.5	22	74	3	2,900	22
Chemung Group	**Dch**	**1.35**	**0.12**	**30.7**	**22**	**270**	**32**	**8,300**	**22**
Brallier and Harrell Fms	Dbh	0.28	0.01	1.6	7	72	3	390	7
Upper to middle Devonian units		0.76	0.19	4.29	15	180	44	760	15
Mahantango Formation	Dmt	0.38	0.01	3.75	10	92	3	840	10
Marcellus and Needmore Formations	Dmn	0.86	0.07	7	15	170	16	1,300	15
Onesquethaw Group and Oriskany Sandstone	Dohl	0.35	0.1	8	8	82	19	1,500	8
Helderburg Group, Tonoloway, Wills Creek and Williamsport Fms	**Stw**	**0.82**	**0.07**	**600**	**13**	**200**	**17**	**160,000**	**13**
Clinton Group, Mckenzie and Tuscarora Formations	Smc	0.11	0.02	6.5	3	23	6	1,100	3

From these data and studies completed by Donovan et al (2006) and interpreting stratigraphic nomenclatural differences presented in various referenced studies, three bedrock aquifers appear to offer median transmissivity values worthy of further consideration for the development of public drinking water supply wells. These are the Pocono Group, the Chemung Group and the Silurian-Devonian carbonate sequence represented by the Helderburg Group, Tonoloway limestone, and the Wills Creek Formation. It is recognized that further subdivision of two of these groups may be required in the future. However, these data provide a reasonable initial stage predictor of where groundwater resource development should be considered in the future.

Preliminary studies completed by Boughton and McCoy (USGS on-going) reveal lower transmissivity values for several aquifers including the Chemung Group and the Tonoloway Formation. However, given that surface exposures of the Chemung Group and the Tonoloway Formation lie in relatively close proximity to the identified Morgan County Priority Area, these units should be considered further.

As indicated by the preceding table, the Silurian-Devonian carbonate sequence represented by the Helderburg Group, Tonoloway limestone, and the Wills Creek Formation represent the most favorable bedrock aquifer present in the County (in terms of maximum transmissivity value). As shown on preliminary project mapping (Exhibit 2), this bedrock aquifer is present within the projected demand center of the Great Cacapon region and is in relatively close proximity to the South region's Route 522 corridor. This aquifer is not present in the North region demand center.

The Cacapon Mountain aquifer of Donovan et al (2006) is present in close proximity to the South region's Route 522 corridor. Within this aquifer it is noted that surface water drainage, which in many instances is similar to groundwater flow directions, drains in two primary directions. According to Donovan et al (2006):

> "The Cold Run Valley drains in its northern half directly into the Potomac River via Sir Johns Run, a small perennial strike-parallel stream of low to moderate discharge. In its southern half, it drains via three small tributaries of Sleepy Creek's West Fork: Breakneck Run, Indian Creek, and Rock Gap Run. Each of these three is strike-normal and exits Cold Run Valley through one of a series of spectacular water gaps in the Oriskany. In this way, surface (and ground) water can be thought to be partly confined within Cold Run Valley by the Oriskany, particularly within its northern half, and "spilling" from the valley through its points of exit at the three water gaps and at the intersection of the anticline with the Potomac.
>
> Both the Tuscarora and the Oriskany are thought to serve primarily as aquitards, due to their low primary porosity and well-cemented competent nature. The aquifers with the highest porosity, and presumably with the highest aquifer potential, are the three carbonate units: the Helderberg, Tonoloway, and Wills Creek.

> The Helderberg limestone (Devonian-Silurian) is one of the state's notorious cave-forming formations ...... It is present all along Warm Springs Ridge on its western flank, yet tends to be poorly exposed, to the point of not being field mappable ..... The tendency of the limestone to form caverns is in part due to its relative purity. It is a biohermal (reef) limestone and fossiliferous, but also contains chert nodules (very hard silica). The expected nature of conduit development in the Helderberg is parallel to bedding, forming a type of dissolution feature known as stratigraphic karst. The Tonoloway and Wills Creek formations are both calcareous, but of very different origin and stratigraphic nature in comparison to the Helderberg. Both were formed in periods of shallower water compared to the Helderberg. The Tonoloway is of intertidal origin and forms parallel-laminated, generally thin-bedded sequences with occasional mudcracks, shale partings, fecal pellets, and gypsum and/or halite casts. Its fabric is commonly fenestral as is typical of intertidal limestones. The Wills Creek is in fact a limey shale, and may represent portions of the intertidal zone in proximity to a sediment source. Both formations have the capability to become porous on dissolution, but neither are cavernous or have the potential for conduit development, as does the Helderberg."

Based on previous experience with groundwater source development in the Silurian-Devonian carbonate sequence represented by the Helderburg Group, Tonoloway limestone, and the Wills Creek Formation, it is not unreasonable to anticipate sustained well yields up to 500 GPM from selected locations with favorable geologic structural or confining bed characteristics. This yield characteristic is comparable to the discharge rates of springs in the area that have been documented by Donovan et al (2006). Water from this formation or group of formations can be hard. In karst areas, direct connection to surface water and associated contaminants is possible.

As shown on preliminary project mapping (Exhibit 2), the Chemung Group is situated adjacent to both the South and North regions. The Pocono Group lies in reasonable proximity to a portion of the North region but is judged too distant to the west of the Great Cacapon region.

Portions of the Chemung Group are equivalent to the Foreknobs Formation, which in Pennsylvania is known to yield in excess of 300 GPM of soft good quality water (Geyer and Wilshusen (1982)). By contrast Geyer and Wilshusen (1982) report significantly lower capacity within the Scherr Formation.

Insufficient data is available at this time to characterize the yield characteristics of the Pocono Group; however, the Purslane Sandstone may represent a reasonable target.

4.6 Spring Characteristics

Based on evaluations completed by Donovan et al (2006) of the Cacapon Mountain area, there are a number of springs that, on the basis of single measurements, discharge at rates near or exceeding 100 gallons per minute. The discharge from these springs is considered sufficient for further evaluation; however, at this time, no additional research was done beyond a review of the existing data.

In general, springs are considered to have higher vulnerability to contamination than wells because they are "open". Many historically reliable carbonate source springs have been removed from the water supply chain by "groundwater under the direct influence (GUDI) of surface water" concerns. Wells in carbonate settings are subject to some of the same suspicions but far fewer have been declared GUDI. With concerns over giardia, cryptosporidium, viruses and endocrine disruptor compounds (EDCs), groundwater wells are considered a less vulnerable source than springs for a public water supply.

What is known about the Cacapon springs comes from the WVU study by Donovan et al (2006). Additional information is contained in older USGS studies (Hobba, 1979). The discharge measurements contained in the WVU report are "point-in time" assessments and would require additional evaluation and study to determine the sustained discharge rates. The most significant aspect of the spring findings is the indication of prolific natural aquifer capacity. The following table (Table 8) summarizes the location of springs evaluated by Donovan et al (2006).

Table 8: Summary of Springs Analyzed in Morgan County, WV

Location of Springs Sampled by WVU in Morgan County, West Virginia (from Donovan et al, 2006)						
Spring ID	Name	Latitude	Longitude	Flow (gpm	Geology	Altitude
S-1	Ridge Cave	39.46275	-78.31540	1187	Dohl	930
S-2	Hoverdale Spring	39.46433	-78.31527	250	Dohl	925
S-3	Rte 9 pond	39.62544	-78.23599	160	Dohl	695
S-4	Clearcut	39.63941	-78.23303	130	Smc	640
S-5	Fleece Spring	39.55329	-78.27674	100	Dohl	878
S-6		39.57459	-78.27479	99	Smc	882
S-7		39.58483	-78.26532	90	Stw	740
S-8		39.61380	-78.25054	76	Stw	670
S-9	High Spring	39.52377	-78.31025	75	St	1400
S-10	Neeley Spring	39.56808	-78.27378	66	Stw	780
S-11		39.57238	-78.27630	61	Smc	895
S-12		39.59945	-78.25345	50	Stw	720
S-13	Tonoloway A	39.55536	-78.27526	50	Dohl	876
S-14	Tonoloway B	39.55533	-78.27543	50	Dohl	876
S-15		39.60019	-78.26331	49	Smc	793
S-16	Cacapon SP Spring	39.50146	-78.30204	40	Stw	930
S-17		39.59926	-78.25434	22	Stw	692
S-18		39.58909	-78.26516	13	Smc	768
S-19		39.62376	-78.24379	11	Stw	673
S-20	Mountainside Spring	39.57997	-78.27274	10	Smc	890
S-21		39.61218	-78.25108	9	Stw	690
S-22		39.61748	-78.24885	9	Stw	665
S-23		39.62217	-78.24597	7	Stw	740
S-24		39.62305	-78.24555	4	Stw	705
S-25	Webber Spring	39.56202	-78.27584	3	Stw	819
S-26	Gap Spring	39.47131	-78.31260		Dohl	1005
S-27	Ladies Spring	39.61764	-78.21794		Dohl	620
S-28	Gentlemens Spring	39.61772	-78.21790		Dohl	620
S-29	Lord Fairfax Spring	39.61769	-78.21791		Dohl	620
S-30	Bathhouse Drain	39.61762	-78.21785		Dohl	620
S-31	Ziler Spring	39.51742	-78.33399		Dohl	535
S-32	Ridge Pond	39.46520	-78.31969		Smc	1030
S-33	Ridge #2	39.46342	-78.31507		Stw	913
S-34		39.58845	-78.26025		Stw	757
S-35		39.59495	-78.25545		Stw	782
S-36	Thunderbird Hills Pond	39.52120	-78.29179		Stw	835
S-37		39.58175	-78.26112		Stw	822
S-38		39.60423	-78.25071			822
S-39		39.61055	-78.24991			718
Discharge 100 gpm or more						

4.7 Well Characteristics

The following table (Table 9) summarizes data provided by Morgan County. It provides information regarding the characteristics of some of the well-based water systems in the County. Additional information is anticipated to be available in the future from both the USGS and WVU studies. However, the location of wells evaluated by these studies is not currently available.

Table 9: Summary of Existing Wells in Morgan County, WV

Location of Wells, Morgan County, West Virginia (County, 2006)					
Well ID	**System Name**	**Well Depth(s)**	**Yield**	**Latitiude**	**Longitude**
W-1	Tri-Lake MHP	140 and 260 ft	60 and 30 gpm	39.45777	-78.27749
W-2	Morgan Vill. MHP	252 and 332 ft	75 and 48 gpm	39.60011	-78.06611
W-3	Skyline MHP	135 ft	13 gpm	39.62666	-78.18291
W-4	McCumbee MHP	86 and 176 ft.	27 and 33 gpm	39.5466	-78.27082
W-5	Apple Orc. Acres	220 and ? ft.	30 and 12 gpm	39.54297	-78.26163
W-6	Valley View Nurs	105 and 100 ft.	60 and 40 gpm	39.57194	-78.22222
W-7	Coolfont Rec.	200 and 300 ft.	31 and 20 gpm	39.57693	-78.23194
W-8	Coolfont Mt. Ass	105 and 210 ft.	25 and 13 gpm	39.57749	-78.27416
W-9	Cacapon S.P.	267 and 400 ft.	Unk. gpm	39.50966	-78.30886
W-10	Country Rd Rest.	220 ft.	1.5 gpm	39.60001	-78.06897
W-11	Great Cac. Elem.	145 ft.	18 gpm	39.6186	-78.29305
W-12	Pine Vall. Sch.	200 ft.	20 gpm	39.46333	-78.23416
W-13	Nikki's Daycare	240 ft.	Unk. gpm	39.62361	-78.19111
W-14	Kat & Rosie Bar	189 ft.	60 gpm	39.62972	-78.17611
W-15	The Glen	85 ft.	20 gpm	39.60361	-78.19722
W-16	Morgan Ind. Pk.	40 ft.	60 gpm	39.47027	-78.26583
W-17	Cacapon B&B	52 ft.	Ukn. gpm	39.50138	-78.29166
W-18	VFW Post	65 ft.	18 gpm	39.56747	-78.26152
W-19	Panorama Steak	500 and 630 ft.	7 and 7 gpm	39.62055	-78.26111
W-20	Pleas.View Elem.	123 ft.	60 gpm	39.60888	-78.08111
W-21	Greenwood Elem.	200 ft.	30 gpm	39.48249	-78.22111
W-22	Bob's Big Beef	220 ft.	32 gpm	39.63194	-78.23135
W-23	Bowlerama	80 ft.	20 gpm	39.56202	-78.26352
W-24	Tom Sealey Furn.	130 ft.	Unk. gpm	39.55672	-78.26713
W-25	Town of Paw Paw	N/A (Surface)	N/A	39.52611	-78.46033
W-26	Town of Bath	N/A (Spring)	1020 gpm	39.62361	-78.22999
W-27	Wheel House Rest	Unknown	Unknown	39.49588	-78.29277
Discharge 100 gpm or more					

In general, the yield of the individual sources enumerated in Table 9 is insufficient to provide the water demand of a typical public water supply. However, it is recognized that these sources were not constructed for long term public use, i.e., they are not of sufficient diameter or depth for this purpose.

4.8 Groundwater Development Process

The primary objectives of the Morgan County project are:

1. Investigate the feasibility of developing a 1.86 MGD groundwater supply within three priority areas;
2. If feasible, explore and develop the additional supply capacity, through test well drilling, production well development and related testing; and
3. Identify and design necessary treatment and pumping facilities for the new groundwater supply.

Groundwater development typically occurs in three stages coincident with the three primary objectives.

- Stage I: Hydrogeologic services provided as part of Stage I include preliminary screening for suitable water bearing formations or aquifers.
- Stage II: Services typically include more specific water budgeting, source water protection/wellhead protection considerations, well siting, property rights acquisition followed by exploratory well drilling and abbreviated testing which is used to assess the potential yield and identify water quality concerns of the targeted aquifer system. Stage II also focuses on production well drilling and comprehensive testing of the successful test wells to develop and permit the available groundwater resource.
- Stage III: Services include engineering design and permitting of treatment, pumping and delivery systems for the production wells, and integration of the new groundwater supply with the existing water system.

Based on preliminary groundwater source evaluations, we estimate achievement of the desired 1.86 MGD groundwater supply will require the drilling of a minimum of six (6) production wells. Based on our experience it is not unusual to drill two to three times as many test well sites to develop this number of production wells. The following items are typically part of the groundwater development process:

(1) Aquifer Identification: Identify potentially high-yielding aquifers and select potential test sites based on review of available hydrogeologic data contained in existing groundwater development and resource reports, and existing geologic reports.

(2) Ranking of Test Sites: Select the most favorable test well sites using the following approach:

   a. Evaluate the theoretical groundwater potential of test sites using water budget analyses;
   b. Acquire existing aerial photographs and review those photographs along with topographic and geologic maps for fracture traces;

c. Acquire databases and other available mapping to inventory existing groundwater uses/withdrawals. Use this information to assess the potential for interference between sources;

d. Inventory potential contaminant sources in and adjacent to the potential test well locations wellhead protection databases and qualitative assessment of their impact on groundwater quality;

e. Acquire existing zoning and property information available and assess any well siting concerns;

f. Use GIS where practical to assess and rank potential well sites;

g. Conduct field views and any field data acquisition.

(3) Right-of-Way and/or Property Acquisition: Following or contemporaneous with test well site ranking is property acquisition.

a. Determine the type and number of right-of-way and/or property acquisitions necessary to provide access to the test site locations. It is assumed that initial site access for conduct of sanitary investigations can be accomplished through a notification letter.

b. Complete more detailed negotiations with property owners at approved sites in order to secure access for and permission to conduct actual test well drilling. An appropriate agreement form will be used for this purpose, and it should include an option for purchase of property in the event that test well drilling is successful and production well development is implemented.

(4) Well Drilling and Testing: After property acquisition, it is appropriate to complete test well drilling and evaluation using some or all of the following steps:

a. Obtain any State and local well construction permits, prepare drilling specifications and obtain the services of a licensed well driller for drilling of test wells.

b. Drilling, well development and water quality testing will be supervised by a hydrogeologist.

c. Prepare lithologic log, detailing geologic descriptions, fracture zones and water bearing zones for each test well.

d. Complete well development and obtain blown yields at the test well stage.

e. Provide appropriate field water quality analyses during well drilling/development, and collect and deliver water samples representative of the finished test wells to a certified laboratory for analysis of critical primary and secondary water quality parameters

f. Make recommendations for production well development. If sufficient groundwater supply capacity is available, include cost estimates for the completion and testing of selected test wells as production wells as well as general requirements for water treatment, pumping, and delivery systems.

(5) Production Well Drilling and Testing: The number of test wells to be converted into production wells is dependent upon the outcome of test well drilling and will typically proceed in the following manner:

a. Coordinate with and assist in securing property owner permission to access the sites for production well drilling, development and testing.

b. Exercise option for property acquisition at the production well sites. Overall property and right-of-way acquisitions will be defined to comply with State and local regulations for the production wells, and account for associated access, pumphouse and pipeline requirements.

c. Obtain appropriate permits and approvals as required by State and local regulations. Production well drilling and testing specifications previously prepared for test well may be used for production well construction.

d. Supervision of drilling, final well construction and well development activities will be completed by a hydrogeologist.

e. The completed production wells should be evaluated through step and 48-hour pump tests under the supervision of a hydrogeologist. Data will be collected during the testing from the pumping well and observation wells using data loggers.

f. Water samples, representative of the aquifer, will be collected near the end of the 48-hour pumping test and delivered to a certified laboratory for analysis of required drinking water parameters in accordance with regulations.

g. Following completion of aquifer testing and evaluation activities, certain wells (test or production) may not be appropriate for future use due to poor quantity, quality or other reasons. Such wells will be abandoned by a licensed well driller in accordance with State requirements under the supervision of a hydrogeologist.

h. Evaluate step and pump test data using accepted hydrogeologic techniques, and review and summarize the analytical data.

i. The work performed, including construction and testing of the production wells should be summarized in a final report. The report will set forth data evaluation, and include conclusions and recommendations. The report should also provide cost estimates for Stage III work activities, including engineering design, permitting and construction of the water treatment, pumping and delivery systems necessary to integrate the new supply with the existing water system.

(6) Engineering and Design: Water Supply Production and Delivery Systems: Stage III activities generally include the following:

a. Develop preliminary design criteria and prepare conceptual design sketches for consideration. The intent will be to identify proposed treatment, pumping, control and siting schemes that will result in a cost-effective project considering both construction and operating advantages.

b. Complete topographic surveys to determine the configuration of the ground and location of existing structures and utilities at proposed construction sites. The data obtained from surveys will be used in preparing construction drawings and will be plotted at an appropriate scale.

c. Perform necessary property surveys to establish final property and rights-of-way for the proposed facilities.

d. Prepare preliminary designs, including draft construction drawings and technical specifications.

e. Secure approval of the preliminary designs and authorization to proceed with final designs.

f. Prepare final designs for the various treatment, pumping, conveyance and related facilities in accordance with approved preliminary designs. The designs, including construction drawings and technical specifications, should be prepared by application of standard engineering techniques. Construction drawings and specifications must be in such form and detail that prospective contractors can understand work requirements.

g. Secure Permits required for approval to construct and operate the designed facilities.

h. Prepare an engineers estimate based on quantities taken from the construction drawings and specifications, adjusted unit price data obtained from past construction projects for similar types of work and other relevant cost information.

In order to focus future efforts and resources in an effective manner it may be appropriate to complete the following in order to further refine aquifer scale site selections made in this study:

- If possible, further subdivide the Chemung Group aquifer area on the basis of lithology so that favorable subunits are targeted
- Revise project base mapping of the Silurian-Devonian carbonate sequence
- Complete an assessment of geologic structural features such as lineaments and fracture traces which can favorable influence flow to groundwater pumping centers
- Obtain completed works from USGS Scientific Investigation and WVU projects
- Evaluate the location of any industrial scale water uses that might conflict with potential future groundwater sources
- Complete preliminary water budget analyses for target formations so that adequate land area allotments can be set aside for future well/well field development

4.9 Estimated Costs of Groundwater Development

Table 10 is an estimate of the costs associated with development of a single groundwater source of supply using typically required items as enumerated above.

Table 10: Conceptual Cost Estimate for Groundwater Source Development

Task	Approximate Cost or Range
Aquifer Identification	$10,000 to $25,000
Ranking of Test Sites	*$10,000 to $25,000*
Right-of-Way and/or Property Acquisition *	$10,000 to $20,000
Well Drilling and Testing	$30,000 to $50,000
Production Well Drilling and Testing	$50,000 to $100,000
Permitting	$25,000 to $40,000
Engineering and Design: Water Supply Production Facility**	$30,000 to $40,000
Pumping Station Capital Cost **	$125,000 to $150,000
Total	$290,000 To $450,000

* Includes engineering but not legal fees or real estate

** Submersible Pump Pumping Station with chlorination treatment

4.10 Conclusions

Based on the foregoing analyses, it is apparent that bedrock aquifers are present in Morgan County that are worthy of further consideration for purposes of development of groundwater-based public water supply systems. Most favorable targets for further consideration are the Silurian-Devonian carbonate sequence represented by the Helderburg Group, Tonoloway limestone, and the Wills Creek Formation and the Chemung Group. It is apparent that for geographic reasons and due to uncertainty about its aquifer characteristics, that the Pocono Group represents a potential target of lower but not inconsequential favor.

Multiple wells or well fields comprised of various combinations of high yielding sources in the Silurian-Devonian carbonate sequence (represented by the Helderberg Group, Tonoloway limestone, and the Wills Creek Formation) and moderate capacity wells situated in areas underlain by the Chemung Group will be required to provide the 2030 average and peak daily demands.

It is recognized that the Silurian-Devonian carbonate sequence represented by the Helderburg Group, Tonoloway limestone, and the Wills Creek Formation and formations associated with it are situated to the west of Warm Springs Ridge remote from the South region of the Priority Area, which is the largest projected demand center. However, given the potential capacity of this aquifer, consideration should be given to development of conveyance systems that transect Warm Springs Ridge.

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5.0 WATER QUALITY EVALUATIONS

Table 11 is an evaluation of the various raw water sources identified for the Priority Area based on available information.

Table 11: Summary of Water Quality Evaluations for Relevant Raw Water Sources

Source Water Quality	Source Water Supply Options									
	Chemung Aquifer Wells	Tonoloway Aquifer Wells	Pocono Aquifer Wells[1]	Berkeley Springs Area Wells	Cacapon Aquifer - Clastic Source Springs	Cacapon Aquifer - Carbonate Source Springs	Cacapon Aquifer - Clastic Source Wells	Cacapon Aquifer - Carbonate Source Wells	Sleepy Creek at Confluence with Potomac River	Potomac River
pH	Average 6.7 Range 5.4 - 7.6 Acidic to Neutral pH. May require chemical addition to raise pH for corrosion control	Average 7.1 Range 6.7 - 7.4 Neutral pH. pH adjustment not required	Average 6.2 Slightly Acidic pH. Chemical addition recommended to raise pH for corrosion control	Average 7.0 Range 6.8 - 7.3 Neutral pH. pH adjustment not required	Average 4.7 Range 4.0 - 5.1 Acidic pH. Chemical addition required to raise pH for corrosion control	Average 6.9 Range 6.5 - 7.3 Neutral pH. pH adjustment not required	Average 6.5 Range 6.2 to 6.8 Slightly acidic pH. Chemical addition recommended to raise pH for corrosion control	Average 6.7 Range 5.8 - 7.3 Acidic to Neutral pH. May require chemical addition for corrosion control	Average 8.0 Range 6.8 - 8.8 Basic pH. Chemical addition recommended to lower pH	Data not available
Total Hardness/ Alkalinity (mg/L as CaCO3)	Average 98 / 107 Range 42 - 190 / 22 - 239 Moderate hardness. Softening, likely, not required	Average 240 / 200 Range 160 - 400 / 140 - 305 Hard water. Chemical softening recommended. NF/RO membranes or ion exchange units could be used.	Average 58 / 67 Soft water, alkalinity adjustment may be required	Average 240 / 265 Range 135 - 365 / 170 - 410 Hard water. Softening required, may require ion exchange units or NF/RO membranes	Average 18 / 5.4 Range 12 - 49 / 0 - 37 Soft Water, may be corrosive. Chemical addition required to raise alkalinity	Average 160 / 186 Range 71 - 243 / 80 - 270 Moderately hard to hard water. Softening beneficial	Average 115 / 118 Range 105 - 145 / 88 - 160 Moderate hardness. Softening likely, not required	Average 255 / 255 Range 92 - 472 / 44 - 480 Very hard water. Would likely require softening with NF/RO membranes or ion exchange units	Data not available	Data not available
Iron (mg/L)	Average 1.07 Range 0.003 - 6.07 Very high iron levels. Sequestering limited by regulations. Oxidation/filtration required	Average 0.07 Range 0.005 - 0.22 Iron levels are below SMCL (0.3 mg/L). Addition of sequestering agent may be beneficial	Average 0.012 Iron levels low in single sample. More data required to evaluate the need for chemical addition	Average 0.6 Range 0 - 1.4 Iron levels are above SMCL. Sequestering may be limited by regulations. Oxidation/ filtration may be required	Average 0.1 Range <0.1 - 0.15 Iron levels are below SMCL. Treatment, likely, will not be required	Iron concentrations in all samples from these springs are less than 0.1 mg/L. Treatment, likely, will not be required	Average 1.80 Range 0.2 - 3.81 Very high iron levels. Sequestering limited by regulations. Oxidation/ filtration required	Average 0.47 Range <0.1 - 2.65 Iron levels above SMCL. One very high sample. Sequestering agent required, possible oxidation/filtration	Data not available	Data not available
Manganese (mg/L)	Average 0.42 Range 0.0006 - 1.5 Very high manganese levels. Sequestering limited by regulations. Oxidation/filtration required	Average 0.03 Range 0.0005 - 0.116 Manganese levels slightly above SMCL (0.05 mg/L). Addition of sequestering agent would be required	Average 0.21 Manganese level is above SMCL. Addition of sequestering agent would be required	Average 0.05 Range 0 - 0.1 Manganese levels above SMCL. Sequestering may be limited by regulations. Oxidation/ filtration may be required.	Average 0.1 Range <0.1 - 0.13 Manganese levels are above SMCL. Addition of sequestering agent would be required	Managanese concentrations in all samples from these springs are less than 0.1 mg/L. It is likely that treatment will not be required	Managanese concentrations in all samples from these wells are less than 0.1 mg/L. It is likely that treatment will not be required	Managanese concentrations in all samples from these wells are less than 0.1 mg/L. It is likely that treatment will not be required	Data not available	Data not available
Turbidity/ Suspended Solids (NTU / mg/L)	Average 24 / No Solids Data Range <1 - 310 / No Solids Data Extremely high turbidity for ground water. Turbidity of this level would require clarification/filtration	Average 17 / No Solids Data Range: <1 - 91 / No Solids Data High turbidity for ground water. Turbidity of this level would require clarification/filtration	Average 5.8 / No Solids Data May require treatment for removal or turbidity/solids	Turbidity/Suspended Solids data not available	Turbidity/Suspended Solids data not available.	Turbidity/Suspended Solids data not available	Turbidity/Suspended Solids data not available	Turbidity/Suspended Solids data not available	Average: No Turb Data / 29 Range: No Turb Data / 0 - 168 Some samples have high suspended solids concentrations. Clarification/ filtration will be required	Average 17 / No Solids Data Range: 2 - 301 / No Solids Data High turbidity. Clarification/ filtration treatment will be required
Arsenic (mg/L)	Average 4 Range 1.0 - 8.0 Arsenic levels are less than the MCL, but could be problematic. Adsorption treatment for arsenic removal may be required	Arsenic concentrations in all samples from these wells are less than 4.0 μg/L. It is likely that treatment will not be required	Average < 2.0 The arsenic concentration in the single sample is low. Treatment may not be required, but more data analysis is needed	Arsenic data is not available	Arsenic data is not available	Arsenic data is not available	Arsenic data is not available	Arsenic data is not available	Arsenic data is not available	Arsenic data is not available
Relative Level of Treatment for Source Water[2]	Chemical addition may be required for pH adjustment and oxidation of iron and manganese. Filtration will be required for iron and manganese removal. If well turbidity remains elevated, clarification/filtration will be required. Arsenic levels are a concern and may require treatment for removal. Level of Treatment - 4	Chemical addition will be required for softening, and may be required for iron and manganese removal. Ion exchange units may be required for softening if hardness remains high. If well turbidity remains elevated, clarification/filtration will be required. Level of Treatment - 4	Data is limited for this source supply. The sample set indicated that chemical addition could be necessary for pH and alkalinity adjustment, as well as sequestering iron and manganese. If turbidity is consistently elevated, clarification/filtration will be required. Level of Treatment - 3	Chemical softening is required and chemical addition will also be required to sequester iron and manganese. Because hardness, iron and manganese concentrations are very high in some samples, ion exchange units or NF/RO membranes may be required to remove those contaminants. If turbidity is typical of well sources, clarification will not be required. Level of Treatment - 2	Chemical addition will be required for pH and alkalinity adjustment. A sequestering agent will also need to be added to remove manganese. Turbidity data is not available, but because the source is a spring, a clarification/filtration process may be required. Level of Treatment - 3	Softening recommended. Additionally, because the source is a spring, a clarification/filtration process may be required. Level of Treatment - 3	Chemical addition may be required for pH adjustment, and will be required to oxidize iron in the source water. Because iron levels are very high, filtration will be required to remove the contaminant to below the SMCL. If turbidity is typical of well sources, clarification will not be required. Level of Treatment - 1	Chemical addition may be required for pH adjustment, and iron sequestration. Softening Beneficial. If the iron concentrations are frequently above 1.5 mg/l oxidation/filtration treatment will be required for iron removal. If turbidity is typical of well water sources, clarification will not be required. Level of Treatment - 3.	Chemical addition may be required for pH adjustment. Because this is a surface water source, a conventional clarification/filtration treatment process will, likely, be required. Level of Treatment - 3	The Potomac River serves as the raw water source for the Hagerstown, R.C. Wilson WTP. That treatment process includes pre-sedimentation, flocculation and sedimentation basins followed by filter units. A similar treatment process would likely be employed if this source was chosen as a raw water supply. Level of Treatment - 3

Level of Treatment Rankings
1- Chemical addition, filtration
2- Chemical addition, Filtration, Ion exchange units
3- Chemical addition, Conventional Clarification/Filtration Process
4- Chemical addition, Conventional Clarification/Filtration, Ion exchange units, NF/RO

(1) 1 sample from this aquifer

(2) Level of Treatment rankings are assigned assuming treatment for arsenic is not required and the turbidity of the well supplies is low. If treatment for arsenic or turbidity is required, the level of treatment required will increase

6.0 DEVELOPMENT AND EVALUATION OF RAW WATER ALTERNATIVES

The purpose of the Morgan County Water Resources Study is to determine the most cost-effective means of providing water to the Priority Area. This section will discuss the formation of potential alternatives based on the findings of the prior sections, costs associated with the alternatives and other factors deemed relevant for selection of a preferred alternative.

6.1 Priority Area Regions and Potential Water Sources

For the three regions of the Priority Area, there are three possible raw water sources associated with each: groundwater wells, a surface water intake, and a reservoir. The following sections discuss the availability of these options for each region. Table 12 summarizes these discussions.

6.1.1 South Region

The South region of the Priority Area contains the largest portion (65%) of the projected 2030 water demands. Due to the region's location and large demands, the only feasible raw water option is the construction of groundwater wells.

Even though a new reservoir on Meadow Branch of Sleepy Creek was deemed plausible by the surface water quantity work paper, a reservoir serving the South region is not considered due to its lack of phasing potential and disproportionate costs relative to a groundwater source option. The surface water quantity work paper indicates that a new reservoir of the required size for the Priority Area would cost between $7,000,000 and $16,000,000 to construct. Taking the average of these two prices results in a dam construction cost of approximately $11,500,000. This value does not consider the added cost that would be incurred by having to increase the size of the Route 9 transmission main backbone n the North region to convey the finished water to the South region, which could be in the millions of dollars. Comparatively, as seen in the groundwater source quantity work paper, the approximate cost for developing a well site is $450,000 per well. Assuming that three wells would be needed in the South region, it will cost approximately $1,350,000 to develop the well sites. When the two total costs are compared, the fact that the reservoir option is approximately $10,000,000 more expensive warrants the decision to eliminate it from further consideration.

Another factor that supports eliminating the reservoir option is the requirement that the dam and pipelines would need to be constructed immediately at the beginning of the planning period in order for it to benefit anybody in the Priority Area. This results in a phasing potential for a reservoir that is extremely low and eliminates it from further consideration.

The same logic can be used to dismiss a surface water intake option for the South region. Although the surface water quantity work paper recognizes that there is enough water available in the Potomac and Cacapon Rivers to satisfy the entire projected water demand of the Priority Area, the surface water intake structure, pump station and transmission line to the South region would need to be constructed in one phase at the beginning of the planning period.

Exhibit 3-1 is an illustration of the groundwater source option for the South region. Based on the groundwater work paper, it is assumed that three well sources would be required. These well sources are located in the Tonoloway Formation at three water gaps in Warm Springs Ridge: Rock Gap, Indian Run Gap and Break Neck Run Gap. At this time, it is assumed that each well is capable of producing 1/3 of the PDD of the South region, or 0.60 MGD (419 gpm) each. It is possible that one of the potential well sites will produce a higher yield than approximately 419 gpm which could eliminate the need for three well sites, but in order to produce a conservative cost estimate, three well sites will be considered. Associated with these well sources are water treatment facilities located at each well location that can treat the 0.60 MGD produced at each well, as well as two storage tanks on the north and south ends of the South region.

The storage tanks are sized to provide the equivalent of the average daily demand for the South region, which equals 1.21 million gallons. The required storage volume was split evenly between the two tanks, resulting in two 605,000-gallon water storage tanks.

Approximately 10,200 l.f. of 12" DIP transmission mains located near the well/treatment sites and storage tanks, as well as 82,400 l.f. of 8" DIP transmission mains will be required to deliver water to the South region. Pipeline sizes are based on projected flow rates and did not include fire flow requirements, which could result in a slight increase in pipeline diameters if this option is advanced into Phase II.

6.1.2 North Region

For the North region, the only option no longer considered for future development is the new reservoir based on the fact that it has been eliminated for the South region. Due to disproportionate dam construction costs relative to a small demand and the lack of phasing potential for construction, a reservoir to service just the North region is not being considered. Therefore, the two options that are advancing for the North region are groundwater wells and a surface water intake on the Potomac River near Sleepy Creek.

Exhibit 3-2 illustrates the conceptual layout for a groundwater source option in the North region. It consists of two well sources located in the Chemung Group with an anticipated withdrawal capacity of approximately 0.42 MGD (292 gpm) each, or half of the PDD in the North region. Each well source has a water treatment facility with a treatment capacity of approximately 0.42 MGD each. Due to elevation differences in the North region, at this time it is assumed that there would be two distinct pressure zones, which would require a pump station to lift water into the western pressure zone. The pump station would also include a pressure reducing valve in order to allow water to flow from the western pressure zone into the lower-pressured eastern zone.

Also associated with the North region groundwater option would be two storage tanks, one for each pressure zone, with a storage volume of 279,000 gallons each. The total storage volume of 558,000 gallons is equivalent to the projected ADD for the North region.

Assuming that each well site will produce half of the projected demands of the North region and the fact that the well sites will service two distinct pressure zone, it can be assumed that only half of the ADD and PDD will be carried in the majority of the transmission mains. Therefore, it is estimated that approximately 52,600 l.f. of 8" DIP transmission mains would be required for this option. The pipeline sizing did not include fire flow requirements, which could result in a slight increase in pipeline diameter if this option is advanced into Phase II.

Exhibit 3-3 illustrates the conceptual layout for a surface water intake on the Potomac River to serve the North region. The intake, water treatment facility and pump station are situated near the mouth of Sleepy Creek due to its centralized location and proximity to the identified Priority Area. The facilities would be sized to accommodate the PDD of the North region, which is approximately 0.84 MGD.

The pipeline that connects the facilities near the Potomac River to the North region transmission main backbone is approximately 21,800 l.f. in length and is assumed to be 12" diameter DIP due to the need to carry the majority of the PDD to the transmission backbone. The 52,600 l.f. Route 9 transmission main backbone is considered to be 8" diameter DIP based on the assumption that approximately half of the PDD would be carried in either direction once the 12" DIP pipeline reaches Route 9. Pipeline sizes did not include fire flow requirements, which could result in a slight increase in pipeline diameters if this option is advanced into Phase II. Due to elevation differences in the North region, at this time it is assumed that there would be two distinct pressure zones, which would require the pressure reducing valve/booster pump station near the Shady Grove area.

Also associated with the North region surface water intake option would be two storage tanks, one for each pressure zone, with a storage volume of 279,000 gallons each. The total storage volume of 558,000 gallons is equivalent to the projected ADD for the North region.

6.1.3 Great Cacapon Region

The Great Cacapon region has been considered a stand-alone region due to the topographic boundaries that separate it from the other two regions. Based on the fact that only 5% of the projected water demands will be in the Great Cacapon region, a new reservoir is not being considered due to the high costs associated with dam construction compared to the low water demands. Therefore, the two options that are advancing for the Great Cacapon region are groundwater wells and a surface water intake on the Cacapon River near the Town of Great Cacapon.

Exhibit 3-4 illustrates the conceptual layout for a groundwater source option in the Great Cacapon region. West Virginia regulations dictate that a community water system of over 500 people that uses a groundwater source must have at least 2 well sources in order to provide redundancy. Due to the scale of the map and the size of the Great Cacapon region, the well source in Figure 4 is shown as a single point; however, the cost estimates addressing the use of groundwater in the Great Cacapon region accurately represent the need for an additional well. The well sources for the Great Cacapon region are situated in the Tonoloway Formation on the southern edge of the Great Cacapon region and are expected to have a withdrawal capacity equivalent to the Great Cacapon regions PDD, which is 0.14 MGD (97 gpm). The well source would have a 0.14 MGD water treatment facility associated with it and the transmission backbone is estimated to be 6" diameter DIP based on the projected demands and will be approximately 3,100 l.f. in length. The pipeline sizing did not include fire flow requirements and does not take into account industry standards that prefer the use of 8" DIP pipelines, both of which could result in a slight increase in pipeline diameter if this option is advanced into Phase II. A storage tank with a volume equivalent to the projected ADD for the Great Cacapon region, or 90,000 gallons, is situated in the Town of Great Cacapon.

Exhibit 3-5 illustrates the conceptual layout of a surface water intake on the Cacapon River to serve the Great Cacapon region. The intake is situated the bank of the Cacapon River on the southern edge of the Great Cacapon region due to the desire to be upstream of any potential discharges into the river associated with the Town of Great Cacapon. The intake, water treatment facility and pump station would be sized to accommodate the PDD of the region, which is approximately 0.14 MGD. The transmission backbone is estimated to be 6" diameter DIP based on the projected demands and will be approximately 2,300 l.f. in length. The pipeline sizing did not include fire flow requirements and does not take into account industry standards that prefer the use of 8" DIP pipelines, both of which could result in a slight increase in pipeline diameter if this option is advanced into Phase II. A storage tank with a volume equivalent to the projected ADD for the Great Cacapon region, or 90,000 gallons, is situated in the Town of Great Cacapon.

Table 12: Comparison of Priority Area Regions and Potential Raw Water Sources

Priority Area Regions / Raw Water Sources	Groundwater Sources	Surface Water Intakes	Surface Water Reservoirs
"South" Region (Rt. 522 Corridor South of Berkeley Springs) Average Daily Demand (ADD): 2030 ADD = 65% of 2030 Priority Area Demand = **1.21 MGD** Peak Daily Demand (PDD): 2030 PDD = 1.5 x 1.20 MGD = **1.81 MGD**	**Source Description:** 3 groundwater wells located in the Tonoloway Formation. Well locations are near Rock Gap, Indian Gap, and Break Neck Run Gap. **Analysis/Comments:** Sufficient water quantity and acceptable water quality for development as an alternative. Groundwater wells are practical for this region due to their ease of location and phasing capabilities. **Decision: Include in alternatives development.**	**Source Description:** Surface water intake from either the Cacapon River or the Potomac River **Analysis/Comments:** No surface water body in this region is large enough to provide the required PDD. Due to phasing difficulties and excessive costs associated with piping water from the Potomac or Cacapon Rivers to this region of the Priority Area, this option is not feasible. **Decision: Eliminated from alternatives development.**	**Source Description:** A reservoir located near Meadow Branch of Sleepy Creek. This new reservoir would be sized to provide drinking water for the South and North regions of the Priority Area. **Analysis/Comments:** Due to phasing difficulties and excessive costs associated with piping water from the reservoir to the South region of the Priority Area and environmental impacts, this option is not feasible. **Decision: Eliminated from alternatives development.**
"North" Region (Rt. 522 Corridor North of Berkeley Springs and Rt. 9 Corridor East of Berkeley Springs) Average Daily Demand (ADD): 2030 ADD = 30% of 2030 Priority Area Demand = **0.56 MGD** Peak Daily Demand (PDD): 2030 PDD = 1.5 x 0.55 MGD = **0.84 MGD**	**Source Description:** 2 groundwater wells located in the Chemung Group. **Analysis/Comments:** Sufficient water quantity and acceptable water quality for development as an alternative. Groundwater wells are practical for this region due to their ease of location and phasing capabilities. **Decision: Include in alternatives development.**	**Source Description:** A surface water intake on the Potomac River. **Analysis/Comments:** Adequate quantities of water are available in the Potomac River. The relatively small amount of water required for the North region of the Priority Area should make any approval process easier. Water quality is acceptable for development. **Decision: Include in alternatives development.**	**Source Description:** A reservoir located near Meadow Branch of Sleepy Creek. This new reservoir would be sized to provide drinking water for the South and North regions of the Priority Area. **Analysis/Comments:** Due to phasing difficulties and excessive costs associated with piping water from the reservoir to the South region of the Priority Area and environmental impacts, this option is not feasible. **Decision: Eliminated from alternatives development.**
Great Cacapon Average Daily Demand (ADD): 2030 ADD = 5% of 2030 Priority Area Demand = **0.09 MGD** Peak Daily Demand (PDD): 2030 PDD = 1.5 x 0.09 MGD = **0.14 MGD**	**Source Description:** 1 groundwater well located in the Tonoloway Formation. Well located in the southern edge of the Great Cacapon region. **Analysis/Comments:** Sufficient water quantity and acceptable water quality for development as an alternative. Groundwater wells are practical for this region due to their ease of location and phasing capabilities. **Decision: Include in alternatives development.**	**Source Description:** A surface water intake on the Cacapon River. **Analysis/Comments:** Adequate quantities of water are available in the Cacapon River. Water quality is acceptable for development. Surface water intake should be located upstream of potential discharges to the Cacapon River from the Town of Great Cacapon. **Decision: Include in alternatives development.**	**Source Description:** None considered. **Analysis/Comments:** No reservoir was considered for the Town of Great Cacapon based on a high construction cost associated with a low water demand in this region. Likewise, it would seem illogical to pipe water from a new reservoir located near the South and North regions of the Priority Area to the Great Cacapon region. **Decision: Eliminated from alternatives development.**

6.2 Comparison of Raw Water Source Options

Based on the findings of this report, the only viable raw water option for the South region of the Priority Area is a groundwater well system. For the North and Great Cacapon regions, the viable options identified in Table 12 have been evaluated based on preliminary estimated construction costs and ranking criteria. The ranking criteria categories are:

- Raw Water Quality/Level of Treatment (Taken from Section 5 of this report)
- Public Acceptance
- Risk of Negatively Impacting Aquifer
- Reliability
- Funding Potential
- Phasing Potential & Flexibility
- Conceptual Environmental Impacts
- Ease of Implementation
- Potential Regulatory Response (Permitability)

Estimated Construction Cost

Tables 13 through 17 are conceptual cost estimates for the five viable raw water options associated with the Water Resources Study. Table 13 contains the costs associated with the development of a groundwater system in the South region. Table 14 contains the costs associated with the development of a groundwater system in the North region. Table 15 contains the costs associated with the development of a surface water system in the North region. Table 16 contains the costs associated with the development of a groundwater system in the Great Cacapon region. Table 17 contains the costs associated with the development of a surface water system in the Great Cacapon region.

The costs listed in Tables 13 through 17 are approximations based on engineering experience and judgment. Due to these approximations, the cost estimates apply a 20% mark-up associated with additional engineering, permitting and construction management services, as well as a 25% contingency for project components that may not have been included in this conceptual level estimate.

Raw Water Quality/Level of Treatment

Based on the results of the raw water quality evaluations contained in Section 5 of this report, the regions were given a score based on the level of treatment required. The lowest level of treatment required earned a score of 5, the mid level treatment requirements earned a score of 3, and the highest level of treatment required for a raw water source earned a score of 1.

Public Acceptance

This ranking was based on the perceived public reaction to the various raw water options. At this time, all four options were given a score of 3, or "fair", due to the lack of serious opposition to any of the options.

Table 13: Preliminary Cost Estimate for South Region – Groundwater Option

Item No.	Cost Item	Quantity		Unit Cost	Total Cost	Remarks
		No.	Unit			
	South					
1	Development groundwater source of supply	3	each	$450,000.00	$1,350,000	Includes engineering but not legal fees or real estate. Submersible Pump
2	Groundwater Treatment Plant	1,800,000	gallons	$2.00	$3,600,000	Includes level 4 treatment per water quality evaluation
3	Surface Water Treatment Plant	0	gallons	$1.50	$0	Includes level 3 treatment per water quality evaluation
4	High Lift Station/Booster Pumping Stations	1	lump sum	$250,000.00	$250,000	
5	Pipeline (12")	10,200	l.f.	$66.00	$673,200	Assumes public r-o-w. Unit cost is $5.50/inch of pipe diameter.
6	Pipeline (8")	82,400	l.f.	$44.00	$3,625,600	Assumes public r-o-w. Unit cost is $5.50/inch of pipe diameter.
7	Storage Tanks	1,200,000	gallons	$2.00	$2,400,000	Includes necessary ancillary work but not land acquisition
8	Additional Engineering, Permitting, and CM (20%)				$2,380,000	
	Subtotal				**$14,278,800**	
	Project Contingencies (25%)				$3,570,000	
	TOTAL				**$17,848,800**	

Table 14: Preliminary Cost Estimate for North Region – Groundwater Option

Item No.	Cost Item	Quantity		Unit Cost	Total Cost	Remarks
		No.	Unit			
	North					
1	Development groundwater source of supply	2	each	$370,000.00	$740,000	Includes engineering but not legal fees or real estate. Submersible Pump
2	Groundwater Treatment Plant	830,000	gallons	$2.00	$1,660,000	Includes level 4 treatment per water quality evaluation
3	Surface Water Treatment Plant	0	gallons	$1.50	$0	Includes level 3 treatment per water quality evaluation
4	High Lift Station/Booster Pumping Stations	2	lump sum	$250,000.00	$500,000	
5	Pipeline (12")	0	l.f.	$66.00	$0	Assumes public r-o-w. Unit cost is $5.50/inch of pipe diameter.
6	Pipeline (8")	52,600	l.f.	$44.00	$2,314,400	Assumes public r-o-w. Unit cost is $5.50/inch of pipe diameter.
7	Storage Tanks	550,000	gallons	$2.00	$1,100,000	Includes necessary ancillary work but not land acquisition
8	Additional Engineering, Permitting, and CM (20%)				$1,263,000	
	Subtotal				**$7,577,400**	
	Project Contingencies (25%)				$1,894,000	
	TOTAL				**$9,471,400**	

Table 15: Preliminary Cost Estimate for North Region – Surface Water Option

Item No.	Cost Item	Quantity No.	Quantity Unit	Unit Cost	Total Cost	Remarks
	North					
1	Potomac River Intake Structure & Low Lift Pump Station	1	lump sum	$750,000.00	$750,000	Includes engineering but not legal fees or real estate. Submersible Pump
2	Groundwater Treatment Plant	0	gallons	$2.00	$0	Includes level 4 treatment per water quality evaluation
3	Surface Water Treatment Plant	830,000	gallons	$1.50	$1,245,000	Includes level 3 treatment per water quality evaluation
4	High Lift Station/Booster Pumping Stations	2	lump sum	$250,000.00	$500,000	
5	Pipeline (12")	21,800	l.f.	$66.00	$1,438,800	Assumes public r-o-w. Unit cost is $5.50/inch of pipe diameter.
6	Pipeline (8")	52,600	l.f.	$44.00	$2,314,400	Assumes public r-o-w. Unit cost is $5.50/inch of pipe diameter.
7	Storage Tanks	550,000	gallons	$2.00	$1,100,000	Includes necessary ancillary work but not land acquisition
8	Additional Engineering, Permitting, and CM (20%)				$1,470,000	
	Subtotal				**$8,818,200**	
	Project Contingencies (25%)				$2,205,000	
	TOTAL				**$11,023,200**	

Table 16: Preliminary Cost Estimate for Great Cacapon Region – Groundwater Option

Item No.	Cost Item	Quantity No.	Quantity Unit	Unit Cost	Total Cost	Remarks
	Great Cacapon					
1	Development groundwater source of supply	1	each	$290,000.00	$290,000	Includes engineering but not legal fees or real estate. Submersible Pump
2	Additional groundwater well (redundancy)	1	each	$175,000.00	$175,000	Only includes production well drilling and testing and pump station costs
3	Groundwater Treatment Plant	140,000	gallons	$2.00	$280,000	Includes level 4 treatment per water quality evaluation
4	Surface Water Treatment Plant	0	gallons	$1.50	$0	Includes level 3 treatment per water quality evaluation
5	High Lift Station/Booster Pumping Stations	1	lump sum	$250,000.00	$250,000	
6	Pipeline (12")	0	l.f.	$66.00	$0	Assumes public r-o-w. Unit cost is $5.50/inch of pipe diameter.
7	Pipeline (8")	0	l.f.	$44.00	$0	Assumes public r-o-w. Unit cost is $5.50/inch of pipe diameter.
8	Pipeline (6")	3,100	l.f.	$33.00	$102,300	Assumes public r-o-w. Unit cost is $5.50/inch of pipe diameter.
9	Storage Tanks	90,000	gallons	$2.00	$180,000	Includes necessary ancillary work but not land acquisition
10	Additional Engineering, Permitting, and CM (20%)				$255,000	
	Subtotal				**$1,532,300**	
	Project Contingencies (25%)				$383,000	
	TOTAL				**$1,915,300**	

Table 17: Preliminary Cost Estimate for Great Cacapon Region – Surface Water Option

Item No.	Cost Item	Quantity No.	Quantity Unit	Unit Cost	Total Cost	Remarks
	Great Cacapon					
1	Cacapon River Intake Structure & Low Lift Pump Station	1	lump sum	$250,000.00	$250,000	Includes engineering but not legal fees or real estate. Submersible Pump
2	Groundwater Treatment Plant	0	gallons	$2.00	$0	Includes level 4 treatment per water quality evaluation
3	Surface Water Treatment Plant	140,000	gallons	$1.50	$210,000	Includes level 3 treatment per water quality evaluation
4	High Lift Station/Booster Pumping Stations	1	lump sum	$250,000.00	$250,000	
5	Pipeline (12")	0	l.f.	$66.00	$0	Assumes public r-o-w. Unit cost is $5.50/inch of pipe diameter.
6	Pipeline (8")	0	l.f.	$44.00	$0	Assumes public r-o-w. Unit cost is $5.50/inch of pipe diameter.
7	Pipeline (6")	2,300	l.f.	$33.00	$76,000	Assumes public r-o-w. Unit cost is $5.50/inch of pipe diameter.
8	Storage Tanks	90,000	gallons	$2.00	$180,000	Includes necessary ancillary work but not land acquisition
9	Additional Engineering, Permitting, and CM (20%)				$193,000	
	Subtotal				**$1,159,000**	
	Project Contingencies (25%)				$290,000	
	TOTAL				**$1,449,000**	

Risk of Negatively Impacting Aquifer

This ranking criterion was developed as a method of documenting the possibility of having an adverse impact on aquifers that may be supplying water to the region, including the Town of Berkeley Springs. Due to the preliminary nature of this report, it is assumed that the groundwater options for the North and Great Cacapon regions may have a slight to moderate ability to have negative impacts on the area's aquifers. Therefore, these options were given a score of 3, or "fair". The surface water options for the regions were given scores of 5, or "low", for this criterion based on the knowledge that groundwater in Morgan County predominantly flows to the North and the proposed surface water intake locations are located on the northern edges of the County.

Reliability

"Reliability" for the raw water options refers to the option's ability to consistently meet the projected demands of the region. The historical streamflow data contained in Table 2 of this report indicates that the Cacapon and Potomac Rivers should be able to consistently handle the projected demands of the Great Cacapon and North regions, respectively. Therefore, the surface water options were given a score of 5, or "good". Based on their long-term unpredictability, the groundwater options were given a score of 3, or "fair".

Funding Potential

Funding potential looks at the likelihood of securing local, state or federal funds for construction of the potential water system. Based on preliminary conversations held with the West Virginia Infrastructure and Jobs Development Council, projects that can be constructed over time will be more likely to receive funding. Therefore, the groundwater well options for the North and Great Cacapon regions have been ranked higher than the surface water systems.

Phasing Potential and Flexibility

The phasing potential and flexibility ranking is based on the possibility that the alternative can be constructed in a phased manner, versus the need to construct all facilities at the beginning of the planning period. The ranking also takes into account the ability of the alternative to provide water efficiently and effectively to the various Priority Area regions. As discussed under "funding potential", the groundwater options have a higher degree of phasing potential associated with them due to the fact that a well, treatment plant and distribution system in the immediate vicinity of the well can be constructed based on the development of the demands over the planning horizon.

For the North region, the groundwater option can be phased such that the first well, treatment and distribution system are constructed as needed. As the water demands develop over time in the remaining portion of the region, the remaining well, treatment plant and connecting distribution system can be constructed. Based on this evaluation, the groundwater option in the North region has been given a score of 5, or "good". The surface water option in the North region has been given a score of 1, or "low", based on the fact that a majority of the costs associated with this option will need to be spent in the initial phase of construction. The initial construction phase would include the river intake, pump station and water treatment plant sized for the PDD of the North region to avoid the need to expand the facilities at a later time. A significant portion of the distribution system would also need to be installed at this time in order to deliver the finished water to the customers.

For the Great Cacapon region, both the groundwater and surface water options earned a score of 3, or "fair". This is based on the assumption that the Great Cacapon region water supply system will be small enough that there would not be a considerable difference between the two options.

Conceptual Environmental Impacts

The conceptual environmental impacts ranking is a broad review of the potential environmental conflicts associated with the various alternatives. Items like stream crossings or construction in wetlands would result in higher conceptual environmental impacts and a lower ranking for this category. Since the surface water options require that a river intake structure be constructed, these options have been given a score of 3, or "reasonable". The groundwater options have been given a score of 5, or "minimal".

Ease of Implementation

Ease of implementation takes into account the overall difficulty associated with constructing the alternatives. Items such as dams and river intakes are relatively more difficult to construct than a groundwater well source. Assuming that the level of difficulty associated with constructing the distribution systems are equal for the two options in each region, the most important factor is the level of difficulty associated with a river intake versus that of a groundwater well.

In the North region, the groundwater option was given a score of 5, or "good". For the surface water option in the North region, it was necessary to consider the issues surrounding "river ownership" relative to the state of Maryland, as well as permitting an intake facility on a major waterway. Based on these factors, the surface water option in the North region was given a score of 1, or "poor".

Like the North region, the groundwater option in the Great Cacapon region received a score of 5. The surface water option in the Great Cacapon region received a score of 3, or "fair" based on the facts that the intake would be relatively small in scale and that the intake would be located entirely within West Virginia.

Potential Regulatory Response (Permitability)

Preliminary conversations with regulatory agencies in West Virginia indicated that, regardless of the option selected, the projects should be able to be permitted as long as the designed facilities meet the applicable federal and state regulations. Therefore, a score of 3, or "fair", has been given to all options.

Table 18 summarizes the cost estimates and the ranking criteria comparisons.

Table 18: Comparison of Raw Water Concepts in the North and Great Cacapon Regions

Priority Area Region	Raw Water Source Concept	Estimated Construction Cost of Raw Water Concept*	Additional Ranking Criteria									TOTAL SCORE
			Raw Water Quality/Level of Treatment**	**Public Acceptance**	**Risk of Negatively Impacting Aquifer**	**Reliability**	**Funding Potential**	**Phasing Potential & Flexibility**	**Conceptual Environmental Impacts**	**Ease of Implementation**	**Potential Regulatory Response (Permitability)**	
			Lowest Treatment Level = 5 Mid-Level Treatment Level = 3 Highest Treatment Level = 1	Good = 5 Fair = 3 Poor = 1	Low = 5 Fair = 3 High = 1	Good = 5 Fair = 3 Poor = 1	Good = 5 Fair = 3 Poor = 1	Good = 5 Fair = 3 Poor = 1	Minimal = 5 Reasonable = 3 Significant = 1	Good = 5 Fair = 3 Poor = 1	Good = 5 Fair = 3 Poor =1	Max. Score = 45 Min. Score = 9
North	Groundwater (Chemung)	$9,471,400	1	3	3	3	5	5	5	5	3	33
	Surface Water (Potomac River)	$11,023,200	3	3	5	5	3	1	3	1	3	27
Great Cacapon	Groundwater (Tonoloway)	$1,915,300	1	3	3	3	5	3	5	5	3	31
	Surface Water (Cacapon River)	$1,449,000	3	3	5	5	3	3	3	3	3	31

* - Estimated costs include 20% adjustment for "Additional Engineering, Permitting and CM" and 25% adjustment for "Project Contingencies". South region raw water option cost is approximately $17,848,800.

** - From Section 5 ("Work Paper – Confirmed Sources Water Quality")

7.0 PUBLIC PARTICIPATION

In April of 2006, significant project activities by the Project Team, Gannett Fleming and the many local, state and federal agencies were initiated. Significant project events relative to Phase I of the project are summarized below.

7.1 Project Schedule Summary

Date	Project Activity
June 13, 2006	Kickoff Meeting is held.
July 20, 2006	Meeting is held in Berkeley Springs to advise Project Team of progress and seek guidance.
August 23, 2006	Draft work papers presented to Project Team.
August 29, 2006	Meeting is held in Berkeley Springs to discuss Project Team comments from work papers.
September 21, 2006	Meeting is held in Berkeley Springs. Groundwater option selected by Project Team for South and Great Cacapon regions of the Priority Area. No decision made for North region. Project Team requested that Gannett Fleming investigate the possible use of an abandoned sand mine at the US Silica facility as a raw water reservoir.
September 29, 2006	Morgan County Commission endorses the groundwater source options for the South and Great Cacapon regions of the Priority Area.
October 19, 2006	Research indicates that the sand mine at US Silica is not a feasible option and will not be advance for further consideration.
October 26, 2006	Meeting is held in Berkeley Springs. Groundwater option selected for the North region.
November 3, 2006	Morgan County Commission endorses the groundwater source option for the North region of the Priority Area.

7.2 Public Agency Input

Gannett Fleming contacted various government agencies to obtain preliminary guidance relating to the development of a public water supply for the Priority Area of Morgan County. The following paragraphs summarize these conversations.

7.2.1 West Virginia Public Service Commission

Upon describing the work being conducted for the Water Resources Study, the Commission stated that they would be supportive of the overall effort and that the new water supply system would not have to be connected to the Town of Bath system expansion. The Commission did mention that a review would be completed by the Commission to identify if it would be more sensible for the Town of Bath to serve portions of the County than the new water system. The Commission also indicated that an economic analysis supporting the selected water supply alternative would be required.

In general, the Commission had no issues with the direction of the Water Resources Study and offered no specific recommendation regarding alternative selection, except for the comment about economic issues.

7.2.2 West Virginia Bureau for Public Health – Office of Environmental Resources

No recommendations on alternative selection were offered. The only significant comment made at this time was that if the facilities designed met the WV regulations than they could probably be approved.

7.2.3 West Virginia Infrastructure and Jobs Development Council

The representative of this agency mentioned that the ability to construct the water system in phases would be important in decisions made regarding project funding. Many funding sources were discussed and it was determined that this agency acts as a form of clearinghouse in that all funding activities are initiated by submitting applications to this agency. The representative offered to meet with the Project Team at a later date once the preferred alternative is selected to discuss funding opportunities in greater detail.

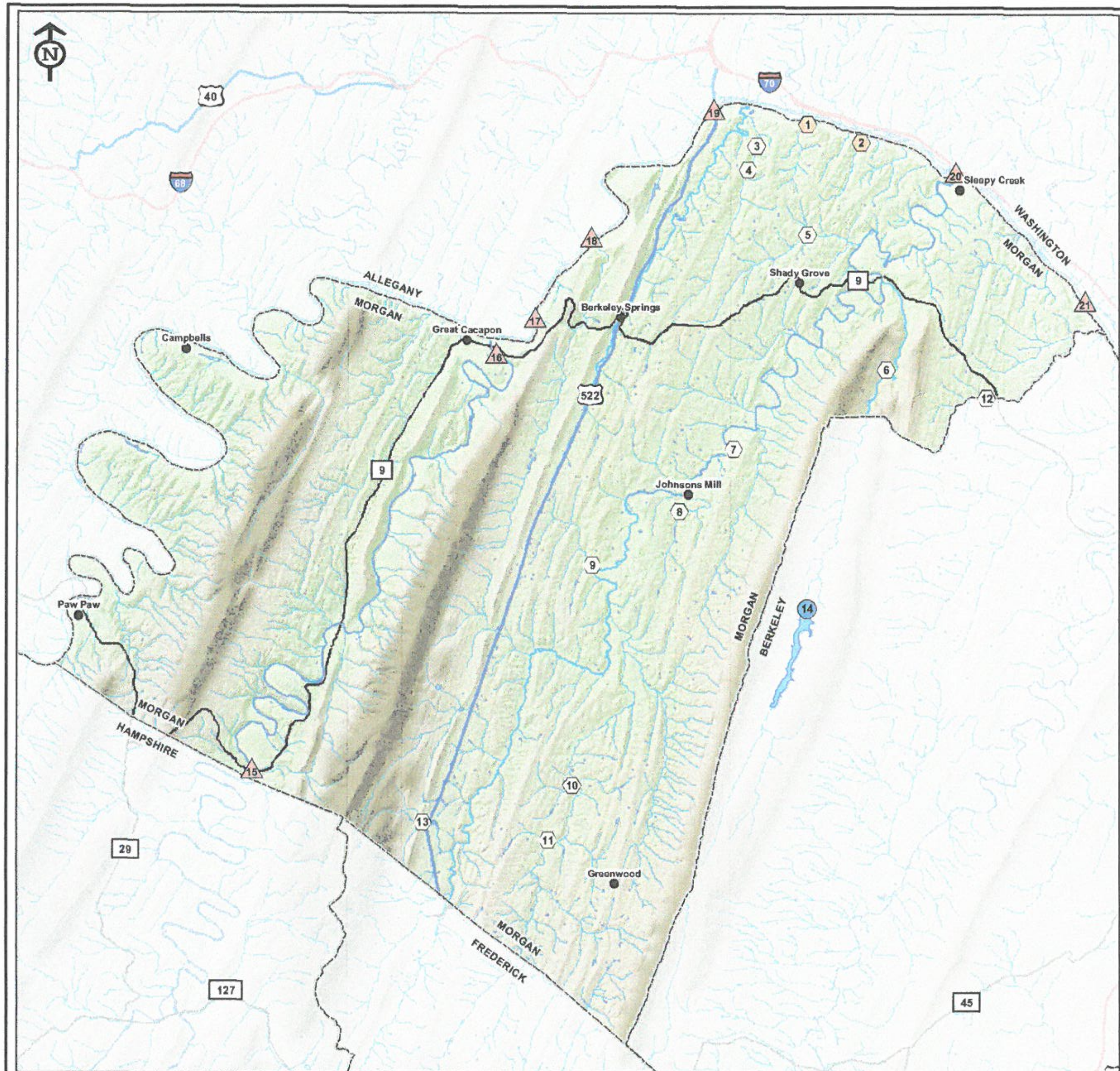
7.3 Recommended Alternative

At the conclusion of Phase I activities, the Project Team selected the use of groundwater wells for all three regions of the Priority Area. Phase II of the Water Resources Study will further develop the groundwater options.

EXHIBIT 1

POTENTIAL SURFACE WATER SOURCES MAP

Morgan County Water Resources Study
Eastern Panhandle Conservation District (EPCD)



LOCATION MAP

Summary of Potential Surface Water Sources

ID	Surface Water Source	Stream Name
1	Pumped-Storage Reservoir	Stoney Run
2	Pumped-Storage Reservoir	Unnamed Trib. To Potomac River
3	Conventional Reservoir	Dry Run
4	Conventional Reservoir	Dry Run
5	Conventional Reservoir	Swim Run
6	Conventional Reservoir	Meadow Branch of Sleepy Creek
7	Conventional Reservoir	Mountain Run
8	Conventional Reservoir	Unnamed Trib. To Sleepy Creek
9	Conventional Reservoir	Unnamed Trib. To Sleepy Creek
10	Conventional Reservoir	Unnamed Trib. To Middle Fork Sleepy Creek
11	Conventional Reservoir	Unnamed Trib. To Middle Fork Sleepy Creek
12	Conventional Reservoir	Cherry Run
13	Conventional Reservoir	Breakneck Run
14	Existing Reservoir	Sleepy Creek Lake (Berkeley County)
15	River Intake	Cacapon River at Largent
16	River Intake	Cacapon River at Great Cacapon
17	River Intake	Potomac River
18	River Intake	Potomac River
19	River Intake	Potomac River at Hancock
20	River Intake	Potomac River at Sleepy Creek
21	River Intake	Potomac River at Cherry Run

Legend

- Cities
- Proposed Conventional Reservoir Sites
- Proposed Pumped Storage Reservoir Sites
- Existing Reservoirs
- Proposed River Intake Sites
- U.S. Highways
- Interstates
- State Highways
- Streams / Rivers
- Reservoirs / Lakes / Ponds
- County Boundries

0 6,000 12,000 24,000 Feet

1 inch equals 12,000 feet

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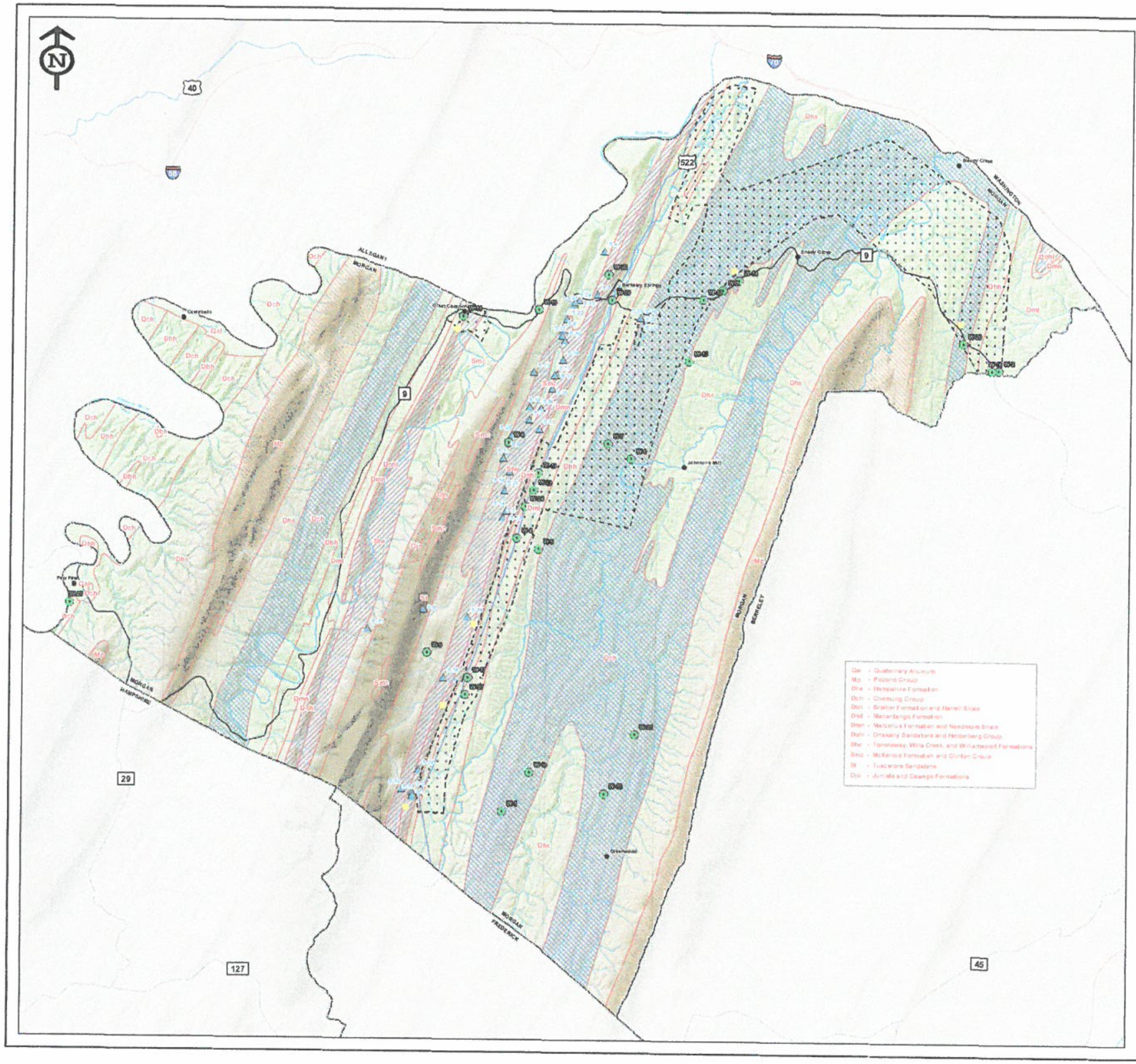
Figure 1 - Potential Surface Water Sources

February 2007

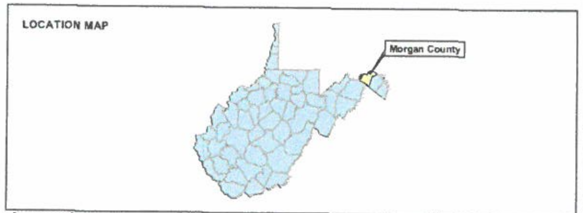
EXHIBIT 2

POTENTIAL GROUNDWATER SOURCE QUANTITY EVALUATION MAP



Morgan County Water Resources Study
Eastern Panhandle Conservation District (EPCD)

LOCATION MAP



Legend

- Springs
- Wells
- Proposed Well Sites
- U.S. Highways
- Interstates
- State Highways
- Hydrology
- Formation Contacts
- Helderberg Group, Tonoloway, Wills Creek, and Williamsport Formations
- Chemung Group
- Pocono Group
- Designated Priority Area

0 3,000 6,000 12,000 18,000 Feet

1 inch equals 6,000 feet

Statistical summary of specific capacity and transmissivity data for hydrogeologic units in Morgan County, West Virginia (from Kozar and Mathes, 2001)

Hydrogeologic Unit (Aquifer)	Map Symbol	Specific Capacity (gpm/ft)				Transmissivity (ft2/d)			
		median value	minimum value	maximum value	number of sites	median value	minimum value	maximum value	number of sites
Maccrady Formation and Pocono Group	**Mp**	**0.83**	**0.17**	**8.67**	**7**	**210**	**33**	**2,300**	**7**
Hampshire Formation	Dhs	0.51	0.01	12.5	22	74	3	2,900	22
Chemung Group *	**Dch**	**1.35**	**0.12**	**30.7**	**22**	**270**	**32**	**8,300**	**22**
Brallier and Harrell Fms	Dbh	0.28	0.01	1.6	7	72	3	390	7
Upper to middle Devonian units		0.76	0.19	4.29	15	180	44	760	15
Mahantango Formation	Dmt	0.38	0.01	3.75	10	92	3	640	10
Marcellus and Needmore Formations	Dmn	0.98	0.07	7	15	170	16	1,300	15
Oriskany Group and Oriskany Sandstone	Dohl	0.35	0.1	8	8	82	19	1,500	8
Helderberg Group, Tonoloway, Wills Creek and Williamsport Fms **	**Dohl/Stw**	**0.82**	**0.07**	**600**	**13**	**200**	**17**	**160,000**	**13**
Clinton Group, Mckenzie and Tuscarora Formations	Smc	0.11	0.02	6.5	3	23	6	1,100	3
Target Aquifer									

* USGS uses Greenland Gap Group which is divided into the Foreknobs and Scherr Fms. (Source, USGS-GEOLEX)

** Digital Geologic Base Map (West Virginia Geological and Economic Survey, 1968) includes Helderberg in Dohl

Spring ID	Name	Latitude	Longitude	Flow (gpm)	Geology	Altitude
S-1	Ridge Cave	39.46275	-78.31540	3197	Dohl	930
S-2	Hovgedale Spring	39.46433	-78.31527	250	Dohl	925
S-3	Big Pond	39.62548	-78.24599	140	Dohl	805
S-4	Clearcut	39.63940	-78.24303	130	Smc	640
S-5	Pioneer Spring	39.55320	-78.27074	100	Dohl	878
S-6		39.57450	-78.27479	99	Smc	892
S-7		39.58493	-78.26512	90	Stw	540
S-8		39.61390	-78.25654	76	Stw	650
S-9	High Spring	39.52477	-78.31025	75	St	1400
S-10	Neeley Spring	39.55608	-78.27378	66	Stw	780
S-11		39.57238	-78.27630	61	Smc	805
S-12		39.59945	-78.25345	50	Stw	720
S-13	Tonoloway A	39.55538	-78.27526	50	Dohl	876
S-14	Tonoloway B	39.55533	-78.27543	50	Dohl	876
S-15		39.60010	-78.26331	49	Smc	731
S-16	Cacapon SP Spring	39.50146	-78.30204	49	Stw	980
S-17		39.59928	-78.25434	22	Stw	892
S-18		39.59800	-78.26518	13	Smc	568
S-19		39.62476	-78.24479	11	Stw	673
S-20	Mountainside Spring	39.57999	-78.27274	10	Smc	800
S-21		39.61218	-78.25108	9	Stw	600
S-22		39.61748	-78.24805	9	Stw	663
S-23		39.62217	-78.24597	7	Stw	540
S-24		39.62105	-78.24555	4	Stw	705
S-25	Webber Spring	39.56202	-78.27584	3	Stw	819
S-26	Gap Spring	39.47131	-78.31280		Dohl	1005
S-27	Ladies Spring	39.61764	-78.21734		Dohl	620
S-28	Gentlemens Spring	39.61772	-78.21730		Dohl	620
S-29	Lord Fairfax Spring	39.61769	-78.21731		Dohl	620
S-30	Bathhouse Drain	39.61782	-78.21795		Dohl	620
S-31	Zitter Spring	39.51742	-78.33399		Dohl	535
S-32	Ridge Pond	39.46520	-78.31960		Smc	1030
S-33	Ridge #2	39.46342	-78.31507		Stw	913
S-34		39.58845	-78.26025		Stw	757
S-35		39.53498	-78.25545		Stw	792
S-36	Thunderbird Hills Pond	39.52120	-78.29179		Stw	815
S-37		39.59175	-78.26112		Stw	822
S-38		39.60425	-78.25073			822
S-39		39.61055	-78.24930			718
Discharge 100 gpm or more						

Well ID	System Name	Well Depth(s)	Yield	Latitude	Longitude
W-1	Tri-Lake MHP	140 and 260 ft	60 and 30 gpm	39.45777	-78.27389
W-2	Morgan Vill. MHP	292 and 332 ft	75 and 48 gpm	39.60001	-78.04411
W-3	Skyline MHP	135 ft	13 gpm	39.62006	-78.18201
W-4	McCumbee MHP	90 and 170 ft	27 and 13 gpm	39.5466	-78.27082
W-5	Apple Orc. Acres	220 and ? ft	30 and 12 gpm	39.54297	-78.26163
W-6	Valley View Nurs	105 and 300 ft	60 and 40 gpm	39.57198	-78.22222
W-7	Coolfont Rec.	200 and 300 ft	21 and 20 gpm	39.57003	-78.23194
W-8	Coolfont Mt. Acr	105 and 210 ft	25 and 13 gpm	39.57749	-78.27416
W-9	Cacapon S.P.	287 and 400 ft	Unk. gpm	39.50966	-78.30086
W-10	Country Rd Rest.	220 ft	1.5 gpm	39.60088	-78.06807
W-11	Great Cac. Elem.	145 ft	18 gpm	39.6130	-78.29805
W-12	Pine Vall. Sch.	200 ft	20 gpm	39.48533	-78.21416
W-13	Mill Ct. Daycare	240 ft	Unk. gpm	39.62304	-78.19111
W-14	Kat & Ronnie Bar	189 ft	60 gpm	39.60972	-78.17611
W-15	The Glen	85 ft	20 gpm	39.60304	-78.19722
W-16	Morgan Ind. Pk.	40 ft	60 gpm	39.47027	-78.26583
W-17	Cacapon B&H	52 ft	Unk. gpm	39.50138	-78.29166
W-18	VFW Post	65 ft	18 gpm	39.56747	-78.26152
W-19	Panorama Subd.	300 and 630 ft	7 and 7 gpm	39.62166	-78.26111
W-20	Pleas. View Elem.	123 ft	60 gpm	39.60888	-78.08111
W-21	Greenwood Elem.	200 ft	30 gpm	39.48289	-78.22111
W-22	Holl. Hig. Bap.	220 ft	22 gpm	39.63108	-78.21135
W-23	Hawkeyama	90 ft	20 gpm	39.56282	-78.26152
W-24	Tom Sealey Farm	130 ft	Unk. gpm	39.55672	-78.26713
W-25	Town of Paw Paw	N/A (Surface)	N/A	39.52001	-78.46033
W-26	Town of Bath	N/A (Spring)	1020 gpm	39.62301	-78.22999
W-27	Wheel House Rest	Unknown	Unknown	39.49598	-78.20277
Discharge 100 gpm or more					

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Figure 2 - Potential Groundwater Source Quantity Evaluation

February 2007

EXHIBIT 3

PRIORITY AREA RAW WATER OPTION MAPS

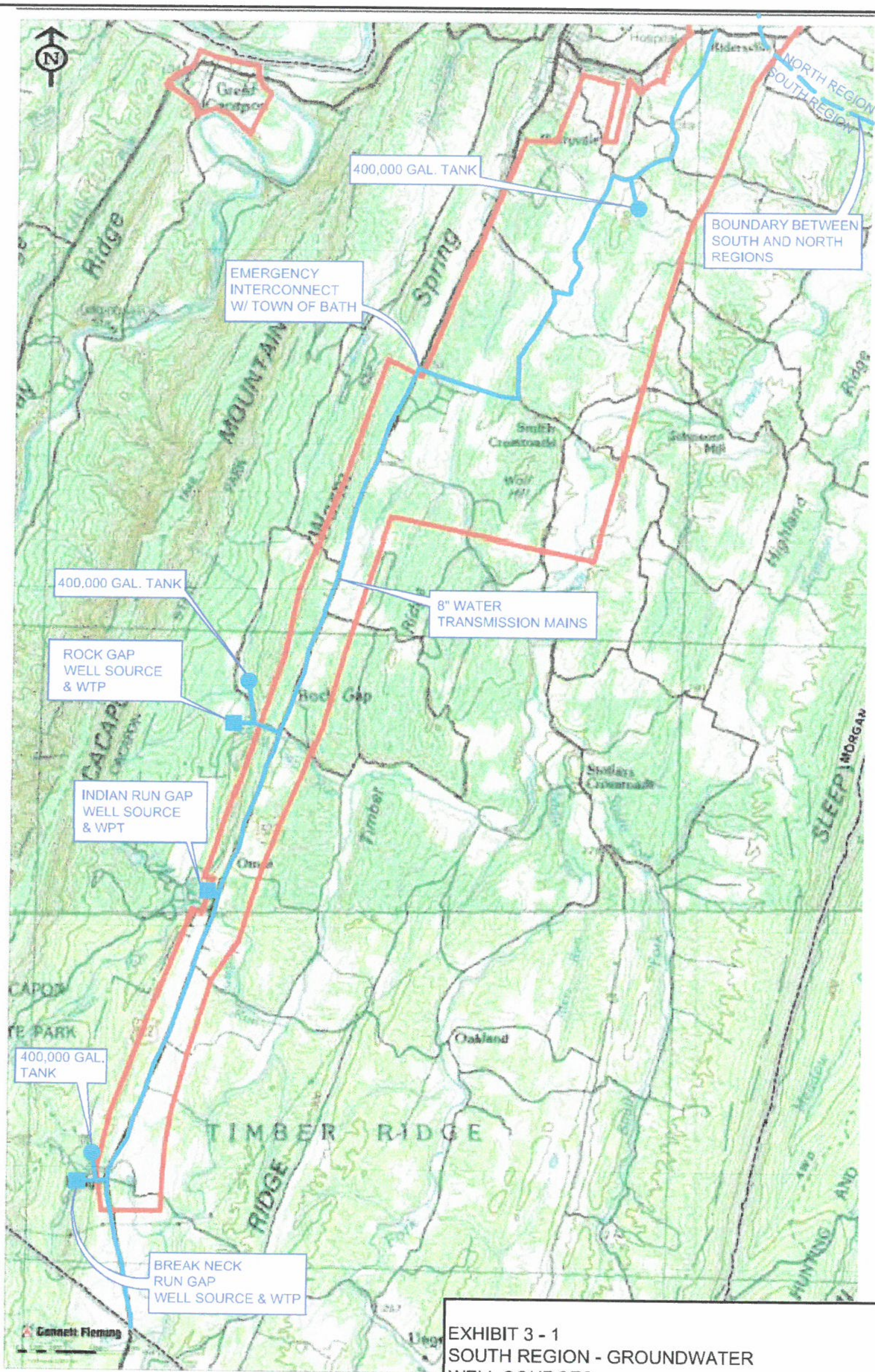

EXHIBIT 3 - 1
SOUTH REGION - GROUNDWATER
WELL SOURCES
(PROPOSED WATER FACILITIES - NOT TO SCALE)

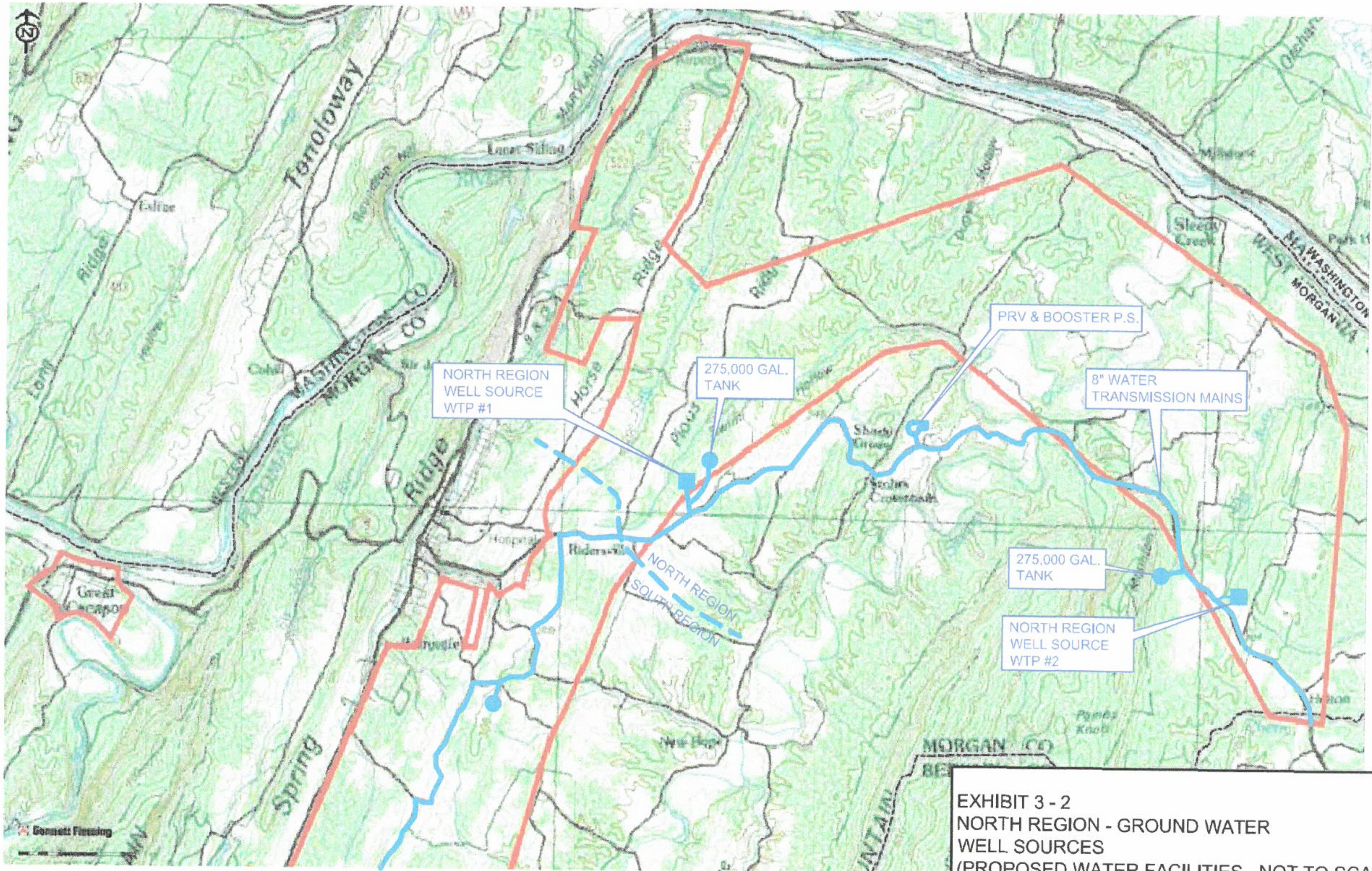

EXHIBIT 3 - 2
NORTH REGION - GROUND WATER
WELL SOURCES
(PROPOSED WATER FACILITIES - NOT TO SCALE)

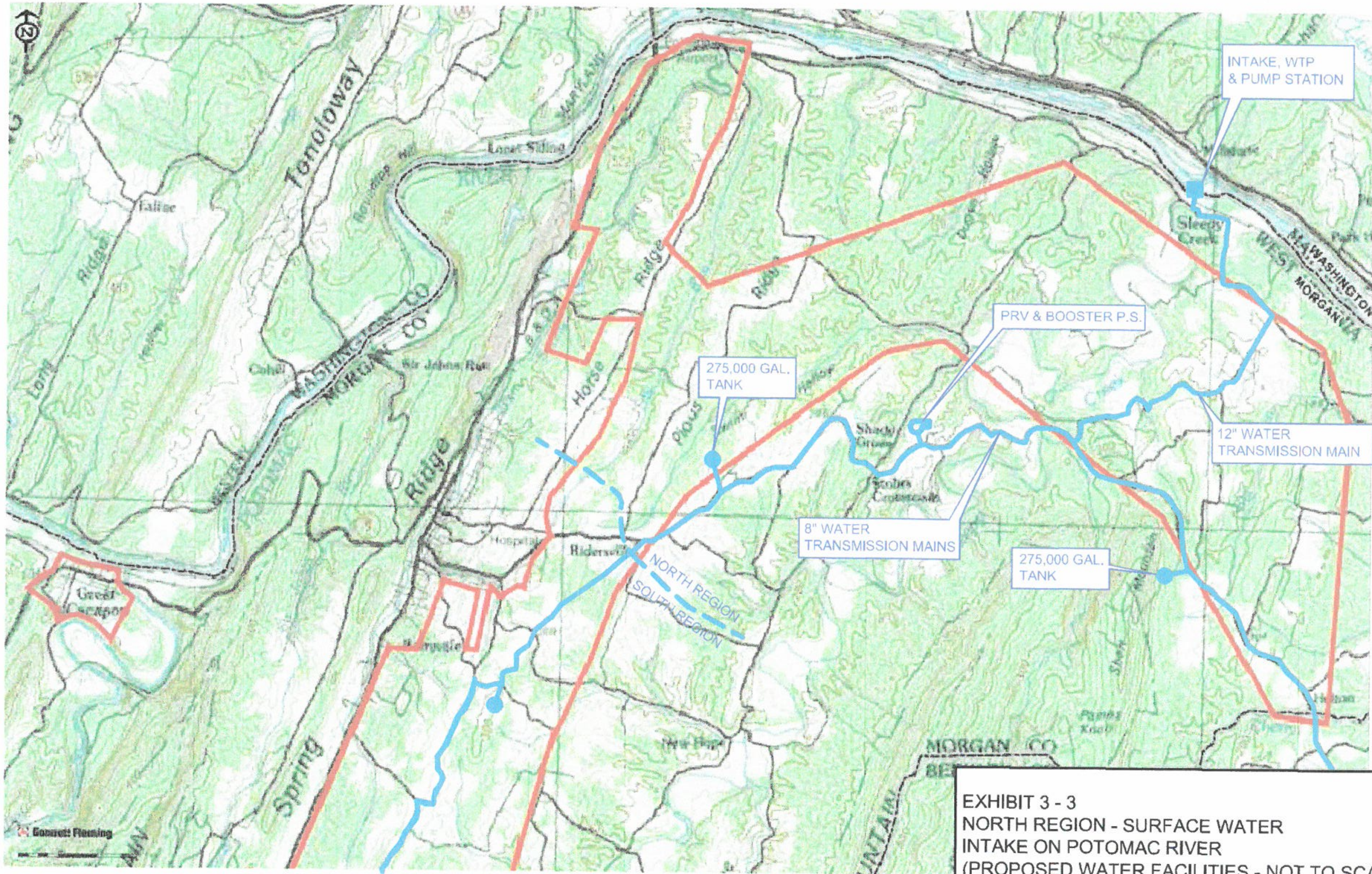

EXHIBIT 3 - 3
NORTH REGION - SURFACE WATER
INTAKE ON POTOMAC RIVER
(PROPOSED WATER FACILITIES - NOT TO SCALE)

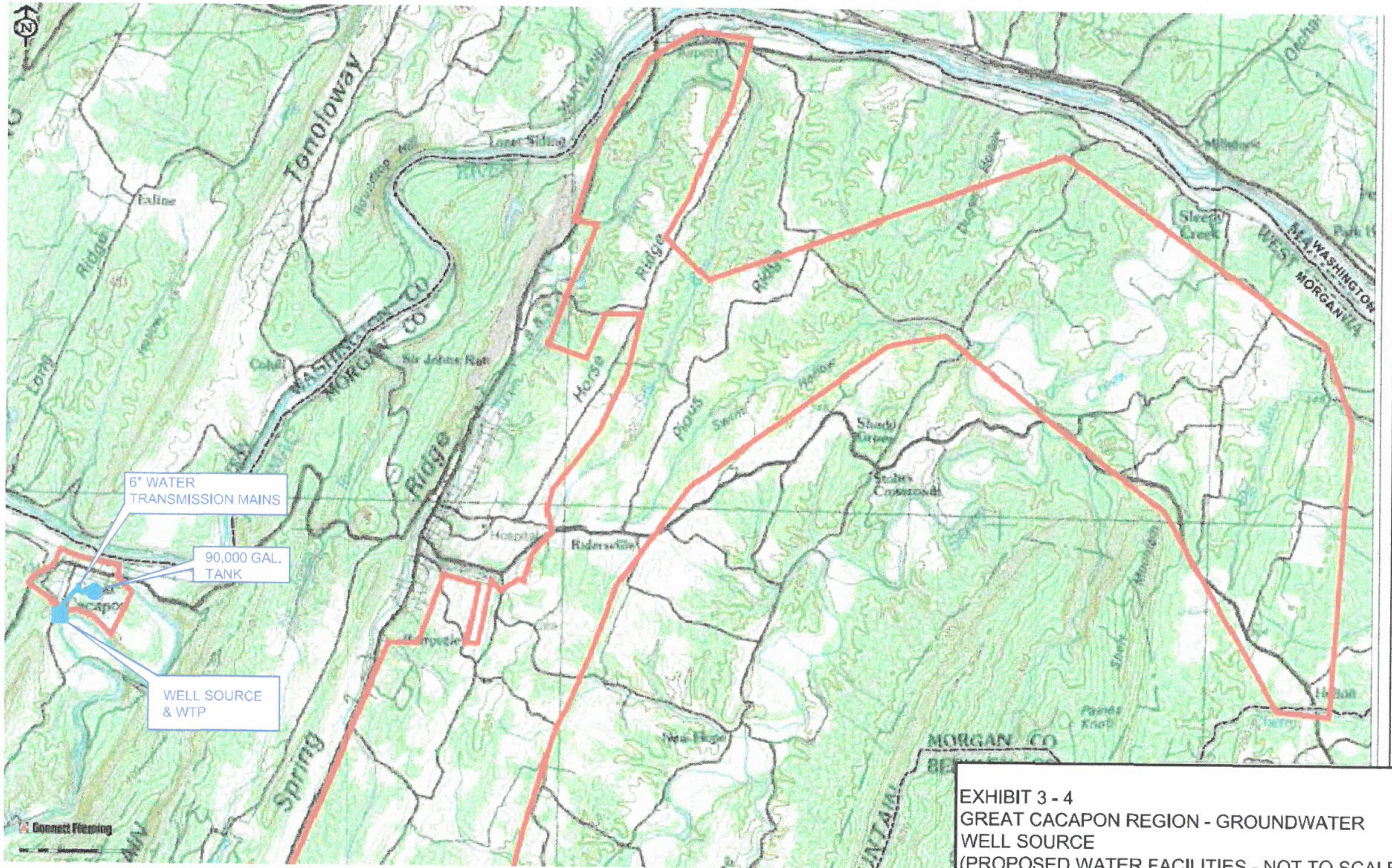

EXHIBIT 3 - 4
GREAT CACAPON REGION - GROUNDWATER
WELL SOURCE
(PROPOSED WATER FACILITIES - NOT TO SCALE)

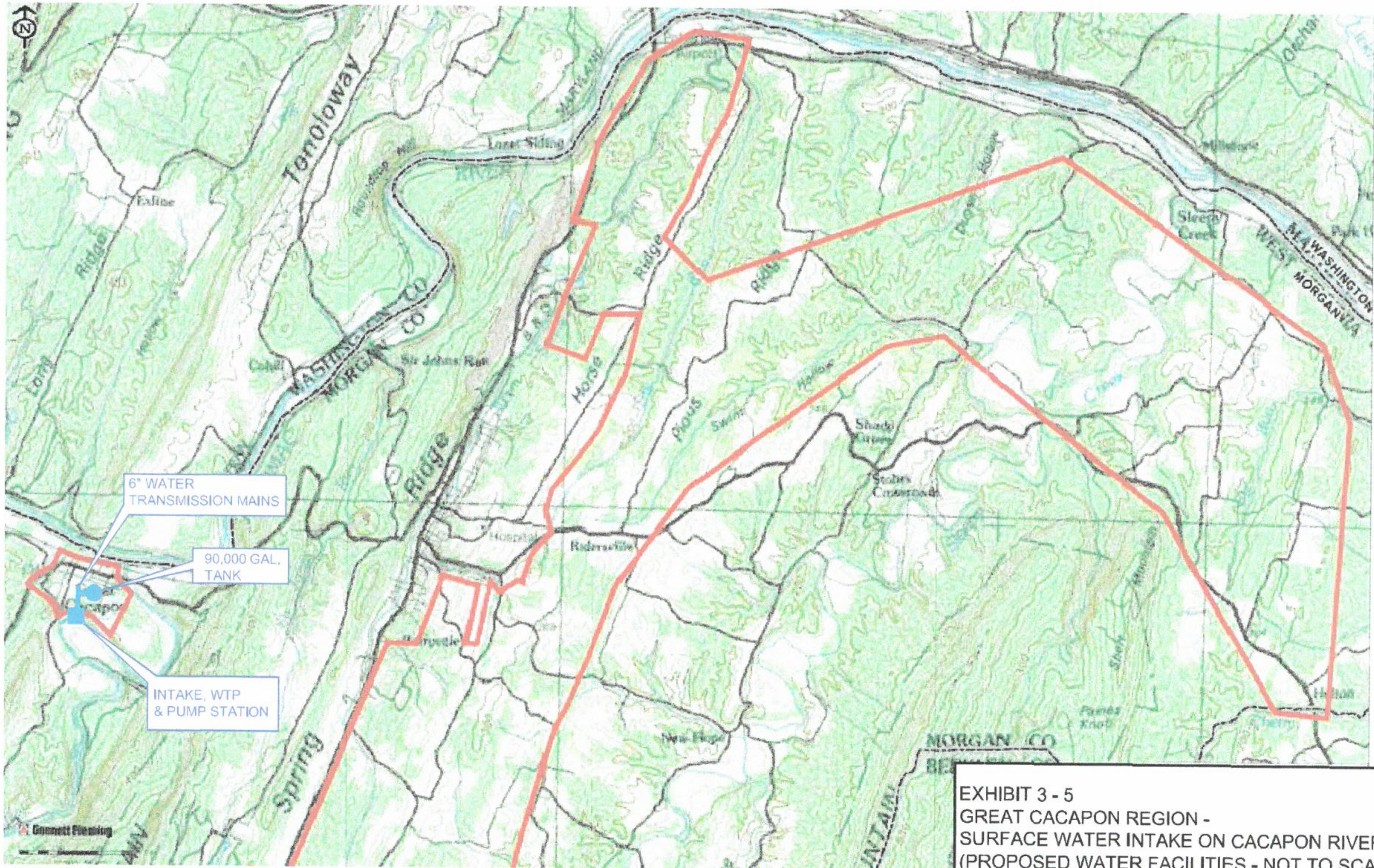

EXHIBIT 3 - 5
GREAT CACAPON REGION -
SURFACE WATER INTAKE ON CACAPON RIVER
(PROPOSED WATER FACILITIES - NOT TO SCALE)

APPENDIX A

GENERAL DATA INDEX

GENERAL DATA INDEX

MORGAN COUNTY WATER RESOURCES STUDY

Gannett Fleming Data Inventory No.	Category	Description
GF 001	Census/Population	"Population Changes in Morgan County" (Powerpoint presentation – 02/22/2006)
GF 002	Water Supply	1-page listing of water systems in Morgan County and number of people served
GF 003	Groundwater	WVU report – "Springs, Source Water Areas, and Potential for High-Yield Aquifers Along the Cacapon Mountain Anticline, Morgan County, West Virginia"
GF 004a	Groundwater	USGS water supply data and report – "Groundwater Resource Assessment of Morgan County, West Virginia"
GF 004b	Groundwater	USGS water supply data and report – "Supplement II to County-Wide Assessment of Groundwater Resources in Morgan County, West Virginia – Trace Elements"
GF 005	Water Supply	"Town of Bath Public Water System – Summary of Major Problems and Concerns"
GF 006	Water Supply	WV Dept. of Health and Human Resources "Infrastructure and Capacity Development – Permits Issued" for Town of Bath
GF 007	Water Supply	"Administrative Orders" report generated on 07/26/1999 – water quality violations from various locations in Morgan County
GF 008	Water Supply	"Safe Drinking Water Information System" from EPA website (printed on 01/17/2006) – lists all community water systems, non-transient non-community systems, and transient non-community water systems (active and closed) in Morgan County, WV
GF 009	Water Supply	2004 Compliance Report – 06/28/2005
GF 010	Water Supply	"Response of the Morgan County Commission to Public Service Commission Staff Memorandum" from 02/09/2003 – discusses expansion/creation of Warm Springs PSD
GF 011	Water Supply	WVCA 2005 Annual Report
GF 012	Water Supply	"Monthly Operational Reports – Berkeley Springs Water Works", May 2004 – April 2005

Gannett Fleming Data Inventory No.	Category	Description
GF 013	GIS/Mapping	Map of Priority Area (GIS) – 04/06/2006
GF 014	Surface Water	"Sleepy Creek Watershed Assessment" – March 2006
GF 015	Water Supply	"Berkeley Springs Water Works – Source Water Assessment, Delineation, and Protection Plan" – November 2001
GF 016	Water Supply	SWAP reports for Paw Paw (2002 and 2004), Morgan Village MHP (2001), Apple Orchard Acres (2002), Tri Lake Park (2005), Valley View Nursing Home and Autumn Acres Personal Care (2003), Skyline Village MHP (2006), McCumbee/Waugh MHP (2002), Berkeley Springs (2000 and 2004)
GF 017	Roads	"WVDOT 6-Year Highway Improvement Plan"
GF 018	Census/Population	"2005 Population Estimates" – U.S. Census Bureau
GF 019	Census/Population	"Morgan County, West Virginia by County Subdivision" – U.S. Census Bureau (2000)
GF 020	Census/Population	"Quick Facts: Morgan County, West Virginia" – U.S. Census Bureau
GF 021	Groundwater	USGS Report (draft format – received June 2006)
GF 022	Census/Population	"Land Use" section (draft) of Morgan County Comprehensive Plan – received from Arro Group (07/14/2006)
GF 023	Water Supply	"Water Treatment Facilities in Washington County – Capacity Analysis, November 9, 2005" – data on Hancock, MD WTP capacity
GF 024	Water Demand Projections	Facsimile from MCRWC – indicates percentage of growth/water demands in Priority Area (received 07/26/2006)
GF 025	Surface Water	Map of small flood control dams in Morgan County, WV
GF 026	WV Regulations	WV Public Water System Regulations (DHHR) – Title 64, Series 3 and Series 77
GF 027	Water Demand Projections	USGS "Estimated Use of Water in the United States"
GF 028	Water Demand Projections	AWWA average water consumption data
GF 029	Water Demand Projections	Route 522 Industrial Park information (from WV Development Office website)
GF 030	Water Demand Projections	"Survey of State Agency Water Loss Reporting Practices" – Report to AWWA discussing acceptable water losses and goals.

APPENDIX B

SURFACE WATER SOURCE OPTIONS DATA