West Virginia Water Resources Protection Act
Project 3: Potential Growth Areas

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DRAFT REPORT

Prepared for:

West Virginia Department of
Environmental Protection

Prepared by:

Center for Business and
Economic Research
Marshall University
One John Marshall Way
Huntington, WV 25755

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I. INTRODUCTION

This report is completed in fulfillment of work directed under Project 3 of the West Virginia Water Resources Protection Act (WRPA). The WRPA outlines four separate sub-tasks that fell under the Center for Business and Economic Research's (CBER) work schedule. These tasks were Task 7.1 through Task 7.4.

This report completes Task 7.1 and Task 7.3. The goal of task 7.1 is to identify potential economic growth areas that would impact water consumption and apply that expectation to forecasts of near-term regional economic development. The goal of Task 7.3 is to estimate water demand by industry and households in the near term. This projection was completed for 2005 through 2010. These estimates cover the state at the county level, although results are often presented at the state level. The numbers presented here are preliminary calculations and for many sectors are based on sparse data regarding actual gross and net consumption.

The goal of Task 7.2 is to evaluate out-of-state industries' impact on water use. This task has not yet been completed as the list of out-of-state users has not yet been compiled in entirety. The West Virginia Department of Environmental Protection (DEP) has collected data on Ohio facilities that withdraw water from the Ohio River, and is in the process of collecting equivalent data for the other states that border West Virginia. This task will be completed in 2006.

The goal of Task 7.4 is to evaluate potential competing use scenarios regarding existing water resources for both surface water and groundwater. Estimates of the supply of surface water are not available for all bodies of water, nor is groundwater data available. Because the question of potential competing use requires analysis of demand and supply of both surface and groundwater, this analysis was not able to be completed. However, some data on groundwater use was collected from the DEP's major user survey that provides a starting point on which to evaluate this issue.[1] It is expected that additional insight on how to compare water demand data with data on water availability will develop in the next stage of this project.

II. METHODOLOGY

Potential Growth Areas: Commercial and Industrial

Economic activity for the years 2005 through 2010 is forecasted based on the North American Industry Classification System (NAICS). Future water use is based on economic activity and recent county-level trends combined with aggregate state-wide forecasts of industry-specific employment change.

[1] The DEP survey results have considerably more information on the use of groundwater and surface water by facilities than was able to be incorporated into this analysis. Not all the data was provided in enough detail to attribute consumption to a particular county and industry.

Economic forecasts published by West Virginia University's Bureau of Business and Economic Research (BBER) in their 2005 Economic Outlook are used to calculate industry forecasts for the State as a whole. [2] The following industry categories were evaluated as listed below, along with BBER's forecasted rate of change for employment by industry at the two-digit NAICS level. The industries with the highest rate of growth are the service industries. These industries generally have lower rates of water consumption than non-services industries. Other industries projected to experience growth are recreation and accommodation and food services. The mining industry is also projected to see employment growth, although that growth is not projected to translate into increased water use from current levels as 2006 coal production is expected to be at a level that is the high for the decade.

Figure 1 – WVU BBER Forecasted Employment by Industry

NAICS	Industry	WVU BBER Employment Annual change 2004-2009
11	Forestry, fishing, hunting, and agriculture support	-2.7%
21	Mining	0.3%
22	Utilities	-1.8%
23	Construction	0.2%
31-33	Manufacturing	-0.6%
42	Wholesale trade	0.2%
44-45	Retail trade	0.3%
48-49	Transportation & warehousing	1.0%
51	Information	0.4%
52	Finance & insurance	0.6%
53	Real estate & rental & leasing	0.6%
54	Professional, scientific & technical services	2.3%
55	Management of companies & enterprises	2.3%
56	Admin, support, waste mgt, remediation services	2.3%
61	Educational services	0.3%
62	Health care and social assistance	1.5%
71	Arts, entertainment & recreation	1.2%
72	Accommodation & food services	1.2%
81	Other services (except public administration)	0.9%
92	Public Administration	-0.1%

For most industries it is assumed that negative employment growth corresponds with a decline in water use for that industry, and that an increase in employment represents an increase in water use. However, this relationship is not necessarily true for some industries, including power generation and mining, and was not assumed in this analysis for those two industries. A direct correlation may also not be true for many manufacturing facilities, but due to the lack of data defining an actual relationship a direct employment to water use coefficient was utilized.

[2] West Virginia University, Bureau of Business and Economic Research, 2005. "West Virginia Economic Outlook."

CBER compiled individual county-level economic activity data provided by the Bureau of Employment Programs for 1998 and 2003. To translate this economic activity into water consumption levels, trends in number of establishments, number of employees and payroll were examined at the two-digit NAICS code and for some sector at the six-digit code. For industries with economic activity that generates little variation in water use, the higher two-digit level of activity was evaluated. These industries comprise the majority of NAICS sectors but a relatively small portion of water production.

The following two-digit industries were evaluated at the six-digit industry code for water consumption, due to economic activity that creates more variation in water use per employee. These industries were analyzed at a lower level of activity to account for as much detail as possible. Major use activities are described below.

- Forestry, Fishing, Hunting and Agriculture Support - Sub-industry activities include agriculture and logging, with livestock accounting for the largest quantity of water use.
- Arts and Recreation – This group includes fitness centers, theaters, casinos and sports. Golf courses are the largest sub-group in terms of water use.
- Manufacturing – This sector includes activities ranging from chemical manufacturing to food production. Sub-industry water use estimates were obtained from a combination of USGS and DEP survey data for gross consumption. The highest use sub-industries are in chemical manufacturing.
- Utilities - Thermoelectric power generation (NAICS 221112 - Fossil Fuel Electric Power Generation) was calculated separately.
- Mining – Coal mining, quarries and oil production were evaluated separately.

The results of the DEP major user survey, which provides consumption data at the facility level and thus corresponds with the six-digit NAICS level of economic activity, were applied to these sectors whenever possible. The remaining industry categories all consume water at consistent levels, at lower levels as represented by commercial office users or higher levels as represented by hospitals or other types of accommodation, that can be applied at the two-digit level of economic activity. Few facilities within these sectors were required to participate in the DEP survey due to water consumption not meeting the required quantity. Data provided within the USGS survey of water users was applied to estimate water withdrawals for these industries.[3]

Potential Growth Areas: Residential

Household consumption is directly related to population growth, which in aggregate is projected to be flat through 2010. Average annual consumption estimates were calculated using publicly available annual reports for public service districts from the West Virginia Public Service Commission website (www.state.psc.wv.us). These

[3] USGS, Dunn & Bradstreet and Harris Interactive, Inc, 2004.

consumption levels are then applied to individual counties. The assumptions to this analysis are provided in Section V.

Net Use versus Withdrawals

It is important to note the distinguishing of net versus gross water consumption. While estimates of total withdrawals, or gross consumption, are available for most industry groups, estimates of net consumption (withdrawals minus discharges) are less readily available. This report focuses on net consumption, due to emphasis by the WRPA on estimating consumptive use. The DEP survey results include figures that can be used to calculate net consumption, although some calculations often resulted in negative net consumption.

Water Use Calculation

Number of employees is used to calculate water consumption for most industries due to the availability of estimates that are a function of number of employees. No assumptions were made regarding the underlying productivity of labor in any water-consuming industry in West Virginia. This implies that industrial efficiency is constant with the addition or subtraction of employees and that water use is directly proportional to employment. This method has been criticized for not accounting for operational efficiencies achieved by many facilities that have been able to maintain output with reductions in employment or that have reduced water consumption while maintaining output. This criticism is legitimate, but due to the lack of alternative methods of estimation gallons per employee per day (GED) was used for most industries evaluated in this report.

Water consumption for the power industry was calculated based on production and at rates determined by consultation with industry. Mining consumption is also based on production, but due to the range of estimates, a more thorough analysis at the county or watershed level is needed.

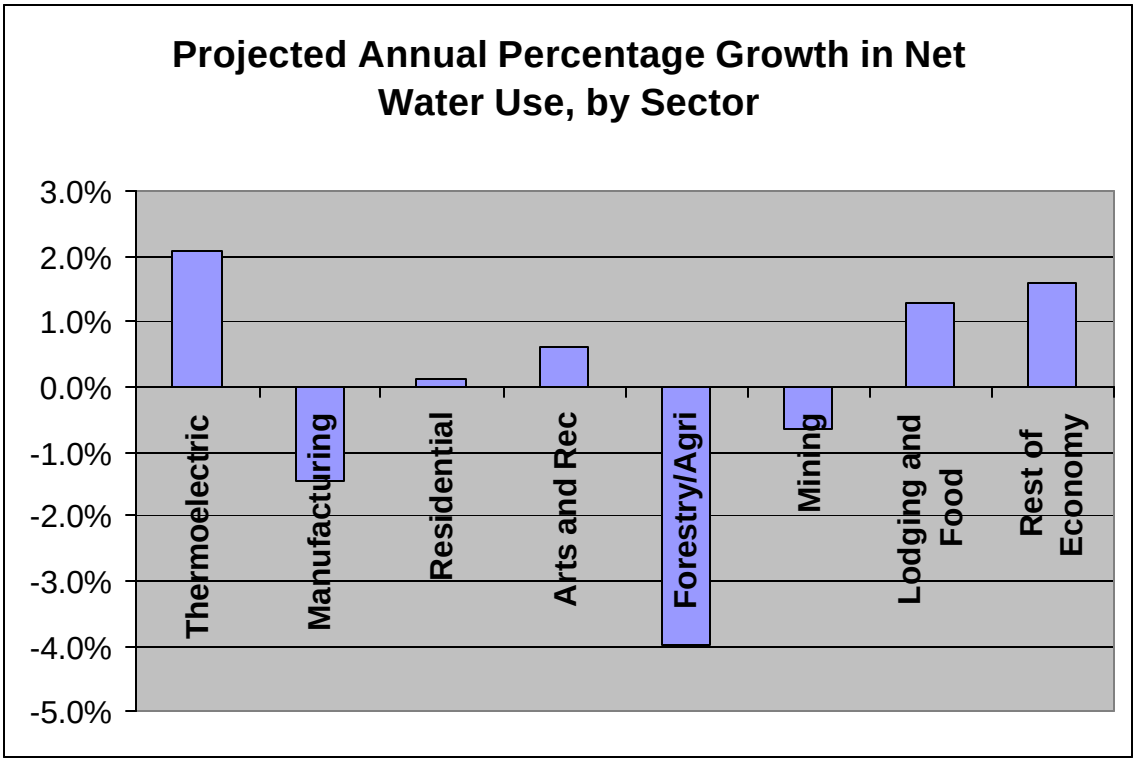
Recent trends in employment by industry and by county were analyzed to provide a basis for near-term consumption trends. For industries where water consumption was calculated based on number of employees, the forecast for state-level employment was matched to the WVU BBER forecast shown above. Individual county growth within that forecast was estimated from data on employment changes between 1998 and 2003. A logic formula was applied to project a percentage growth in a specific two-digit industry for a specific county based on the recent historical growth. Historical county-level growth was grouped into tiers and used to project future county growth, also in tiers, that is representative of past growth, while also matching the overall projected state growth.

In other words, the projected 2005 to 2010 employment growth rate for $County_y$ in $Industry_x$ is a function of 1998 to 2003 employment growth rate for $County_y$ in $Industry_x$, plus WVU BBER's forecasted employment growth for West Virginia in $Industry_x$.

The logic formula applied to each county to determine the projected growth rate is based on four conditions:
1. If historical employment growth was positive and greater than a, than projected growth is a_1;
2. If historical growth was positive and less than or equal to a, but greater than 0, than projected growth is a_2;
3. If historical growth was less than or equal to 0, but greater than b, than projected growth is b_1; and,
4. If historical growth was less than or equal to b, than projected growth is b_2.

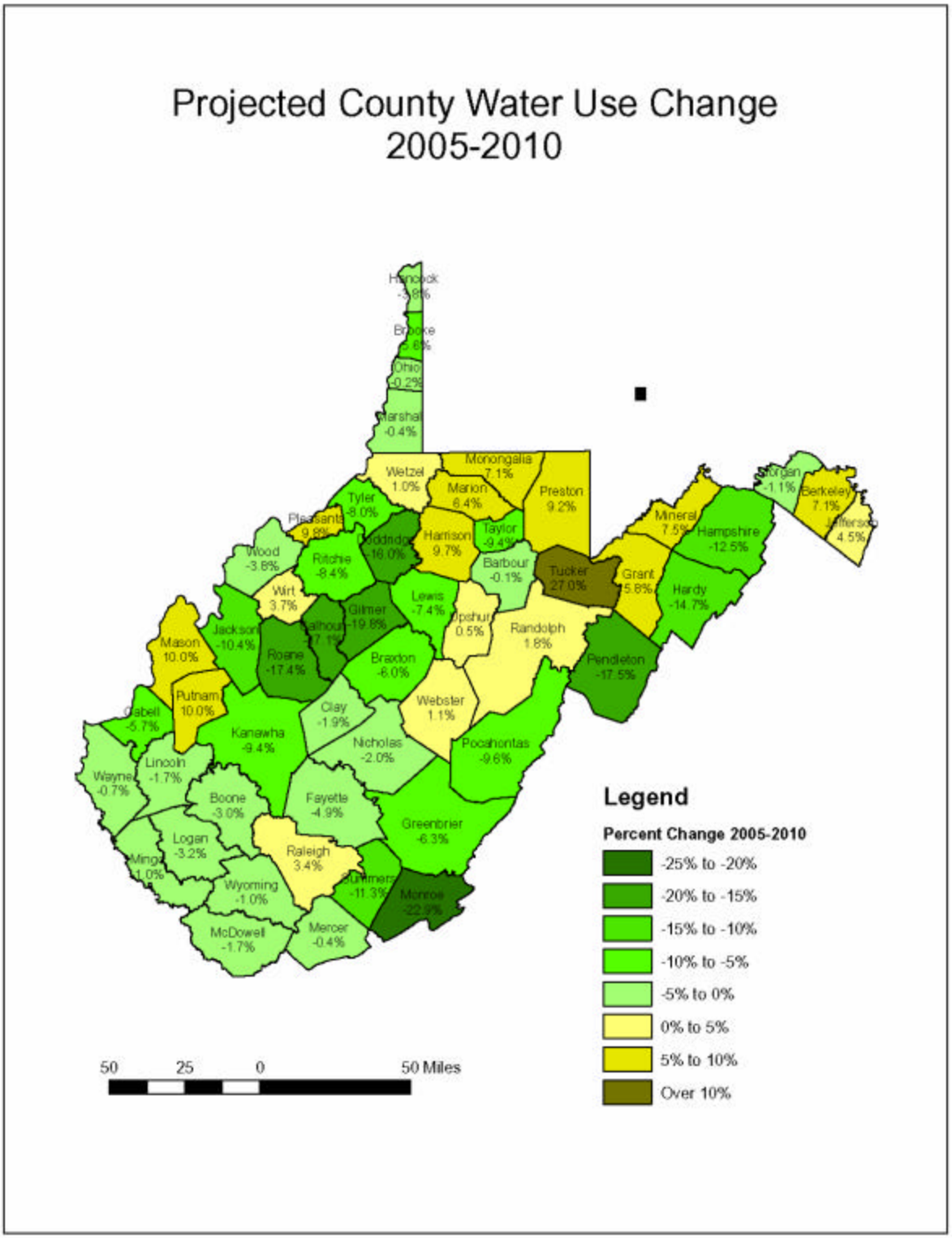
The four growth rates, a_1, a_2, b_1 and b_2, were calculated using an iterative process that forces the combined employment for all counties in each sector to equal the growth rate forecasted by WVU BBER. For example, counties that experienced greater than four percent annual growth in employment in the accommodation and food service industry are projected to continue that growth, although at a slower pace of three percent. Counties that saw positive growth of less than four percent are projected to see one percent growth and counties that lost employment in this industry are projected to continue to do so at a rate of negative one percent. Total aggregate county employment growth in accommodation equals 1.2%. The following chart shows projected changes in net water use by sector for 2005 to 2010 based on these employment calculations.

Figure 2



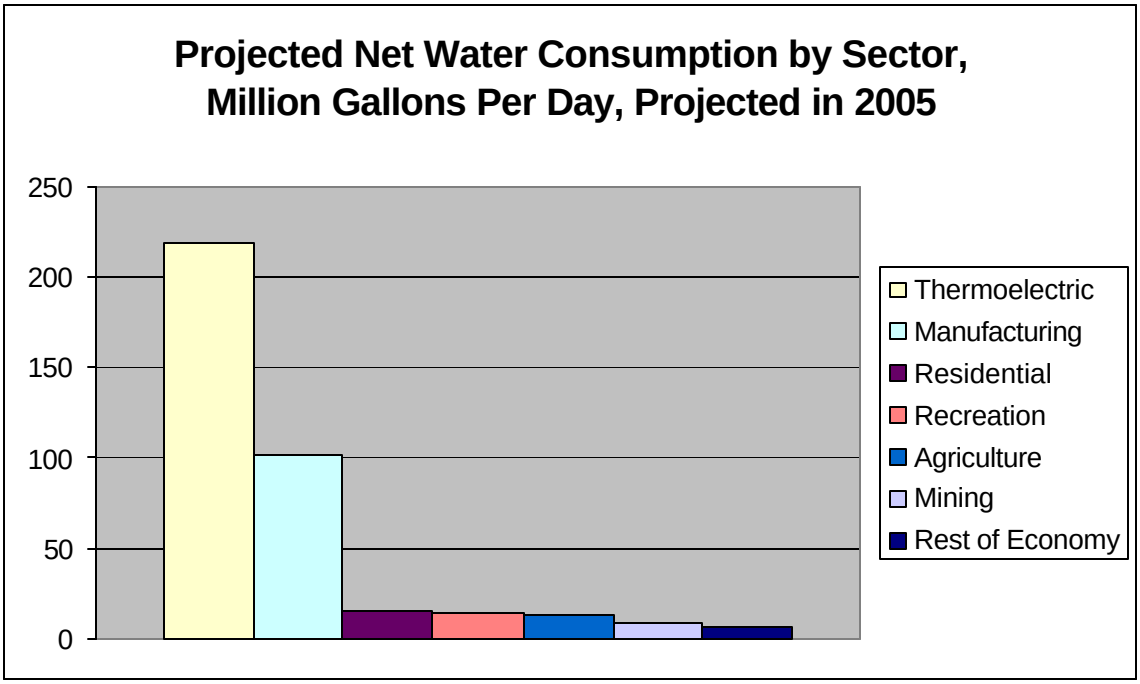
The following map describes the overall results for the change in projected water consumption by county between 2005 and 2010.

Figure 3 – Preliminary Estimates of County Water Use Change



The next chart describes relative net water use projected by sector for 2005. The category "Rest of Economy" represents all other water consumption that is not covered in the other sectors and is primarily lodging and food services, schools, commercial office buildings and healthcare facilities. Most of the businesses within these sectors will use water from public sources. The relative levels of consumption are not significantly changed over the forecast period and, with the exception of the assumed increase in thermoelectric power generation, are for the most part not observable on a chart of this scale.

Figure 4



** Preliminary Estimates*

This report will next describe water use estimation for individual sectors of the economy. Because thermoelectric power generation for dispatch to the electricity grid accounts for the single largest category of water use, both gross and net consumption, this industry is reported first.

III. THERMOELECTRIC POWER GENERATION

Utility thermoelectric power generation occurs in ten counties in West Virginia. With the exception of one plant, all the facilities rely on a major river or water body for cooling water. Total water withdrawals for this category of activity were 3,785 million gallons per day (mgpd) in 2004. For comparison, the USGS estimated this category of withdrawals at 3,950 mgpd in 2000 for West Virginia. The range of both gross and net withdrawals by plant is fairly large and depends on the type of cooling system utilized. Once-through cooling systems withdraw at much higher rates than do recirculating systems, although recirculating systems return a much lower portion to the water system

due to evaporation. By county, net water use (withdrawals minus discharges) ranges from 1% to 81% for power generation.

Rates of return also vary for plants utilizing the same type of system. Due to NPDES standards regarding thermal discharges, plants that utilize once-through cooling tend to overestimate water discharges. This practice led to the reporting of negative water consumption for several of these plants. For this analysis, a one percent net water consumption was assumed based on discussion with industry regarding typical plant operation.[4]

One small power plant in the state, located in Grant County, utilizes an air-cooled condenser and thus relies much less on water for cooling. This plant's water consumption was not reported in the DEP's water survey. Thus, an intake rate of 1% of a similar vintage once-through system was assumed.[5] Net use of eight percent was assumed.[6]

Forecasted net water consumption from utility power generation is shown below. A two percent annual increase is assumed, matching expected increases in power generation for the country. Increases also reflect the addition of scrubbers to several of the plants, between 2007 and 2009, in compliance with the Clean Air Act.[7] These plants are all located along major rivers and most take 100% of their water from those rivers. One exception is the Mountaineer Plant in Mason County. That plant reported two percent of its withdrawals from groundwater.[8]

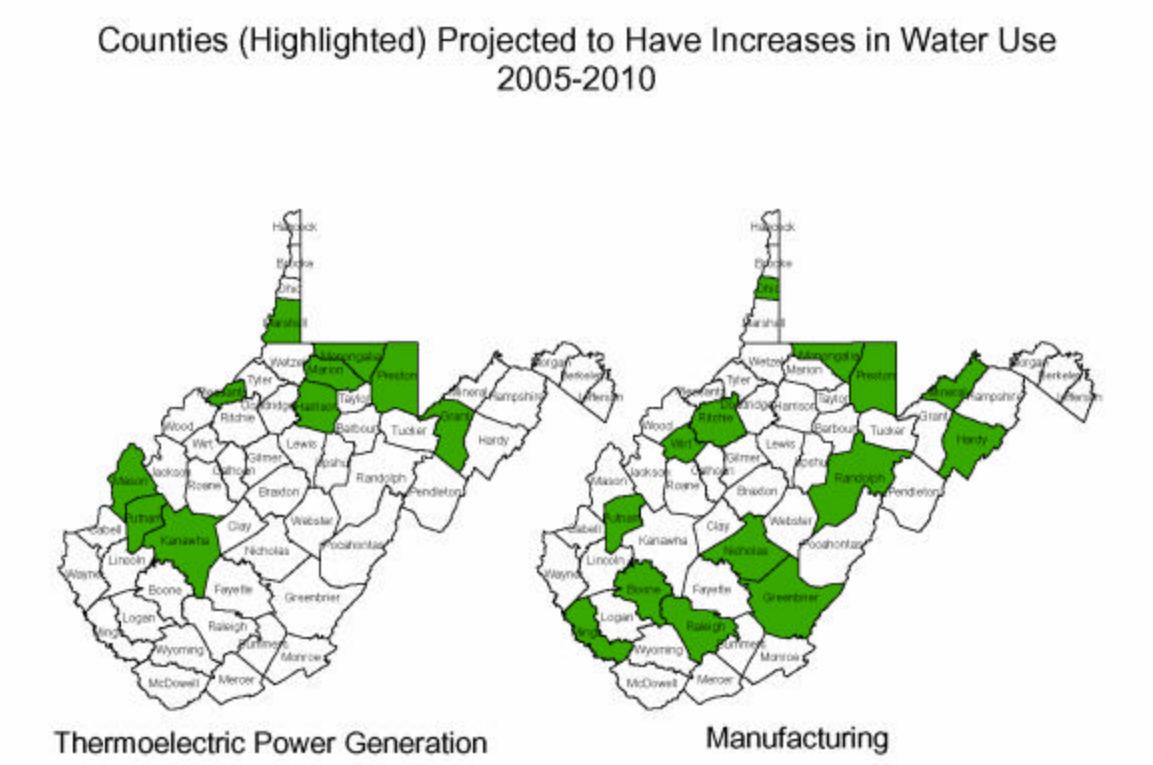
Projected Net Water Consumption from Utility Power Generation, by County, Million Gallons per Day (2005 to 2010)

County	2005	2006	2007	2008	2009	2010
Grant	11.79	12.03	12.27	12.51	12.76	13.02
Harrison	32.26	32.90	33.56	34.23	34.92	35.62
Kanawha	3.51	3.58	3.65	3.72	3.80	3.87
Marion	3.60	3.67	3.75	3.82	3.90	3.98
Marshall	10.11	10.31	10.52	10.73	10.94	11.16
Mason	108.14	110.30	112.51	114.76	117.05	119.39
Monongalia	8.49	8.66	8.83	9.01	9.19	9.37
Pleasants	10.98	11.20	11.43	11.66	11.89	12.13
Preston	3.11	3.17	3.23	3.30	3.36	3.43
Putnam	26.90	27.44	27.99	28.55	29.12	29.70

[4] Bill Cannon of Allegheny Energy provided fundamental guidance on calculation of net consumption.
[5] The plant of similar vintage is the Morgantown Energy Facility. This percentage is from the EPA's overview report on dry cooling facilities, http://www.epa.gov/waterscience/316b/technical/ch4.pdf.
[6] Afonso, Rui (2001). Energy and Environmental Strategies for the Clean Air Task Force. "Dry vs. Wet-Cooling Technologies."
[7] Bill Cannon of Allegheny Energy and Tim Mallen of American Electric Power provided guidance on calculation of water use related to scrubber installation.
[8] DEP Water User Survey, 2005.

These quantities do not include water consumed by utility employees in operation of utility offices. This consumption is calculated separately and included in the category referred to as "Rest of Economy." While some overlap may exist, as power plants also report water used in plant offices, the majority of utility employees are not located on site of a power plant. Utility employment is dispersed throughout the state and is represented in 54 counties. This employment also includes those employed by water and gas utilities. And, while power generation is expected to increase by two percent annually over the next five to six years, total employment in the utility industry is projected to decline by 1.6% per year. A spatial representation of the counties expected to see growth in water use resulting from increased thermoelectric power generation is shown in Figure 5.

Figure 5



** Preliminary Estimates*

IV. MANUFACTURING

Manufacturing water use was evaluated by county at the six-digit industry code and aggregated at the county level. Water use is a function of the number of employees in an establishment. Because manufacturing employment is projected to decline over the next five years, water consumption from manufacturing is also projected to decline in most counties. The 14 counties that have been experiencing growth in manufacturing employment are projected to continue that trend, at rates of either two or three percent a year. These counties are: Boone, Greenbrier, Hardy, Mineral, Mingo, Monongalia, Nicholas, Ohio, Preston, Putnam, Raleigh, Randolph, Ritchie and Wirt. Again, these

counties are projected to have increases due to the recent trends of increasing employment and the expectation that these trends will continue. The remaining counties are projected to experience declines in water use, also in continuation of recent trends.

The distinction between withdrawals and net consumptive use is very important, yet difficult to estimate for this category of economic activity. While reported and estimated withdrawals are considered to be good approximations of actual water used in the manufacturing processes, net consumption is much less accurate. This is the result of several factors:

- Varying reporting methods on water discharges
- Lack of reporting on some sub-industries
- Lack of estimates on many sub-industries. Most published estimates of consumption tend to provide ranges of consumptive use in manufacturing and those ranges are not specific to individual manufacturing sub-industries.

CBER's calculation of consumptive use, based on total withdrawals and discharges reported to the DEP, varied considerably, in some cases even within the same six-digit industry. Several manufacturers also reported negative water use numbers, where total water withdrawn minus total water discharged is less than zero. This is presumed to be a function of the NPDES standards and tendency to overestimate the quantity of discharges in compliance with temperature release standards, combined with the reporting of storm-water runoff from facilities. For example, in the chemical manufacturing industry, reported net use ranged from -475% to 92%. This type of reporting is standard practice for many industries, but to avoid reporting negative consumption for this analysis, assumptions were made regarding internal water use rates.

Where positive net consumption was reported, these ratios were applied to other establishments in the same or similar manufacturing NAICS code. If a facility reported negative net use and no information was available regarding actual net internal water use for a similar manufacturer, it was assumed that the facility used 25% of its withdrawals for consumptive use. Due to the large number of manufacturers that reported negative net use and the large number of industries that were not represented in the DEP survey, the 25% rate was assumed for about two-thirds of the 1,017 county-specific manufacturing industries evaluated. By contrast, a net use rate of 15% was applied to non-manufacturing industries that typically operate out of commercial office space. It is expected that the 25% net rate overestimates some industries and underestimates others. However, due to the lack of available data this is a fair approximation, although due to the range of use estimates these calculations are considered preliminary.[9]

Total manufacturing net water consumption projected for the state is in line with overall forecasted employment decline this sector. The counties that are projected to increase water use due to increased employment in manufacturing are shown above in Figure 5.

[9] The USGS estimates that self-supplied industrial water users' net consumption is between 10 and 40 percent of withdrawals.

V. RESIDENTIAL

This consumption is estimated at the county level. Input data and assumptions to the analysis are as follows:

- Metered sales in gallons to residential customers and the annual average of the monthly number of customers were used to derive average household consumption.
- Data was compiled for 2003, 2002 and 2001 as it was available for each of the public service districts.
- The zip code of the primary city for each of the service districts was used to determine the representative county for further calculation. (Many public service districts transcend zip code and/or county lines and accurate determination of the exact portions of counties served by any individual service district was, at this point, impossible to establish).
- Zip code level consumption data were aggregated to the county level with the support of the US Census 2000 American Fact Finder database.
- Average annual consumption data was weighted by the number of residential customers observed as purchasing metered service (households) to derive a county-level consumption figure.
- All but 6 of West Virginia's 55 counties provided a reliable estimate of annual water consumption per household using this method without modification.
- Data for Randolph and Ritchie Counties were obtained from the public service district annual reports. However, careful examination indicated that the resulting figures for these two counties were outliers as compared with the remaining observed averages as they were in excess of 5 standard deviations of the mean consumption level for all observed averages within the state.
- Averages for Cabell, Doddridge, Gilmer and Wirt Counties were not available from the public service district annual reports.
- To develop workable averages for these 6 counties, a spatial average was calculated based upon the counties bordering the counties with the absent consumption value. These were also weighted by the number of observed residential customers in each tabulated county. The number of counties used to calculate each new figure was necessarily limited by the geography and established boundary lines.

Population estimates from the U.S. Census Bureau were used to gather an average annual rate of population change for each of West Virginia's 55 counties.

- Estimated population changes from the Population Estimates Program at the U.S. Census Bureau for each year, beginning in July, were used to determine the average rate of change at the county level.[10]
- Straight line projections for each year, 2005 to 2010, were maintained for counties. The straight-line method employed in these calculations appears to follow in-line with state level population projections through the year 2010 also produced by the Census Bureau. However, the state level projections indicate a marked declined in population for estimates in 2015, 2020, 2025 and 2030. This indicates that using the

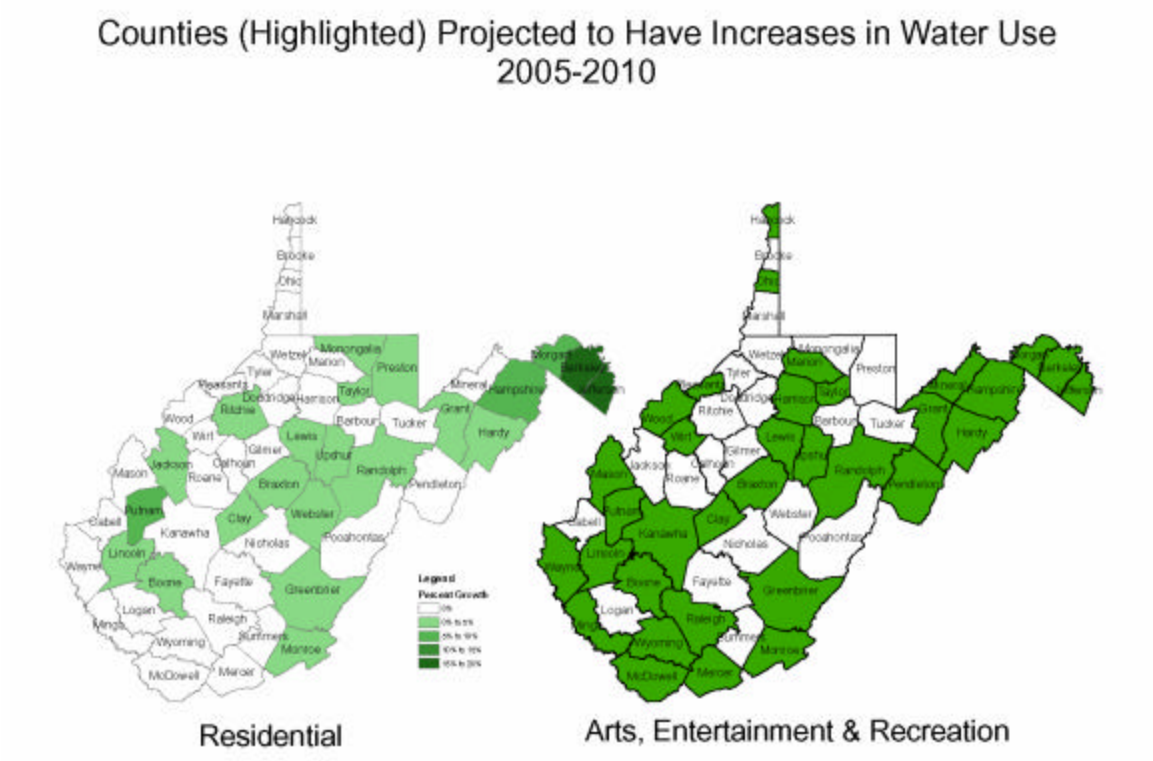
[10] http://www.census.gov/popest/counties/

straight-line projection for population change beyond the 2005-2010 time period would be unreliable.

- Using the annual rate of population change for each county, population estimates for each year in the projection period 2005 to 2010 were calculated.
- The approximate number of households for each year was calculated via an estimate of average household size from the 2000 U.S. Census Summary Tape File 3 Long Form (1 in 6 sample).
- Average annual consumption patterns from the public service districts aggregated to the county level were then applied to the population projections to estimate annual water consumption in gallons per county.
- A range for each county using a +/- one standard deviation from the mean of all observed consumption patterns was also developed as a check figure to ensure the likelihood that the estimates were reliable.
- No significant outliers were observed upon comparison of the estimates and their expected ranges.

Figure 6 shows the expected change in residential water use by county. As expected, the largest increases are concentrated in the Eastern Panhandle and Putnam County.

Figure 6



** Preliminary Estimates*

VI. ARTS, ENTERTAINMENT AND RECREATION

Golf courses are the majority consumer of water in this sector, and consumption for this category of activity varies considerably. Golf courses in the DEP survey reported gross consumption equal to net consumption of between 1,800 GED for a small course and 15,000 GED for a larger course. For the purposes of this analysis, if a golf course employed 20 people or less it was considered a small course, and the 1,800 GED net consumption rate was applied. For larger golf courses the larger rate was applied. According the WVBEP, forty counties in West Virginia have golf courses.

Most other categories of activity were assumed to consume 175 GED. This rate was taken from the USGS survey and was applied to include health and fitness centers, racetracks, performing arts centers and bowling centers, and other types of recreational facilities. A 15% net rate of consumption was applied. Due to projected overall industry growth, within this category more counties are projected to have increasing water consumption than decreasing. Overall net consumption rises from about 14.2 mgpd to about 14.7 mgpd. Figure 6 above provides a spatial representation of counties expected to see increased water use from increased economic activity in this sector.

VII. FORESTRY, FISHING, HUNTING AND AGRICULTURE

Farm animals comprise the bulk of water use in this category. County level data on the number of animals was combined with estimates of water use per animal to calculate total withdrawals for this sub-group. All 55 counties have livestock. The number one livestock producing county and thus water consuming county for this activity is Hardy County, followed by Pendleton County and Grant County. Water use per animal per day was calculated as follows, based on data estimated by the Pennsylvania State University[11]:

- Milk Cows (50% of cattle) – 35 gallons
- Dry Cows (beef cattle or steers, 25% of cattle) – 12 gallons
- Calves (10% of cattle) – 3 gallons
- Heifers (15% of cattle) – 8 gallons
- Swine – 1.5 gallons
- Horses – 12 gallons
- Sheep or Goats – 2 gallons
- Chickens (per 100 head) – 9 gallons
- Turkeys (per 100 head) – 15 gallons

A net use coefficient of 80% was applied for livestock. This rate represents that estimated by a number of eastern and mid-western states including Illinois, Indiana, Michigan, Minnesota, Ohio and Pennsylvania.[12]

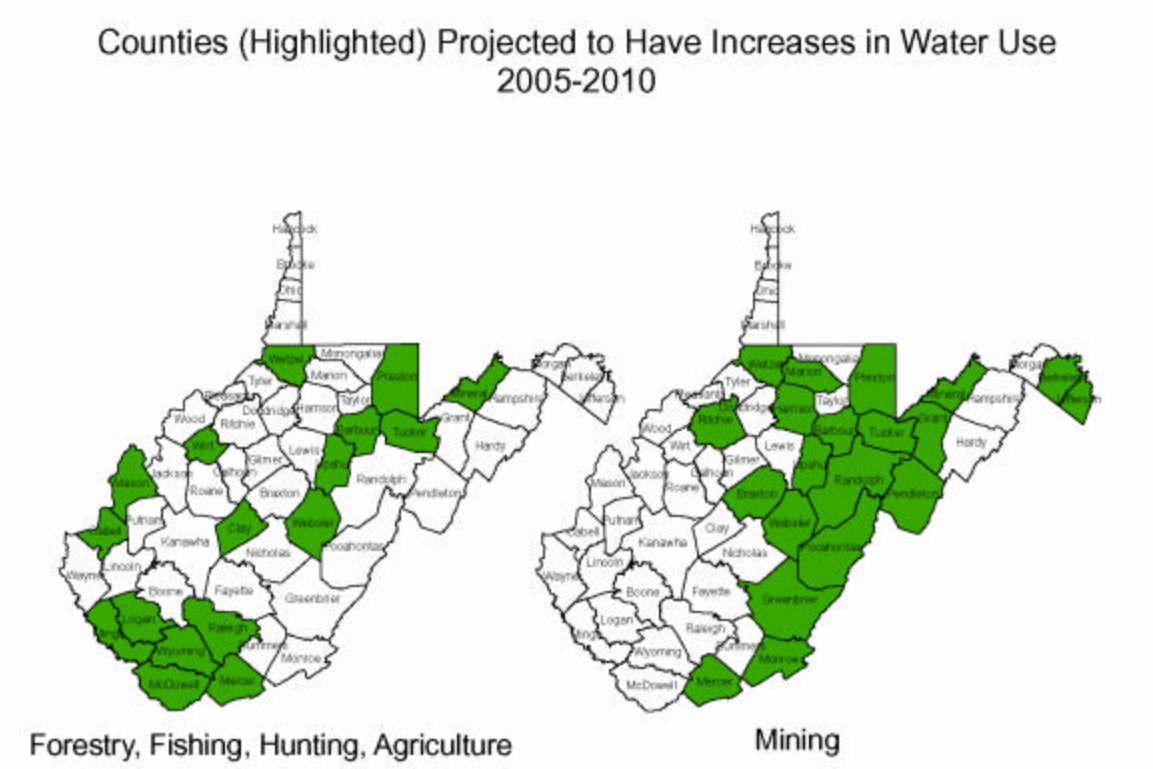
[11] The Pennsylvania State University, College of Agricultural Sciences (2003). "Estimating Water Use For the Farm and Home."

[12] Great Lakes Commission and the Water Withdrawal and Use Technical Subcommittee of the Water Resources Management Decision Support System Project, 2003. "Measuring and Estimating Consumptive Use of the Great Lakes Water"

Other categories of water use in this industry are fruit and vegetable crops and logging. Little data or estimation was available regarding water use for crops or for logging. The USGS estimates provides gross use coefficients of 25 GED for some crops and 1,600 GED for logging, but does not estimate net consumption. These rates were applied based on the number of employees in each of these categories, with a net use rate of 90% assumed for crop production.[13] A net use rate of 2% was assumed for logging. No timbering operations were included in the DEP survey and no alternative source could be found that provided an estimate of consumption for that industry.

As described in Table 1, the state is projected to experience declines in employment in this economic sector. Water use is projected to decline at about four percent per year, although the counties that saw recent growth in this sector are projected to experience a one percent annual increase in water use. These counties are shown in Figure 7 below. This industry is worthy of additional analysis, as it is possible that efficiencies of production could overcome employment changes and the direct water use to employment relationship assumed.

Figure 7



** Preliminary Estimates*

[13] Ibid.

VIII. MINING

Coal Mining

Estimation of both withdrawals and net consumption for the coal industry is difficult. Reported withdrawals per ton of coal mined varied considerably when calculated using a per ton or per employee rate. This is most likely the cause of the varying amount of water required for different grades of coal and different mining techniques. While most coal requires processing, some low sulfur, surface-mined coal often requires little processing and can be shipped run-of-mine.

Tonnage was chosen as the unit of consumption to evaluate due to the availability of county-level production numbers and the ability to forecast those levels. The DEP's water use survey provided a range of water use per ton. For operations where the combined mining and processing tonnage was known, the middle range was about 30 to 40 gallons per ton for mining and about 60 gallons per ton for processing. Based on these numbers, a rate of 95 gallons per ton was applied to total coal production to arrive at an estimate of water withdrawals for the 27 counties that produce coal.

The source of water used for mining is also worthy of further analysis. Groundwater that is transferred to the surface as part of the dewatering process prior to underground mining is not considered consumptive use. This practice applies most often to underground mines as groundwater is typically re-injected into the geological formation. Surface mines do not re-inject groundwater and any resulting displacement of groundwater is thus consumptive. Based on the DEP survey results, it is not possible to get a complete picture of the quantity of groundwater transferred. The encountering of groundwater during the mining process is a function of the water table, and the need to use groundwater for processing or dust control depends on the availability of other sources. Both these variables are not uniform in mining regions and may vary considerably by surface and underground operations.

About one-third of mining operations reported use of groundwater, with portions that ranged from 2% to 100%, and an average of 20%. For this analysis it was thus assumed that 20% of water used for mining is displaced groundwater, and that that rate represents net consumption for mining. This rate was applied to forecasted county-level coal production to arrive at net water use for this industry of nine mgpd in 2005. However, because the survey sample is not a statistically significant representation of either surface or underground operations for either mining or preparation, this rate is considered preliminary and needs additional analysis.

County-level coal production was calculated based on historical trends and accounts for differences in surface and underground mining. Each county's portion of total coal production was projected to remain constant through 2010, as was their portion of surface and underground coal production. Total production in West Virginia was based in part on the "Consensus Coal Production Forecast for West Virginia"[14] That forecast was pushed

[14] Hammond, George W, 2004. West Virginia University, Bureau of Business and Economic Research.

out by two years to account for the recent and sustained increase in coal prices and production experienced in 2004 and to date in 2005. Projected county-level increases and decreases and shown above in Figure 7.

It is likely that other variations in mining operations could also impact the quantity of water used. For example, some surface-mined coal in the southern part of the state may require less processing water per ton than surface-mined coal in the north. However, due to the difficulties of estimating what portion of production this might be, all coal was assumed to require the same quantity of water per ton, and no distinction was made between location or mode of production. Again, due to regional variation in mining and processing techniques and the resulting variation in water consumption, further analysis for this industry group is recommended.

Stone Quarries

One limestone quarry reported water consumption to the DEP. That rate was applied to all limestone quarries in the state based on the GED reported by that single producer. That reported GED was 12,078. Net use was reported as 10%. These rates were applied to operations in all 19 counties for which the DEP reported this type of mining. Use is projected to increase slightly, in line with overall mining employment.

Oil Production

West Virginia produced 1,339 barrels of oil in 2004. Of this quantity, about half is produced using secondary oil recovery methods, including water injection.[15] Wells that use production water re-inject that water back into the geological formation and the use is non-consumptive. Water injection wells that use non-production water and where water is not returned to the originating body are considered consumptive use. Thus, for this analysis only production of that nature is included. In West Virginia, this type of use is confined to Wetzel County, where production is expected to increase and by 2010 water use will return to 2003 levels for this activity.

IX. OTHER INDUSTRIES

The following industries' gross water use is based on the withdrawal estimates calculated by the USGS survey. The growth projected for most of these industries is representative of overall growth in the service sector, with much of the impact on demand for water to be seen in increasing demand from commercial buildings. The large majority of these industries will demand water from public supply.

With the exception of public administration, these industries are projected to experience overall annual employment growth through 2010, at rates of between 0.2% and 2.3%. Net

[15] Energy Information Administration, 2005.
www.eia.doe.gov/oil_gas/petroleum/info_glance/crudeoil.html.

water is assumed to be 15%. The combined total water consumption for these industries is less than the each of the other industries profiled thus far.

Accommodation and Food Services. A gross water use coefficient of 187 gallons per employee per day was assumed for this category of activity. Positive growth is expected for all but 12 counties.

Construction. A gross water use coefficient of 20 gallons per employee per day was assumed. Growth is expected for 23 counties and overall growth leads declines.

Utilities. A water use coefficient of 7 gallons per employee per day was assumed for utility services. With the exception of Doddridge County, all counties have employment in utility services. This level of activity excludes the power generation process. That water use is accounted for separately under thermoelectric power generation. Growth is expected in 23 counties. Overall, declines lead increases.

Wholesale Trade. This category is broken down into durable and non-durable goods. A water use coefficient of 21 GED was assumed for durable goods, and a coefficient of 77 GED was assumed for non-durable goods. Employment in the two categories varies by county, with most counties having more activity in durable goods. State-wide, about 60% of the employment occurs in non-durable goods. However, as expected, the more agricultural counties have larger portions of employment in non-durable goods. The range for the population of counties is 21, for four counties with no wholesale activity in non-durable goods, and 77 for two counties with no wholesale activity in durable goods. Growth is expected in 18 counties.

Educational Services. A gross water use coefficient of 56 GED per day was assumed for this category of activity. Growth is expected in 23 counties.

Healthcare and Social Assistance. A gross water use coefficient of 70 GED was assumed for this category of activity. Growth is expected in all but nine counties.

Retail Trade. A gross water use coefficient of 31 GED was assumed for this category of activity. Growth is expected in 20 counties.

Other Categories. Industries with businesses that operate out of commercial office space are assumed to have gross water use of 47 GED. These include: Administration, Support, Waste Management and Remediation, Information, Finance and Insurance, Real Estate Professional, Scientific and Technical Services, Management of Companies and Enterprises, Public Administration, Other Services, Unclassified Establishments and Transportation and Warehousing.

With the exception of Public Administration, growth is expected in all these industries statewide. That growth is spread throughout West Virginia's 55 counties, with more counties seeing growth than declines for these activities.

X. SUMMARY AND CONCLUSIONS

This analysis projects net water consumption for the State of West Virginia based on forecasts of economic activity. Consumption is calculated at both the county and industry level. The largest increase in water consumption is expected to occur in thermoelectric power generation. Other increases are expected in the food and lodging industry, the recreation industry and in what is termed for this analysis, the "rest of the economy" that represents the service industries, education, healthcare and construction. Over the 2005 to 2010 time period, small declines are projected in the mining industry and larger decline in the agriculture and manufacturing industries.

By county, changes in water use are a function of expected levels of economic activity. For this report, this is an expectation of the continuation of recent trends. Thus, growth in water consumption is located in most of the Eastern Panhandle, the northern counties with the exception of the Northern Panhandle, and the counties in which power generation facilities are located. Declines in consumption are expected in most of the mid-Ohio valley counties, many of the central counties, the southern counties and in the eastern counties due to declines in agricultural employment. Overall, 19 counties are expected to have growth in water consumption and growth leads declines as West Virginia as a whole is projected to see growth of 3.7% over the forecast time period.

The estimates reported here should be considered imperfect, but reasonable approximations of actual consumptive water use. Projections for most sectors could be improved with more thorough evaluation and more data. A primary issue is the calculation of net versus gross consumption. Little data exists on which to base net consumption equations. A more in-depth review of the DEP user survey combined with acquisition of other state data could prove informative and help to refine these preliminary estimates.