APPENDIX M

ANIMAL AND IRRIGATION WATER USE IN PENNSYLVANIA IN 2002, 2010, 2020, AND 2030

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EXECUTIVE SUMMARY

The purpose of this project was to estimate the volume of water that was expected to be used by agriculture in Pennsylvania on irrigated onto plant production units and used by animal production units in the years 2002 and projected to be used in 2010, 2020, and 2030. It was assumed that the growing seasons (March to October) of 2010, 2020, and 2030 will have 10-year return period droughts.

The number of irrigated acres of for each crop was taken from the United States Department of Commerce National Agricultural Statistics Service (NASS) for the years of 1982, 1987, 1992, 1997, and 2002. Total irrigated crop acreages were collected as well as irrigated acreages in corn (for grain and silage), vegetables, orchards, and berries. The irrigated crop acreages were summarized for each county, plotted as a function of year and extrapolated to 2010, 2020, and 2030 using multiple linear regression with year of interest and growing season rainfall deficit as independent variables (Appendix C). The estimated maximum 7-day water needed for irrigation in each county and for each crop are presented in Chapter 5 with additional details in Appendix D. Based on this analysis, the maximum daily ($Q_{7\text{-}10}$) water needed for Pennsylvania was about 140 MGD for all crops in 2002; a year with a 1.2- to 1.8-year drought. Under the assumption that 2010, 2020, and 2030 would experience a 10-year drought, 245, 304, and 360 MGD, respectively will be needed to meet the $Q_{7\text{-}10}$ requirement in each of these years.

An annual analysis of irrigation water needs was also completed, which showed that about 11,300 MG of water was used for irrigating crops in 2002, which had a drought return period of between 1.2 and 1.8 years. Under the assumption that 2010, 2020, and 2030 would experience a 10-year drought, 22,500, 27,900, and 33,300 MG, will be needed for irrigating crops in each of these years, respectively, see Chapter 6 and Appendix E for details.

The animal populations were taken from the United States Department of Commerce NASS for the years 1982, 1987, 1992, 1997 and 2002. The animals taken into consideration for this study were cattle (milk, adult cows, and young cattle), poultry (young birds, layers, broilers, and turkeys), swine, sheep, goats, and horses. Within each county, the populations of each animal were plotted as a function of year and extrapolated to 2010, 2020, and 2030 using a straight-line extension of the 20 years of available data. These estimated animal populations and resulting water needed for each species are presented in Chapter 9 with additional details in Appendix F. Based on this analysis, about 48 MGD of water was used for raising animals in 2002. Animal water use is expected to require 49, 50, and 51 MGD for 2010, 2020, and 2030, respectively.

Using these irrigated cropland and animal estimates, the maximum daily water requirement for agriculture in 2002 was 188 MGD. In 2010, 2020, and 2030 assuming a 10-year drought occurs in each of these years, agriculture is expected to have a maximum daily water requirement of 294, 354, and 414 MGD, respectively, see Chapter 10.

Finally, estimates were made of how much agricultural water was already registered in comparison to how much should have been registered in each county, see Chapter 12. When the monthly registration data was used to identify registered irrigation and animal water, there was considerable water that could be identified as un-registered. When the total registered volumes were compared to the water needed in each county for all agricultural water use, there was actually more water registered than is expected to be needed by agriculture.

CHAPTER 1

Scope of Work

The goal of this project was to estimate the maximum quantity of water used by both animal production units and irrigated on to plant production units within the Commonwealth of Pennsylvania. The irrigation water needed for plant production units to supplement natural rainfall with irrigation will be based on a 10-year drought when producers are most likely to irrigate at a level that will stress the available water resources of the Commonwealth. Total water needed for agriculture, both for crop irrigation and animal production, was developed from the Ag Census/Ag Statistics data (National Ag Statistics Service (NASS)). If practical, the estimates reported will be based on water used by production units large enough to require more than 10,000 gpd. The study focused on the 2002 NASS data, which was the latest available data available. NASS data from 1982, 1987, 1992, and 1997 were used to establish trends in crop acreages irrigated and animal populations, which were used to extrapolate agricultural water use to 2010, 2020, and 2030. PADEP also supplied partial results from the agricultural water registration program. These data were available to verify and it was hoped that these data could be used to establish how many farmers in each county should have registered. The hope was that with a record of those who had registered and how much water was needed in total by agriculture, those farmers who had not registered, and should have, would be identified. This was impossible from the data supplied. It was also hoped that it might be possible to identify how much of the water used by agricultural production units was being used on farms large enough to use more than 10,000 gpd; thus needing to register their water use. There was nothing in the NASS data source or the registration data supplied by PADEP to make this extrapolation of the water use data. The water use data for the current (2002) results and the predictions of how much water will be needed in the future were delineated into the monthly and annual animal and plant irrigation water use needed in each county. Summarization of the county results to include the three major watersheds (Ohio, Susquehanna, and Delaware) and other smaller watersheds will be the responsibility of PADEP.

Estimates of maximum agricultural water use for the years 2010, 2020, and 2030 were evaluated on a county-by-county basis. These estimates specifically delineate the water needed for both animal and irrigated crop agriculture and are presented on a monthly, annual and county basis.

- **Estimating Crop Irrigation Water Use:** Irrigated crop acreages were available from NASS, which published summaries every five years. The crops that are most often irrigated in Pennsylvania are small fruits, turfgrasses, tree fruits (apples and peaches), vegetables, potatoes and corn. Turfgrasses will not be included in this study. The acreages taken from the NASS data and extrapolated into the future were multiplied times the water-needed results from the PA-DER (1978) study to convert crop acreages grown in Pennsylvania to equivalent depths of water needed for irrigation in Pennsylvania. The influence on irrigated crop acreages by the local climatological data (USDC, 1974) resulted in excellent extrapolations to determine the irrigated acreages in 2010, 2020, and 2030.

  These results were summarized to determine the annual irrigated water needed during each month during a 10-year drought. These monthly water use values were then summarized for each major crop, each month of the growing season, and within each county.

- **Estimating Animal Water Use:** Animal populations for each county within the state are available from the NASS, which are published every five years. The county-wide animal populations for cattle, swine and poultry as well as horse, goats and sheep were collected from data published since 1980. The latest census data will form the basis for estimating the current agricultural animal water needs within each county. These animal populations were extrapolated to yield animal populations in 2010, 2020, and 2030. Using the extrapolated animal populations, the average water intake (by drinking) for each animal will be applied to compute total animal water use in 2002 (the current use level), 2010, 2020, and 2030.

PART I

Irrigation Water Assessment

CHAPTER 2

Irrigation Water Needs Assessment

The irrigation water needs assessment consisted of three parts; (1) estimate the present annual and Q_{7-10} irrigation water needs for each County based on the most recent (2002) irrigated acreages available, (2) extrapolate the historical (1982, 1987, 1992, 1997, and 2002) irrigated acreages to predict the 2010, 2020, and 2030 annual and Q_{7-10} irrigation water needs in each County, and (3) attempt to estimate what portion of the irrigating farmers in each County who have already registered (or have not registered) their water use with PADEP. The present (part 1) and extrapolated (part 2) irrigation water needs assessment for each County and the state are contained in the EXCEL spreadsheet named “Irrigation Projection Analysis*.xls” found on the CD in the rear pocket. The sheets named “Soils Data”, Weather”, “BaseI”, and “Irrig” contain the data and the various analyses performed. The results of the irrigation analysis are summarized on a county-by-county basis on the sheet named “Summary”. The county and state irrigation and animal water need results are also combined and summarized into a separate spreadsheets named “Water Results*.xls”, which are also on the Report CD. The “*” in the name of each spreadsheet mentioned above refers to the first letter of the counties included in each spreadsheet. The spreadsheets that include the number “7” contain the Q_{7-10} analyses.

The registration analysis (part 3) for each County and the state is contained in the EXCEL spreadsheet named “Registration Analysis”. The sheets named “Soil Data”, “Weather”, “Reg”istration, “BaseI”, and “Irrig” contain the data and the various analyses performed. Again the results are summarized on a sheet named “Summary”.

Acreages of irrigated land in each county were available for several crops. The acreages of corn (for grain + for greenchop or silage), all vegetables, orchards, berries and the total irrigated acreage for each county were taken from the NASS data base. Unidentified irrigated acreages (total – corn – vegetables – orchards - berries) were then calculated and identified as “unknown crops”. One of the difficulties with trying to use NASS data was that NASS is careful to protect the reporting farmers from identification. Therefore, when a county had only a one, or a few, reporting farmers in a crop category, NASS reports how many farmers reported irrigated acreage in that crop, but they will not identify how many acres were irrigated. For instance, under acres of corn for grain irrigated in Adams County in 1987, there were only 2 farmers reporting irrigated corn. Therefore, NASS reported that “2” farmers irrigated corn, but because it might be possible for a local person to figure out which specific farmers these two farmers might be, NASS did not report the total acres of corn these two farmers irrigated; instead they simply report the acreage as “(D)”. These holes in the data sets caused some concern during this analysis because on the one hand it is misleading to report the “(D)” as zero acres irrigated, but it is also impossible to know how many acres were actually irrigated. This problem was solved by artificially inserting a number into the analysis. These numbers varied with the different crops irrigated. In the case of berries, we assumed a “(D)” was equal to 2 acres/farm. In the case of most other crops the “(D)” was assumed to be 5 acres. If you look at the specific data in the spreadsheets, these estimated values are evident because they are rounded to 1 or 2 significant figures while the actual NASS data are reported to the last acre.

Present Irrigation Water Volume

The present irrigation water needs in each County were estimated from the irrigated acreages reported in NASS (2002). The NASS irrigated crop acreages were multiplied times the monthly irrigation water depths needed in each County on a annual or Q_{7-10} basis (Chapter 3) to determine the volume of water needed for irrigation in each County under the present circumstances. These data are in attached EXCEL spreadsheet named “Irrigation Projection Analysis” in sheet “Irrig” and summarized in sheet “Summary”.

Extrapolated Future Irrigated Water Volume

The extrapolated irrigated acreage predictions for 2010, 2020, and 2030 were based on a linear equation fit to the historical irrigated acreages from 1982, 1987, 1992, and 1997 (NASS, 1982, 1987, 1992, 1997) and the irrigated crop acreages for 2002 used to determine the present water needs to produce the minimum sum of squares between the actual and predicted acreages.

The procedure for extrapolating the historical irrigated acreages between 1982 and 2002 to predict the irrigated acreages expected in the future years of 2010, 2020, and 2030 required that we identify one or more parameters that were expected to influence a grower’s decision to either purchase or put-into-use an irrigation system. The two most important parameters were (1) the years of interest (1982, 1987, 1992, 1997, 2002, 2010, 2020, and 2030) and (2) the precipitation deficit for each growing season. For the historical years in the analysis, the actual growing season precipitation deficits were used. For the extrapolated years (2010, 2020, and 2030) the precipitation deficit expected during a 10-year return period drought in that region of Pennsylvania was used.

Effect of Year. The correlation to the year of interest, Y is essentially the understanding that if we look at acres irrigated in 2002 and compare these with acres irrigated during any earlier year, the more recent year will have more irrigators (or acres irrigated). Growers tend to adopt irrigation technology with time and when they are faced with a particularly dry growing season (when crops are essentially lost to drought) they may be stimulated to purchase an irrigation system. Once purchased, this grower will have a tendency to use his/her irrigation system, especially during years when rainfall is below normal.

For purposes of developing an equation that could be used to extrapolate irrigated acreages into the future years an equation of the form.

$$A(Y) = a_1 Y^{b_1} + c_1 \qquad (1)$$

Where A is the acres irrigated in year Y, a_1 is the slope of the best fit line, b_1 is the exponent and c_1 is the intercept where this best fit line crosses year zero.

Effect of Precipitation Deficit. The other strongly correlated parameter was the precipitation deficit that occurred during each growing season. Precipitation deficits were developed from the Pennsylvania climatological data summaries as described in Chapter 4. For purposes of developing an equation that could be used to extrapolate irrigation acreages into the future years, the acreages were related to the precipitation deficits, D as

$$A(Y) = a_2 D(Y)^{b_2} + c_2 \qquad (2)$$

Where A is the acres irrigated in year Y, a_2 is the slope of the best fit line, b_2 is the exponent and c_2 is the intercept where this best fit line crosses the zero deficit. By adding equations 1 and 2 the following predictive equation is formed.

$$A(Y) = a_1 Y^{b_1} + a_2 D(Y)^{b_2} + c_1 + c_2 . \qquad (3)$$

Since c_1 and c_2 are constant intercept coefficients, they can be replaced with a single coefficient, Const = $c_1 + c_2$. When b_1 and b_2 were set equal to 1 (unity), as they were in these evaluations, equation 3 is a linear multiple regression equation. Thus, the extrapolation equation fit to each crop in each county to determine the irrigated acreages expected in 2010, 2020, and 2030 was:

$$A(Y) = a_1 Y + a_2 D(Y) + Const \qquad (4)$$

Various a_1, a_2 and Const coefficients were tried using the "Solver" routine in EXCEL to determine the set of coefficients that yielded the minimum sum of squares, S_{min} where S_{min} was defined as:

$$S_{\min} = \sum_{1}^{n} (A(Y) - A_a(Y))^2 \qquad (5)$$

Where $A_a(Y)$ is the actual acres irrigated in each of the years for which NASS irrigated acreages were available between 1982 and 2002 and the predicted acreages for 2010, 2020, and 2030 (n = 8). This extrapolation procedure was applied to five crops or crop categories in each County. These crops or crop categories were Total Land Irrigated, Corn (total of corn for grain and corn for greenchop), Orchards, All Vegetables, and Berries. The results of each extrapolation are shown with the irrigation data (sheet "Irrig") in the attached "Irrigation Prediction Analysis*.xls" spreadsheets. The acreages predicted to be irrigated were assumed to be the same whether the subsequent analysis was for the annual or $Q_{7\text{-}10}$ assessment.

Assessment of Present Registrations

Included in NASS (2002) are data that tell how many acres of land is under irrigation in each County based on the size of the farm. These data were used to determine the average number of acres of land irrigated on each size of farm. By knowing how much water is likely to be used for irrigation in each County, we could determine approximately how many acres of irrigated land would be needed before the farmer probably used more than the 10,000 gpd trigger volume required for registration. PADEP also supplied the results of the individual farmer water registrations. By making several reasonable assumptions we were able to estimate each of the following parameters for each County:

- Total number of farms irrigating.
- Number of farms irrigating a large enough acreage to require registration based on the 10,000 gpd registration limitation.

- Number of irrigating farms that already registered.
- Total water needed for irrigation in MG.
- Total irrigation water registered in MG.

These results are located in the “Irrig” sheet of the attached “Registration Analysis” spreadsheet and summarized in the sheet named “Summary”. These results are summarized in Chapter 12.

CHAPTER 3

Irrigation Needs for Each Crop

Pennsylvania Irrigation Water Requirement Reports

Many published reports provide information about Pennsylvania's irrigation water requirements. The most important of these are summarized and evaluated below.

1955 Pennsylvania Guide for Sprinkler Irrigation Design. The earliest known report was the Pennsylvania Guide for Sprinkler Irrigation Design (SCS et al., 1955). This Guide was developed by SCS personnel and was written for SCS Farm Planners. This report pointed out the need for good soil and crop management as well as the need for a good water supply. It also identified the major components of a good sprinkler irrigation system and its design. It then divided all Pennsylvania soils into 11 Irrigation Soil Groups and delineated maximum application rate, a wide variety of crops to be considered, their rooting depths and respective available moisture capacities plus each crop's design depth (depth of irrigation water to be applied during each irrigation application), irrigation interval (how many days there should be between irrigation applications) and consumptive use. Finally several graphs were given to help farmers and planners know what maximum volume of irrigation water may be needed over a 30-day drought period based on selected pumping rates. No attempt was made to estimate how often irrigation might be needed or what impact natural precipitation might have on total irrigation water needs. They did indicate that tree fruits, commercial vegetables, truck crops, cabbage, potatoes and improved pastures usually paid the highest cash return for the irrigation system capital invested.

Estimates of Supplemental Water Needed by Forage Crops in Pennsylvania. Dailey et al. (1960) used climatological data from 36 Pennsylvania weather stations covering the 32-year period from 1925 to 1956 to determine the depth of irrigation water needed to grow forages in Pennsylvania. Their soil moisture simulations were based on the following assumptions:

- That forage crops do not need supplemental water before May or after September.
- That 3.0, 3.5, 4.0 and 4.5 inches of available moisture in the root zone at field capacity would cover most irrigable soils in PA.
- That all soils were at field capacity on May 1 of each year.
- That 0.2 inches of water per day would be applied by the irrigation system. This 0.2 inches was assumed to include a safety factor that covered the system losses and the daily evapotranspiration.
- That supplemental water was not applied on days when total rainfall exceeded 0.2 inches.
- If rain raised the moisture content in the root zone above field capacity, the remainder of the rain was considered lost from the plant-growth system.

Their soil water budget was simulated using 55% of the available water as the "trigger" to start irrigation and irrigation was stopped when the root zone moisture content reached field capacity.

The results from this study were intended to aid in the design and management of irrigation systems and did not provide data that helped extrapolate irrigation needs into the future under excessive drought conditions.

Soil-Plant-Water Relationships as a Basis for Irrigation: Crop Response to Irrigation in the Northeast. Vittum et al. (1963) reported the crop yield responses resulting from many different irrigation trials on a wide variety of crops in the northeast U.S. during the period 1949 to 1960. A wide variety of "triggers" were tried including 25, 40, 50, and 75 % of the capillary depletion, once a week, and every 10 days. There was a significant crop yield increase when snap and lima beans received 1.5 to 3.0 inches of irrigation water per season. There was a significant crop yield increase when cabbage received 0.8 to 12.1 inches of irrigation water per season in Connecticut and New Jersey, but not in New York. There was a significant crop yield increase when potatoes received 1.5 to 11.3 inches of irrigation water per season. Sweet corn did not generally respond to irrigation, even when 1.8 to 6.5 inches of irrigation was applied during the growing season, but it did respond to larger amounts of water. In general tomatoes did not respond to irrigation. Like sweet corn, forage crops did not generally respond to irrigation unless very large depths (10 to 15 inches) of water were applied.

1972 Pennsylvania Irrigation Guide. USDA-SCS (1972) re-released the 1955 Pennsylvania Irrigation Guide. This time the soils were divided into 10 Irrigation Groups, with available moisture capacities delineated as a function of rooting depth. In addition to providing guidance on how to design an efficient sprinkler irrigation system, they delineated the monthly and annual depths of irrigation water that should be needed for apples, peaches, potatoes, sweet corn, tomatoes, small vegetables, and strawberries/small fruits during normal and dry years. No data sources or methodologies were given. Thus no explanation was given of how these irrigation requirements were derived. The authors believe these values are rather reliable and consistent with actual irrigation depths needed during Pennsylvania growing seasons. In addition, the guide provided a listing of Critical Periods of Water Needs for various crops.

Analysis of Water Requirements for Agricultural Irrigation in Pennsylvania. In 1977, PA-DER funded an extensive study designed to estimate irrigation water requirements for Pennsylvania agriculture (Kibler et al, 1977). This was a massive study that first identified the crops most likely to be irrigated in Pennsylvania along with each crop's growing season and rooting depth. It then identified the water-related soil characteristics for soils most likely to be irrigated in Pennsylvania. It included stream flow data for 30 small Pennsylvania watersheds and meteorological data for 65 Pennsylvania weather stations during the period 1948 to 1975, thus effective precipitation could be evaluated. It evaluated ET and then developed a daily soil moisture budget for each soil, each crop's rooting zone, and each geographic location to predict how much irrigation water would be needed as a function of 1.01-, 2-, 10- and 50-year drought return periods. They applied total seasonal, 7-, 14-, and 28-day water stress periods and determined the depths of irrigation water needed in each location as a function of crop rooting depth and hardiness. The results of this study were presented as the irrigation water needed to keep root-zone water levels within the optimum plant-growth limits during each of four sub-seasons (3/1-5/2) (5/3-7/4) (7/5-9/5) (9/6-11/7). These four sub-seasons encompassed the entire Pennsylvania crop-growing season. The study simulation model applied irrigation water when the root zone moisture content declined to 50% of root-zone available-water-capacity; This root-zone water-content is often called the irrigation "trigger" point; the root-zone water-content when irrigation should be initiated to keep the growing crops from experiencing water stress. On those occasions when irrigation water was needed (root-zone water-content reached the "trigger" point), the depth of water irrigated was the depth of water needed to bring the crop's root zone moisture content to field capacity. These irrigation depths were summed for the crop's entire growing season. These irrigation depths were then summarized by location, each of the four sub-seasons, each crop and for the drought return periods of 1.01, 2, 10 and 50 years assessed for periods of 7-, 14-, and 28-day precipitation amounts. This was a comprehensive study that produced reliable estimates of irrigation water needs in Pennsylvania and is as close to a comprehensive study of Pennsylvania irrigation needs as exists. The 7-day, 10-year return period results from this study are the basis for the $Q_{7\text{-}10}$ analysis reported herein.

Pennsylvania Irrigation Water Application: Planning and Management Guide. This PA-DER (1978) report is a summary of the irrigation water depth needed for the 1.01, 2, 10, and 50 year return periods extracted from the Kibler et al. (1977) study. The heart of this report is Table 2, which contains two sub-sections; one titled "Total Season Deficits" and a second titled "Maximum 28-Day Amounts". The Maximum 28-Day Amounts were copied directly from Table 12-3 of Kibler et al. (1977). The Total Season Deficits were proportionally adjusted from the Maximum 28-Day Amounts based on the total seasonal deficits computed at 12 selected locations across Pennsylvania, see Chapter 12 of Kibler et al. (1977). These Total Seasonal Deficits (see Appendix A) copied from PA-DER (1978) are the best-documented and most reliable total-season drought return-period based measures of irrigation water needs in Pennsylvania.

Hydro-Economic Analysis and Projection of Irrigation Water Demands in Pennsylvania. In 1981, PA-DER funded a second extensive study (Kibler et al., 1981) that attempted to relate Pennsylvania irrigation water use requirements to the economic climate of Pennsylvania's agriculture. Their intent was to assess how much of the upper bound irrigation based consumptive use water identified by Kibler et al. (1977) and copied into the PA-DER (1978) report was expected to be used by agriculture on an economical basis.

The major finding of this investigation was that irrigation of moderate value cash crops, such as potatoes, is economically justified in Pennsylvania provided the water can be applied near the optimal water-stress point of the crop. Net returns are maximized when crops are irrigated by means of hand-move, portable-set irrigation systems operated at a "trigger" point of 60% of the available moisture content.

They also developed an estimate of the maximum acreage that could be irrigated under optimum conditions without depleting the available water supplies below the 2-year, 30-day ($Q_{30\text{-}2}$) drought level. These upper bound values far exceed the irrigated acreages in Pennsylvania.

The results, reported by Kibler, et al. (1981), were developed entirely from ET and soil moisture data. There was no mention of crop yield reductions from other effects such as high or low temperatures, frost, insect damage, storm damage, field losses etc. In addition they spent a great deal of time considering the "trigger" point, the soil moisture level when irrigation is best initiated and the depth of water that should be applied each time one irrigates. They also indicated that these decisions influence the size of the irrigation system's pumps and pipes and therefore the overall cost of the system. In addition, the capital costs for irrigation are more a function of the actual application time a farmer sets aside for applying water than the "trigger" point. The bottom line is that we believe some of the assumptions behind the water stress index developed in this study are flawed and do not necessarily reflect real farm conditions or how irrigation decisions are made by real farmers.

One last concern we see in the Kibler et al. (1981) report results is in the potential availability of water for irrigation. This analysis assumed that all irrigated waters would come from surface water (streams). Therefore only lands in relative close proximity to existing streams were considered as potential irrigable lands. Historically, Pennsylvania farmers collect surface runoff or spring flows in ponds, pump irrigation water from streams or pump waters from ground water aquifers for irrigation. Two of these three sources can be, and often are, located great distances from flowing streams.

Irrigation Water Depth Data Selection Example

In order to show in detail how the irrigation water depth data was selected for this assessment, the following example will be used:

The example is to estimate of the quantity of water needed to grow potatoes. Potatoes were chosen for this example because they are one of the important crops irrigated in Pennsylvania. Potatoes are normally assumed to have a rooting depth of about 18 inches. The SCS Irrigation Soil Group #1 in Pennsylvania was selected because this analysis requires specific soil information; a SCS Group #1 soil should have the ability to store about 3.5 inches of water between field capacity and the wilting point in the potato's 18-inch root zone. Standard irrigation operating practice of (1) starting each irrigation application when 50% of the available moisture capacity has been used by the crop, and (2) irrigating until the soil moisture has been raised to field capacity was assumed. How this assumption is actually applied by an irrigating farmer is open to a great deal of interpretation. Farmers equipped to irrigate usually initiate irrigation when their crop begins to show signs of water stress. How much water they will apply (or how long they will let the irrigation system run before shutting it off) usually depends on what they have been told by an extension specialist, some other knowledgeable person, or their own judgment. Snyder County was randomly chosen as the Pennsylvania location.

Selection of Best Irrigation Water Depth Data for the Q_{7-10} Analysis

This section shows how the data presented in the reports reviewed earlier in this chapter can best be used to estimate the Q_{7-10} irrigation water needs in Pennsylvania.

Kibler, et al. (1977) Results. Kibler, et al. (1977) presented their total and seasonal soil moisture deficits in terms of the crop's hardiness (hardy, moderate, tender) and the crop's rooting depth. In our example, potatoes are considered to be “moderately” hardy and, as stated earlier, they have an 18-inch root depth. Thus for Snyder County, Table 3-1 summarizes the moisture deficits expected every 1.01, 2, 10, and 50 years for the 7-day analysis period.

These results are somewhat different from what most irrigation engineers are used to seeing. Kibler, et al. (1977) divided the growing season into four sub-seasons of nine weeks each. Their deficits represent the maximum depth of water the potatoes will need during any 7-day drought period within each of the four sub-seasons.

Therefore, by looking at these 7-day maximum deficits (see Appendix A), the maximum water needed for irrigation should be 0.88, 2.17, 3.46, and 4.58 inches for the 1.01-, 2-, 10-, and 50-year drought return periods, respectively. Since our analysis is focused on the 10-year return period, it is reasonable to expect a maximum 7-day irrigation water need of 3.46 inches to occur once every 10 years, most probably during the period from July 5th to September 6th.

Table 3-1. Maximum Soil Moisture Deficits For 7-Day Analysis Periods Predicted by Kibler, et al. (1977).

	Total Sub-Seasonal Deficits (inches)				
Drought Return Period (Years)	Mar 1 to May 2	May 3 to July 4	July 5 to Sept 6	Sept 7 to Nov 7	Maximum 7-Day Deficit (Inches)
1.01	0.05	0.66	0.88	0.67	0.88
2	0.15	1.55	2.17	1.30	2.17
10	0.25	1.91	3.46	1.94	3.46
50	0.32	2.03	4.58	2.49	4.58

It is clear from Kibler et al.'s (1977) documentation that these results are the depth of water that needs to be placed into the root zone to be used by the growing potatoes. Under normal irrigation practice, these irrigation depths need to be increased, by 30% for sprinkler irrigation and 5 to 10% for drip irrigation, to ensure that the total water needed by the potatoes reach the root zone. The extra water applied is expected to be lost to runoff, evaporation, deep percolation, etc. The design depths, from Table 3-1 should be considered consumptive use. The total depth a farmer would apply contains both consumptively used and non-consumptively used water.

Recommended Procedure

To generate estimates of the $Q_{7\text{-}10}$ depths of irrigation water needed for Pennsylvania agriculture, we recommend using the 7-day water deficit results from Kibler et al. (1977) and exemplified in Table 3-1 for our example to convert crop acreages grown in Pennsylvania to equivalent maximum 7-day volumes of water needed for irrigation in Pennsylvania. Each PA County's crop acreage-data will be collected. Crop acreages are available for each County 1982, 1987, 1992, 1997, and 2002 from the US Department of Commerce, United State Census of Agriculture (Ag Census, NASS).

After the acreages of each crop have been determined from the best available data, these irrigated crop acreages will be summed within each county and appropriate climatological data (see Chapter 4) will be regressed to yield a relationship that extrapolates the irrigated acreages to the years 2010, 2020 and 2030.

Once the 2010, 2020 and 2030 irrigated crop acreages have been estimated and the best available crop and rooting depth data assessed, the maximum 10-year return period irrigation water needs data for each county will be used, with the projected crop acreages to determine the maximum volumes of water needed in Pennsylvania for irrigation.

The Kibler et al. (1977) data are presented for four growing sub-seasons defined as March 1 to May 2, May 3 to July 4, July 5 to September 6, and September 7 to November 7. In order to determine expected 10-year drought return period water use values on the desired monthly basis, it was necessary to parse the available sub-seasonal results into values for each individual month. This was done by assigning a percentage of each sub-season's water needed depth to each of the months in that sub-season. Table 3-2 shows how these values were divided for each sub-season using the 10-year drought return period data from Snyder County shown in Table 3-1. The 10-year drought return period water use values from Table 3-1 are summarized into the first two columns of Table 3-2. The fourth column shows, by percentage how each of the sub-seasonal water needed depths were assigned to each month in that sub-season. For instance, the first sub-season, from March 1 to May 2, is expected to need 0.25 inches of irrigation water during a 7-day period once every 10 years to keep the potatoes from experiencing water stress. This 0.25 inches of irrigation was assigned to the months of March and April by assuming 20% would be needed in March and 80% would be needed in April. Likewise in the third sub-season, the 3.46 inches of irrigation water needed for July 5 to Sept 6, was divided equally (50% and 50%) to yield 1.73 inches in July and August.

Table 3-2. Percentages of Kibler et al. (1977) 7-day, 10-year Drought Return Period Sub-Seasonal Water Need Assigned to Each Month.

Kibler et al. (1977) Sub-Season	10-Year Sub-Seasonal Water Need (Inches)	Individual Months	How Each Sub-Season was Divided by Percentage (%)	10-Year Water Need Assigned to Each Month (Inches)
March 1 to	0.25	**March**	20	0.05
May 2		**April**	80	0.20
May 3 to	1.91	**May**	40	0.76
July 4		**June**	60	1.15
July 5 to	3.46	**July**	50	1.73
Sept 6		**August**	50	1.73
Sept 7 to	1.94	**September**	70	1.36
Nov 7		**October**	30	0.58
			Maximum =	**1.73**

Selection of Best Irrigation Water Depth Data for the Annual Analysis

This section shows how the data presented in the reports reviewed earlier in this chapter might best be used to estimate annual irrigation water needs in Pennsylvania. The potato example will be used here as well.

Dailey et al. (1960) Results. If we look at Dailey, et al. (1960), for a rooting zone holding 3.5 inches of available water, their results show that we can expect to apply 10.0 inches of irrigation water 3 years out of any 10-year period. The other return period results are given in Table 3-3. One also needs to note that these results were for the entire northeast U.S. and for forages.

Table 3-3. Summary of Dailey, et at. (1960) Irrigation Application Results.

Irrigation Needed (Inches)	Return Period
10.0	3/10
8.5	5/10
7.1	7/10

It must also be noted that this study was based on a daily application of irrigation water equivalent to 0.2 inches/day when soil moisture conditions were dry enough to stress the crops. The authors also indicate that this 0.2 inches/day of water includes a safety factor because the actual daily ET rate during the normal growing season is usually somewhat less than 0.2 inches/day. They never mention the water application efficiency (WAE), but this is the parameter used by irrigation designers to account for system losses via:

- Evaporation into the atmosphere,
- Runoff due to applying the water faster than the soil's infiltration rate,
- Deep percolation due to over irrigation, and
- System losses due to leakage.

For a well designed and managed sprinkler irrigation system, the WAE is usually about 70%. That means that 70% of the water taken from the source is expected to reach its target of the crop's root zone. Conversely, this assumes that 30% of the water taken from the source will be lost in the sense that it will never reach the crop's root zone.

Therefore, from the results presented in Table 3-3, one should assume that in the 3 out of 10-year drought only 70% of the 10.0 inches, or 7.0 inches, will actually reach its target (the root zone) and be available for crop uptake. In 5 out of 10 and 7 out of 10 years, the plant uptake is estimated to be 6.0 and 4.9 inches, respectively.

USDA-SCS (1972) Results. If we try to analyze this example using the 1972 Pennsylvania Irrigation Guide, we must first decide whether the growing season is "normal" or "dry". There is no guidance given by USDA-SCS (1972) to assist the user in determining whether a season is normal or dry. Based on how Kibler, et al. (1977) and others seemed to define a dry year, we assumed the dry growing season to be one in which there was at least a 2-year return period drought.

A summary of the depths of irrigation water needed to satisfy a crop of potatoes in Snyder County, Pennsylvania for each month of a normal and dry growing season are summarized in Table 3-4.

Table 3-4. Depth of Irrigation Water Needed In a Normal and Dry Year Using USDA-SCS (1972).

Month	Normal	Dry
June	0.0	0.2
July	2.0	2.7
August	4.1	4.6
September	3.1	3.6
October	0.3	0.8
Total =	**9.5 in**	**11.9 in**

The total irrigation needed for the dry year was 11.9 inches. This source also helps in being able to suggest how this irrigation-water need will probably be distributed across the growing season.

The weakness in these results is that USDA-SCS (1972) discusses the impact of the water application efficiency (WAE) on total water to be applied and the design depths given are adjusted for the 70% WAE. The charts that summarize the depth of water to be applied give no hint of whether the WAE was included or not. From using the data in this publication for many years, we are convinced the results presented are the actual depths of water that must reach the crop's root zone and this depth of water will be used by the crop to off-set moisture stress.

It is worth including a note about the critical period included by USDA-SCS (1972). This publication also indicates that potatoes are most sensitive to moisture stress from the "Blossom stage to Harvest". This is the period when it is most important to be sure to try to reduce or eliminate moisture stress.

Kibler, et al. (1977) Results. Kibler, et al. (1977) presented their total and seasonal soil moisture deficits in terms of the crop's hardiness (hardy, moderate, tender) and the crop's rooting depth. In our example, potatoes are considered to be “moderately” hardy and, as stated earlier, they have an 18-inch root depth. Thus for Snyder County, Table 3-5 summarizes the moisture deficits expected every 1.01, 2, 10, and 50 years for the 28-day analysis period.

These results are somewhat different from what most irrigation engineers are used to seeing. Kibler, et al. (1977) divided the growing season into four sub-seasons of nine weeks each. Their deficits are given for each of these four sub-seasons, which are added to the right to yield the total growing season deficit.

Therefore, by looking at these 28-day maximum deficits for the total growing season, the water needed for irrigation is 3.7, 11.0, 16.1, and 19.6 inches for the 1.01-, 2-, 10-, and 50-year drought return periods, respectively. Since a dry year was defined earlier as the 2-year return period drought, we expect to need about 11.0 inches of water for this field of potatoes. These 11.0 inches of irrigation water would be needed every other year.

Table 3-5. Maximum Soil Moisture Deficits For 28-Day Analysis Periods Predicted by Kibler, et al. (1977).

Drought Return Period (Years)	Total Sub-Seasonal Deficits (inches) Mar 1 to May 2	May 3 to July 4	July 5 to Sept 6	Sept 7 to Nov 7	Growing Season Total (Inches)
1.01	0.0	0.7	2.8	0.2	3.7
2	0.2	2.7	6.0	2.1	11.0
10	0.4	4.4	7.4	3.9	16.1
50	0.7	5.4	7.9	5.6	19.6

It is clear from the documentation given in this report that these results are the depth of water that needs to be placed into the root zone and can be expected to be used by the crop. Under normal irrigation practice, these irrigation depths need to be increased by 30% to ensure that the total water needed by the plants reach the root zone.

PA-DER (1978) Results. Following the completion of the Kibler, et al. (1977) report, PA-DER further summarized the Kibler results to yield what they called "Total Seasonal Deficits", see Appendix B. If we again use the Sunbury, Snyder County, PA data for the moderately hardy potatoes with an 18-inch root zone, we can predict the depth of irrigation expected on a drought return period basis as shown in Table 3-6. The format here is the same as Table 3-5 with four sub-seasons that were combined to yield the total seasonal deficit. Again the results are very similar to those of Kibler et al. (1977).

Table 3-6. Total Seasonal Deficits Predicted by PA-DER (1978).

Drought Return Period (Years)	Total Sub-Seasonal Deficits (inches) Mar 1 to May 2	May 3 to July 4	July 5 to Sept 6	Sept 7 to Nov 7	Total Seasonal Deficit (Inches)
1.01	0.0	0.5	1.9	0.1	2.5
2	0.2	2.8	6.3	2.2	11.5
10	0.5	4.5	7.7	4.1	16.8
50	0.7	5.3	7.7	5.5	19.2

Summary Comments. What this example has shown is encouraging. Of the four studies available to predict the irrigation water needed for potatoes, one gave much lower answers, the other three gave very similar results.

The most difficult result to explain is the 6.0-inch irrigation depth needed to grow forages by Dailey, et al. (1960). It is easy in 2001, to simply indicate that this was old science or technology, but this is unacceptable. The basic procedures used by Dailey, et al. (1960) were essentially the same as the procedures used by Kibler, et al. (1977, 1981). One plausible explanation for the low depth of irrigation given by this study may be that this was a northeast U.S. study and much of the data was from locations further north than PA. It should also be noted that the procedure used by Dailey, et al. (1960) had the poorest documentation of the four studies.

On the other hand the results from USDA-SCS (1972), Kibler, et al. (1977), and PA-DEP (1978) are nearly identical assuming we equate "DRY" in USDA-SCS (1972) with a 2-year drought return period in Kibler, et al. (1977) and PA-DER (1978).

Finally, before we conclude this example, let's compare the results we have assembled for potatoes in Pennsylvania into Table 3-7. It is quite clear from Table 3-7, that there is good agreement between the PA results at the 2-year return period.

Table 3-7. Summary of Irrigation Water Needed to Grow Potatoes in Snyder County, Pennsylvania as a Function of Drought Return Period.

Drought Return Period (Years)	Kibler et al. (1977) PA (Inches)	PA-DER (1978) PA (Inches)	USDA-SCS (1972) PA (Inches)
1.01	3.7	2.5	9.5 (Normal)
2	11.0	11.5	11.9 (Dry)
10	16.1	16.8	--
50	19.6	19.2	--

In this example the Kibler, et al. (1977) and PA-DER (1978) results were applied to a potato crop. Because of the extensive analysis completed and published by both of these researchers, including results for 43 of the 67 counties in PA and for each of the crops irrigated, these results were brought to this project with very little effort.

Recommended Procedure

We used the water use results from the PA-DER (1978) study to convert crop acreages grown in Pennsylvania to equivalent depths of water needed for irrigation in Pennsylvania. Each PA County's crop acreage-data will be collected. Crop acreages are available for each County 1982, 1987, 1992, 1997, and 2002 from the US Department of Commerce, United State Census of Agriculture (Ag Census, NASS).

After the acreages of each crop have been determined from the best available data, these irrigated crop acreages will be summed within each county and appropriate climatological data (see Chapter 4) will be regressed to yield a relationship that extrapolates the irrigated acreages to the years 2010, 2020 and 2030.

Once the 2010, 2020 and 2030 irrigated crop acreages have been estimated, the best available crop and rooting depth data, the average 10-year return period irrigation water needs data for each county will be used, with the projected crop acreages to determine volumes of water needed in Pennsylvania for irrigation.

The PA-DER (1978) data are presented for four growing sub-seasons defined as March 1 to May 2, May 3 to July 4, July 5 to September 6, and September 7 to November 7. In order to determine expected 10-year drought return period water use values on the desired monthly basis, it was necessary to parse the available sub-seasonal results into values for each individual month. This was done by assigning a percentage of each sub-season's expected consumptive use to each of the months in that sub-season. Table 3-8 shows how these values were divided for each sub-season using the 10-year drought return period data from Snyder County shown in Table 3-6. The 10-year drought return period water use values from Table 3-6 are summarized into the first two columns of Table 3-8. The fourth column shows, by percentage how each of the PA-DER sub-seasonal consumptive use values were assigned to each month in that sub-season. For instance, the first PA-DER sub-season, from March 1 to May 2, is expected to need 0.5 inches of irrigation water once every 10 years to keep the potatoes from experiencing water stress. This 0.5 inches of irrigation was assigned to the months of March and April by assuming 20% would be needed in March and 80% would be needed in April. Likewise in the third sub-season, the 7.7 inches of irrigation water needed for July 5 to Sept 6, was divided equally (50% and 50%) into July and August. The 3.8 versus 3.9 inches was due to rounding.

Table 3-8. Percentages of PA-DER (1978) 10-year Drought Return Period Sub-Seasonal Water Need Assigned to Each Month.

PA-DER (1978) Sub-Season	10-Year Sub-Seasonal Water Need (Inches)	Individual Months	How Each Sub-Season was Divided by Percentage (%)	10-Year Water Need Assigned to Each Month (Inches)
March 1 to	0.5	**March**	20	0.1
May 2		**April**	80	0.4
May 3 to	4.5	**May**	40	1.8
July 4		**June**	60	2.7
July 5 to	7.7	**July**	50	3.8
Sept 6		**August**	50	3.9
Sept 7 to	4.1	**September**	70	2.9
Nov 7		**October**	30	1.2
Total =	**16.8**			**16.8**

Influence of Type of Irrigation System Used

This entire discussion about how much water is needed for Pennsylvania irrigation has been presented under the assumption that irrigation water is applied by a sprinkler system. What does this mean in a practical sense?

The water needs depths shown in the summary tables above for both the Q_{7-10} (Table 3-2) and annual (Table 3-8) were given as water needed by the crop(s) or water that needs to be placed into the crop root zone so it can be used by the crop in subsequent days or weeks following the irrigation application. Adjustments to these water needs depth can be made in two ways; (1) by looking at the depth of water that an irrigator will need to pump (or take from the water source) in order to make sure they prescribed depths of water actually reach the crop root zones, and (2) how does the specific crop and the type of irrigation system used to apply water to each crop vary.

Influence of water application losses on the total depth of water needed. Irrigation designer's account for the losses expected as water is taken from a source and delivered to the crop's root zone. This term is referred to as the Water Application Efficiency (WAE). For sprinkler irrigation systems, the WAE is usually assumed to be about 70% for a well designed and managed irrigation system. This means that when Table 3-8 indicates that a potato grower in Snyder County will be expected to apply 3.8 inches of irrigation water to the root zone during July of a 10-year drought year, this grower will take (3.8/0.7 =) 5.4 inches of water from his/her water source. Of this 5.4 inches taken from the water source, only 3.8 will be expected to reach the root zone. Therefore, for sprinkler irrigation all water-need depths must be increased by (1/.7 = 1.4), though this extra water will is not expected to be used (evapotranspired) by the crop. In reality some of this "lost" water is evaporated off the sprinkler spray and some is returned to the waters of the Commonwealth.

In Pennsylvania crops like corn and potatoes and some strawberries are usually sprinkler irrigated. Crops such as orchards, many vegetables, and some strawberries are drip or trickle irrigated. What difference does drip irrigation make on the water depths needed for irrigation? The water needed by the crop remains the same. However, the ability of a drip irrigation system to deliver this water to the crop's root zone is better than if sprinklers are used to deliver the water. Generally we assume a drip system has a WAE of about 90 to 95%. Thus the water that must be taken from the source in July (assuming these potatoes are drip irrigated) would be only (3.8/.95 =) 4.0 inches. This is one reason drip irrigation is considered superior to sprinkler when it is appropriate for it to be used.

Influence of Crop Canopy. When comparing sprinkler and drip irrigation, however, drip irrigation has another substantial "water-need" advantage. This second advantage is created because with drip irrigation, water is only applied to the plant; only the area under the plant's canopy is irrigated. An orchard makes an easy example. In an orchard with 12-foot diameter trees planted in rows spaced 20 feet apart, there will be an 8-foot wide path between the rows of trees. With drip irrigation only the trees (in this example only (12/20 =) 60% of the total orchard area) are irrigated. The path is not. With sprinkler irrigation, the whole orchard area (trees and paths) would be irrigated.

Applying this concept to our examples means that when we sprinkler irrigate 3.8 inches of water on to an acre of potatoes in July, we must pump (3.8/.7 =) 5.4 in = 5.4 ac-in = 147,000 gallons of water to get 103,000 gallons (70%) to the crop's root zone. The grower drip irrigating an acre of orchard and wishing to apply 3.8 inches of water to his/her trees (use numbers from the example above), will only need to pump 65,000 gallons of water (3.8/.95 = 4.0 inches(.6) = 2.4 inches = 2.4 ac-in = 65,000 gal) and 62,000 gallons will reach the crop's root zone.

Crops that can effectively be drip irrigated, such as orchards, some vegetables and maybe strawberries all have different portions of canopy covers. We used 60% in the above example for orchards, but these percentages can vary greatly depending on how the trees or plants are planted and maintained. Likewise the canopy covers of one vegetable will be greatly different from another vegetable and the planting schemes will also greatly influence how much of the planted field will actually be irrigated. We often assume that if a crop's canopy cover is more than about 80% of the field area, drip irrigation is probably not a good idea. Sprinkler irrigation is better choice.

For purposes of this water assessment, only the acreage in orchards was assumed to be drip irrigated. Thus, the water needed volumes presented for orchards were adjusted downward by 60% assuming that all orchards will be drip irrigated. In reality the acreages were reduced by 60% to account for the effect of drip irrigation. Water volumes for all other crops were presented under the assumption that sprinkler irrigation would most probably be used to apply the irrigation water. The depths presented always represent the depth of water that should be needed by the growing plant. No adjustment has been made to account for losses.

Consumptive Use Factors

The $Q_{7\text{-}10}$ and annual volumes of water reported herein as needed by crop farmers for irrigation all assume that all of the water will be delivered to the plant root zone. Thus, it is fair to assume that the total volumes of the water reported will be consumptively used by the irrigated plants and returned to the atmosphere as either evaporated or transpired water.

This also assumes that when a farmer irrigates, he/she will be pumping more water than is reported in this report. If the farmer is using sprinkler irrigation, the volume pumped should be about 30% more than what the crop needs. Likewise, if the farmer is using drip irrigation, the volume pumped should be 5 to 10% more than what the crop needs.

CHAPTER 4

Drought Conditions Influence Irrigation

Rainfall Data

Irrigation in Pennsylvania is dependent upon many factors. The most important of which is natural precipitation, or the lack thereof. In Pennsylvania, about 2 years in 10, there is sufficient natural precipitation to render irrigation unnecessary. Likewise, about 2 to 3 years in 10, there is such a large deficit in natural precipitation that without irrigation most crops yield very little quality produce. The remaining 5 to 6 years in 10, irrigation water is applied, as needed, to relieve occasional water stress. Thus it is important, in trying to estimate the irrigation water needed in Pennsylvania, that we include the influence of natural precipitation on the crop acreages that are expected to be irrigated in future years.

Precipitation data are available in many forms from many sources. The data we have found most useful were in the annual summaries of Climatological Data produced by U.S. Department of Commerce (USDC, 1978 to 2004). In these publications, Pennsylvania is divided into 10 sub-regions (see Figure 4-1), each containing 10 to 25 weather stations. The monthly precipitation data are summarized for each weather station in each sub-region for each month of each year. Then all the stations within each region were averaged on a monthly basis with its average deficit from normal.

The deviations from normal precipitation for each of the months between March and October were collected for each year between 1978 and 2004 for each of the 10 sub-regions.

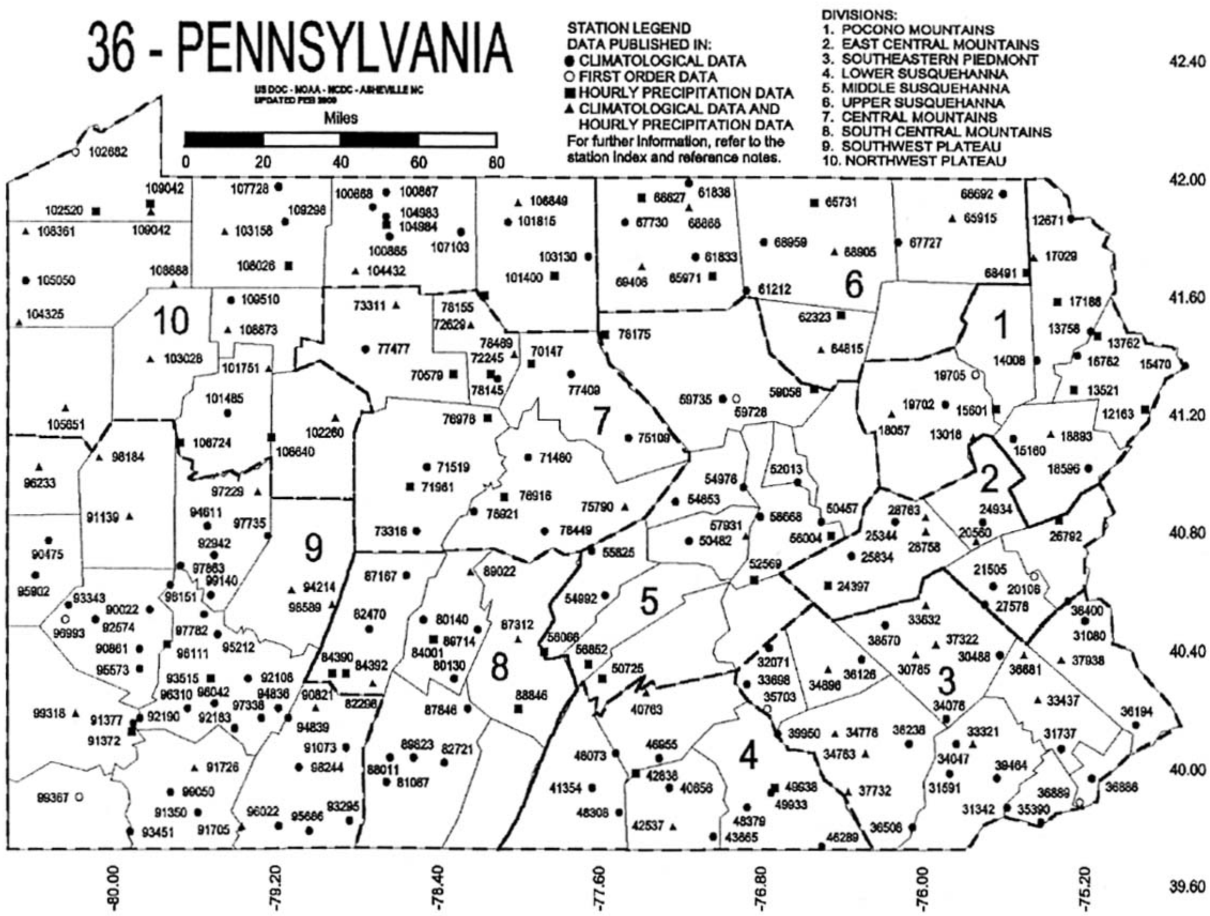

Figure 4-1. Pennsylvania Climatological Sub-regions.

By summing the regional monthly precipitation deviations over the March to October growing season, the growing seasonal precipitation deviations from normal were determined. These generated a 27-year annual series of seasonal precipitation deviations from normal that were then evaluated using a Log-Pearson Type III extreme probability analysis to yield the seasonal precipitation deficits expected on a drought return period basis. Thus the degree or level of drought was determined for each of the years when irrigated crop data were available.

Table 4-1 shows how the deviation from normal precipitation during the March to October growing season is related the drought return period for each of the 10 Pennsylvania sub-regions for the period from 1978 to 2004. From these return period data summaries it was possible to assign a drought return period to the rainfall deficit associated with each year the irrigated crop acreages were available from NASS. These drought return periods or rainfall deficits were then used with the historical NASS acreages for each crop to determine a crop-irrigated acreage expected in the years 2020, 2020 and 2030.

Table 4-1. Deviation from Normal Precipitation for each Pennsylvania Sub-Region And Return Periods between 1.01 and 100 years.

Return	Deviation from Normal during March to October Growing season (inches)									
Period	Pennsylvania Sub-Region									
(Yrs)	1	2	3	4	5	6	7	8	9	10
1.01	7.50	8.50	10.00	12.00	8.30	6.70	6.90	8.50	7.10	8.00
2	1.39	0.86	0.68	0.14	1.02	1.26	0.73	0.19	0.39	1.53
5	-2.22	-2.36	-2.61	-3.44	-2.52	-2.16	-2.54	-3.00	-2.84	-2.39
10	-3.88	-3.87	-4.14	-5.01	-4.13	-3.76	-4.06	-4.48	-4.34	-4.14
20	-5.13	-5.03	-5.30	-6.15	-5.34	-4.97	-5.22	-5.59	-5.47	-5.43
50	-6.37	-6.21	-6.45	-7.24	-6.54	-6.19	-6.38	-6.70	-6.59	-6.68
100*	-7.08	-6.90	-7.13	-7.85	-7.23	-6.91	-7.07	-7.34	-7.25	-7.38

*The 100-year return period results are not reliable for n = 28 years of data.

It should be noted that when the irrigated acreages were extrapolated to 2010, 2020, and 2030, it was assumed that each of these years was under the influence of a 10-year return period drought. The appropriate return period, or rainfall deficit that occurred during each of the years for which the NASS data was available were also included and used in the linear regression analysis introduced in Chapter 2.

Current and Future Water Needed for Irrigation

Based on the actual acreages downloaded from the 2002 NASS (2002) and the acreages predicted to be under irrigation in each County in 2010, 2020, and 2030, these acreages were multiplied times the growing season's irrigation water needed to yield the volumes of water needed reported herein. The $Q_{7\text{-}10}$ (Kibler et al. (1977) and annual (PA-DER, 1978) irrigation water needed for each of the four years in question was adjusted to match the return period of the rainfall patterns for that year. Specifically, the drought return period experienced in 2002 in each of the 10 climatic regions ranged from a 1.2- to 1.8-year return period. In each county, the 1.01- and 2-year return period water needed data from the PA-DER (1978) report was interpolated to yield the best estimate of the water that should have been needed for each crop in each county. The 10-year return period water need data were applied to the 2010, 2020, and 2030 projected acreages.

CHAPTER 5

Current and Future $Q_{7\text{-}10}$ Water Volumes Needed for Irrigation

The results of the current and future $Q_{7\text{-}10}$ irrigation water needs assessment are presented in this chapter. It is strongly recommended that you read this chapter while near a computer where you can open and have available for reference the EXCEL Spreadsheets named “Irrigation Projection AnalysisA-C7” and “Irrigation Projection AnalysisD-Y7”. The file named “Water Results7” also contains a summary of these irrigation results and will also be helpful. These files are on the CD at the end of this report.

Irrigated acreages were determined for each major crop along with the total acreage within each county by the procedures outlined in Chapters 2 to 4. The total acreages irrigated in each county in 2002 and those irrigated acreages projected for 2010, 2020, and 2030 are summarized in Table 5-1. These total irrigated acreages were summarized from the more detailed summary that includes the acreages of specific crops irrigated or expected to be irrigated in each of the counties in each evaluation year. These data are summarized in Appendix C. It is useful to observe from the results shown in Appendix C and summarized in Table 5-1, that the majority of the irrigated acreage in Pennsylvania occurred and will most probably continue to occur in a few select counties, see Table 5-2. The county with the largest irrigated acreage is Lancaster with just over 6,000 acres and expected to grow to upwards of 10,000 acres by 1030. These top ten irrigating counties currently (2002) account for 58% of the irrigated land in Pennsylvania and the top ten counties should continue to account for nearly 60% of the land irrigated in Pennsylvania. There is and will continue to be little or no irrigated land in several counties.

Table 5-1. Current and future acreages irrigated in 2002, 2010, 2020, and 2030.

No.	County	2002 acres	2010 acres	2020 Acres	2030 acres
1	Adams	2656	3028	3360	3692
2	Allegheny	289	454	574	695
3	Armstrong	482	311	370	429
4	Beaver	467	576	739	902
5	Bedford	205	503	618	732
6	Berks	1914	2096	2614	3131
7	Blair	250	160	81	3
8	Bradford	220	311	395	478
9	Bucks	1017	1292	1361	1430
10	Butler	682	283	341	399
11	Cambria	53	38	28	18
12	Cameron	0	0	0	0
13	Carbon	80	103	143	182
14	Centre	606	815	1091	1367
15	Chester	1846	1877	2261	2645
16	Clarion	140	78	106	134
17	Clearfield	129	169	225	282
18	Clinton	570	1693	2013	2334
19	Columbia	1259	1327	1785	2244
20	Crawford	189	544	671	799
21	Cumberland	1155	261	264	267
22	Dauphin	596	622	663	705
23	Delaware	63	55	47	46
24	Elk	16	14	17	19
25	Erie	2302	2833	3721	4609
26	Fayette	80	37	53	68
27	Forest	5	9	12	15
28	Franklin	2712	2723	3088	3452
29	Fulton	42	8	8	8
30	Greene	34	10	13	15
31	Huntingdon	336	812	1064	1315
32	Indiana	1086	1075	1462	1848
33	Jefferson	23	131	160	190
34	Juniata	283	448	588	728
35	Lackawanna	174	498	659	821
36	Lancaster	6051	6951	8842	10734
37	Lawrence	124	43	53	63
38	Lebanon	1857	2155	2859	3562
39	Lehigh	676	203	284	365
40	Luzerne	686	643	786	929
41	Lycoming	1770	3461	4577	5692
42	McKean	169	179	238	297
43	Mercer	207	100	126	153
44	Mifflin	85	88	101	115
45	Monroe	119	119	153	190
46	Montgomery	464	701	828	956
47	Montour	87	83	105	126
48	Northampton	366	434	468	503
49	Northumberland	589	55	625	716
50	Perry	491	321	458	595
51	Philadelphia	5	5	6	7
52	Pike	20	73	97	120
53	Potter	10	6	10	13
54	Schuylkill	1876	1573	2155	2738
55	Snyder	528	1018	1262	1505
56	Somerset	504	849	1128	1406
57	Sullivan	11	34	46	58
58	Susquehanna	41	187	237	288
59	Tioga	174	96	79	61
60	Union	98	355	449	543
61	Venango	70	63	85	107
62	Warren	259	395	482	569
63	Washington	833	336	331	327
64	Wayne	133	146	166	186
65	Westmoreland	287	231	200	168
66	Wyoming	95	70	62	53
67	York	1689	1656	2074	2492
	Total	42335	47825	59966	71640

Table 5-2. Top ten irrigating Counties in Pennsylvania.

		Year = 2002	T = 1.2 to 1.8 yrs	Maximum	Water Needed
			Area Irrigated	Water Needed	per acre
Rank	No	County	acres	MGD	MGD/ac
1	36	**Lancaster**	6051	22.730	0.0038
2	28	**Franklin**	2712	7.312	0.0027
3	1	**Adams**	2656	8.691	0.0033
4	25	**Erie**	2302	7.402	0.0032
5	6	**Berks**	1914	6.455	0.0034
6	54	**Schuylkill**	1876	6.362	0.0034
7	38	**Lebanon**	1857	6.721	0.0036
8	15	**Chester**	1846	6.692	0.0036
9	41	**Lycoming**	1770	5.060	0.0029
10	67	**York**	1689	5.684	0.0034
		State Totals	42335	140.367	0.0033

Rank	No	Year = 2010	T = 10 years		
1	36	**Lancaster**	6951	31.962	0.0046
2	41	**Lycoming**	3461	19.083	0.0055
3	1	**Adams**	3028	11.274	0.0037
4	25	**Erie**	2833	11.799	0.0042
5	28	**Franklin**	2723	28.853	0.0106
6	38	**Lebanon**	2155	9.773	0.0045
7	6	**Berks**	2096	11.566	0.0055
8	15	**Chester**	1877	8.341	0.0044
9	19	**Clinton**	1693	9.548	0.0056
10	67	**York**	1656	7.221	0.0044
		State Totals	47825	245.660	0.0051

Rank	No	Year = 2020	T = 10 years		
1	36	**Lancaster**	8842	40.820	0.0046
2	41	**Lycoming**	4577	25.386	0.0055
3	25	**Erie**	3721	15.385	0.0041
4	1	**Adams**	3360	12.523	0.0037
5	28	**Franklin**	3088	32.920	0.0107
6	38	**Lebanon**	2859	12.903	0.0045
7	6	**Berks**	2614	14.419	0.0055
8	15	**Chester**	2261	10.067	0.0045
9	54	**Schuylkill**	2155	11.360	0.0053
10	67	**York**	2074	9.197	0.0044
		State Totals	59966	304.132	0.0051

Rank	No	Year = 2030	T = 10 years		
1	36	**Lancaster**	10734	49.677	0.0046
2	41	**Lycoming**	5692	31.690	0.0056
3	25	**Erie**	4609	18.970	0.0041
4	1	**Adams**	3692	13.807	0.0037
5	38	**Lebanon**	3562	16.033	0.0045
6	28	**Franklin**	3452	36.987	0.0107
7	6	**Berks**	3131	17.272	0.0055
8	54	**Schuylkill**	2738	14.434	0.0053
9	15	**Chester**	2645	11.792	0.0045
10	67	**York**	2492	11.172	0.0045
		State Totals	71640	362.783	0.0051

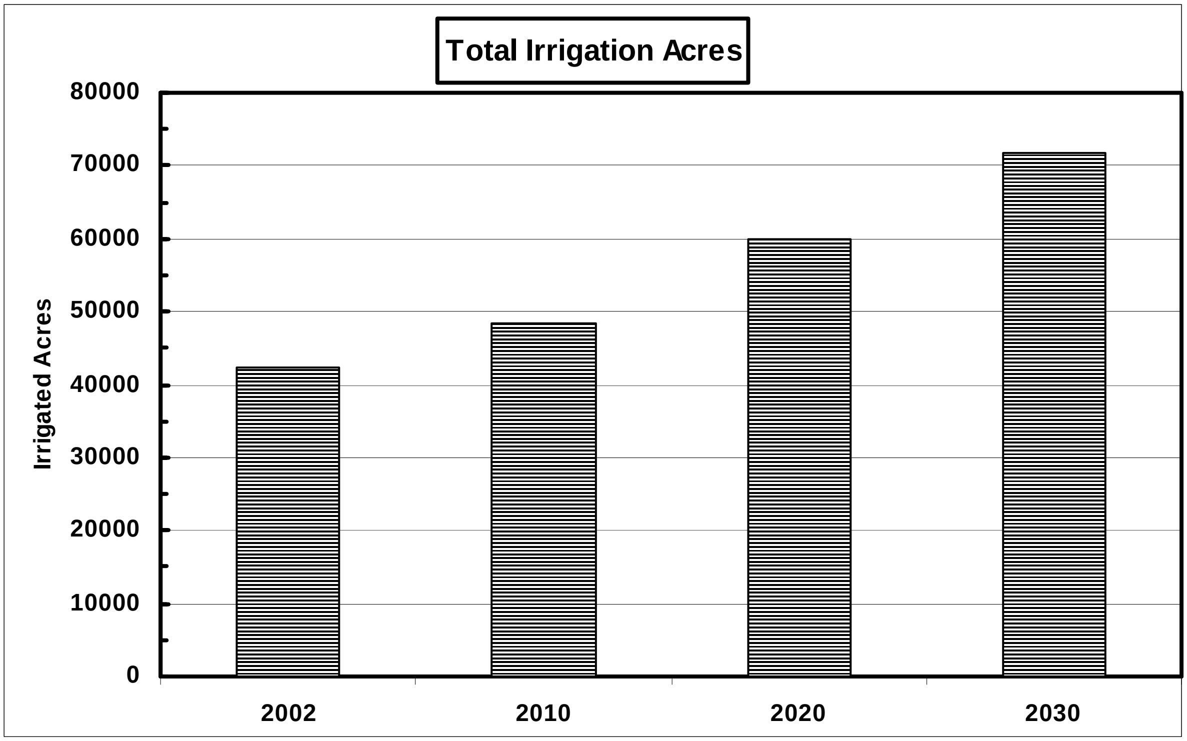

Figure 5-1. Total irrigated land in 2002, 2010, 2020, and 2030.

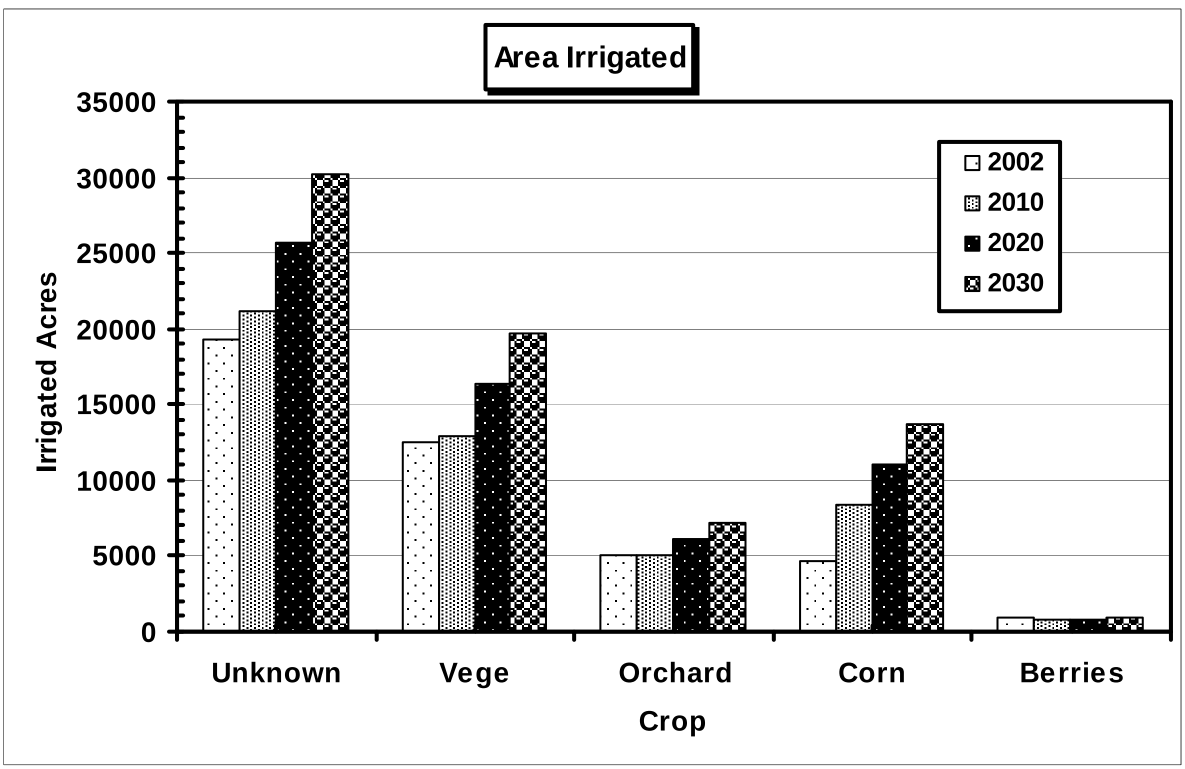

Figure 5-2. Irrigated area by crop in 2002, 2010, 2020, and 2030.

If we look at the overall irrigation picture, irrigated land is expected to continue to increase during the next few decades. Figure 5-1 shows the increase expected based on the four years evaluated in this study. There are currently (2002) 42,335 acres of land irrigated. By 2030, this is expected to increase to 71,640 acres, or approximately (71640 - 42335 = 29305) 1,050 (29305/28) acres of new land is expected to be irrigated each year. Figure 5-2 shows how irrigated land area is expected to change with crop irrigated and year of interest.

Water needed for Irrigation

With the irrigated land areas established, these acreages (2002) and extrapolated acreages (2010, 2020, and 2030) were multiplied times the maximum monthly 7-day irrigation water needs (Kibler et al. (1977) developed for each crop in each county (see Chapter 3) and divided by seven to determine the maximum daily Q_{7-10} water needed for irrigation on a monthly basis. The maximum of the eight monthly Q_{7-10} water volumes were then selected and summarized to yield the maximum daily Q_{7-10} volume of water needed for irrigation in each county, see Table 5-3. The values shown at the bottom of each column are the maximum Q_{7-10} water needed for irrigation for the entire state of Pennsylvania assuming a 10-year drought occurred uniformly in all counties during the month with the greatest 10-year, 7-day water need.

These Q_{7-10} irrigation water needed results and the detailed results from which these values were derived reveal many interesting concepts that may be helpful from the standpoint of the Pennsylvania "State Water Plan". By plotting the total water needed for irrigation against each of the years evaluated (see Figure 5-3), we can see the historical and precipitation evidence shows that use of water for irrigation is expected to grow over the next few decades. It should be remembered that part of the growth shown in Figure 5-3 is from the increased land area being irrigated (see Figure 5-1) and part is from the fact that the 2002 irrigation water need was based on the 1.2- to 1.8-year return period drought conditions that existed during the 2002 growing season. The future irrigation water needs, shown for 2010, 2020, and 2030, were based on a 10-year return period drought. However, even if the return period effect is removed, an irrigation water growth rate of approximately 2.0 to 2.5%/year must be planned for. Another factor that may actually increase this irrigation water use growth rate is that the Federal Government through the USDA-Natural Resources Conservation Service (NRCS) currently has two specific programs; one designed to encourage farmers to adopt irrigation as a crop management practice, and a second designed to help farmers already irrigating improve the efficiency of their irrigation systems.

In Table 5-2, the Q_{7-10} water needed for irrigation from Table 5-3 and the water needed for irrigation on a per acre basis were added to the two right-hand columns to show how irrigation water application changes from county to county within the top ten irrigating counties. If you examine the tables near the end of Appendix C, where similar information is presented for individual crops, these variations can be seen as well. The important issue is that the data from which the irrigated water quantities were derived (Kibler et al., 1977) assumed uniform drought conditions across the growing season—we used the 10-year drought for the 2010, 2020, and 2030 projections. Thus some Q_{7-10} irrigation water is recommended every month. In the typical, real world, every irrigator schedules his/her irrigation differently; some apply water independently of natural rainfall, some apply water only when the crop(s) show signs of severe water stress, others only irrigate during those periods when the crops are in what is referred to as the "Critical Period" of crop growth. The Critical Period varies from crop to crop. The crops for which we had NASS data will need irrigation most critically during the months shown in Table 5-4.

Table 5-3. Current and future maximum 7-d irrigation water needed (Q_{7-10}).

County	2002 MGD	2010 MGD	2020 MGD	2030 MGD
Adams	8.691	11.274	12.523	13.807
Allegheny	1.072	1.936	2.467	2.998
Armstrong	1.447	1.177	1.401	1.625
Beaver	1.456	2.384	3.065	3.745
Bedford	0.662	2.718	3.335	3.952
Berks	6.455	11.566	14.419	17.272
Blair	0.620	1.350	0.659	0.101
Bradford	0.552	1.210	1.534	1.858
Bucks	4.808	5.790	6.015	6.240
Butler	2.454	1.621	1.951	2.281
Cambria	0.153	0.152	0.112	0.071
Cameron	0.000	0.000	0.000	0.001
Carbon	0.253	0.448	0.621	0.794
Centre	1.789	3.705	4.963	6.220
Chester	6.692	8.341	10.067	11.792
Clarion	0.474	0.389	0.528	0.666
Clearfield	0.367	0.678	0.905	1.131
Clinton	1.531	9.548	11.367	13.186
Columbia	3.139	7.824	10.545	13.267
Crawford	0.692	2.419	2.998	3.578

County	2002 MGD	2010 MGD	2020 MGD	2030 MGD
Cumberland	4.163	1.198	1.238	1.278
Dauphin	2.447	3.005	3.267	3.503
Delaware	0.278	0.234	0.194	0.183
Elk	0.049	0.066	0.076	0.085
Erie	7.402	11.799	15.385	18.970
Fayette	0.283	0.186	0.261	0.337
Forest	0.021	0.043	0.058	0.073
Franklin	7.312	28.853	32.920	36.987
Fulton	0.129	0.062	0.061	0.060
Greene	0.100	0.047	0.056	0.066
Huntingdon	1.041	4.918	6.482	8.046
Indiana	3.594	4.819	6.579	8.339
Jefferson	0.075	0.522	0.639	0.757
Juniata	0.775	2.329	3.071	3.813
Lackawanna	0.564	1.853	2.475	3.096
Lancaster	22.730	31.962	40.820	49.677
Lawrence	0.391	0.180	0.228	0.276
Lebanon	6.721	9.773	12.903	16.033
Lehigh	2.092	0.895	1.240	1.584
Luzerne	2.022	2.702	3.257	3.814
Lycoming	5.060	19.083	25.386	31.690
McKean	0.524	0.719	0.956	1.192
Mercer	0.687	0.565	0.716	0.869
Mifflin	0.251	0.428	0.496	0.564
Monroe	0.405	0.584	0.756	0.944
Montgomery	1.621	3.738	4.435	5.132
Montour	0.211	0.464	0.590	0.716
Northampton	1.315	1.995	2.167	2.338
Northum.	1.481	3.308	3.838	4.367
Perry	1.647	1.482	2.125	2.768
Philadelphia	0.026	0.022	0.027	0.031
Pike	0.050	0.260	0.343	0.426
Potter	0.032	0.023	0.034	0.045
Schuylkill	6.362	8.287	11.360	14.434
Snyder	1.361	5.319	6.611	7.887
Somerset	1.631	4.033	5.356	6.679
Sullivan	0.029	0.131	0.179	0.226
Susque.	0.107	0.658	0.835	1.012
Tioga	0.427	0.367	0.303	0.239
Union	0.248	1.688	2.110	2.532
Venango	0.247	0.289	0.390	0.490
Warren	0.828	1.678	2.048	2.417
Washington	3.087	1.544	1.473	1.409
Wayne	0.354	0.559	0.643	0.726
Westmoreland	0.927	0.956	0.815	0.674
Wyoming	0.268	0.279	0.259	0.240
York	5.684	7.221	9.197	11.172
Total =	140.367	245.660	304.132	362.783

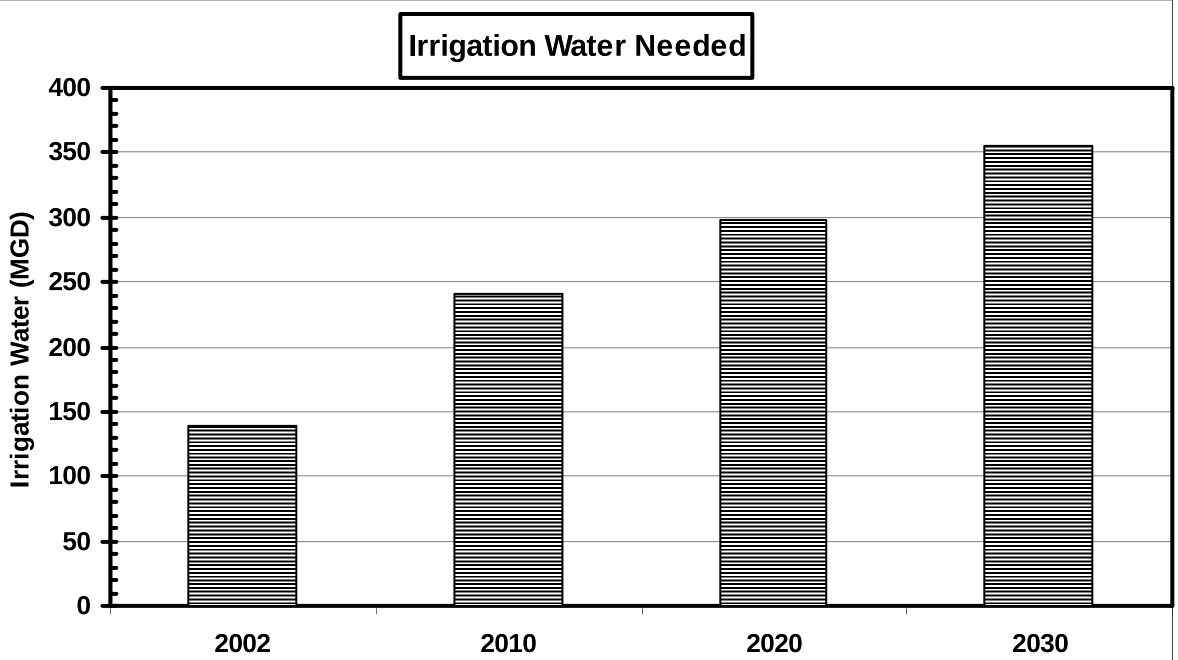

Figure 5-3. Current and future maximum daily (Q_{7-10}) irrigation water needed.

Table 5-4. Critical Periods for crops evaluated in this study (USDA-SCS, 1972).

Crop	Critical Period	Critical Months
Corn	Tasseling, silking	Late July, Early August
Vegetables	Varies with crop	April to August
Orchards	Fruit enlargement	July, August
Berries	Fruit enlargement	May to early June
Potatoes	Blossom to harvest	June to September

The water use results shown for crops like corn, orchards, and berries are most likely quite reliable. The results shown for the "Vegetables" category and especially the "Unknown" category reflect the water needs of a wide variety of crops. For example it is my best guess that much of the 'unknown" irrigated crop in Erie County is applied to grapes, while the unknown crop(s) in counties like Berks or Schuylkill Counties is most likely potatoes. My contacts at NRCS tell me many irrigation adopters are looking to irrigate sweet corn. Note: Prior to 2002, NASS included "sweet corn" and "potatoes" as "irrigated acreage" categories in their data base. These breakout categories were dropped in the 2002 census.

Another useful piece of information from Table 5-2 is how the volume of water needed for irrigation varies with the drought return period. For 2002, when Pennsylvania had a very mild drought (T = 1.2- to 1.8-year return period) approximately 0.0033 MGD of irrigation water was needed on a Q_{7-10} basis for each acre of land irrigated. During the 10-year drought used for the 2010, 2020, and 2030 extrapolation, each acre of irrigated land will need approximately 0.0050 MGD of irrigation water during the Q_{7-10} event.

Figure 5-4 shows how the volume of water needed for irrigation varies with crop and year if interest.

Before we close this chapter on how much water Pennsylvania agriculture has used and will most likely need on a Q_{7-10} basis for irrigation during the next few decades, it is worth including a few comments about the reliability of these results and the estimates for the future. A great deal of science was brought to bear on the 1982, 1987, 1992, 1997, and 2002 NASS data to establish the present and future irrigation water needs. It must be remembered that the results are no better than the raw data. We have taken the NASS data at face value. I know from experience and from interacting with farmers, that there are few if any farmers who consider their report to NASS as important or "any of the government's business". Many farmers refuse to fill out the questionnaire and many provide "loose" estimates. The farming community generally considers the "government" an entity they dislike and many refuse to cooperate with it in any way. They mostly fear that data reported will eventually return to them in some way that will restrict their freedom or cost them money in the form of taxes, levies, or lower prices for their produce. Thus even the 2002 (present conditions) results reported must be considered to have a large error. If someone were to ask me how many acres of Pennsylvania were irrigated in 2002, I would respond with “about 40,000 acres, maybe a few more”.

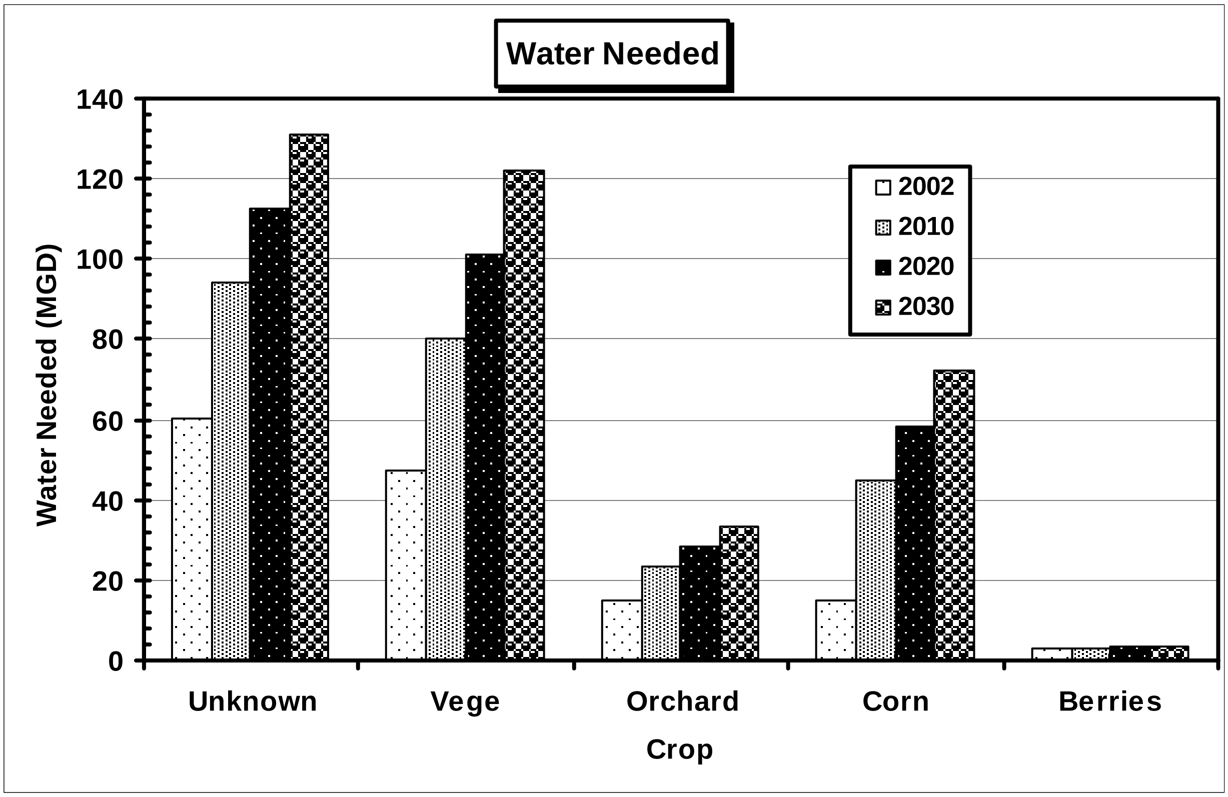

Figure 5-4. . Q_{7-10} irrigation water needed by crop in 2002, 2010, 2020, and 2030.

This then raises questions about how good the projected irrigated land acreages are for 2010, 2020, and 2030. As described earlier, these projections were based on a multiple linear regression using “Year of interest” and “Growing season rainfall deficit from normal” as independent variables. This regression approach was applied to the historical acreages of “corn”, “vegetables”, “orchards”, “berries”, and the “total acres irrigated” in each county. The “unknown” projections were determined by differences. It should be remembered that during the past 20 years, there were only five sets of data available. Obviously I feel better about the predicted results in 2010 than in the later years. With “big” agricultural operations being planned and implemented, major shifts in crop acreages and irrigation practice can occur in just a few years.

I guess the bottom-line is that I do not believe the numbers in this report to be better than one or 1.5 significant figures. It is my hope that the reader will not get too hung-up in minor differences.

CHAPTER 6

Current and Future Annual Water Volumes Needed for Irrigation

The results of the current and future irrigation annual water needs assessment are presented in this chapter. It is strongly recommended that you read this chapter while near a computer where you can open and have available for reference the EXCEL Spreadsheets named “Irrigation Projection AnalysisA-C” and “Irrigation Projection AnalysisD-Y”. The file named “Water Results” also contains a summary of these irrigation results and will also be helpful. These files are on the CD at the end of this report.

Irrigated acreages were determined for each major crop along with the total acreage within each county by the procedures outlined in Chapters 2 to 4. The total acreages irrigated in each county in 2002 and those irrigated acreages projected for 2010, 2020, and 2030 were summarized in the first part of Chapter 5 and Appendix C.

Annual Water needed for Irrigation

With the irrigated land areas established, these acreages (2002) and extrapolated acreages (2010, 2020, and 2030) were multiplied times the monthly irrigation water needs (Kibler et al. (1977) developed for each crop in each county to determine the monthly water needed for irrigation. These monthly water volumes were summed to yield the annual volume of water needed for irrigation in each county in million gallons (MG), see Table 6-1. The totals shown at the bottom of each column are the total water needed for irrigation for the entire state of Pennsylvania.

Table 6-1. Current and future annual irrigation water needs.

County	2002 MG	2010 MG	2020 MG	2030 MG
Adams	569	1201	1334	1469
Allegheny	96	208	264	320
Armstrong	138	135	161	186
Beaver	136	263	337	412
Bedford	48	242	298	353
Berks	629	1005	1255	1504
Blair	55	78	39	8
Bradford	32	123	156	189
Bucks	379	700	727	753
Butler	227	155	187	219
Cambria	11	17	13	8
Cameron	0	0	0	0
Carbon	20	46	63	81
Centre	99	312	418	523
Chester	669	1036	1248	1461
Clarion	42	36	49	62
Clearfield	22	62	83	103
Clinton	97	694	826	958
Columbia	158	551	743	934
Crawford	61	268	332	397
Cumberland	330	131	136	140
Dauphin	230	342	372	399
Delaware	23	29	23	21
Elk	3	7	8	9
Erie	715	1393	1826	2259
Fayette	27	20	28	36
Forest	2	5	6	8
Franklin	618	1474	1686	1898
Fulton	8	4	4	4
Greene	10	5	6	7
Huntingdon	71	364	479	594
Indiana	327	528	721	914
Jefferson	6	50	61	73
Juniata	39	179	234	290
Lackawanna	26	186	247	308
Lancaster	1851	3407	4344	5281
Lawrence	38	19	23	28
Lebanon	602	1071	1416	1762

County	2002 MG	2010 MG	2020 MG	2030 MG
Lehigh	171	93	128	162
Luzerne	93	270	326	382
Lycoming	211	1367	1807	2247
McKean	36	63	84	105
Mercer	64	56	71	86
Mifflin	12	35	40	46
Monroe	23	60	77	96
Montgomery	157	347	414	481
Montour	10	33	42	51
Northampton	105	228	248	268
Northumberland	80	230	268	306
Perry	116	156	224	292
Philadelphia	2	3	3	4
Pike	3	28	38	47
Potter	2	2	3	4
Schuylkill	567	798	1091	1385
Snyder	64	387	481	573
Somerset	131	386	512	638
Sullivan	1	11	15	19
Susquehanna	5	67	85	104
Tioga	18	33	27	21
Union	11	128	161	193
Venango	22	32	43	55
Warren	75	175	213	252
Washington	314	187	182	176
Wayne	18	58	66	74
Westmoreland	93	109	92	76
Wyoming	13	26	23	20
York	435	748	944	1140
Total =	11265	22463	27863	33276

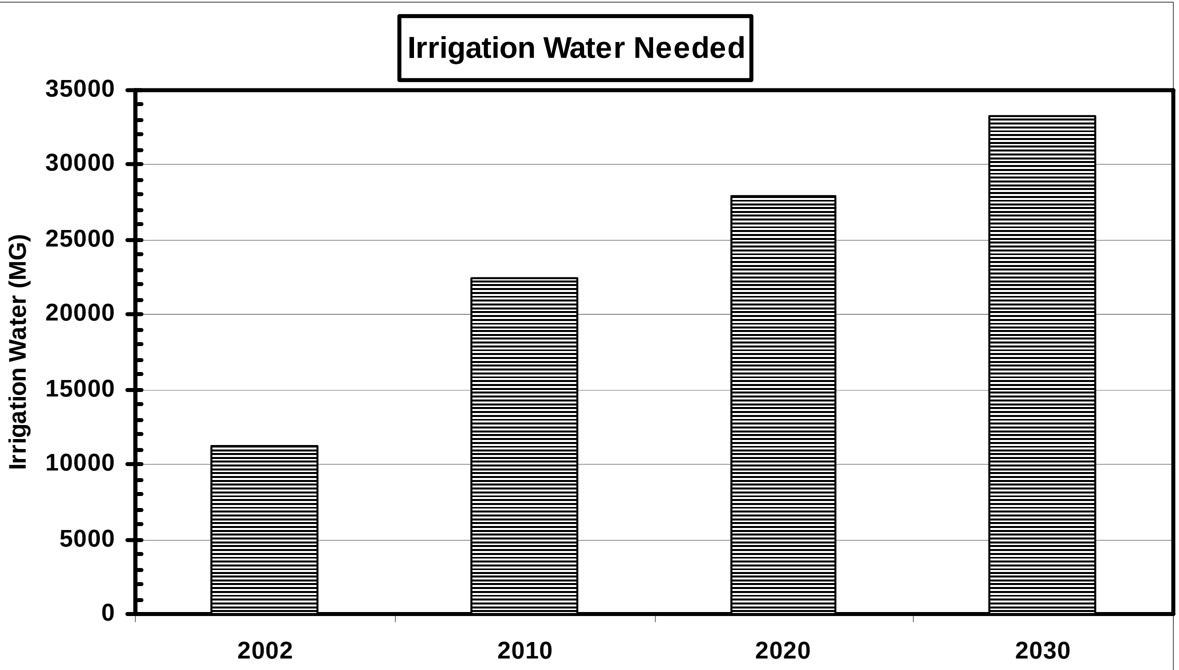

Figure 6-1. Current and future total irrigation water needed.

As with the maximum daily water needs reported in Chapter 5, the trends shown here are similar. Water needed on an annual basis to support irrigation in Pennsylvania is expected to grow at a rate of 2 to 2.5%/year. Likewise the assessment of the top ten counties in land irrigated and annual irrigation water used are also similar, see Table 6-2. If you examine the tables near the end of Appendix E, the trends are similar for the individual crops.

Another useful piece of information from Table 6-2 is how the volume of water needed for irrigation varies with the drought return period. For 2002, when Pennsylvania had a very mild drought (T = 1.2- to 1.8-year return period) approximately 0.27 MG of irrigation water was needed annually for each acre of land irrigated. During the 10-year drought used for the 2010, 2020, and 2030 extrapolation, each acre of irrigate land will need approximately 0.47 MG of irrigation water annually.

Table 6-2. Top ten irrigating counties in 2002, 2010, 2020, and 2030.

		Year = 2002	T = 1.2 to 1.8 yrs		Water Needed
			Area Irrigated	Water Needed	per acre
Rank	No	County	acres	MG	MG/ac
1	36	Lancaster	6051	1851	0.31
2	28	Franklin	2712	618	0.23
3	1	Adams	2656	569	0.21
4	25	Erie	2302	715	0.31
5	6	Berks	1914	629	0.33
6	54	Schuylkill	1876	567	0.30
7	38	Lebanon	1857	602	0.32
8	15	Chester	1846	669	0.36
9	41	Lycoming	1770	211	0.12
10	67	York	1689	435	0.26
		State Totals	42335	11265	0.27

Rank	No	Year = 2010	T = 10 years		
1	36	Lancaster	6951	3407	0.49
2	41	Lycoming	3461	1367	0.39
3	1	Adams	3028	1201	0.40
4	25	Erie	2833	1393	0.49
5	28	Franklin	2723	1474	0.54
6	38	Lebanon	2155	1071	0.50
7	6	Berks	2096	1005	0.48
8	15	Chester	1877	1036	0.55
9	19	Clinton	1693	694	0.41
10	67	York	1656	748	0.45
		State Totals	47825	22463	0.47

Rank	No	Year = 2020	T = 10 years		
1	36	Lancaster	8842	4344	0.49
2	41	Lycoming	4577	1807	0.39
3	25	Erie	3721	1826	0.49
4	1	Adams	3360	1334	0.40
5	28	Franklin	3088	1686	0.55
6	38	Lebanon	2859	1416	0.50
7	6	Berks	2614	1255	0.48
8	15	Chester	2261	1248	0.55
9	54	Schuylkill	2155	1091	0.51
10	67	York	2074	944	0.46
		State Totals	59966	27863	0.46

Rank	No	Year = 2030	T = 10 years		
1	36	Lancaster	10734	5281	0.49
2	41	Lycoming	5692	2247	0.39
3	25	Erie	4609	2259	0.49
4	1	Adams	3692	1469	0.40
5	38	Lebanon	3562	1762	0.49
6	28	Franklin	3452	1898	0.55
7	6	Berks	3131	1504	0.48
8	54	Schuylkill	2738	1385	0.51
9	15	Chester	2645	1461	0.55
10	67	York	2492	1140	0.46
		State Totals	71640	33276	0.46

Figure 6-2 shows how the volume of water needed for irrigation varies with crop and year if interest.

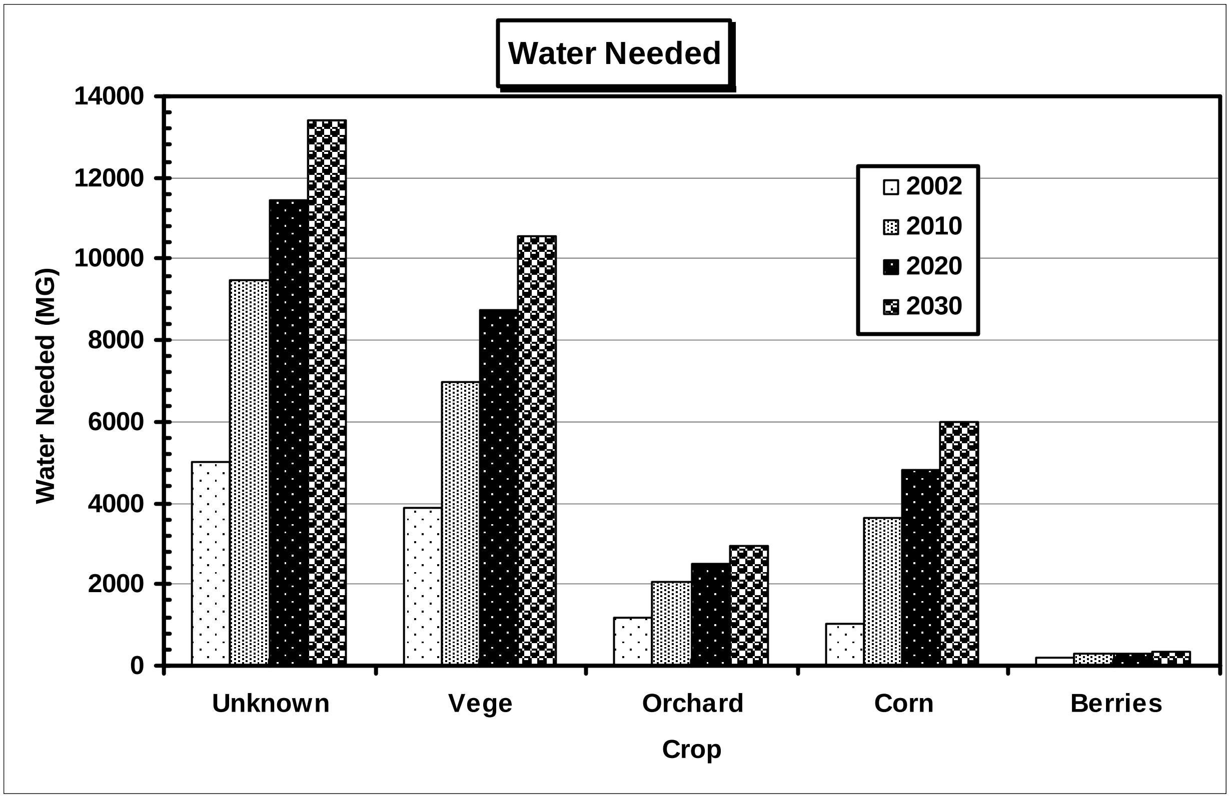

Figure 6-2. Annual irrigation water needed by crop in 2002, 2010, 2020, and 2030.

PART II

Animal Water Needs Assessment

CHAPTER 7

Extrapolating Animal Populations

The animal water needs assessment consisted of three parts; (1) estimate the present animal water needs for each county based on the most recent animal populations available, (2) extrapolate the historical animal populations to predict the 2010, 2020, and 2030 irrigation water needs in each county, and (3) attempt to estimate what portion of the animal producers in each county have already registered (or have not registered) their water use with PADEP. The present (part 1) and extrapolated (part 2) animal water needs assessment for each county and the state are contained in two attached EXCEL spreadsheets named “Animal Projection Analysis*.xls”, where the “*” refers to the first letter of the counties contained in the spreadsheet. For example “Animal Projection AnalysisM-Y” contains the data and analysis for the counties whose names begin with the letters “A” to “M”. The remaining counties are in the second spreadsheet. Both spreadsheets are laid out the same. Both spreadsheets also have a “7” to reference the analysis in units of million gallons per day (MGD). Both spreadsheets contain worksheets named “BaseA”, and “Animal”, which contain the data and various analyses performed. Both spreadsheets also contain a “Summary” worksheet that summarizes the county-by-county results. The county and state animal and irrigation water need results are also combined and presented in a separate spreadsheet named “Water Results7”, also found on the Report CD.

The registration analysis (part 3) for each County and the state is contained in the attached EXCEL spreadsheet named “Registration Analysis”. The sheets named “BaseA”, and “Animal” contain the data and the various analyses performed.

Animal Populations Available

NASS collects and reports a wide variety of animal populations in each County. These are divided into several large categories including Cattle (Bovines), Swine, Sheep, Goats, Horses, and Poultry. In some of these categories, populations are collected in several sub-categories such as the Cattle populations include “Cattle and Calves”, “Cows and Heifers that calved”, “Beef Cows”, “Milk Cows”, and Steers and Bulls”. The poultry category includes “Chickens 3 mon +”, “Hens and pullets”, “Broilers and Meat Birds”, and “Turkeys”. Because of the water use data available from NASS and the need to assign water use data to each group of animals, some of the animal populations taken from the NASS statistics were adjusted and combined as described below.

As with the acreages of irrigated land in each county, one of the difficulties with trying to use NASS data is that NASS is careful to protect the reporting farmers from identification. Therefore, when a county has only a one, or a few, farmers reporting animals in a category, they reported how many farmers reported animals in that group, but they did not identify how many animals were reported. For instance, under hogs in Cameron County in 1987, there were only 3 farmers reporting. Therefore, NASS reports the “3” hog farmers, but because it might be possible for a local person to figure out which specific farmers these three farmers might be, NASS did not report the number of hogs these three farmers owned; instead they simply report the acreage as “(D)”. These holes in the data sets caused some concern during this analysis because on the one hand it is misleading to report the “(D)” as zero hogs, but it is also impossible to know how many hogs were grown. This problem was solved by artificially inserting a number into the analysis. These numbers varied with the different animals. In the case of large animals (cows, horses, etc), I assumed a “(D)” was equal to 5 animals. In the case of smaller animals (hogs, chickens, etc) the “(D)” was assumed to be 10 animals. In a few cases, larger estimates were used. If you look at the specific data in the spread sheets, these estimated values are evident because they are rounded to 1 or 2 significant figures while the actual NASS data are reported to the last animal.

Cattle. The water use data available for cattle was limited to “Milk Cows”, “Other Adult Cows”, and “Young Cows”. Therefore the animal populations taken from NASS were adjusted as follows. It should be noted that between 1997 and 2002, NASS changed the way they combined “Steers and Bulls” and “Heifers”, thus the adjustment is different for the different years:

- Milk Cows = Milk Cows (no adjustments were made)
- Young Cows (1982, 1987, 1992, and 1997) = Cattle & Calves – Beef Cows – Milk Cows – Steers & Bulls. Because of the change in reporting in 2002, the category “Young Cows = Cattle & Calves - Beef Cows – Milk Cows - (1/3)Other Cattle. The 1/3 was an approximation of how many of the Other Cattle were thought to be young stock.

- Other Adult Cows (1982, 1987, 1992, and 1997) = Cattle & Calves – Milk Cows – Young Cows (defined above). In the 2002 NASS data, the old category of Steers and Bulls was changed to “Other Cattle”, which changed the category “Other Adult Cows” = Cattle & Calves – Milk Cows – Young Cows (defined above).
- Young Cows (1982, 1987, 1992, and 1997) = Cattle & Calves – Beef Cows – Milk Cows – Steers & Bulls. Because of the change in reporting in 2002, the category “Young Cows = Beef Cows + (1/3)Other Cattle.

Other Animal Populations. The other animal populations were used and reported directly as presented in the NASS statistics.

Present Animal Water Volume

The present animal water needs in each County were estimated from the animal populations reported in NASS (2002). These animal populations were multiplied times the daily water volume needed by each individual animal type (see Chapter 8) to determine the volume of water needed for animals in each County under the present circumstances. These data and analyses are in the two EXCEL spreadsheets named “Animal Projection Analysis*.xls”.

Extrapolated Future Irrigated Water Volume

The extrapolated animal water prediction for 2010, 2020, and 2030 was based on a linear equation fit to the historical animal populations from 1982, 1987, 1992, and 1997 (NASS, 1982, 1987, 1992, 1997) and the animal populations for 2002 used to determine the present water needs.

The procedure for extrapolating the historical animal populations between 1982 and 2002 to predict the animal populations expected in the future years of 2010, 2020, and 2030 was based entirely on drawing a straight line through the historical animal populations attempting to take into account how these populations had changed during the past 20 years. This extrapolation procedure was applied to each of the three cattle categories, the four poultry categories, and the swine, sheep, goats, and horse categories in each county. The results of each extrapolation are shown with the animal data and plotted in one of the three graphs located to the right of each county’s animal data in the attached “Animal Prediction Analysis” spreadsheets.

Assessment of Present Registrations

Included in NASS (2002) are data that tell how many farms with various animal populations are located in each county. The farm-size data available includes “Cattle and Calves”, “Beef Cows”, “Milk Cows”, “Steers and Bulls (Other Cattle)”, “Hogs and Pigs”, and “Layers”. By knowing how much water is likely to be needed by each type of animal, we could determine approximately how many of each type of animal would need to be grown (or kept) on each individual farm before that farmer’s animals probably used more than the 10,000 gpd trigger volume required for registration. PADEP also supplied the results of the individual farmer water registrations. By making several reasonable assumptions we were able to determine an estimate of each of the following parameters for each county:

- Total number of farms with each type of animal.
- Number of farms with a large enough numbers of animals to require registration based on the 10,000 gpd registration limitation.
- Number of animal production farms that already registered.
- Total water needed for animal production in MG.
- Total animal production water registered in MG.

These results are located in the “Animal” sheet of the attached “Registration Analysis” spreadsheet and summarized in Part IV.

CHAPTER 8

Animal Water Needed

The production of animals and associated meat and milk require considerable quantities of water. Before we attempt to suggest levels of animal water use for each type of animal raised in Pennsylvania, let's take a look at a rather detailed analysis of animal water use to demonstrate the complexities of determining appropriate animal water use values. Thus we have developed three relevant examples. These examples include determination of water use, respiration, and waste production for three specific animals; a 1400-pound dairy cow, a 125-pound pig, and a 4-pound laying hen. The data used in these examples were obtained from Esmay and Dixon (1986) and Midwest Plan Service (1985).

1400-Pound Dairy Cow; Typical Holstein

A typical 1400-pound dairy cow, milking 80 pounds of milk per day, takes in about 23 gallons of water each day. Of these 23 gallons, eight gallons are converted into milk. Of the remaining 15 gallons of water (23 - 8 = 15), 12 gallons appears in the cow's waste (fecal plus urine). The water in the waste stream will be returned to the hydrologic cycle as a liquid or vapor depending on how the farmer manages his/her waste operation. The other 3 gallons is respired to the atmosphere. Finally, each dairy operation uses additional water to clean the milking equipment and flush manure from within the production facility. Midwest Plan Service (1985) encourages dairy operations to add an additional 7 gallons per day for each animal's water need to cover these clean-up uses. Therefore, a dairy cow uses, on average about 35 gallons of water per day; 23 gallons are consumed and 12 more is used to make the milking operation function.

If we assume the milk (8 gpd) is consumed within Pennsylvania and converted to waste via digestion that is returned to Pennsylvania, the cow's waste (12 gpd) is returned to the waters of Pennsylvania, and the cleanup water (12 gpd) is also returned to the waters of Pennsylvania, then only the 3 gpd of respired water is consumed. Thus the consumptive use for a daily cow is only (3/35) 9%. If one assumes the milk is shipped outside of Pennsylvania, then the consumptive use increases to (11/35) 31%.

Non-milking adult cows will drink about 15 gpd and respire about 3 gpd, yielding a consumptive use of only (3/15) 20%. This is a reasonable value for young cattle as well.

On the other hand some will argue that water consumed and returned in the animal's waste stream is also consumptively used. If this is true (which I disagree with) the a milk cow consumptively uses (12/35) 34% and non-milk cow consumptively use 100%.

125-Pound Pig

Each 125-pound pig will usually use about four gallons of water per day. Of this four gal/pig/day, about 0.75 gal/pig/day is respired and 1.07 gal/pig/day is discharged in the waste (fecal and urine). The remainder of the water is wasted (pigs are sloppy drinkers).

4-Pound Laying Hen

Four-pound laying hens take in about 0.08 gallons of water each day. About half or 0.04 gal/hen/day is respired.

Animal Design and Consumptive Use Rates

Based on evaluations similar to those discussed above, we have developed estimates for each of the animal categories in the NASS data by using the water use data available (Esmay and Dixon, 1986; and Midwest Plan Service, 1985). The design water needs of each animal category are summarized in Table 8-1. The design values shown in Table 8-1 tend to be those used by agricultural planners based on the larger animal in each category. Thus, there was a tendency to over estimate the water used by animals in some of the groups. The daily water use values in Table 8-1 were used in this analysis. The last column of Table 8-1 contains an estimate of the percentage of he design volume that should be considered consumptive use or

Table 8-1. Daily Design and Consumptive Water Use by Farm Animals.

Animal Groups	Design Animal Use (Gallons/Animal/Day)	Consumptive Use Factors (%)
Milk Cows	35	9 to 31
Other Adult Cows	15	20
Young Stock	11	20
Hogs & Pigs	4	20
Sheep & Lambs	2	20
Goats	2	20
Horses & Ponies	12	20
Chickens (3 months +)	0.055	50
Hens & Pullets	0.06	50
Broilers & Meat Birds	0.08	50
Turkeys	1.2	50

CHAPTER 9

Current and Future Water Needed by Animals

The results of the current and future animal water needs assessment are presented in this chapter. It is strongly recommended that you read this chapter while near a computer where you can open and have available for reference the EXCEL Spreadsheets named "Animal Projections Analysis*.xls" and "Animal Projections Analysis*.xls". The "*" in the two previous file names refer to the first letter of the county names in each file. There is also a "7" in the file name to denote the water use units of MGD used to present the results. The file named "Water Results7.xls" also contains a summary of these animal use results. These files are on the CD at the end of this report.

Animal populations were determined from the NASS statistics for evaluation years 1982, 1987, 1992, 1997, and 2002 for each major species within each county and extrapolated to predict animal populations expected in 2010, 2020, and 2030 by the procedures outlined in Chapters 7 and 8. The current (2002) animal populations in each county and those predicted for 2010, 2020, and 2030 are summarized in Appendix F. These tables and related animal population data can be found in the "Water Results7" spreadsheet.

Animal populations are projected to change over the next few decades. Figures 9-1 to 9-6 show the current and projected animal populations for the major species raised in the State of Pennsylvania. These six figures are shown in descending order of the volume of water each species will need starting with cattle, which need the largest volume of water and ending in Figure 9-6 with goats, which needs the smallest volume of water. These six figures give a visual picture of what each species' population is (or was) in 2002 and how, based on the county-by-county and species-by-species extrapolations performed, during this analysis, and how the population of each species is expected to change during the next 28 years. From Figure 9-1 we can easily see that cattle populations are expected to decline. The milk cow populations are expected to decline about 9,000 head over the next 28 years or about 300 head/year. The decline in adult cows (most of these are beef cattle) and the decline in young stock is slightly less, but an overall decline in cattle population is predicted. All of the other species, for which we had data, showed growth trends over the next 28 years. These growth rates varied from about 2%/year for several poultry groups to as high as 3.5%/year for goats. In summary, except for slowly declining cattle populations, other animal populations are expected to increase over the next three decades. Current and projected animal populations are shown for each county in Section 1 of Appendix F.

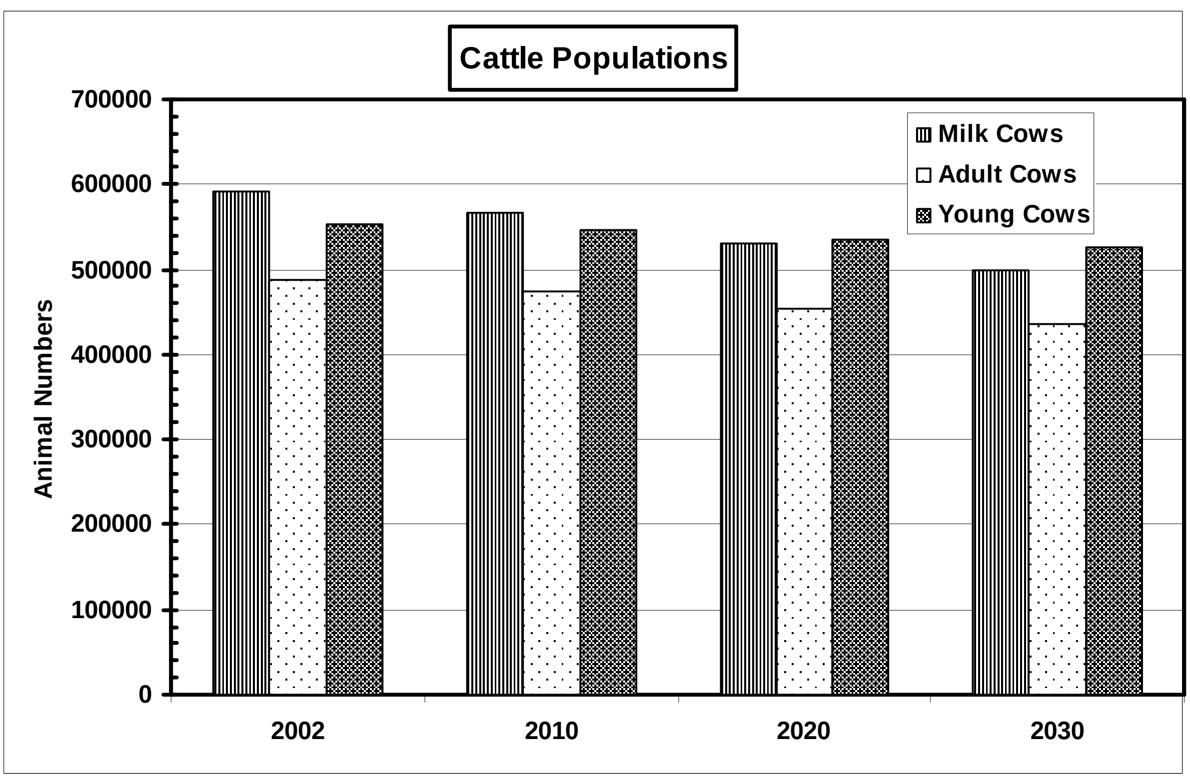

Figure 9-1. Current and predicted cattle populations.

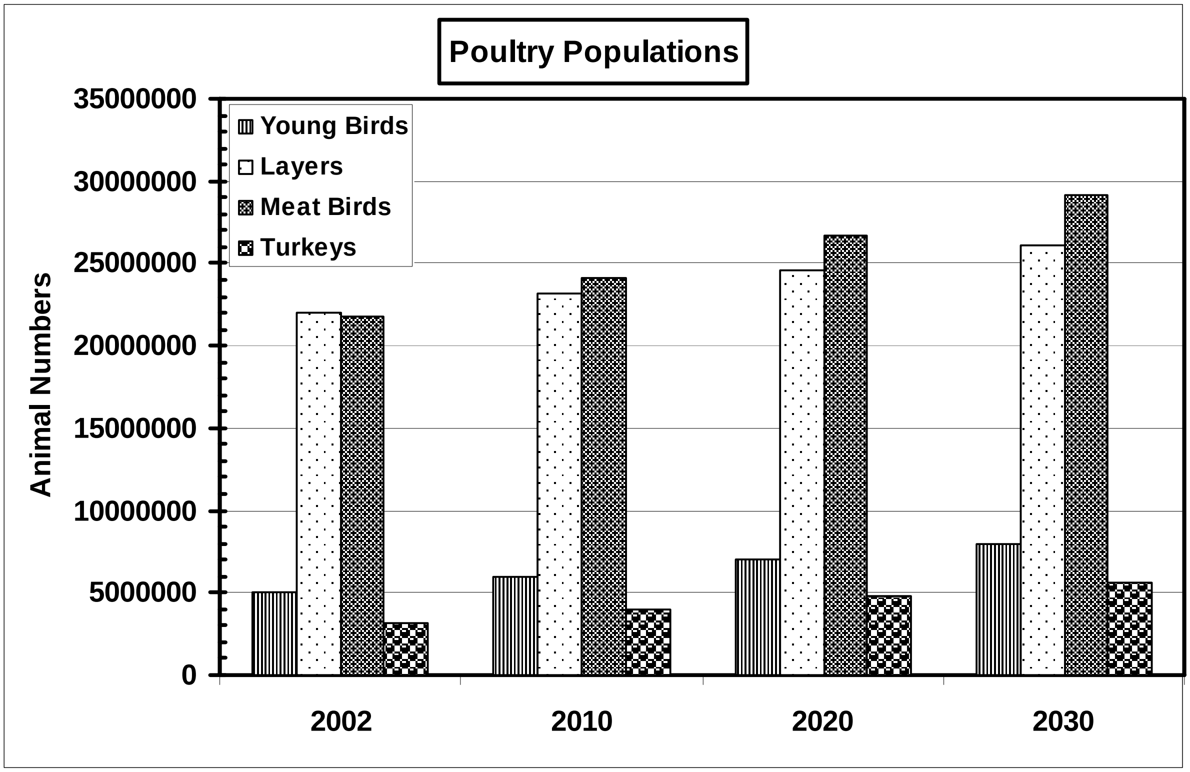

Figure 9-2. Current and predicted poultry populations.

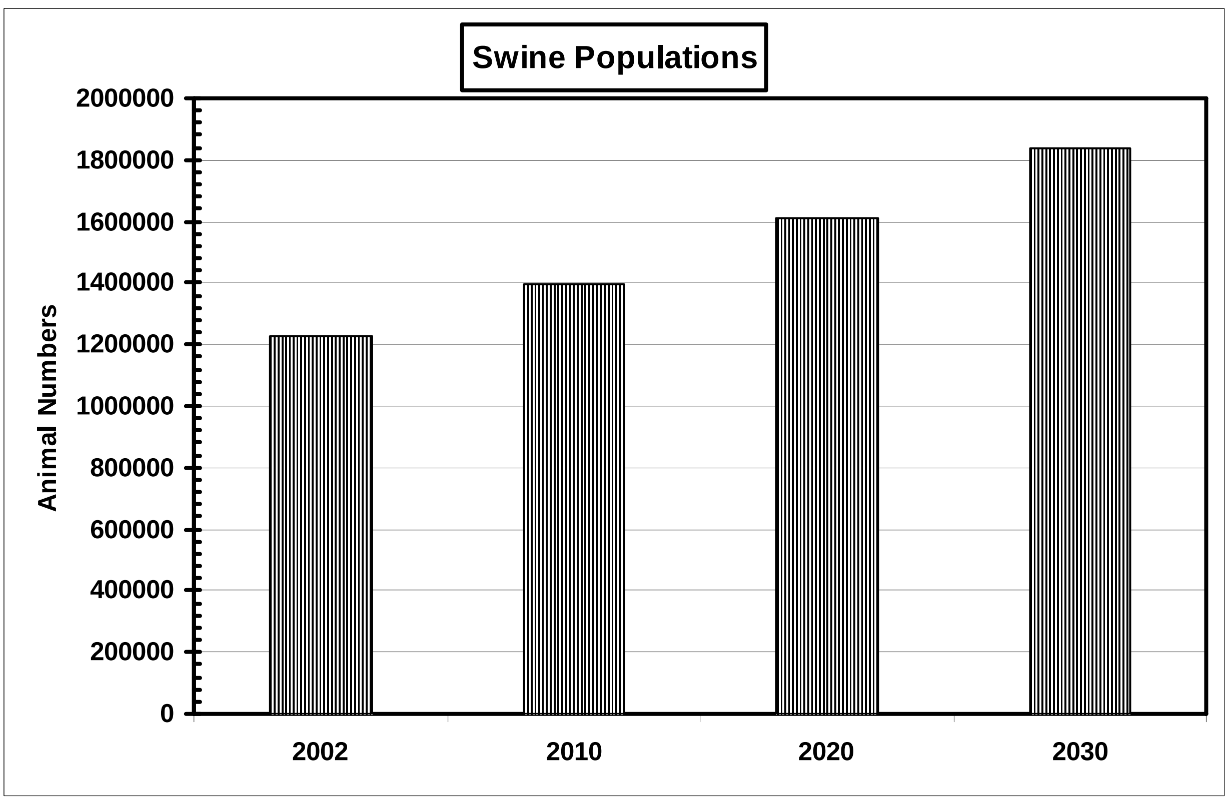

Figure 9-3. Current and projected swine populations.

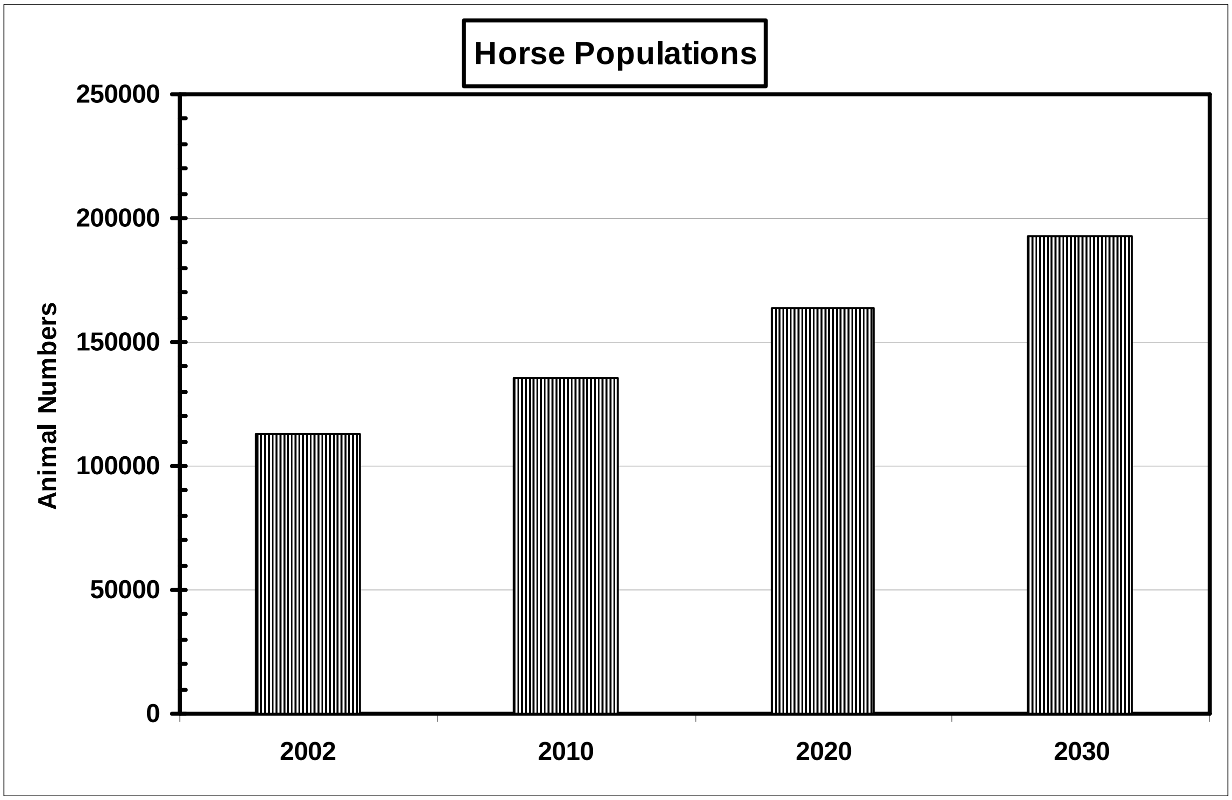

Figure 9-4. Current and predicted horse populations.

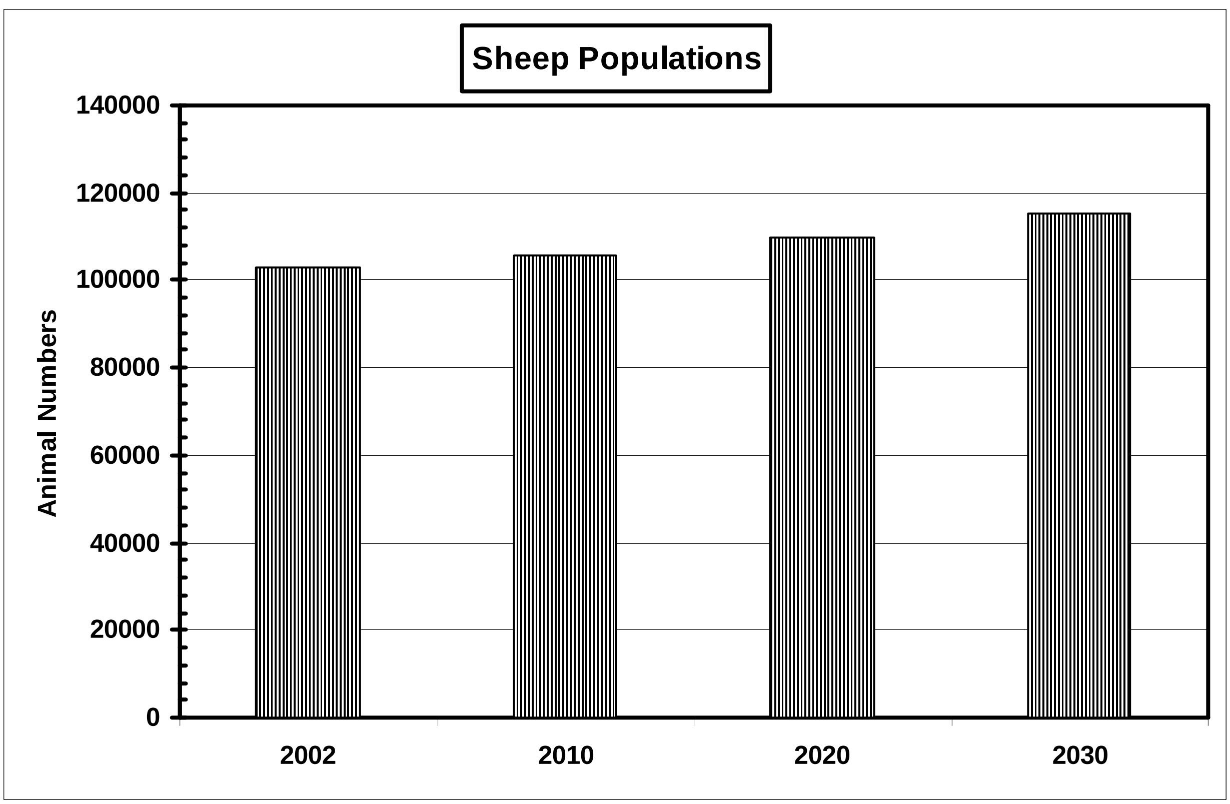

Figure 9-5. Current and predicted sheep populations.

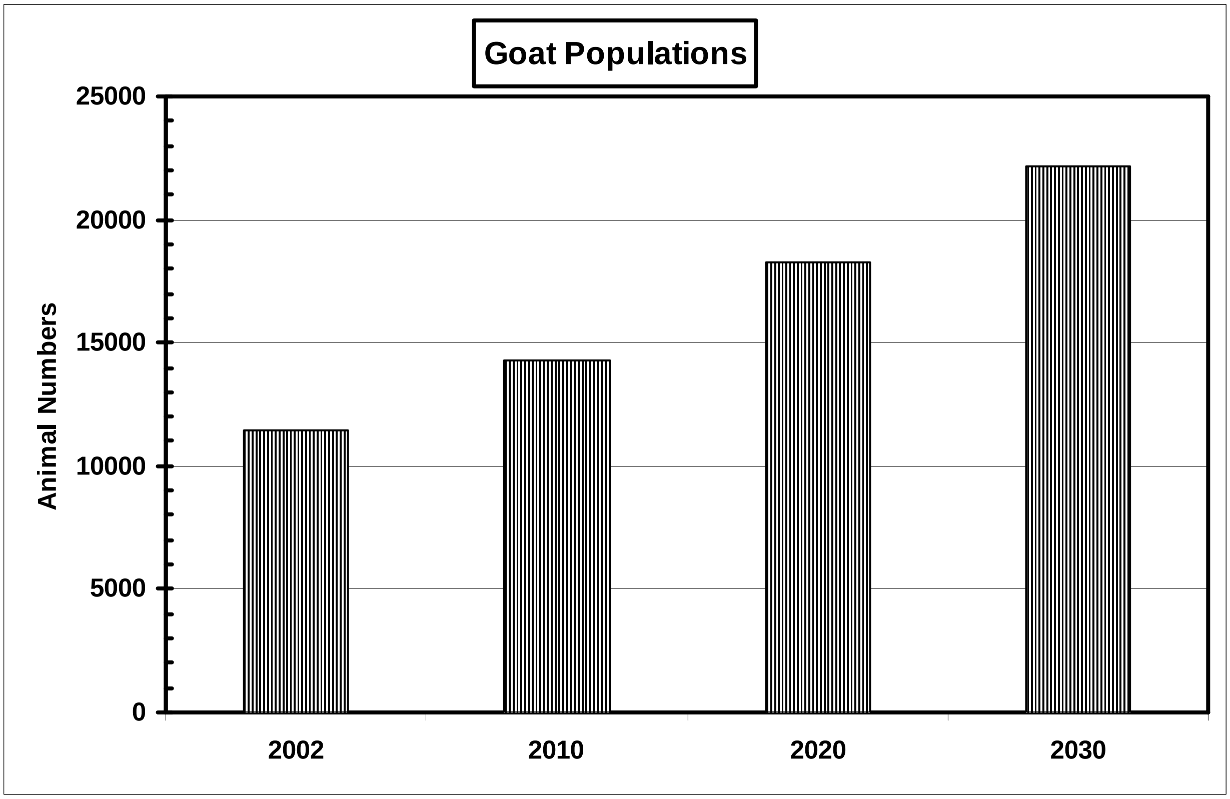

Figure 9-6. Current and predicted goat populations.

Animal Water Needed

By multiplying the animal populations times the daily water use volumes needed by each species presented earlier, the volume of water needed to sustain these animal populations was determined. The detailed water volumes needed to raise each species in each county are presented in Section 2 of Appendix F. The total water needed for all animals in each county is shown in Table 9-1 for the current conditions (2002) and for 2010, 2020, and 2030 extrapolations.

Table 9-1. Current and predicted animal water needed by county.

County	2002 MGD	2010 MGD	2020 MGD	2030 MGD
Adams	1.660	1.937	2.132	2.328
Allegheny	0.058	0.059	0.053	0.047
Armstrong	0.303	0.299	0.278	0.257
Beaver	0.194	0.176	0.147	0.117
Bedford	0.965	0.921	0.859	0.796
Berks	1.860	1.872	1.885	1.899
Blair	0.840	0.931	1.049	1.168
Bradford	1.710	1.624	1.510	1.396
Bucks	0.198	0.177	0.134	0.092
Butler	0.413	0.370	0.315	0.260
Cambria	0.231	0.226	0.218	0.209
Cameron	0.005	0.005	0.004	0.004
Carbon	0.022	0.019	0.016	0.014
Centre	0.758	0.762	0.765	0.768
Chester	1.231	1.106	0.961	0.815
Clarion	0.322	0.326	0.329	0.332
Clearfield	0.151	0.135	0.109	0.083
Clinton	0.361	0.409	0.471	0.535
Columbia	0.305	0.295	0.283	0.272
Crawford	0.854	0.738	0.592	0.446
Cumberland	1.287	1.362	1.445	1.528
Dauphin	0.573	0.521	0.461	0.412
Delaware	0.012	0.008	0.004	0.001
Elk	0.050	0.049	0.047	0.044
Erie	0.495	0.383	0.238	0.180
Fayette	0.389	0.391	0.387	0.383
Forest	0.011	0.011	0.011	0.012
Franklin	3.469	3.808	4.233	4.658
Fulton	0.531	0.557	0.589	0.621
Greene	0.274	0.274	0.267	0.277
Huntingdon	0.692	0.724	0.767	0.810
Indiana	0.451	0.404	0.354	0.304
Jefferson	0.216	0.191	0.155	0.119
Juniata	0.867	0.933	1.019	1.105
Lackawanna	0.092	0.073	0.047	0.022
Lancaster	8.771	8.991	9.244	9.498
Lawrence	0.419	0.391	0.354	0.317
Lebanon	2.248	2.537	2.918	3.299
Lehigh	0.118	0.085	0.072	0.060
Luzerne	0.112	0.092	0.068	0.045
Lycoming	0.577	0.581	0.582	0.583
McKean	0.087	0.072	0.052	0.039
Mercer	0.692	0.673	0.632	0.591
Mifflin	0.983	1.082	1.212	1.343
Monroe	0.031	0.025	0.023	0.025
Montgomery	0.189	0.160	0.121	0.082
Montour	0.156	0.153	0.153	0.153
Northampton	0.163	0.059	0.013	0.009
Northum.	0.819	0.963	1.130	1.296
Perry	1.060	1.255	1.498	1.740
Philadelphia	0.000	0.000	0.000	0.000
Pike	0.012	0.013	0.015	0.017
Potter	0.305	0.293	0.273	0.252
Schuylkill	0.412	0.422	0.408	0.394
Snyder	1.055	1.186	1.362	1.537
Somerset	1.130	1.151	1.184	1.218
Sullivan	0.120	0.110	0.095	0.080
Susque.	0.705	0.647	0.534	0.421
Tioga	0.896	0.847	0.758	0.668
Union	0.777	0.856	0.938	1.019
Venango	0.166	0.154	0.134	0.114
Warren	0.289	0.266	0.234	0.202
Washington	0.664	0.631	0.592	0.554
Wayne	0.409	0.303	0.159	0.113
Westmoreland	0.522	0.469	0.387	0.310
Wyoming	0.192	0.157	0.105	0.053
York	1.868	2.040	2.230	2.421
Total =	47.794	48.737	49.615	50.767

Table 9-2. Top ten counties needing water for animals.

Rank	No	2002 County	Water Needed MGD
1	36	**Lancaster**	8.771
2	28	**Franklin**	3.469
3	41	**Lebanon**	2.248
4	67	**York**	1.868
5	6	**Berks**	1.860
6	8	**Bradford**	1.710
7	1	**Adams**	1.660
8	21	**Cumberland**	1.287
9	15	**Chester**	1.231
10	56	**Somerset**	1.130
		State Totals	47.794

Rank	No	2010	
1	36	**Lancaster**	8.991
2	28	**Franklin**	3.808
3	38	**Lebanon**	2.537
4	67	**York**	2.040
5	1	**Adams**	1.937
6	6	**Berks**	1.872
7	8	**Bradford**	1.624
8	21	**Cumberland**	1.362
9	50	**Perry**	1.255
10	55	**Snyder**	1.186
		State Totals	48.737

Rank	No	2020	
1	36	**Lancaster**	9.244
2	28	**Franklin**	4.233
3	38	**Lebanon**	2.918
4	67	**York**	2.230
5	1	**Adams**	2.132
6	6	**Berks**	1.885
7	8	**Bradford**	1.510
8	50	**Perry**	1.498
9	21	**Cumberland**	1.445
10	55	**Snyder**	1.362
		State Totals	49.615

Rank	No	2030	
1	36	**Lancaster**	9.498
2	28	**Franklin**	4.658
3	38	**Lebanon**	2.328
4	67	**York**	2.421
5	1	**Adams**	2.328
6	6	**Berks**	1.899
7	50	**Perry**	1.740
8	55	**Snyder**	1.537
9	21	**Cumberland**	1.528
10	8	**Bradford**	1.396
		State Totals	50.767

As with the irrigation analysis, it is useful to observe from the results shown in Section 2 of Appendix F, that the majority of the water needed to raise animals in Pennsylvania is (and will) be needed in a few select counties, see Table 9-2. The county with the largest animal water need is Lancaster where approximately 9 MGD of water is or will be needed for animals. These top ten animal-producing counties currently (2002) account for 53% of the animal water needed in Pennsylvania and the top ten counties should continue to account for nearly 60% of the animal water needed in Pennsylvania.

These animal water needed results and the detailed results from which these values were derived reveal many interesting concepts that may be helpful from the standpoint of the Pennsylvania “State Water Plan”. By plotting the total water needed for animals against each of the years evaluated (see Figure 9-7), we can see that the historical evidence shows that animal water needs are expected to grow over the next few decades. The rate of growth in animal water needed resulting from this study was an annual growth rate of about 0.2%/year (90,000 gal/day/year).

Before we close this chapter on how much water Pennsylvania agriculture has used and will most likely need for animal production during the next few decades, it is worth including a few comments about the reliability of these results and the estimates for the future. A great deal of science was brought to bear on the 1982, 1987, 1992, 1997, and 2002 NASS data to establish the present and future animal water needs. It must be remembered that the results are no better than the raw data. We have taken the NASS data at face value. I know from experience and from interacting with farmers, that there few if any farmers who consider their report to NASS as "important" or "any of the government's business". Many farmers refuse to fill out the questionnaire and many provide only loose estimates. The farming community generally considers the "government" an entity they dislike and most refuse to cooperate with it in any way. They mostly fear that data reported will eventually return to them in some way that will restrict their freedom or cost them money in the form of taxes, levies, or reduced prices for their produce. Thus even the 2002 (present conditions) results reported must be considered to have a large error. If someone were to ask me how much water is needed for animals in Pennsylvania in 2002, I would respond with "about 50 MGD, maybe a bit more".

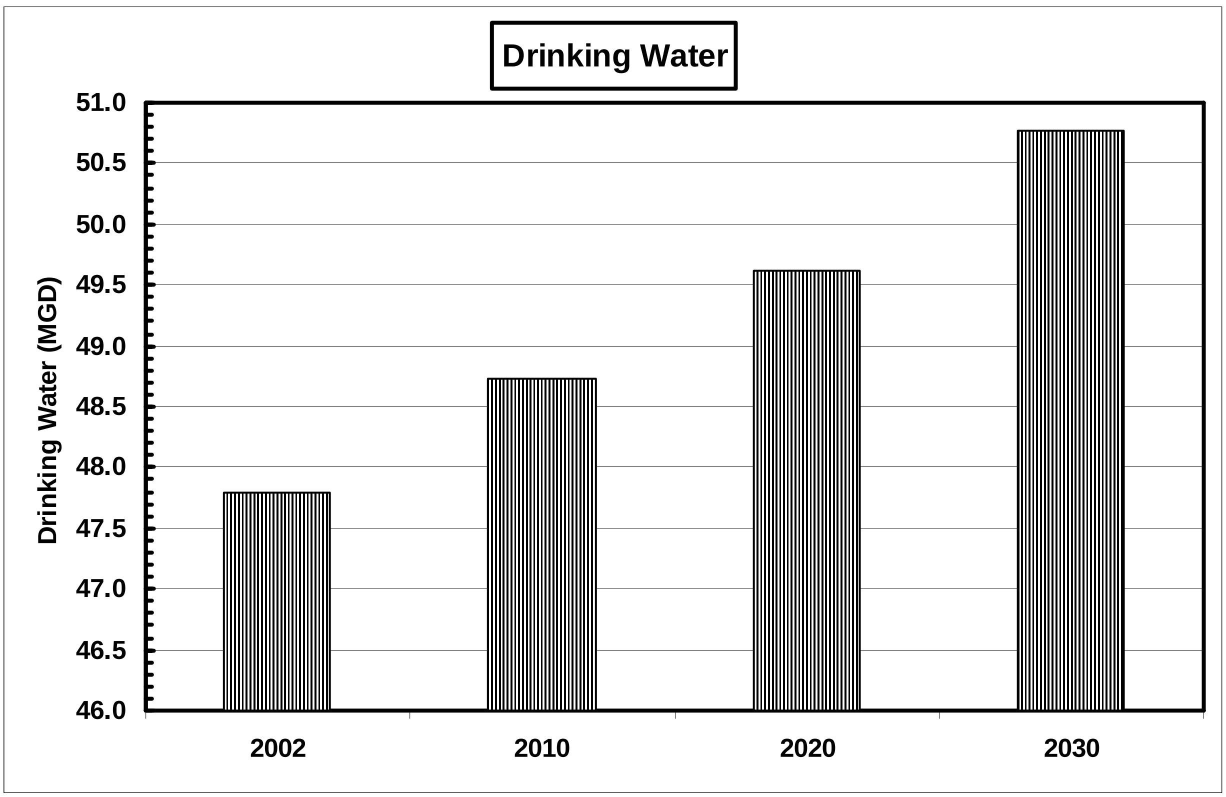

Figure 9-7. Current and predicted animal water needed.

This then raises questions about how good the projected animal water needs are for 2010, 2020, and 2030. As described earlier, these projections were based on my best-guess at a straight-line extrapolation using the NASS acreages from the past 20 years. It should be remembered that during the past 20 years, there were only five sets of data available. Obviously I feel better about the predicted results in 2010 than in the later years. With "big" agricultural operations being planned and implemented, major shifts in animal production units can occur in just a few years.

I guess the bottom-line is that I do not believe the numbers in this report to be better than one or 1.5 significant figures. It is my hope that the reader will not get too hung-up in minor differences.

PART III
Summary of Irrigation and Animal Water Needs

CHAPTER 10
Current and Future Maximum Daily Water Needed by Irrigation and Animals

The analysis used to determine the water needed for irrigation was presented in Part I. The maximum daily irrigation water needs (Q_{7-10}) were presented in Chapter 5 with supporting data summarized in Appendices C and D. The supporting data and computations are in files named “Irrigation Projection AnalysisA-C7.xls” and “Irrigation Projection AnalysisD-Y7.xls” and summarized in a file named “Water Results7” all of which can be found on the CD at the end of this report.

The analysis used to determine the daily water needed for animals was presented in Part II. The results of this assessment were presented in Chapter 9 with supporting data summarized in Appendix F. The supporting data and computations are in files named “Animal Projection AnalysisA-M7” and “Animal Projection AnalysisM-Y7” and summarized in a file named “Water Results7” all of which can be found on the CD at the end of this report.

The purpose of this chapter is to present the combined daily irrigation (Q_{7-10}) and daily animal water needed currently (in 2002) and projected to be needed by agriculture in 2010, 2020, and 2030. The numerical summary for each of the four evaluation years are shown in Tables 10-1 to 10-4. The final agricultural water-use totals are shown in Figure 10-1. It is evident from the data summarized here that agricultural water use is expected to grow over the next 28 years. Water needed for raising animals will grow slightly, from 48 to 51 MGD. The 10-year, 7-day maximum (Q_{7-10}) water needed to support irrigation of agricultural crops is expected to grow more rapidly, from 140 to 360 MGD. The water needed for animals will be nearly uniformly distributed across the year while the water needed for irrigation will be needed only during periods that match the Q_{7-10} criteria.

Table 10-1. Daily maximum irrigation (Q_{7-10}) and daily animal water needs in 2002.

		2002 Animals	2002 Irrigated	2002 Total
Item	**Units**	**State Totals**	**State Totals**	
Irrigated Area by Crop				
Corn	acres		4645	
Vegetables	acres		12484	
Orchards	acres		5031	
Berries	acres		915	
Other	acres		19260	
Total Irrigated Area	acres		42335	
Maximum 7-Day Water Needed by Crop				
Corn	MGD (Q_{7-10})		14.98	
Vegetables	MGD (Q_{7-10})		47.22	
Orchards	MGD (Q_{7-10})		14.96	
Berries	MGD (Q_{7-10})		2.74	
Other	MGD (Q_{7-10})		60.47	
Maximum 7-Day Water Needed	MGD (Q_{7-10})		140.37	
Animal Numbers by Species				
Swine	#	1,228,334		
Sheep	#	102,797		
Goats	#	11,432		
Horses	#	113,079		
Young Birds	#	5,075,534		
Layers	#	21,964,731		
Meat Birds	#	21,740,389		
Turkeys	#	3,201,432		
Milk Cows	#	591,772		
Adult Cows	#	488,324		
Young Cows	#	552,754		

Annual Water Needed by Species				
Swine	MGD	4.91		
Sheep	MGD	0.21		
Goats	MGD	0.02		
Horses	MGD	1.36		
Poultry	MGD	7.18		
Cattle	MGD	34.12		
Total Water Needed for Livestock	MGD	47.79		
Maximum Daily Water Needed =	MGD	47.79	140.37	188.16

Table 10-2. Daily maximum irrigation (Q_{7-10}) and daily animal water needs in 2010.

		2010 Animals	2010 Irrigated	2010 Total
Item	Units	State Totals	State Totals	
Irrigated Area by Crop				
Corn	acres		8357	
Vegetables	acres		12933	
Orchards	acres		5092	
Berries	acres		752	
Other	acres		21170	
Total Irrigated Area	acres		48303	
Maximum 7-Day Water Needed by Crop				
Corn	MGD (Q_{7-10})		44.71	
Vegetables	MGD (Q_{7-10})		80.42	
Orchards	MGD (Q_{7-10})		23.21	
Berries	MGD (Q_{7-10})		3.18	
Other	MGD (Q_{7-10})		94.13	
Maximum 7-Day Water Needed	MGD (Q_{7-10})		245.66	
Animal Numbers by Species				
Swine	#	1,394,702		
Sheep	#	105,458		
Goats	#	14,316		
Horses	#	135,274		
Young Birds	#	6,020,205		
Layers	#	23,133,938		
Meat Birds	#	24,133,529		
Turkeys	#	3,929,300		
Milk Cows	#	565,902		
Adult Cows	#	473,767		
Young Cows	#	547,034		
Annual Water Needed by Species				
Swine	MGD	5.58		
Sheep	MGD	0.21		
Goats	MGD	0.03		
Horses	MGD	1.62		
Poultry	MGD	8.36		
Cattle	MGD	32.93		
Total Water Needed for Livestock	MGD	48.73		
Maximum Daily Water Needed =	MGD	48.73	245.66	294.39

Table 10-3. Daily maximum irrigation (Q_{7-10}) and daily animal water needs in 2020.

Item	Units	2020 Animals State Totals	2020 Irrigated State Totals	2020 Total
Irrigated Area by Crop				
Corn	acres		11041	
Vegetables	acres		16319	
Orchards	acres		6094	
Berries	acres		817	
Other	acres		25695	
Total Irrigated Area	acres		59966	
Maximum 7-Day Water Needed by Crop				
Corn	MGD (Q_{7-10})		58.52	
Vegetables	MGD (Q_{7-10})		101.20	
Orchards	MGD (Q_{7-10})		28.26	
Berries	MGD (Q_{7-10})		3.44	
Other	MGD (Q_{7-10})		112.71	
Maximum 7-Day Water Needed	MGD (Q_{7-10})		304.13	
Animal Numbers by Species				
Swine	#	1,613,563		
Sheep	#	109,746		
Goats	#	18,238		
Horses	#	164,017		
Young Birds	#	7,002,597		
Layers	#	24,581,944		
Meat Birds	#	26,653,776		
Turkeys	#	4,748,615		
Milk Cows	#	530,255		
Adult Cows	#	453,783		
Young Cows	#	534,520		
Annual Water Needed by Species				
Swine	MGD	6.45		
Sheep	MGD	0.22		
Goats	MGD	0.04		
Horses	MGD	1.97		
Poultry	MGD	9.69		
Cattle	MGD	31.25		
Total Water Needed for Livestock	MGD	49.61		
Maximum Daily Water Needed =	MGD	49.61	304.13	353.75

Table 10-4. Daily maximum irrigation (Q_{7-10}) and daily animal water needs in 2030.

Item	Units	2030 Animals State Totals	2030 Irrigated State Totals	2030 Total
Irrigated Area by Crop				
Corn	acres		13729	
Vegetables	acres		19743	
Orchards	acres		7142	
Berries	acres		884	
Other	acres		30159	
Total Irrigated Area	acres		71658	

Maximum 7-Day Water Needed by Crop				
Corn	MGD		72.35	
Vegetables	MGD		122.22	
Orchards	MGD		33.47	
Berries	MGD		3.71	
Other	MGD		131.04	
Maximum 7-Day Water Needed	MGD		362.78	
Animal Numbers by Species				
Swine	#	1,838,332		
Sheep	#	115,488		
Goats	#	22,163		
Horses	#	192,835		
Young Birds	#	7,985,060		
Layers	#	26,052,850		
Meat Birds	#	29,174,895		
Turkeys	#	5,567,943		
Milk Cows	#	499,900		
Adult Cows	#	434,780		
Young Cows	#	526,190		
Annual Water Needed by Species				
Swine	MGD	7.35		
Sheep	MGD	0.23		
Goats	MGD	0.04		
Horses	MGD	2.31		
Poultry	MGD	11.02		
Cattle	MGD	29.81		
Total Water Needed for Livestock	MGD	50.77		
Maximum Daily Water Needed =	MGD	50.77	362.78	413.55

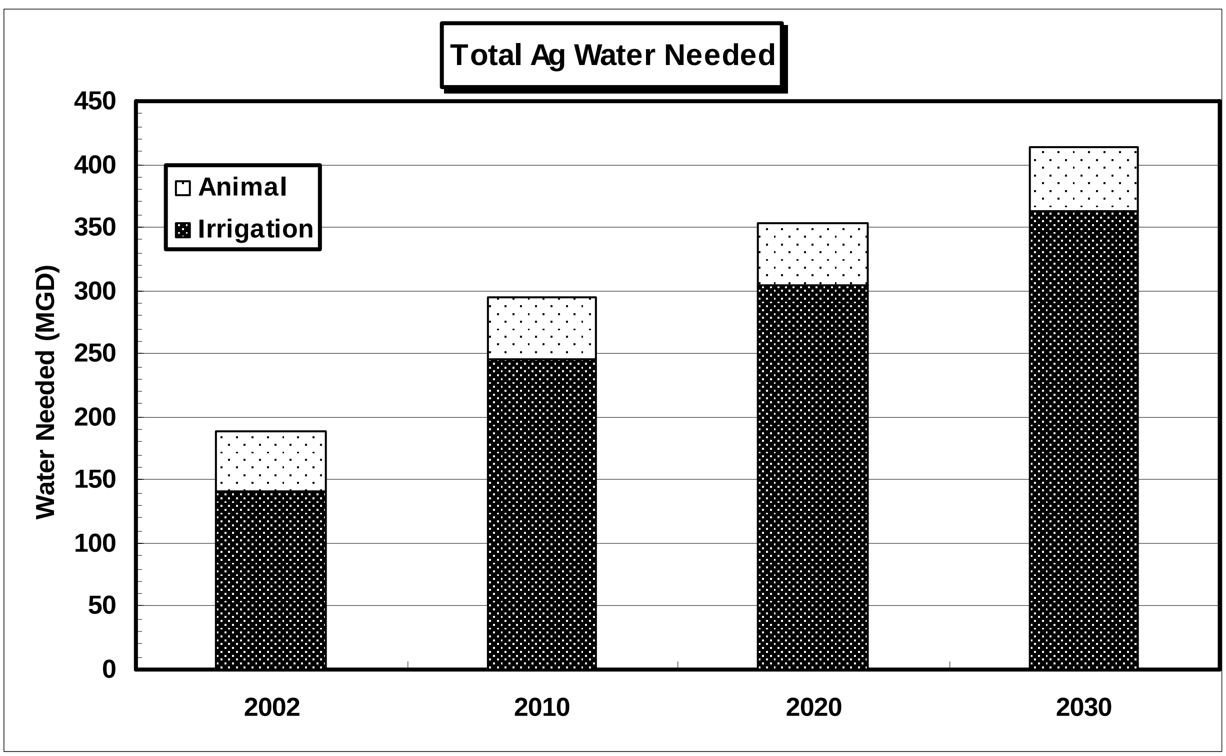

Figure 10-1. Total maximum daily agricultural water currently (2002) needed and expected to be needed in 2010, 2020, and 2030.

As noted in Chapter 9, there is an important rainfall-driven factor that greatly influences the volume of irrigation water needed in any given year. The projections of the volume of irrigation water needed in 2010, 2020, and 2030 was based on a 10-year return period drought occurring during each of these three evaluation years. If growing-seasonal rainfall is nearly normal (or above normal), daily water needed for irrigation will be less than those values shown. If, on the other hand, growing-seasonal rainfall is less than expected during a 10-year drought, water needed for irrigation could be greater than those values shown above.

Monthly Distribution of Maximum Agricultural Water Needed

It maybe useful to see how the daily maximum agricultural water use is expected to be distributed among the 12 months of the calendar year. If you remember, maximum daily irrigation water needed to supplement rainfall was presented based on the results of a study by Kibler et al. (1977), who showed that, based on the drought return period, different amounts of irrigation water will be needed in different months during the growing season from March through October. Irrigation water would not normally be needed during the dormant winter months. On the other hand, animals are typically raised in the context of an annual population that does not normally change much throughout the year. Thus for animals, water is needed at approximately the same volume every month of the year. The maximum daily water volumes presented above were parceled into monthly volumes for irrigation and animal use for each of the four evaluation years. The numerical data are shown in Tables 10-5 to 10-8 and plotted in Figures 10-2 to 10-5. The results shown in Tables 10-5 to 10-8 and plotted in Figures 10-2 to 10-5 assume a Q_{7-10} drought in each month that causes the maximum daily irrigation to occur in each month. It was not considered appropriate to sum the monthly values so no total annual value is given.

Table 10-5. Monthly distribution of agricultural water needed in 2002.

Monthly Water Needed		Animals	Irrig.	Total
January	MGD	47.79	0.00	47.79
February	MGD	47.79	0.00	47.79
March	MGD	47.79	11.10	58.89
April	MGD	47.79	42.99	90.78
May	MGD	47.79	82.65	130.45
June	MGD	47.79	123.98	171.77
July	MGD	47.79	133.89	181.68
August	MGD	47.79	133.89	181.68
September	MGD	47.79	98.96	146.75
October	MGD	47.79	42.41	90.20
November	MGD	47.79	0.00	47.79
December	MGD	47.79	0.00	47.79

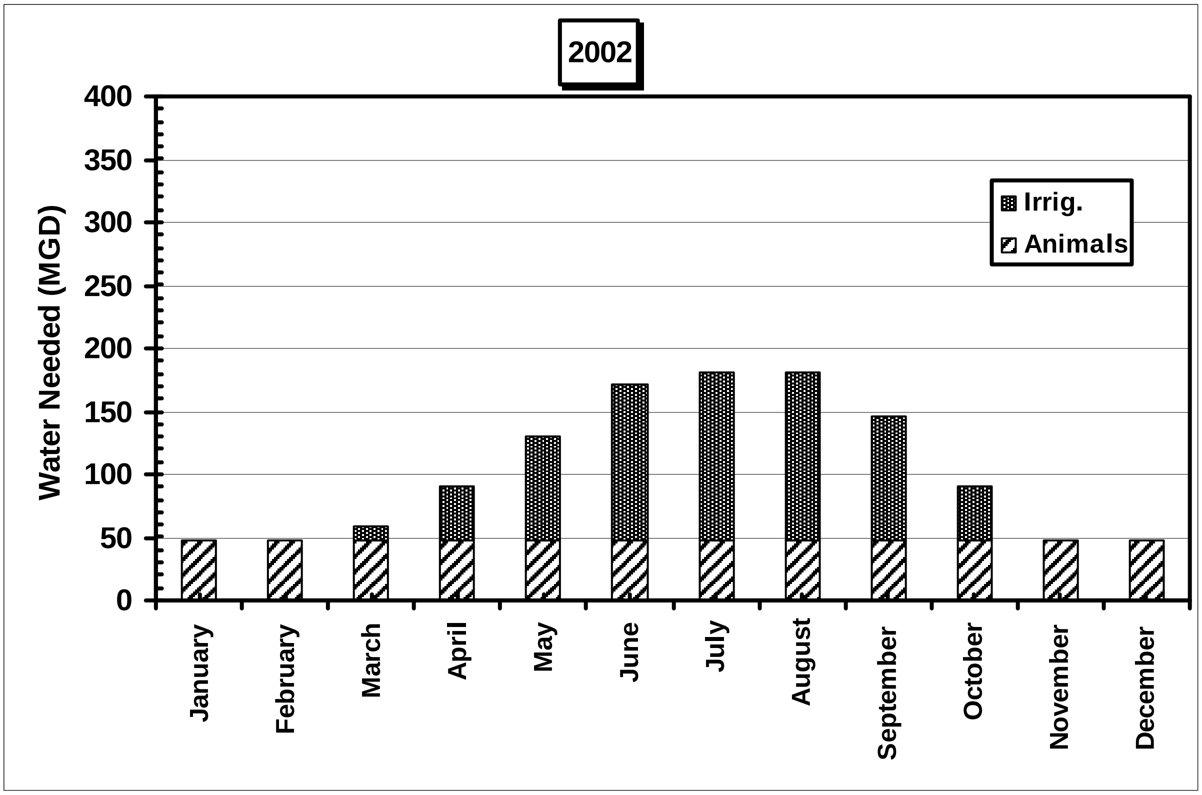

Figure 10-2. Monthly distribution of agricultural water needed in 2002.

Table 10-6. Monthly distribution of agricultural water needed in 2010.

Monthly Water Needed		Animals	Irrig.	Total
January	MGD	48.73	0.00	48.73
February	MGD	48.73	0.00	48.73
March	MGD	48.73	23.28	72.01
April	MGD	48.73	93.13	141.86
May	MGD	48.73	143.31	192.04
June	MGD	48.73	214.96	263.69
July	MGD	48.73	225.23	273.96
August	MGD	48.73	225.23	273.96
September	MGD	48.73	183.66	232.39
October	MGD	48.73	78.71	127.44
November	MGD	48.73	0.00	48.73
December	MGD	48.73	0.00	48.73

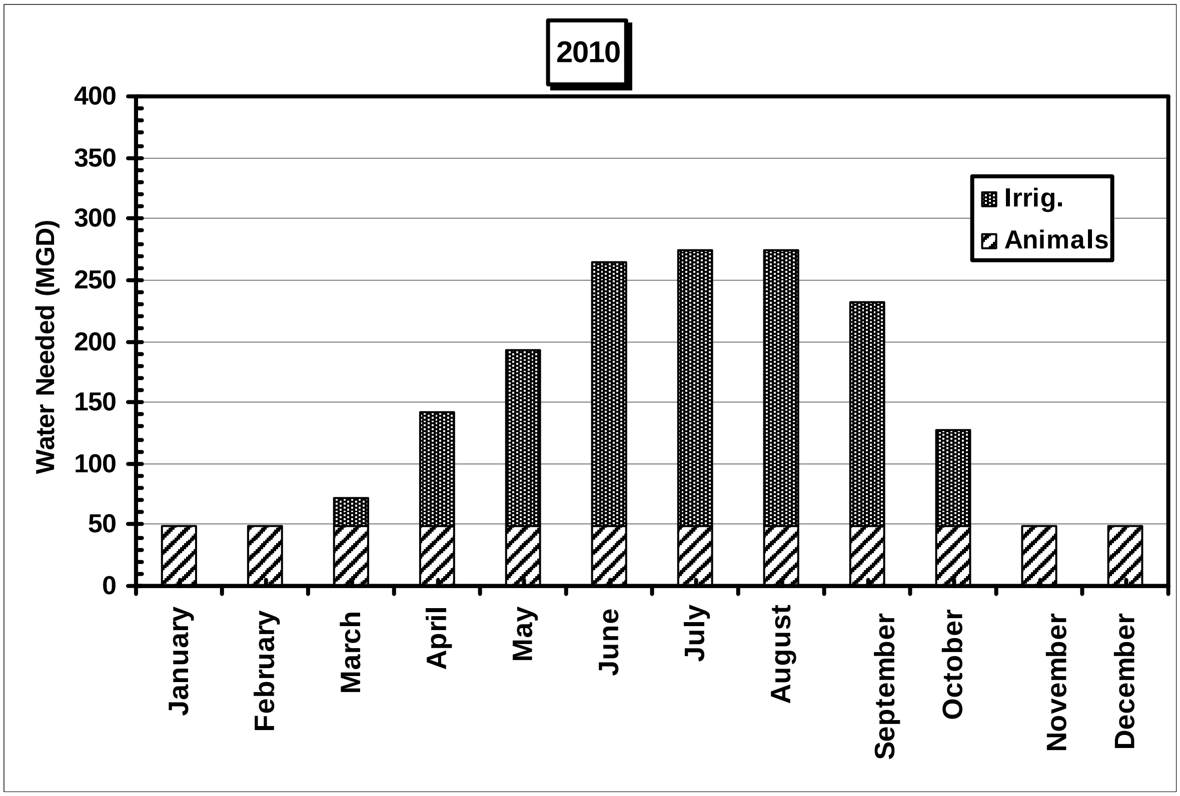

Figure 10-3. Monthly distribution of agricultural water needed in 2010.

Table 10-7. Monthly distribution of agricultural water needed in 2020.

Monthly Water Needed		Animals	Irrig.	Total
January	MGD	49.61	0.00	49.61
February	MGD	49.61	0.00	49.61
March	MGD	49.61	28.70	78.32
April	MGD	49.61	114.80	164.42
May	MGD	49.61	178.63	228.25
June	MGD	49.61	267.95	317.56
July	MGD	49.61	278.34	327.95
August	MGD	49.61	278.34	327.95
September	MGD	49.61	228.98	278.59
October	MGD	49.61	98.13	147.75
November	MGD	49.61	0.00	49.61
December	MGD	49.61	0.00	49.61

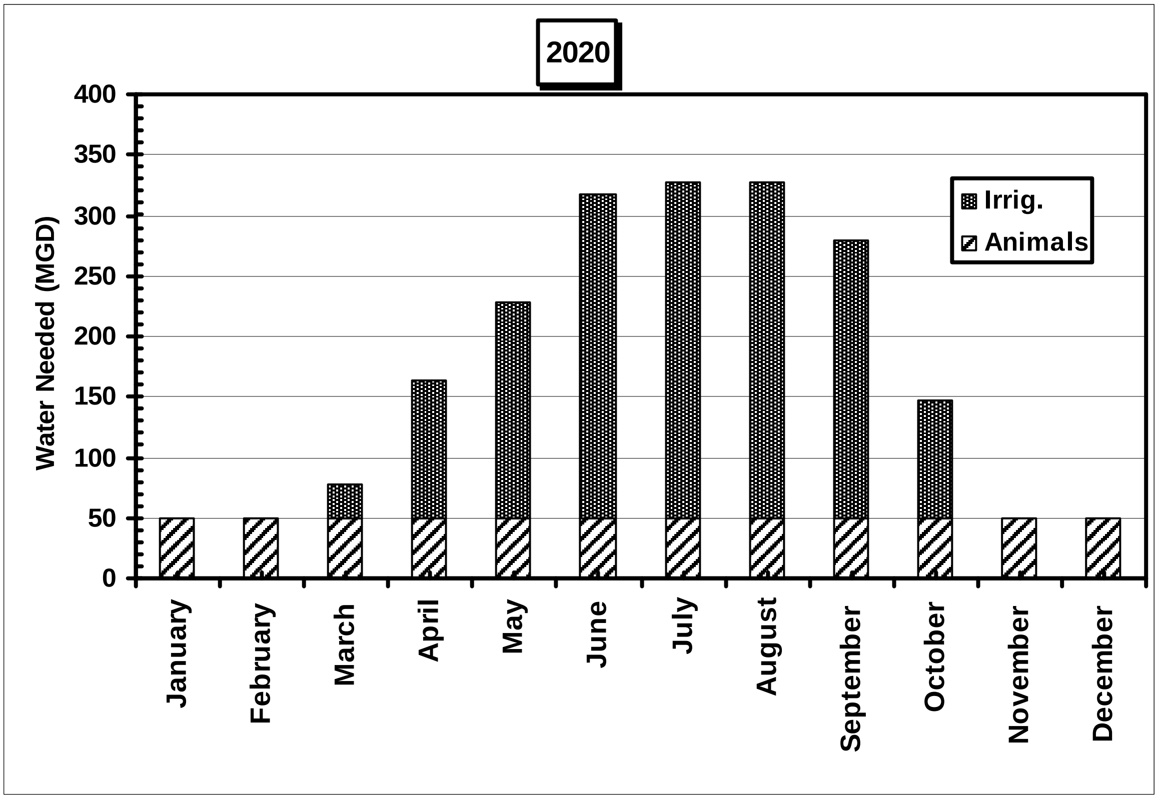

Figure 10-4. Monthly distribution of agricultural water needed in 2020.

Table 10-8. Monthly distribution of agricultural water needed in 2030.

Monthly Water Needed		Animals	Irrig.	Total
January	MGD	50.77	0.00	50.77
February	MGD	50.77	0.00	50.77
March	MGD	50.77	34.13	84.90
April	MGD	50.77	136.53	187.29
May	MGD	50.77	214.03	264.79
June	MGD	50.77	321.04	371.81
July	MGD	50.77	331.62	382.39
August	MGD	50.77	331.62	382.39
September	MGD	50.77	274.39	325.16
October	MGD	50.77	117.60	168.36
November	MGD	50.77	0.00	50.77
December	MGD	50.77	0.00	50.77

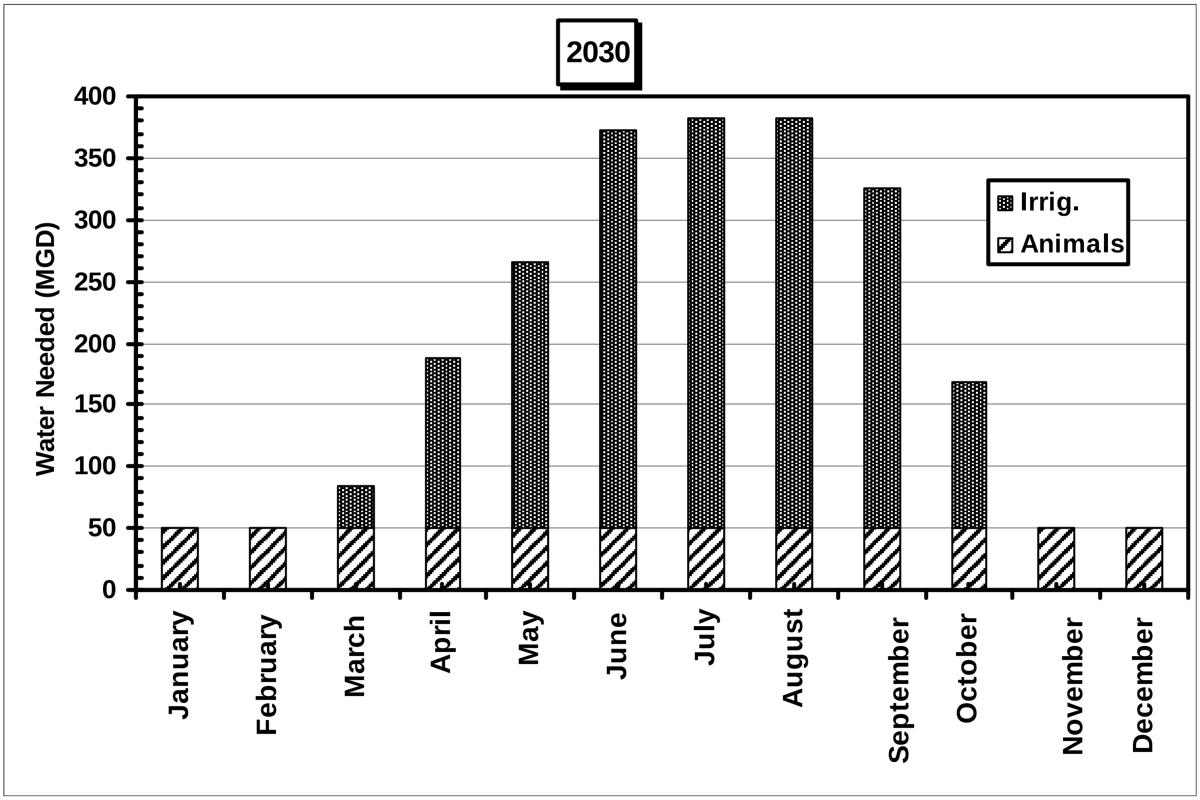

Figure 10-5. Monthly distribution of agricultural water needed in 2030.

The overall summary of how much water Pennsylvania agriculture used in 2002 is about 188 MGD. In the future maximum daily agricultural water used is expected to increase in 2010 to about 294 MGD based on the occurrence of a 10-year drought in 2010, increase in 2020 to about 354 MGD based on the occurrence of a 10-year drought in 2020, and increase in 2030 to about 414 MGD based on the occurrence of a 10-year drought in 2030. In this context it is assumed that the 10-year drought will occur uniformly across Pennsylvania and that the Q_{7-10} daily maximum water volumes will be needed every where at once.

PART IV

Registration Analysis

CHAPTER 11

Water Registration Assessment Procedure

After annual water volumes needed by agriculture to irrigate crops and grow animals were determined for the current conditions (2002) and extrapolated to 2010, 2020, and 2030, (see Chapters 6 and 9) these results were compared on a county-by-county basis to the water registration results provided by PADEP. In addition to the acreage irrigated and animal populations, which were instrumental in helping to determine the volume of water needed by the farmers in each county, the NASS data also provided additional information about “Irrigated Acreage by Farm Size” for each county. These data were presented in a form similar to that shown in Table 11-1. The “farm size” categories, “number of farms”, and “acres irrigated” were taken directly from the 2002 NASS data. The last column labeled “acres irrigated per farm” was added to summarize the average farm size represented by each category. In cases where “acres irrigated” were not given (the blanks) because of confidentiality issues, the average irrigated area per farm was not available. From these data, and the knowledge that only 2 to 3 acres of cropland needed to be irrigated before a farmer was most likely applying more than 10,000 gpd of irrigation water, we were able to estimate how many irrigating farms were large enough to require registration. In Adams County, for example, farms in all size categories except the “1 to 9 acres” category are most likely irrigating enough water to require registration with PADEP. In other words 91 of the 114 irrigating farmers in Adams County should most probably have registered their water use.

Table 11-1. NASS data on “Irrigated Acres By Farm Size” for Adams County in 2002.

Farms w/Irrigation =		114	
Acres Irrigated =		2656	
Irrigated Acres By Farm Size			**Acres Irrig.**
Acres	**# Farms**	**Acres Irrig.**	**per Farm**
1 to 9	23	47	2.0
10 to 49	33	97	2.9
50 to 69	2		NA
70 to 99	10	66	6.6
100 to 139	11	222	20.2
140 to 179	3		NA
180 to 219	5	82	16.4
220 to 259	4		NA
260 to 499	8	259	32.4
500 to 999	9	1139	126.6
1000 to 1999	4	330	82.5
>2000	2		NA

Based on the registration data supplied by PADEP, we were able to estimate that 11 irrigating farmers had already registered their water use totaling 31 MG/year. This 31 MG/yr was compared to the 569 MG/yr all irrigators in Adams County should most likely have been applying.

PADEP Water Use Registration Data

PADEP provided a summary of the agricultural water use registration data. These data included “County”, “Location”, “Annual Withdrawal”, “Annual Days this water was Used”, and a monthly breakdown of “volume used” and “days used” each month. First the registration data were sorted by county. These sorted registration data are in the “Reg” sheet of the “Registration Analysis” spreadsheet (see the CD at the end of this report). Then in order to identify whether a farmer was using the water for irrigation or animal agriculture, we used the given monthly data as follows:

- If the water was withdrawn nearly uniformly over all months, the farmer was assumed to be supplying the water to animals. No data was provided about what animals might be being raised.
- If the water was withdrawn only during selected growing season months, the farmers were most likely irrigating crops. No data was provided about what crops might be irrigated.

- When the registered annual volume of water was given as “0”, we could not use the data (marked in yellow). We have no idea what these represent.
- If the registered annual volume of water included no monthly breakdown, it was impossible to determine whether the water was to be used for animal or crop irrigation purposes. These too are marked in yellow.

The average water volume registrations for the months of January, February, November, and December were used to estimate the animal use. Any registered water over and above this “animal” average was considered to be irrigation water.

NASS Animal Data

The NASS data base also included a detailed breakdown of how many farms contained “how many animals”. These details were given for several animals sub-groups. These data were used to estimate how many farms should have been registering animal water use in each county. The animal data available relating to farm size and animal populations in each county included:

- Farms with cattle,
- Farms with Beef cows,
- Farms with Milk cows,
- Farms with Other Cattle,
- Farms with Hogs, and
- Farms with Layers.

Table 11-2. NASS data on “Farm w/ Milk Cows” for Adams County in 2002.

		10000 gpd	
		Flag =	286
	Farms w/Milk Cows =		60
	Total Milk Cows =		7280
Farm Size			**Milk Cows**
# Animals	**# Farms**	**# Milk Cows**	**per Farm**
1 to 9	5	6	1
10 to 19	4	66	17
20 to 49	16	540	34
50 to 99	21	1454	69
100 to 199	6	907	151
200 to 499	5	1127	225
> 500	3	3180	1060

These data were developed and used similar to those described earlier for irrigation. Table 11-2 shows the “Farms with Milk Cows” for Adams County in 2002. The first three columns were taken directly from the NASS data. The last column we added to determine the average number of milk cows on a typical farm in each category.

Note that the number at the top of the table tells how many milk cows can be raised on a farm before the farmer should be using more than 10,000 gpd of water. Again, the farms large enough to have more than the 286 head/farm were those identified as needing registration. In Adams County only 3 farms were (on average) large enough to require registration.

Each animal group for which these data were available was similarly evaluated and added to the 3 farms with milk cows to determine the number of animal farms that should probably be registering from Adams County. After looking at all of the animal groups, we identified 21 farms that should have been registered to use more than 10,000 gpd for animal production in Adams County. A complicating factor was that this analysis assumed no farmer was raising more than one species of animal. If a farmer was raising enough hogs to require registration and also raising enough milk cows to require registration, this farmer would most likely be counted twice as a potential registrant.

The results of this analysis are given in Chapter 12.

CHAPTER 12

Water Registration Assessment Results

The PADEP Water Registration data were evaluated to determine how many farmers had registered and what volume of water was registered in each county. When monthly data was available, it was possible to split out the number of registrants and volume registered pertaining to raising animals and irrigating crops. These data were evaluated and are summarized in Tables 12-1 for irrigation and Table 12-2 for animals.

In Table 12-1, for each county, the annual "irrigation water needed", "the number of farms that should be registering irrigation water", "the volume of irrigation water that was actually registered", and the number of farms that registered irrigation water" are shown. In most counties the volume of water registered is less (in many counties, much less) than the volume of water our analysis shows may be needed for irrigation in that county. There are a few counties where the volume of water registered was greater than the volume of water our analysis suggests will be needed. (More about this later). The totals for the state are shown at the bottom of Table 11-1. Here, for the whole state we see that, based on the data available, 8,700 ac-ft of the 33,000 ac-ft needed for irrigated agriculture was registered. This registered water was from 199 of the 3039 farms that should probably be registering irrigation water use.

Table 12-1. Registration assessment results for annual irrigation water.

No	County	Water Needed MG	Farms that Should Reg #	Reg'd. Water MG	Reg'd. Farms #
1	Adams	569	91	31	11
2	Allegheny	96	30	0	0
3	Armstrong	138	36	0	0
4	Beaver	136	16	4	1
5	Bedford	48	45	71	1
6	Berks	629	134	167	10
7	Blair	55	30	10	2
8	Bradford	32	34	0	1
9	Bucks	379	80	8	1
10	Butler	227	53	0	0
11	Cambria	11	13	0	0
12	Cameron	0	0	0	0
13	Carbon	20	8	0	0
14	Centre	99	58	71	5
15	Chester	669	150	6	3
16	Clarion	42	18	0	0
17	Clearfield	22	26	0	0
18	Clinton	97	29	0	0
19	Columbia	158	50	2	4
20	Crawford	61	29	192	4
21	Cumberland	330	87	199	6
22	Dauphin	230	21	23	5
23	Delaware	23	5	0	0
24	Elk	3	2	0	0
25	Erie	64	79	1,509	36
26	Fayette	27	13	0	0
27	Forest	2	2	0	0
28	Franklin	618	84	86	9
29	Fulton	8	9	0	0
30	Greene	10	12	0	0
31	Huntingdon	71	36	13	4
32	Indiana	327	55	0	1
33	Jefferson	6	9	0	0
34	Juniata	39	15	0	1
35	Lackawanna	26	15	0	0
36	Lancaster	1851	531	61	12
37	Lawrence	38	20	0	0
38	Lebanon	602	54	1	2
39	Lehigh	171	47	2	2
40	Luzerne	93	59	0	0
41	Lycoming	211	58	14	6

No	County	Water Needed MG	Farms that Should Reg #	Reg'd. Water MG	Reg'd. Farms #
42	McKean	36	13	0	0
43	Mercer	64	34	0	0
44	Mifflin	12	34	1	1
45	Monroe	23	16	15	1
46	Montgomery	157	56	24	3
47	Montour	10	34	0	0
48	Northampton	105	34	1	2
49	Northum.	80	34	13	9
50	Perry	116	42	1	1
51	Philadelphia	2	2	0	0
52	Pike	3	1	0	0
53	Potter	2	7	0	0
54	Schuylkill	567	62	236	30
55	Snyder	64	82	2	2
56	Somerset	131	49	19	1
57	Sullivan	1	2	0	0
58	Susque.	5	19	0	0
59	Tioga	18	29	30	3
60	Union	11	25	7	2
61	Venango	22	11	0	0
62	Warren	75	17	141	1
63	Washington	314	63	0	2
64	Wayne	18	27	0	2
65	Westmoreland	93	50	0	0
66	Wyoming	13	23	0	0
67	York	435	130	8	12
	Total =	10614	3039	2969	199

Table 12-2. Registration assessment results for water needed by animals.

No	County	Water Needed MD	Farms that hould Reg #	Reg'd. Water MG	Reg'd. Farms #
1	Adams	606	21	64	37
2	Allegheny	21	3	0	0
3	Armstrong	111	0	75	9
4	Beaver	71	0	0	0
5	Bedford	352	10	1,151	7
6	Berks	679	45	55	45
7	Blair	307	46	35	9
8	Bradford	624	36	16	16
9	Bucks	72	0	23	10
10	Butler	151	6	0	0
11	Cambria	84	3	270	1
12	Cameron	2	0	0	0
13	Carbon	8	0	0	0
14	Centre	277	1	1,384	9
15	Chester	449	12	31	21
16	Clarion	118	4	0	0
17	Clearfield	55	0	0	0
18	Clinton	132	8	31	8
19	Columbia	111	7	16	7
20	Crawford	312	3	227	3
21	Cumberland	470	21	4,208	24
22	Dauphin	209	3	0	1
23	Delaware	4	0	0	0
24	Elk	18	2	0	0
25	Erie	181	3	723	22
26	Fayette	142	1	0	0
27	Forest	4	0	744	3
28	Franklin	1267	49	786	46
29	Fulton	194	14	8	5
30	Greene	100	0	0	0
31	Huntingdon	253	9	2	4
32	Indiana	165	1	0	3
33	Jefferson	79	0	0	1
34	Juniata	316	3	12	8

No	County	Water Needed MD	Farms that hould Reg #	Reg'd. Water MG	Reg'd. Farms #
35	Lackawanna	33	0	0	0
36	Lancaster	3202	162	125	51
37	Lawrence	153	4	4	1
38	Lebanon	821	41	7	5
39	Lehigh	43	0	0	2
40	Luzerne	41	18	0	0
41	Lycoming	211	0	0	6
42	McKean	32	0	0	0
43	Mercer	253	7	4	1
44	Mifflin	359	13	8	6
45	Monroe	11	0	1,083	12
46	Montgomery	69	4	1	3
47	Montour	57	6	0	0
48	Northampton	59	2	0	2
49	Northum.	299	8	13	5
50	Perry	387	15	16	7
51	Philadelphia	0	0	0	0
52	Pike	4	1	5	3
53	Potter	111	7	4	3
54	Schuylkill	150	14	31	8
55	Snyder	385	18	18	18
56	Somerset	413	18	13	10
57	Sullivan	44	0	0	0
58	Susque.	257	2	8	4
59	Tioga	327	15	12	11
60	Union	284	9	2	3
61	Venango	60	2	1	1
62	Warren	105	1	2	1
63	Washington	242	5	1	5
64	Wayne	149	0	124	2
65	Westmoreland	191	6	519	1
66	Wyoming	70	0	1	1
67	York	682	32	9	11
	Total =	17449	721	11871	482

In Table 12-2, for each county, the "animal water needed", "the number of farms that should be registering animal water", "the volume of animal water that was actually registered", and the number of farms that registered animal water" are shown. As with the irrigation analysis, in most counties the volume of water registered is less (in many counties, much less) than the volume of water our analysis shows may be needed for animals in that county. There are a few counties where the volume of water registered was greater than the volume of water our analysis suggests will be needed. (More about this later). The totals for the state are shown at the bottom of Table 12-2. Here, for the whole state we see that, based on the data available, 11,900 MG of the 17,500 MG needed for animal agriculture was registered. This registered water was from 482 of the 721 farms that should probably be registering animal water use.

Registration Summary

The registration analysis, to this point was not able to show the total volume of agricultural water that was registered because many of the registrations did not provide a monthly breakdown of when the water would be used. In addition, it became evident that there was poor correlation between the volume of water needed, for both irrigation and animals, and the volume of water actually registered. In an attempt to show more clearly the total registration picture, we developed Table 12-3. Table 12-3 shows the total registration results along with the irrigation (Table 12-1) registrations we were able to split out and the animal (Table 12-2) registrations we were able to split out of the earlier analyses. In addition the register water shown for each county is the total registered water in each county (all registered water is included even the registrations with no monthly breakdown that were rejected in the earlier irrigation and animal analysis). The headings in Table 12-3 are total "water needed" for irrigation and animal needs combined, total "irrig + animal registered", which is the sum of columns 3 from Tables 12-1 and 12-2, total "water registered", which is the total water registered including the registrants that gave no monthly breakdown, and "Unregistered water", which is the subtraction of column5 from column 3 (the "total water needed" for both irrigated and animal agriculture obtained from our evaluation and presented in Chapters 6 and 9 minus the "total water registered" for each county. The right-hand column of Table 12-3 paints a slightly different picture. Since many of the final column values are negative () it indicates that in many counties more agricultural water was registered than is most probably going to be used by the farmers in these counties. No monthly breakdown was given by these registrants, so we had no way of including these data in our analysis relative to irrigation or animals, but there has apparently been very good response to registration. In fact, the state totals show the total water needed for agriculture in 2002 at about 28,000 MG and the total registered water just under 52,000 MG.

Table 12-3. Total registration assessment results.

No	County	Water Needed MG	Irrig. + Animal Reg'd MG	Water Reg'd MG	UnReg'd. Water MG
1	Adams	1175	95	356	819
2	Allegheny	117	0	0	117
3	Armstrong	248	75	233	16
4	Beaver	207	4	4	203
5	Bedford	401	1222	1470	(1070)
6	Berks	1309	222	591	718
7	Blair	362	45	723	(362)
8	Bradford	656	16	141	515
9	Bucks	451	32	138	313
10	Butler	378	0	0	378
11	Cambria	95	270	539	(444)
12	Cameron	2	0	110	(109)
13	Carbon	28	0	61	(33)
14	Centre	376	1456	10618	(10242)
15	Chester	1118	37	441	677
16	Clarion	160	0	39	120
17	Clearfield	77	0	443	(366)
18	Clinton	229	31	2765	(2536)
19	Columbia	269	18	613	(344)
20	Crawford	373	418	445	(72)
21	Cumberland	800	4406	6114	(5314)
22	Dauphin	439	23	805	(366)
23	Delaware	27	0	0	27
24	Elk	22	0	425	(403)
25	Erie	244	2232	3474	(3229)
26	Fayette	169	0	195	(26)
27	Forest	6	744	547	(541)
28	Franklin	1884	872	2019	(135)
29	Fulton	202	8	511	(309)
30	Greene	110	0	0	110
31	Huntingdon	323	15	666	(343)
32	Indiana	492	0	152	339
33	Jefferson	84	0	493	(409)
34	Juniata	356	13	255	101
35	Lackawanna	60	0	0	60
36	Lancaster	5053	186	954	4099
37	Lawrence	191	4	151	40
38	Lebanon	1423	8	682	741
39	Lehigh	214	2	848	(634)
40	Luzerne	134	0	0	134
41	Lycoming	421	14	235	187
42	McKean	68	0	179	(111)
43	Mercer	316	4	18	299
44	Mifflin	371	8	8	364
45	Monroe	34	1098	6272	(6237)
46	Montgomery	226	25	264	(37)
47	Montour	67	0	79	(12)
48	Northampton	164	1	76	89
49	Northum.	379	26	146	234
50	Perry	503	17	700	(197)
51	Philadelphia	2	0	0	2
52	Pike	7	5	7	0
53	Potter	113	4	1058	(945)
54	Schuylkill	717	268	1287	(570)
55	Snyder	449	20	288	161
56	Somerset	544	32	972	(428)
57	Sullivan	45	0	0	45
58	Susque.	263	8	193	69
59	Tioga	345	42	460	(114)
60	Union	294	8	55	239

No	County	Water Needed MG	Irrig. + Animal Reg'd MG	Water Reg'd MG	UnReg'd. Water MG
61	Venango	82	1	1	81
62	Warren	181	142	266	(86)
63	Washington	556	1	0	556
64	Wayne	168	124	341	(174)
65	Westmoreland	283	519	526	(242)
66	Wyoming	83	1	1	82
67	York	1118	17	545	573
	Total =	28062	14840	51998	(23936)

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APPENDIX A

TABLE 12-3 COPIED FROM Kibler et al., (1977)

7-Day SOIL MOISTURE DEFICITS FOR PENNSYLVANIA

County	Adams							
Gauge Site	Gettysburg							
Hardiness	Moderate				Hardy			
Rooting Depth (in)	18				RLD			
Return Period (Yrs)	1.01	2	10	50	1.01	2	10	50
Mar-Apr	0.10	0.20	0.33	0.46	0.69	1.26	1.73	2.07
May-June	0.95	1.53	1.97	2.28	1.45	2.12	2.46	2.65
July-Aug	1.88	2.38	2.91	2.73	1.45	2.00	2.39	2.64
Sept-Oct	0.77	1.51	1.90	2.09	0.48	1.06	1.34	1.47

County	Allegheny							
Gauge Site	Pittsburgh							
Hardiness	Hardy				Moderate			
Rooting Depth (in)	9				18			
Return Period (Yrs)	1.01	2	10	50	1.01	2	10	50
Mar-Apr	0.24	0.48	0.71	0.91	0.06	0.16	0.26	0.35
May-June	0.95	1.42	1.61	1.69	0.65	1.29	1.64	1.82
July-Aug	0.94	1.44	1.75	1.95	1.56	2.14	2.48	2.68
Sept-Oct	0.37	0.80	1.08	1.23	0.74	1.47	1.89	2.12

County	Bedford											
Gauge Site	Everette											
Hardiness	Moderate				Moderate				Hardy			
Rooting Depth (in)	18				30				RLD			
Return Period (Yrs)	1.01	2	10	50	1.01	2	10	50	1.01	2	10	50
Mar-Apr	0.09	0.21	0.35	0.49	0.30	0.53	0.81	1.09	0.66	1.15	1.69	2.18
May-June	0.90	1.58	1.93	2.11	1.06	1.63	1.97	2.16	1.80	2.36	2.75	3.03
July-Aug	1.72	2.28	2.52	2.63	1.38	1.93	2.25	2.47	1.81	2.48	2.92	3.21
Sept-Oct	1.08	1.31	2.45	4.82	0.78	0.96	1.80	3.51	0.97	1.23	2.33	4.50

County	Berks											
Gauge Site	Port Clinton											
Hardiness	Hardy				Moderate				Moderate			
Rooting Depth (in)	9				18				30			
Return Period (Yrs)	1.01	2	10	50	1.01	2	10	50	1.01	2	10	50
Mar-Apr	0.25	0.53	0.80	1.03	0.08	0.19	0.32	0.46	0.24	0.48	0.73	0.96
May-June	1.25	1.39	1.89	2.63	1.10	1.55	2.26	3.06	1.22	1.59	2.17	2.81
July-Aug	1.07	1.43	1.70	1.90	1.78	2.24	2.52	2.71	1.36	1.87	2.22	2.46
Sept-Oct	0.21	0.63	0.88	1.00	0.63	1.28	1.69	1.94	0.41	0.91	1.22	1.38

County	Berks											
Gauge Site	Reading											
Hardiness	Hardy				Moderate				Moderate			
Rooting Depth (in)	9				18				30			
Return Period (Yrs)	1.01	2	10	50	1.01	2	10	50	1.01	2	10	50
Mar-Apr	0.32	0.63	0.90	1.09	0.11	0.22	0.33	0.43	0.32	0.57	0.79	0.96
May-June	1.20	1.56	1.83	2.03	0.83	1.60	1.99	2.19	1.05	1.68	2.02	2.20
July-Aug	1.29	1.64	1.86	2.05	1.83	2.40	2.60	2.67	1.65	2.05	2.33	2.52
Sept-Oct	0.37	0.92	1.13	1.19	0.88	1.60	1.98	2.18	0.58	1.22	1.49	1.59

County	Blair							
Gauge Site	Martinsburg							
Hardiness	Hardy				Moderate			
Rooting Depth (in)	9				18			
Return Period (Yrs)	1.01	2	10	50	1.01	2	10	50
Mar-Apr	0.20	0.48	0.70	0.84	0.07	0.16	0.24	0.30
May-June	1.03	1.44	1.67	1.81	0.70	1.50	1.85	1.98
July-Aug	0.00	1.43	2.97	4.32	0.00	2.14	4.87	7.00
Sept-Oct	0.22	0.61	0.89	1.05	0.60	1.22	1.61	1.83

County	Bradford											
Gauge Site	Canton											
Hardiness	Hardy				Moderate				Moderate			
Rooting Depth (in)	9				18				30			
Return Period (Yrs)	1.01	2	10	50	1.01	2	10	50	1.01	2	10	50
Mar-Apr	0.17	0.45	0.72	0.94	0.01	0.15	0.24	0.25	0.15	0.42	0.62	0.75
May-June	1.00	1.41	1.63	1.76	0.74	1.58	1.89	2.00	1.02	1.54	1.89	2.12
July-Aug	0.79	1.37	1.68	1.83	1.35	2.12	2.47	2.63	1.06	1.73	2.15	2.41
Sept-Oct	0.14	0.52	0.81	0.99	0.45	1.09	1.53	1.79	0.21	0.80	1.14	1.28

County	Bradford											
Gauge Site	Towanda											
Hardiness	Hardy				Moderate				Moderate			
Rooting Depth (in)	9				18				30			
Return Period (Yrs)	1.01	2	10	50	1.01	2	10	50	1.01	2	10	50
Mar-Apr	0.21	0.49	0.69	0.83	0.02	0.16	0.24	0.27	0.20	0.45	0.62	0.72
May-June	0.95	1.40	1.69	1.87	0.68	1.55	1.95	2.12	0.94	1.52	1.90	2.15
July-Aug	0.81	1.41	1.67	1.78	1.53	2.14	2.42	2.55	1.03	1.78	2.12	2.28
Sept-Oct	0.19	0.56	0.78	0.89	0.51	1.19	1.58	1.78	0.34	0.84	1.13	1.27

County	Bucks											
Gauge Site	George School											
Hardiness	Hardy				Moderate				Hardy			
Rooting Depth (in)	9				18				RLD			
Return Period (Yrs)	1.01	2	10	50	1.01	2	10	50	1.01	2	10	50
Mar-Apr	0.24	0.53	0.76	0.92	0.09	0.17	0.27	0.37	0.63	1.24	1.65	1.90
May-June	1.02	1.54	1.86	2.06	0.85	1.57	2.01	2.28	1.59	2.14	2.69	3.17
July-Aug	1.24	1.54	1.81	2.04	2.06	2.33	2.65	2.93	1.53	1.97	2.37	2.68
Sept-Oct	0.39	0.82	1.02	1.09	0.81	1.54	1.86	2.00	0.56	1.06	1.31	1.42

County	Butler							
Gauge Site	Butler							
Hardiness	Hardy				Moderate			
Rooting Depth (in)	9				18			
Return Period (Yrs)	1.01	2	10	50	1.01	2	10	50
Mar-Apr	0.18	0.45	0.71	0.91	0.09	0.15	0.24	0.36
May-June	0.99	1.42	1.61	1.71	0.82	1.56	1.88	2.02
July-Aug	0.87	1.43	1.64	1.72	1.53	2.18	2.53	2.72
Sept-Oct	0.26	0.63	1.04	1.41	0.88	1.31	2.16	3.28

County	Cambria											
Gauge Site	Ebensburg											
Hardiness	Hardy				Moderate				Hardy			
Rooting Depth (in)	9				18				RLD			
Return Period (Yrs)	1.01	2	10	50	1.01	2	10	50	1.01	2	10	50
Mar-Apr	0.16	0.48	0.71	1.41	0.05	0.14	0.25	0.35	0.49	0.96	1.33	1.60
May-June	0.85	1.42	1.64	1.74	0.62	1.54	1.96	2.12	1.54	2.26	2.62	2.81
July-Aug	0.87	1.41	1.64	1.73	1.60	2.19	2.49	2.65	1.59	2.32	2.64	2.80
Sept-Oct	0.17	0.68	0.89	0.94	0.50	1.43	1.83	1.96	0.45	1.34	1.70	1.81

County	Cambria											
Gauge Site	Johnstown											
Hardiness	Hardy				Moderate				Hardy			
Rooting Depth (in)	9				18				RLD			
Return Period (Yrs)	1.01	2	10	50	1.01	2	10	50	1.01	2	10	50
Mar-Apr	0.15	0.51	0.72	0.80	0.05	0.16	0.26	0.33	0.49	1.02	1.35	1.55
May-June	0.98	1.45	1.66	1.77	0.55	1.49	1.83	1.92	1.56	2.36	2.66	2.77
July-Aug	0.93	1.47	1.72	1.83	1.64	2.19	2.53	2.75	1.74	2.38	2.78	3.07
Sept-Oct	0.43	0.79	1.02	1.16	0.94	1.51	1.91	2.18	0.88	1.45	1.82	2.05

County	Carbon							
Gauge Site	Palmerton							
Hardiness	Hardy				Moderate			
Rooting Depth (in)	9				18			
Return Period (Yrs)	1.01	2	10	50	1.01	2	10	50
Mar-Apr	0.26	0.54	0.80	1.00	0.09	0.18	0.27	0.36
May-June	1.08	1.53	1.79	1.95	0.86	1.60	1.97	2.15
July-Aug	1.14	1.54	1.84	2.06	1.87	2.34	2.65	2.87
Sept-Oct	0.27	0.72	0.97	1.09	0.72	1.39	1.78	1.99

County	Centre							
Gauge Site	State College							
Hardiness	Hardy				Moderate			
Rooting Depth (in)	9				18			
Return Period (Yrs)	1.01	2	10	50	1.01	2	10	50
Mar-Apr	0.18	0.48	0.72	0.89	0.05	0.16	0.27	0.35
May-June	1.02	1.48	1.73	1.87	0.69	1.55	1.90	2.02
July-Aug	0.95	1.44	1.70	1.85	1.60	2.15	2.42	2.57
Sept-Oct	0.20	0.65	0.95	1.11	0.62	1.26	1.72	2.02

County	Chester							
Gauge Site	Coatsville							
Hardiness	Hardy				Moderate			
Rooting Depth (in)	9				18			
Return Period (Yrs)	1.01	2	10	50	1.01	2	10	50
Mar-Apr	0.33	0.56	0.80	1.02	0.10	0.20	0.32	0.44
May-June	1.06	1.49	1.77	1.95	0.76	1.56	1.92	2.07
July-Aug	1.27	1.59	1.81	1.97	1.98	2.38	2.68	2.90
Sept-Oct	0.44	0.88	1.10	1.19	0.90	1.60	1.92	2.07

County	Chester							
Gauge Site	Phoenixville							
Hardiness	Hardy				Moderate			
Rooting Depth (in)	9				18			
Return Period (Yrs)	1.01	2	10	50	1.01	2	10	50
Mar-Apr	0.45	0.60	1.10	2.00	0.14	0.22	0.44	0.83
May-June	1.13	1.59	1.81	1.92	1.17	1.78	2.12	2.31
July-Aug	1.25	1.61	1.84	1.98	2.07	2.47	2.77	2.99
Sept-Oct	0.41	0.83	1.04	1.15	0.91	1.62	1.92	2.04

County	Chester							
Gauge Site	West Chester							
Hardiness	Hardy				Moderate			
Rooting Depth (in)	9				18			
Return Period (Yrs)	1.01	2	10	50	1.01	2	10	50
Mar-Apr	0.27	0.61	0.86	1.02	0.10	0.22	0.34	0.45
May-June	1.05	1.54	1.84	2.02	0.91	1.58	1.96	2.16
July-Aug	1.28	1.64	1.88	2.05	2.08	2.43	2.75	3.00
Sept-Oct	0.45	0.91	1.12	1.21	0.93	1.64	1.97	2.13

County	Clearfield							
Gauge Site	Karthus							
Hardiness	Hardy				Moderate			
Rooting Depth (in)	9				18			
Return Period (Yrs)	1.01	2	10	50	1.01	2	10	50
Mar-Apr	0.20	0.44	0.68	0.88	0.07	0.14	0.22	0.28
May-June	0.99	1.39	1.64	1.79	0.62	1.54	1.89	2.00
July-Aug	0.81	1.35	1.71	1.94	1.53	2.12	2.51	2.77
Sept-Oct	0.03	0.48	0.76	0.82	0.23	1.15	1.58	1.71

County	Clinton							
Gauge Site	Lock Haven							
Hardiness	Hardy				Moderate			
Rooting Depth (in)	9				18			
Return Period (Yrs)	1.01	2	10	50	1.01	2	10	50
Mar-Apr	0.20	0.48	0.70	0.84	0.07	0.16	0.24	0.30
May-June	1.03	1.44	1.67	1.81	0.70	1.50	1.85	1.98
July-Aug	0.00	1.43	2.97	4.32	0.00	2.14	4.87	7.00
Sept-Oct	0.22	0.61	0.89	1.05	0.60	1.22	1.61	1.83

County	Crawford											
Gauge Site	Conneautville											
Hardiness	Hardy				Moderate				Moderate			
Rooting Depth (in)	9				18				30			
Return Period (Yrs)	1.01	2	10	50	1.01	2	10	50	1.01	2	10	50
Mar-Apr	0.11	0.47	0.66	0.73	0.04	0.14	0.23	0.29	0.11	0.42	0.59	0.66
May-June	0.93	1.45	1.89	2.21	0.73	1.47	2.08	2.53	0.87	1.52	2.07	2.49
July-Aug	1.00	1.45	1.79	2.02	1.75	2.22	2.81	3.37	1.38	1.84	2.28	2.64
Sept-Oct	0.28	0.65	0.94	1.16	0.72	1.39	1.84	2.11	0.41	1.00	1.35	1.52

County	Crawford											
Gauge Site	Meadville											
Hardiness	Hardy				Moderate				Moderate			
Rooting Depth (in)	9				18				30			
Return Period (Yrs)	1.01	2	10	50	1.01	2	10	50	1.01	2	10	50
Mar-Apr	0.16	0.43	0.67	0.83	0.05	0.14	0.23	0.30	0.15	0.40	0.60	0.72
May-June	0.91	1.46	1.86	2.15	0.70	1.43	2.10	2.64	0.84	1.53	2.09	2.51
July-Aug	0.99	1.50	1.79	1.96	1.62	2.29	2.63	2.81	1.29	1.93	2.27	2.47
Sept-Oct	0.23	0.65	0.93	1.08	0.68	1.39	1.86	2.15	0.41	0.98	1.35	1.56

County	Cumberland															
Gauge Site	Carlisle															
Hardiness	Hardy				Moderate				Moderate				Hardy			
Rooting Depth (in)	9				18				30				RLD			
Return Period (Yrs)	1.01	2	10	50	1.01	2	10	50	1.01	2	10	50	1.01	2	10	50
Mar-Apr	0.36	0.64	0.91	1.15	0.11	0.22	0.35	0.48	0.34	0.56	0.79	1.00	0.85	1.36	1.85	2.27
May-June	1.23	1.57	1.85	2.07	1.06	1.72	2.14	2.40	1.22	1.75	2.12	2.38	1.64	2.14	2.44	2.62
July-Aug	1.23	1.59	1.89	2.12	1.90	2.44	2.76	2.97	1.53	2.03	2.37	2.60	1.44	2.04	2.44	2.70
Sept-Oct	0.34	0.78	1.06	1.22	0.74	1.51	1.95	2.18	0.51	1.09	1.41	1.57	0.47	1.04	1.40	1.60

County	Dauphin											
Gauge Site	Harrisburg											
Hardiness	Hardy				Moderate				Hardy			
Rooting Depth (in)	9				18				RLD			
Return Period (Yrs)	1.01	2	10	50	1.01	2	10	50	1.01	2	10	50
Mar-Apr	0.28	0.64	0.91	1.09	0.10	0.22	0.36	0.49	0.76	1.28	1.68	1.98
May-June	1.26	1.55	1.82	2.03	1.03	1.71	2.15	2.42	1.87	2.13	2.47	2.78
July-Aug	1.14	1.64	1.89	2.03	1.84	2.49	2.76	2.88	1.41	2.09	2.45	2.64
Sept-Oct	0.34	0.80	1.03	1.13	0.79	1.52	1.90	2.09	0.49	1.08	1.35	1.48

County	Elk							
Gauge Site	Ridgeway							
Hardiness	Hardy				Moderate			
Rooting Depth (in)	9				18			
Return Period (Yrs)	1.01	2	10	50	1.01	2	10	50
Mar-Apr	0.19	0.38	0.58	0.78	0.05	0.12	0.19	0.26
May-June	0.94	1.44	1.76	1.96	0.75	1.44	1.98	2.37
July-Aug	1.06	1.40	1.66	1.84	1.68	2.23	2.57	2.79
Sept-Oct	0.04	0.59	0.84	0.88	0.34	1.25	1.80	2.05

County	Erie							
Gauge Site	Corry							
Hardiness	Hardy				Moderate			
Rooting Depth (in)	9				18			
Return Period (Yrs)	1.01	2	10	50	1.01	2	10	50
Mar-Apr	0.10	0.45	0.61	0.66	0.04	0.13	0.19	0.22
May-June	0.97	1.47	1.84	2.10	0.70	1.52	2.16	2.60
July-Aug	0.99	1.51	1.80	1.96	1.63	2.34	2.71	2.91
Sept-Oct	0.08	0.58	0.91	1.04	0.41	1.34	1.83	2.03

County	Erie											
Gauge Site	Erie											
Hardiness	Hardy				Moderate				Hardy			
Rooting Depth (in)	9				18				RLD			
Return Period (Yrs)	1.01	2	10	50	1.01	2	10	50	1.01	2	10	50
Mar-Apr	0.12	0.43	0.60	0.68	0.04	0.13	0.20	0.25	0.53	1.02	1.36	1.58
May-June	0.82	1.38	1.82	2.17	0.51	1.06	1.57	2.00	1.32	2.12	2.66	3.01
July-Aug	1.10	1.57	1.84	2.02	1.52	2.17	2.49	2.68	1.51	2.08	2.46	2.72
Sept-Oct	0.42	0.90	1.22	1.44	0.92	1.55	2.04	2.41	0.59	1.15	1.53	1.77

County	Fayette							
Gauge Site	Newell							
Hardiness	Hardy				Moderate			
Rooting Depth (in)	9				18			
Return Period (Yrs)	1.01	2	10	50	1.01	2	10	50
Mar-Apr	0.22	0.50	0.72	0.88	0.07	0.17	0.25	0.30
May-June	0.96	1.45	1.61	1.67	0.80	1.52	1.80	1.92
July-Aug	0.87	1.44	1.71	1.85	1.59	2.23	2.56	2.74
Sept-Oct	0.32	0.78	1.01	1.11	0.75	1.51	1.91	2.10

County	Fayette							
Gauge Site	Uniontown							
Hardiness	Hardy				Moderate			
Rooting Depth (in)	9				18			
Return Period (Yrs)	1.01	2	10	50	1.01	2	10	50
Mar-Apr	0.20	0.59	0.78	0.87	0.05	0.21	0.32	0.37
May-June	0.94	1.43	1.64	1.73	0.72	1.48	1.85	2.02
July-Aug	0.94	1.38	1.64	1.79	1.54	2.14	2.48	2.67
Sept-Oct	0.35	0.78	1.02	1.15	0.84	1.47	1.86	2.10

County	Franklin															
Gauge Site	Chambersburg															
Hardiness	Hardy				Moderate				Moderate				Hardy			
Rooting Depth (in)	9				18				30				RLD			
Return Period (Yrs)	1.01	2	10	50	1.01	2	10	50	1.01	2	10	50	1.01	2	10	50
Mar-Apr	0.30	0.59	0.86	1.09	0.10	0.21	0.33	0.46	0.29	0.52	0.74	0.92	0.84	1.53	2.31	3.06
May-June	0.97	1.49	1.74	1.88	0.85	1.63	2.01	2.18	0.96	1.65	2.01	2.19	1.97	2.64	3.02	3.26
July-Aug	1.17	1.54	1.78	1.93	1.88	2.34	2.59	2.74	1.46	1.97	2.23	2.38	1.57	2.52	2.94	3.12
Sept-Oct	0.27	0.76	0.99	1.08	0.68	1.45	1.83	1.99	0.46	1.05	1.35	1.48	0.39	1.18	2.03	2.75

County	Franklin															
Gauge Site	Mercersburg															
Hardiness	Hardy				Moderate				Moderate				Hardy			
Rooting Depth (in)	9				18				30				RLD			
Return Period (Yrs)	1.01	2	10	50	1.01	2	10	50	1.01	2	10	50	1.01	2	10	50
Mar-Apr	0.30	0.57	0.84	1.07	0.09	0.20	0.31	0.41	0.30	0.51	0.72	0.91	0.82	1.54	2.22	2.79
May-June	0.88	1.48	1.77	1.91	0.68	1.57	2.04	2.26	0.79	1.60	2.03	2.23	1.79	2.65	3.03	3.21
July-Aug	0.00	1.60	4.12	6.88	0.00	2.47	7.49	11.90	0.00	2.03	5.75	9.01	0.00	2.58	5.99	8.99
Sept-Oct	0.24	0.76	1.03	1.14	0.63	1.44	1.90	2.12	0.42	1.07	1.41	1.58	0.34	1.37	2.13	2.52

County	Huntingdon											
Gauge Site	Burnt Cabins											
Hardiness	Moderate				Moderate				Hardy			
Rooting Depth (in)	18				30				RLD			
Return Period (Yrs)	1.01	2	10	50	1.01	2	10	50	1.01	2	10	50
Mar-Apr	0.07	0.21	0.40	0.59	0.32	0.51	0.85	1.29	0.76	1.10	1.93	3.17
May-June	1.24	1.51	2.62	4.63	1.23	1.60	2.83	4.99	1.87	2.20	3.89	6.91
July-Aug	0.86	2.35	3.82	5.11	1.57	1.87	2.64	3.65	2.11	2.36	3.39	5.01
Sept-Oct	0.63	1.44	1.80	1.94	0.46	1.01	1.33	1.50	0.60	1.25	1.70	1.99

County	Huntingdon											
Gauge Site	Huntingdon											
Hardiness	Moderate				Moderate				Hardy			
Rooting Depth (in)	18				30				RLD			
Return Period (Yrs)	1.01	2	10	50	1.01	2	10	50	1.01	2	10	50
Mar-Apr	0.08	0.15	0.26	0.37	0.25	0.45	0.68	0.89	0.61	1.01	1.48	1.92
May-June	0.74	1.54	1.97	2.18	0.88	1.54	2.14	2.63	0.79	2.23	3.65	4.90
July-Aug	1.76	2.29	2.56	2.71	1.24	1.90	2.17	2.29	1.57	2.39	2.77	2.96
Sept-Oct	0.64	1.33	1.73	1.94	0.43	0.95	1.25	1.40	0.54	1.21	1.70	2.00

County	Indiana							
Gauge Site	Indiana							
Hardiness	Hardy				Moderate			
Rooting Depth (in)	9				18			
Return Period (Yrs)	1.01	2	10	50	1.01	2	10	50
Mar-Apr	0.16	0.49	0.69	0.78	0.06	0.15	0.25	0.34
May-June	0.94	1.42	1.62	1.71	0.77	1.42	1.82	2.05
July-Aug	0.84	1.40	1.66	1.79	1.46	2.14	2.49	2.66
Sept-Oct	0.26	0.68	0.96	1.12	0.67	1.40	1.80	2.01

County				
Gauge Site				
Hardiness	Moderate			
Rooting Depth (in)	18			
Return Period (Yrs)	1.01	2	10	50
Mar-Apr	0.00	0.15	0.82	1.41
May-June	0.84	1.43	1.85	2.12
July-Aug	1.64	2.05	2.57	2.66
Sept-Oct	0.64	1.16	1.63	2.00

County	Lancaster															
Gauge Site	Lancaster															
Hardiness	Hardy				Moderate				Moderate				Hardy			
Rooting Depth (in)	9				18				30				RLD			
Return Period (Yrs)	1.01	2	10	50	1.01	2	10	50	1.01	2	10	50	1.01	2	10	50
Mar-Apr	0.32	0.58	0.85	1.09	0.11	0.20	0.32	0.44	0.32	0.53	0.74	0.92	0.67	1.17	1.60	1.93
May-June	0.17	1.55	2.92	4.13	1.19	1.66	2.35	3.10	1.43	1.60	2.42	3.83	0.41	2.43	4.43	6.19
July-Aug	1.15	1.54	1.81	2.00	1.77	2.38	2.64	2.76	1.51	1.94	2.23	2.42	1.72	2.50	2.95	3.22
Sept-Oct	0.30	0.75	1.00	1.11	0.69	1.48	1.88	2.06	0.50	1.07	1.38	1.53	0.61	1.40	1.80	1.98

County	Lancaster															
Gauge Site	Landisville															
Hardiness	Hardy				Moderate				Moderate				Hardy			
Rooting Depth (in)	9				18				30				RLD			
Return Period (Yrs)	1.01	2	10	50	1.01	2	10	50	1.01	2	10	50	1.01	2	10	50
Mar-Apr	0.27	0.57	0.87	1.12	0.07	0.20	0.33	0.43	0.24	0.52	0.75	0.93	0.55	1.13	1.61	1.96
May-June	1.10	1.50	1.72	1.84	0.96	1.64	2.00	2.18	1.06	1.67	2.00	2.18	1.72	2.35	2.71	2.92
July-Aug	1.13	1.50	1.75	1.91	1.79	2.31	2.58	2.73	1.36	1.90	2.18	2.33	1.87	2.40	2.80	3.10
Sept-Oct	0.30	0.72	0.95	1.05	0.74	1.42	1.77	1.95	0.51	1.03	1.28	1.40	0.64	1.36	1.69	1.83

County	Lawrence											
Gauge Site	New Castle											
Hardiness	Hardy				Moderate				Hardy			
Rooting Depth (in)	9				18				RLD			
Return Period (Yrs)	1.01	2	10	50	1.01	2	10	50	1.01	2	10	50
Mar-Apr	0.18	0.44	0.70	0.90	0.05	0.14	0.25	0.36	0.54	1.08	1.48	1.75
May-June	0.96	1.37	1.59	1.71	0.88	1.48	1.79	1.94	1.39	1.96	2.15	2.22
July-Aug	0.87	1.36	1.60	1.72	1.46	2.11	2.44	2.62	1.13	1.77	2.05	2.18
Sept-Oct	0.37	0.63	1.01	1.43	1.00	1.25	2.06	3.38	0.69	0.95	1.58	2.48

County	Lebanon							
Gauge Site	Lebanon							
Hardiness	Hardy				Moderate			
Rooting Depth (in)	9				18			
Return Period (Yrs)	1.01	2	10	50	1.01	2	10	50
Mar-Apr	0.27	0.56	0.85	1.12	0.10	0.19	0.31	0.44
May-June	0.99	1.49	1.76	1.92	0.71	1.50	1.87	2.01
July-Aug	1.17	1.57	1.87	2.09	1.93	2.22	2.66	3.11
Sept-Oct	0.40	0.83	1.06	1.18	0.83	1.49	1.86	2.05

County	Lehigh							
Gauge Site	Allentown							
Hardiness	Moderate				Hardy			
Rooting Depth (in)	18				RLD			
Return Period (Yrs)	1.01	2	10	50	1.01	2	10	50
Mar-Apr	0.07	0.18	0.28	0.36	0.72	1.19	1.63	1.98
May-June	0.82	1.51	1.80	1.92	1.62	2.18	2.49	2.67
July-Aug	1.85	2.25	2.51	2.67	1.52	2.05	2.45	2.73
Sept-Oct	0.87	1.42	1.63	1.98	0.61	1.04	1.32	1.51

County	Luzerne							
Gauge Site	Wilkes Barre							
Hardiness	Hardy				Moderate			
Rooting Depth (in)	9				18			
Return Period (Yrs)	1.01	2	10	50	1.01	2	10	50
Mar-Apr	0.24	0.52	0.79	1.02	0.04	0.16	0.27	0.34
May-June	1.13	1.53	1.71	1.80	0.73	1.59	1.98	2.14
July-Aug	1.09	1.50	1.75	1.91	1.74	2.67	2.58	2.76
Sept-Oct	0.32	0.72	1.00	1.17	0.73	1.40	1.82	2.08

County	Lycoming							
Gauge Site	Williamsport							
Hardiness	Hardy				Moderate			
Rooting Depth (in)	9				18			
Return Period (Yrs)	1.01	2	10	50	1.01	2	10	50
Mar-Apr	0.21	0.51	0.78	0.98	0.06	0.17	0.27	0.35
May-June	1.09	1.46	1.68	1.82	0.62	1.54	1.84	1.92
July-Aug	1.00	1.40	1.69	1.90	1.68	2.09	2.41	2.66
Sept-Oct	0.23	0.66	0.92	1.04	0.61	1.26	1.66	1.89

County								
Gauge Site								
Hardiness	Moderate				Moderate			
Rooting Depth (in)	18				30			
Return Period (Yrs)	1.01	2	10	50	1.01	2	10	50
Mar-Apr	0.06	0.14	0.20	0.24	0.14	0.39	0.54	0.62
May-June	0.74	1.47	1.99	2.33	0.96	1.54	2.06	2.49
July-Aug	1.49	2.14	2.53	2.77	1.26	1.75	2.16	2.48
Sept-Oct	0.57	1.28	1.72	1.98	0.33	0.93	1.29	1.47

County	McKean											
Gauge Site	Kane											
Hardiness	Hardy				Moderate				Moderate			
Rooting Depth (in)	9				18				30			
Return Period (Yrs)	1.01	2	10	50	1.01	2	10	50	1.01	2	10	50
Mar-Apr	0.16	0.36	0.55	0.70	0.04	0.11	0.18	0.23	0.16	0.35	0.51	0.63
May-June	0.83	1.39	1.71	1.89	0.73	1.55	2.05	2.33	0.97	1.59	2.01	2.29
July-Aug	0.89	1.35	1.63	1.81	1.66	2.19	2.56	2.81	1.18	1.73	2.11	2.37
Sept-Oct	0.00	0.28	0.66	0.99	0.04	0.88	1.51	1.67	0.00	0.50	1.12	1.67

County	Mercer							
Gauge Site	Greenville							
Hardiness	Hardy				Moderate			
Rooting Depth (in)	9				18			
Return Period (Yrs)	1.01	2	10	50	1.01	2	10	50
Mar-Apr	0.19	0.48	0.79	1.07	0.05	0.16	0.29	0.41
May-June	1.09	1.47	2.15	2.99	0.75	1.56	2.44	3.26
July-Aug	0.98	1.56	1.82	1.94	1.68	2.40	2.77	2.97
Sept-Oct	0.19	0.68	0.99	1.13	0.48	1.45	2.01	2.26

County	Mifflin											
Gauge Site	Lewistown											
Hardiness	Moderate				Moderate				Hardy			
Rooting Depth (in)	18				30				RLD			
Return Period (Yrs)	1.01	2	10	50	1.01	2	10	50	1.01	2	10	50
Mar-Apr	0.07	0.17	0.26	0.34	0.25	0.48	0.68	0.82	0.58	1.03	1.46	1.82
May-June	1.15	1.32	2.05	3.30	0.37	1.51	2.65	3.65	0.90	2.35	3.80	5.06
July-Aug	1.58	2.23	2.51	2.64	1.17	1.92	2.24	2.37	1.67	2.51	2.91	3.11
Sept-Oct	0.65	1.37	1.83	2.10	0.44	1.01	1.40	1.63	0.65	1.40	1.82	2.03

County	Northampton											
Gauge Site	Bethlehem											
Hardiness	Moderate				Moderate				Hardy			
Rooting Depth (in)	18				30				RLD			
Return Period (Yrs)	1.01	2	10	50	1.01	2	10	50	1.01	2	10	50
Mar-Apr	0.08	0.18	0.28	0.36	0.29	0.53	0.76	0.96	0.74	1.28	1.76	2.13
May-June	0.84	1.50	1.90	2.12	1.08	1.57	2.09	2.56	1.78	2.18	2.97	3.92
July-Aug	1.91	2.32	2.57	2.74	1.62	2.03	2.32	2.53	1.56	2.08	2.47	2.76
Sept-Oct	0.85	1.50	1.85	2.02	0.60	1.11	1.37	1.50	0.58	1.06	1.28	1.39

County	Perry															
Gauge Site	Newport															
Hardiness	Hardy				Moderate				Moderate				Hardy			
Rooting Depth (in)	9				18				30				RLD			
Return Period (Yrs)	1.01	2	10	50	1.01	2	10	50	1.01	2	10	50	1.01	2	10	50
Mar-Apr	0.29	0.55	0.79	1.00	0.10	0.18	0.30	0.42	0.30	0.49	0.70	0.90	0.65	1.07	1.49	1.86
May-June	1.18	1.47	1.71	1.90	1.01	1.60	2.00	2.26	1.13	1.63	2.00	2.26	1.86	2.32	2.71	3.02
July-Aug	1.05	1.51	1.78	1.95	1.69	2.33	2.61	2.74	1.31	1.95	2.27	2.45	1.69	2.47	2.88	3.11
Sept-Oct	0.27	0.71	0.97	1.10	0.69	1.41	1.80	2.00	0.47	1.00	1.30	1.46	0.62	1.30	1.73	1.96

County	Philadelphia			
Gauge Site	Philadelphia			
Hardiness	Moderate			
Rooting Depth (in)	18			
Return Period (Yrs)	1.01	2	10	50
Mar-Apr	0.09	0.25	0.38	0.47
May-June	1.02	0.55	1.88	2.10
July-Aug	1.92	2.38	2.72	2.96
Sept-Oct	0.96	1.67	2.05	2.25

County	Snyder															
Gauge Site	Sunbury															
Hardiness	Hardy				Moderate				Moderate				Hardy			
Rooting Depth (in)	9				18				30				RLD			
Return Period (Yrs)	1.01	2	10	50	1.01	2	10	50	1.01	2	10	50	1.01	2	10	50
Mar-Apr	0.19	0.51	0.72	0.83	0.05	0.15	0.25	0.32	0.16	0.48	0.64	0.70	0.63	1.17	1.56	1.83
May-June	0.96	1.47	1.72	1.86	0.66	1.55	1.91	2.03	0.92	1.58	1.92	2.10	1.25	2.03	2.29	2.39
July-Aug	1.06	1.36	2.04	2.96	0.88	2.17	3.46	4.58	1.42	1.72	2.51	3.60	1.26	1.74	2.56	3.55
Sept-Oct	0.27	0.67	0.97	1.17	0.67	1.30	1.94	2.49	0.45	0.93	1.38	1.74	0.43	0.85	1.34	1.81

County	Sullivan			
Gauge Site	Eagle Mere			
Hardiness	Moderate			
Rooting Depth (in)	18			
Return Period (Yrs)	1.01	2	10	50
Mar-Apr	0.04	0.13	0.23	0.32
May-June	0.54	1.25	1.58	1.71
July-Aug	1.39	1.99	2.37	2.61
Sept-Oct	0.59	1.13	1.55	1.85

County	Susquehanna															
Gauge Site	Montrose															
Hardiness	Hardy				Moderate				Moderate				Hardy			
Rooting Depth (in)	9				18				30				RLD			
Return Period (Yrs)	1.01	2	10	50	1.01	2	10	50	1.01	2	10	50	1.01	2	10	50
Mar-Apr	0.13	0.36	0.60	0.80	0.04	0.12	0.21	0.28	0.14	0.38	0.63	0.82	0.39	0.99	1.47	1.81
May-June	0.88	1.39	1.53	1.57	0.52	1.27	1.64	1.81	0.78	1.39	1.66	1.77	1.37	1.97	2.22	2.33
July-Aug	1.04	1.43	1.64	1.77	1.60	2.13	2.45	2.65	1.28	1.78	2.10	2.31	1.23	1.81	2.13	2.32
Sept-Oct	0.20	0.56	0.86	1.03	0.50	1.23	1.68	1.93	0.38	0.84	1.20	1.45	0.36	0.84	1.21	1.46

County	Tioga							
Gauge Site	Austinburg							
Hardiness	Hardy				Moderate			
Rooting Depth (in)	9				18			
Return Period (Yrs)	1.01	2	10	50	1.01	2	10	50
Mar-Apr	0.26	0.43	0.93	1.87	0.09	0.14	0.31	0.63
May-June	0.26	1.40	2.53	3.52	0.68	1.53	2.03	2.28
July-Aug	0.77	1.33	1.56	1.64	1.24	2.09	2.31	2.36
Sept-Oct	0.11	0.53	0.74	0.81	0.21	1.11	1.49	1.57

County	Tioga							
Gauge Site	Wellsboro							
Hardiness	Hardy				Moderate			
Rooting Depth (in)	9				18			
Return Period (Yrs)	1.01	2	10	50	1.01	2	10	50
Mar-Apr	0.16	0.41	0.64	0.82	0.03	0.14	0.21	0.23
May-June	0.89	1.38	1.61	1.73	0.66	1.53	1.87	1.99
July-Aug	0.77	1.32	1.61	1.76	1.36	2.08	2.38	2.51
Sept-Oct	0.00	0.35	0.72	1.04	0.24	0.90	1.56	2.14

County	Venango							
Gauge Site	Franklin							
Hardiness	Hardy				Moderate			
Rooting Depth (in)	9				18			
Return Period (Yrs)	1.01	2	10	50	1.01	2	10	50
Mar-Apr	0.18	0.42	0.95	1.98	0.08	0.14	0.29	0.56
May-June	0.91	1.50	1.94	2.25	0.73	1.44	2.07	2.55
July-Aug	0.96	1.53	1.81	1.96	1.55	2.33	2.68	2.85
Sept-Oct	0.28	0.68	1.04	1.29	0.89	1.40	2.12	2.91

County	Warren			
Gauge Site	Warren			
Hardiness	Moderate			
Rooting Depth (in)	18			
Return Period (Yrs)	1.01	2	10	50
Mar-Apr	0.04	0.14	0.20	0.24
May-June	0.61	1.35	1.99	2.47
July-Aug	1.45	2.34	2.62	2.71
Sept-Oct	0.71	1.45	2.08	2.55

County	Washington											
Gauge Site	Claysville											
Hardiness	Hardy				Moderate				Hardy			
Rooting Depth (in)	9				18				RLD			
Return Period (Yrs)	1.01	2	10	50	1.01	2	10	50	1.01	2	10	50
Mar-Apr	0.42	0.92	1.16	1.26	0.05	0.18	0.27	0.32	0.56	1.14	1.54	1.80
May-June	1.49	1.91	2.11	2.22	0.85	1.66	2.03	2.20	1.40	2.07	2.28	2.35
July-Aug	1.42	1.90	2.13	2.24	1.64	2.38	2.67	2.85	1.18	1.87	2.22	2.41
Sept-Oct	0.54	1.24	1.47	1.53	0.51	1.58	1.88	1.93	0.34	1.10	1.33	1.37

County	Wayne							
Gauge Site	Hawley							
Hardiness	Hardy				Moderate			
Rooting Depth (in)	9				18			
Return Period (Yrs)	1.01	2	10	50	1.01	2	10	50
Mar-Apr	0.16	0.42	0.73	1.01	0.03	0.14	0.25	0.31
May-June	0.90	1.36	1.55	1.63	0.58	1.33	1.68	1.82
July-Aug	1.05	1.41	1.61	1.74	1.67	2.13	2.43	2.63
Sept-Oct	0.14	0.57	0.83	0.94	0.46	1.23	1.65	1.85

County	Westmoreland							
Gauge Site	Donegal							
Hardiness	Hardy				Moderate			
Rooting Depth (in)	9				18			
Return Period (Yrs)	1.01	2	10	50	1.01	2	10	50
Mar-Apr	0.16	0.58	0.77	0.83	0.05	0.21	0.34	0.40
May-June	0.89	1.38	1.55	1.61	0.77	1.52	1.89	2.06
July-Aug	0.86	1.31	1.57	1.72	1.37	2.09	2.42	2.59
Sept-Oct	0.37	0.75	1.00	1.14	0.77	1.41	1.83	2.11

County	Westmoreland							
Gauge Site	Donora							
Hardiness	Hardy				Moderate			
Rooting Depth (in)	9				18			
Return Period (Yrs)	1.01	2	10	50	1.01	2	10	50
Mar-Apr	0.35	0.68	0.94	1.14	0.09	0.25	0.40	0.51
May-June	1.23	1.59	1.98	2.32	0.90	1.78	2.15	2.29
July-Aug	1.09	1.53	1.81	1.99	1.75	2.34	2.66	2.85
Sept-Oct	0.39	0.81	1.12	1.32	0.95	1.54	2.00	2.33

County	York											
Gauge Site	Hanover											
Hardiness	Hardy				Moderate				Hardy			
Rooting Depth (in)	9				18				RLD			
Return Period (Yrs)	1.01	2	10	50	1.01	2	10	50	1.01	2	10	50
Mar-Apr	0.30	0.55	0.82	1.05	0.10	0.18	0.27	0.37	0.77	1.26	1.75	2.35
May-June	1.03	1.49	1.79	2.00	0.79	1.41	1.90	2.26	1.57	2.14	2.53	2.80
July-Aug	1.13	1.58	1.86	2.04	1.81	2.35	2.59	2.71	1.47	2.02	2.43	2.72
Sept-Oct	0.40	0.83	1.05	1.15	0.80	1.51	1.87	2.05	0.59	1.05	1.33	1.49

County	York											
Gauge Site	Holtwood											
Hardiness	Hardy				Moderate				Hardy			
Rooting Depth (in)	9				18				RLD			
Return Period (Yrs)	1.01	2	10	50	1.01	2	10	50	1.01	2	10	50
Mar-Apr	0.29	0.52	0.74	0.92	0.09	0.17	0.26	0.34	0.74	1.23	1.61	1.90
May-June	1.04	1.45	1.72	1.89	0.62	1.28	1.68	1.90	1.66	2.12	2.48	2.75
July-Aug	1.25	1.57	1.79	1.93	1.74	2.20	2.55	2.80	1.48	2.12	2.41	2.56
Sept-Oct	0.48	0.93	1.15	1.25	0.71	1.64	1.96	2.04	0.50	1.18	1.43	1.51

County	York											
Gauge Site	York											
Hardiness	Hardy				Moderate				Hardy			
Rooting Depth (in)	9				18				RLD			
Return Period (Yrs)	1.01	2	10	50	1.01	2	10	50	1.01	2	10	50
Mar-Apr	0.33	0.57	0.85	1.12	0.09	0.20	0.32	0.44	0.78	1.24	1.70	2.11
May-June	1.01	1.51	1.83	2.04	1.03	1.64	2.09	2.40	1.48	2.08	2.45	2.78
July-Aug	1.19	1.53	1.81	2.01	1.86	2.38	2.66	2.82	1.49	1.95	2.36	2.66
Sept-Oct	0.35	0.75	0.96	1.06	0.76	1.49	1.79	1.91	0.53	1.05	1.30	1.41

APPENDIX B

TABLE 2 COPIED FROM PA-DEP (1978)

TOTAL AND MAXIMUM SEASONAL SOIL MOISTURE DEFICITS FOR PENNSYLVANIA

TABLE 2

TOTAL AND MAXIMUM SEASONAL SOIL MOISTURE DEFICITS

SEASONAL DEFICITS AT GETTYSBURG (ADAMS COUNTY)

Crop (Hardiness-Rooting Depth)	Return Period (Years)	Total Seasonal Deficits (Inches) (Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)	Maximum 28-Day Amounts (Inches) (Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)
Moderate - 18 inches	1.01	0.1	1.2	4.2	0.7	0.1	1.0	3.4	0.6
	2	0.3	3.5	8.7	3.9	0.3	2.8	6.8	3.0
	10	0.6	5.5	9.4	5.6	0.5	4.9	8.4	4.9
	50	0.8	6.7	9.9	5.9	0.8	6.8	9.0	5.9
Moderate - 24 inches	1.01	0.4	1.8	2.7	0.4	0.3	1.4	2.0	0.3
	2	0.8	3.4	6.1	2.4	0.8	3.1	5.6	2.2
	10	1.5	5.2	7.2	3.8	1.5	5.0	7.0	3.7
	50	2.2	6.7	7.4	4.3	2.2	6.7	7.3	4.3
Tender - ~~18~~ inches 24	1.01	0.4	0.9	1.5	0.1	0.3	0.8	1.4	0.2
	2	0.9	2.3	5.0	1.5	0.8	2.1	3.6	1.1
	10	1.5	3.5	6.3	2.9	1.4	3.6	5.8	2.4
	50	2.4	4.9	7.6	4.4	2.2	4.8	7.6	3.6
Hardy - Root Limiting Depth	1.01	1.3	2.9	2.5	0.1	1.0	2.2	1.9	0.1
	2	2.9	6.3	6.5	2.1	2.5	5.4	5.6	1.8
	10	4.1	7.6	7.7	3.5	3.9	7.2	7.3	3.3
	50	5.3	8.9	8.6	4.1	4.9	8.1	7.8	3.7

SEASONAL DEFICITS AT PITTSBURGH (ALLEGHENY COUNTY)

Crop (Hardiness-Rooting Depth)	Return Period (Years)	Total Seasonal Deficits (Inches) (Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)	Maximum 28-Day Amounts (Inches) (Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)
Hardy - 9 inches	1.01	0.2	2.5	2.6	0.4	0.2	2.0	2.3	0.1
	2	0.9	2.8	5.4	2.0	0.7	3.2	3.8	1.5
	10	1.5	4.8	5.6	2.7	1.2	4.1	4.8	2.3
	50	1.8	5.1	5.8	2.9	1.5	4.7	5.3	2.4
Moderate - 18 inches	1.01	0.1	0.9	4.6	1.0	0.1	0.8	4.0	0.6
	2	0.2	2.7	8.2	4.9	0.2	2.0	6.0	3.6
	10	0.4	3.9	8.7	5.7	0.3	3.4	7.2	4.6
	50	0.5	4.7	8.8	5.8	0.5	4.7	8.2	4.7
Moderate - 24 inches	1.01	0.3	2.3	4.4	0.9	0.2	1.5	2.9	0.5
	2	0.8	3.3	6.4	3.2	0.6	2.6	4.9	2.5
	10	1.4	4.2	7.1	4.0	1.1	3.8	6.1	3.5
	50	1.8	5.1	7.3	4.1	1.6	4.8	6.8	3.9

SEASONAL DEFICITS AT EVERETTE (BEDFORD COUNTY)

Crop (Hardiness-Rooting Depth)	Return Period (Years)	Total Seasonal Deficits (Inches) (Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)	Maximum 28-Day Amounts (Inches) (Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)
Moderate - 18 inches	1.01	0.1	1.7	4.9	0.5	0.1	1.4	3.9	0.4
	2	0.2	3.3	7.3	3.6	0.2	3.0	6.5	3.2
	10	0.5	5.1	8.4	5.5	0.5	4.8	8.0	5.3
	50	0.8	6.8	9.0	6.3	0.8	6.6	8.8	6.1
Moderate - 24 inches	1.01	0.1	1.7	3.1	0.4	0.1	1.5	2.8	0.3
	2	0.8	3.4	5.5	2.2	0.8	3.2	5.3	2.1
	10	1.8	5.3	7.0	4.2	1.7	5.1	6.7	4.0
	50	2.5	7.2	8.1	5.7	2.3	6.7	7.5	5.3
Moderate - 30 inches	1.01	0.1	1.8	3.3	0.3	0.1	1.6	2.9	0.3
	2	0.9	3.4	5.5	2.0	0.8	3.3	5.3	1.9
	10	1.8	5.3	7.0	3.8	1.7	5.1	6.7	3.7
	50	2.5	7.3	8.2	5.2	2.3	6.8	7.6	4.8
Hardy - Root Limiting Depth	1.01	1.1	4.0	4.6	0.0	0.9	3.5	4.1	0.0
	2	2.6	6.2	7.1	2.7	2.5	6.1	6.9	2.6
	10	3.9	8.4	9.0	5.9	3.7	8.1	8.7	5.6
	50	4.8	10.4	10.6	9.0	4.5	9.6	9.8	8.3

TABLE 2 (Cont.)

TOTAL AND MAXIMUM SEASONAL SOIL MOISTURE DEFICITS

SEASONAL DEFICITS AT CANTON (BRADFORD COUNTY)

Crop (Hardiness-Rooting Depth)	Return Period (Years)	Total Seasonal Deficits (Inches) (Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)	Maximum 28-Day Amounts (Inches) (Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)
Hardy - 9 inches	1.01	0.0	0.2	0.1	0.0	0.0	1.2	0.7	0.0
	2	0.7	3.0	2.6	0.1	0.7	3.1	2.7	0.1
	10	1.0	3.9	4.1	3.4	1.1	4.3	4.5	3.8
	50	0.8	4.5	4.1	6.0	1.2	4.9	5.7	8.4
Moderate - 18 inches	1.01	0.0	0.6	1.7	0.0	0.0	0.8	2.1	0.0
	2	0.1	3.4	5.9	1.8	0.1	3.1	5.4	1.7
	10	0.4	5.0	7.7	3.1	0.4	4.7	7.2	3.0
	50	0.7	5.6	8.3	3.2	0.7	5.4	8.0	3.1
Tender - 18 inches	1.01	0.0	0.1	0.5	0.0	0.0	0.2	1.1	0.0
	2	0.7	1.4	3.6	0.6	0.7	1.4	3.6	0.6
	10	1.2	2.4	4.9	1.8	1.2	2.5	5.0	1.9
	50	1.1	2.8	4.9	2.6	1.3	3.2	5.7	3.0
Moderate - 30 inches	1.01	0.0	0.3	0.4	0.0	0.0	0.9	1.1	0.0
	2	0.6	3.0	3.7	0.7	0.7	3.3	4.1	0.8
	10	1.1	4.3	5.3	2.0	1.2	4.7	5.8	2.2
	50	1.1	4.5	5.5	3.0	1.3	5.3	6.5	3.5

SEASONAL DEFICITS AT TOWANDA (BRADFORD COUNTY)

Crop (Hardiness-Rooting Depth)	Return Period (Years)	Total Seasonal Deficits (Inches) (Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)	Maximum 28-Day Amounts (Inches) (Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)
Hardy - 9 inches	1.01	0.1	1.1	1.1	0.0	0.1	1.1	1.2	0.0
	2	0.7	4.0	3.9	0.4	0.6	3.4	3.3	0.3
	10	1.5	5.3	4.8	2.8	1.3	4.8	4.4	2.6
	50	2.1	6.0	5.3	3.5	1.9	5.5	4.9	3.2
Moderate - 18 inches	1.01	0.0	0.7	3.0	0.1	0.1	0.7	3.2	0.1
	2	0.3	3.8	6.9	2.2	0.3	3.2	5.9	1.9
	10	0.4	5.8	7.8	3.7	0.4	5.3	7.2	3.4
	50	0.5	7.1	8.5	4.3	0.4	6.6	7.8	3.9
Tender - 18 inches	1.01	0.0	0.2	2.0	0.0	0.0	0.3	2.1	0.0
	2	0.7	2.1	4.6	0.9	0.6	1.8	3.9	0.8
	10	1.5	3.0	5.4	2.1	1.4	2.7	5.0	2.0
	50	1.8	3.3	6.0	3.3	1.7	3.0	5.5	3.0
Moderate - 30 inches	1.01	0.0	1.1	1.8	0.0	0.0	1.1	1.9	0.0
	2	0.7	4.1	5.4	1.1	0.6	3.5	4.6	1.0
	10	1.5	5.7	6.3	2.6	1.4	5.3	5.8	2.4
	50	1.8	6.8	6.7	4.0	1.7	6.3	6.2	3.6

SEASONAL DEFICITS AT GEORGE SCHOOL (BUCKS COUNTY)

Crop (Hardiness-Rooting Depth)	Return Period (Years)	Total Seasonal Deficits (Inches) (Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)	Maximum 28-Day Amounts (Inches) (Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)
Hardy - 9 inches	1.01	0.4	2.6	2.7	0.6	0.3	2.0	2.0	0.4
	2	1.1	5.2	5.6	1.8	0.8	3.9	4.1	1.3
	10	1.8	6.5	7.0	3.0	1.4	5.1	5.5	2.3
	50	2.4	6.9	7.6	3.9	2.0	5.7	6.3	3.2
Moderate - 18 inches	1.01	0.1	2.0	5.3	2.6	0.1	1.3	3.3	1.6
	2	0.3	4.2	8.6	4.4	0.2	3.2	6.5	3.3
	10	0.6	6.0	10.5	6.3	0.5	4.7	8.2	4.9
	50	1.0	7.2	11.6	7.8	0.8	5.7	9.2	6.1
Moderate - 30 inches	1.01	0.5	2.6	3.0	1.7	0.3	1.5	1.8	1.0
	2	0.9	4.5	6.8	2.7	0.7	3.7	5.6	2.2
	10	1.6	5.8	7.9	4.2	1.4	5.0	6.7	3.6
	50	2.4	6.5	8.0	5.5	2.1	5.6	6.9	4.7
Hardy - Root Limiting Depth	1.01	1.6	4.1	2.8	1.1	1.0	2.6	1.8	0.7
	2	3.4	8.0	6.7	2.4	2.6	6.2	5.2	1.9
	10	4.5	8.8	8.9	3.9	3.6	7.1	7.1	3.1
	50	5.1	8.8	9.8	5.1	4.2	7.3	8.1	4.2

TABLE 2 (Cont.)

TOTAL AND MAXIMUM SEASONAL SOIL MOISTURE DEFICITS

SEASONAL DEFICITS AT BUTLER (BUTLER COUNTY)

Crop (Hardiness-Rooting Depth)	Return Period (Years)	Total Seasonal Deficits (Inches) (Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)	Maximum 28-Day Amounts (Inches) (Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)
Hardy - 9 inches	1.01	0.2	2.8	1.1	0.0	0.2	2.0	0.8	0.0
	2	0.9	4.6	5.4	1.1	0.6	3.3	3.9	0.8
	10	1.3	5.1	5.4	2.1	1.1	4.4	4.6	1.8
	50	1.6	5.4	4.9	2.1	1.5	5.1	4.6	2.0
Moderate - 18 inches	1.01	0.1	1.0	4.0	0.3	0.1	0.9	3.5	0.3
	2	0.2	3.9	8.8	3.7	0.2	2.8	6.4	2.7
	10	0.4	5.2	9.1	5.8	0.3	4.3	7.5	4.8
	50	0.5	5.2	9.5	5.9	0.5	5.2	8.0	5.9
Moderate - 24 inches	1.01	1.0	2.3	5.3	0.2	0.6	1.5	3.3	0.1
	2	1.0	4.5	7.3	2.9	0.8	3.5	5.5	2.2
	10	1.2	6.0	9.0	5.2	1.0	5.2	7.8	4.5
	50	1.4	7.0	10.5	6.0	1.3	6.5	9.7	5.6

SEASONAL DEFICITS AT EBENSBURG (CAMBRIA COUNTY)

Crop (Hardiness-Rooting Depth)	Return Period (Years)	Total Seasonal Deficits (Inches) (Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)	Maximum 28-Day Amounts (Inches) (Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)
Hardy - 9 inches	1.01	0.2	1.8	1.5	0.0	0.2	1.5	1.3	0.0
	2	0.7	3.5	3.9	0.7	0.6	3.0	3.4	0.6
	10	1.1	4.8	4.9	5.8	1.0	4.3	4.4	5.2
	50	1.5	5.9	5.3	7.0	1.4	5.3	4.8	6.4
Moderate - 18 inches	1.01	0.1	0.7	3.9	0.5	0.1	0.6	3.3	0.4
	2	0.2	3.2	7.3	3.0	0.2	2.7	6.1	2.5
	10	0.3	5.1	8.4	5.1	0.3	4.5	7.4	4.5
	50	0.4	5.9	8.4	5.8	0.4	5.7	8.0	5.5
Hardy - Root Limiting Depth	1.01	0.5	4.7	4.2	0.3	0.4	3.8	3.4	0.2
	2	2.0	6.5	7.3	2.6	1.7	5.5	6.2	2.2
	10	3.0	8.1	8.7	4.5	2.7	7.2	7.8	4.0
	50	3.5	9.4	9.4	5.2	3.2	8.7	8.7	4.9

SEASONAL DEFICITS AT JOHNSTOWN (CAMBRIA COUNTY)

Crop (Hardiness-Rooting Depth)	Return Period (Years)	Total Seasonal Deficits (Inches) (Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)	Maximum 28-Day Amounts (Inches) (Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)
Hardy - 9 inches	1.01	0.2	1.7	2.4	0.1	0.2	1.5	2.1	0.1
	2	0.8	3.8	4.0	1.1	0.7	3.3	3.5	1.0
	10	1.3	5.2	5.3	2.4	1.2	4.7	4.8	2.2
	50	1.7	6.2	6.5	3.5	1.6	5.6	5.9	3.2
Moderate - 18 inches	1.01	0.1	0.7	4.6	1.2	0.1	0.6	4.0	1.0
	2	0.2	2.9	7.4	3.7	0.2	2.5	6.2	3.1
	10	0.4	4.9	8.6	5.6	0.3	4.3	7.6	5.0
	50	0.5	5.9	8.9	6.7	0.5	5.7	8.5	6.4
Hardy - Root Limiting Depth	1.01	0.5	4.6	5.3	1.1	0.4	3.8	4.3	0.9
	2	2.1	6.8	7.6	3.2	1.8	5.8	6.5	2.7
	10	2.2	8.5	9.2	5.1	2.9	7.6	8.3	4.6
	50	3.9	9.8	12.3	6.4	3.6	9.1	11.4	6.0

TABLE 2 (Cont.)

TOTAL AND MAXIMUM SEASONAL SOIL MOISTURE DEFICITS

SEASONAL DEFICITS AT PALMERTON (CARBON COUNTY)

Crop (Hardiness-Rooting Depth)	Return Period (Years)	Total Seasonal Deficits (Inches)				Maximum 28-Day Amounts (Inches)			
		(Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)	(Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)
Hardy - 9 inches	1.01	0.2	1.1	1.6	0.3	0.2	1.1	1.7	0.3
	2	0.9	4.5	4.7	0.8	0.8	3.7	3.8	0.7
	10	1.5	5.5	5.7	1.9	1.3	4.9	5.0	1.6
	50	2.0	5.9	6.3	2.8	1.8	5.3	5.6	2.5
Moderate - 18 inches	1.01	0.0	0.9	2.3	0.9	0.0	0.9	2.2	0.8
	2	0.3	4.0	9.0	3.3	0.2	3.0	6.8	2.5
	10	0.5	5.4	8.9	4.7	0.4	4.7	7.7	4.0
	50	0.6	5.9	8.9	5.4	0.6	5.8	7.7	5.3
Tender - 18 inches	1.01	0.1	0.2	0.9	0.0	0.1	0.3	0.8	0.1
	2	1.0	2.5	5.3	1.1	0.8	2.2	3.6	0.8
	10	1.4	3.4	5.6	2.4	1.2	3.3	4.6	2.0
	50	1.5	3.4	5.8	3.1	1.3	3.7	4.7	2.9
Moderate - 24 inches	1.01	0.0	0.4	1.5	0.1	0.1	0.7	2.6	0.2
	2	1.1	4.5	6.2	2.1	0.8	3.5	4.8	1.7
	10	1.2	5.2	7.4	3.1	1.1	5.0	7.0	3.0
	50	1.3	5.9	8.0	3.3	1.2	5.4	8.9	3.7

SEASONAL DEFICITS AT STATE COLLEGE (CENTRE COUNTY)

Crop (Hardiness-Rooting Depth)	Return Period (Years)	Total Seasonal Deficits (Inches)				Maximum 28-Day Amounts (Inches)			
		(Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)	(Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)
Hardy - 9 inches	1.01	0.0	0.3	0.2	0.0	0.1	1.5	1.3	0.0
	2	0.5	3.0	3.1	0.4	0.5	3.2	3.3	0.4
	10	1.1	4.0	4.3	1.5	1.3	4.4	4.7	1.7
	50	1.6	4.6	4.8	2.5	2.2	5.1	5.7	3.6
Moderate - 18 inches	1.01	0.0	0.6	2.2	0.3	0.0	0.8	3.2	0.4
	2	0.1	2.8	6.0	2.2	0.1	2.7	5.7	2.1
	10	0.3	4.3	7.6	4.3	0.3	4.2	7.4	4.1
	50	0.5	5.0	8.2	5.7	0.6	5.2	8.4	5.8
Moderate - 24 inches	1.01	0.0	0.4	0.7	0.1	0.0	1.1	2.2	0.2
	2	0.5	2.8	4.1	1.3	0.5	3.0	4.4	1.4
	10	1.1	4.1	5.6	2.9	1.2	4.5	6.1	3.1
	50	1.2	4.5	6.2	3.9	1.4	5.3	7.3	4.6
Tender - 18 inches	1.01	0.0	0.3	0.4	0.0	0.0	0.7	1.1	0.0
	2	0.4	1.8	3.0	0.6	0.4	1.9	3.1	0.6
	10	1.4	2.8	4.2	1.9	1.4	2.9	4.4	2.0
	50	1.8	3.2	4.4	3.2	2.1	3.8	5.2	3.8

SEASONAL DEFICITS AT COATSVILLE (CHESTER COUNTY)

Crop (Hardiness-Rooting Depth)	Return Period (Years)	Total Seasonal Deficits (Inches)				Maximum 28-Day Amounts (Inches)			
		(Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)	(Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)
Hardy - 9 inches	1.01	0.5	1.6	3.1	0.5	0.3	1.1	2.2	0.4
	2	1.1	4.8	5.3	1.8	0.8	3.6	4.0	1.4
	10	1.9	6.7	7.4	3.1	1.5	5.2	5.8	2.4
	50	2.7	7.4	9.1	4.2	2.2	5.9	7.3	3.3
Moderate - 18 inches	1.01	0.2	1.3	7.2	1.0	0.1	0.7	4.1	0.6
	2	0.3	3.5	8.9	4.9	0.2	2.6	6.5	3.6
	10	0.5	6.0	10.5	6.3	0.4	4.8	8.3	5.0
	50	0.8	8.3	11.7	6.5	0.7	6.7	9.5	5.3
Moderate - 24 inches	1.01	0.5	1.2	3.9	1.4	0.3	0.7	2.3	0.8
	2	0.9	3.7	6.4	2.7	0.7	3.1	5.4	2.3
	10	1.6	6.4	8.4	4.6	1.4	5.3	6.9	3.7
	50	2.7	8.5	9.7	6.3	2.1	6.6	7.5	4.9
Tender - 18 inches	1.01	0.5	0.7	3.0	0.1	0.3	0.4	1.9	0.1
	2	0.9	2.2	6.1	2.4	0.7	1.7	4.7	1.9
	10	1.7	3.8	7.7	4.1	1.3	3.1	6.2	3.3
	50	2.6	5.2	8.5	4.6	2.0	4.2	6.8	3.7

TABLE 2 (Cont.)

TOTAL AND MAXIMUM SEASONAL SOIL MOISTURE DEFICITS

SEASONAL DEFICITS AT PHOENIXVILLE (CHESTER COUNTY)

Crop (Hardiness-Rooting Depth)	Return Period (Years)	Total Seasonal Deficits (Inches) (Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)	Maximum 28-Day Amounts (Inches) (Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)
Hardy - 9 inches	1.01	0.5	2.2	2.9	0.3	0.4	1.6	2.1	0.2
	2	1.4	5.5	5.8	1.4	1.0	4.2	4.4	1.1
	10	2.4	6.9	6.9	2.8	1.9	5.4	5.4	2.2
	50	3.5	7.3	7.2	4.0	2.8	5.8	5.8	3.2
Moderate - 18 inches	1.01	0.2	2.4	7.2	2.0	0.1	1.4	4.1	1.1
	2	0.4	5.2	10.1	4.7	0.3	3.8	7.4	3.5
	10	0.8	7.2	10.8	6.6	0.6	5.6	8.5	5.2
	50	1.3	8.3	10.9	7.6	1.0	6.7	8.9	6.2
Moderate - 24 inches	1.01	0.6	2.4	3.9	1.0	0.4	1.4	2.3	0.6
	2	1.1	4.9	7.0	2.6	0.9	4.1	5.9	2.2
	10	2.1	6.8	8.4	4.7	1.7	5.6	6.9	3.8
	50	3.4	7.9	9.1	6.8	2.6	6.2	7.1	5.3
Tender - 18 inches	1.01	0.5	0.5	3.4	0.0	0.3	0.3	2.1	0.0
	2	1.1	3.1	7.0	2.0	0.9	2.4	5.4	1.5
	10	2.1	3.8	7.5	3.8	1.7	3.0	6.0	3.0
	50	3.2	3.8	7.6	5.4	2.5	3.1	6.0	4.3

SEASONAL DEFICITS AT WEST CHESTER (CHESTER COUNTY)

Crop (Hardiness-Rooting Depth)	Return Period (Years)	Total Seasonal Deficits (Inches) (Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)	Maximum 28-Day Amounts (Inches) (Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)
Hardy - 9 inches	1.01	0.5	2.7	2.9	0.7	0.4	1.9	2.1	0.5
	2	1.1	5.4	5.7	1.9	0.9	4.1	4.3	1.4
	10	2.0	6.8	7.2	3.3	1.6	4.3	5.6	2.6
	50	2.8	7.4	7.9	4.6	2.3	5.9	6.3	3.7
Moderate - 18 inches	1.01	0.2	1.7	6.5	2.4	0.1	1.0	3.7	1.4
	2	0.3	4.4	9.4	5.0	0.3	3.2	6.9	3.7
	10	0.6	6.4	10.8	6.7	0.5	5.0	8.5	5.3
	50	0.8	7.7	11.5	7.7	0.7	6.2	9.4	6.2
Moderate - 24 inches	1.01	0.5	2.1	3.3	0.4	0.3	1.3	2.0	0.2
	2	0.1	3.7	4.1	0.5	0.8	3.8	5.9	2.7
	10	1.8	6.5	8.7	4.8	1.4	5.3	7.1	3.9
	50	2.8	7.7	9.5	5.4	2.2	6.0	7.4	4.2
Tender - 18 inches	1.01	0.5	0.8	2.8	0.8	0.3	0.5	1.7	0.5
	2	1.0	2.8	6.6	4.2	0.8	2.2	5.1	2.1
	10	1.8	4.1	7.7	4.1	1.4	3.2	6.1	3.3
	50	2.6	4.7	8.0	4.9	2.1	3.7	6.3	3.9

SEASONAL DEFICITS AT KARTHUS (CLEARFIELD COUNTY)

Crop (Hardiness-Rooting Depth)	Return Period (Years)	Total Seasonal Deficits (Inches) (Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)	Maximum 28-Day Amounts (Inches) (Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)
Hardy - 9 inches	1.01	0.0	0.2	0.2	0.0	0.1	1.1	1.2	0.0
	2	0.6	2.9	2.8	0.4	0.6	3.1	2.9	0.4
	10	1.2	4.0	4.1	1.1	1.3	4.4	4.5	1.2
	50	1.5	3.6	4.6	1.3	2.1	5.1	5.6	1.9
Moderate - 18 inches	1.01	0.0	0.6	2.3	0.0	0.1	0.8	3.3	0.0
	2	0.2	2.7	5.8	1.3	0.2	2.6	5.6	1.3
	10	0.4	4.3	7.6	2.9	0.3	4.2	7.3	2.8
	50	0.5	5.1	8.3	4.0	0.5	5.2	8.4	4.1
Tender - 18 inches	1.01	0.1	0.3	0.3	0.0	0.2	0.7	0.8	0.0
	2	0.6	1.9	2.7	0.5	0.6	1.9	2.8	0.5
	10	1.3	2.9	4.0	1.4	1.3	3.1	4.1	1.5
	50	1.8	3.4	4.1	1.9	2.1	4.0	4.8	2.3
Moderate - 24 inches	1.01	0.0	0.4	0.5	0.0	0.1	1.1	1.4	0.0
	2	0.5	2.6	3.9	0.8	0.6	2.8	4.3	0.9
	10	1.2	4.0	5.3	2.1	1.3	4.4	5.8	2.2
	50	1.7	4.6	5.4	2.9	2.1	5.5	6.4	3.4

TABLE 2 (Cont.)

TOTAL AND MAXIMUM SEASONAL SOIL MOISTURE DEFICITS

SEASONAL DEFICITS AT LOCK HAVEN (CLINTON COUNTY)

Crop (Hardiness-Rooting Depth)	Return Period (Years)	Total Seasonal Deficits (Inches) (Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)	Maximum 28-Day Amounts (Inches) (Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)
Hardy - 9 inches	1.01	0.0	0.2	0.2	0.0	0.1	0.9	1.2	0.0
	2	0.7	3.0	3.6	0.7	0.6	3.0	3.1	0.5
	10	1.5	4.3	4.4	1.7	1.3	4.5	5.2	1.9
	50	1.3	3.7	5.1	1.5	1.8	5.2	7.2	2.1
Moderate - 18 inches	1.01	0.0	0.5	1.7	0.1	0.0	0.8	2.5	0.2
	2	0.2	2.5	5.7	2.1	0.2	2.4	5.5	2.0
	10	0.4	4.4	8.9	4.1	0.4	4.3	8.6	3.9
	50	0.5	5.7	11.2	4.8	0.5	5.8	11.4	4.9
Tender - 18 inches	1.01	0.0	0.1	0.7	0.0	0.0	0.4	1.7	0.0
	2	0.5	1.3	3.4	0.7	0.5	1.5	3.7	0.8
	10	1.1	2.4	5.6	2.1	1.2	2.6	6.1	2.3
	50	1.3	3.0	7.3	3.0	1.6	3.5	8.6	3.5

SEASONAL DEFICITS AT CONNEAUTVILLE (CRAWFORD COUNTY)

Crop (Hardiness-Rooting Depth)	Return Period (Years)	Total Seasonal Deficits (Inches) (Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)	Maximum 28-Day Amounts (Inches) (Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)
Hardy - 9 inches	1.01	0.2	2.7	2.9	0.0	0.1	1.6	1.7	0.0
	2	0.7	4.5	4.3	0.3	0.6	3.4	3.3	0.2
	10	1.3	6.2	6.4	4.7	1.0	4.7	4.9	3.6
	50	1.7	7.4	8.3	7.6	1.3	5.6	6.2	5.6
Moderate - 18 inches	1.01	0.1	1.0	5.8	0.2	0.1	0.6	3.7	0.1
	2	0.2	4.3	7.9	2.7	0.1	3.2	5.9	2.0
	10	0.3	6.3	11.0	4.9	0.2	4.7	8.1	3.7
	50	0.4	6.9	13.5	5.6	0.3	5.1	10.1	4.2
Moderate - 30 inches	1.01	0.1	1.6	3.4	0.0	0.1	1.2	2.5	0.0
	2	0.5	4.3	5.6	1.1	0.4	3.5	4.5	0.9
	10	1.1	6.3	8.5	2.8	0.9	4.8	6.5	2.2
	50	1.8	7.4	11.2	4.4	1.3	5.4	8.3	3.2

SEASONAL DEFICITS AT MEADVILLE (CRAWFORD COUNTY)

Crop (Hardiness-Rooting Depth)	Return Period (Years)	Total Seasonal Deficits (Inches) (Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)	Maximum 28-Day Amounts (Inches) (Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)
Hardy - 9 inches	1.01	0.1	2.5	1.6	0.0	0.1	1.5	0.9	0.0
	2	0.8	3.9	4.9	0.5	0.6	3.0	3.8	0.4
	10	1.5	6.0	5.8	1.5	1.2	4.6	4.4	1.2
	50	2.0	8.0	6.0	2.5	1.5	6.0	4.5	1.8
Moderate - 18 inches	1.01	0.0	1.1	4.8	0.2	0.0	0.7	3.1	0.2
	2	0.1	3.4	8.7	2.8	0.1	2.5	6.6	2.1
	10	0.3	6.2	10.2	5.4	0.2	4.6	7.6	4.0
	50	0.3	8.8	10.8	6.6	0.2	6.4	7.8	4.8
Moderate - 30 inches	1.01	0.0	1.6	2.8	0.0	0.0	1.1	2.1	0.0
	2	0.7	3.6	6.3	1.2	0.5	2.9	5.1	1.0
	10	1.5	6.2	8.0	3.4	1.2	4.8	6.2	2.6
	50	2.0	8.7	8.7	5.0	1.5	6.4	6.4	3.7

SEASONAL DEFICITS AT CARLISLE (CUMBERLAND COUNTY)

Crop (Hardiness-Rooting Depth)	Return Period (Years)	Total Seasonal Deficits (Inches) (Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)	Maximum 28-Day Amounts (Inches) (Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)
Hardy - 9 inches	1.01	0.2	2.8	2.6	0.0	0.2	2.4	2.2	0.0
	2	1.1	4.2	4.6	1.0	1.0	3.6	3.9	0.9
	10	2.0	5.4	6.0	2.4	1.9	5.0	5.5	2.2
	50	2.6	6.5	7.1	3.5	2.5	6.3	6.9	3.4
Moderate - 18 inches	1.01	0.0	2.0	5.6	1.0	0.0	1.7	4.6	0.8
	2	0.3	4.3	8.9	3.9	0.2	3.3	6.8	3.0
	10	0.6	6.0	9.9	5.8	0.5	5.2	8.6	5.0
	50	0.6	6.3	10.2	6.5	0.5	6.2	10.0	6.4
Moderate - 30 inches	1.01	0.1	3.3	4.2	0.3	0.1	2.4	3.0	0.2
	2	1.0	4.3	6.2	2.0	0.9	3.6	5.2	1.7
	10	1.9	6.0	8.0	3.9	1.6	5.3	7.1	3.5
	50	2.3	8.0	9.6	5.5	2.1	7.1	8.5	4.9
Hardy - Root Limiting Depth	1.01	1.9	3.9	3.3	0.2	1.5	3.1	2.6	0.1
	2	4.0	6.8	6.2	1.9	3.3	5.6	5.1	1.5
	10	5.0	8.1	8.0	3.8	4.4	7.2	7.1	3.4
	50	5.4	8.8	9.1	5.0	5.1	8.3	8.6	4.7

SEASONAL DEFICITS AT HARRISBURG (DAUPHIN COUNTY)

Crop (Hardiness-Rooting Depth)	Return Period (Years)	Total Seasonal Deficits (Inches) (Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)	Maximum 28-Day Amounts (Inches) (Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)
Hardy - 9 inches	1.01	0.3	2.1	3.1	0.3	0.2	1.6	2.3	0.2
	2	1.2	4.5	4.7	1.2	1.0	3.7	3.9	1.0
	10	2.1	5.8	6.2	2.4	1.8	5.1	5.5	2.2
	50	2.6	6.5	7.4	3.6	2.4	5.9	6.7	3.2
Moderate - 18 inches	1.01	0.1	2.0	7.1	1.7	0.0	1.3	4.6	1.1
	2	0.3	4.3	8.3	4.0	0.3	3.5	6.8	3.3
	10	0.6	6.2	9.8	5.8	0.5	5.3	8.4	5.0
	50	0.9	7.8	11.2	7.2	0.8	6.6	9.6	6.1
Moderate - 24 inches	1.01	0.2	2.4	4.8	0.8	0.1	0.9	2.9	0.3
	2	1.0	4.4	6.3	2.8	0.8	2.1	4.8	1.7
	10	1.9	6.1	7.9	4.3	1.7	3.4	6.2	2.9
	50	2.7	7.6	9.4	5.2	2.3	4.5	7.2	3.7
Tender - 18 inches	1.01	0.2	1.2	4.0	0.5	0.1	1.7	3.5	0.6
	2	1.0	2.6	5.8	2.0	0.9	3.7	5.3	2.4
	10	1.9	3.9	7.1	3.3	1.7	5.4	7.0	3.8
	50	2.6	5.0	8.1	4.2	2.4	6.8	8.4	4.6
Hardy - Root Limiting Depth	1.01	2.4	5.0	4.5	0.9	1.7	3.5	3.1	0.6
	2	3.8	6.9	6.2	2.3	3.1	5.7	5.1	1.9
	10	4.8	8.3	8.0	3.8	4.2	7.3	7.0	3.3
	50	5.5	9.4	9.7	5.2	4.8	8.3	8.5	4.6

SEASONAL DEFICITS AT RIDGWAY (ELK COUNTY)

Crop (Hardiness-Rooting Depth)	Return Period (Years)	Total Seasonal Deficits (Inches) (Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)	Maximum 28-Day Amounts (Inches) (Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)
Hardy - 9 inches	1.01	0.2	1.8	1.2	0.0	0.2	1.3	0.9	0.0
	2	0.7	4.2	5.0	0.4	0.5	3.0	3.6	0.3
	10	1.2	5.3	5.2	1.6	1.0	4.5	4.4	1.4
	50	1.7	5.9	5.8	3.6	1.6	5.6	4.5	3.4
Moderate - 18 inches	1.01	0.0	0.9	4.6	0.1	0.0	0.8	3.9	0.1
	2	0.2	3.4	8.4	2.0	0.1	2.5	6.1	1.5
	10	0.3	5.2	9.9	4.3	0.3	4.3	8.2	3.6
	50	0.4	6.2	10.7	5.4	0.4	5.8	10.0	5.0
Tender - 18 inches	1.01	0.2	0.8	1.8	0.0	0.2	0.6	1.4	0.0
	2	0.7	1.7	5.9	1.0	0.5	1.2	4.3	0.7
	10	1.2	2.5	5.9	2.4	1.0	2.1	5.0	2.0
	50	1.7	3.3	6.5	3.4	1.6	3.1	5.1	3.2

TABLE 2 (Cont.)

TOTAL AND MAXIMUM SEASONAL SOIL MOISTURE DEFICITS

SEASONAL DEFICITS AT CORRY (ERIE COUNTY)

Crop (Hardiness-Rooting Depth)	Return Period (Years)	Total Seasonal Deficits (Inches) (Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)	Maximum 28-Day Amounts (Inches) (Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)
Hardy - 9 inches	1.01	0.0	2.3	2.6	0.0	0.0	1.4	1.6	0.0
	2	0.6	4.2	4.3	0.3	0.5	3.2	3.3	0.2
	10	1.2	5.8	6.5	4.0	0.9	4.4	5.0	3.1
	50	1.4	6.8	8.6	5.9	1.1	5.1	6.5	4.4
Moderate - 18 inches	1.01	0.0	0.8	6.1	0.0	0.0	0.5	3.9	0.0
	2	0.1	4.0	8.3	1.9	0.1	3.0	6.2	1.4
	10	0.2	6.2	11.5	4.7	0.2	4.6	8.5	3.5
	50	0.3	7.3	14.5	6.1	0.2	5.3	10.5	4.4
Moderate - 24 inches	1.01	0.1	1.3	3.6	0.0	0.1	0.9	2.6	0.0
	2	0.4	3.9	5.8	1.2	0.3	3.1	4.7	1.0
	10	1.0	5.8	8.9	3.2	0.8	4.5	6.8	2.5
	50	1.7	6.9	11.8	5.1	1.3	5.1	8.6	3.8
Tender - 18 inches	1.01	0.1	0.6	1.9	0.0	0.1	0.4	1.3	0.0
	2	0.4	1.6	5.4	0.7	0.4	1.4	4.5	0.6
	10	1.0	2.6	6.4	4.6	0.8	2.2	5.3	3.8
	50	1.9	3.7	7.3	5.9	1.4	2.7	5.4	4.3

SEASONAL DEFICITS AT ERIE (ERIE COUNTY)

Crop (Hardiness-Rooting Depth)	Return Period (Years)	Total Seasonal Deficits (Inches) (Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)	Maximum 28-Day Amounts (Inches) (Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)
Hardy - 9 inches	1.01	0.1	1.6	2.9	0.2	0.1	1.0	1.7	0.1
	2	0.8	4.1	5.7	1.8	0.6	3.2	4.4	1.4
	10	1.5	6.2	6.7	2.9	1.1	4.7	5.1	2.3
	50	2.0	7.6	7.0	3.4	1.5	5.7	5.2	2.6
Moderate - 18 inches	1.01	0.0	0.7	5.1	0.7	0.0	0.4	3.3	0.4
	2	0.2	2.7	8.4	4.2	0.1	2.0	6.3	3.2
	10	0.3	4.4	10.0	6.1	0.2	3.2	7.4	4.5
	50	0.5	5.5	10.9	6.8	0.4	4.0	7.9	5.0
Moderate - 24 inches	1.01	0.0	0.9	3.7	0.5	0.0	0.7	2.7	0.4
	2	0.8	3.2	6.9	2.4	0.7	2.6	5.6	2.0
	10	1.4	5.4	8.1	4.5	1.1	4.1	6.3	3.5
	50	1.5	6.8	8.7	6.0	1.1	5.0	6.4	4.4
Tender - 18 inches	1.01	0.1	0.4	2.3	0.4	0.0	0.3	1.5	0.2
	2	0.8	1.7	4.6	2.0	0.7	1.5	3.9	1.7
	10	1.4	3.1	6.4	3.8	1.2	2.6	5.2	3.1
	50	1.8	4.4	7.9	5.3	1.4	3.3	5.8	4.0
Hardy - Root Limiting Depth	1.01	1.4	4.8	4.7	0.0	0.9	3.1	3.0	0.0
	2	2.8	6.4	7.0	2.2	2.4	5.4	6.0	1.8
	10	3.9	8.8	8.4	3.8	3.2	7.3	6.9	3.1
	50	4.9	11.8	9.8	4.4	3.6	8.7	7.2	3.2

SEASONAL DEFICITS AT NEWELL (FAYETTE COUNTY)

Crop (Hardiness-Rooting Depth)	Return Period (Years)	Total Seasonal Deficits (Inches) (Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)	Maximum 28-Day Amounts (Inches) (Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)
Hardy - 9 inches	1.01	0.3	2.2	2.0	0.2	0.2	1.6	1.5	0.1
	2	1.0	4.6	4.9	1.2	0.7	3.3	3.5	0.9
	10	1.6	5.3	5.6	2.2	1.4	4.5	4.7	1.9
	50	2.0	5.5	5.7	2.8	1.9	5.2	5.4	2.7
Moderate - 18 inches	1.01	0.1	1.1	4.4	1.0	0.1	1.0	3.8	0.9
	2	0.2	3.9	8.4	4.3	0.2	2.8	6.1	3.1
	10	0.4	5.4	9.2	5.7	0.3	4.5	7.6	4.7
	50	0.5	6.2	9.2	5.9	0.5	5.8	8.6	5.6

SEASONAL DEFICITS AT UNIONTOWN (FAYETTE COUNTY)

Crop (Hardiness-Rooting Depth)	Return Period (Years)	Total Seasonal Deficits (Inches) (Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)	Maximum 28-Day Amounts (Inches) (Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)
Hardy - 9 inches	1.01	0.2	2.6	2.6	0.2	0.1	1.9	1.9	0.2
	2	1.3	4.7	4.7	1.5	0.9	3.4	3.4	1.1
	10	1.7	5.1	5.4	2.5	1.4	4.4	4.6	2.1
	50	1.7	5.2	5.8	3.1	1.6	5.0	5.5	2.9
Moderate - 18 inches	1.01	0.1	1.2	4.8	1.4	0.1	1.0	4.1	1.2
	2	0.3	3.9	9.1	4.4	0.2	2.8	7.3	3.2
	10	0.4	5.3	9.7	5.7	0.4	4.4	8.0	4.7
	50	0.4	5.9	9.7	6.0	0.4	5.5	8.5	5.6

SEASONAL DEFICITS AT CHAMBERSBURG (FRANKLIN COUNTY)

Crop (Hardiness-Rooting Depth)	Return Period (Years)	Total Seasonal Deficits (Inches) (Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)	Maximum 28-Day Amounts (Inches) (Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)
Hardy - 9 inches	1.01	0.2	0.9	1.8	0.1	0.2	0.9	1.7	0.1
	2	0.9	3.7	4.4	0.7	0.8	3.2	3.9	0.7
	10	1.5	4.8	5.6	1.9	1.5	4.6	5.4	1.8
	50	2.1	4.9	5.8	3.0	2.2	5.1	5.7	3.1
Moderate - 18 inches	1.01	0.1	1.1	3.0	0.2	0.1	1.2	3.4	0.2
	2	0.3	3.9	9.0	3.7	0.2	2.8	6.4	2.7
	10	0.4	5.3	8.9	5.1	0.4	4.6	7.8	4.5
	50	0.5	5.5	9.2	4.4	0.6	6.4	8.3	5.1
Tender - 18 inches	1.01	0.1	0.4	1.9	0.0	0.1	0.4	1.9	0.0
	2	0.9	2.1	5.7	1.5	0.7	1.7	4.5	1.2
	10	1.4	3.3	6.2	2.8	1.3	3.0	5.7	2.6
	50	1.4	3.8	6.6	3.0	1.5	4.1	6.2	3.2
Moderate - 30 inches	1.01	0.1	1.1	2.6	0.0	0.1	1.1	2.7	0.0
	2	0.9	3.9	6.4	1.8	0.7	3.1	5.0	1.4
	10	1.4	5.3	7.0	3.4	1.3	4.9	6.4	3.1
	50	1.4	5.7	7.6	3.4	1.5	6.3	7.2	3.7
Hardy - Root Limiting Depth	1.01	1.2	3.2	4.0	0.1	1.2	3.0	3.5	0.0
	2	3.0	8.6	9.2	3.0	2.6	6.3	6.3	1.7
	10	4.3	9.5	9.8	5.3	4.3	8.2	7.9	4.1
	50	5.1	9.8	10.1	5.3	6.0	9.2	8.9	5.2

SEASONAL DEFICITS AT MERCERSBURG (FRANKLIN COUNTY)

Crop (Hardiness-Rooting Depth)	Return Period (Years)	Total Seasonal Deficits (Inches) (Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)	Maximum 28-Day Amounts (Inches) (Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)
Hardy - 9 inches	1.01	0.2	1.0	2.6	0.0	0.2	0.9	2.4	0.0
	2	1.0	3.9	4.1	0.9	0.9	3.4	3.6	0.8
	10	1.7	5.1	6.0	2.1	1.7	4.9	5.8	2.0
	50	2.1	5.3	8.3	2.9	2.2	5.6	8.6	3.0
Moderate - 18 inches	1.01	0.0	0.7	4.8	0.2	0.0	0.8	5.3	0.2
	2	0.3	3.9	8.4	3.5	0.2	2.8	6.1	2.5
	10	0.5	5.7	10.6	5.5	0.4	5.0	9.3	4.8
	50	0.6	6.1	12.9	6.0	0.6	7.1	14.9	6.9
Moderate - 30 inches	1.01	0.1	1.0	3.7	0.0	0.1	1.0	3.8	0.0
	2	1.0	4.1	6.1	1.8	0.8	3.2	4.8	1.5
	10	1.7	5.6	8.2	3.5	1.5	5.2	7.5	3.2
	50	2.3	7.1	12.4	5.1	2.2	6.5	11.4	4.7
Hardy - Root Limiting Depth	1.01	1.4	3.5	4.3	0.1	1.5	3.0	2.8	0.0
	2	3.1	8.8	9.1	3.2	2.7	6.7	6.3	2.0
	10	4.4	9.8	11.2	5.5	4.3	8.5	8.8	4.3
	50	5.3	9.9	12.0	6.7	6.1	9.3	10.5	6.4

SEASONAL DEFICITS AT BURNT CABINS (HUNTINGDON COUNTY)

Crop (Hardiness-Rooting Depth)	Return Period (Years)	Total Seasonal Deficits (Inches) (Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)	Maximum 28-Day Amounts (Inches) (Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)
Moderate - 18 inches	1.01	0.0	1.2	3.7	0.4	0.0	1.3	4.0	0.5
	2	0.2	3.0	7.2	2.9	0.2	2.8	6.6	2.7
	10	0.6	5.4	8.6	4.7	0.6	5.1	8.3	4.5
	50	0.9	7.9	9.3	5.6	0.9	7.8	9.2	5.6
Moderate - 30 inches	1.01	0.1	1.2	1.9	0.0	0.1	1.6	2.5	0.0
	2	0.8	3.0	5.1	1.4	0.8	3.1	5.2	1.4
	10	1.7	5.1	6.4	3.1	1.7	5.2	6.6	3.1
	50	2.3	7.4	6.9	3.7	2.4	7.7	7.2	3.8
Hardy - Root Limiting Depth	1.01	0.3	1.8	2.0	0.2	0.6	3.3	3.6	0.3
	2	2.2	5.3	6.4	2.0	2.4	5.7	6.9	2.2
	10	3.9	8.1	8.3	4.1	4.0	8.3	8.5	4.3
	50	4.6	10.0	8.6	5.2	5.0	10.8	9.3	5.6

SEASONAL DEFICITS AT HUNTINGDON (HUNTINGDON COUNTY)

Crop (Hardiness-Rooting Depth)	Return Period (Years)	Total Seasonal Deficits (Inches) (Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)	Maximum 28-Day Amounts (Inches) (Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)
Moderate - 18 inches	1.01	0.0	0.8	3.7	0.1	0.0	0.9	4.0	0.2
	2	0.2	2.9	6.5	2.9	0.1	2.7	6.0	2.7
	10	0.4	4.8	7.8	4.6	0.4	4.6	7.5	4.4
	50	0.7	6.3	8.5	4.8	0.7	6.2	8.4	4.8
Moderate - 30 inches	1.01	0.0	0.9	1.9	0.7	0.0	1.2	2.6	0.9
	2	0.7	3.0	4.5	1.4	0.7	3.1	4.6	1.5
	10	1.2	4.9	5.9	2.8	1.2	5.0	6.1	2.9
	50	1.2	6.4	6.8	3.4	1.2	6.6	7.1	3.5
Hardy - Root Limiting Depth	1.01	0.4	2.1	2.7	0.1	0.5	2.8	3.6	0.1
	2	1.9	5.6	6.3	2.2	1.9	5.6	6.3	2.2
	10	3.3	8.1	7.8	4.0	3.3	8.2	7.8	4.0
	50	4.1	9.8	8.3	4.4	4.3	10.1	8.6	4.5

SEASONAL DEFICITS AT INDIANA (INDIANA COUNTY)

Crop (Hardiness-Rooting Depth)	Return Period (Years)	Total Seasonal Deficits (Inches) (Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)	Maximum 28-Day Amounts (Inches) (Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)
Hardy - 9 inches	1.01	0.2	2.1	1.4	0.0	0.2	1.6	1.1	0.0
	2	1.0	4.4	5.1	1.1	0.7	3.1	3.7	0.8
	10	1.4	5.3	5.4	2.3	1.2	4.5	4.6	1.9
	50	1.5	5.9	5.0	2.8	1.5	5.5	4.7	2.6
Moderate - 18 inches	1.01	0.1	1.0	3.6	1.0	0.1	0.9	3.1	0.9
	2	0.2	3.5	8.7	3.8	0.2	2.5	6.3	2.8
	10	0.4	5.2	8.8	5.2	0.3	4.3	7.2	4.3
	50	0.5	6.3	9.0	5.7	0.4	5.9	7.5	5.3
Moderate - 24 inches	1.01	0.3	1.6	3.1	0.3	0.2	1.0	2.0	0.2
	2	0.8	3.9	6.4	2.2	0.6	3.0	4.9	1.7
	10	1.3	5.4	6.8	3.8	1.2	4.6	5.9	3.3
	50	1.7	6.2	6.9	4.7	1.6	5.7	6.2	4.3

SEASONAL DEFICITS AT NEW CASTLE (LAWRENCE COUNTY)

Crop (Hardiness-Rooting Depth)	Return Period (Years)	Total Seasonal Deficits (Inches)				Maximum 28-Day Amounts (Inches)			
		(Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)	(Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)
Hardy - 9 inches	1.01	0.2	2.7	1.1	0.1	0.2	2.0	0.8	0.1
	2	0.9	4.3	5.1	1.0	0.6	3.1	3.7	0.8
	10	1.4	4.9	5.1	2.2	1.2	4.1	4.3	1.9
	50	1.7	5.2	4.6	3.0	1.6	4.9	4.3	2.8
Moderate - 18 inches	1.01	0.1	1.0	3.9	1.0	0.1	0.8	3.4	0.9
	2	0.2	3.5	8.3	3.5	0.2	2.6	6.0	2.5
	10	0.4	4.8	8.7	5.5	0.3	4.0	7.2	4.6
	50	0.5	5.3	8.9	7.0	0.4	4.9	7.6	6.5
Moderate - 24 inches	1.01	0.5	2.0	2.5	1.0	0.3	1.2	1.6	0.6
	2	0.8	4.0	6.9	2.8	0.6	3.1	5.2	2.1
	10	1.2	5.2	6.9	4.5	1.0	4.5	6.0	3.9
	50	1.6	5.9	7.5	5.8	1.4	5.4	6.0	5.4
Hardy - Root Limiting Depth	1.01	0.9	4.5	3.5	0.1	0.7	3.3	2.6	0.1
	2	2.9	7.2	6.2	2.3	2.2	5.3	4.6	1.7
	10	3.9	7.6	7.6	3.8	3.4	6.5	6.5	3.3
	50	4.5	7.8	8.8	4.2	4.2	7.3	8.3	3.9

SEASONAL DEFICITS AT LEBANON (LEBANON COUNTY)

Crop (Hardiness-Rooting Depth)	Return Period (Years)	Total Seasonal Deficits (Inches)				Maximum 28-Day Amounts (Inches)			
		(Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)	(Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)
Hardy - 9 inches	1.01	0.1	1.8	1.7	0.3	0.0	1.2	1.2	0.2
	2	0.8	3.4	4.6	1.3	0.7	2.9	4.0	1.1
	10	1.6	4.8	5.9	2.5	1.5	4.5	5.4	2.4
	50	2.0	6.0	6.4	3.6	1.9	5.7	6.0	3.4
Moderate - 18 inches	1.01	0.0	1.4	4.5	1.1	0.0	0.9	2.9	0.7
	2	0.3	3.0	7.5	3.9	0.2	2.5	6.2	3.2
	10	0.5	4.6	9.3	5.5	0.5	4.1	8.2	4.8
	50	0.7	6.1	10.4	6.2	0.6	5.4	9.2	5.4
Moderate - 24 inches	1.01	0.0	1.4	2.7	0.6	0.0	1.0	1.9	0.4
	2	0.5	3.1	5.9	2.6	0.6	2.8	5.2	2.3
	10	1.5	4.8	7.5	3.9	1.4	4.4	6.9	3.6
	50	2.0	6.2	7.8	4.5	1.9	5.8	7.3	4.2
Tender - 18 inches	1.01	0.0	1.0	1.2	0.2	0.0	0.7	0.8	0.1
	2	0.7	2.0	4.2	1.4	0.6	1.7	3.6	1.2
	10	1.5	3.3	5.7	2.9	1.4	3.0	5.2	2.6
	50	2.3	4.6	6.3	4.0	2.1	4.2	5.7	3.7

SEASONAL DEFICITS AT ALLENTOWN (LEHIGH COUNTY)

Crop (Hardiness-Rooting Depth)	Return Period (Years)	Total Seasonal Deficits (Inches)				Maximum 28-Day Amounts (Inches)			
		(Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)	(Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)
Moderate - 18 inches	1.01	0.1	1.6	4.0	1.2	0.0	0.9	2.3	0.7
	2	0.2	3.6	8.3	4.0	0.2	2.6	6.0	2.9
	10	0.6	5.1	9.8	5.5	0.4	4.1	7.8	4.4
	50	0.9	6.0	10.1	6.0	0.7	5.0	8.5	5.1
Moderate - 24 inches	1.01	0.2	0.6	2.3	0.7	0.1	0.3	1.3	0.4
	2	0.9	4.2	5.8	2.6	0.7	3.4	4.8	2.1
	10	1.5	5.1	8.0	3.7	1.3	4.5	7.0	3.2
	50	2.0	5.2	9.1	4.1	1.7	4.6	8.0	3.6
Tender - 18 inches	1.01	0.2	0.5	1.7	0.2	0.1	0.3	1.0	0.1
	2	0.9	2.5	5.6	1.9	0.7	1.9	4.2	1.5
	10	1.6	3.9	7.4	3.3	1.3	3.3	6.1	2.7
	50	2.0	4.6	8.0	3.9	1.7	4.0	6.8	3.4
Hardy - Root Limiting Depth	1.01	1.4	3.7	2.6	0.2	1.0	2.5	1.8	0.2
	2	3.6	7.9	6.5	2.2	2.7	5.8	4.8	1.6
	10	4.7	9.0	8.9	3.7	3.8	7.3	7.2	3.0
	50	5.1	9.1	10.1	4.3	4.3	7.8	8.7	3.7

SEASONAL DEFICITS AT WILKES-BARRE/SCRANTON (LUZERNE COUNTY)

Crop (Hardiness-Rooting Depth)	Return Period (Years)	Total Seasonal Deficits (Inches) (Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)	Maximum 28-Day Amounts (Inches) (Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)
Hardy - 9 inches	1.01	0.1	0.8	1.5	0.0	0.1	0.8	1.6	0.0
	2	0.7	4.0	4.1	0.9	0.6	3.5	3.5	0.7
	10	1.4	5.1	5.3	2.1	1.3	4.7	4.9	2.0
	50	1.9	5.6	6.2	3.3	1.8	5.1	5.7	3.1
Moderate - 18 inches	1.01	0.0	0.5	3.4	0.6	0.0	0.5	3.6	0.6
	2	0.2	3.2	7.3	2.8	0.2	2.8	6.2	2.4
	10	0.3	4.9	8.5	5.0	0.3	4.5	7.8	4.6
	50	0.4	5.8	9.5	7.1	0.4	5.3	8.7	6.5
Moderate - 24 inches	1.01	0.1	0.8	2.4	0.4	0.2	0.9	2.5	0.4
	2	0.6	3.7	5.6	2.0	0.5	3.2	4.8	1.7
	10	1.2	5.2	7.0	3.8	1.1	4.8	6.4	3.5
	50	2.0	6.2	8.0	6.0	1.8	5.7	7.4	5.5
Tender - 18 inches	1.01	0.1	0.4	1.9	0.0	0.1	0.4	2.0	0.1
	2	0.5	2.0	5.1	1.3	0.5	1.7	4.4	1.2
	10	1.2	3.2	6.0	3.0	1.1	2.9	5.6	2.8
	50	2.1	4.0	6.6	4.1	1.9	3.6	6.1	3.8

SEASONAL DEFICITS AT WILLIAMSPORT (LYCOMING COUNTY)

Crop (Hardiness-Rooting Depth)	Return Period (Years)	Total Seasonal Deficits (Inches) (Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)	Maximum 28-Day Amounts (Inches) (Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)
Hardy - 9 inches	1.01	0.0	0.1	0.2	0.0	0.2	0.6	1.1	0.0
	2	0.6	3.3	2.9	0.6	0.6	3.5	3.0	0.7
	10	1.2	3.8	4.2	1.6	1.3	4.2	4.6	1.8
	50	1.5	4.1	4.3	2.0	2.1	4.3	5.7	2.8
Moderate - 18 inches	1.01	0.0	0.5	2.1	0.1	0.0	0.8	3.0	0.2
	2	0.2	2.7	5.7	2.5	0.2	2.6	5.4	2.4
	10	0.4	4.4	7.6	4.1	0.4	4.2	7.3	4.0
	50	0.6	5.2	8.4	4.3	0.6	5.3	8.6	4.4
Moderate - 24 inches	1.01	0.0	0.3	0.5	0.0	0.1	0.9	1.6	0.0
	2	0.5	2.8	3.9	1.4	0.6	3.0	4.2	1.5
	10	1.2	4.0	5.5	3.0	1.3	4.4	5.9	3.2
	50	1.8	4.3	5.8	4.0	2.1	5.1	6.8	4.8

SEASONAL DEFICITS AT BRADFORD (McKEAN COUNTY)

Crop (Hardiness-Rooting Depth)	Return Period (Years)	Total Seasonal Deficits (Inches) (Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)	Maximum 28-Day Amounts (Inches) (Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)
Hardy - 30 inches	1.01	0.0	0.3	0.2	0.0	0.2	1.5	1.1	0.0
	2	0.5	3.1	3.3	0.1	0.5	3.3	3.5	0.1
	10	0.9	4.0	3.8	4.0	1.0	4.4	4.6	5.8
	50	1.0	3.6	4.2	5.2	1.5	5.1	5.0	5.9
Moderate - 18 inches	1.01	0.0	0.7	2.0	0.0	0.0	0.8	2.5	0.0
	2	0.1	3.2	6.9	1.4	0.1	2.9	6.2	1.3
	10	0.3	4.6	8.1	4.7	0.3	4.4	7.6	4.4
	50	0.4	5.3	8.3	6.9	0.4	5.2	8.0	6.6
Moderate - 30 inches	1.01	0.0	0.4	0.6	0.0	0.1	1.0	1.8	0.0
	2	0.4	2.9	4.3	0.7	0.4	3.1	4.7	0.7
	10	0.8	4.2	4.8	3.9	0.9	4.5	5.9	4.2
	50	1.1	4.5	5.2	4.2	1.4	5.3	6.1	5.0

SEASONAL DEFICITS AT CLAYSVILLE (WASHINGTON COUNTY)

Crop (Hardiness-Rooting Depth)	Return Period (Years)	Total Seasonal Deficits (Inches) (Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)	Maximum 28-Day Amounts (Inches) (Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)
Hardy - 9 inches	1.01	0.8	5.8	6.3	1.8	0.6	4.3	4.7	1.4
	2	2.6	7.1	8.2	3.6	1.9	5.8	5.9	2.6
	10	3.4	8.0	8.9	4.4	2.9	6.8	6.7	3.8
	50	3.7	8.8	9.7	5.1	3.5	7.4	7.3	4.8
Moderate - 18 inches	1.01	0.1	1.0	5.1	0.8	0.1	0.9	4.4	0.7
	2	0.3	4.7	9.3	4.1	0.2	3.4	6.7	3.0
	10	0.4	6.5	9.5	5.4	0.3	5.3	7.8	4.5
	50	0.4	6.9	10.0	5.5	0.4	6.5	8.4	5.1
Moderate - 24 inches	1.01	0.5	1.5	5.1	0.2	0.3	0.9	3.2	0.1
	2	0.8	5.1	7.1	3.2	0.6	3.9	5.4	2.4
	10	1.4	6.5	7.6	4.5	1.2	5.6	6.6	3.9
	50	2.1	6.8	7.8	4.5	2.0	6.3	7.2	4.2
Hardy - Root Limiting Depth	1.01	0.8	4.0	3.8	0.2	0.6	2.9	2.8	0.1
	2	3.3	7.6	6.6	2.0	2.4	5.6	4.9	1.5
	10	3.9	8.2	7.1	3.3	3.4	7.0	6.1	2.8
	50	4.0	8.3	7.3	3.7	3.7	7.8	6.8	3.5

SEASONAL DEFICITS AT HAWLEY (WAYNE COUNTY)

Crop (Hardiness-Rooting Depth)	Return Period (Years)	Total Seasonal Deficits (Inches) (Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)	Maximum 28-Day Amounts (Inches) (Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)
Hardy - 9 inches	1.01	0.0	1.5	1.5	0.0	0.0	1.6	1.5	0.0
	2	0.7	3.7	4.0	0.5	0.6	3.2	3.4	0.4
	10	1.3	4.9	5.1	3.2	1.2	4.5	4.7	2.9
	50	1.4	5.8	5.9	3.6	1.3	5.4	5.4	3.3
Moderate - 18 inches	1.01	0.0	0.6	3.4	0.0	0.0	0.6	3.6	0.0
	2	0.1	3.2	7.1	1.7	0.1	2.7	6.0	1.5
	10	0.5	4.3	8.1	3.9	0.4	3.9	7.4	3.6
	50	1.0	4.8	9.0	5.9	0.9	4.4	8.3	5.4

SEASONAL DEFICITS AT DONEGAL (WESTMORELAND COUNTY)

Crop (Hardiness-Rooting Depth)	Return Period (Years)	Total Seasonal Deficits (Inches) (Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)	Maximum 28-Day Amounts (Inches) (Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)
Hardy - 9 inches	1.01	0.2	2.0	2.1	0.1	0.2	1.5	1.6	0.0
	2	1.1	4.3	4.4	1.2	0.8	3.1	3.1	0.8
	10	1.7	5.0	5.1	1.9	1.4	4.2	4.3	1.6
	50	1.8	5.8	5.4	2.0	1.7	5.4	5.1	1.9
Moderate - 18 inches	1.01	0.1	1.1	2.9	1.3	0.1	1.0	2.5	1.1
	2	0.3	3.8	7.9	3.9	0.3	2.8	5.7	2.8
	10	0.5	5.7	8.4	5.0	0.4	4.7	6.9	4.2
	50	0.5	6.7	7.8	5.4	0.5	6.3	7.3	5.0

SEASONAL DEFICITS AT DONORA (WESTMORELAND COUNTY)

Crop (Hardiness-Rooting Depth)	Return Period (Years)	Total Seasonal Deficits (Inches) (Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)	Maximum 28-Day Amounts (Inches) (Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)
Hardy - 9 inches	1.01	0.6	2.7	2.0	0.3	0.5	2.0	1.5	0.2
	2	1.7	5.0	5.1	1.6	1.2	3.6	3.7	1.2
	10	2.4	6.0	6.0	2.9	2.0	5.1	5.1	2.4
	50	2.9	6.7	6.3	3.7	2.7	6.4	5.9	3.5
Moderate - 18 inches	1.01	0.1	1.6	5.4	1.8	0.1	1.4	4.6	1.6
	2	0.4	5.3	9.4	5.3	0.3	3.9	6.8	3.8
	10	0.8	6.7	9.5	6.5	0.6	5.5	7.9	5.4
	50	0.9	6.9	10.1	6.7	0.9	6.5	8.5	6.2

SEASONAL DEFICITS AT HANOVER (YORK COUNTY)

Crop (Hardiness-Rooting Depth)	Return Period (Years)	Total Seasonal Deficits (Inches) (Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)	Maximum 28-Day Amounts (Inches) (Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)
Hardy - 9 inches	1.01	0.3	2.8	2.5	0.1	0.2	1.7	1.5	0.1
	2	0.8	3.7	4.8	1.6	0.7	3.3	4.3	1.4
	10	1.5	5.1	5.6	2.3	1.5	5.0	5.4	2.3
	50	2.2	6.7	5.8	2.5	2.1	6.6	5.7	2.5
Moderate - 18 inches	1.01	0.0	1.2	4.8	1.5	0.0	0.8	3.1	1.0
	2	0.3	3.0	7.8	3.8	0.2	2.6	6.7	3.3
	10	0.4	5.1	8.8	5.6	0.4	4.6	7.9	5.0
	50	0.5	6.9	9.2	6.6	0.5	6.3	8.3	6.0
Moderate - 24 inches	1.01	0.2	1.6	3.2	0.7	0.1	1.2	2.4	0.5
	2	0.7	3.2	6.0	2.5	0.7	3.0	5.5	2.3
	10	1.5	5.1	7.0	4.1	1.4	5.0	6.8	4.0
	50	2.2	6.9	7.4	5.6	2.2	6.9	7.4	5.5
Hardy - Root Limiting Depth	1.01	0.9	4.5	3.5	0.1	0.6	3.0	2.3	0.1
	2	2.9	6.2	6.2	2.5	2.6	5.5	5.5	2.2
	10	4.0	7.7	7.6	3.3	3.8	7.3	7.2	3.2
	50	4.5	9.0	8.2	3.4	4.3	8.6	7.8	3.3

SEASONAL DEFICITS AT HOLTWOOD (YORK COUNTY)

Crop (Hardiness-Rooting Depth)	Return Period (Years)	Total Seasonal Deficits (Inches) (Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)	Maximum 28-Day Amounts (Inches) (Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)
Hardy - 9 inches	1.01	0.4	2.2	3.9	0.8	0.3	1.3	2.4	0.5
	2	0.9	3.8	5.0	2.0	0.8	3.4	4.4	1.8
	10	1.5	4.9	5.7	3.0	1.4	4.7	5.5	2.9
	50	1.9	5.6	6.2	3.7	1.8	5.5	6.1	3.6
Moderate - 18 inches	1.01	0.1	0.8	4.8	2.0	0.1	0.5	3.0	1.3
	2	0.2	2.4	7.5	4.5	0.2	2.0	6.4	3.9
	10	0.4	4.0	8.6	5.9	0.4	3.6	7.7	5.4
	50	0.6	5.5	9.1	6.7	0.6	5.0	8.2	6.0
Moderate - 24 inches	1.01	0.4	1.3	3.1	1.1	0.3	0.9	2.3	0.8
	2	0.9	2.9	6.1	3.1	0.8	2.7	5.6	2.8
	10	1.4	4.5	7.0	4.3	1.4	4.4	6.8	4.2
	50	1.9	5.7	7.3	5.1	1.9	5.6	7.2	5.0
Hardy - Root Limiting Depth	1.01	1.5	4.9	3.7	0.6	1.0	3.2	2.4	0.4
	2	3.0	6.3	6.5	2.7	2.7	5.6	5.8	2.4
	10	4.0	7.7	7.9	4.0	3.8	7.2	7.4	3.8
	50	4.6	8.8	8.5	4.5	4.4	8.4	8.1	4.3

SEASONAL DEFICITS AT YORK (YORK COUNTY)

Crop (Hardiness-Rooting Depth)	Return Period (Years)	Total Seasonal Deficits (Inches) (Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)	Maximum 28-Day Amounts (Inches) (Mar 1-May 2)	(May 3-July 4)	(July 5-Sept 6)	(Sept 7-Nov 7)
Hardy - 9 inches	1.01	0.2	1.8	2.1	0.1	0.1	1.1	1.3	0.1
	2	0.9	3.7	4.6	1.0	0.8	3.3	4.1	0.9
	10	1.6	5.3	5.3	2.3	1.6	5.2	5.2	2.2
	50	2.2	6.6	5.5	3.4	2.2	6.5	5.4	3.3
Moderate 18 inches	1.01	0.1	1.6	5.0	1.5	0.0	1.0	3.1	1.0
	2	0.3	3.7	8.1	3.7	0.2	3.2	6.9	3.2
	10	0.5	6.1	9.2	5.5	0.4	5.5	8.3	5.0
	50	0.6	8.3	9.6	6.8	0.6	7.5	8.7	6.2
Moderate - 24 inches	1.01	0.0	1.4	2.7	0.7	0.0	1.1	2.0	0.6
	2	0.7	3.6	6.0	2.4	0.6	3.3	5.5	2.2
	10	1.5	5.8	6.9	4.0	1.4	5.6	6.7	3.9
	50	1.9	7.6	10.1	5.3	1.9	7.5	7.0	5.3
Hardy - Root Limiting Depth	1.01	1.1	3.3	2.5	0.6	0.7	2.2	1.7	0.4
	2	2.9	6.0	6.1	2.0	2.5	5.4	5.4	1.8
	10	4.0	7.9	7.1	3.6	3.8	7.5	6.7	3.4
	50	4.6	9.2	7.3	4.9	4.4	8.8	7.0	4.7

APPENDIX C

Current and Future Irrigation Acreages in 2002, 2010, 2020, and 2030

Table C-1. Irrigated acreages in 2002.

No	County	Corn acres	Vegetables acres	Orchard acres	Berries acres	Unknown acres	Total acres
1	Adams	35	70	1922	47	582	2656
2	Allegheny	5	174	5	2	103	289
3	Armstrong	10	5	15	2	450	482
4	Beaver	39	53	12	14	349	467
5	Bedford	39	65	5	4	92	205
6	Berks	52	475	473	22	892	1914
7	Blair	0	137	5	6	102	250
8	Bradford	10	11	5	49	145	220
9	Bucks	0	295	111	22	589	1017
10	Butler	5	441	8	3	225	682
11	Cambria	0	5	0	2	46	53
12	Cameron	0	0	0	0	0	0
13	Carbon	0	5	5	2	68	80
14	Centre	10	108	24	29	435	606
15	Chester	10	245	160	25	1406	1846
16	Clarion	0	63	0	4	73	140
17	Clearfield	0	18	0	0	111	129
18	Clinton	10	156	0	2	402	570
19	Columbia	5	587	5	23	639	1259
20	Crawford	0	94	5	2	88	189
21	Cumberland	10	672	5	27	441	1155
22	Dauphin	5	345	5	21	220	596
23	Delaware	0	5	21	2	35	63
24	Elk	0	5	0	2	9	16
25	Erie	21	264	121	80	1816	2302
26	Fayette	5	43	0	4	28	80
27	Forest	0	5	0	0	0	5
28	Franklin	499	432	1277	36	468	2712
29	Fulton	10	5	0	2	25	42
30	Greene	0	0	5	0	29	34
31	Huntingdon	0	189	5	4	138	336
32	Indiana	5	474	5	25	577	1086
33	Jefferson	0	6	0	4	13	23
34	Juniata	51	4	5	6	217	283
35	Lackawanna	0	142	0	2	30	174
36	Lancaster	1657	2195	154	93	1952	6051
37	Lawrence	5	26	5	4	84	124
38	Lebanon	573	364	21	18	881	1857
39	Lehigh	12	67	133	44	420	676
40	Luzerne	0	142	5	4	535	686
41	Lycoming	1246	243	5	27	249	1770
42	McKean	5	4	5	4	151	169
43	Mercer	0	31	5	10	161	207
44	Mifflin	10	34	14	4	23	85
45	Monroe	5	60	5	18	31	119
46	Montgomery	0	155	60	8	241	464
47	Montour	5	34	0	3	45	87
48	Northampton	5	169	5	10	177	366
49	Northumberland	0	412	21	7	149	589
50	Perry	12	273	5	3	198	491
51	Philadelphia	0	0	0	0	5	5
52	Pike	0	0	0	2	18	20
53	Potter	0	5	5	0	0	10
54	Schuylkill	56	757	29	28	1006	1876
55	Snyder	113	229	45	15	126	528
56	Somerset	10	32	20	3	439	504
57	Sullivan	0	5	5	0	1	11
58	Susquehanna	0	5	5	6	25	41
59	Tioga	10	7	5	5	147	174
60	Union	16	20	5	6	51	98
61	Venango	5	23	0	4	38	70
62	Warren	5	5	0	2	247	259
63	Washington	30	392	64	16	331	833
64	Wayne	24	14	4	2	89	133
65	Westmoreland	5	21	40	4	217	287
66	Wyoming	0	39	6	0	50	95
67	York	0	1123	146	90	330	1689
	Total =	4645	12484	5031	915	19260	42335

Table C-2. Irrigated acreages in 2010.

No	County	Corn acres	Vegetables acres	Orchard acres	Berries acres	Unknown acres	Total ac-ft
1	Adams	72	24	1955	34	943	3028
2	Allegheny	3	203	29	0	218	454
3	Armstrong	13	5	17	4	271	311
4	Beaver	13	101	9	11	443	576
5	Bedford	88	176	9	3	227	503
6	Berks	126	417	609	23	921	2096
7	Blair	11	117	5	0	26	160
8	Bradford	10	2	1	23	277	311
9	Bucks	4	346	114	3	825	1292
10	Butler	4	262	17	0	0	283
11	Cambria	0	0	0	2	36	38
12	Cameron	0	0	0	0	0	0
13	Carbon	0	9	9	5	80	103
14	Centre	14	117	20	27	636	815
15	Chester	45	290	134	38	1371	1877
16	Clarion	4	74	0	0	0	78
17	Clearfield	2	8	0	0	159	169
18	Clinton	1045	225	0	9	414	1693
19	Columbia	1	848	18	40	421	1327
20	Crawford	0	95	2	0	447	544
21	Cumberland	189	0	51	21	0	261
22	Dauphin	9	352	33	19	209	622
23	Delaware	0	5	18	4	28	55
24	Elk	0	8	0	3	3	14
25	Erie	60	457	93	83	2141	2833
26	Fayette	4	28	0	5	0	37
27	Forest	0	9	0	0	0	9
28	Franklin	230	1001	1003	27	462	2723
29	Fulton	2	4	0	2	0	8
30	Greene	0	7	3	0	0	10
31	Huntingdon	0	168	8	1	636	812
32	Indiana	4	640	9	67	355	1075
33	Jefferson	1	6	0	1	123	131
34	Juniata	144	49	7	0	247	448
35	Lackawanna	5	89	0	3	401	498
36	Lancaster	2167	2438	140	54	2152	6951
37	Lawrence	0	18	19	6	0	43
38	Lebanon	714	463	40	24	914	2155
39	Lehigh	8	68	83	43	0	203
40	Luzerne	2	167	8	12	454	643
41	Lycoming	2136	929	0	0	395	3461
42	McKean	5	7	5	5	157	179
43	Mercer	0	99	1	0	0	100
44	Mifflin	7	35	6	12	27	88
45	Monroe	3	86	5	14	11	119
46	Montgomery	2	178	54	9	458	701
47	Montour	3	40	0	3	38	83
48	Northampton	5	192	0	0	237	434
49	Northumberland	14	450	69	0	0	55
50	Perry	0	168	1	7	144	321
51	Philadelphia	0	0	0	0	5	5
52	Pike	0	0	0	5	69	73
53	Potter	0	2	5	0	0	6
54	Schuylkill	50	546	29	25	922	1573
55	Snyder	295	290	12	34	387	1018
56	Somerset	143	21	26	6	653	849
57	Sullivan	8	2	0	0	23	34
58	Susquehanna	0	6	11	18	152	187
59	Tioga	7	7	9	6	67	96
60	Union	12	58	40	4	241	355
61	Venango	5	20	4	2	32	63
62	Warren	5	5	0	2	383	395
63	Washington	11	112	0	0	213	336
64	Wayne	33	21	4	0	88	146
65	Westmoreland	17	0	37	0	177	231
66	Wyoming	7	19	2	2	40	70
67	York	595	344	306	0	412	1656
	Total =	8357	12933	5092	752	21170	47825

Table C-3. Irrigated acreages in 2020.

No	County	Corn acres	Vegetables acres	Orchard acres	Berries acres	Unknown acres	Total acres
1	Adams	87	0	2106	39	1128	3360
2	Allegheny	5	268	38	0	264	574
3	Armstrong	18	5	24	6	317	370
4	Beaver	21	131	12	15	561	739
5	Bedford	113	216	12	3	274	618
6	Berks	157	518	740	12	1187	2614
7	Blair	13	55	5	0	8	81
8	Bradford	13	2	1	32	347	395
9	Bucks	3	304	159	0	895	1361
10	Butler	5	314	21	0	0	341
11	Cambria	0	0	0	2	26	28
12	Cameron	0	0	0	0	0	0
13	Carbon	0	12	11	4	115	143
14	Centre	19	160	30	37	846	1091
15	Chester	50	393	210	43	1564	2261
16	Clarion	5	101	0	0	0	106
17	Clearfield	2	11	0	0	212	225
18	Clinton	1296	274	0	10	434	2013
19	Columbia	1	1148	23	53	559	1785
20	Crawford	0	134	3	0	534	671
21	Cumberland	213	0	39	12	0	264
22	Dauphin	11	404	0	15	234	663
23	Delaware	0	5	26	6	11	47
24	Elk	0	10	0	2	5	17
25	Erie	73	541	110	80	2918	3721
26	Fayette	5	40	0	7	0	53
27	Forest	0	12	0	0	0	12
28	Franklin	208	1283	1288	28	281	3088
29	Fulton	2	3	0	3	0	8
30	Greene	0	8	5	0	0	13
31	Huntingdon	0	244	10	1	809	1064
32	Indiana	5	895	13	77	471	1462
33	Jefferson	1	6	0	1	152	160
34	Juniata	197	63	9	0	318	588
35	Lackawanna	7	133	0	2	517	659
36	Lancaster	2968	3160	176	47	2492	8842
37	Lawrence	0	24	20	8	0	53
38	Lebanon	981	536	53	26	1263	2859
39	Lehigh	14	80	141	49	0	284
40	Luzerne	0	164	11	9	602	786
41	Lycoming	2895	1222	0	0	459	4577
42	McKean	7	8	7	7	210	238
43	Mercer	0	126	0	0	0	126
44	Mifflin	8	47	8	15	24	101
45	Monroe	5	118	7	20	4	153
46	Montgomery	0	259	83	11	475	828
47	Montour	5	53	0	3	43	105
48	Northampton	6	224	0	0	239	468
49	Northumberland	17	516	92	0	0	625
50	Perry	0	251	1	9	196	458
51	Philadelphia	0	0	0	0	6	6
52	Pike	0	0	0	6	91	97
53	Potter	0	3	7	0	0	10
54	Schuylkill	80	728	42	33	1273	2155
55	Snyder	402	353	0	38	468	1262
56	Somerset	188	30	35	7	867	1128
57	Sullivan	11	3	0	0	31	46
58	Susquehanna	0	8	15	22	192	237
59	Tioga	9	9	12	7	42	79
60	Union	17	63	53	5	312	449
61	Venango	7	27	5	2	44	85
62	Warren	7	5	0	3	467	482
63	Washington	17	52	0	0	263	331
64	Wayne	47	28	6	0	86	166
65	Westmoreland	21	0	46	0	132	200
66	Wyoming	9	26	4	2	21	62
67	York	789	505	372	0	408	2074
	Total =	11041	16319	6094	817	25695	59966

Table C-4. Irrigated acreages in 2030.

No	County	Corn acres	Vegetables acres	Orchard acres	Berries acres	Unknown acres	Total acres
1	Adams	102	0	2257	43	1289	3692
2	Allegheny	6	332	47	0	309	695
3	Armstrong	23	5	31	7	363	429
4	Beaver	28	160	15	19	678	902
5	Bedford	138	255	15	3	321	732
6	Berks	188	618	871	1	1453	3131
7	Blair	15	0	5	0	0	3
8	Bradford	17	2	1	42	417	478
9	Bucks	2	261	205	0	962	1430
10	Butler	6	367	25	0	0	399
11	Cambria	0	0	0	1	16	18
12	Cameron	0	0	0	0	0	0
13	Carbon	0	15	14	3	150	182
14	Centre	24	202	39	47	1055	1367
15	Chester	56	497	287	48	1757	2645
16	Clarion	6	128	0	0	0	134
17	Clearfield	2	15	0	0	266	282
18	Clinton	1547	323	0	10	453	2334
19	Columbia	2	1449	29	66	698	2244
20	Crawford	0	174	4	0	621	799
21	Cumberland	238	0	27	3	0	267
22	Dauphin	14	455	0	11	225	705
23	Delaware	0	5	33	7	0	46
24	Elk	0	11	0	1	6	19
25	Erie	86	625	127	76	3695	4609
26	Fayette	6	52	0	9	0	68
27	Forest	0	15	0	0	0	15
28	Franklin	186	1565	1573	28	100	3452
29	Fulton	2	2	0	4	0	8
30	Greene	0	9	6	0	0	15
31	Huntingdon	0	320	12	1	983	1315
32	Indiana	6	1151	17	87	588	1848
33	Jefferson	1	7	0	2	180	190
34	Juniata	251	78	12	0	388	728
35	Lackawanna	8	178	0	1	633	821
36	Lancaster	3770	3881	211	40	2832	10734
37	Lawrence	0	31	22	9	0	63
38	Lebanon	1247	609	66	28	1612	3562
39	Lehigh	20	91	199	55	0	365
40	Luzerne	0	161	15	5	748	929
41	Lycoming	3654	1515	0	0	523	5692
42	McKean	9	8	9	9	263	297
43	Mercer	0	153	0	0	0	153
44	Mifflin	9	59	9	17	21	115
45	Monroe	6	150	8	26	0	190
46	Montgomery	0	341	112	13	490	956
47	Montour	6	67	0	4	49	126
48	Northampton	7	256	0	0	241	503
49	Northumberland	20	582	114	0	0	716
50	Perry	0	333	2	12	248	595
51	Philadelphia	0	0	0	0	7	7
52	Pike	0	0	0	7	113	120
53	Potter	0	4	9	0	0	13
54	Schuylkill	109	910	55	40	1624	2738
55	Snyder	509	416	0	42	538	1505
56	Somerset	234	39	44	8	1082	1406
57	Sullivan	14	4	0	0	40	58
58	Susquehanna	0	9	19	27	233	288
59	Tioga	11	11	16	8	16	61
60	Union	22	67	66	6	382	543
61	Venango	9	34	6	2	56	107
62	Warren	9	5	0	4	551	569
63	Washington	22	0	0	0	305	327
64	Wayne	60	34	7	0	84	186
65	Westmoreland	25	0	55	0	88	168
66	Wyoming	11	34	5	2	1	53
67	York	983	665	439	0	405	2492
	Total =	13729	19743	7142	884	30159	71640

APPENDIX D

Current and Future $Q_{7\text{-}10}$ Water Volumes Needed to Provide Irrigation in 2002, 2010, 2020, and 2030

Appendix D is laid out in two sections.

Section 1 shows the maximum daily ($Q_{7\text{-}10}$) volume of water (in MGD) that was used in 2002 or is predicted to be used in 2010, 2020, and 2030 for irrigating each of the crops.

Section 2 shows the top ten counties for each of the major irrigated crops for each of the years 2002, 2010, 2020, and 2030.

Section 1

Shows the maximum daily volume of water (in MGD) that was used in 2002 or is predicted to be used in 2010, 2020, and 2030 for irrigating each of the crops.

Table D-1. Daily maximum (Q_{7-10}) irrigation water needed in 2002.

No	County	Corn MGD	Vegetables MGD	Orchard MGD	Berries MGD	Unknown MGD	Total MGD
1	Adams	0.111	0.279	6.138	0.161	2.003	8.691
2	Allegheny	0.017	0.719	0.013	0.006	0.316	1.072
3	Armstrong	0.034	0.019	0.037	0.006	1.350	1.447
4	Beaver	0.133	0.204	0.030	0.042	1.047	1.456
5	Bedford	0.123	0.248	0.014	0.011	0.265	0.662
6	Berks	0.183	1.978	1.336	0.070	2.888	6.455
7	Blair	0.000	0.337	0.011	0.017	0.255	0.620
8	Bradford	0.027	0.037	0.011	0.126	0.352	0.552
9	Bucks	0.000	1.302	0.315	0.073	3.118	4.808
10	Butler	0.017	1.696	0.024	0.009	0.707	2.454
11	Cambria	0.000	0.018	0.000	0.005	0.130	0.153
12	Cameron	0.000	0.000	0.000	0.000	0.000	0.000
13	Carbon	0.000	0.021	0.014	0.006	0.212	0.253
14	Centre	0.030	0.392	0.055	0.084	1.227	1.789
15	Chester	0.036	1.135	0.497	0.087	4.937	6.692
16	Clarion	0.000	0.240	0.000	0.013	0.220	0.474
17	Clearfield	0.000	0.064	0.000	0.000	0.303	0.367
18	Clinton	0.030	0.398	0.000	0.006	1.097	1.531
19	Columbia	0.015	1.506	0.011	0.061	1.546	3.139
20	Crawford	0.000	0.393	0.014	0.006	0.279	0.692
21	Cumberland	0.033	2.718	0.013	0.085	1.315	4.163
22	Dauphin	0.019	1.578	0.015	0.073	0.762	2.447
23	Delaware	0.000	0.023	0.060	0.007	0.188	0.278
24	Elk	0.000	0.019	0.000	0.006	0.024	0.049
25	Erie	0.073	1.044	0.331	0.236	5.718	7.402
26	Fayette	0.017	0.170	0.000	0.012	0.084	0.283
27	Forest	0.000	0.021	0.000	0.000	0.000	0.021
28	Franklin	1.241	1.065	3.719	0.091	1.196	7.312
29	Fulton	0.033	0.016	0.000	0.005	0.075	0.129
30	Greene	0.000	0.000	0.013	0.000	0.087	0.100
31	Huntingdon	0.000	0.598	0.014	0.011	0.417	1.041
32	Indiana	0.016	1.778	0.014	0.074	1.711	3.594
33	Jefferson	0.000	0.023	0.000	0.012	0.040	0.075
34	Juniata	0.141	0.014	0.011	0.018	0.591	0.775
35	Lackawanna	0.000	0.483	0.000	0.005	0.075	0.564
36	Lancaster	5.966	9.388	0.478	0.307	6.591	22.730
37	Lawrence	0.020	0.096	0.012	0.012	0.250	0.391
38	Lebanon	2.191	1.526	0.061	0.058	2.884	6.721
39	Lehigh	0.039	0.269	0.410	0.123	1.251	2.092
40	Luzerne	0.000	0.554	0.010	0.012	1.445	2.022
41	Lycoming	3.450	0.858	0.012	0.076	0.663	5.060
42	McKean	0.017	0.016	0.013	0.012	0.465	0.524
43	Mercer	0.000	0.136	0.013	0.032	0.506	0.687
44	Mifflin	0.028	0.119	0.032	0.011	0.062	0.251
45	Monroe	0.017	0.234	0.013	0.051	0.091	0.405
46	Montgomery	0.000	0.646	0.169	0.025	0.780	1.621
47	Montour	0.015	0.083	0.000	0.008	0.106	0.211
48	Northampton	0.018	0.699	0.014	0.031	0.553	1.315
49	Northum.	0.000	1.057	0.045	0.018	0.361	1.481
50	Perry	0.036	1.011	0.014	0.009	0.577	1.647
51	Philadelphia	0.000	0.000	0.000	0.000	0.026	0.026
52	Pike	0.000	0.000	0.000	0.005	0.046	0.050
53	Potter	0.000	0.019	0.013	0.000	0.000	0.032
54	Schuylkill	0.185	2.982	0.072	0.086	3.036	6.362
55	Snyder	0.334	0.588	0.095	0.040	0.305	1.361
56	Somerset	0.034	0.131	0.061	0.009	1.395	1.631
57	Sullivan	0.000	0.015	0.011	0.000	0.002	0.029
58	Susque.	0.000	0.017	0.011	0.015	0.064	0.107
59	Tioga	0.028	0.022	0.011	0.012	0.355	0.427
60	Union	0.047	0.051	0.011	0.016	0.123	0.248
61	Venango	0.017	0.096	0.000	0.013	0.120	0.247
62	Warren	0.017	0.021	0.000	0.006	0.783	0.828
63	Washington	0.103	1.639	0.167	0.066	1.112	3.087
64	Wayne	0.066	0.049	0.009	0.005	0.226	0.354
65	Westmoreland	0.017	0.088	0.104	0.014	0.704	0.927
66	Wyoming	0.000	0.135	0.013	0.000	0.120	0.268
67	York	0.000	4.134	0.371	0.247	0.932	5.684
	Total =	14.978	47.219	14.957	2.745	60.469	140.367

Table D-2. Daily maximum (Q_{7-10}) irrigation water needed in 2010.

No	County	Corn MGD	Vegetables MGD	Orchard MGD	Berries MGD	Unknown MGD	Total MGD
1	Adams	0.336	0.134	6.718	0.138	3.949	11.274
2	Allegheny	0.015	1.042	0.093	0.000	0.786	1.936
3	Armstrong	0.061	0.029	0.052	0.017	1.018	1.177
4	Beaver	0.065	0.591	0.026	0.040	1.663	2.384
5	Bedford	0.432	1.173	0.034	0.014	1.065	2.718
6	Berks	0.636	2.195	3.767	0.103	4.865	11.566
7	Blair	0.056	1.109	0.025	0.000	0.160	1.350
8	Bradford	0.043	0.008	0.002	0.090	1.067	1.210
9	Bucks	0.060	1.780	0.428	0.011	3.510	5.790
10	Butler	0.021	1.535	0.066	0.000	0.000	1.621
11	Cambria	0.000	0.000	0.000	0.008	0.144	0.152
12	Cameron	0.000	0.000	0.000	0.000	0.000	0.000
13	Carbon	0.000	0.047	0.037	0.021	0.343	0.448
14	Centre	0.072	0.551	0.103	0.107	2.872	3.705
15	Chester	0.208	1.556	0.505	0.162	5.910	8.341
16	Clarion	0.021	0.368	0.000	0.000	0.000	0.389
17	Clearfield	0.010	0.039	0.000	0.000	0.629	0.678
18	Clinton	5.208	2.124	0.000	0.035	2.181	9.548
19	Columbia	0.003	5.689	0.057	0.161	1.913	7.824
20	Crawford	0.000	0.485	0.007	0.000	1.927	2.419
21	Cumberland	0.933	0.000	0.176	0.089	0.000	1.198
22	Dauphin	0.043	1.885	0.115	0.079	0.883	3.005
23	Delaware	0.000	0.027	0.068	0.018	0.121	0.234
24	Elk	0.000	0.042	0.000	0.011	0.013	0.066
25	Erie	0.290	2.530	0.346	0.353	8.281	11.799
26	Fayette	0.021	0.146	0.000	0.019	0.000	0.186
27	Forest	0.000	0.043	0.000	0.000	0.000	0.043
28	Franklin	2.562	14.540	6.995	0.219	4.537	28.853
29	Fulton	0.010	0.033	0.000	0.019	0.000	0.062
30	Greene	0.000	0.037	0.010	0.000	0.000	0.047
31	Huntingdon	0.000	1.244	0.042	0.003	3.630	4.918
32	Indiana	0.026	3.127	0.035	0.252	1.380	4.819
33	Jefferson	0.008	0.029	0.000	0.002	0.483	0.522
34	Juniata	0.888	0.243	0.038	0.000	1.160	2.329
35	Lackawanna	0.021	0.421	0.000	0.010	1.401	1.853
36	Lancaster	10.088	12.201	0.532	0.216	8.925	31.962
37	Lawrence	0.000	0.100	0.057	0.024	0.000	0.180
38	Lebanon	3.523	2.387	0.139	0.098	3.625	9.773
39	Lehigh	0.034	0.333	0.347	0.180	0.000	0.895
40	Luzerne	0.008	0.835	0.026	0.048	1.784	2.702
41	Lycoming	13.178	4.345	0.000	0.000	1.561	19.083
42	McKean	0.021	0.035	0.014	0.022	0.627	0.719
43	Mercer	0.000	0.562	0.003	0.000	0.000	0.565
44	Mifflin	0.044	0.176	0.033	0.049	0.126	0.428
45	Monroe	0.015	0.444	0.021	0.058	0.047	0.584
46	Montgomery	0.009	0.935	0.337	0.037	2.420	3.738
47	Montour	0.015	0.265	0.000	0.012	0.172	0.464
48	Northampton	0.024	0.966	0.000	0.000	1.005	1.995
49	Northum.	0.067	3.020	0.222	0.000	0.000	3.308
50	Perry	0.002	0.850	0.003	0.029	0.598	1.482
51	Philadelphia	0.000	0.000	0.000	0.000	0.022	0.022
52	Pike	0.000	0.000	0.000	0.017	0.243	0.260
53	Potter	0.000	0.008	0.014	0.000	0.000	0.023
54	Schuylkill	0.253	2.873	0.179	0.112	4.870	8.287
55	Snyder	1.437	1.948	0.037	0.136	1.761	5.319
56	Somerset	0.700	0.143	0.101	0.032	3.058	4.033
57	Sullivan	0.040	0.009	0.000	0.000	0.082	0.131
58	Susque.	0.000	0.030	0.033	0.064	0.531	0.658
59	Tioga	0.032	0.033	0.028	0.023	0.251	0.367
60	Union	0.057	0.389	0.129	0.017	1.096	1.688
61	Venango	0.022	0.102	0.016	0.011	0.139	0.289
62	Warren	0.022	0.028	0.000	0.010	1.617	1.678
63	Washington	0.056	0.579	0.000	0.000	0.909	1.544
64	Wayne	0.136	0.100	0.013	0.000	0.310	0.559
65	Westmoreland	0.081	0.000	0.119	0.000	0.756	0.956
66	Wyoming	0.033	0.090	0.008	0.007	0.142	0.279
67	York	2.768	1.833	1.059	0.000	1.561	7.221
	Total =	44.714	80.419	23.214	3.185	94.129	245.660

Table D-3. Daily maximum (Q_{7-10}) irrigation water needed in 2020.

No	County	Corn MGD	Vegetables MGD	Orchard MGD	Berries MGD	Unknown MGD	Total MGD
1	Adams	0.407	0.000	7.237	0.157	4.723	12.523
2	Allegheny	0.023	1.373	0.122	0.000	0.949	2.467
3	Armstrong	0.086	0.029	0.073	0.022	1.191	1.401
4	Beaver	0.102	0.766	0.036	0.056	2.105	3.065
5	Bedford	0.554	1.436	0.046	0.017	1.283	3.335
6	Berks	0.792	2.723	4.579	0.054	6.271	14.419
7	Blair	0.066	0.520	0.025	0.000	0.048	0.659
8	Bradford	0.058	0.008	0.003	0.127	1.338	1.534
9	Bucks	0.049	1.561	0.599	0.000	3.806	6.015
10	Butler	0.026	1.843	0.081	0.000	0.000	1.951
11	Cambria	0.000	0.000	0.000	0.006	0.105	0.112
12	Cameron	0.000	0.000	0.000	0.000	0.000	0.000
13	Carbon	0.000	0.062	0.047	0.017	0.494	0.621
14	Centre	0.095	0.750	0.151	0.147	3.818	4.963
15	Chester	0.233	2.112	0.797	0.182	6.742	10.067
16	Clarion	0.025	0.502	0.000	0.000	0.000	0.528
17	Clearfield	0.009	0.055	0.000	0.000	0.840	0.905
18	Clinton	6.457	2.586	0.000	0.038	2.286	11.367
19	Columbia	0.007	7.708	0.074	0.213	2.544	10.545
20	Crawford	0.000	0.686	0.011	0.000	2.302	2.998
21	Cumberland	1.054	0.000	0.134	0.051	0.000	1.238
22	Dauphin	0.057	2.160	0.000	0.062	0.988	3.267
23	Delaware	0.000	0.027	0.097	0.024	0.046	0.194
24	Elk	0.000	0.049	0.000	0.008	0.018	0.076
25	Erie	0.355	2.995	0.410	0.337	11.287	15.385
26	Fayette	0.026	0.209	0.000	0.026	0.000	0.261
27	Forest	0.000	0.058	0.000	0.000	0.000	0.058
28	Franklin	2.317	18.639	8.982	0.221	2.762	32.920
29	Fulton	0.012	0.025	0.000	0.024	0.000	0.061
30	Greene	0.000	0.041	0.015	0.000	0.000	0.056
31	Huntingdon	0.000	1.807	0.054	0.003	4.618	6.482
32	Indiana	0.033	4.376	0.048	0.289	1.833	6.579
33	Jefferson	0.008	0.031	0.000	0.004	0.596	0.639
34	Juniata	1.218	0.314	0.050	0.000	1.489	3.071
35	Lackawanna	0.028	0.633	0.000	0.008	1.806	2.475
36	Lancaster	13.818	15.812	0.665	0.188	10.336	40.820
37	Lawrence	0.000	0.137	0.061	0.030	0.000	0.228
38	Lebanon	4.839	2.766	0.183	0.107	5.009	12.903
39	Lehigh	0.060	0.387	0.589	0.204	0.000	1.240
40	Luzerne	0.000	0.821	0.037	0.034	2.365	3.257
41	Lycoming	17.860	5.713	0.000	0.000	1.814	25.386
42	McKean	0.031	0.037	0.020	0.030	0.837	0.956
43	Mercer	0.000	0.716	0.000	0.000	0.000	0.716
44	Mifflin	0.049	0.234	0.041	0.059	0.113	0.496
45	Monroe	0.023	0.608	0.028	0.082	0.015	0.756
46	Montgomery	0.002	1.364	0.515	0.047	2.508	4.435
47	Montour	0.023	0.357	0.000	0.014	0.197	0.590
48	Northampton	0.028	1.125	0.000	0.000	1.014	2.167
49	Northum.	0.082	3.462	0.294	0.000	0.000	3.838
50	Perry	0.000	1.268	0.005	0.038	0.813	2.125
51	Philadelphia	0.000	0.000	0.000	0.000	0.027	0.027
52	Pike	0.000	0.000	0.000	0.022	0.321	0.343
53	Potter	0.000	0.013	0.020	0.000	0.000	0.034
54	Schuylkill	0.402	3.829	0.260	0.144	6.725	11.360
55	Snyder	1.959	2.369	0.000	0.152	2.131	6.611
56	Somerset	0.921	0.200	0.135	0.038	4.062	5.356
57	Sullivan	0.054	0.014	0.000	0.000	0.110	0.179
58	Susque.	0.000	0.037	0.045	0.080	0.672	0.835
59	Tioga	0.041	0.042	0.038	0.026	0.156	0.303
60	Union	0.082	0.420	0.171	0.020	1.418	2.110
61	Venango	0.032	0.138	0.019	0.011	0.189	0.390
62	Warren	0.032	0.028	0.000	0.014	1.974	2.048
63	Washington	0.081	0.270	0.000	0.000	1.122	1.473
64	Wayne	0.191	0.131	0.017	0.000	0.303	0.643
65	Westmoreland	0.103	0.000	0.147	0.000	0.565	0.815
66	Wyoming	0.043	0.125	0.012	0.006	0.073	0.259
67	York	3.673	2.686	1.289	0.000	1.549	9.197
	Total =	58.524	101.196	28.262	3.441	112.708	304.132

Table D-4. Daily maximum (Q_{7-10}) irrigation water needed in 2030.

No	County	Corn MGD	Vegetables MGD	Orchard MGD	Berries MGD	Unknown MGD	Total MGD
1	Adams	0.479	0.000	7.756	0.176	5.397	13.807
2	Allegheny	0.030	1.705	0.151	0.000	1.112	2.998
3	Armstrong	0.111	0.029	0.094	0.028	1.363	1.625
4	Beaver	0.139	0.941	0.046	0.073	2.547	3.745
5	Bedford	0.675	1.700	0.057	0.019	1.501	3.952
6	Berks	0.948	3.251	5.392	0.004	7.676	17.272
7	Blair	0.076	0.000	0.025	0.000	0.000	0.101
8	Bradford	0.074	0.008	0.003	0.165	1.608	1.858
9	Bucks	0.038	1.341	0.770	0.000	4.092	6.240
10	Butler	0.032	2.152	0.097	0.000	0.000	2.281
11	Cambria	0.000	0.000	0.000	0.004	0.066	0.071
12	Cameron	0.000	0.000	0.000	0.000	0.001	0.001
13	Carbon	0.000	0.077	0.057	0.014	0.646	0.794
14	Centre	0.119	0.949	0.200	0.187	4.765	6.220
15	Chester	0.258	2.669	1.088	0.203	7.574	11.792
16	Clarion	0.030	0.636	0.000	0.000	0.000	0.666
17	Clearfield	0.009	0.071	0.000	0.000	1.051	1.131
18	Clinton	7.707	3.048	0.000	0.042	2.391	13.186
19	Columbia	0.010	9.727	0.091	0.264	3.174	13.267
20	Crawford	0.000	0.886	0.015	0.000	2.676	3.578
21	Cumberland	1.174	0.000	0.092	0.012	0.000	1.278
22	Dauphin	0.070	2.436	0.000	0.045	0.952	3.503
23	Delaware	0.000	0.027	0.126	0.030	0.000	0.183
24	Elk	0.000	0.057	0.000	0.005	0.024	0.085
25	Erie	0.420	3.461	0.473	0.321	14.294	18.970
26	Fayette	0.032	0.271	0.000	0.034	0.000	0.337
27	Forest	0.000	0.073	0.000	0.000	0.000	0.073
28	Franklin	2.072	22.738	10.969	0.222	0.986	36.987
29	Fulton	0.013	0.017	0.000	0.030	0.000	0.060
30	Greene	0.000	0.046	0.020	0.000	0.000	0.066
31	Huntingdon	0.000	2.370	0.066	0.004	5.607	8.046
32	Indiana	0.040	5.625	0.061	0.327	2.286	8.339
33	Jefferson	0.008	0.033	0.000	0.007	0.709	0.757
34	Juniata	1.548	0.386	0.061	0.000	1.818	3.813
35	Lackawanna	0.034	0.845	0.000	0.005	2.212	3.096
36	Lancaster	17.549	19.423	0.799	0.159	11.747	49.677
37	Lawrence	0.000	0.174	0.066	0.035	0.000	0.276
38	Lebanon	6.155	3.144	0.227	0.115	6.393	16.033
39	Lehigh	0.085	0.441	0.830	0.228	0.000	1.584
40	Luzerne	0.000	0.807	0.047	0.020	2.940	3.814
41	Lycoming	22.541	7.081	0.000	0.000	2.067	31.690
42	McKean	0.040	0.040	0.027	0.038	1.048	1.192
43	Mercer	0.000	0.869	0.000	0.000	0.000	0.869
44	Mifflin	0.054	0.292	0.048	0.070	0.100	0.564
45	Monroe	0.031	0.772	0.035	0.106	0.000	0.944
46	Montgomery	0.000	1.792	0.693	0.057	2.590	5.132
47	Montour	0.031	0.448	0.000	0.015	0.222	0.716
48	Northampton	0.032	1.284	0.000	0.000	1.022	2.338
49	Northum.	0.097	3.904	0.365	0.000	0.000	4.367
50	Perry	0.000	1.687	0.008	0.046	1.026	2.768
51	Philadelphia	0.000	0.000	0.000	0.000	0.031	0.031
52	Pike	0.000	0.000	0.000	0.027	0.400	0.426
53	Potter	0.000	0.018	0.027	0.000	0.000	0.045
54	Schuylkill	0.552	4.785	0.340	0.177	8.580	14.434
55	Snyder	2.480	2.791	0.000	0.168	2.448	7.887
56	Somerset	1.142	0.257	0.170	0.045	5.066	6.679
57	Sullivan	0.068	0.020	0.000	0.000	0.139	0.226
58	Susque.	0.000	0.045	0.058	0.096	0.813	1.012
59	Tioga	0.049	0.051	0.048	0.029	0.062	0.239
60	Union	0.107	0.451	0.212	0.023	1.739	2.532
61	Venango	0.042	0.175	0.023	0.011	0.240	0.490
62	Warren	0.042	0.028	0.000	0.017	2.330	2.417
63	Washington	0.106	0.000	0.000	0.000	1.303	1.409
64	Wayne	0.246	0.162	0.022	0.000	0.297	0.726
65	Westmoreland	0.124	0.000	0.176	0.000	0.373	0.674
66	Wyoming	0.053	0.161	0.016	0.006	0.004	0.240
67	York	4.577	3.538	1.520	0.000	1.537	11.172
	Total =	72.349	122.216	33.465	3.709	131.044	362.783

Section 2

Shows the top ten counties for each of the major irrigated crops for each of the years 2002, 2010, 2020, and 2030.

Table D-5. Top ten counties for each major crop in 2002.

		Corn	T = 1.2 to 1.8 yrs	Maximum	Water Needed
			Area Irrigated	Water Needed	per acre
Rank	No	County	acres	MGD	MGD/ac
1	36	Lancaster	1657	5.966	0.0036
2	41	Lycoming	1246	3.450	0.0028
3	38	Lebanon	573	2.191	0.0038
4	28	Franklin	499	1.241	0.0025
5	55	Snyder	113	0.334	0.0030
6	54	Schuylkill	56	0.185	0.0033
7	6	Berks	52	0.183	0.0035
8	34	Juniata	51	0.141	0.0028
9	4	Beaver	39	0.133	0.0034
10	5	Bedford	39	0.123	0.0032
		State Totals	4645	14.978	0.0032

Rank	No	Vegetables	T = 1.2 to 1.8 yrs		
1	36	Lancaster	2195	9.388	0.0043
2	67	York	1123	4.134	0.0037
3	54	Schuylkill	757	2.982	0.0039
4	21	Cumberland	672	2.718	0.0040
5	19	Columbia	587	1.506	0.0026
6	6	Berks	475	1.978	0.0042
7	32	Indiana	474	1.778	0.0038
8	10	Butler	441	1.696	0.0038
9	28	Franklin	432	1.065	0.0025
10	49	Northumberland	412	1.057	0.0026
		State Totals	12484	47.219	0.0038

Rank	No	Orchards	T = 1.2 to 1.8 yrs		
1	1	Adams	1922	6.138	0.0032
2	28	Franklin	1277	3.719	0.0029
3	6	Berks	473	1.336	0.0028
4	15	Chester	160	0.497	0.0031
5	36	Lancaster	154	0.478	0.0031
6	67	York	146	0.371	0.0025
7	39	Lehigh	133	0.410	0.0031
8	25	Erie	121	0.331	0.0027
9	9	Bucks	111	0.315	0.0028
10	63	Washington	64	0.167	0.0026
		State Totals	5031	14.957	0.0030

Rank	No	Unknown	T = 1.2 to 1.8 yrs		
1	36	Lancaster	1952	6.591	0.0034
2	25	Erie	1816	5.718	0.0031
3	15	Chester	1406	4.937	0.0035
4	54	Schuylkill	1006	3.036	0.0030
5	6	Berks	892	2.888	0.0032
6	38	Lebanon	881	2.884	0.0033
7	19	Columbia	639	1.546	0.0024
8	9	Bucks	589	3.118	0.0053
9	1	Adams	582	2.003	0.0034
10	32	Indiana	577	1.711	0.0030
		State Totals	19260	60.469	0.0031

Table D-6. Top ten counties for each major crop in 2010.

Rank	No	Corn County	T = 10 years Area Irrigated acres	Maximum Water Needed MGD	Water Needed per acre MGD/ac
1	36	**Lancaster**	2167	10.088	0.0047
2	41	**Lycoming**	1001	13.178	0.0132
3	18	**Clinton**	1045	5.208	0.0050
4	38	**Lebanon**	714	3.523	0.0049
5	67	**York**	595	2.768	0.0047
6	55	**Snyder**	295	1.437	0.0049
7	28	**Franklin**	230	2.562	0.0111
8	21	**Cumberland**	189	0.933	0.0049
9	34	**Juniata**	144	0.888	0.0062
10	56	**Somerset**	143	0.700	0.0049
		State Totals	8357	44.714	0.0054

Rank	No	Vegetables	T = 10 years		
1	36	**Lancaster**	2438	12.201	0.0050
2	28	**Franklin**	1123	14.540	0.0129
3	41	**Lycoming**	929	4.345	0.0047
4	19	**Columbia**	672	5.689	0.0085
5	32	**Indiana**	640	3.127	0.0049
6	54	**Schuylkill**	546	2.873	0.0053
7	38	**Lebanon**	463	2.387	0.0052
8	25	**Erie**	457	2.530	0.0055
9	49	**Northumberland**	450	3.020	0.0067
10	21	**Dauphin**	352	1.885	0.0054
		State Totals	12933	80.419	0.0062

Rank	No	Orchards	T = 10 years		
1	1	**Adams**	1955	6.718	0.0034
2	28	**Franklin**	1003	6.995	0.0070
3	6	**Berks**	609	3.767	0.0062
4	67	**York**	306	1.059	0.0035
5	36	**Lancaster**	140	0.532	0.0038
6	15	**Chester**	134	0.505	0.0038
7	9	**Bucks**	114	0.428	0.0038
8	25	**Erie**	93	0.346	0.0037
9	39	**Lehigh**	83	0.347	0.0042
10	49	**Northumberland**	69	0.222	0.0032
		State Totals	5092	23.214	0.0046

Rank	No	Unknown	T = 10 years		
1	36	**Lancaster**	2152	8.925	0.0041
2	25	**Erie**	2141	8.281	0.0039
3	15	**Chester**	1371	5.910	0.0043
4	54	**Schuylkill**	922	4.870	0.0053
5	1	**Adams**	943	3.949	0.0042
6	6	**Berks**	921	4.865	0.0053
7	38	**Lebanon**	914	3.625	0.0040
8	9	**Bucks**	825	3.510	0.0043
9	56	**Somerset**	653	3.058	0.0047
10	14	**Centre**	636	2.872	0.0045
11	31	**Huntingdon**	636	3.630	0.0057
		State Totals	21170	94.129	0.0044

Table D-7. Top ten counties for each major crop in 2020.

Rank	No	Corn County	T = 10 years Area Irrigated acres	Maximum Water Needed MGD	Water Needed per acre MGD/ac
1	36	Lancaster	2968	13.818	0.0047
2	41	Lycoming	2895	17.860	0.0062
3	18	Clinton	1296	6.457	0.0050
4	38	Lebanon	981	4.839	0.0049
5	67	York	789	3.673	0.0047
6	55	Snyder	402	1.959	0.0049
7	21	Cumberland	213	1.054	0.0049
8	28	Franklin	208	2.317	0.0111
9	34	Juniata	197	1.218	0.0062
10	56	Somerset	188	0.921	0.0049
		State Totals	11041	58.524	0.0053

Rank	No	Vegetables	T = 10 years		
1	36	Lancaster	3160	15.812	0.0050
2	28	Franklin	1283	18.639	0.0145
3	41	Lycoming	1222	5.713	0.0047
4	19	Columbia	1148	7.708	0.0067
5	32	Indiana	895	4.376	0.0049
6	54	Schuylkill	728	3.829	0.0053
7	38	Lebanon	536	2.766	0.0052
8	6	Berks	518	2.723	0.0053
9	49	Northumberland	516	3.462	0.0067
10	67	York	505	2.686	0.0053
		State Totals	16319	101.196	0.0062

Rank	No	Orchards	T = 10 years		
1	1	Adams	2106	7.237	0.0034
2	28	Franklin	1288	8.982	0.0070
3	6	Berks	740	4.579	0.0062
4	67	York	372	2.686	0.0072
5	15	Chester	210	0.797	0.0038
6	36	Lancaster	176	0.665	0.0038
7	9	Bucks	159	0.599	0.0038
8	39	Lehigh	141	0.589	0.0042
9	25	Erie	110	0.410	0.0037
10	49	Northumberland	92	0.294	0.0032
		State Totals	6094	28.262	0.0046

Rank	No	Unknown	T = 10 years		
1	25	Erie	2918	11.287	0.0039
2	36	Lancaster	2492	10.336	0.0041
3	15	Chester	1564	6.742	0.0043
4	54	Schuylkill	1273	6.725	0.0053
5	38	Lebanon	1263	5.009	0.0040
6	1	Berks	1187	6.271	0.0053
7	19	Adams	1128	4.723	0.0042
8	9	Bucks	895	3.806	0.0043
9	56	Somerset	867	4.062	0.0047
10	14	Centre	846	3.818	0.0045
		State Totals	25695	112.708	0.0044

Table D-8. Top ten counties for each major crop in 2030.

Rank	No	Corn County	T = 10 years Area Irrigated acres	Maximum Water Needed MGD	Water Needed per acre MGD/ac
1	36	**Lancaster**	3770	17.549	0.0047
2	41	**Lycoming**	3654	22.541	0.0062
3	18	**Clinton**	1547	7.707	0.0050
4	38	**Lebanon**	1247	6.155	0.0049
5	67	**York**	983	4.577	0.0047
6	55	**Snyder**	509	2.480	0.0049
7	34	**Juniata**	251	1.548	0.0062
8	21	**Cumberland**	238	1.174	0.0049
9	56	**Somerset**	234	1.142	0.0049
10	6	**Berks**	188	0.948	0.0050
		State Totals	13729	72.349	0.0053

Rank	No	Vegetables	T = 10 years		
1	36	**Lancaster**	3881	19.423	0.0050
2	28	**Franklin**	1565	22.738	0.0145
3	41	**Lycoming**	1515	7.081	0.0047
4	19	**Columbia**	1449	9.727	0.0067
5	32	**Indiana**	1151	5.625	0.0049
6	67	**York**	665	3.538	0.0053
7	25	**Erie**	625	3.461	0.0055
8	6	**Berks**	618	3.251	0.0053
9	38	**Lebanon**	609	3.144	0.0052
10	49	**Northumberland**	582	3.904	0.0067
		State Totals	19743	122.216	0.0062

Rank	No	Orchards	T = 10 years		
1	1	**Adams**	2257	7.756	0.0034
2	28	**Franklin**	1573	10.969	0.0070
3	6	**Berks**	871	5.392	0.0062
4	67	**York**	439	1.520	0.0035
5	15	**Chester**	287	1.088	0.0038
6	36	**Lancaster**	211	0.799	0.0038
7	9	**Bucks**	205	0.770	0.0038
8	39	**Lehigh**	199	0.830	0.0042
9	25	**Erie**	127	0.473	0.0037
10	46	**Montgomery**	112	0.693	0.0062
		State Totals	7142	33.465	0.0047

Rank	No	Unknown	T = 10 years		
1	25	**Erie**	3695	14.294	0.0039
2	36	**Lancaster**	2832	11.747	0.0041
3	15	**Chester**	1757	7.574	0.0043
4	54	**Schuylkill**	1624	8.580	0.0053
5	38	**Lebanon**	1612	6.393	0.0040
6	6	**Berks**	1453	7.676	0.0053
7	1	**Adams**	1289	5.397	0.0042
8	56	**Somerset**	1082	5.066	0.0047
9	14	**Centre**	1055	4.765	0.0045
10	31	**Huntingdon**	983	5.607	0.0057
		State Totals	30159	131.044	0.0043

APPENDIX E

Current and Future Annual Water Volumes Needed to Provide Irrigation in 2002, 2010, 2020, and 2030

Appendix E is laid out in two sections.

Section 1 shows the volume of water (in MG) that was used in 2002 or is predicted to be used in 2010, 2020, and 2030 for irrigating each of the crops.

Section 2 shows the top ten counties for each of the major irrigated crops for each of the years 2002, 2010, 2020, and 2030.

Section 1
Shows the volume of water (in acre-feet) that was used in 2002 or is predicted to be used in 2010, 2020, and 2030 for irrigating each of the crops.

Table E-1. Annual irrigation water needed in 2002.

No	County	Corn MG	Vegetables MG	Orchard MG	Berries MG	Unknown MG	Total MG
1	Adams	7	18	409	9	126	569
2	Allegheny	1	63	1	0	29	96
3	Armstrong	3	2	4	1	129	138
4	Beaver	10	19	3	4	100	136
5	Bedford	9	18	1	0	20	48
6	Berks	15	188	138	6	282	629
7	Blair	0	35	1	1	18	55
8	Bradford	2	2	1	6	22	32
9	Bucks	0	128	33	7	210	379
10	Butler	1	158	2	1	65	227
11	Cambria	0	1	0	0	9	11
12	Cameron	0	0	0	0	0	0
13	Carbon	0	1	1	0	17	20
14	Centre	2	21	4	3	70	99
15	Chester	3	124	44	8	489	669
16	Clarion	0	20	0	1	21	42
17	Clearfield	0	3	0	0	19	22
18	Clinton	2	27	0	0	68	97
19	Columbia	0	89	0	2	66	158
20	Crawford	0	34	1	0	25	61
21	Cumberland	3	212	1	5	109	330
22	Dauphin	2	147	1	6	73	230
23	Delaware	0	3	6	1	13	23
24	Elk	0	1	0	0	2	3
25	Erie	6	98	33	24	555	715
26	Fayette	1	16	0	1	8	27
27	Forest	0	2	0	0	0	2
28	Franklin	103	109	300	6	100	618
29	Fulton	2	1	0	0	5	8
30	Greene	0	0	1	0	8	10
31	Huntingdon	0	45	1	0	24	71
32	Indiana	1	168	1	6	151	327
33	Jefferson	0	2	0	1	3	6
34	Juniata	6	1	1	1	31	39
35	Lackawanna	0	22	0	0	4	26
36	Lancaster	449	785	43	21	553	1851
37	Lawrence	2	9	1	1	25	38
38	Lebanon	192	130	6	4	270	602
39	Lehigh	3	22	27	10	109	171
40	Luzerne	0	28	0	0	65	93
41	Lycoming	137	37	1	2	34	211
42	McKean	1	1	1	1	32	36
43	Mercer	0	12	1	3	48	64
44	Mifflin	1	6	2	0	3	12
45	Monroe	1	13	1	3	6	23
46	Montgomery	0	61	18	2	76	157
47	Montour	0	5	0	0	4	10
48	Northampton	1	56	1	2	45	105
49	Northumberland	0	63	2	1	15	80
50	Perry	2	72	1	0	40	116
51	Philadelphia	0	0	0	0	2	2
52	Pike	0	0	0	0	2	3
53	Potter	0	1	1	0	0	2
54	Schuylkill	14	264	7	7	275	567
55	Snyder	11	35	4	1	13	64
56	Somerset	3	11	5	0	112	131
57	Sullivan	0	0	1	0	0	1
58	Susquehanna	0	1	1	1	3	5
59	Tioga	1	1	1	0	15	18
60	Union	2	3	0	0	5	11
61	Venango	1	8	0	1	11	22
62	Warren	1	2	0	0	72	75
63	Washington	8	159	17	8	121	314
64	Wayne	3	2	0	0	12	18
65	Westmoreland	1	10	11	1	70	93
66	Wyoming	0	6	1	0	6	13
67	York	0	307	32	22	75	435
	Total =	1014	3888	1175	197	4991	11265

Table E-2. Annual irrigation water needed in 2010.

No	County	Corn MG	Vegetables MG	Orchard MG	Berries MG	Unknown MG	Total MG
1	Adams	33	14	730	12	413	1201
2	Allegheny	1	103	11	0	93	208
3	Armstrong	6	3	6	2	118	135
4	Beaver	7	56	3	4	193	263
5	Bedford	43	93	4	1	101	242
6	Berks	60	239	259	10	437	1005
7	Blair	5	61	2	0	11	78
8	Bradford	4	1	0	9	109	123
9	Bucks	2	220	49	1	428	700
10	Butler	2	146	8	0	0	155
11	Cambria	0	0	0	1	16	17
12	Cameron	0	0	0	0	0	0
13	Carbon	0	5	4	2	35	46
14	Centre	6	53	8	8	238	312
15	Chester	21	200	55	20	740	1036
16	Clarion	2	34	0	0	0	36
17	Clearfield	1	3	0	0	58	62
18	Clinton	420	109	0	3	162	694
19	Columbia	0	387	5	12	147	551
20	Crawford	0	57	1	0	210	268
21	Cumberland	102	0	21	9	0	131
22	Dauphin	5	214	14	8	102	342
23	Delaware	0	3	8	2	15	29
24	Elk	0	5	0	1	1	7
25	Erie	31	258	38	39	1028	1393
26	Fayette	2	16	0	2	0	20
27	Forest	0	5	0	0	0	5
28	Franklin	119	606	505	11	233	1474
29	Fulton	1	2	0	1	0	4
30	Greene	0	4	1	0	0	5
31	Huntingdon	0	88	3	0	273	364
32	Indiana	2	340	4	26	156	528
33	Jefferson	0	3	0	0	47	50
34	Juniata	54	22	3	0	100	179
35	Lackawanna	2	38	0	1	145	186
36	Lancaster	1000	1357	58	21	971	3407
37	Lawrence	0	9	7	2	0	19
38	Lebanon	384	250	16	10	411	1071
39	Lehigh	4	39	33	17	0	93
40	Luzerne	1	85	2	5	178	270
41	Lycoming	801	416	0	0	150	1367
42	McKean	1	3	1	2	56	63
43	Mercer	0	56	0	0	0	56
44	Mifflin	3	16	2	4	10	35
45	Monroe	2	46	2	5	5	60
46	Montgomery	1	102	23	4	218	347
47	Montour	1	18	0	1	13	33
48	Northampton	3	115	0	0	110	228
49	Northumberland	5	205	20	0	0	230
50	Perry	0	89	0	3	64	156
51	Philadelphia	0	0	0	0	3	3
52	Pike	0	0	0	2	27	28
53	Potter	0	1	1	0	0	2
54	Schuylkill	24	313	12	11	438	798
55	Snyder	106	132	3	10	135	387
56	Somerset	70	11	12	2	291	386
57	Sullivan	3	1	0	0	8	11
58	Susquehanna	0	3	3	6	55	67
59	Tioga	2	3	3	2	23	33
60	Union	4	26	12	1	84	128
61	Venango	2	12	2	1	15	32
62	Warren	2	3	0	1	169	175
63	Washington	6	66	0	0	116	187
64	Wayne	13	10	1	0	34	58
65	Westmoreland	8	0	14	0	87	109
66	Wyoming	2	8	1	1	14	26
67	York	274	177	118	0	179	748
	Total =	3650	6957	2087	295	9473	22463

Table E-3. Annual irrigation water needed in 2020.

No	County	Corn MG	Vegetables MG	Orchard MG	Berries MG	Unknown MG	Total MG
1	Adams	40	0	786	13	494	1334
2	Allegheny	2	136	14	0	112	264
3	Armstrong	9	3	9	2	138	161
4	Beaver	10	73	4	6	244	337
5	Bedford	55	114	5	1	122	298
6	Berks	75	297	315	5	564	1255
7	Blair	5	29	2	0	3	39
8	Bradford	6	1	0	13	137	156
9	Bucks	2	193	68	0	464	727
10	Butler	3	175	9	0	0	187
11	Cambria	0	0	0	1	12	13
12	Cameron	0	0	0	0	0	0
13	Carbon	0	6	5	2	51	63
14	Centre	8	72	11	11	316	418
15	Chester	23	271	87	22	844	1248
16	Clarion	3	47	0	0	0	49
17	Clearfield	1	5	0	0	77	83
18	Clinton	521	132	0	3	170	826
19	Columbia	1	524	7	16	196	743
20	Crawford	0	81	1	0	251	332
21	Cumberland	115	0	16	5	0	136
22	Dauphin	6	245	0	7	114	372
23	Delaware	0	3	11	3	6	23
24	Elk	0	5	0	1	2	8
25	Erie	38	305	45	37	1401	1826
26	Fayette	3	23	0	3	0	28
27	Forest	0	6	0	0	0	6
28	Franklin	107	777	649	11	142	1686
29	Fulton	1	2	0	1	0	4
30	Greene	0	4	2	0	0	6
31	Huntingdon	0	128	4	0	347	479
32	Indiana	2	476	5	30	207	721
33	Jefferson	0	3	0	0	58	61
34	Juniata	74	29	4	0	128	234
35	Lackawanna	3	56	0	1	187	247
36	Lancaster	1370	1759	73	18	1124	4344
37	Lawrence	0	13	8	3	0	23
38	Lebanon	527	290	22	10	567	1416
39	Lehigh	7	45	56	20	0	128
40	Luzerne	0	83	3	3	236	326
41	Lycoming	1085	548	0	0	174	1807
42	McKean	2	3	2	3	74	84
43	Mercer	0	71	0	0	0	71
44	Mifflin	3	21	3	4	9	40
45	Monroe	2	63	3	8	2	77
46	Montgomery	0	149	35	5	225	414
47	Montour	2	24	0	1	15	42
48	Northampton	3	134	0	0	111	248
49	Northumberland	6	235	27	0	0	268
50	Perry	0	133	1	4	87	224
51	Philadelphia	0	0	0	0	3	3
52	Pike	0	0	0	2	35	38
53	Potter	0	1	2	0	0	3
54	Schuylkill	38	417	18	14	605	1091
55	Snyder	144	161	0	11	164	481
56	Somerset	92	16	16	2	386	512
57	Sullivan	3	1	0	0	11	15
58	Susquehanna	0	3	5	8	70	85
59	Tioga	3	3	4	2	15	27
60	Union	6	29	16	2	109	161
61	Venango	3	16	2	1	21	43
62	Warren	3	3	0	1	206	213
63	Washington	8	31	0	0	143	182
64	Wayne	18	13	2	0	33	66
65	Westmoreland	10	0	17	0	65	92
66	Wyoming	3	11	1	1	7	23
67	York	364	259	143	0	178	944
	Total =	4815	8755	2514	317	11462	27863

Table E-4. Annual irrigation water needed in 2030.

No	County	Corn MG	Vegetables MG	Orchard MG	Berries MG	Unknown MG	Total MG
1	Adams	47	0	842	15	565	1469
2	Allegheny	3	169	17	0	131	320
3	Armstrong	11	3	12	3	158	186
4	Beaver	14	89	6	7	296	412
5	Bedford	67	135	7	1	143	353
6	Berks	89	354	371	0	690	1504
7	Blair	6	0	2	0	0	8
8	Bradford	7	1	0	16	164	189
9	Bucks	1	166	87	0	499	753
10	Butler	3	204	11	0	0	219
11	Cambria	0	0	0	1	7	8
12	Cameron	0	0	0	0	0	0
13	Carbon	0	8	6	1	66	81
14	Centre	10	91	15	14	395	523
15	Chester	26	343	119	25	949	1461
16	Clarion	3	59	0	0	0	62
17	Clearfield	1	6	0	0	97	103
18	Clinton	622	156	0	3	178	958
19	Columbia	1	661	8	20	244	934
20	Crawford	0	104	2	0	291	397
21	Cumberland	128	0	11	1	0	140
22	Dauphin	8	277	0	5	110	399
23	Delaware	0	3	14	4	0	21
24	Elk	0	6	0	0	2	9
25	Erie	45	353	52	36	1774	2259
26	Fayette	3	29	0	4	0	36
27	Forest	0	8	0	0	0	8
28	Franklin	96	948	792	11	51	1898
29	Fulton	1	1	0	2	0	4
30	Greene	0	5	2	0	0	7
31	Huntingdon	0	168	5	0	421	594
32	Indiana	2	613	7	34	259	914
33	Jefferson	1	3	0	0	69	73
34	Juniata	94	35	4	0	157	290
35	Lackawanna	3	75	0	1	229	308
36	Lancaster	1740	2161	87	15	1278	5281
37	Lawrence	0	16	8	4	0	28
38	Lebanon	671	329	27	11	724	1762
39	Lehigh	10	52	79	22	0	162
40	Luzerne	0	82	4	2	294	382
41	Lycoming	1369	679	0	0	198	2247
42	McKean	3	3	3	3	93	105
43	Mercer	0	86	0	0	0	86
44	Mifflin	3	26	3	5	8	46
45	Monroe	3	80	3	10	0	96
46	Montgomery	0	195	48	6	233	481
47	Montour	2	30	0	1	17	51
48	Northampton	3	153	0	0	112	268
49	Northumberland	7	265	33	0	0	306
50	Perry	0	176	1	4	110	292
51	Philadelphia	0	0	0	0	4	4
52	Pike	0	0	0	3	44	47
53	Potter	0	2	3	0	0	4
54	Schuylkill	52	521	23	17	771	1385
55	Snyder	183	190	0	13	188	573
56	Somerset	114	20	20	3	482	638
57	Sullivan	4	1	0	0	13	19
58	Susquehanna	0	4	6	9	84	104
59	Tioga	3	4	5	3	6	21
60	Union	8	31	19	2	134	193
61	Venango	4	21	3	1	26	55
62	Warren	4	3	0	2	243	252
63	Washington	11	0	0	0	166	176
64	Wayne	24	16	2	0	32	74
65	Westmoreland	12	0	20	0	43	76
66	Wyoming	3	14	2	1	0	20
67	York	454	341	169	0	177	1140
	Total =	5980	10574	2959	340	13424	33276

Section 2

Shows the top ten counties for each of the major irrigated crops for each of the years 2002, 2010, 2020, and 2030.

Table E-5. Top ten counties for each major crop in 2002.

		Corn	T = 1.2 to 1.8 yrs		Water Needed
			Area Irrigated	Water Needed	per acre
Rank	No	County	acres	MG	MG/ac
1	36	Lancaster	1657	449	0.27
2	41	Lycoming	1246	137	0.11
3	38	Lebanon	573	192	0.34
4	28	Franklin	499	103	0.21
5	55	Snyder	113	11	0.10
6	54	Schuylkill	56	14	0.25
7	6	Berks	52	15	0.29
8	34	Juniata	51	6	0.11
9	4	Beaver	39	10	0.27
10	5	Bedford	39	9	0.23
		State Totals	4645	1014	0.22

Rank	No	Vegetables	T = 1.2 to 1.8 yrs		
1	36	Lancaster	2195	785	0.36
2	67	York	1123	307	0.27
3	54	Schuylkill	757	264	0.35
4	21	Cumberland	672	212	0.32
5	19	Columbia	587	89	0.15
6	6	Berks	475	188	0.40
7	32	Indiana	474	168	0.35
8	10	Butler	441	158	0.36
9	28	Franklin	432	109	0.25
10	49	Northumberland	412	63	0.15
		State Totals	12484	3888	0.31

Rank	No	Orchards	T = 1.2 to 1.8 yrs		
1	1	Adams	1922	409	0.21
2	28	Franklin	1277	300	0.23
3	6	Berks	473	138	0.29
4	15	Chester	160	44	0.28
5	36	Lancaster	154	43	0.28
6	67	York	146	32	0.22
7	39	Lehigh	133	27	0.20
8	25	Erie	121	33	0.28
9	9	Bucks	111	33	0.30
10	63	Washington	64	17	0.26
		State Totals	5031	1175	0.23

Rank	No	Unknown	T = 1.2 to 1.8 yrs		
1	36	Lancaster	1952	553	0.28
2	25	Erie	1816	555	0.31
3	15	Chester	1406	489	0.35
4	54	Schuylkill	1006	275	0.27
5	6	Berks	892	282	0.32
6	38	Lebanon	881	270	0.31
7	19	Columbia	639	66	0.10
8	9	Bucks	589	210	0.36
9	1	Adams	582	126	0.22
10	32	Indiana	577	151	0.26
		State Totals	19260	4991	0.26

Table E-6. Top ten counties for each major crop in 2010.

		Corn	T = 10 years		Water Needed
			Area Irrigated	Water Needed	per acre
Rank	No	County	acres	MG	MG/ac
1	36	**Lancaster**	2167	1000	0.46
2	41	**Lycoming**	1001	801	0.80
3	18	**Clinton**	1045	420	0.40
4	38	**Lebanon**	714	384	0.54
5	67	**York**	595	274	0.46
6	55	**Snyder**	295	106	0.36
7	28	**Franklin**	230	119	0.52
8	21	**Cumberland**	189	102	0.54
9	34	**Juniata**	144	54	0.37
10	56	**Somerset**	143	70	0.49
		State Totals	8357	3650	0.44

Rank	No	Vegetables	T = 10 years		
1	36	**Lancaster**	2438	1357	0.56
2	28	**Franklin**	1123	606	0.54
3	41	**Lycoming**	929	416	0.45
4	19	**Columbia**	672	387	0.58
5	32	**Indiana**	640	340	0.53
6	54	**Schuylkill**	546	313	0.57
7	38	**Lebanon**	463	250	0.54
8	25	**Erie**	457	258	0.56
9	49	**Northumberland**	450	205	0.46
10	21	**Dauphin**	352	214	0.61
		State Totals	12933	6957	0.54

Rank	No	Orchards	T = 10 years		
1	1	**Adams**	1955	730	0.37
2	28	**Franklin**	1003	505	0.50
3	6	**Berks**	609	259	0.43
4	67	**York**	306	118	0.38
5	36	**Lancaster**	140	58	0.42
6	15	**Chester**	134	55	0.41
7	9	**Bucks**	114	49	0.43
8	25	**Erie**	93	38	0.41
9	39	**Lehigh**	83	33	0.40
10	49	**Northumberland**	69	20	0.29
		State Totals	5092	2087	0.41

Rank	No	Unknown	T = 10 years		
1	36	**Lancaster**	2152	971	0.45
2	25	**Erie**	2141	1028	0.48
3	15	**Chester**	1371	740	0.54
4	54	**Schuylkill**	922	438	0.47
5	1	**Adams**	943	413	0.44
6	6	**Berks**	921	437	0.47
7	38	**Lebanon**	914	411	0.45
8	9	**Bucks**	825	428	0.52
9	56	**Somerset**	653	291	0.45
10	14	**Centre**	636	238	0.37
11	31	**Huntingdon**	636	273	0.43
		State Totals	21170	9473	0.45

Table E-7. Top ten counties for each major crop in 2020.

Rank	No	Corn	T = 10 years		Water Needed
			Area Irrigated	Water Needed	per acre
Rank	No	County	acres	MG	MG/ac
1	36	Lancaster	2968	1370	0.46
2	41	Lycoming	2895	1085	0.37
3	18	Clinton	1296	521	0.40
4	38	Lebanon	981	527	0.54
5	67	York	789	364	0.46
6	55	Snyder	402	144	0.36
7	21	Cumberland	213	115	0.54
8	28	Franklin	208	107	0.52
9	34	Juniata	197	74	0.38
10	56	Somerset	188	92	0.49
		State Totals	11041	4815	0.44

Rank	No	Vegetables	T = 10 years		
1	36	Lancaster	3160	1759	0.56
2	28	Franklin	1283	777	0.61
3	41	Lycoming	1222	548	0.45
4	19	Columbia	1148	524	0.46
5	32	Indiana	895	476	0.53
6	54	Schuylkill	728	417	0.57
7	38	Lebanon	536	290	0.54
8	6	Berks	518	297	0.57
9	49	Northumberland	516	235	0.46
10	67	York	505	259	0.51
		State Totals	16319	8755	0.54

Rank	No	Orchards	T = 10 years		
1	1	Adams	2106	786	0.37
2	28	Franklin	1288	649	0.50
3	6	Berks	740	315	0.43
4	67	York	372	143	0.38
5	15	Chester	210	87	0.41
6	36	Lancaster	176	73	0.41
7	9	Bucks	159	68	0.43
8	39	Lehigh	141	56	0.40
9	25	Erie	110	45	0.41
10	49	Northumberland	92	27	0.29
		State Totals	6094	2514	0.41

Rank	No	Unknown	T = 10 years		
1	25	Erie	2918	1401	0.48
2	36	Lancaster	2492	1124	0.45
3	15	Chester	1564	844	0.54
4	54	Schuylkill	1273	605	0.47
5	38	Lebanon	1263	567	0.45
6	1	Berks	1187	564	0.47
7	19	Adams	1128	494	0.44
8	9	Bucks	895	464	0.52
9	56	Somerset	867	386	0.45
10	14	Centre	846	316	0.37
		State Totals	25695	11462	0.45

Table E-8. Top ten counties for each major crop in 2030.

Rank	No	Corn	T = 10 years		Water Needed
			Area Irrigated	Water Needed	per acre
Rank	No	County	acres	MG	MG/ac
1	36	**Lancaster**	3770	1740	0.46
2	41	**Lycoming**	3654	671	0.18
3	18	**Clinton**	1547	622	0.40
4	38	**Lebanon**	1247	671	0.54
5	67	**York**	983	454	0.46
6	55	**Snyder**	509	183	0.36
7	34	**Juniata**	251	94	0.37
8	21	**Cumberland**	238	128	0.54
9	56	**Somerset**	234	114	0.49
10	6	**Berks**	188	89	0.47
		State Totals	13729	5980	0.44
Rank	**No**	**Vegetables**	**T = 10 years**		
1	36	**Lancaster**	3881	2161	0.56
2	28	**Franklin**	1565	948	0.61
3	41	**Lycoming**	1515	329	0.22
4	19	**Columbia**	1449	661	0.46
5	32	**Indiana**	1151	613	0.53
6	67	**York**	665	341	0.51
7	25	**Erie**	625	353	0.56
8	6	**Berks**	618	354	0.57
9	38	**Lebanon**	609	329	0.54
10	49	**Northumberland**	582	265	0.46
		State Totals	19743	10574	0.54
Rank	**No**	**Orchards**	**T = 10 years**		
1	1	**Adams**	2257	842	0.37
2	28	**Franklin**	1573	792	0.50
3	6	**Berks**	871	371	0.43
4	67	**York**	439	169	0.38
5	15	**Chester**	287	119	0.41
6	36	**Lancaster**	211	87	0.41
7	9	**Bucks**	205	87	0.42
8	39	**Lehigh**	199	79	0.40
9	25	**Erie**	127	52	0.41
10	46	**Montgomery**	112	48	0.43
		State Totals	7142	2959	0.41
Rank	**No**	**Unknown**	**T = 10 years**		
1	25	**Erie**	3695	1774	0.48
2	36	**Lancaster**	2832	1278	0.45
3	15	**Chester**	1757	949	0.54
4	54	**Schuylkill**	1624	771	0.47
5	38	**Lebanon**	1612	724	0.45
6	6	**Berks**	1453	690	0.47
7	1	**Adams**	1289	565	0.44
8	56	**Somerset**	1082	482	0.45
9	14	**Centre**	1055	395	0.37
10	31	**Huntingdon**	983	421	0.43
		State Totals	30159	13424	0.45

APPENDIX F

Current and Future Animal Populations and Water Volumes Needed to Support Animal Agriculture in 2002, 2010, 2020, and 2030. . . . . .

Appendix F is laid out in three sections.

Section 1 shows the current animal populations or the predicted animal populations in each county in 2002, 2010, 2020, and 2030 identified by each species for which population numbers were available.

Section 2 shows the volume of water (in MGD) that was used in 2002 or is predicted to be used in 2010, 2020, and 2030 for supplying each species.

Section 3 shows the top ten counties for each of the major animal species for each of the years 2002, 2010, 2020, and 2030.

Section 1

Shows the current animal populations or the predicted animal populations in each county in 2002, 2010, 2020, and 2030 identified by each species for which population numbers were available.

Table F-1. Animal populations in 2002.

No	County	Swine #	Sheep #	Goats #	Horses #	Peeps #	Layers #	Broilers #	Turkeys #	Milk C #	Adult C #	Young C #
1	Adams	15122	1375	206	2850	400000	2028071	250000	738090	7280	9656	10239
2	Allegheny	292	858	56	1295	724	5487	96	500	173	1612	783
3	Armstrong	2020	1214	253	1268	263	1264	781	16	3319	6944	5102
4	Beaver	484	1412	57	1261	10	44280	282	49	2334	3949	2797
5	Bedford	14243	3452	74	1544	121	4052	973	70	15949	11823	13293
6	Berks	61517	1979	50	2281	698430	2574506	1230768	250	23886	13959	22353
7	Blair	1336	599	235	724	358	200	450	73	17729	6523	9625
8	Bradford	30013	2489	297	1384	190	1000	1869	88	24863	23310	31621
9	Bucks	1546	1918	165	2530	453	5426	2465	2000	2485	2489	2700
10	Butler	2650	2342	419	2207	370	2498	1071	178	4201	9431	7433
11	Cambria	2179	2463	35	697	3811	4655	1100	50	2543	4908	4166
12	Cameron	42	3	20	45	0	100	8	0	43	112	73
13	Carbon	246	244	17	218	25	1024	40	25	219	391	395
14	Centre	7054	2191	488	3485	50	22726	2036	120	12547	9161	9467
15	Chester	12860	2856	170	8597	508862	552808	108024	36129	18966	10223	12689
16	Clarion	1297	1004	8	793	1171	3756	403	25	4470	6432	4729
17	Clearfield	483	94	50	637	62	1189	133	112	1891	3121	2540
18	Clinton	1164	342	32	1231	30	32319	950	196	6434	3682	5295
19	Columbia	11602	764	15	973	282	250	77785	75	3974	3820	3900
20	Crawford	2642	1585	247	3142	617	1500	1756	313	14114	12117	11442
21	Cumberland	13560	1539	409	1772	1346	343690	455591	123902	18844	10957	16143
22	Dauphin	5545	3297	25	1970	250694	678007	427182	63943	6385	4836	5401
23	Delaware	0	101	15	149	0	500	10	10	275	0	0
24	Elk	217	103	15	327	47	1145	185	10	535	1336	584
25	Erie	1752	825	236	1941	218	1187	431	23	8087	7226	6427
26	Fayette	1736	1204	165	1923	626	3532	1351	35	4128	10162	5344
27	Forest	224	9	10	119	0	72	0	0	35	217	420
28	Franklin	105131	2903	1068	1592	350504	1394573	849231	432281	47213	21045	33104
29	Fulton	22382	718	149	726	107	7519	363	70554	5586	6592	4673
30	Greene	409	3912	15	1292	367	1303	36	10	567	11824	4658
31	Huntingdon	12123	1286	465	922	225	13730	30000	10000	11461	7827	8659
32	Indiana	1196	2604	90	0	524	2209	612	1000	6887	6808	7054
33	Jefferson	500	826	94	791	700	1132	100	0	2529	5229	3210
34	Juniata	38913	1896	105	722	107	351582	2075622	72300	7882	5094	6555
35	Lackawanna	29	166	30	452	150	670	103	10	1432	1448	1243
36	Lancaster	386801	6125	1060	16516	1835137	7500336	7823907	174605	107591	57431	90684
37	Lawrence	7359	1912	90	1578	100	10000	1694	110	6039	6289	5453
38	Lebanon	112809	1636	55	1426	898954	2293370	2377194	191542	22636	11677	18304
39	Lehigh	2896	1031	70	1426	866	15000	1755	10000	1202	1237	1211
40	Luzerne	395	467	66	855	652	1547	1627	200	1477	1851	1727
41	Lycoming	20279	1815	55	1799	826	177450	165108	169	6821	7690	8365
42	McKean	317	217	52	492	321	768	40	10	1113	1902	1026
43	Mercer	4877	2251	30	3039	1294	19448	2473	170	10195	10666	10251
44	Mifflin	22528	972	295	1988	43904	4933	232978	110551	13584	7943	10760
45	Monroe	134	337	30	659	131	1935	1880	10	170	586	639
46	Montgomery	4795	1689	65	1737	1936	100000	3034	84	2148	2341	2647
47	Montour	784	583	13	547	252	400	50000	10	2087	2099	3347
48	Northampton	3255	564	64	626	936	2480	801	50	2425	2044	2297
49	Northumberland	35453	1217	66	809	61032	684823	390323	202380	5120	5365	7859
50	Perry	63098	1518	257	613	30	249250	785733	190996	8360	6730	8726
51	Philadelphia	0	3	0	0	0	1	0	0	0	0	0
52	Pike	8	62	10	174	0	384	0	2	184	138	89
53	Potter	514	701	148	505	259	384	513	130	5339	3967	4414
54	Schuylkill	21876	311	15	1046	100	802079	471550	20000	2879	3411	4479
55	Snyder	49087	1222	60	1460	2000	252833	2494887	89592	8606	6738	10370
56	Somerset	1606	2164	1081	2119	570	35000	670	204	19943	14004	16505
57	Sullivan	1606	455	25	127	100	201	10	0	2059	1481	1516
58	Susquehanna	436	1635	25	1527	616	2099	787	208	12316	9395	9897
59	Tioga	33245	2840	392	1185	120	11197	634	114	12364	12105	11535
60	Union	19822	416	190	650	695	219036	1138747	89497	9115	4949	7617
61	Venango	769	865	488	892	321	1678	315	28	1819	3618	2814
62	Warren	299	556	82	1411	273	1398	1080	79	5074	3565	3455
63	Washington	1743	9146	161	5132	812	3578	550	34	4346	21148	9737
64	Wayne	1261	1081	120	883	405	2567	232	56	7541	4946	4788
65	Westmoreland	2933	2783	140	2516	938	19405	1108	75	6324	10809	8108
66	Wyoming	142	1044	5	380	10	445	250	0	3440	2587	2284
67	York	54698	4606	437	5535	500	1462744	268702	568089	10189	15350	17731
	Total =	1228334	102797	11432	111512	5075534	21964731	21740389	3201432	591772	488324	552754

Table F-2. Animal populations in 2010.

		Swine	Sheep	Goats	Horses	Peeps	Layers	Broilers	Turkeys	Milk C	Adult C	Young C
No	**County**	**#**	**#**	**#**	**#**	**#**	**#**	**#**	**#**	**#**	**#**	**#**
1	Adams	14333	1271	175	3446	400000	2216667	717750	957500	6607	8167	10917
2	Allegheny	279	917	88	1425	683	5475	279	892	238	1508	600
3	Armstrong	1633	1042	350	1625	333	892	1000	79	3333	6750	4750
4	Beaver	363	1492	58	1550	10	91667	258	50	1796	3813	2492
5	Bedford	16583	4500	75	2000	142	5158	975	96	14917	10792	12500
6	Berks	67917	1750	53	2825	891667	3458333	1291667	308	22917	10983	21417
7	Blair	1017	708	313	904	471	238	425	71	19583	8250	9542
8	Bradford	40750	1803	400	1542	185	717	2708	119	19917	25000	33250
9	Bucks	1188	2067	246	3158	667	4333	3042	1808	2050	2192	2008
10	Butler	1933	1750	538	2567	471	0	1575	296	3092	8967	7642
11	Cambria	1833	3258	49	850	4083	3779	1492	150	2450	4342	4600
12	Cameron	34	5	23	60	12	0	9	0	43	87	92
13	Carbon	0	233	11	267	25	0	208	25	166	303	454
14	Centre	7000	2375	513	4417	33	30292	2867	138	12292	9917	8550
15	Chester	12800	3058	89	10333	691667	658333	0	35583	16200	8750	9625
16	Clarion	975	1125	8	925	1021	4200	333	23	4483	6783	4483
17	Clearfield	500	217	70	750	0	400	63	108	1417	3129	2388
18	Clinton	433	421	65	1508	31	32000	1175	210	7458	3917	6008
19	Columbia	13250	421	17	1083	38	250	75000	77	3742	3333	3696
20	Crawford	2842	1983	279	3667	583	1500	1833	275	11175	12833	8525
21	Cumberland	12500	1633	525	2142	1738	359167	550000	175000	18633	11333	16717
22	Dauphin	2750	3717	47	2450	320938	662500	346667	61250	5900	3750	4717
23	Delaware	0	0	15	76	0	600	23	10	201	0	0
24	Elk	238	146	17	415	50	1375	180	10	442	1471	496
25	Erie	1750	967	354	2342	275	0	488	30	5208	7517	4589
26	Fayette	1313	1383	238	2488	533	4333	1467	40	4033	10208	5221
27	Forest	284	8	10	123	0	317	0	0	0	169	508
28	Franklin	130417	3483	1458	1958	383333	1583333	983333	458333	50833	24875	32375
29	Fulton	23833	792	204	921	132	9500	454	78333	5633	7033	4650
30	Greene	475	1083	16	1575	375	1667	42	11	442	11967	5050
31	Huntingdon	15250	1438	667	1283	292	19250	30000	12833	11617	8383	8358
32	Indiana	0	2800	90	1763	583	2625	650	1000	6167	5850	6550
33	Jefferson	438	921	98	954	700	1458	83	4	1875	5500	2508
34	Juniata	51167	2219	106	875	92	364167	2441667	72000	7442	5342	6267
35	Lackawanna	0	71	17	533	186	442	88	10	1042	1275	958
36	Lancaster	409583	5808	1313	19958	2058333	6041667	7883333	195833	114167	44500	99500
37	Lawrence	6950	2033	114	1683	92	17500	1992	117	5500	6408	4425
38	Lebanon	145417	1779	52	1631	1116667	2883333	2491667	225000	24250	10992	19492
39	Lehigh	0	1342	84	1665	1021	7500	1775	0	983	1042	1038
40	Luzerne	0	451	88	1058	846	0	1917	258	1063	1625	1467
41	Lycoming	26750	2329	60	2350	1021	216667	225417	263	5992	6742	8950
42	McKean	371	158	45	592	467	633	67	38	813	1883	533
43	Mercer	4225	2142	4	3708	1408	14167	2417	213	9575	10308	10542
44	Mifflin	27500	1317	360	2367	51250	0	220833	145833	13783	9500	10917
45	Monroe	0	376	50	842	185	2250	2500	15	17	353	670
46	Montgomery	4292	2167	71	2083	2625	75000	4200	0	1713	1667	2087
47	Montour	0	738	20	642	294	667	38333	10	1979	1871	3908
48	Northampton	1725	468	80	646	1219	0	838	121	333	1242	1150
49	Northumberland	38333	1083	80	958	72917	883333	525042	288333	5175	4675	9083
50	Perry	84792	1858	311	708	42	253750	908333	258333	8583	6863	9267
51	Philadelphia	0	0	0	0	0	0	0	0	0	0	0
52	Pike	40	79	10	230	0	333	0	3	211	113	92
53	Potter	613	538	208	633	333	279	673	196	5021	4133	3921
54	Schuylkill	22875	233	19	1381	292	831667	491667	25417	2775	2842	4883
55	Snyder	61250	1363	61	1696	3333	350000	3116667	87917	8825	7317	11208
56	Somerset	0	2292	1490	2492	633	21250	825	292	20083	15292	16333
57	Sullivan	2154	506	28	138	113	146	10	0	1750	1483	1375
58	Susquehanna	417	1604	45	1883	894	2717	888	292	9500	10917	11167
59	Tioga	45000	3104	496	1381	252	0	792	175	9375	14083	9417
60	Union	22250	446	249	739	825	258333	1520000	87500	10058	4604	8492
61	Venango	879	894	665	1038	583	1333	33	13	1646	3154	2683
62	Warren	229	325	96	1667	363	1800	1008	75	4558	3763	2575
63	Washington	1250	9017	159	5179	800	4133	229	0	3500	21875	8575
64	Wayne	1638	1300	117	1088	508	2925	46	57	5083	4971	2500
65	Westmoreland	1792	2708	154	2771	993	0	637	70	5417	10042	7492
66	Wyoming	135	1194	5	354	23	504	260	0	2583	2688	1750
67	York	58167	4750	504	6917	525	1737083	233333	756250	8250	12333	19042
	Total =	1394702	105458	14316	135274	6020205	23133938	24133529	3929300	565902	473767	547034

Table F-3. Animal populations in 2020.

		Swine	Sheep	Goats	Horses	Peeps	Layers	Broilers	Turkeys	Milk C	Adult C	Young C
No	**County**	#	#	#	#	#	#	#	#	#	#	#
1	Adams	10167	1010	238	4123	400000	2508333	708875	1153750	5803	6083	11958
2	Allegheny	165	958	119	1613	392	2788	165	496	144	1404	350
3	Armstrong	1217	771	475	2063	417	496	1250	90	2917	6375	4375
4	Beaver	206	1596	79	1925	10	120833	279	50	973	3656	2096
5	Bedford	19292	5750	75	2500	121	6679	788	123	13458	9646	11250
6	Berks	76458	1375	37	3513	1120833	4604167	1395833	204	21458	6692	21208
7	Blair	558	854	406	1102	585	144	363	43	22292	10125	9021
8	Bradford	53875	912	525	1771	180	383	3604	134	13458	27500	35125
9	Bucks	719	2233	323	3929	833	2667	3771	1454	1175	1546	1154
10	Butler	1017	875	719	2983	635	0	2138	398	1696	8383	7871
11	Cambria	1417	4279	60	975	4292	1915	1846	200	2325	3571	5100
12	Cameron	23	6	29	77	16	0	10	0	31	53	116
13	Carbon	0	217	8	333	25	0	104	25	93	187	527
14	Centre	7000	2438	656	5708	0	40146	3283	184	11896	10958	7175
15	Chester	12800	3329	50	12667	920833	804167	0	35792	12700	6875	5563
16	Clarion	538	1313	4	1113	1260	4700	167	11	4442	7242	4192
17	Clearfield	500	133	85	875	0	0	0	104	708	3140	2169
18	Clinton	0	535	83	1904	20	32000	1488	243	8729	4208	6904
19	Columbia	15125	535	8	1292	0	250	75000	43	3471	2667	3498
20	Crawford	3071	2442	290	4333	542	1500	1917	313	7488	13667	4963
21	Cumberland	11250	1717	713	2621	2269	369583	675000	237500	18217	11667	17258
22	Dauphin	0	4258	63	3075	435469	631250	238333	70625	5150	1875	3758
23	Delaware	0	0	15	0	0	725	32	10	115	0	0
24	Elk	264	193	21	520	58	1688	97	7	296	1635	373
25	Erie	1750	1133	477	2821	338	0	644	35	1354	8058	2300
26	Fayette	781	1592	319	3144	367	5417	1633	40	3867	10104	4960
27	Forest	357	4	10	149	0	358	0	0	0	105	604
28	Franklin	162708	4192	1979	2479	441667	1791667	1191667	479167	55417	30188	31438
29	Fulton	25917	896	277	1160	161	12000	527	86667	5717	7617	4525
30	Greene	538	0	14	1888	438	2083	21	8	0	12133	5425
31	Huntingdon	19125	1594	883	1742	396	26125	30000	17417	11908	9092	7879
32	Indiana	0	3050	90	1981	792	3063	525	1000	5333	4725	5925
33	Jefferson	344	1035	129	1152	700	1979	42	2	938	5750	1654
34	Juniata	66583	2609	128	1063	46	387083	2920833	72000	6921	5571	5933
35	Lackawanna	0	0	8	617	233	421	69	10	521	1088	479
36	Lancaster	439792	5454	1656	24229	2079167	4270833	7841667	222917	122083	28250	110750
37	Lawrence	6575	2117	137	1892	71	23750	2346	141	4750	6554	3113
38	Lebanon	187708	1915	26	1866	1408333	3591667	2595833	287500	26125	10096	20846
39	Lehigh	0	1571	107	1982	1260	0	1838	0	692	771	819
40	Luzerne	0	415	119	1329	1023	0	2208	329	531	1313	1133
41	Lycoming	34875	2965	70	2975	1260	258333	300208	356	4846	5721	9575
42	McKean	460	79	58	696	633	467	33	19	406	1842	0
43	Mercer	3413	1996	0	4604	1554	7083	2208	247	8638	9704	10021
44	Mifflin	33750	1358	480	2783	60625	0	210417	197917	13992	11500	10958
45	Monroe	0	403	25	1071	243	2625	3250	18	0	87	695
46	Montgomery	3146	2583	73	2542	3563	37500	5700	0	1181	833	1403
47	Montour	0	919	28	771	372	333	24167	5	1865	1610	4554
48	Northampton	0	339	100	673	1609	0	869	160	0	221	0
49	Northumberland	41667	917	100	1154	98958	1141667	712521	384167	5238	3738	10542
50	Perry	112396	2279	405	804	21	256875	1054167	341667	8792	7081	9933
51	Philadelphia	0	0	0	0	0	0	0	0	0	0	0
52	Pike	45	94	10	305	0	167	0	4	245	81	96
53	Potter	731	319	279	776	417	165	886	248	4510	4367	3210
54	Schuylkill	23938	117	9	1791	396	835833	520833	15208	2588	2071	5342
55	Snyder	75625	1531	50	1998	1667	425000	3908333	86458	9263	8108	13104
56	Somerset	0	2396	1995	2971	717	3125	1013	396	20292	16896	15917
57	Sullivan	2877	553	34	169	122	73	10	0	1375	1442	938
58	Susquehanna	208	1552	33	2342	1197	3508	1044	396	5750	12958	9583
59	Tioga	60000	3427	673	1616	326	0	996	238	4688	16792	6708
60	Union	25125	473	335	839	1013	304167	2010000	73750	11279	3902	9496
61	Venango	1015	892	882	1219	792	917	0	0	1373	2477	2392
62	Warren	115	13	123	1983	456	2300	904	83	3829	3981	1388
63	Washington	625	8808	154	6090	800	3467	0	0	2250	22938	6888
64	Wayne	2169	1550	149	1369	654	3363	0	59	1542	5085	0
65	Westmoreland	396	2554	127	3135	947	0	68	65	3958	8771	6596
66	Wyoming	68	1397	5	377	14	577	290	0	1292	2844	875
67	York	63083	4925	602	8458	463	2043542	191667	978125	5875	8167	20521
	Total =	1613563	109746	18238	164017	7002597	24581944	26653776	4748615	530255	453783	534520

Table F-4. Animal populations in 2030.

		Swine	Sheep	Goats	Horses	Peeps	Layers	Broilers	Turkeys	Milk C	Adult C	Young C
No	**County**	**#**	**#**	**#**	**#**	**#**	**#**	**#**	**#**	**#**	**#**	**#**
1	Adams	6000	750	300	4800	400000	2800000	700000	1350000	5000	4000	13000
2	Allegheny	50	1000	150	1800	100	100	50	100	50	1300	100
3	Armstrong	800	500	600	2500	500	100	1500	100	2500	6000	4000
4	Beaver	50	1700	100	2300	10	150000	300	50	150	3500	1700
5	Bedford	22000	7000	75	3000	100	8200	600	150	12000	8500	10000
6	Berks	85000	1000	20	4200	1350000	5750000	1500000	100	20000	2400	21000
7	Blair	100	1000	500	1300	700	50	300	15	25000	12000	8500
8	Bradford	67000	20	650	2000	175	50	4500	150	7000	30000	37000
9	Bucks	250	2400	400	4700	1000	1000	4500	1100	300	900	300
10	Butler	100	0	900	3400	800	0	2700	500	300	7800	8100
11	Cambria	1000	5300	70	1100	4500	50	2200	250	2200	2800	5600
12	Cameron	12	8	35	95	20	0	10	0	20	20	140
13	Carbon	0	200	5	400	25	0	0	25	20	70	600
14	Centre	7000	2500	800	7000	0	50000	3700	230	11500	12000	5800
15	Chester	12800	3600	10	15000	1150000	950000	0	36000	9200	5000	1500
16	Clarion	100	1500	0	1300	1500	5200	0	0	4400	7700	3900
17	Clearfield	500	50	100	1000	0	0	0	100	0	3150	1950
18	Clinton	0	650	100	2300	10	32000	1800	275	10000	4500	7800
19	Columbia	17000	650	0	1500	0	250	75000	10	3200	2000	3300
20	Crawford	3300	2900	300	5000	500	1500	2000	350	3800	14500	1400
21	Cumberland	10000	1800	900	3100	2800	380000	800000	300000	17800	12000	17800
22	Dauphin	0	4800	80	3700	550000	600000	130000	80000	4400	0	2800
23	Delaware	0	0	15	0	0	850	40	10	30	0	0
24	Elk	290	240	25	625	65	2000	15	3	150	1800	250
25	Erie	1750	1300	600	3300	400	0	800	40	0	8600	10
26	Fayette	250	1800	400	3800	200	6500	1800	40	3700	10000	4700
27	Forest	430	0	10	175	0	400	0	0	0	40	700
28	Franklin	195000	4900	2500	3000	500000	2000000	1400000	500000	60000	35500	30500
29	Fulton	28000	1000	350	1400	190	14500	600	95000	5800	8200	4400
30	Greene	600	0	13	2200	500	2500	0	5	0	12300	5800
31	Huntingdon	23000	1750	1100	2200	500	33000	30000	22000	12200	9800	7400
32	Indiana	0	3300	90	2200	1000	3500	400	1000	4500	3600	5300
33	Jefferson	250	1150	160	1350	700	2500	0	0	0	6000	800
34	Juniata	82000	3000	150	1250	0	410000	3400000	72000	6400	5800	5600
35	Lackawanna	0	0	0	700	280	400	50	10	0	900	0
36	Lancaster	470000	5100	2000	28500	2100000	2500000	7800000	250000	130000	12000	122000
37	Lawrence	6200	2200	160	2100	50	30000	2700	165	4000	6700	1800
38	Lebanon	230000	2050	0	2100	1700000	4300000	2700000	350000	28000	9200	22200
39	Lehigh	0	1800	130	2300	1500	0	1900	0	400	500	600
40	Luzerne	0	380	150	1600	1200	0	2500	400	0	1000	800
41	Lycoming	43000	3600	80	3600	1500	300000	375000	450	3700	4700	10200
42	McKean	550	0	70	800	800	300	0	0	0	1800	0
43	Mercer	2600	1850	0	5500	1700	0	2000	280	7700	9100	9500
44	Mifflin	40000	1400	600	3200	70000	0	200000	250000	14200	13500	11000
45	Monroe	0	430	0	1300	300	3000	4000	20	0	0	720
46	Montgomery	2000	3000	75	3000	4500	0	7200	0	650	0	720
47	Montour	0	1100	35	900	450	0	10000	0	1750	1350	5200
48	Northampton	0	210	120	700	2000	0	900	200	0	0	0
49	Northumberland	45000	750	120	1350	125000	1400000	900000	480000	5300	2800	12000
50	Perry	140000	2700	500	900	0	260000	1200000	425000	9000	7300	10600
51	Philadelphia	0	0	0	0	0	0	0	0	0	0	0
52	Pike	50	110	10	380	0	0	0	5	280	50	100
53	Potter	850	100	350	920	500	50	1100	300	4000	4600	2500
54	Schuylkill	25000	0	0	2200	500	840000	550000	5000	2400	1300	5800
55	Snyder	90000	1700	40	2300	0	500000	4700000	85000	9700	8900	15000
56	Somerset	0	2500	2500	3450	800	0	1200	500	20500	18500	15500
57	Sullivan	3600	600	40	200	130	0	10	0	1000	1400	500
58	Susquehanna	0	1500	20	2800	1500	4300	1200	500	2000	15000	8000
59	Tioga	75000	3750	850	1850	400	0	1200	300	0	19500	4000
60	Union	28000	500	420	940	1200	350000	2500000	60000	12500	3200	10500
61	Venango	1150	890	1100	1400	1000	500	0	0	1100	1800	2100
62	Warren	0	0	150	2300	550	2800	800	90	3100	4200	200
63	Washington	0	8600	150	7000	800	2800	0	0	1000	24000	5200
64	Wayne	2700	1800	180	1650	800	3800	0	60	0	5200	0
65	Westmoreland	0	2400	100	3500	900	0	0	60	2500	7500	5700
66	Wyoming	0	1600	5	400	5	650	320	0	0	3000	0
67	York	68000	5100	700	10000	400	2350000	150000	1200000	3500	4000	22000
	Total =	1838332	115488	22163	192835	7985060	26052850	29174895	5567943	499900	434780	526190

Section 2

Shows the volume of water (in acre-feet) that was used in 2002 or is predicted to be used in 2010, 2020, and 2030 for supplying each species.

Table F-5. Water needed for animals in 2002.

No	County	Swine MGD	Sheep MGD	Goats MGD	Horses MGD	Poultry MGD	Cattle MGD	Total MGD
1	Adams	0.060	0.003	0.000	0.034	1.049	0.512	1.660
2	Allegheny	0.001	0.002	0.000	0.016	0.001	0.039	0.058
3	Armstrong	0.008	0.002	0.001	0.015	0.000	0.276	0.303
4	Beaver	0.002	0.003	0.000	0.015	0.003	0.172	0.194
5	Bedford	0.057	0.007	0.000	0.019	0.000	0.882	0.965
6	Berks	0.246	0.004	0.000	0.027	0.292	1.291	1.860
7	Blair	0.005	0.001	0.000	0.009	0.000	0.824	0.840
8	Bradford	0.120	0.005	0.001	0.017	0.000	1.568	1.710
9	Bucks	0.006	0.004	0.000	0.030	0.003	0.154	0.198
10	Butler	0.011	0.005	0.001	0.026	0.000	0.370	0.413
11	Cambria	0.009	0.005	0.000	0.008	0.001	0.208	0.231
12	Cameron	0.000	0.000	0.000	0.001	0.000	0.004	0.005
13	Carbon	0.001	0.000	0.000	0.003	0.000	0.018	0.022
14	Centre	0.028	0.004	0.001	0.042	0.002	0.681	0.758
15	Chester	0.051	0.006	0.000	0.103	0.113	0.957	1.231
16	Clarion	0.005	0.002	0.000	0.010	0.000	0.305	0.322
17	Clearfield	0.002	0.000	0.000	0.008	0.000	0.141	0.151
18	Clinton	0.005	0.001	0.000	0.015	0.002	0.339	0.361
19	Columbia	0.046	0.002	0.000	0.012	0.006	0.239	0.305
20	Crawford	0.011	0.003	0.000	0.038	0.001	0.802	0.854
21	Cumberland	0.054	0.003	0.001	0.021	0.206	1.001	1.287
22	Dauphin	0.022	0.007	0.000	0.024	0.165	0.355	0.573
23	Delaware	0.000	0.000	0.000	0.002	0.000	0.010	0.012
24	Elk	0.001	0.000	0.000	0.004	0.000	0.045	0.050
25	Erie	0.007	0.002	0.000	0.023	0.000	0.462	0.495
26	Fayette	0.007	0.002	0.000	0.023	0.000	0.356	0.389
27	Forest	0.001	0.000	0.000	0.001	0.000	0.009	0.011
28	Franklin	0.421	0.006	0.002	0.019	0.690	2.332	3.469
29	Fulton	0.090	0.001	0.000	0.009	0.085	0.346	0.531
30	Greene	0.002	0.008	0.000	0.016	0.000	0.248	0.274
31	Huntingdon	0.048	0.003	0.001	0.011	0.015	0.614	0.692
32	Indiana	0.005	0.005	0.000	0.019	0.001	0.421	0.451
33	Jefferson	0.002	0.002	0.000	0.009	0.000	0.202	0.216
34	Juniata	0.156	0.004	0.000	0.009	0.274	0.424	0.867
35	Lackawanna	0.000	0.000	0.000	0.005	0.000	0.086	0.092
36	Lancaster	1.547	0.012	0.002	0.198	1.386	5.625	8.771
37	Lawrence	0.029	0.004	0.000	0.019	0.001	0.366	0.419
38	Lebanon	0.451	0.003	0.000	0.017	0.607	1.169	2.248
39	Lehigh	0.012	0.002	0.000	0.017	0.013	0.074	0.118
40	Luzerne	0.002	0.001	0.000	0.010	0.000	0.098	0.112
41	Lycoming	0.081	0.004	0.000	0.022	0.024	0.446	0.577
42	McKean	0.001	0.000	0.000	0.006	0.000	0.079	0.087
43	Mercer	0.020	0.005	0.000	0.036	0.002	0.630	0.692
44	Mifflin	0.090	0.002	0.001	0.024	0.154	0.713	0.983
45	Monroe	0.001	0.001	0.000	0.008	0.000	0.022	0.031
46	Montgomery	0.019	0.003	0.000	0.021	0.006	0.139	0.189
47	Montour	0.003	0.001	0.000	0.007	0.004	0.141	0.156
48	Northampton	0.013	0.001	0.000	0.008	0.000	0.141	0.163
49	Northum.	0.142	0.002	0.000	0.010	0.319	0.346	0.819
50	Perry	0.252	0.003	0.001	0.007	0.307	0.490	1.060
51	Philadelphia	0.000	0.000	0.000	0.000	0.000	0.000	0.000
52	Pike	0.000	0.000	0.000	0.002	0.000	0.009	0.012
53	Potter	0.002	0.001	0.000	0.006	0.000	0.295	0.305
54	Schuylkill	0.088	0.001	0.000	0.013	0.110	0.201	0.412
55	Snyder	0.196	0.002	0.000	0.018	0.322	0.516	1.055
56	Somerset	0.006	0.004	0.002	0.025	0.002	1.090	1.130
57	Sullivan	0.006	0.001	0.000	0.002	0.000	0.111	0.120
58	Susque.	0.002	0.003	0.000	0.018	0.000	0.681	0.705
59	Tioga	0.133	0.006	0.001	0.014	0.001	0.741	0.896
60	Union	0.079	0.001	0.000	0.008	0.212	0.477	0.777
61	Venango	0.003	0.002	0.001	0.011	0.000	0.149	0.166
62	Warren	0.001	0.001	0.000	0.017	0.000	0.269	0.289
63	Washington	0.007	0.018	0.000	0.062	0.000	0.576	0.664
64	Wayne	0.005	0.002	0.000	0.011	0.000	0.391	0.409
65	Westmoreland	0.012	0.006	0.000	0.030	0.001	0.473	0.522
66	Wyoming	0.001	0.002	0.000	0.005	0.000	0.184	0.192
67	York	0.219	0.009	0.001	0.066	0.791	0.782	1.868
	Total =	4.913	0.206	0.023	1.357	7.178	34.117	47.794

Table F-6. Water needed for animals in 2010.

No	County	Swine MGD	Sheep MGD	Goats MGD	Horses MGD	Poultry MGD	Cattle MGD	Total MGD
1	Adams	0.057	0.003	0.000	0.041	1.361	0.474	1.937
2	Allegheny	0.001	0.002	0.000	0.017	0.001	0.038	0.059
3	Armstrong	0.007	0.002	0.001	0.020	0.000	0.270	0.299
4	Beaver	0.001	0.003	0.000	0.019	0.000	0.147	0.176
5	Bedford	0.066	0.009	0.000	0.024	0.001	0.821	0.921
6	Berks	0.272	0.004	0.000	0.034	0.360	1.202	1.872
7	Blair	0.004	0.001	0.001	0.011	0.000	0.914	0.931
8	Bradford	0.163	0.004	0.001	0.019	0.000	1.438	1.624
9	Bucks	0.005	0.004	0.000	0.038	0.003	0.127	0.177
10	Butler	0.008	0.004	0.001	0.031	0.001	0.327	0.370
11	Cambria	0.007	0.007	0.000	0.010	0.001	0.201	0.226
12	Cameron	0.000	0.000	0.000	0.001	0.000	0.004	0.005
13	Carbon	0.000	0.000	0.000	0.003	0.000	0.015	0.019
14	Centre	0.028	0.005	0.001	0.053	0.002	0.673	0.762
15	Chester	0.051	0.006	0.000	0.124	0.120	0.804	1.106
16	Clarion	0.004	0.002	0.000	0.011	0.000	0.308	0.326
17	Clearfield	0.002	0.000	0.000	0.009	0.000	0.123	0.135
18	Clinton	0.002	0.001	0.000	0.018	0.002	0.386	0.409
19	Columbia	0.053	0.001	0.000	0.013	0.006	0.222	0.295
20	Crawford	0.011	0.004	0.001	0.044	0.001	0.677	0.738
21	Cumberland	0.050	0.003	0.001	0.026	0.276	1.006	1.362
22	Dauphin	0.011	0.007	0.000	0.029	0.159	0.315	0.521
23	Delaware	0.000	0.000	0.000	0.001	0.000	0.007	0.008
24	Elk	0.001	0.000	0.000	0.005	0.000	0.043	0.049
25	Erie	0.007	0.002	0.001	0.028	0.000	0.346	0.383
26	Fayette	0.005	0.003	0.000	0.030	0.000	0.352	0.391
27	Forest	0.001	0.000	0.000	0.001	0.000	0.008	0.011
28	Franklin	0.522	0.007	0.003	0.023	0.745	2.508	3.808
29	Fulton	0.095	0.002	0.000	0.011	0.095	0.354	0.557
30	Greene	0.002	0.002	0.000	0.019	0.000	0.251	0.274
31	Huntingdon	0.061	0.003	0.001	0.015	0.019	0.624	0.724
32	Indiana	0.000	0.006	0.000	0.000	0.001	0.376	0.404
33	Jefferson	0.002	0.002	0.000	0.011	0.000	0.176	0.191
34	Juniata	0.205	0.004	0.000	0.011	0.304	0.410	0.933
35	Lackawanna	0.000	0.000	0.000	0.006	0.000	0.066	0.073
36	Lancaster	1.638	0.012	0.003	0.240	1.341	5.758	8.991
37	Lawrence	0.028	0.004	0.000	0.020	0.001	0.337	0.391
38	Lebanon	0.582	0.004	0.000	0.020	0.704	1.228	2.537
39	Lehigh	0.000	0.003	0.000	0.020	0.001	0.061	0.085
40	Luzerne	0.000	0.001	0.000	0.013	0.001	0.078	0.092
41	Lycoming	0.107	0.005	0.000	0.028	0.031	0.409	0.581
42	McKean	0.001	0.000	0.000	0.007	0.000	0.063	0.072
43	Mercer	0.017	0.004	0.000	0.045	0.001	0.606	0.673
44	Mifflin	0.110	0.003	0.001	0.028	0.195	0.745	1.082
45	Monroe	0.000	0.001	0.000	0.010	0.000	0.013	0.025
46	Montgomery	0.017	0.004	0.000	0.025	0.005	0.108	0.160
47	Montour	0.000	0.001	0.000	0.008	0.003	0.140	0.153
48	Northampton	0.007	0.001	0.000	0.008	0.000	0.043	0.059
49	Northum.	0.153	0.002	0.000	0.012	0.445	0.351	0.963
50	Perry	0.339	0.004	0.001	0.008	0.398	0.505	1.255
51	Philadelphia	0.000	0.000	0.000	0.000	0.000	0.000	0.000
52	Pike	0.000	0.000	0.000	0.003	0.000	0.010	0.013
53	Potter	0.002	0.001	0.000	0.008	0.000	0.281	0.293
54	Schuylkill	0.092	0.000	0.000	0.017	0.120	0.193	0.422
55	Snyder	0.245	0.003	0.000	0.020	0.376	0.542	1.186
56	Somerset	0.000	0.005	0.003	0.030	0.002	1.112	1.151
57	Sullivan	0.009	0.001	0.000	0.002	0.000	0.099	0.110
58	Susque.	0.002	0.003	0.000	0.023	0.001	0.619	0.647
59	Tioga	0.180	0.006	0.001	0.017	0.000	0.643	0.847
60	Union	0.089	0.001	0.000	0.009	0.242	0.515	0.856
61	Venango	0.004	0.002	0.001	0.012	0.000	0.134	0.154
62	Warren	0.001	0.001	0.000	0.020	0.000	0.244	0.266
63	Washington	0.005	0.018	0.000	0.062	0.000	0.545	0.631
64	Wayne	0.007	0.003	0.000	0.013	0.000	0.280	0.303
65	Westmoreland	0.007	0.005	0.000	0.033	0.000	0.423	0.469
66	Wyoming	0.001	0.002	0.000	0.004	0.000	0.150	0.157
67	York	0.233	0.010	0.001	0.083	1.030	0.683	2.040
	Total =	5.579	0.211	0.028	1.602	8.360	32.930	48.737

Table F-7. Water needed for animals in 2020.

No	County	Swine MGD	Sheep MGD	Goats MGD	Horses MGD	Poultry MGD	Cattle MGD	Total MGD
1	Adams	0.041	0.002	0.000	0.049	1.614	0.426	2.132
2	Allegheny	0.001	0.002	0.000	0.019	0.001	0.030	0.053
3	Armstrong	0.005	0.002	0.001	0.025	0.000	0.246	0.278
4	Beaver	0.001	0.003	0.000	0.023	0.007	0.112	0.147
5	Bedford	0.077	0.012	0.000	0.030	0.001	0.739	0.859
6	Berks	0.306	0.003	0.000	0.042	0.450	1.085	1.885
7	Blair	0.002	0.002	0.001	0.013	0.000	1.031	1.049
8	Bradford	0.216	0.002	0.001	0.021	0.000	1.270	1.510
9	Bucks	0.003	0.004	0.001	0.047	0.002	0.077	0.134
10	Butler	0.004	0.002	0.001	0.036	0.001	0.272	0.315
11	Cambria	0.006	0.009	0.000	0.012	0.001	0.191	0.218
12	Cameron	0.000	0.000	0.000	0.001	0.000	0.003	0.004
13	Carbon	0.000	0.000	0.000	0.004	0.000	0.012	0.016
14	Centre	0.028	0.005	0.001	0.069	0.003	0.660	0.765
15	Chester	0.051	0.007	0.000	0.152	0.142	0.609	0.961
16	Clarion	0.002	0.003	0.000	0.013	0.000	0.310	0.329
17	Clearfield	0.002	0.000	0.000	0.011	0.000	0.096	0.109
18	Clinton	0.000	0.001	0.000	0.023	0.002	0.445	0.471
19	Columbia	0.061	0.001	0.000	0.016	0.006	0.200	0.283
20	Crawford	0.012	0.005	0.001	0.052	0.001	0.522	0.592
21	Cumberland	0.045	0.003	0.001	0.031	0.361	1.002	1.445
22	Dauphin	0.000	0.009	0.000	0.037	0.166	0.250	0.461
23	Delaware	0.000	0.000	0.000	0.000	0.000	0.004	0.004
24	Elk	0.001	0.000	0.000	0.006	0.000	0.039	0.047
25	Erie	0.007	0.002	0.001	0.034	0.000	0.194	0.238
26	Fayette	0.003	0.003	0.001	0.038	0.001	0.341	0.387
27	Forest	0.001	0.000	0.000	0.002	0.000	0.008	0.011
28	Franklin	0.651	0.008	0.004	0.030	0.802	2.738	4.233
29	Fulton	0.104	0.002	0.001	0.014	0.105	0.364	0.589
30	Greene	0.002	0.000	0.000	0.023	0.000	0.242	0.267
31	Huntingdon	0.077	0.003	0.002	0.021	0.025	0.640	0.767
32	Indiana	0.000	0.006	0.000	0.024	0.001	0.323	0.354
33	Jefferson	0.001	0.002	0.000	0.014	0.000	0.137	0.155
34	Juniata	0.266	0.005	0.000	0.013	0.343	0.391	1.019
35	Lackawanna	0.000	0.000	0.000	0.007	0.000	0.040	0.047
36	Lancaster	1.759	0.011	0.003	0.291	1.265	5.915	9.244
37	Lawrence	0.026	0.004	0.000	0.023	0.002	0.299	0.354
38	Lebanon	0.751	0.004	0.000	0.022	0.846	1.295	2.918
39	Lehigh	0.000	0.003	0.000	0.024	0.000	0.045	0.072
40	Luzerne	0.000	0.001	0.000	0.016	0.001	0.051	0.068
41	Lycoming	0.140	0.006	0.000	0.036	0.040	0.361	0.582
42	McKean	0.002	0.000	0.000	0.008	0.000	0.042	0.052
43	Mercer	0.014	0.004	0.000	0.055	0.001	0.558	0.632
44	Mifflin	0.135	0.003	0.001	0.033	0.258	0.783	1.212
45	Monroe	0.000	0.001	0.000	0.013	0.000	0.009	0.023
46	Montgomery	0.013	0.005	0.000	0.031	0.003	0.069	0.121
47	Montour	0.000	0.002	0.000	0.009	0.002	0.140	0.153
48	Northampton	0.000	0.001	0.000	0.008	0.000	0.003	0.013
49	Northum.	0.167	0.002	0.000	0.014	0.592	0.355	1.130
50	Perry	0.450	0.005	0.001	0.010	0.510	0.523	1.498
51	Philadelphia	0.000	0.000	0.000	0.000	0.000	0.000	0.000
52	Pike	0.000	0.000	0.000	0.004	0.000	0.011	0.015
53	Potter	0.003	0.001	0.001	0.009	0.000	0.259	0.273
54	Schuylkill	0.096	0.000	0.000	0.021	0.110	0.180	0.408
55	Snyder	0.303	0.003	0.000	0.024	0.442	0.590	1.362
56	Somerset	0.000	0.005	0.004	0.036	0.001	1.139	1.184
57	Sullivan	0.012	0.001	0.000	0.002	0.000	0.080	0.095
58	Susque.	0.001	0.003	0.000	0.028	0.001	0.501	0.534
59	Tioga	0.240	0.007	0.001	0.019	0.000	0.490	0.758
60	Union	0.101	0.001	0.001	0.010	0.268	0.558	0.938
61	Venango	0.004	0.002	0.002	0.015	0.000	0.112	0.134
62	Warren	0.000	0.000	0.000	0.024	0.000	0.209	0.234
63	Washington	0.003	0.018	0.000	0.073	0.000	0.499	0.592
64	Wayne	0.009	0.003	0.000	0.016	0.000	0.130	0.159
65	Westmoreland	0.002	0.005	0.000	0.038	0.000	0.343	0.387
66	Wyoming	0.000	0.003	0.000	0.005	0.000	0.097	0.105
67	York	0.252	0.010	0.001	0.102	1.312	0.554	2.230
	Total =	6.454	0.219	0.036	1.968	9.691	31.245	49.615

Table F-8. Water needed for animals in 2030.

No	County	Swine MGD	Sheep MGD	Goats MGD	Horses MGD	Poultry MGD	Cattle MGD	Total MGD
1	Adams	0.024	0.002	0.001	0.058	1.866	0.378	2.328
2	Allegheny	0.000	0.002	0.000	0.022	0.000	0.022	0.047
3	Armstrong	0.003	0.001	0.001	0.030	0.000	0.222	0.257
4	Beaver	0.000	0.003	0.000	0.028	0.009	0.076	0.117
5	Bedford	0.088	0.014	0.000	0.036	0.001	0.658	0.796
6	Berks	0.340	0.002	0.000	0.050	0.539	0.967	1.899
7	Blair	0.000	0.002	0.001	0.016	0.000	1.149	1.168
8	Bradford	0.268	0.000	0.001	0.024	0.001	1.102	1.396
9	Bucks	0.001	0.005	0.001	0.056	0.002	0.027	0.092
10	Butler	0.000	0.000	0.002	0.041	0.001	0.217	0.260
11	Cambria	0.004	0.011	0.000	0.013	0.001	0.181	0.209
12	Cameron	0.000	0.000	0.000	0.001	0.000	0.003	0.004
13	Carbon	0.000	0.000	0.000	0.005	0.000	0.008	0.014
14	Centre	0.028	0.005	0.002	0.084	0.004	0.646	0.768
15	Chester	0.051	0.007	0.000	0.180	0.163	0.414	0.815
16	Clarion	0.000	0.003	0.000	0.016	0.000	0.312	0.332
17	Clearfield	0.002	0.000	0.000	0.012	0.000	0.069	0.083
18	Clinton	0.000	0.001	0.000	0.028	0.002	0.503	0.535
19	Columbia	0.068	0.001	0.000	0.018	0.006	0.178	0.272
20	Crawford	0.013	0.006	0.001	0.060	0.001	0.366	0.446
21	Cumberland	0.040	0.004	0.002	0.037	0.447	0.999	1.528
22	Dauphin	0.000	0.010	0.000	0.044	0.173	0.185	0.412
23	Delaware	0.000	0.000	0.000	0.000	0.000	0.001	0.001
24	Elk	0.001	0.000	0.000	0.008	0.000	0.035	0.044
25	Erie	0.007	0.003	0.001	0.040	0.000	0.129	0.180
26	Fayette	0.001	0.004	0.001	0.046	0.001	0.331	0.383
27	Forest	0.002	0.000	0.000	0.002	0.000	0.008	0.012
28	Franklin	0.780	0.010	0.005	0.036	0.860	2.968	4.658
29	Fulton	0.112	0.002	0.001	0.017	0.115	0.374	0.621
30	Greene	0.002	0.000	0.000	0.026	0.000	0.248	0.277
31	Huntingdon	0.092	0.004	0.002	0.026	0.031	0.655	0.810
32	Indiana	0.000	0.007	0.000	0.026	0.001	0.270	0.304
33	Jefferson	0.001	0.002	0.000	0.016	0.000	0.099	0.119
34	Juniata	0.328	0.006	0.000	0.015	0.383	0.373	1.105
35	Lackawanna	0.000	0.000	0.000	0.008	0.000	0.014	0.022
36	Lancaster	1.880	0.010	0.004	0.342	1.190	6.072	9.498
37	Lawrence	0.025	0.004	0.000	0.025	0.002	0.260	0.317
38	Lebanon	0.920	0.004	0.000	0.025	0.988	1.362	3.299
39	Lehigh	0.000	0.004	0.000	0.028	0.000	0.028	0.060
40	Luzerne	0.000	0.001	0.000	0.019	0.001	0.024	0.045
41	Lycoming	0.172	0.007	0.000	0.043	0.049	0.312	0.583
42	McKean	0.002	0.000	0.000	0.010	0.000	0.027	0.039
43	Mercer	0.010	0.004	0.000	0.066	0.001	0.511	0.591
44	Mifflin	0.160	0.003	0.001	0.038	0.320	0.821	1.343
45	Monroe	0.000	0.001	0.000	0.016	0.001	0.008	0.025
46	Montgomery	0.008	0.006	0.000	0.036	0.001	0.031	0.082
47	Montour	0.000	0.002	0.000	0.011	0.001	0.139	0.153
48	Northampton	0.000	0.000	0.000	0.008	0.000	0.000	0.009
49	Northum.	0.180	0.002	0.000	0.016	0.739	0.360	1.296
50	Perry	0.560	0.005	0.001	0.011	0.622	0.541	1.740
51	Philadelphia	0.000	0.000	0.000	0.000	0.000	0.000	0.000
52	Pike	0.000	0.000	0.000	0.005	0.000	0.012	0.017
53	Potter	0.003	0.000	0.001	0.011	0.000	0.237	0.252
54	Schuylkill	0.100	0.000	0.000	0.026	0.100	0.167	0.394
55	Snyder	0.360	0.003	0.000	0.028	0.508	0.638	1.537
56	Somerset	0.000	0.005	0.005	0.041	0.001	1.166	1.218
57	Sullivan	0.014	0.001	0.000	0.002	0.000	0.062	0.080
58	Susque.	0.000	0.003	0.000	0.034	0.001	0.383	0.421
59	Tioga	0.300	0.008	0.002	0.022	0.000	0.337	0.668
60	Union	0.112	0.001	0.001	0.011	0.293	0.601	1.019
61	Venango	0.005	0.002	0.002	0.017	0.000	0.089	0.114
62	Warren	0.000	0.000	0.000	0.028	0.000	0.174	0.202
63	Washington	0.000	0.017	0.000	0.084	0.000	0.452	0.554
64	Wayne	0.011	0.004	0.000	0.020	0.000	0.078	0.113
65	Westmoreland	0.000	0.005	0.000	0.042	0.000	0.263	0.310
66	Wyoming	0.000	0.003	0.000	0.005	0.000	0.045	0.053
67	York	0.272	0.010	0.001	0.120	1.593	0.425	2.421
	Total =	7.353	0.231	0.044	2.314	11.018	29.806	50.767

Section 3

Shows the top ten counties for each of the major animal species for each of the years 2002, 2010, 2020, and 2030.

Table F-9. Water needed for animal production in the top ten counties in 2002.

		Cattle			Water Needed
			No of	Water Needed	per animal
Rank	No	County	Animals	MGD	gal/an-d
1	36	Lancaster	255,706	5.625	22
2	28	Franklin	101,362	2.332	23
3	8	Bradford	79,794	1.568	20
4	6	Berks	60,198	1.291	21
5	38	Lebanon	52,617	1.169	22
6	56	Somerset	50,452	1.090	22
7	21	Cumberland	45,944	1.001	22
8	15	Chester	41,878	0.957	23
9	5	Bedford	41,065	0.882	21
10	7	Blair	33,877	0.824	24
		State Totals	1,632,850	34.117	21

Rank	No	Poultry			
1	36	Lancaster	17,333,985	1.386	0.080
2	1	Adams	3,416,161	1.049	0.307
3	67	York	2,300,035	0.791	0.344
4	28	Franklin	3,026,589	0.690	0.228
5	38	Lebanon	5,761,060	0.607	0.105
6	55	Snyder	2,839,312	0.322	0.114
7	49	Northumberland	1,338,558	0.319	0.238
8	50	Perry	1,226,009	0.307	0.250
9	5	Berks	4,503,954	0.292	0.065
10	34	Juniata	2,499,611	0.274	0.110
		State Totals	51,982,086	7.178	0.138

Rank	No	Swine			
1	36	Lancaster	386,801	1.547	4.0
2	38	Lebanon	112,809	0.451	4.0
3	28	Franklin	105,131	0.421	4.0
4	50	Perry	63,098	0.252	4.0
5	6	Berks	61,517	0.246	4.0
6	67	York	54,698	0.219	4.0
7	55	Snyder	49,087	0.196	4.0
8	34	Juniata	38,913	0.156	4.0
9	49	Northumberland	35,453	0.142	4.0
10	59	Tioga	33,245	0.133	4.0
		State Totals	1,228,334	4.913	4.0

Table F-10. Water needed for animal production in the top ten counties in 2010.

Rank	No	County	No of Animals	Water Needed MGD	Water Needed per animal gal/an-d
		Cattle			
1	36	**Lancaster**	258,167	5.758	22
2	28	**Franklin**	108,083	2.508	23
3	8	**Bradford**	78,167	1.438	18
4	38	**Lebanon**	54,733	1.228	22
5	6	**Berks**	55,317	1.202	22
6	56	**Somerset**	51,708	1.112	22
7	21	**Cumberland**	46,683	1.006	22
8	7	**Blair**	37,375	0.914	24
9	5	**Bedford**	38,208	0.821	21
10	15	**Chester**	34,575	0.804	23
		State Totals	1,586,703	32.930	21
Rank	**No**	**Poultry**			
1	1	**Adams**	4,291,917	1.361	0.317
2	36	**Lancaster**	16,179,167	1.341	0.083
3	67	**York**	2,727,192	1.030	0.378
4	28	**Franklin**	3,408,333	0.745	0.219
5	38	**Lebanon**	6,716,667	0.704	0.105
6	49	**Northumberland**	1,769,625	0.445	0.251
7	50	**Perry**	1,420,458	0.398	0.280
8	55	**Snyder**	3,557,917	0.376	0.106
9	5	**Berks**	5,641,975	0.360	0.064
10	34	**Juniata**	2,877,925	0.304	0.105
		State Totals	57,216,971	8.360	0.146
Rank	**No**	**Swine**			
1	36	**Lancaster**	409,583	1.638	4.0
2	38	**Lebanon**	145,417	0.582	4.0
3	28	**Franklin**	130,417	0.522	4.0
4	50	**Perry**	84,792	0.339	4.0
5	6	**Berks**	67,917	0.272	4.0
6	55	**Snyder**	61,250	0.245	4.0
7	67	**York**	58,167	0.233	4.0
8	34	**Juniata**	51,167	0.205	4.0
9	59	**Tioga**	45,000	0.180	4.0
10	5	**Bradford**	40,750	0.163	4.0
		State Totals	1,394,702	5.579	4.0

Table F-11. Water needed for animal production in the top ten counties in 2020.

Rank	No	Cattle County	No of Animals	Water Needed MGD	Water Needed per animal gal/an-d
1	36	**Lancaster**	261,083	5.915	23
2	28	**Franklin**	117,042	2.738	23
3	38	**Lebanon**	57,067	1.295	23
4	5	**Bradford**	76,083	1.270	17
5	56	**Somerset**	53,104	1.139	21
6	6	**Berks**	49,358	1.085	22
7	7	**Blair**	41,438	1.031	25
8	21	**Cumberland**	47,142	1.002	21
9	44	**Mifflin**	36,450	0.783	21
10	5	**Bedford**	34,354	0.739	22
		State Totals	1,518,559	31.245	21

Rank	No	Poultry			
1	1	**Adams**	4,770,958	1.614	0.338
2	67	**York**	3,213,796	1.312	0.408
3	36	**Lancaster**	14,414,583	1.265	0.088
4	38	**Lebanon**	7,883,333	0.846	0.107
5	28	**Franklin**	3,904,167	0.802	0.205
6	49	**Northumberland**	2,337,313	0.592	0.253
7	6	**Berks**	7,121,037	0.450	0.063
8	55	**Snyder**	4,421,458	0.442	0.100
9	21	**Cumberland**	1,284,352	0.361	0.281
10	34	**Juniata**	3,379,962	0.343	0.102
		State Totals	62,986,932	9.691	0.154

Rank	No	Swine			
1	36	**Lancaster**	439,792	1.759	4.0
2	38	**Lebanon**	187,708	0.751	4.0
3	28	**Franklin**	162,708	0.651	4.0
4	50	**Perry**	112,396	0.450	4.0
5	6	**Berks**	76,458	0.306	4.0
6	55	**Snyder**	75,625	0.303	4.0
7	34	**Juniata**	66,583	0.266	4.0
8	67	**York**	63,083	0.252	4.0
9	59	**Tioga**	60,000	0.240	4.0
10	8	**Bradford**	53,875	0.216	4.0
		State Totals	1,613,563	6.454	4.0

Table F-12. Water needed for animal production in the top ten counties in 2030.

Rank	No	County	No of Animals	Water Needed MGD	Water Needed per animal gal/an-d
		Cattle			
1	36	**Lancaster**	264,000	6.072	23
2	28	**Franklin**	126,000	2.968	24
3	41	**Lebanon**	59,400	1.362	23
4	56	**Somerset**	54,500	1.166	21
5	7	**Blair**	45,500	1.149	25
6	8	**Bradford**	74,000	1.102	15
7	21	**Cumberland**	47,600	0.999	21
8	6	**Berks**	43,400	0.967	22
9	44	**Mifflin**	38,700	0.821	21
10	5	**Bedford**	30,500	0.658	22
		State Totals	1,460,870	29.806	20
Rank	**No**	**Poultry**			
1	1	**Adams**	5,250,000	1.866	0.355
2	67	**York**	3,700,400	1.593	0.430
3	36	**Lancaster**	12,650,000	1.190	0.094
4	38	**Lebanon**	9,050,000	0.988	0.109
5	28	**Franklin**	4,400,000	0.860	0.195
6	49	**Northumberland**	2,905,000	0.739	0.254
7	50	**Perry**	1,885,000	0.622	0.330
8	6	**Berks**	8,600,100	0.539	0.063
9	55	**Snyder**	5,285,000	0.508	0.096
10	21	**Cumberland**	1,482,800	0.447	0.301
		State Totals	68,780,748	11.018	0.160
Rank	**No**	**Swine**			
1	36	**Lancaster**	470,000	1.880	4.0
2	38	**Lebanon**	230,000	0.920	4.0
3	28	**Franklin**	195,000	0.780	4.0
4	50	**Perry**	140,000	0.560	4.0
5	55	**Snyder**	90,000	0.360	4.0
6	6	**Berks**	85,000	0.340	4.0
7	34	**Juniata**	82,000	0.328	4.0
8	59	**Tioga**	75,000	0.300	4.0
9	67	**York**	68,000	0.272	4.0
10	8	**Bradford**	67,000	0.268	4.0
		State Totals	1,838,332	7.353	4.0