CEE 371 Fall 2009

Homework #1 Water Demands and Population Projections

6 points total for entire homework

Table 1 contains water demand and population data for Amherst, Massachusetts. This data is to be used in answering the questions for this assignment.

Table 1. Average Daily, Maximum Daily & Peak Hourly Demands, and Population for Amherst, MA, 1960 -2000

Year	Annual Average Daily Demand (MGD)	Maximum Daily Demand (MGD)	Peak Hourly Demand (MGD)	Population
1960	1.34	1.91	3.62	13,718
1970	2.90	4.25	7.25	26,331
1980	3.19	4.24	9.57	33,229
1985	3.73	4.75	9.24	34,537
1990	3.95	5.27	9.85	35,228
1995	3.97	5.43	10.4	35,065
2000	4.15	5.81	10.1	34,874

1. Prepare a figure showing the average daily and maximum daily water demand data provided in Table 1 Put two plots on the same figure; one plot showing average daily demand and the other showing maximum daily demand. Use units of MGD for the demands with a scale from 0 to 8 MGD, and the time scale should go from 1950 to 2030. Based on the plots (no calculations), what is your estimate of the average daily and maximum daily demands for 2010 and 2020?

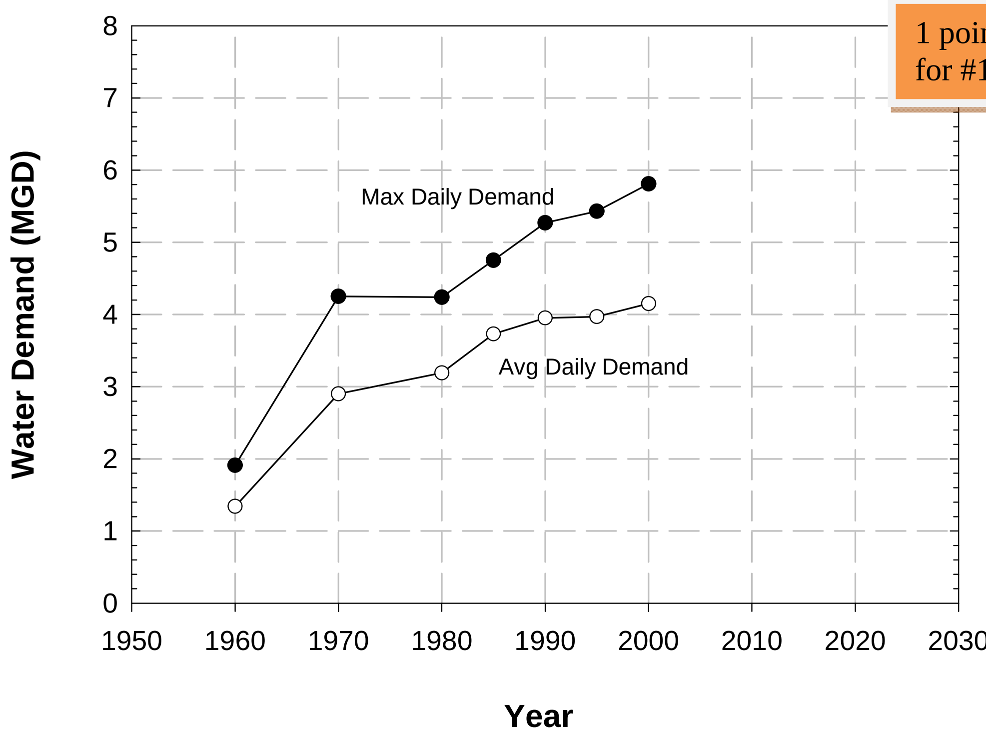
<u>A word about graphing:</u>

For presentation quality graphics use one of the following:

1. a well crafted figure using a real graphics software package such as “SigmaPlot”
2. a carefully prepared graph on graph paper
3. a very carefully prepared graph on engineering paper; spreading the graph out over at least half a page so that it isn’t compressed

Avoid using the following

1. a software package not primarily designed for graphics, such as Excel
2. a small hand-drawn graph on a grid of low resolution, such as a small portion of engineering paper
3. do not use curve fits between points; use straight lines to assist the reader in following the data trend. Curve fits imply that there is some underlying model that the curve represents



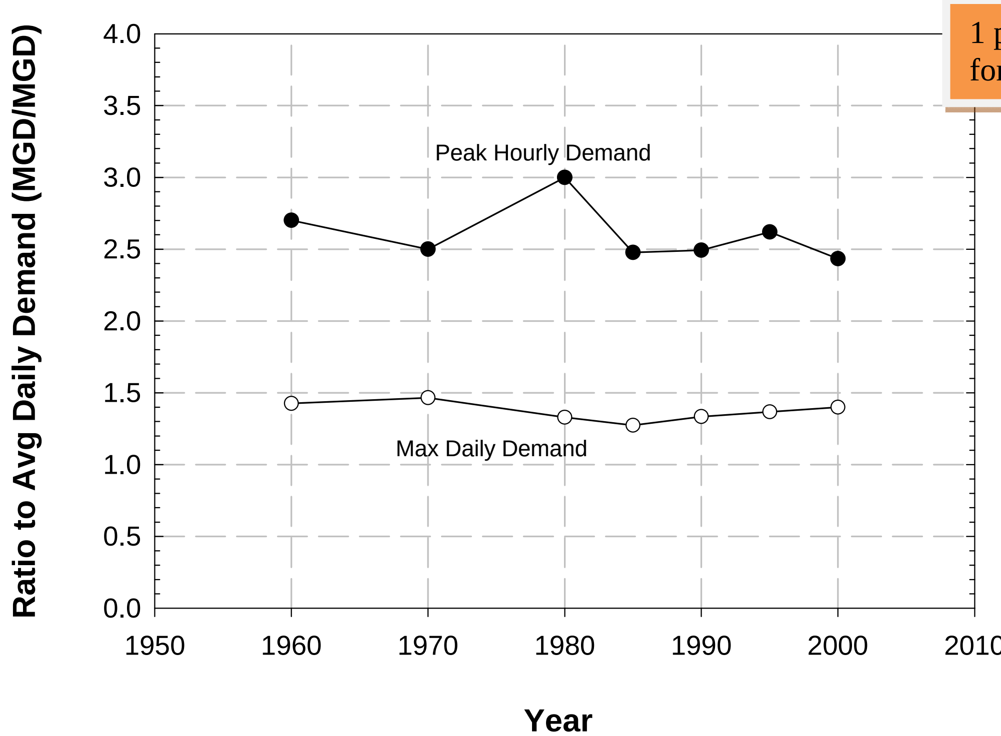
1 point for #1

"eyeball" projection

Date	Avg Daily Demand	Max Daily Demand
2010	4.6 MGD	6.5 MGD
2020	5.0 MGD	7.2 MGD

2. Prepare a figure with two plots showing the ratios of maximum to average daily demand and of peak hourly to average daily demand using all the available data in Table 1. Plot these ratios (scale: 0 to 4.0) versus year (scale: 1950 to 2010). Compute the minimum, maximum, and mean value for each ratio and compare the mean values to the national averages presented in class.

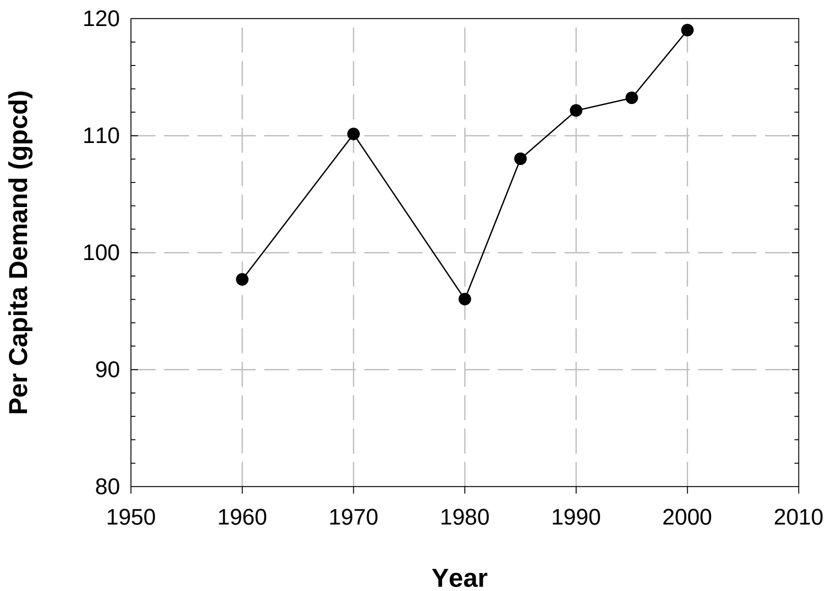
1 point for #2



Location	Statistic	Max Daily /Avg Daily	Peak Hr / Avg Daily
Amherst	Minimum	1.273	2.434
	Maximum	1.466	3.000
	Mean	1.371	2.604
US average	Mean	1.8	3.0

3. Using population data and Amherst water demand data from Table 1, compute the minimum, maximum, and mean for the average daily per capita demand in gpcd. Prepare a figure plotting average daily per capita demand (scale of 80 to 120 gpcd) versus year (scale of 1950 to 2010). Compare the mean value to the U.S. national average presented in class.

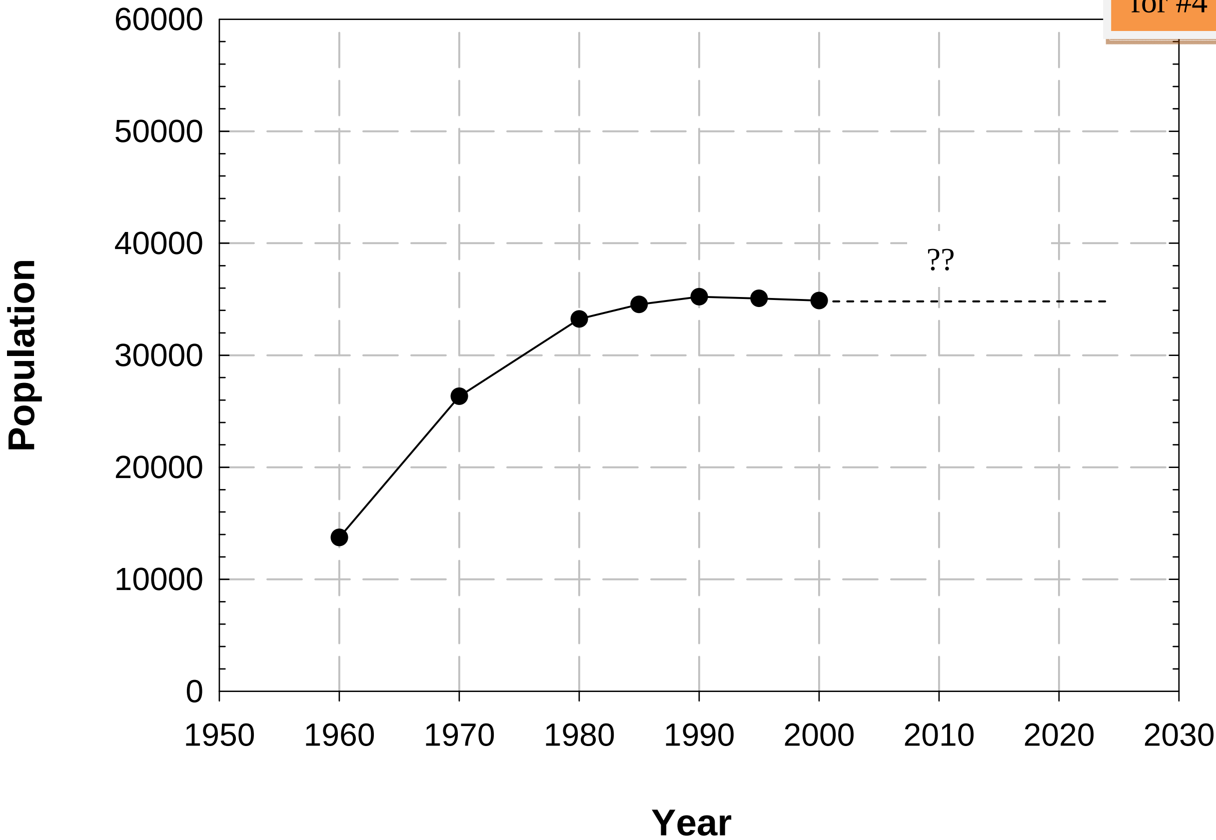
1 point for #3



Location	Statistic	Per Capita demand
Amherst	Minimum	96.0
	Maximum	119.0
	Mean	108.3
US Average	Mean	180

4. Using the historical population data for Amherst in Table 1, make population projections for 2010 and 2020 using the linear growth mathematical model and one other mathematical model. Give reasons for the second type of model that you choose. Clearly explain your approach and state all assumptions.

1.5 points for #4



Linear models are obviously not ideal for this case. If they are used, one must decide on the range of data to be used for calibrating the linear model. Use of the entire dataset in this case is probably not warranted and will give high future population estimates. It makes more sense to use data from 1980 onward, a period in which the population seems to have stabilized.

The second model would best reflect to idea of a limiting population. The existing population data seems to reflect some limit near or below 40,000. There may be good reasons for this that are known independently of the data above (e.g., housing availability, land sales, zoning restrictions). In either case, a logistics or declining growth model is probably best. The exact calibration will depend on how much of the above data are used in the calibration processes (e.g., determination of the model parameters). With both linear and declining growth models you might find that the population projects will show a decrease in total numbers depending on the way you calibrated

The table below shows results from some of the possible models. Exact estimates and calibration will depend on the range of data used in the calibration.

Date	Linear	Logistics	Declining Growth
2010	34,500	37,900	34,100
2020	34,200	39,200	32,200

5. Using your population projections from part "4", calculate the average daily and maximum daily demands (in MGD) for 2010 and 2020. Select an average per capita daily demand value and a ratio of maximum daily to average daily demand based on your analysis of the Amherst data from parts "2" and "3" above; indicate why you chose the value of each parameter.

Linear model predictions are probably not the best, so the "other" model (declining growth or logistics) is preferred. Use of actual per capita demand data from Amherst is also preferred over a national estimate.

Date	**Avg Daily Demand**	**Max Daily Demand**
2010	3.8 MGD	5.2 MGD
2020	3.5 MGD	4.9 MGD

1 point for #5

6. Calculate the fire demand needed for Amherst for 2020 using your population projections from part "4". Express answers in units of gpm and MGD.

0.5 points for #6

Use the fire flow model presented in class:
:

Q = 1020 (P)1/2 (1 – 0.01 (P)1/2)

Results here will depend on the population figure you used. A typical set of values is:

5,500 gpm
7.9 MGD