

Assignment 6

Water supply project

This is the exercise to introduce you to the water demand analysis, and determination of safe yield.

Consider the City with the following historical census data:

Year	2000	2002	2005	2008	2012
Households	220,000	240,000	280,000	300,000	355,000

Data collected from residential customers yield the following empirical expression for the annual water demand in each household:

$$\ln Q = 3.61 + 0.251 \ln M + 0.212 \ln I + 1.64 \ln N$$

where Q is the annual water use in $\text{m}^3/(\text{year household})$; M is the marginal water rate in $\$/\text{m}^3$, I is the household income in $\$$, and N is the number of persons in the household.

PART A (in class)

1. Given that the average demand in the year 2011 is found to be $6.12 \times 10^5 \text{m}^3/\text{d}$ and the annual water demand rate growth is expected to be 5%, find the average demand in the year 2025.
2. Calculate the number of households (use extrapolation method) and expected population in the service area using the census data. The number of persons per household is expected to reach 2.8 in 2025. What is the per capita water use rate in the service area?
3. Use the empirical expression to estimate the average daily water demand and the price elasticity for the service area in the year 2035. In 2035, water rates will be $\$2.35/\text{m}^3$ a typical household in the service area will have an annual income of $\$150000$ and consist of 2.4 persons.
4. Using the per capita rate as in 2025 check how many pumps (each able to handle 2500 L/s) will need to be installed to meet the demand if the ratio of maximum daily to average demand is 3.0.

PART B (at home)

5. The City is getting its water supply from an aquifer with an area of 12,500 km². Estimate the safe yield of the aquifer using (i) zero fluctuation, (ii) average draft and (iii) simplified water balance methods. Will the aquifer be sufficient to meet the demand for water in 2035? Monitoring program established between 2000 and 2011 provides the following data:

Year	Annual draft (10 ⁸ m ³)	Water table elevation (m)	Surface runoff + evapotranspiration (10 ⁸ m ³)	Rainfall (cm)
2000	-	5.442	-	-
2001	2.90	5.577	50.0	65
2002	2.84	5.630	63.8	62
2003	3.36	5.655	53.8	59.6
2004	2.76	5.395	54.9	50.7
2005	3.43	5.313	69.2	63.9
2006	2.80	5.436	75.0	73.1
2007	3.16	5.370	56.8	61.6
2008	2.99	5.153	63.8	59.4
2009	2.94	5.265	62.0	68.6
2010	3.19	5.098	55.5	52.4
2011	3.20	5.200	56.7	56.1

Due Thursday, March 1, 2012