CE 3372 WATER SYSTEMS DESIGN

DEMAND ESTIMATION PART 1 (FALL 2020)

WATER SUPPLY DEMANDS

- Uses
  - Withdrawl
    - Removal from stream, lake, or aquifer to supply user(s) – water is moved to satisfy the use
  - Non-Withdrawl
    - On-site uses for navigation, recreation – water can stay in same location to satisfy use
  - Consumptive
    - Fraction of withdrawl that is no longer available for further use – incorporated into crops and animals (actual biomass); industrial processes (heat exchange)

WATER NEEDS FOR A CITY

- Consider some generic urban area
  - Municipal Requirements
  - Large Industrial Requirements
  - Waste Assimilation Requirements

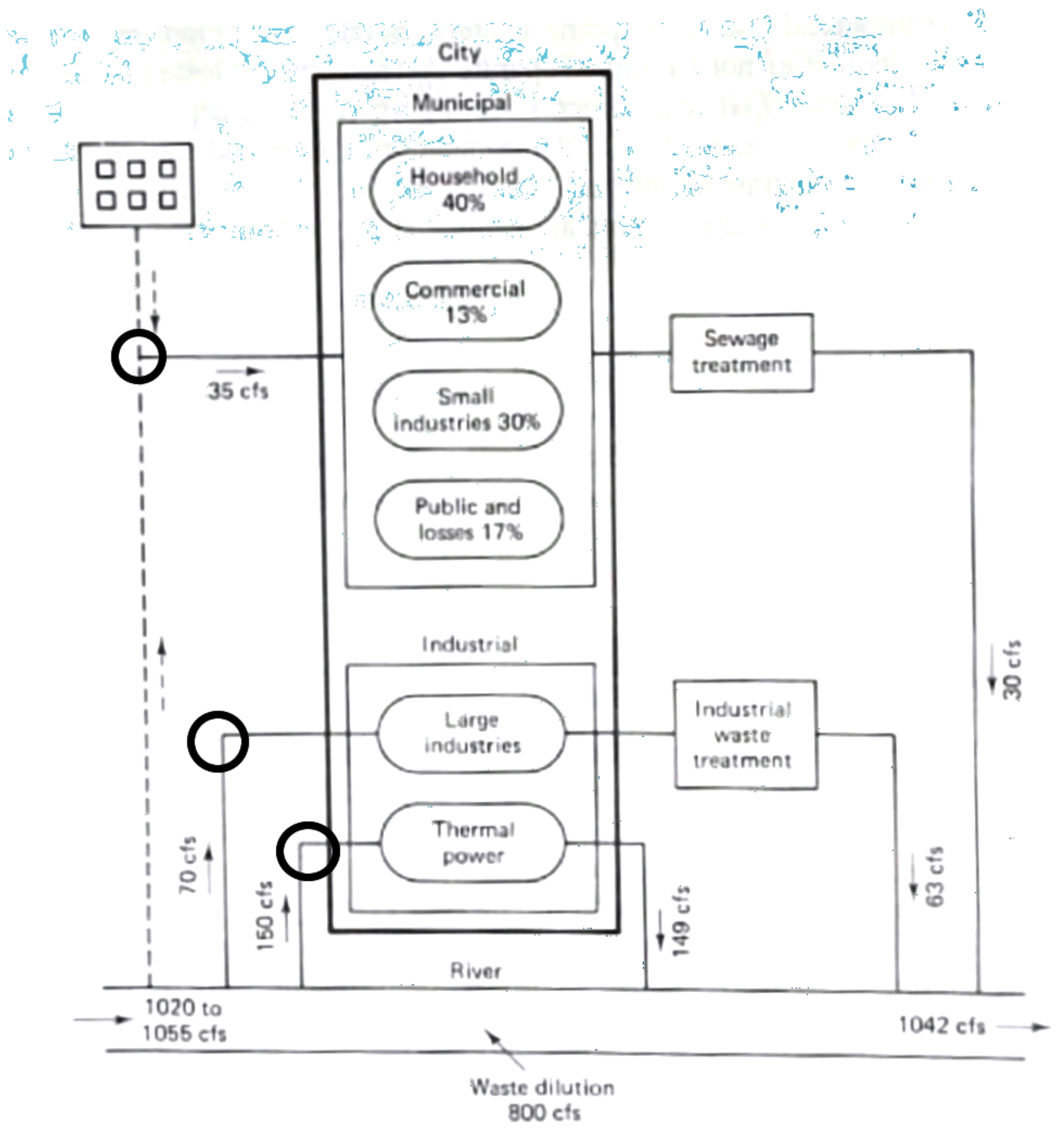


Figure 2.1 Water requirements of a city of 150,000 population.

MUNICIPAL REQUIREMENTS

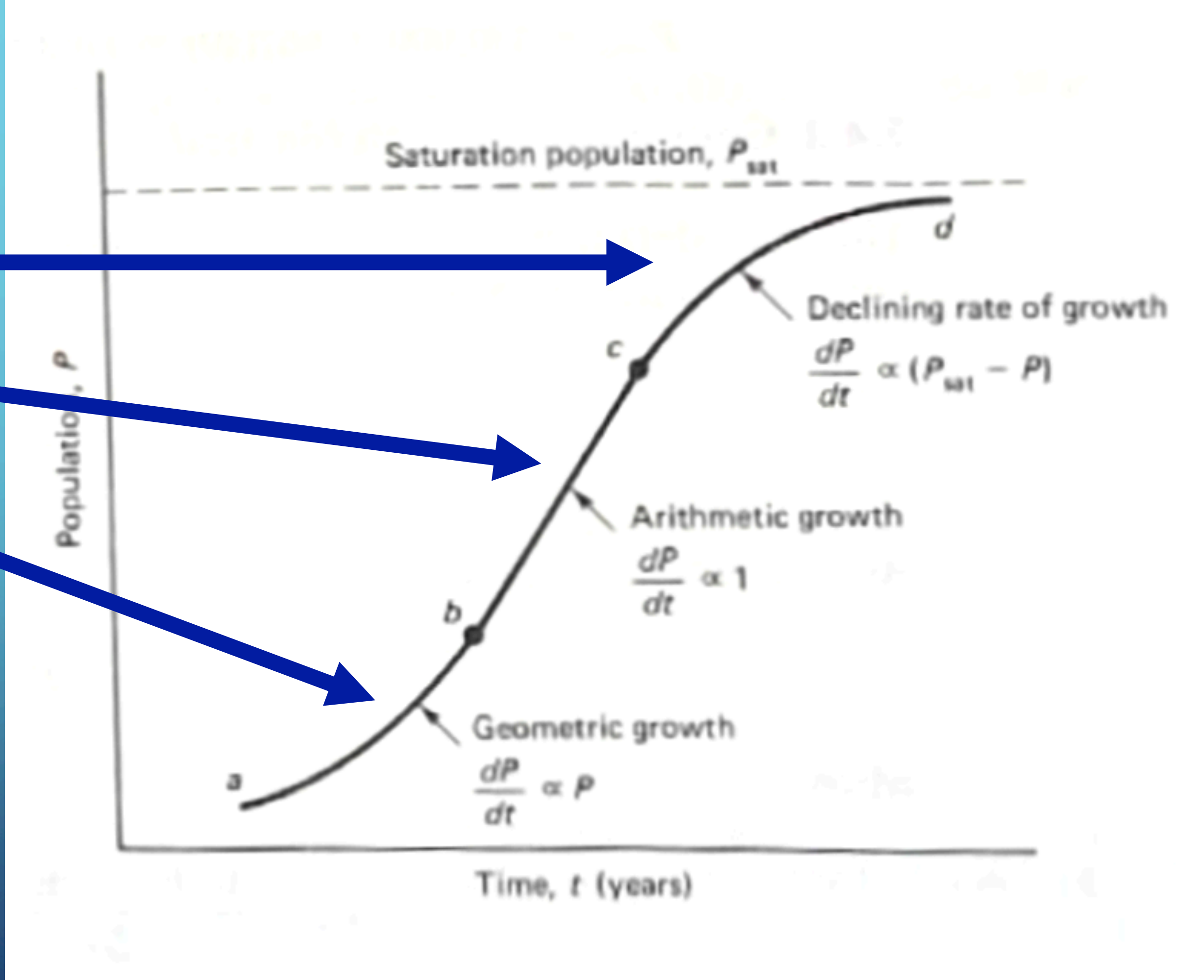
- The municipal requirements are related to the number of users by means of the simple relation:

$$V = P \times \left(\frac{V}{P} \right)$$

- Where V=volume, P=population, V/P = volume per person (used).

POPULATION FORECASTING (GRAPHICAL)

- Short-term forecasting
  - Declining growth
  - Arithmetic growth
  - Geometric growth
- Same arithmetic as substrate limited growth that you learn in Envriomental Engineering



GEOMETRIC GROWTH (MATHEMATICAL)

- When the growth curve is in the exponential phase

$$P_2 = P_1 \cdot e^{K_P(t_2 - t_1)}$$

- Where K_P is the exponential growth constant

ARITHMETIC GROWTH (MATHEMATICAL)

- When the growth curve is roughly a straight line, then

$$P_2 = P_1 + K_A(t_2 - t_1)$$

- Where K_A is the slope of the growth curve

DECLINING GROWTH (MATHEMATICAL)

- When the growth curve approaching the carrying capacity of the region

$$P_2 = P_1 + (P_{sat} - P_1) \cdot (1 - e^{-K_D(t_2 - t_1)})$$

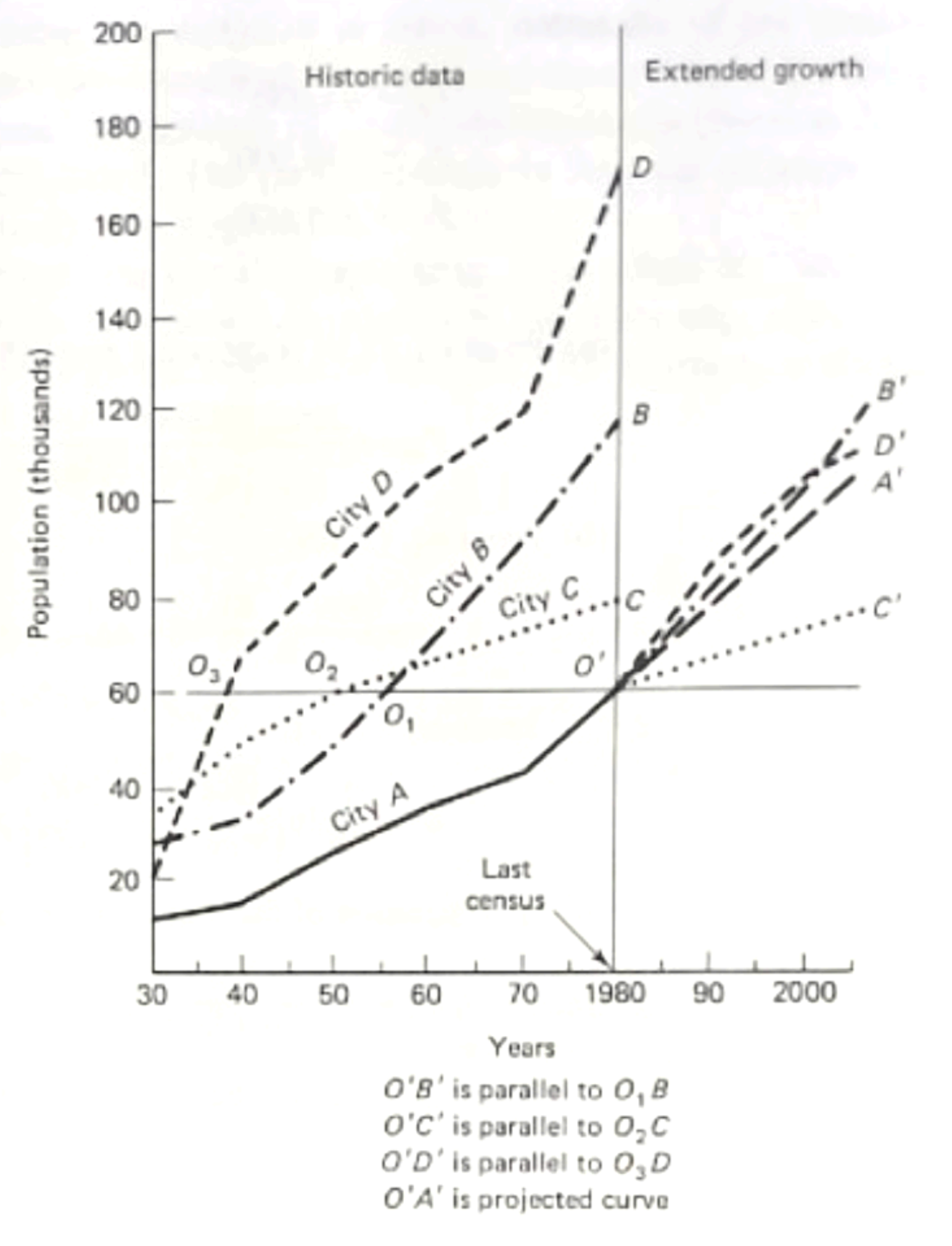
- Where K_D is the declining rate constant

LONGER-TERM FORECASTING

- Naturally, none of the constants are convienently tabulated and historical census data are used both for short term forecasts – the US Census Bureau makes estimates of census values between the every decade census.
- If the region has been around awhile (in the population sense) then the plot might be strightforward to construct.
- Longer term adds the ratio and correlation techniques and component techniques

COMPARISON FORECASTING

- Geographically similar areas are used and projections are made by comparing these growth curves to the area of interest.
- Uncertainty that area of interest may not progress similarily to past growth of comparision areas.



FORECASTING (RATIO/CORRELATION)

- Ratio (transposition) method is based on the ratio of observed populations of two study areas.

$$P_t = \frac{P_0}{P'_0} \cdot P'_t$$

- Correlation method fits (ordinary least squares on the populations or log-populations) to generate a predictive equation based on a reference population.

$$P_t = aP'_t + b$$

FORECASTING (COMPONENT)

- Formal model of a population that considers birth rate (B), death rate (D), net migration rate (M) over a forecasting interval

$$P_t = P_0 + (B - D \pm M)\Delta t$$

- Non-trivial modeling activity
- Nice introduction to the mathematics in:

  Frauenthal, J.C. 1980. Introduction to Population Modeling. Birkhäuser, Boston, Basel, Stuttgart 186p. ISBN 3-7643-3015-5