Part I: Water Network Design Considerations

8 Steps to Designing a Pipe Network

1) Review existing System
   a) gather information like maps, plans, new measurements for layout (GPS)
   b) determine pipe ages, locations, roughness, condition of devices
   c) prepare a detailed mapping of the "current-state-of-affairs"

More on this later

2) Forecast Population (10 – 50 years)
   a) Project water use patterns for the pipe network lifetime cycle
   b) determine the maximum hour flow
      maximum peak flow
      average daily flow
   c) compute special event demands like max. day rate or fire demand
      fire demand: 500 gpm (34 L/s) – 3000 gpm (200 L/s)
      required pressure in hydrant: > 20 psi (140 kPa) help mobile pump
      > 100 psi (700 kPa) without

3) Develop Analytical Model
   a) Try to reduce network into essential lines (do not need every delivery connection for every household)
   b) Combine elevation model DEM with pipe network, need to get elevations right

4) Apply and compare with Measured Data
   a) calibrate and validate with measured data
   b) identify problem points in existing network, such as
      i) **low pressure regions**; pressure drop below following values:
         > 150 psi (1050 kPa) for transmission mains
         > 60 psi (420 kPa) for commercial sectors
         > 40 psi (280 kPa) for residential areas
         > 20 psi (140 kPa) at all times
      ii) **high pressure regions**
         < 90 psi (620 kPa) for residential areas
      iii) **pipes with large/small velocities**
         0.6 m/s < velocity < 2.5 m/s

5) Design new System
   a) Outline your network
      i) **inter-connect feeders every 1200 feet or less**
      ii) two smaller mains running in parallel are better than one big feeder
   b) Mark the positions of devices
      i) valves
      ii) service connections (1/customer)
      iii) **hydrants (< 500 feet apart)**

6) Run your new System for desired Load
    a) Inspect your system for high/low velocity sections
       $0.6 \text{ m/s} < \text{velocity} < 2.5 \text{ m/s}$
    b) Inspect your system for regions with pressures too high or too low

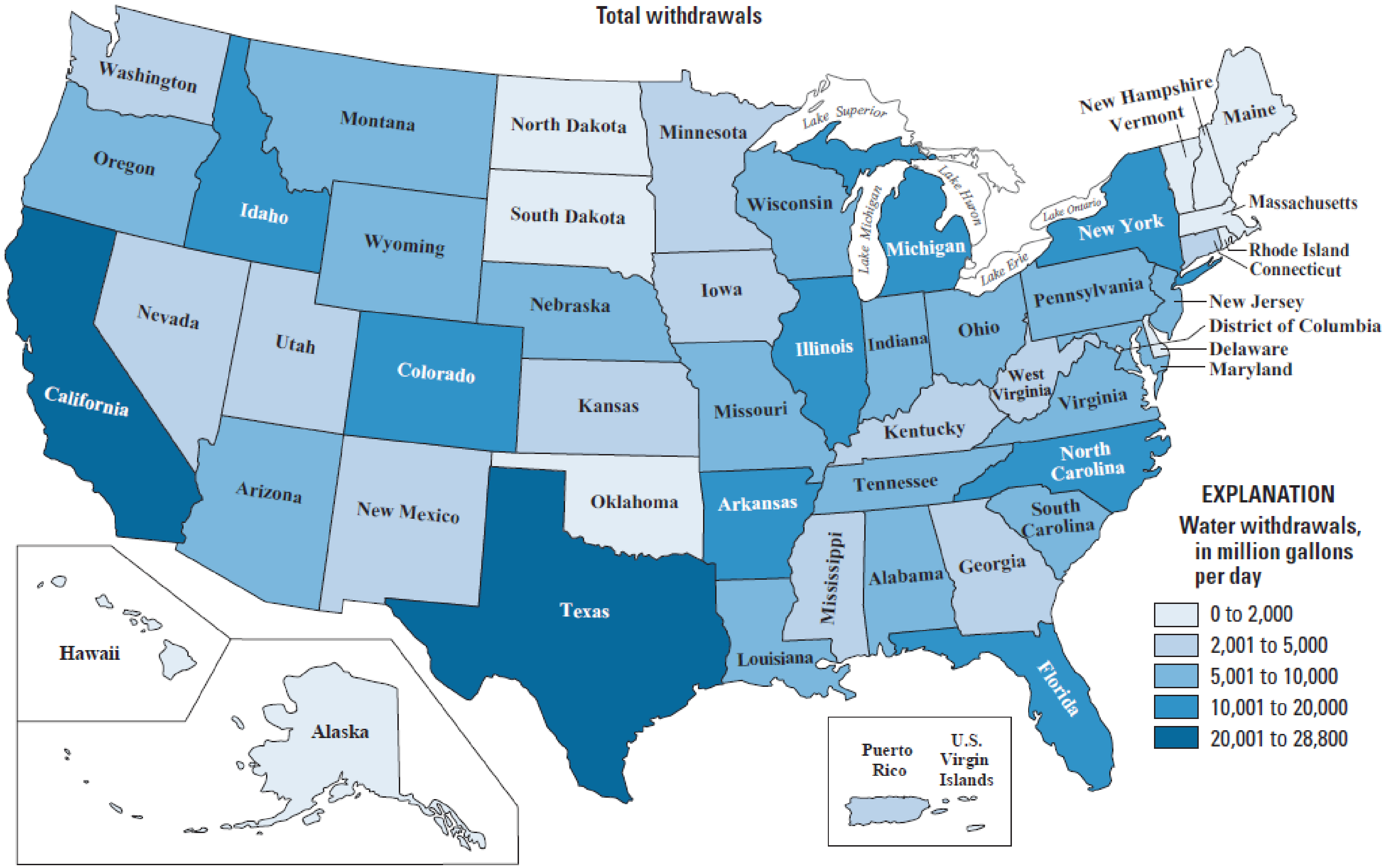
7) Update your System (fixes) and rerun
    a) Change pipe diameter if necessary
    b) Introduce control devices like pressure reducing valve, booster pump etc
    c) Iterate until you have a workable (hydraulic) solution

8) Compute Costs for each alternative

Part II: Water Demand Considerations

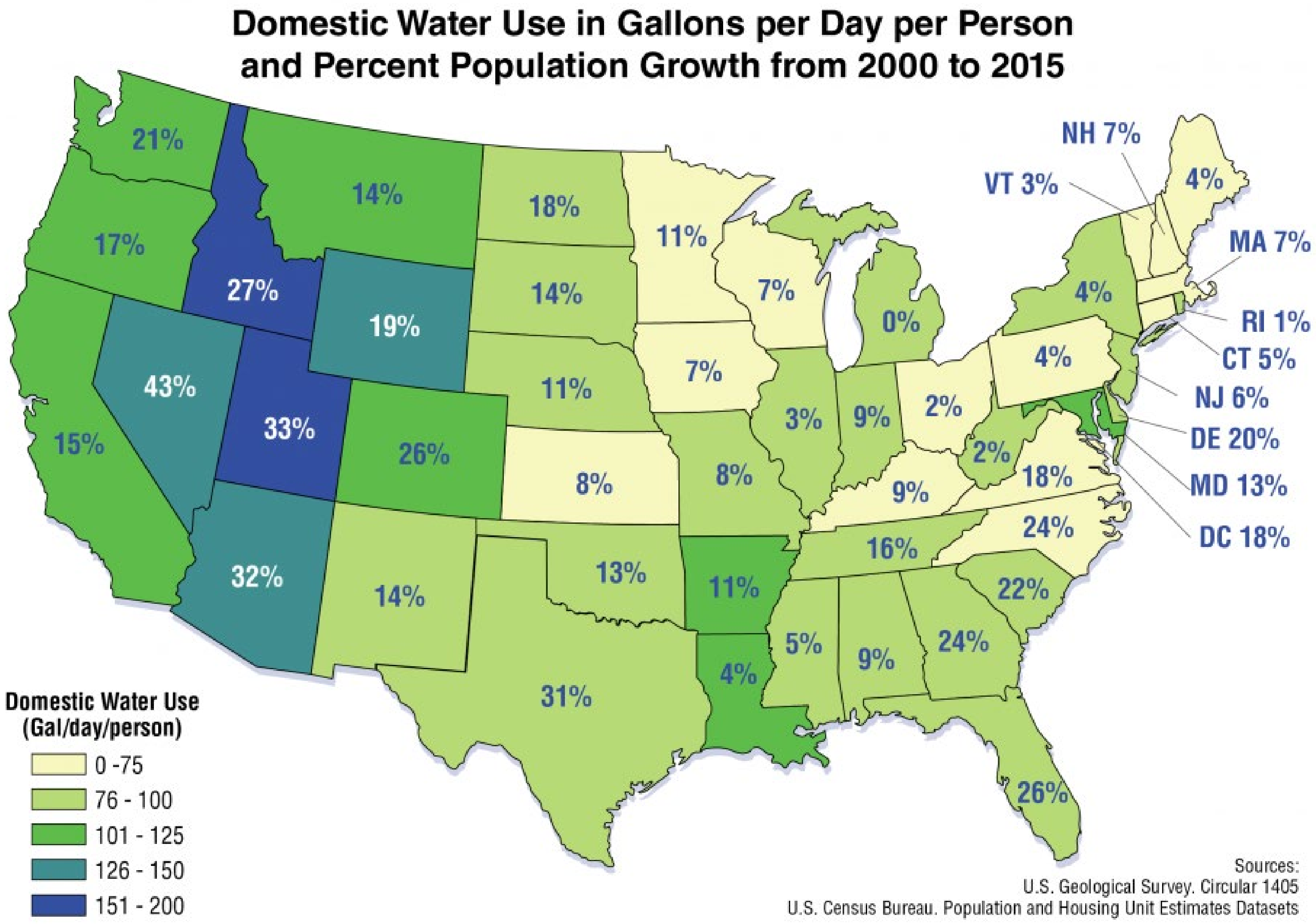
Water Demand: Useage in US

Estimated Use of Water in the United States in 2015

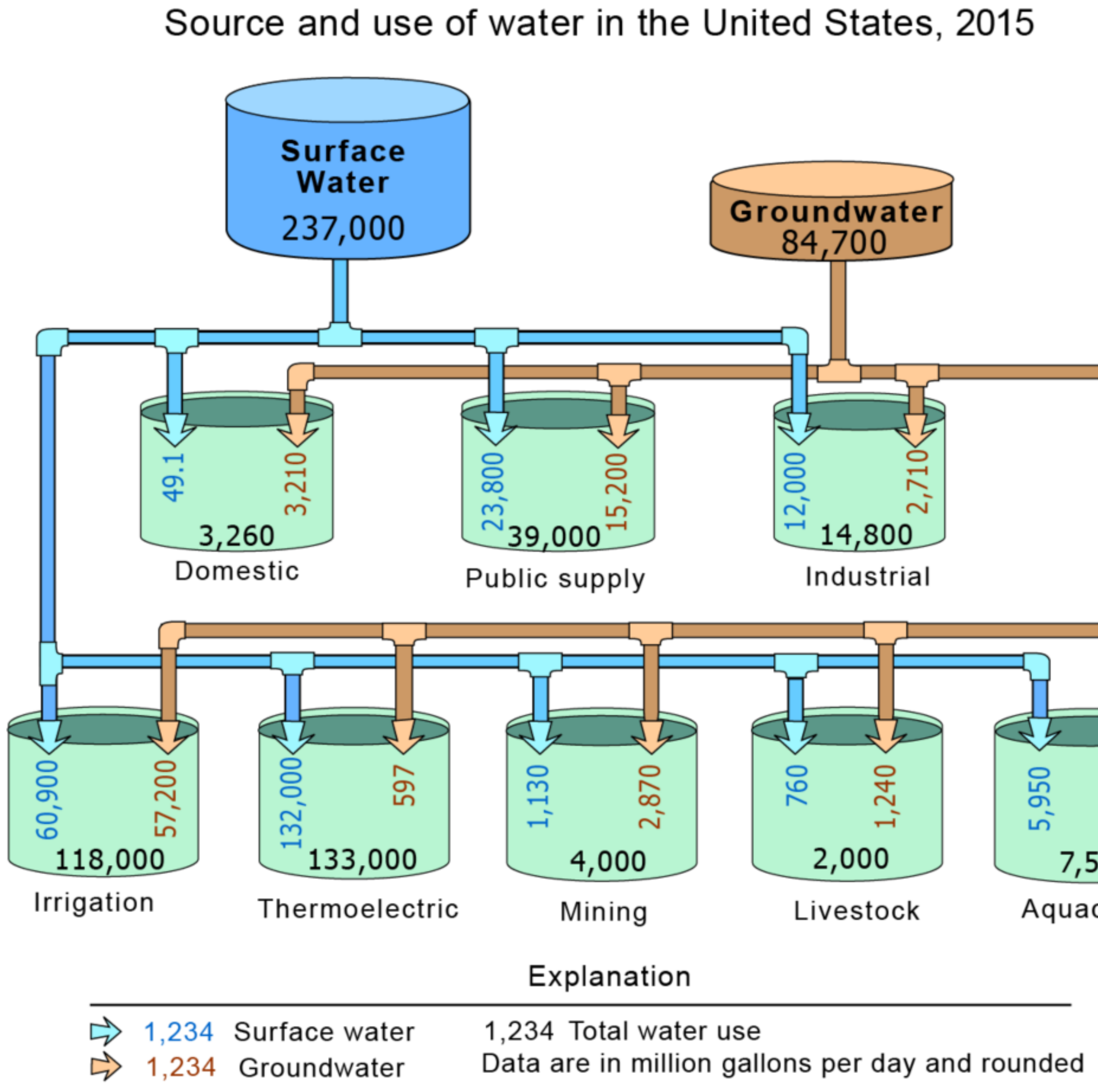


Total water withdrawals by State, 2015.

Water Demand: Useage in US



Water Demand: Useage in US

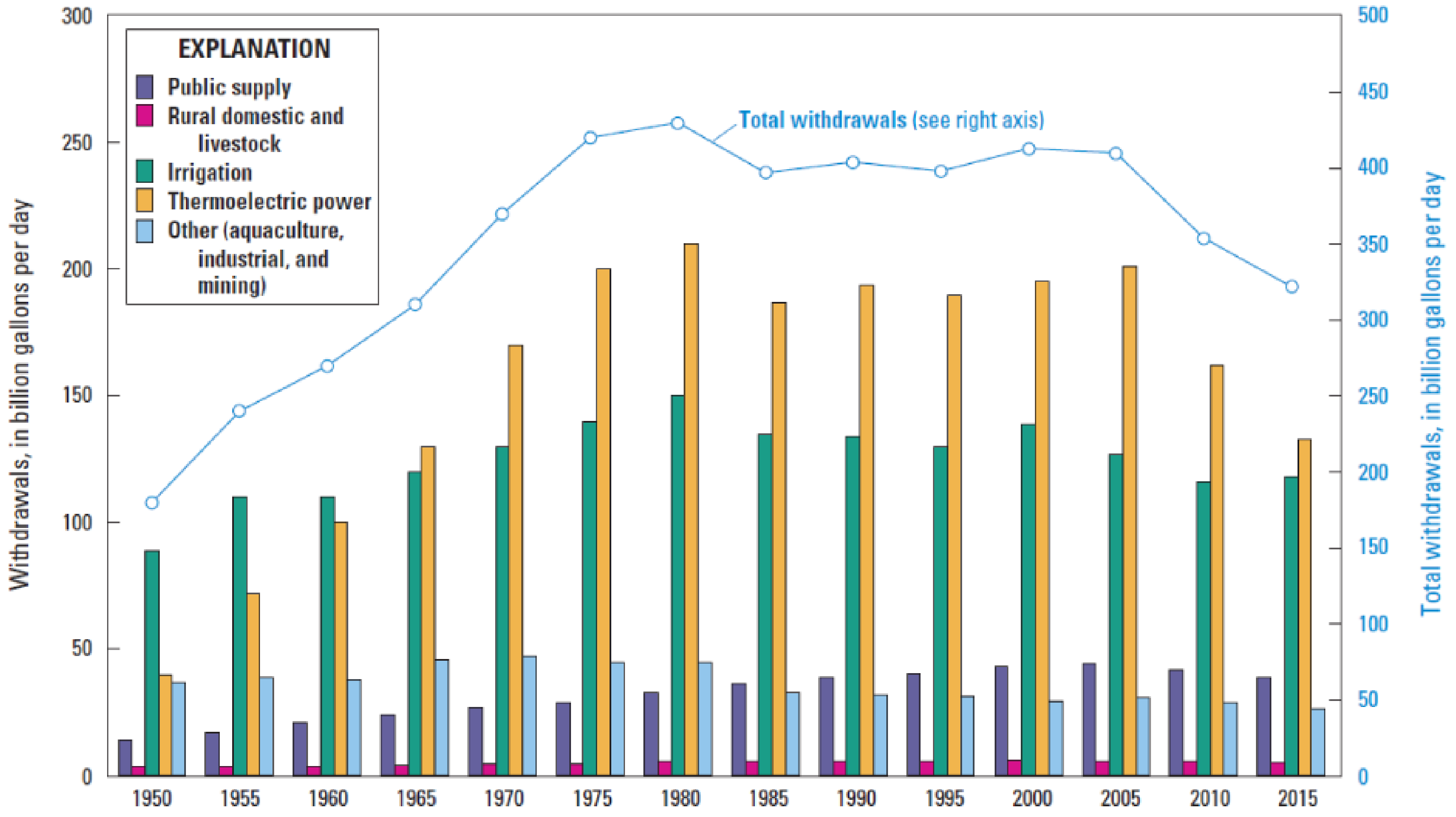


[Bgal/d]	2010	2015
Total Useage	**354**	**322**
Thermo Elec	165	113
Irrigation	116	118
Public Supply	41.9	39.0
Domestic	30.0	26.5
Industrial	16.3	14.8
Acquaculture	9.00	7.55
Mining	5.32	4.00
Livestock	2.00	2.00

Source: USGS

Water Demand: Useage in US

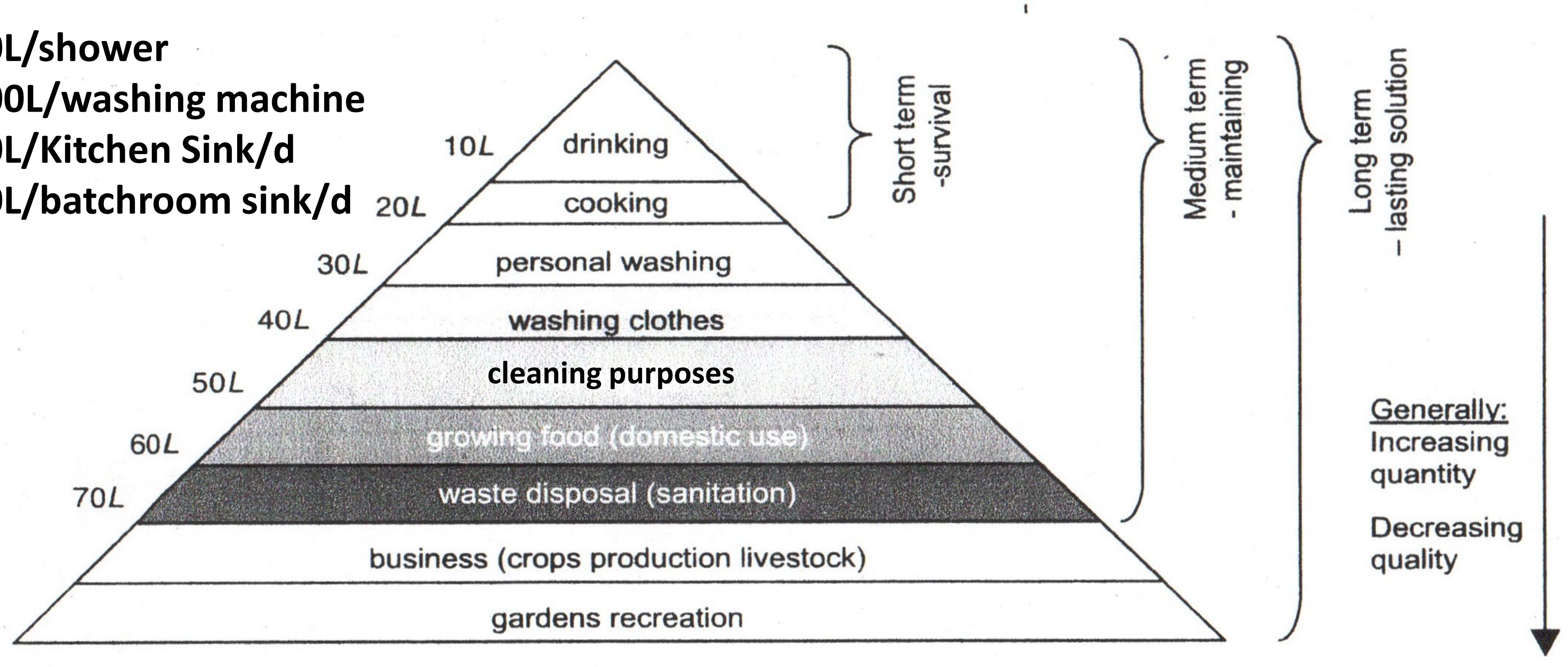
26gal/one ear of corn
2000gal/one #beef
120gal/one egg
300gal/loaf bread
12000gal/bushel wheat
1400gal/fast food meal



Trends in total water withdrawals by water-use category, 1950–2015

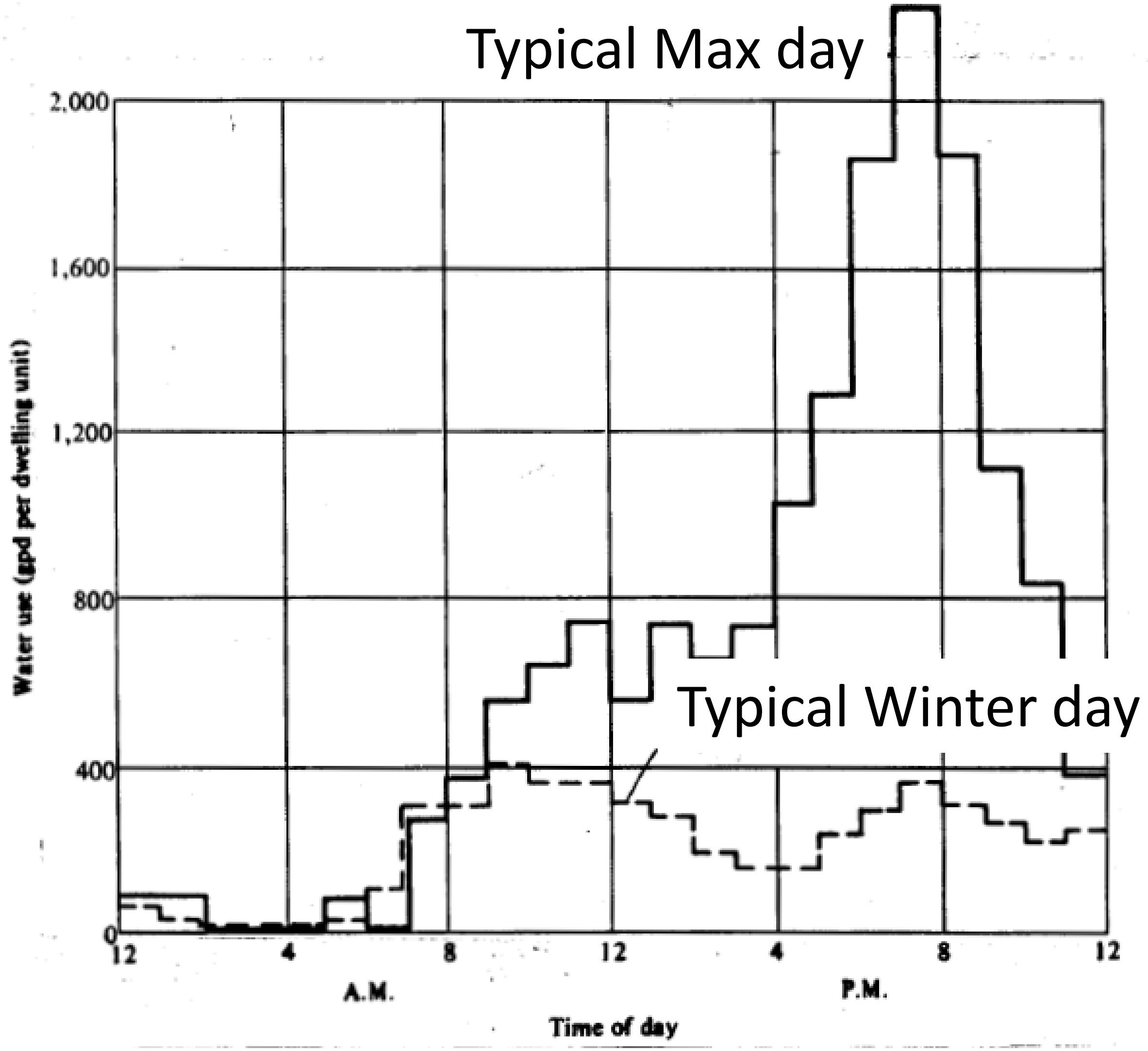
Water Demand: Daily Use

80L/shower
100L/washing machine
80L/Kitchen Sink/d
60L/batchroom sink/d



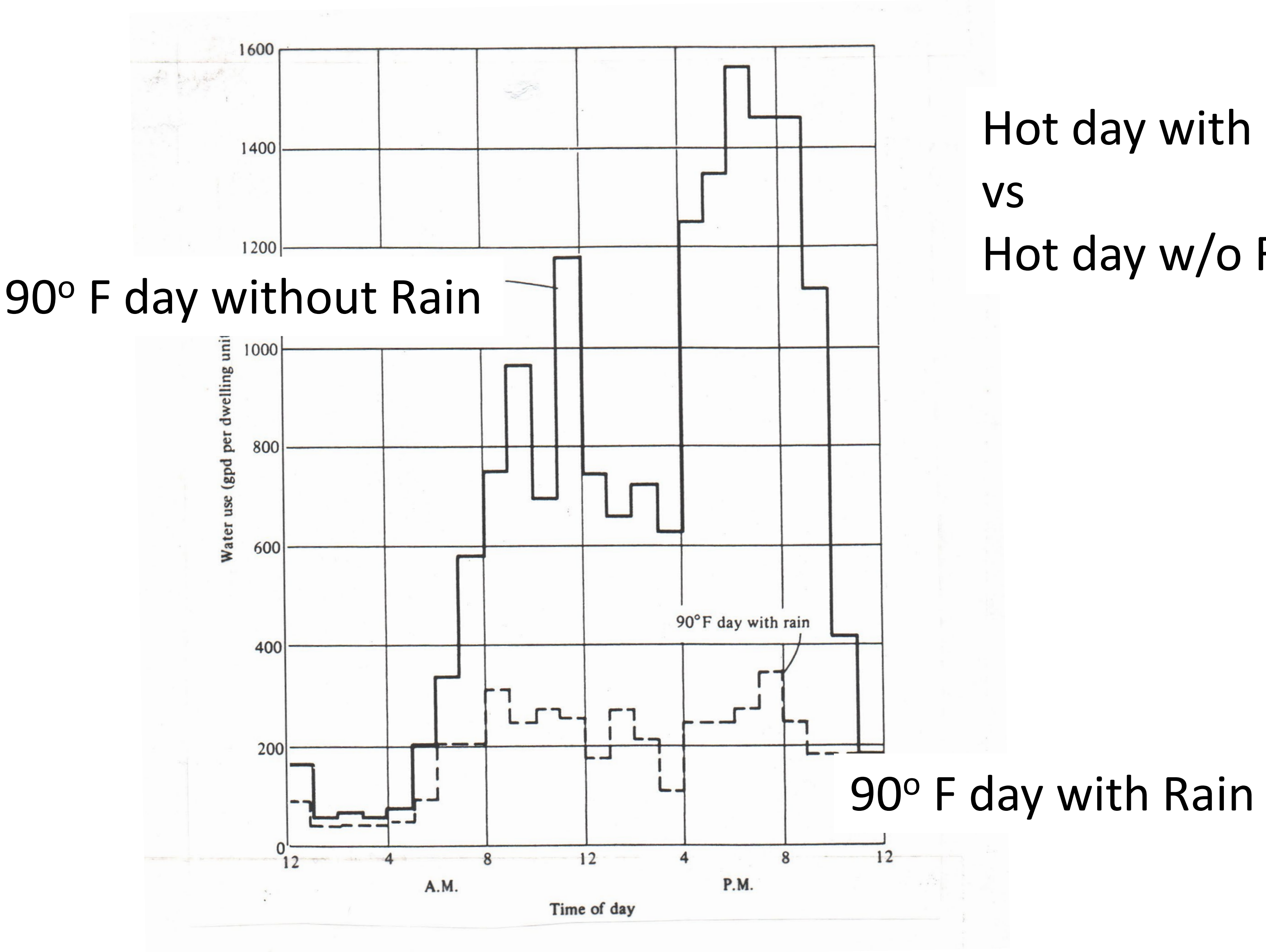
Hierarchy of Water Demands

Water Demand: Daily Patterns



Typical Winter day
vs
Typical Max day

Water Demand: Daily Patterns



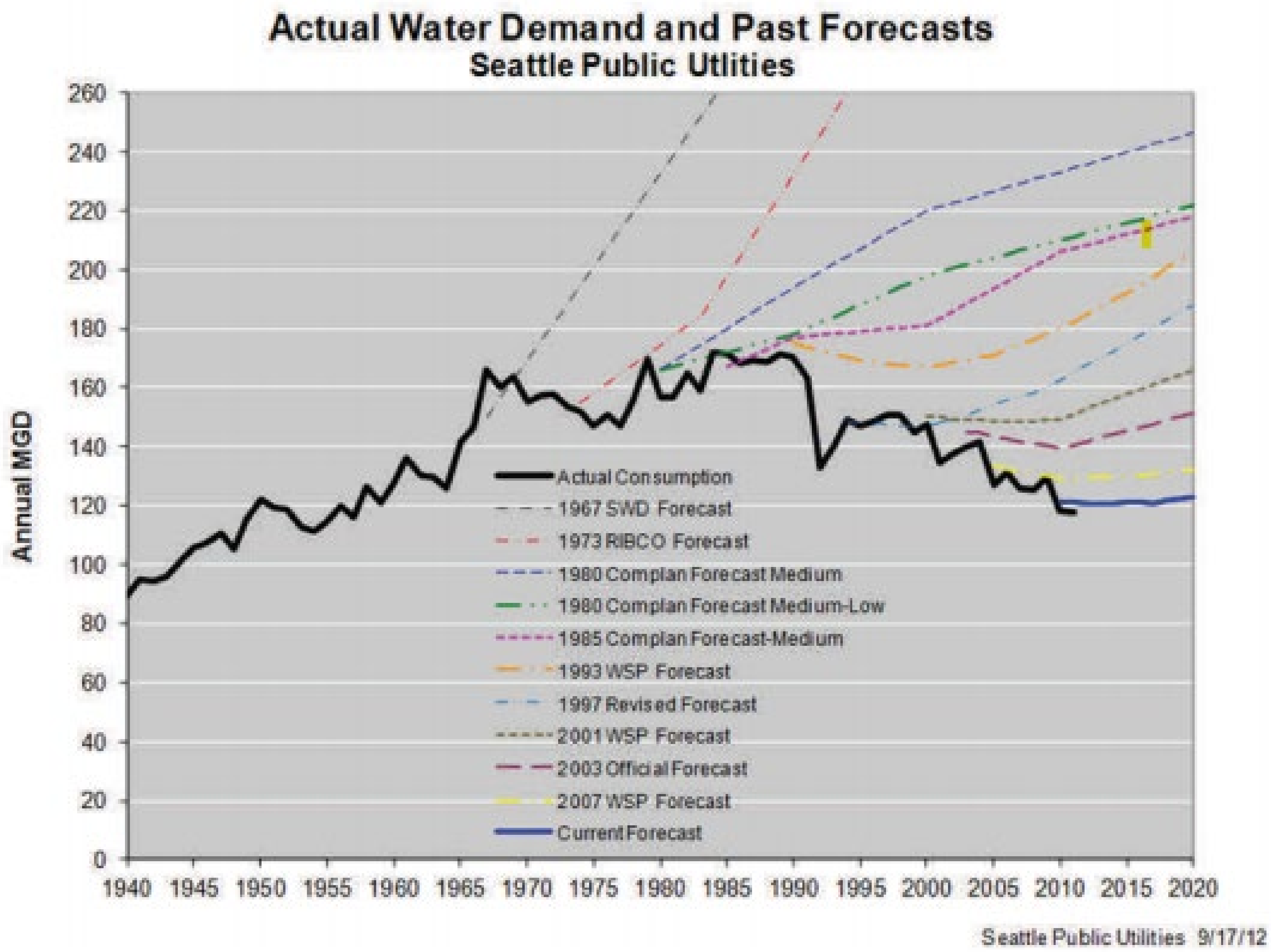
Hot day with Rain
vs
Hot day w/o Rain

Forecasting

Simplest and most traditional means of forecasting future demand has been to estimate current per-capita water consumption, usually measured as gallons per cpaita per day (gpcd), and ultiply this by expected future populations. Population estimates may be based on simple linear growth, percent annual increase (exponential growth), or more detailed analyses by demographers or forecasters. This simple approach has drawbacks, as it does not not account for changes in technology, the economy, or culture over time.

More detailed models may take into account a wide variety of factors, such as changes to population, water prices (e.g., price elasticity); the climate (e.g., weather variability is appropriate for short-term forecasts while global climate models are useful for longer-term forecasts); customer behavior (e.g., increased conservation and efficiency); and new regulations (e.g., the Water Conservation Act of 2009). In a survey of water service providers in California, less than half of respondents indicated that they consider future land uses in the forecasts of future demand or incorporate the impacts of price elasticity on water.

Forecasting



Forecasting

A better strategy is to:

- Include a **multitude of variables**: legislation, conservation programs, demographic changes, and climate change.

- **20 X 2020 Targets**: 20% per capita water conservation by 2020

- **Price effects**: indoor pricing is less elastic but outdoor demand is very much a target. People will safe (conserve) water for pools and watering if the $$ gets too high.

- **Utlize existing software**: these target everything from short term (a few weeks) to long -term (decades) forecast

Forecasting

Table 2. A Selection of Existing Software for Estimating Future Water Demand and the Impact of Water Conservation and Efficiency on Demand

Software Name	Applications	Source
IWR-MAIN*	The Forecast Manager can assist water planners in projecting future water demands for municipal and industrial uses. The Conservation Manager can assist water planners in forecasting water demand and analyzing water conservation at the end-use level.	www.cdmsmith.com
Demand Side Management Least Cost Planning Decision Support System**	Provides 30-year water demand forecasts, 30-year water conservation forecasts, and 30-year benefit-cost ratios of conservation measures and programs.	www.cuwcc.org/resource-center/technical-resources/bmp-tools.aspx
Water Conservation Tracking Tool	Develops forecasts of the water savings related to long-range conservation plans, constructs conservation portfolios containing up to 50 separate conservation program activities.	www.allianceforwaterefficiency.org/Tracking-Tool.aspx
California Urban Water Demand to 2100	Provides long-term forecasts of urban water demand, allows users to analyze effects of climate, population, prices, and technology on urban water demand in California through 2100.	www.pacinst.org/reports/urban_water_demand_2100