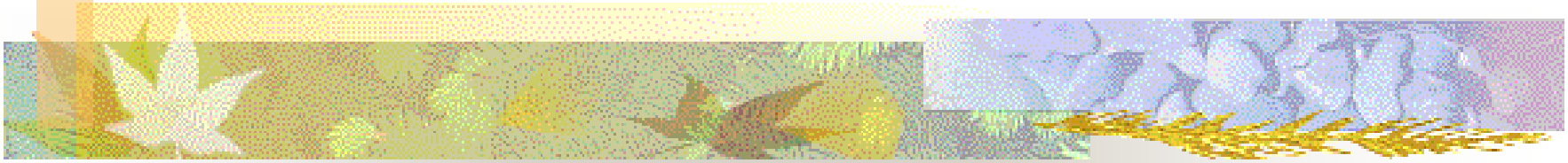
TRAFFIC FLOW PARAMETERS



Traffic Definitions

- **Volume:**
  - number of vehicles, pedestrians, etc. passing a point during a specific period of time
  - for vehicles, usually expressed as veh/hour (vph) or veh/hour/lane (vphpl)

UNINTERRUPTED FLOW

- **VOLUME AND FLOW RATE:**
- Volume—the total number of vehicles that pass over a given point or section of a lane or roadway during a given time interval; volumes can be expressed in terms of annual, daily, hourly, or subhourly periods.

UNINTERRUPTED FLOW

- **Flow rate** —the equivalent hourly rate at which vehicles pass over a given point or section of a lane or roadway during a given time interval of less than 1 h, usually 15 min.
- Volume and flow are variables that quantify demand, that is, the number of vehicle occupants or drivers (usually expressed as the number of vehicles) who desire to use a given facility during a specific time period.

UNINTERRUPTED FLOW

- The distinction between volume and flow rate is important. Volume is the number of vehicles observed or predicted to pass a point during a time interval. Flow rate represents the number of vehicles passing a point during a time interval less than 1 h, but expressed as an equivalent hourly rate. A flow rate is the number of vehicles observed in a subhourly period, divided by the time (in hours) of the observation. For example, a volume of 100 vehicles observed in a 15-min period implies a flow rate of 100 veh/0.25 h or 400 veh/h.

UNINTERRUPTED FLOW

- Peak flow rates and hourly volumes produce the peak-hour factor (PHF), the ratio of total hourly volume to the peak flow rate within the hour, computed by Equation:

$$PHF = \frac{Hourly\ volume}{Peak\ flow\ rate\ (within\ the\ hour)}$$

Calculating a peak-hour factor computed by

Where:
PHF = peak-hour factor,
V = hourly volume (veh/h), and
V15 = volume during the peak 15 min of the peak hour (veh/15 min).

UNINTERRUPTED FLOW

- When the PHF is known, it can convert a peak-hour volume to a peak flow rate, as in Equation :

$$v = \frac{V}{PHF}$$

where

- *v = flow rate for a peak 15-min period (veh/h),*
- *V = peak-hour volume (veh/h), and*
- *PHF = peak-hour factor.*

SPEED

speed (or its reciprocal of travel time) is an important measure of the quality of the traffic service provided to the motorist. It is an important measure of effectiveness defining levels of service for many types of facilities, such as rural two-lane highways, urban streets, freeway weaving segments, and others.

SPEED

- S rate of motion
  e per unit of time,

$$S = \frac{nL}{\sum_{i=1}^{n} t_i} = \frac{L}{\frac{1}{n}\sum_{i=1}^{n} t_i} = \frac{L}{t_a}$$

where

S = average travel speed (km/h),
L = length of the highway segment (km),
t_i = travel time of the ith vehicle to traverse the section (h),
n = number of travel times observed, and
t_a = $\frac{1}{n}\sum_{i=1}^{n} t_i$ = average travel time over L (h).

a segment of length L, the average travel speed is computed using Equation

SPEED

- Several different speed parameters can be applied to a traffic stream. These include the following:
- **Average running speed**—A traffic stream measure based on the observation of vehicle travel times traversing a section of highway of known length. It is the length of the segment divided by the average running time of vehicles to traverse the segment. Running time includes only time that vehicles are in motion.

SPEED

- **Average travel speed**—A traffic stream measure based on travel time observed on a known length of highway. It is the length of the segment divided by the average travel time of vehicles traversing the segment, including all stopped delay times. It is also a space mean speed.

SPEED

- **Space mean speed**—A statistical term denoting an average speed based on the average travel time of vehicles to traverse a segment of roadway. It is called a space mean speed because the average travel time weights the average to the time each vehicle spends in the defined roadway segment or space.

SPEED

- **Time mean speed :**The arithmetic average of speeds of vehicles observed passing a point on a highway; also referred to as the average spot speed. The individual speeds of vehicles passing a point are recorded and averaged arithmetically.

SPEED

- **Free-flow speed**: The average speed of vehicles on a given facility, measured under low-volume conditions, when drivers tend to drive at their desired speed and are not constrained by control delay.

SPEED

- **As measures of effectiveness**, speed criteria must recognize driver expectations and roadway function. For example, a driver expects a higher speed on a freeway than on an urban street. Lower free-flow speeds are tolerable on a roadway with more severe horizontal and vertical alignment, since drivers are not comfortable driving at high speeds. LOS criteria reflect these expectations.

DENSITY

- **Density** is the number of vehicles (or pedestrians) occupying a given length of a lane or roadway at a particular instant. For the computations in this manual, density is averaged over time and is usually expressed as vehicles per kilometer (veh/km) or passenger cars per kilometer (pc/km).

DENSITY

$$D = \frac{v}{S}$$

where

v = flow rate (veh/h),
S = average travel speed (km/h), and
D = density (veh/km).

Density can be computed, however, from the average travel speed and flow rate, which are measured more easily. Equation 7-5 is used for under saturated traffic conditions.

HEADWAY AND SPACING

- **Spacing** is the distance between successive vehicles in a traffic stream, measured from the same point on each vehicle (e.g., front bumper, rear axle, etc.).
- **Headway** is the time between successive vehicles as they pass a point on a lane or roadway, also measured from the same point on each vehicle.

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HEADWAY AND SPACING

- **Spacing** is a distance, measured in meters. It can be determined directly by measuring the distance between common points on successive vehicles at a particular instant. This generally requires complex aerial photographic techniques, so that spacing usually derives from other direct measurements. **Headway**, in contrast, can be easily measured with stopwatch observations as vehicles pass a point on the roadway.

HEADWAY AND SPACING

- The average vehicle spacing in a traffic stream is directly related to the density of the traffic stream, as determined by Equation

$$Density\ (veh/km) = \frac{1000}{spacing\ (m/veh)}$$

- The relationship between average spacing and average headway in a traffic stream depends on speed, as indicated in Equation

$$Headway\ (s/veh) = \frac{spacing\ (m/veh)}{speed\ (m/s)}$$

HEADWAY AND SPACING

- This relationship also holds for individual headways and spacings between pairs of vehicles. The speed is that of the second vehicle in a pair of vehicles. **Flow rate** is related to the average headway of the traffic stream with Equation

$$\text{Flow rate (veh/h)} = \frac{3600}{\text{headway (s/veh)}}$$

- **Demand:**
  - number of vehicles, pedestrians, etc. that desire to travel between locations during a specific period
  - Frequently higher than volume during certain peak times
  - Trips are diverted or not made when there are constraints in the system
  - difficult to measure actual demand because capacity constrains the demand
- **Capacity:**
  - maximum number of vehicles that can pass a point during a specific period
  - A characteristic of the roadway or facility

INTERRUPTED FLOW

- **Interrupted flow** is more complex than uninterrupted flow because of the time dimension involved in allocating space to conflicting traffic streams. On an interrupted flow facility, flow usually is dominated by points of fixed operation, such as **traffic signals and stop signs**. These controls have different impacts on overall flow.

INTERRUPTED FLOW

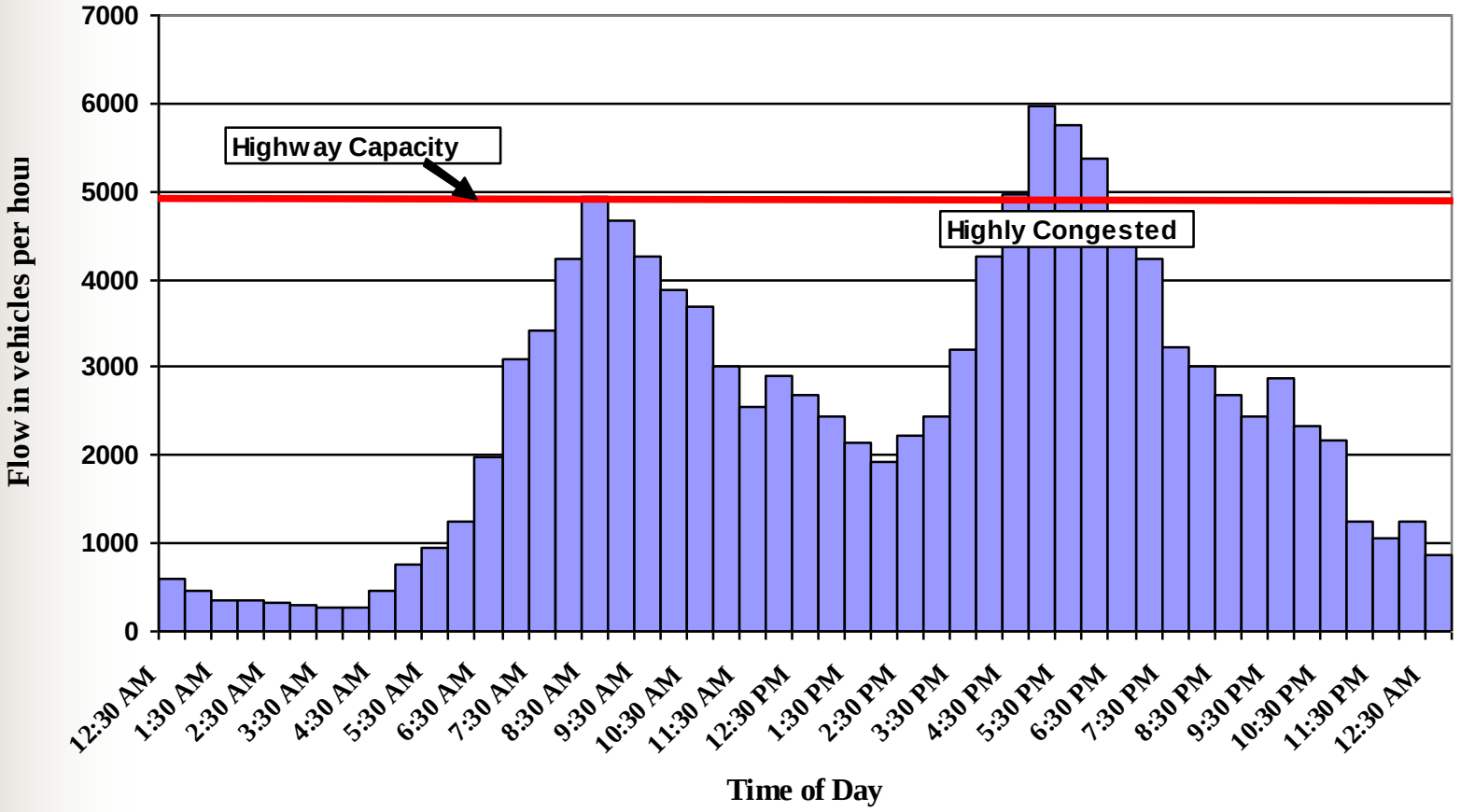
- The operational state of traffic at an interrupted traffic-flow facility is defined by the following measures:

- Volume and flow rate,
- Saturation flow and departure headways,
- Control variables (stop or signal control),
- Gaps available in the conflicting traffic streams, and
- Delay.

Characteristics of Traffic Flow

- Highly variable
  - Time of day
  - Day of week
  - Season
  - Road characteristics
  - Direction

Traffic Typically Peaks twice per day



Source: www.ecn.purdue.edu/~darcy

Volume Studies

- AADT: Annual average daily traffic (counted for 365 days)
- ADT: average daily traffic (counted for > 1 day and < 365)
- PHV: peak hour volume
- Classification counts: fleet mix

Estimating AADT

- Annual Average Daily Traffic
- Use count station information
- Extrapolate to non-count locations
- Used to adjust ADT for
  - Seasons
  - Daily variation

AADT Data Helps to:

- Estimate highway revenues
- Establish overall volume trends
- Establish annual accident rates
- Analyze benefits of road improvements

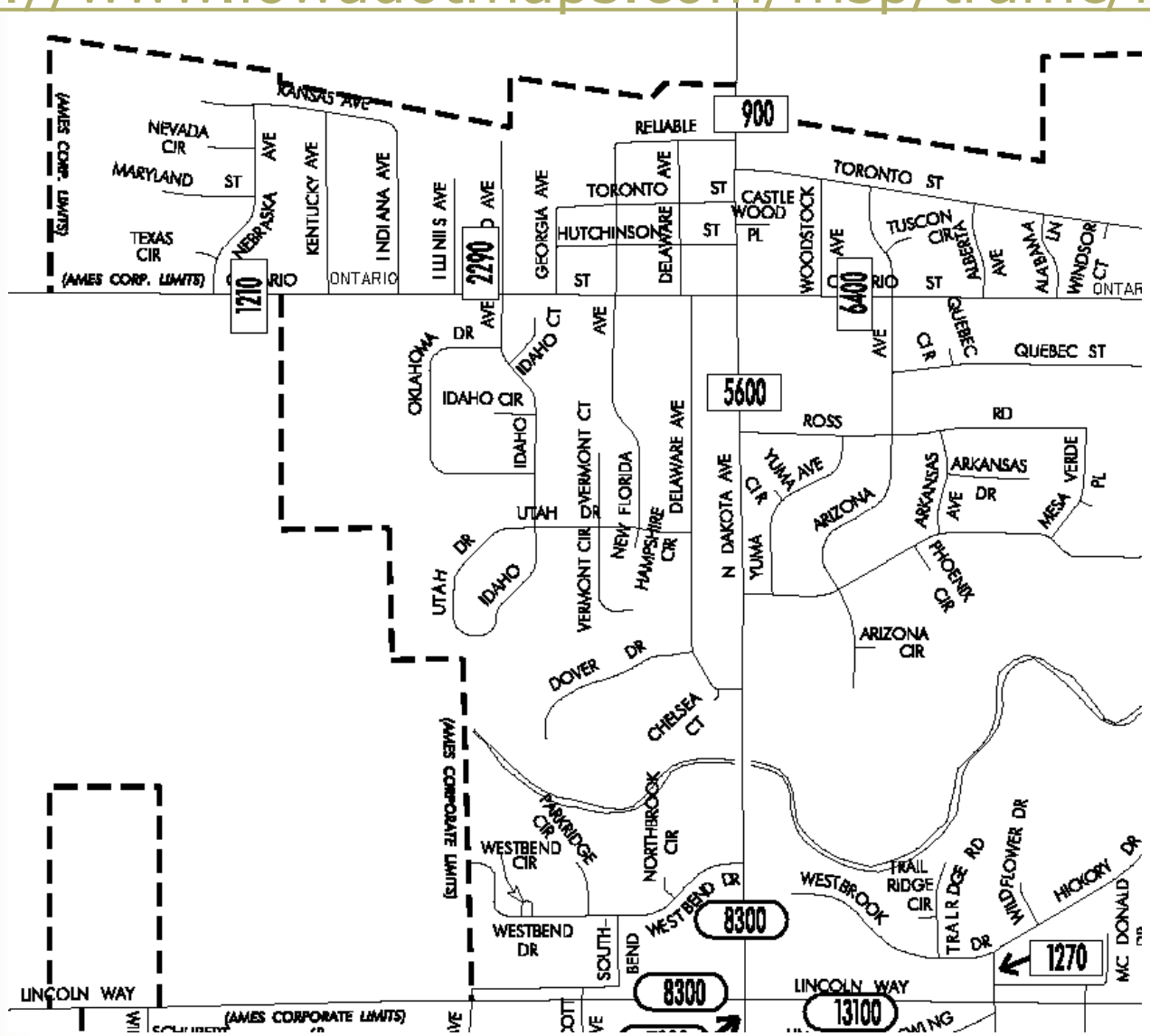
Counting Program

- To satisfy the traffic volume data needs for all roads under a particular jurisdiction, we establish a **Counting Program**

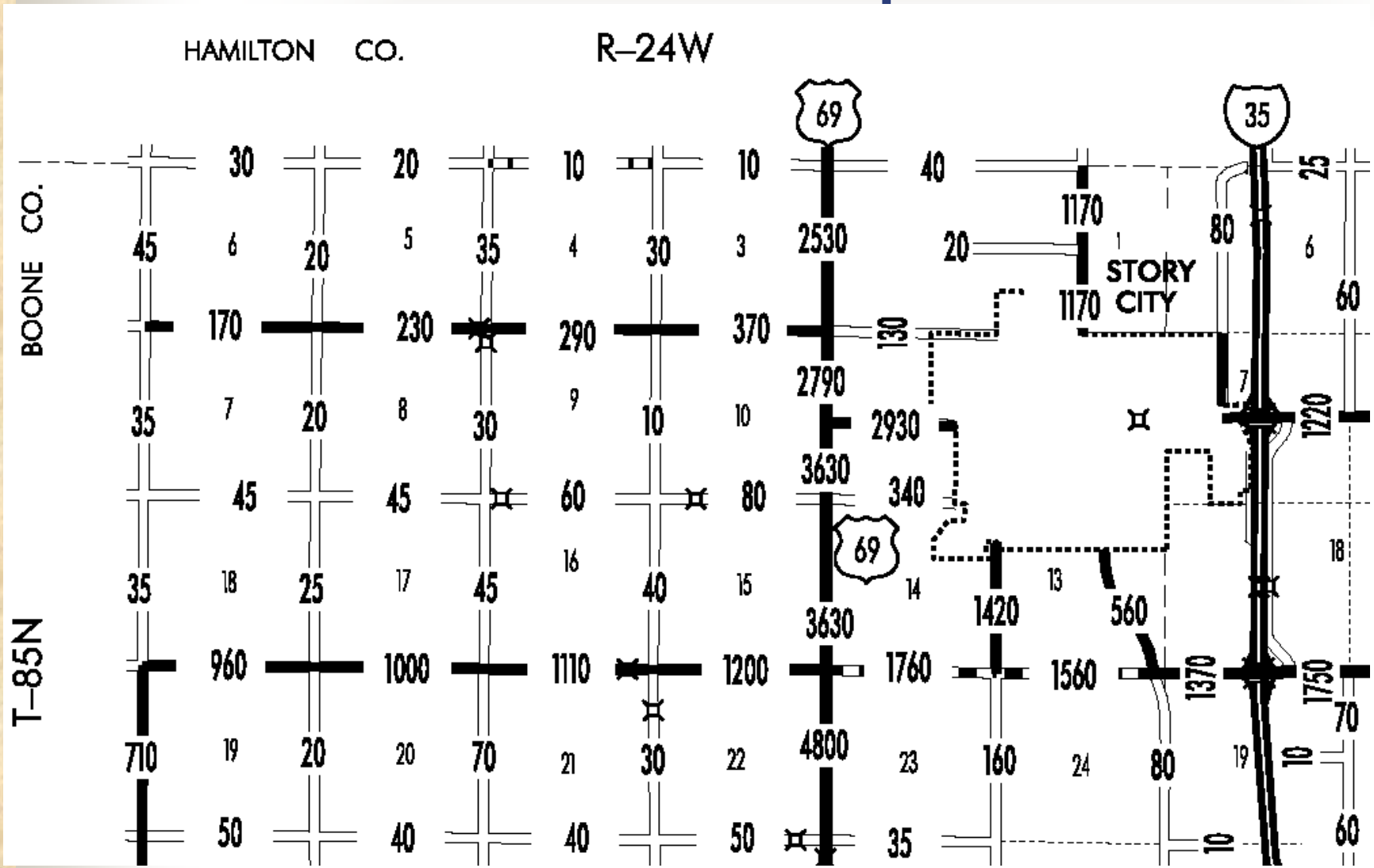
  A systematic pattern of counting at different times and locations

Traffic Counts Maps

http://www.iowadotmaps.com/msp/traffic/index.html



Traffic Counts Maps



Design Volume

- Usually hourly volume
- Which hour?
  - Average hourly volume – inadequate design
  - Maximum peak hour – not economical
  - Hourly volume used for design should not be exceeded very often or by very much
  - Usually use 30th highest hourly volume of the year
  - On rural roads 30 HHV is ~ 15% of ADT
  - Tends to be constant year to year

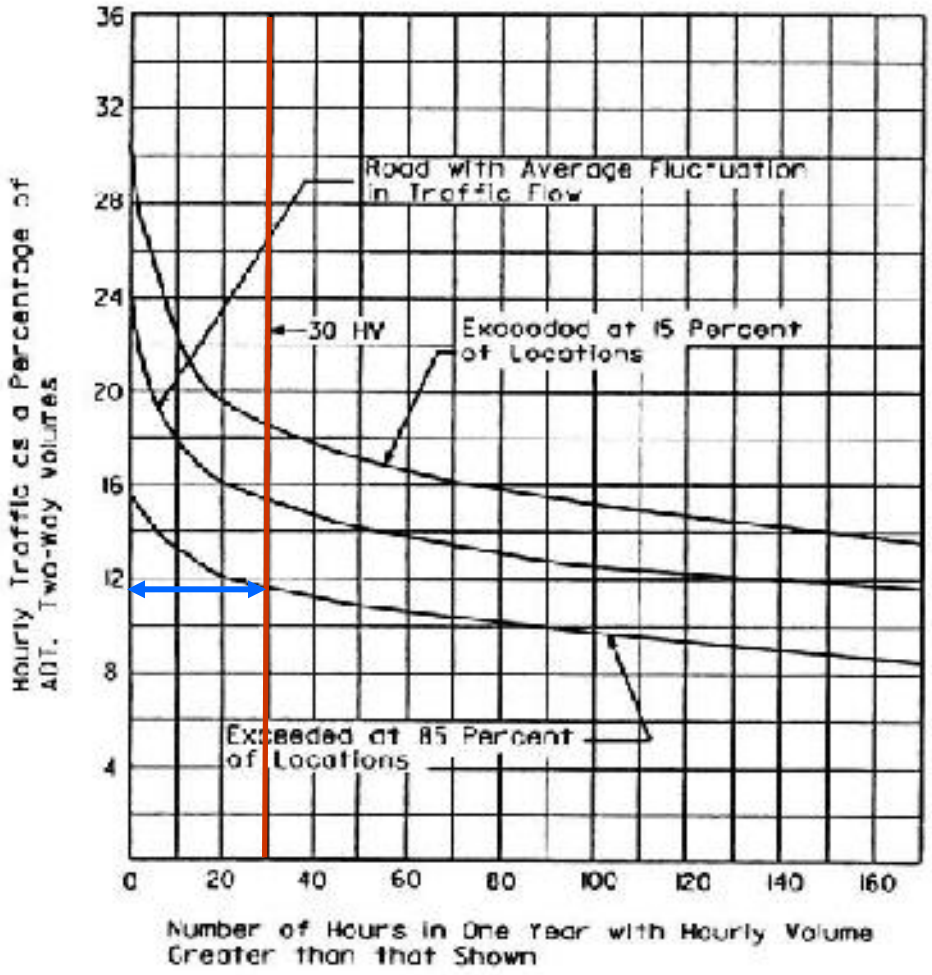
Traffic Demand

- Design Hourly Volume (DHV) – future hourly volume (both directions) used for design - typically 30th HHV (highest hourly volume) in the design year
- Why 30th HHV?
  - Breakpoint of 2-28
  - Compromise: too high is wasteful, too low poor operation
  - Approximately median weekly peak hour volume (top highest week peak hours)

(30th HHV exceed 29 times in year)

Traffic Demand (cont.)

3. Exhibit 2-28 relationship between HHV and percent of ADT in peak hour (referred to as K-factor)



Source: *A Policy on Geometric Design of Highways and Streets* (The Green Book). Washington, DC. American Association of State Highway and Transportation Officials, 2001 4th Ed.

Design Hourly Volume

DHV is a representation of peak hour traffic, usually for the future, or horizon year

K-factor represents proportion of AADT that occurs in the 30th HHV

$$\text{K-factor} = \frac{\text{DHV}}{\text{AADT}} \times 100$$

K = 8 to 12% urban, 12 to 18% rural

Design Hourly Volume (Example)

If AADT is 3500 vpd and the 30th highest hourly volume for the year is 420 vph what is the K-factor for that facility?

$$\text{K-factor} = \frac{\text{DHV}}{\text{AADT}} \times 100$$

$$\text{K-factor} = \frac{420}{3500} \times 100 = 12$$

Question: What's the impact of choosing different K factor for design?

If AADT is 3500 vpd, how will the design volume differ for K-factor = 8% vs. 12%?

$$DHV = \frac{\text{K-factor x AADT}}{100}$$

$$DHV_{k=8\%} = \frac{8 \times 3500}{100} = 280 \text{ vph}$$

$$DHV_{k=12\%} = \frac{12 \times 3500}{100} = 420 \text{ vph}$$

(diff of 140 veh)

Traffic Demand (cont.)

- D = directional distribution = one way volume in peak direction (expressed as a percentage of two-way traffic) Rural 55 to 80%
- Can also adjust for how traffic is distributed between lanes (e.g., 3 lanes, highest/outside lane may be 40% of total directional flow)

Directional Distribution (example)

If traffic is directionally split 60/40, what is directional distribution of traffic for previous example (Design hourly volume = 420 veh/hr)?

Directional Design Hourly Volume (DDHV) =

0.6 x 420 = 252 veh/hr

Notice we use 0.6 not 0.4!!

Traffic Demand (cont.)

- T = percentage of heavy vehicles during design hour (Iowa interstate 35% plus)
- Affects capacity, ability to pass on two-lane rural roads, etc.
- Larger, occupy more space
- Should determine % during design hour (truck patterns may not be same as passenger vehicles)

Peak Hour Factor (PHF)

$$PHF = \frac{\text{peak-hour volume}}{4(\text{peak 15-min volume})}$$

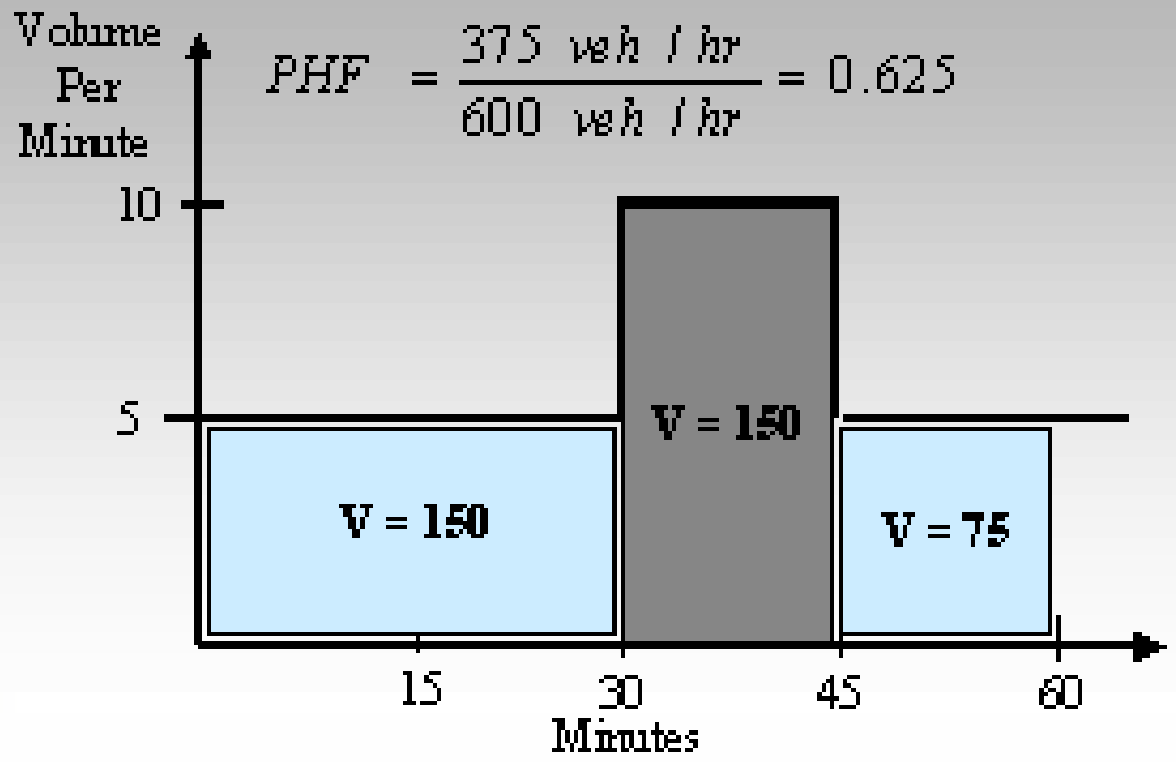
Flow is not uniform throughout an hour

HCM considers operating conditions during most congested 15-minute period of the hour to determine service level for the hour as a whole

Peak Hour Factor

$$PHF = \frac{hourly\ \ volume}{peak\ 15\ min\ \ flow\ \ rate}$$

$$PHF = \frac{375\ veh\ /\ hr}{600\ veh\ /\ hr} = 0.625$$



$$DHV = \frac{\text{Peak-Hour Volume}}{PHF}$$

Example

Peak hour volume from previous = 375 vph

PHF = 0.625

$$DHV = \frac{375}{0.625} = \mathbf{600\ vph}$$

Note: the traffic you design for is the busiest 15 minutes during the peak hour … another way to think of it is 150 vehicles per 15 minutes = 600 vehicles per 60 minutes