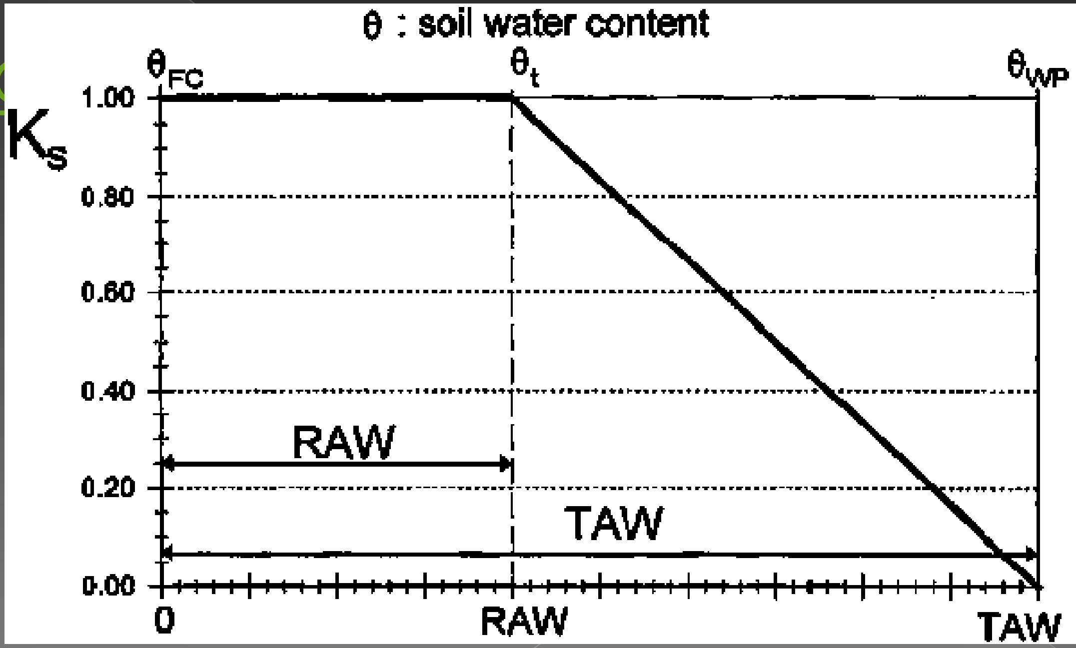
Impacts of water stress on ET

- ET is only affected by Water stress when readily available water (RAW) is depleted
- Grow it is restricted, we want to avoid this if possible
- http://www.fao.o... 0e0e.htm



Additional adjustments to Kc

-
- http://www.fao.org/docrep/x0490e/x0490e0b.htm

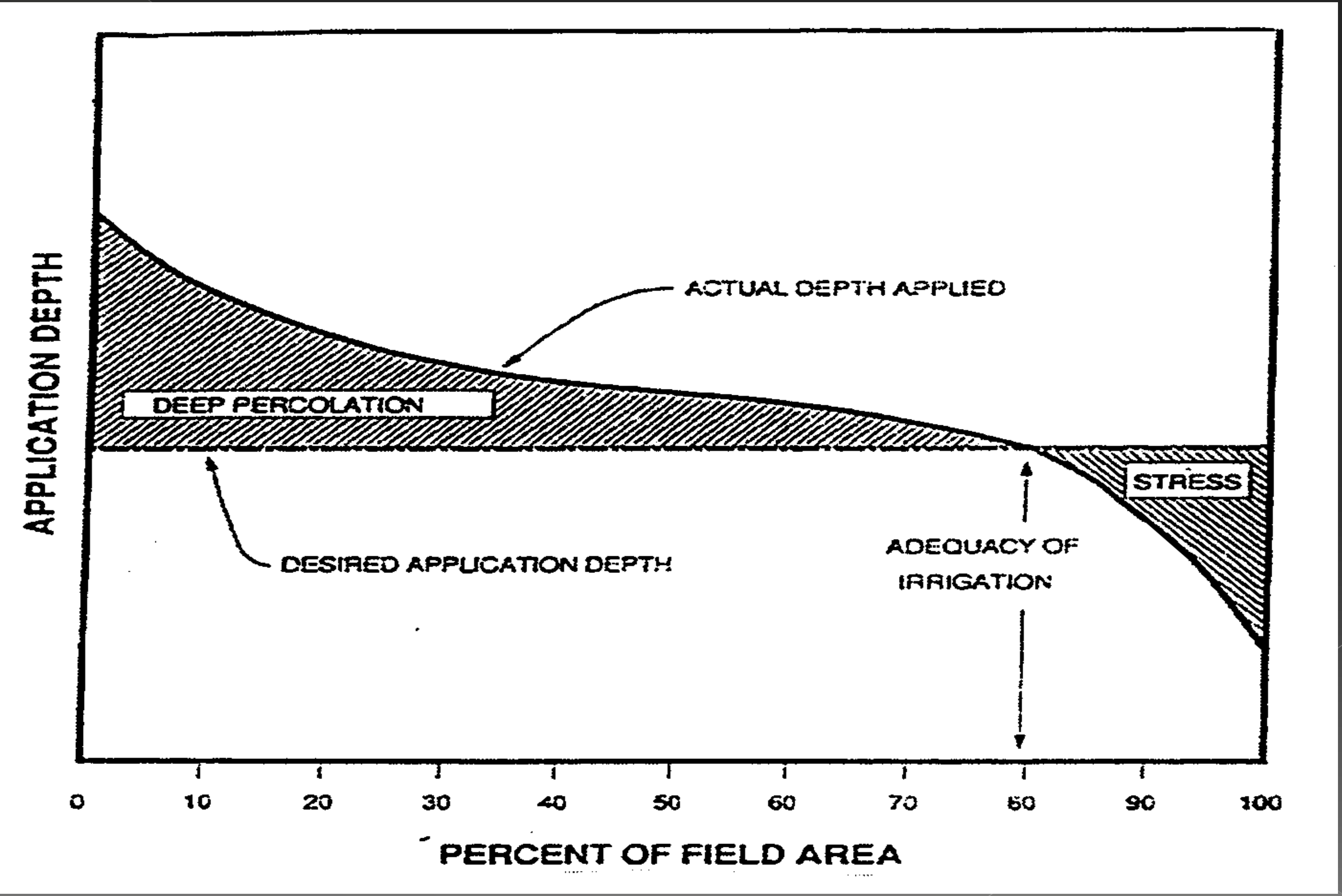
Efficiencies and Uniformities

- Application efficiency (E_a)

$$E_a = \frac{d_n}{d_g}$$

  - d_n = net irrigation depth
  - d_g = gross irrigation depth
  - fraction or percentage
- Water losses
  - Evaporation
  - Drift
  - Runoff
  - Deep percolation

Water Losses



Application Uniformity

- Distribution uniformity (DU)

$$DU = 100\left[\frac{d_{LQ}}{d_Z}\right]$$

  - d_{LQ} = average low-quarter depth of water received
  - d_Z = average depth applied
- Popular parameter for surface irrigation systems in particular

Application Uniformity Cont'd…

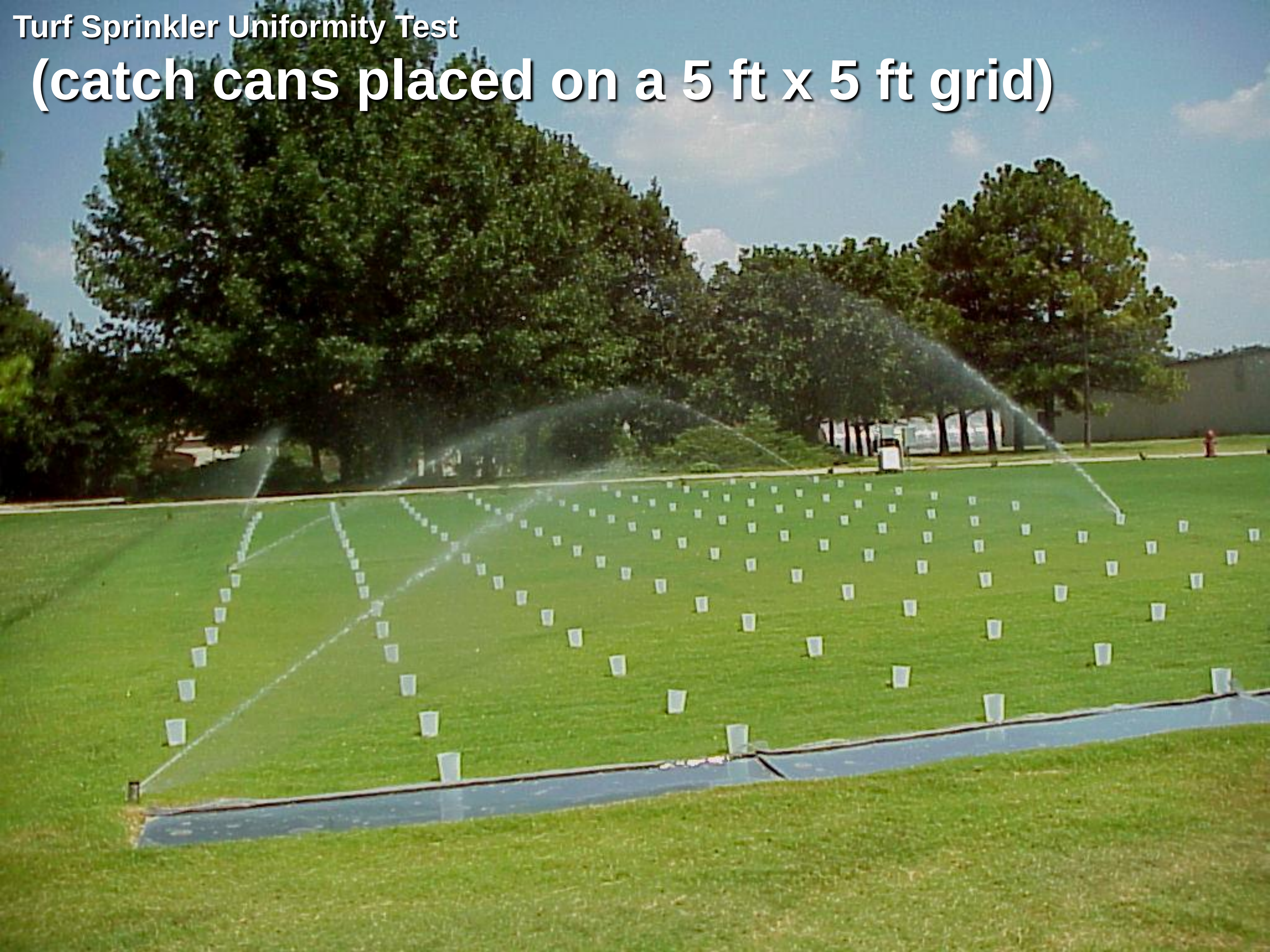
- Christiansen's Coefficient of Uniformity (CU)

$$CU = 100\left[1 - \sum_{i=1}^{n} \frac{|d_z - d_i|}{n d_z}\right]$$

  - n = number of observations (each representing the same size area)
  - d_z = average depth for all observations
  - d_i = depth for observation i
- Popular parameter for sprinkler and microirrigation systems in particular
- For relatively high uniformities (CU > 70%),

Turf Sprinkler Uniformity Test

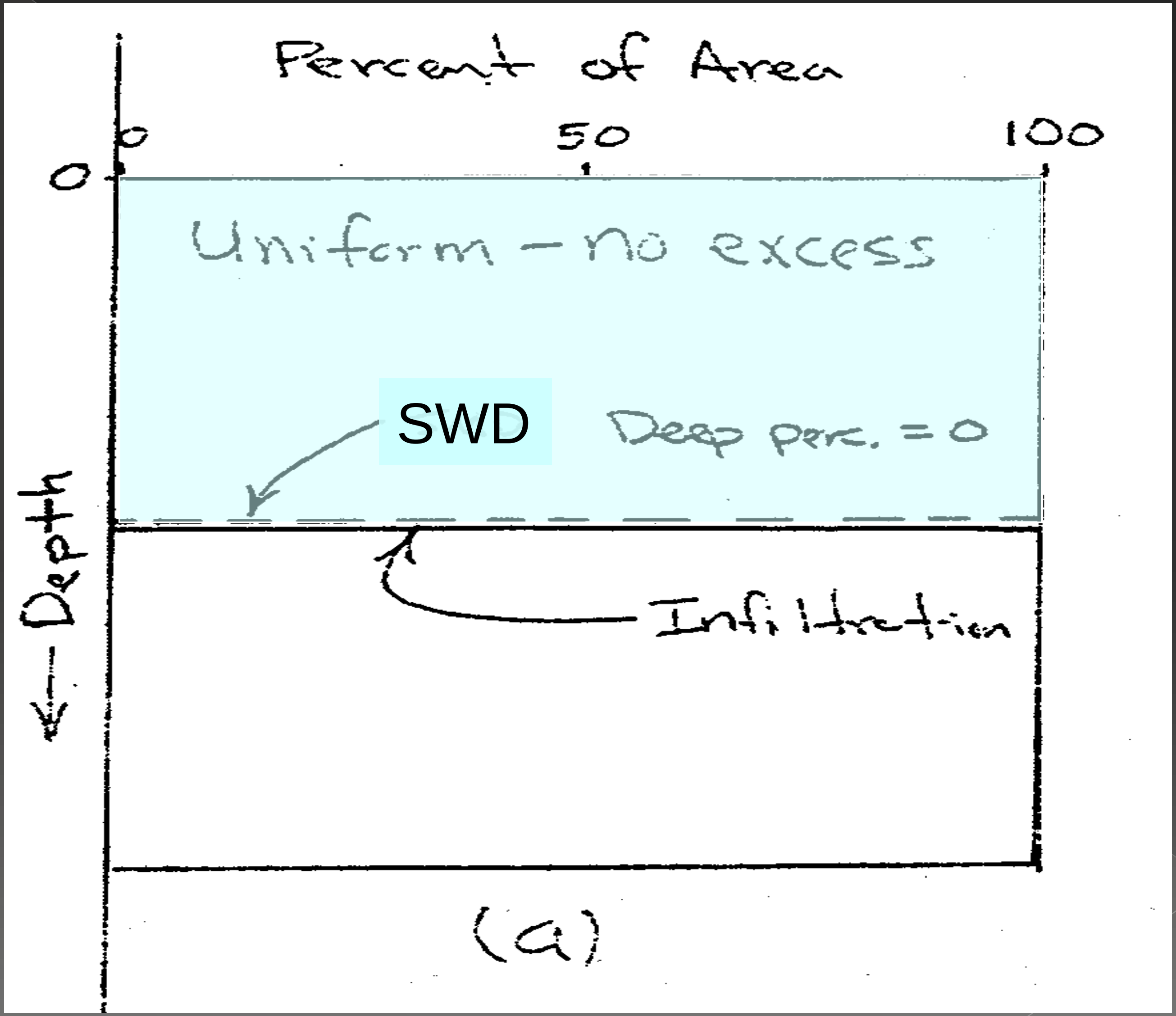
(catch cans placed on a 5 ft x 5 ft grid)



Adequacy

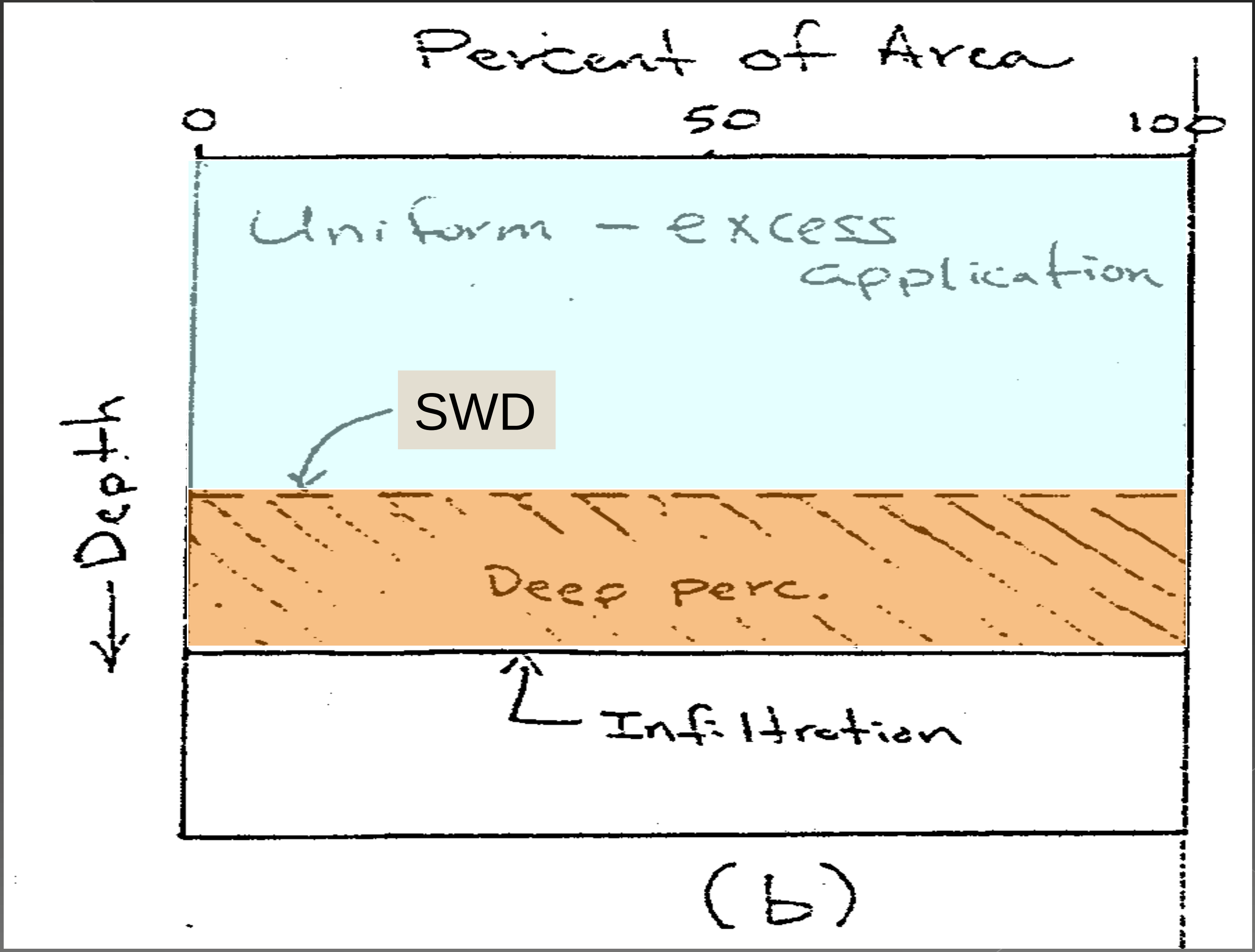
- Because of nonuniformity, there is a tradeoff between excessive deep percolation and plant water stress
- Adequacy: the percent of the irrigated area that receives the desired depth of water or more

Figure 5.3a



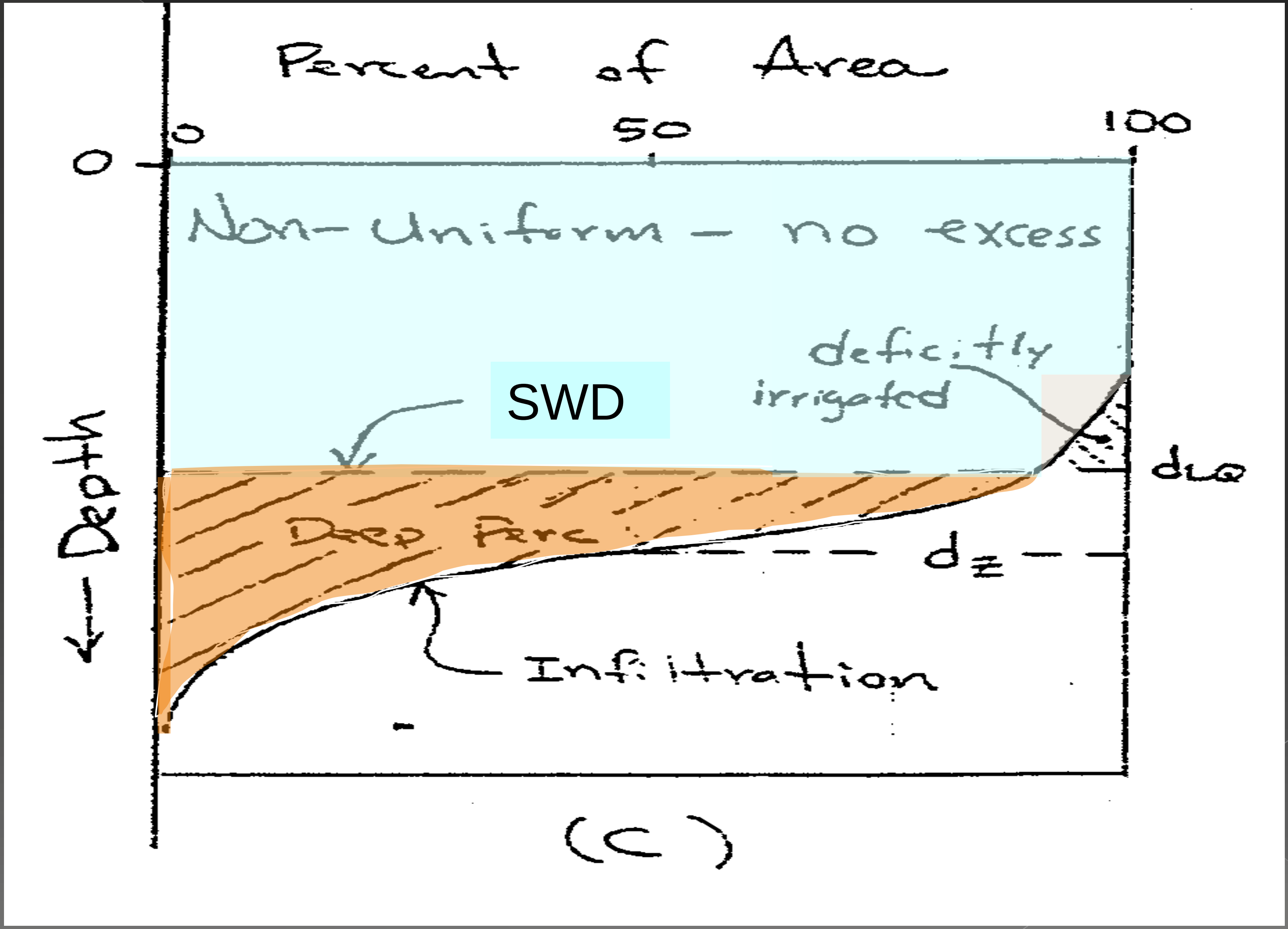
Percent of Area
0
50
100
0
Uniform – no excess
SWD
Deep perc. = 0
Infiltration
← Depth
(a)

Fig 5.3b



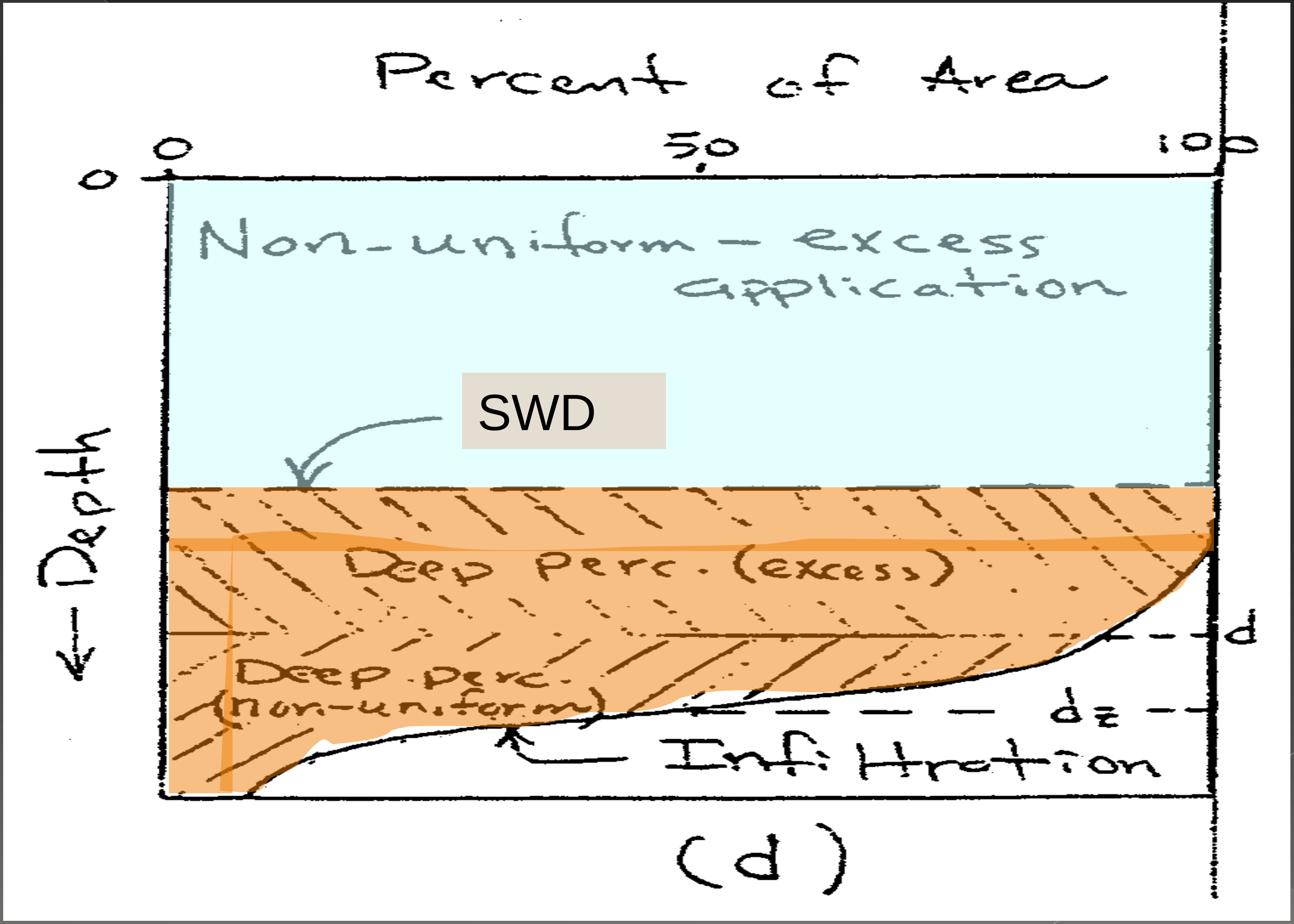
Percent of Area
0
50
100
Uniform - excess application
SWD
Deep perc.
Infiltration
Depth
(b)

Figure 5.3c



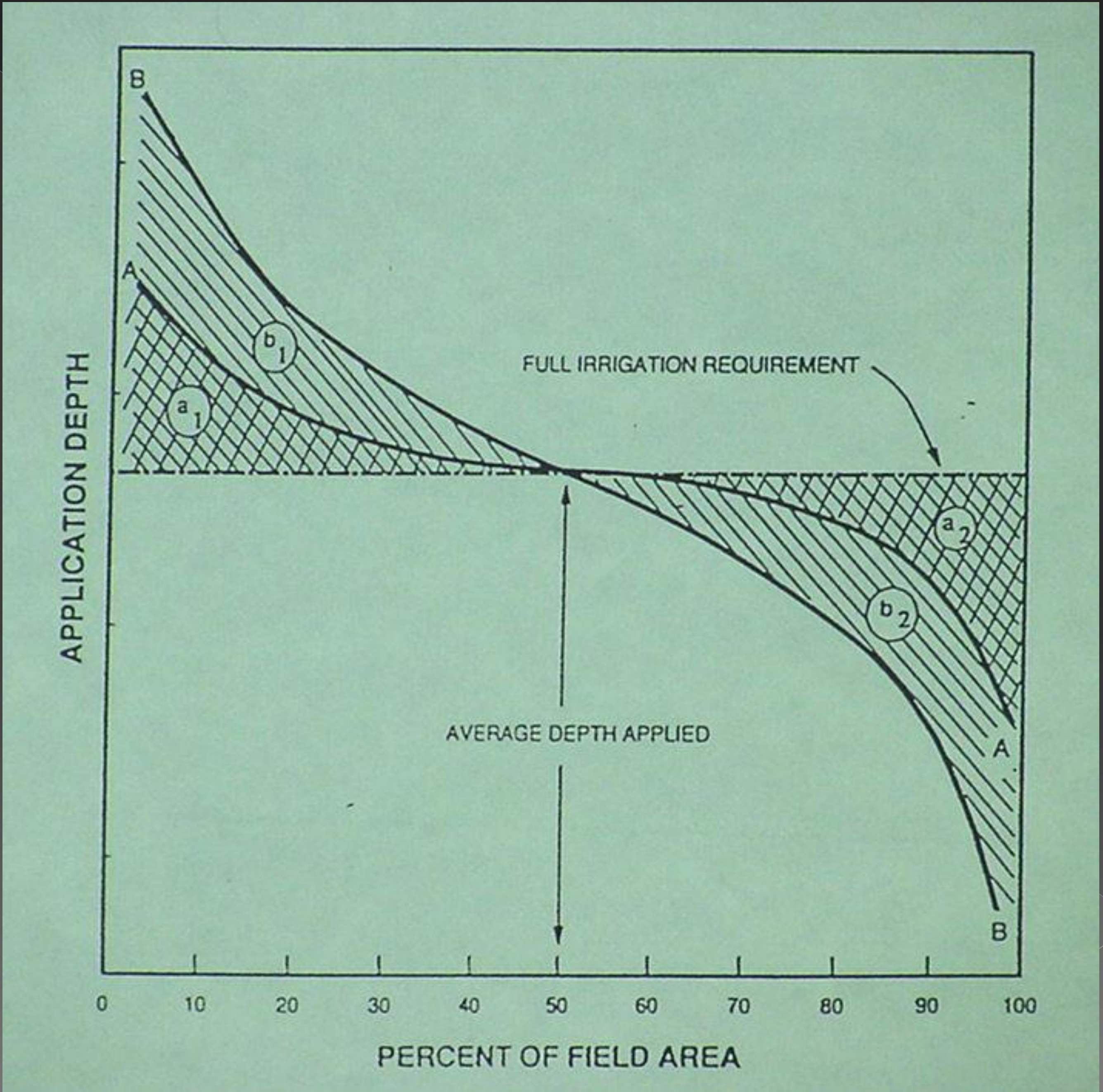
Percent of Area
0
50
100
0
Non-Uniform – no excess
deficitly irrigated
SWD
Depth
Deep Perc
d_{LQ}
d_z
Infiltration
(c)

Figure 5.3d

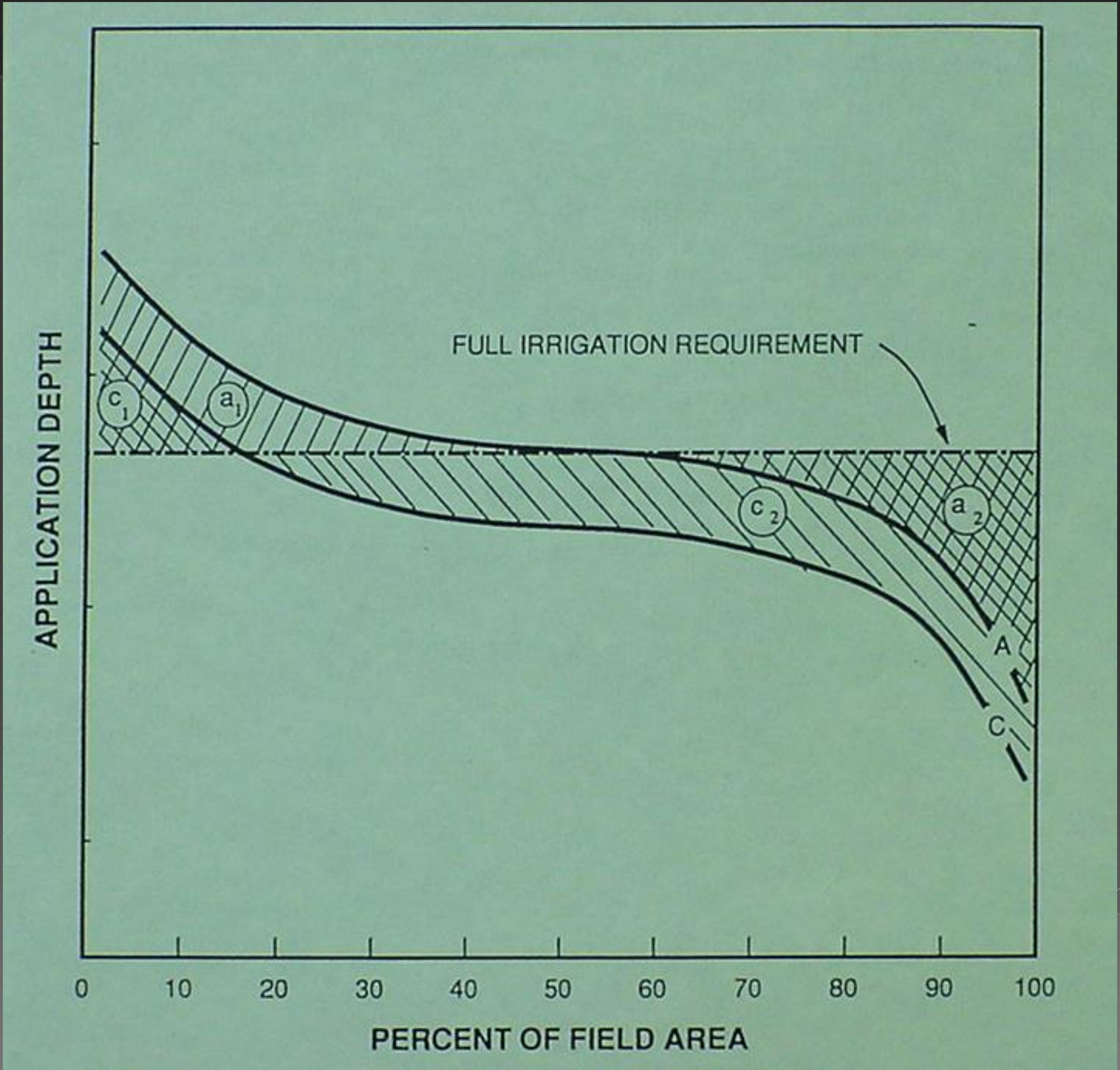


Percent of Area
0
50
100
0
Depth
Non-uniform – excess application
SWD
Deep Perc. (excess)
Deep Perc. (non-uniform)
d
dz
Infiltration
(d)

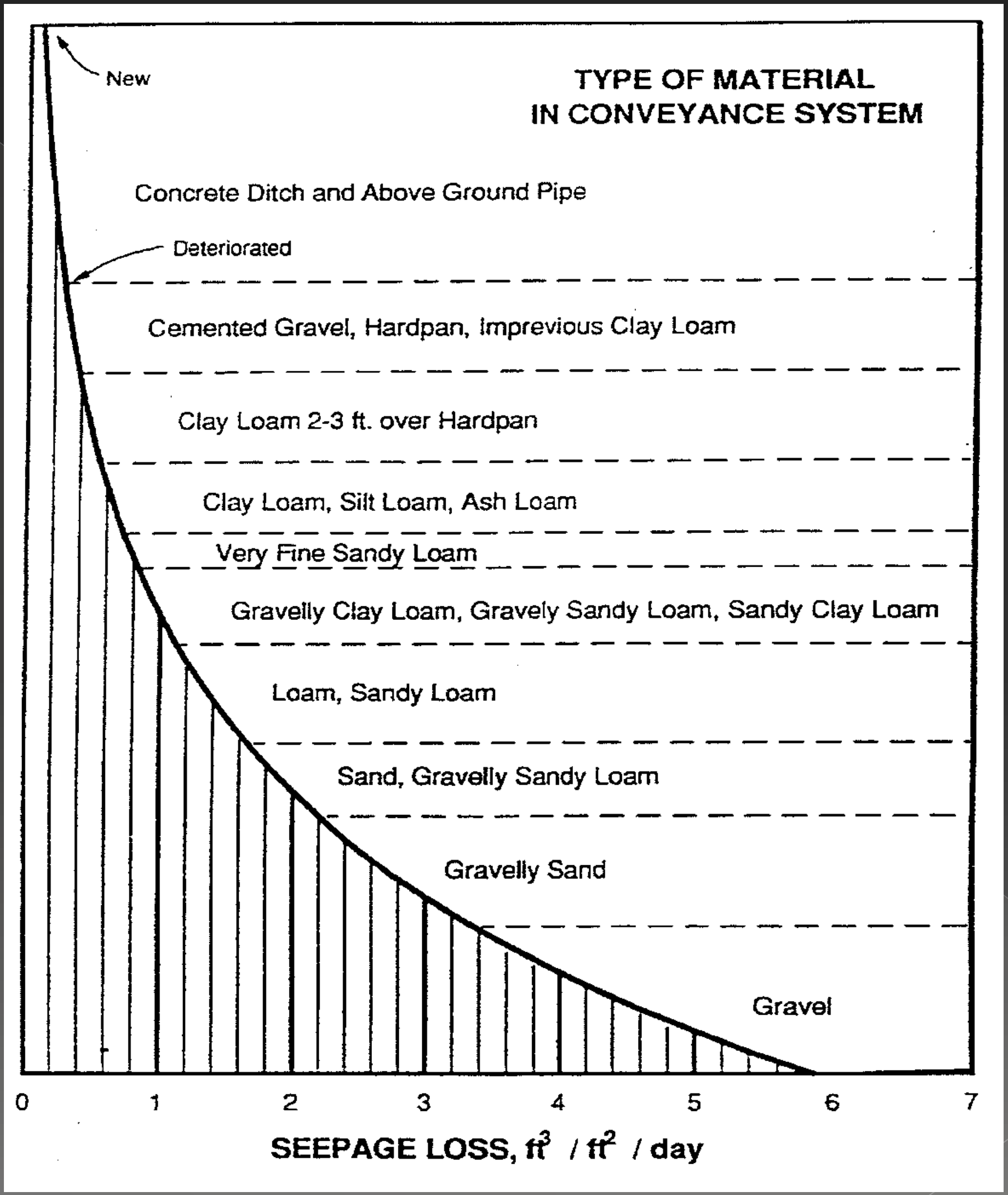
Same adequacy but different uniformities and Ea's



Same uniformity but different adequacies and Ea’s



Conveyance Losses



Application Efficiency of The Low Quarter (AELQ)

- Ratio of the average low-quarter depth of water that infiltrates and is stored in the crop root zone relative to the average depth of water applied (x 100 for %)
- AELQ = DU when all applied water infiltrates
- Also AELH (low-half)
- Accurate rules of thumb
  - for 90% adequacy, apply a gross depth = (desired net depth)/AELQ (acceptable for higher-valued crops)
  - For 80% adequacy, apply a gross depth = (desired net depth)/AELH (acceptable for lower-valued crops)

System Capacity

- Net system capacity (Q_n)
  - Function of plant needs (keep soil water balance above some specified level)
  - The rate at which water must be stored in the root zone
- Peak ET method:
  - Provide enough capacity to meet peak ET over a given time period
- Less conservative method:
  - Recognize that rainfall and/or soil water can allow a reduced capacity
  - Water stored in the soil can provide a buffer over short time periods
  - Also, over longer time periods, concept of an allowable depletion (AD) -- amount of water that can be depleted from the soil before plant stress occurs

System Capacity

- Gross system capacity (Q_g)
  - The rate at which water must be supplied by the water source
  - A function of:
    - the net system capacity, Q_n
    - the efficiency of the irrigation system
    - the system downtime

System Capacity

- Definition
  - Required system capacity is the water supply rate that must be provided to prevent plant water stress (may or may not = actual system capacity)
  - Units could be inches per day or gpm per acre or gpm over a given area (Q_n & Q_g must be in consistent units)

$$Q_g = \frac{Q_n}{\frac{AELQ}{100}\left(1 - \frac{D_t}{100}\right)}$$

  - Q_g = gross system capacity, in/day or gpm/A
  - Q_n = net system capacity, in/day or gpm/A
  - AELQ = application efficiency of low quarter, (%)
  - D_t = irrigation system downtime (%)

- Q_n=4gpm/acre=0.2 inches/day
- AELQ=80%
- D_t=1
- Q_g=5 gpm/acre
  - =625gpm/pivot
- If AELQ=70
- Then Q_g=5.8 gpm/acre
  - =725 gpm/acre
- AELQ includes application efficiency and uniformity

$$Q_g = \frac{Q_n}{\frac{AELQ}{100}\left(1 - \frac{D_t}{100}\right)}$$

Operational Terminology

- Set or zone:
  - Smallest portion of the total area that can be irrigated separately
- Application time :
  - Length of time that water is applied to a set/zone
- Set time :
  - Time between starting successive sets in a field
    - Application time = set time if system is not stopped to change sets (automated vs. manual systems

Operational Terminology

- Cycle time or irrigation interval:
  - Length of time between successive irrigations
- Idle time:
  - Time during the irrigation interval that the system is not operated
- Duration:
  - Time that water is provided to the farm by an irrigation district
- Rotation:
  - Time between times when the water is provided by the district

Irrigation Scheduling

General Approaches

- Maintain soil moisture within desired limits
  - direct measurement
  - moisture accounting
- Use plant status indicators to trigger irrigation
  - wilting, leaf rolling, leaf color
  - canopy-air temperature difference
- Irrigate according to calendar or fixed schedule
  - Irrigation district delivery schedule
  - Watching the neighbors

Yield/Appearance vs. ET_c