Irrigation Training Toolbox
Water Management

QT = DA

National Employee Development Center
Natural Resources Conservation Service
Fort Worth, Texas
October 1996

LESSON PLAN

COURSE:	IRRIGATION WATER MANAGEMENT
LESSON TITLE:	QT=DA
DEVELOPED BY:	Charles Schmitt
OBJECTIVES:	Understand the relationship of water flow rate, time and volume
REFERENCES:	NEH, SCS; NebGuide
TRAINING AIDS:	Overheads
ARRANGEMENTS:	
TIME REQUIRED:	1.5-2.0 Hours

QT=DA

IRRIGATION FLOW/TIME/VOLUME RELATIONSHIPS

1. Introduction

To this point in the training we have reviewed the concepts of soil, water, plant relationships. The water holding capacity of soil, plant evaporation (ET) and the need and amount of irrigation have been discussed. We now need to relate this information to the irrigation water supply and distribution system.

For a given water supply and distribution system we need to know how long (time) for a given area or how much (area) for a given time we need to irrigate to replenish the water used. We may also need to know if the water supply and distribution system is adequate for the plant needs with the given soil texture; if not, a deficit irrigation situation may exist.

2. Conversion of Flow Rate to Volume

a. Flow-Volume Relationship

Overhead #1

$$\text{Flow Rate (Q) x Time (T)} = \text{Volume (V)}$$

$$Q\ (ft^3/sec) \times T\ (sec) = V\ ft^3$$

b. Development of Conversion Factors

Determine the volume of water supplied by a well pumping for 12 hours

$$V = Q \times T$$

$$V = \frac{1\ ft^3}{sec} \times \frac{60\ sec}{min} \times \frac{60\ min}{hr} \times 12\ hr$$

$$V = 43{,}200\ ft^3$$

What is this volume in acre-ft (depth of water in feet per acre of area)?

Blackboard

$$V = 43{,}200\ ft^3 \times \frac{1\ acre}{43{,}560\ ft^3}$$

$$V = .992\ \text{acre-ft} \approx 1\ \text{acre-ft}$$

Blackboard

What is the volume in acre-inches?

$$V = .992 \text{ acre-ft} \times \frac{12 \text{ in.}}{1 \text{ ft.}}$$

$$V = 11.9 \text{ acre-in} \div 12 \text{ acre-in.}$$

Blackboard

What is the volume of water supplied from a 1 cfs well in 1 hour in acre-inches.

$$V = Q \times T$$

$$V = \frac{1 \text{ ft}^3}{\text{sec}} \times \frac{60 \text{ sec}}{\text{min}} \times \frac{60 \text{ min}}{\text{hr}} \times 1 \text{ hr} \times \frac{12 \text{ in}}{\text{ft}} \times \frac{1 \text{ acre}}{43{,}560 \text{ ft}^3}$$

$$V = .992 \text{ acre-inches} \div 1 \text{ acre-inch}$$

From the above example it can be shown that a water source delivering:

-1 cfs for 1 hour will supply a volume of 1 acre-inch of water.

-1 cfs for 12 hours will supply a volume of 1 acre-foot of water.

-1 cfs for 1 day will supply a volume of 2 acre-feet of water.

-1 cfs = 1 acre-in/hr = 1 acre-ft/12 hrs = 2 acre-ft/day.

Overhead #2

CLASS PROBLEM

Problem No. 1

What volume of water is supplied in 18 hours if an irrigation canal supplies 3.5 cfs to the field? (Use the conversion factors)

Problem No. 2

What volume of water is supplied by a well pumping 1200 gpm over a 36 hour time period? (449 gpm = 1 cfs)

Problem No. 3

A well pumping 900 gpm has a "totalizer" flow meter which indicates that 200,000 gallons have been pumped. How many acre inches have been pumped? (1 ft^3 = 7.48 gallons) Hint: Remember what the totalizer is doing to the flow over time.

3. Volume, Depth, Area Relationship (QT=DA)

a. Basic Relationships

A basic formula to remember is $Q \times T = D \times A$

Overhead #3
Ref. NEH is Ch.3
NebGuide G78-393

Where
D = gross depth of water applied in inches
A = area to be irrigated in acres
Q = flow in cfs
T = time in hours

This formula relates the volume of water delivered to the field to the application depth for the irrigated area. The above relationship is true using gross application. The relationship showing net application and efficiency will be shown later.

The above equation is based on volume balance and is independent of soil intake and advance parameters. It **assumes** a uniform application depth over the irrigated area. Applying the right amount of water to the irrigated area does not guarantee efficient irrigation. Water also must be uniformly applied over the irrigated area. The relationships affecting the uniform application and volume balance will be further discussed in the furrow uniformity and sprinkler sections of this training.

In order to compute the gross application depth, acres irrigated, and time required, a reliable and known flow rate needs to be known. Flow rates should be determined from the methods previously mentioned. Variability in the flow rate can have significant effects on application depth if no adjustments are made to the other variables (ie longer irrigation, smaller areas irrigated). The importance of measurement of the flow rate throughout the individual irrigation and the flow rate throughout the season cannot be stressed enough.

Other derivations of the volume balance equation can be found and are listed below for your reference.

Overhead #4
Ref. NEH is Ch. 3

$$Q \times T = 453 \times A \times D$$

Where:
Q= flow rate in gpm
all other parameters are as defined above.

15

Overhead #5
Ref. NebGuide G91-1021

Where:
q = the furrow stream size in **gpm**
w = distance between watered furrows in **inches**
l = length of furrow in feet
all other parameters are as defined above.

EXAMPLES

Blackboard

1. How long would it take for a 1200 well to apply 4 inches of water on 48 acres?

$$T = D \times A \div Q$$

$$T = (4 \text{ in} \times 48 \text{ acres}) \div (1200 \text{ gpm} \times \frac{1 \text{cfs}}{449 \text{ gpm}} \times \frac{1 \text{ ac-in}}{\text{hr}} \div 1 \text{ cfs})$$

$$T = 71.8 \text{ hours}$$

2. How many inches would be applied to the 48 acres above in 48 hours?

$$D = Q \times T \div A$$

$$D = (1200 \text{ gpm} \times \frac{1 \text{ cfs}}{449 \text{ gpm}} \times \frac{1 \text{ ac-in}}{\text{hr}} \div 1 \text{ cfs} \times 48 \text{ hr}) \div 48 \text{ acres}$$

$$D = 2.67 \text{ inches}$$

3. What well capacity would be needed to apply 4 inches to the 48 acres in 48 hours?

$$Q = D \times A \div T$$

$$Q = (4 \text{ in.} \times 48 \text{ ac.}) \div 48 \text{ hours}$$

$$Q = \frac{4 \text{ ac-in}}{\text{hr}}$$

In cfs

$$Q = \frac{4 \text{ ac-in}}{\text{hr}} \times 1\text{cfs} \div \frac{1 \text{ ac-in}}{\text{hr}} = 4 \text{ cfs}$$

In gpm

$$Q = 4 \text{ cfs} \times \frac{449 \text{ gpm}}{1 \text{ cfs}} = 1796 \text{ gpm}$$

4. How many acres can be irrigated to apply 4 inches with 1200 gpm for 48 hours?

$$A = Q \times T \div D$$

$$A = \left(1200 \text{ gpm} \times \frac{1 \text{ cfs}}{449 \text{ gpm}} \times \frac{1 \text{ ac-in}}{\text{hr}} \div 1 \text{ cfs} \times 48 \text{ hr}\right) \div 4 \text{ inches}$$

$$A = 32.1 \text{ acres}$$

CLASS PROBLEM

Problem No. 4

If a gross application of 3 inches is required and the water is being supplied by a canal system is 2.5 cfs. How many acres could be irrigated in two days?

b. Variability in Flow Rate

As previously stated variability of the flow rate can have significant effect on the depth of application.

EXAMPLE

5. If the 1200 gpm well in the previous example drops production to 900 gpm in August what application depth will be supplied if the pump operates 48 hours on the 48 acre field?

Blackboard

$$D = Q \times T \div A$$

$$D = \left(900 \text{ gpm} \times \frac{1 \text{ cfs}}{449 \text{ gpm}} \times \frac{1 \text{ ac-in}}{\text{hr}} \div 1 \text{ cfs} \times 48 \text{ hr}\right) \div 48 \text{ acres}$$

$$D = 2.00 \text{ inches}$$

This shows the importance of knowing well capacity or canal flow rate throughout the season. If the flow rate decreases the length of irrigation must be increased or the area irrigated must be decreased.

CLASS PROBLEM

Problem No. 5

From the previous example (well capacity 900 gpm) what is the maximum area that could be irrigated in order to supply a 4 inch gross application in 48 hours?

L10

CLASS PROBLEM

Problem No. 1

What volume of water is supplied in 18 hours if an irrigation canal supplies 3.5 cfs to the field? (Use the conversion factors)

$V = Q \times T$

$V = 3.5 \text{ cfs} \times \frac{1 \text{ ac-in/hr}}{1 \text{ cfs}} \times 18 \text{ hrs}$

$V = 63 \text{ ac-in} = 5.25 \text{ ac-ft.}$

Problem No. 2

What volume of water is supplied by a well pumping 1200 gpm over a 36 hour time period? (449 gpm = 1 cfs)

$V = Q \times T$

$V = 1200 \text{ gpm} \times \frac{1 \text{ cfs}}{449 \text{ gpm}} \times \frac{1 \text{ ac-in/hr}}{1 \text{ cfs}} \times 36 \text{ hrs}$

$V = 96.2 \text{ ac-in} = 8.02 \text{ ac-ft.}$

Problem No. 3

A well pumping 900 gpm has a "totalizer" flow meter which indicates that 200,000 gallons have been pumped. How many acre inches have been pumped? (1 ft^3 = 7.48 gallons) Hint: Remember what the totalizer is doing to the flow over time.

$V = Q \times T$ = Volume from Totalizer

$V = 200{,}000 \text{ gal} \times \frac{1 \text{ ft}^3}{7.48 \text{ gal}} \times \frac{1 \text{ acre}}{43{,}560 \text{ ft}^2}$

$V = 0.61 \text{ ac-ft} = 7.4 \text{ ac-in}$

4. How many acres can be irrigated to apply 4 inches with 1200 gpm for 48 hours?

$$A = Q \times T \div D$$

$$A = (1200 \text{ gpm} \times \frac{1 \text{ cfs}}{449 \text{ gpm}} \times \frac{1 \text{ ac-in}}{\text{hr}} \div 1 \text{ cfs} \times 48 \text{ hr}) \div 4 \text{ inches}$$

$$A = 32.1 \text{ acres}$$

CLASS PROBLEM

Problem No. 4

If a gross application of 3 inches is required and the water is being supplied by a canal system is 2.5 cfs. How many acres could be irrigated in two days?

$$QT = DA$$

$$A = \frac{Q \times T}{D}$$

$$A = \frac{2.5 \text{ cfs} \times \frac{1 \text{ ac-in/hr}}{1 \text{ cfs}} \times 2 \text{ days} \times \frac{24 \text{ hr}}{1 \text{ day}}}{3 \text{ inches}}$$

$$A = 40 \text{ acres}$$

CLASS PROBLEM

Problem No. 5

From the previous example (well capacity 900 gpm) what is the maximum area that could be irrigated in order to supply a 4 inch gross application in 48 hours?

$$QT = DA$$

$$A = \frac{Q \times T}{D}$$

$$A = \frac{900\ \text{gpm} \times \frac{1\ \text{cfs}}{449\ \text{gpm}} \times \frac{1\ \text{ac-in/hr}}{1\ \text{cfs}} \times 48\ \text{hr}}{4\ \text{inches}}$$

$$A = 24.1\ \text{acres}$$