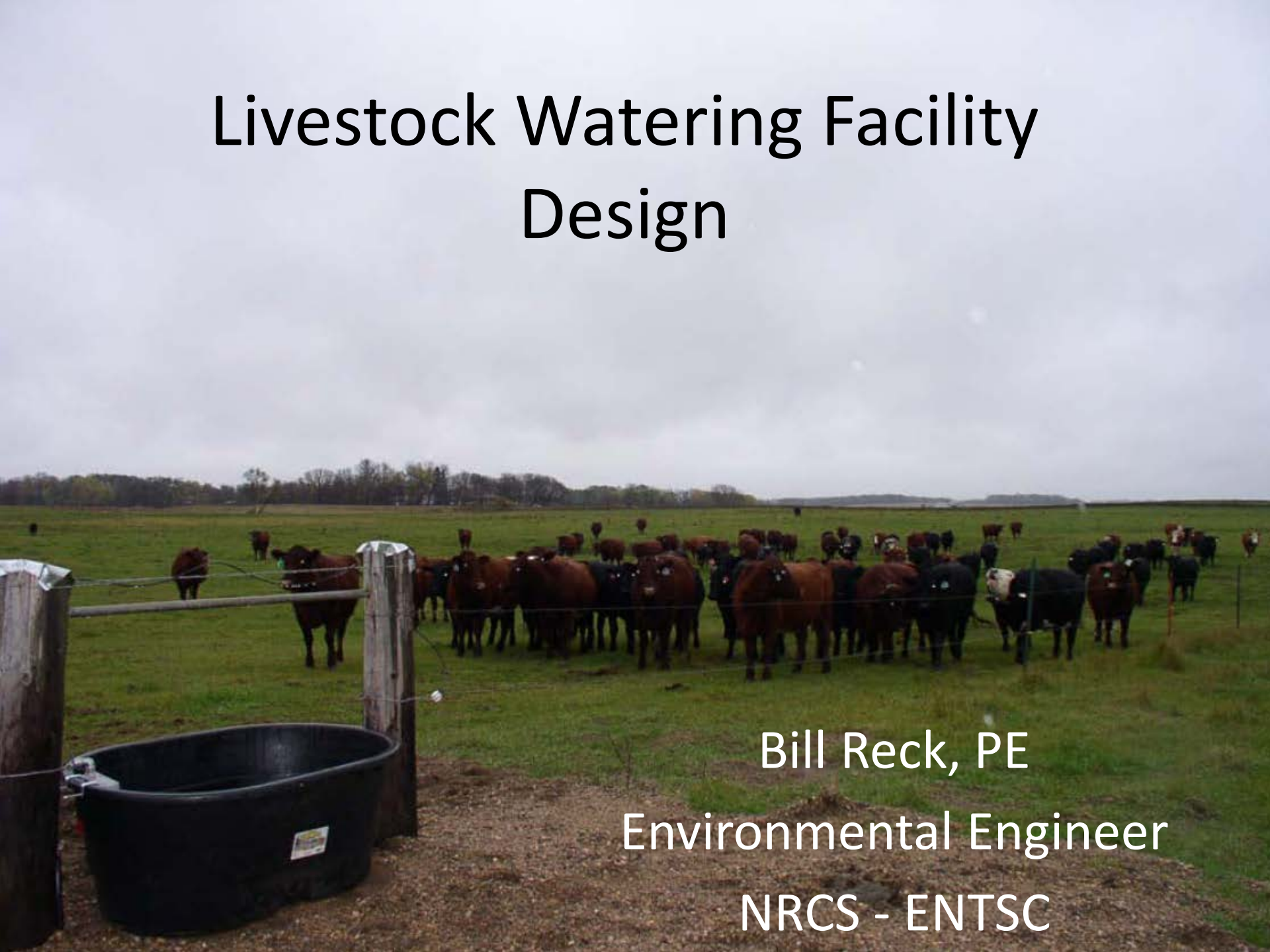
Livestock Watering Facility Design



Bill Reck, PE
Environmental Engineer
NRCS - ENTSC

ENTSC Webinars

- Watering Facilities for Managed Grazing Systems by Kevin Ogles and Michael Hall
- Windmills and Water Pumps for Livestock Water by Dr. Carlos Rosencrans

Outline

- Water Source
- Delivery System
  - Tank
  - Pump
  - Pipeline
  - Fittings
- Design

Sources

- Spring
- Stream
- Pond or lake
- Well
- Municipal
- Rainfall

Looking at your primary source

- Is a municipal source available?
  - What is the cost?
- Is well water reliable?

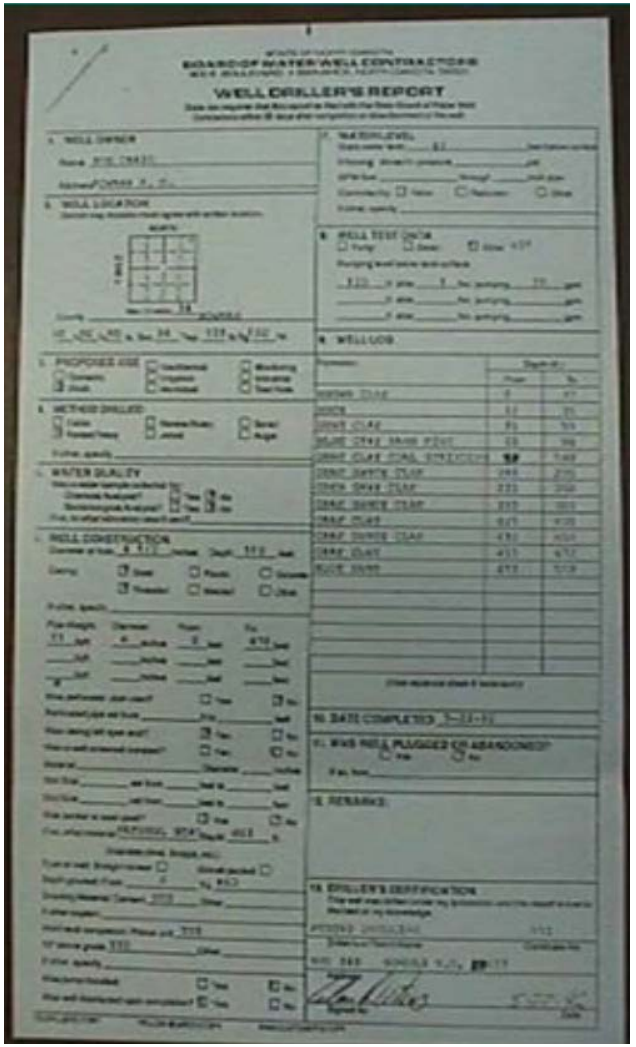
Spring

Stream

Pond

Well

- Well Driller Report
  - Delivery rate
  - Drawdown depth
- Condition



BOARD OF WATER WELL CONTRACTORS

WELL DRILLER'S REPORT

Watering Trough/Tank Size

- Large Tank
  - Large herd
  - Large paddocks
  - Rough terrain
  - Slow delivery of water
- Small Tank
  - Small herd
  - Small paddocks
  - Rapid delivery of water

Trough Size

- Is flow rate limited?
- Total Daily Demand
  - # animals * animal demand (gpd)
  - Size for percentage of demand (50% typical)
- Peak water demand
  - Daily Demand / # events / event time (gpm)
  - Size for an event

Kinds of Tanks

- Portable
- Permanent
- Frost proof
- Robust

Portable Tank

Portable Tank

Permanent Tank

Permanent Tank

Frost Proof

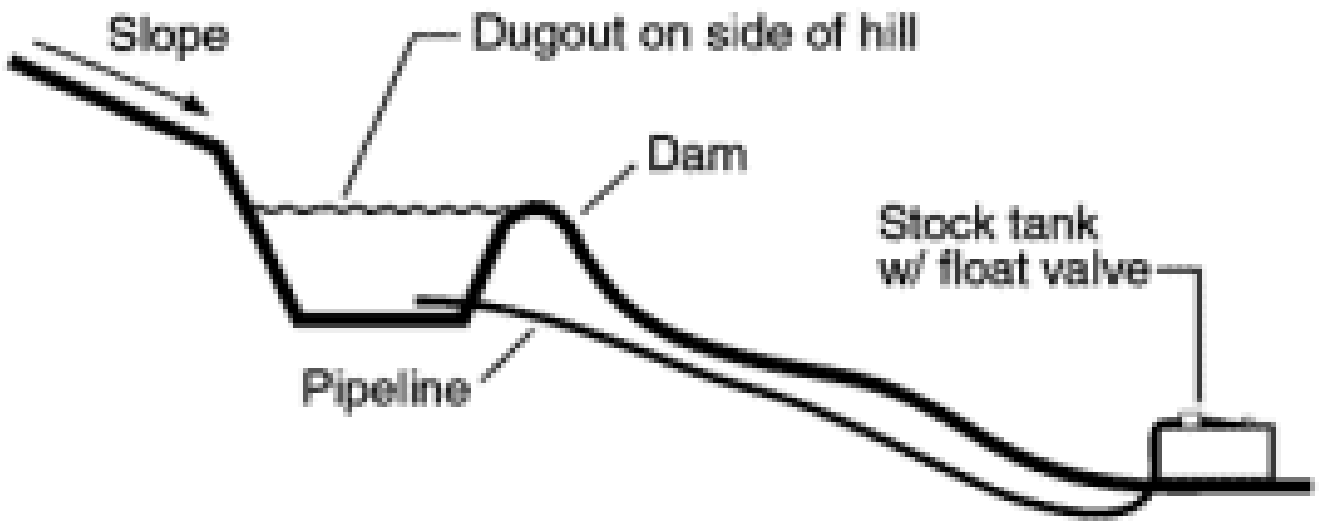
Frost Proof

Pipeline system pumping options

- Gravity feed systems
- Solar powered pumps
- Windmill pumping systems
- Gas or diesel powered pumps
- Electric powered pumps
- Municipal water supply

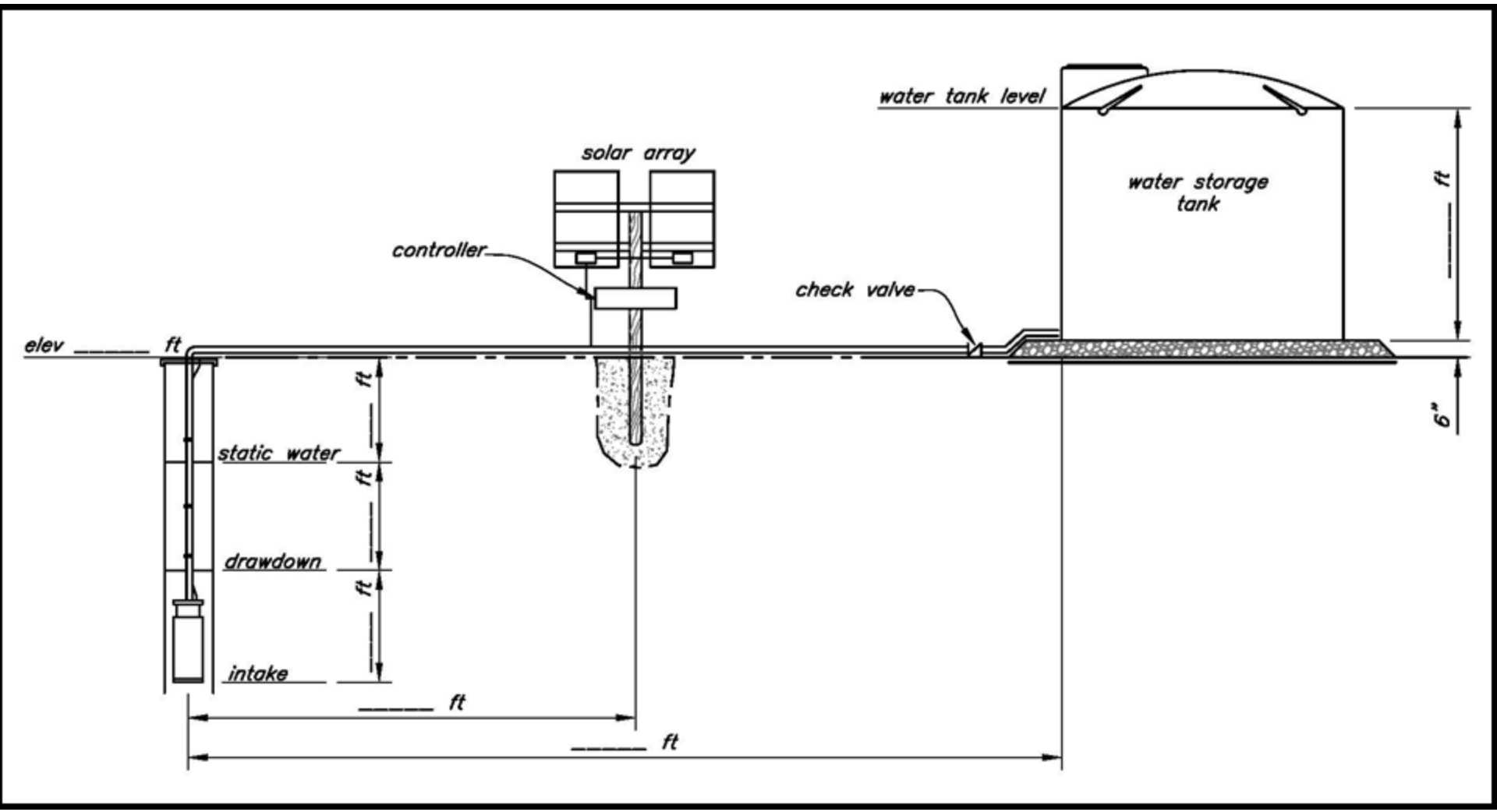
Gravity feed pumping systems

Gravity feed pumping systems



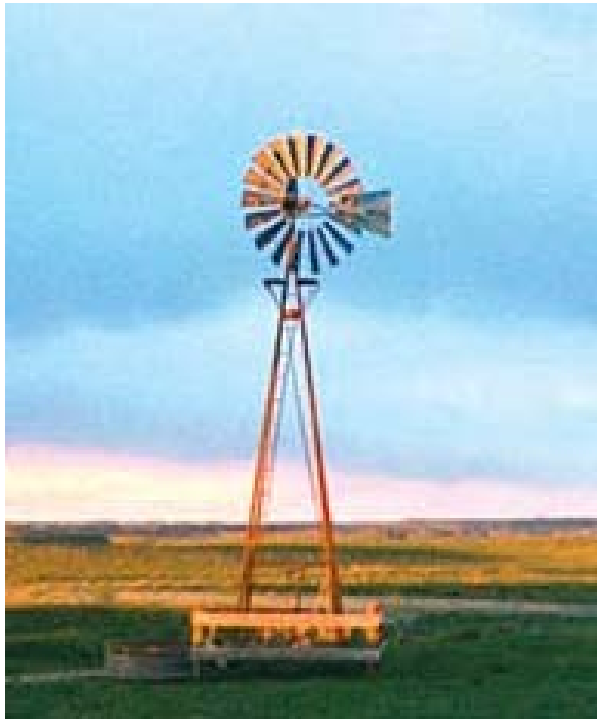
Solar Pumps

- Remote locations – no electric
- Low maintenance
- Expensive
- Not easily portable
- 3 Day Water Reserve


water tank level
solar array
water storage tank
ft
controller
check valve
elev _____ ft
ft
static water
ft
drawdown
ft
intake
6"
_____ ft
_____ ft

Windmill

- Can power a generator, piston pump, or air compressor
- 3 day water reserve needed

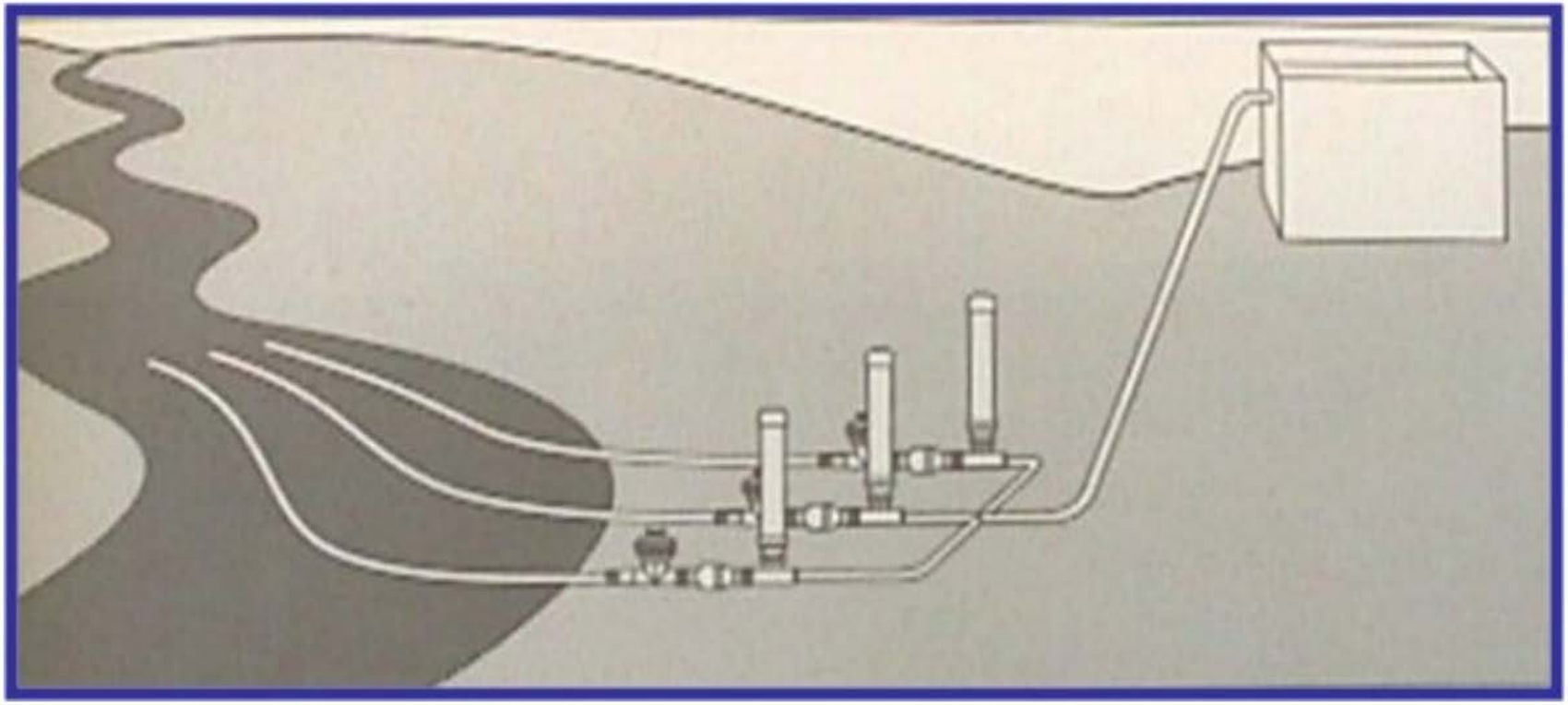


Gas or diesel powered pumps

Nose pumps

Nose Pump

- Animals must be trained
- Portable
- No power required
- Less than 300 feet to source
- Lift less than 30 feet
- Large animals only



HYDRAULIC RAMS-

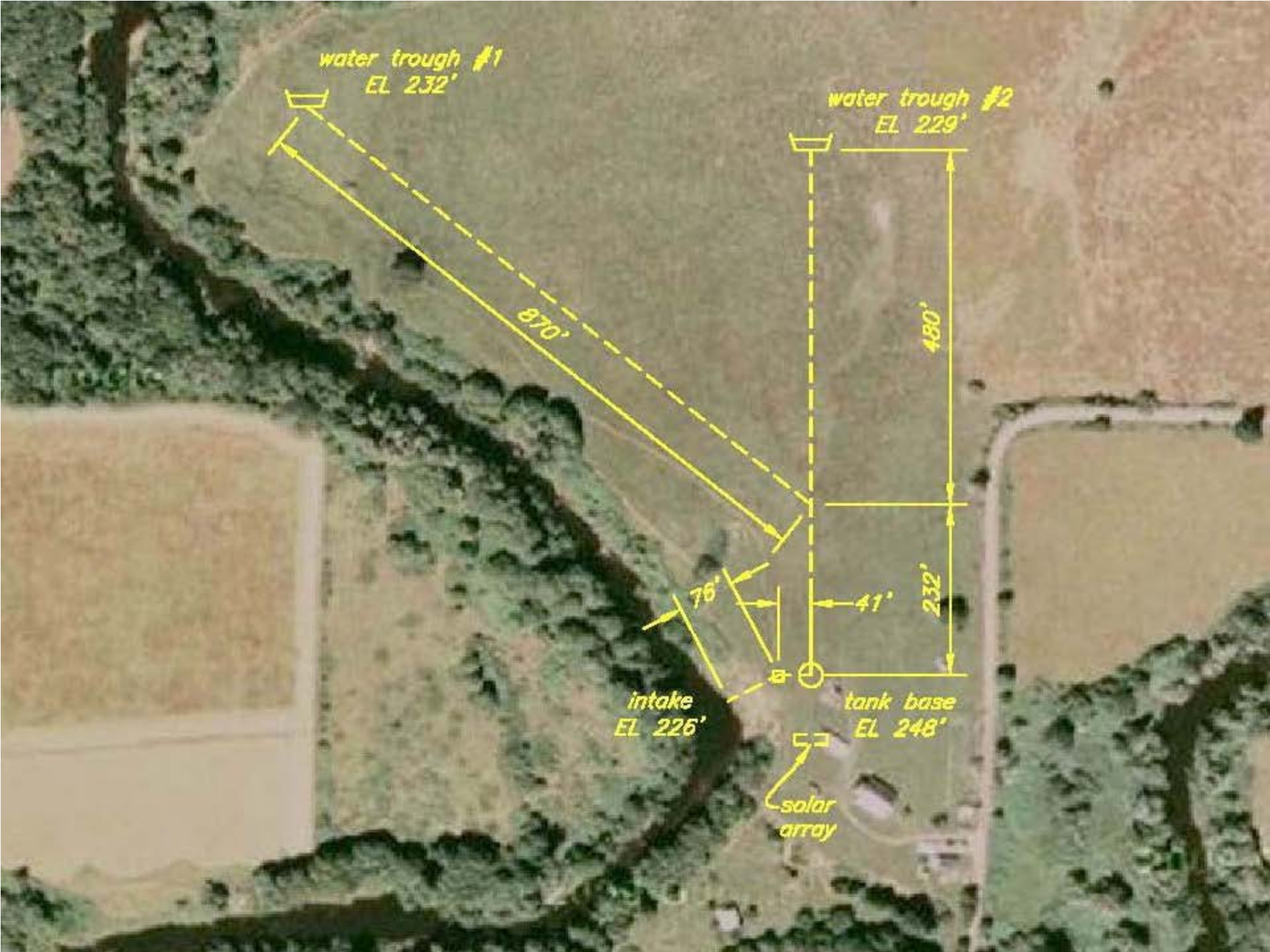
Energy (head) from flowing water boosts a small amount of water to higher elevations. No outside energy is used.

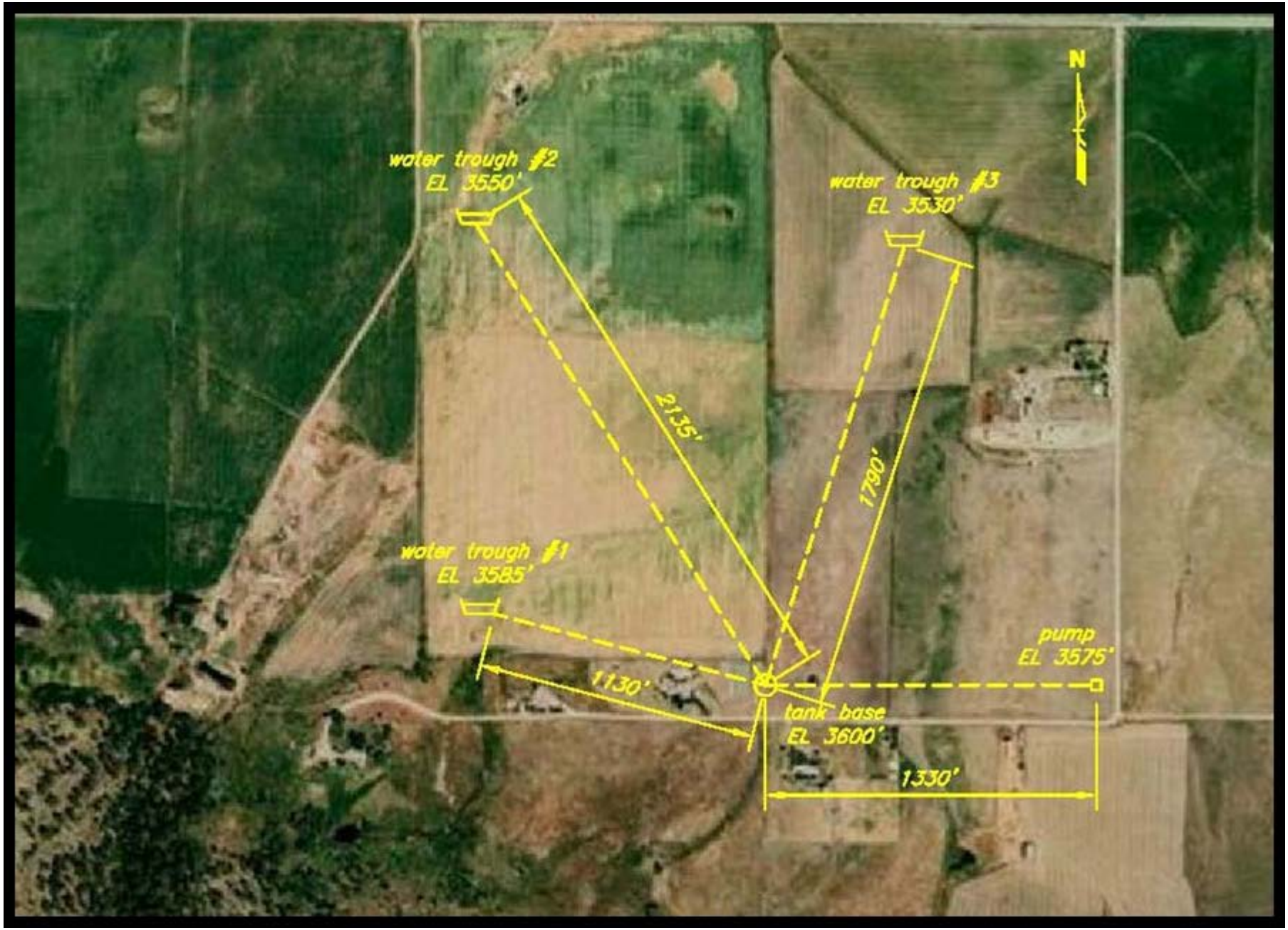
Hydraulic Ram Pump

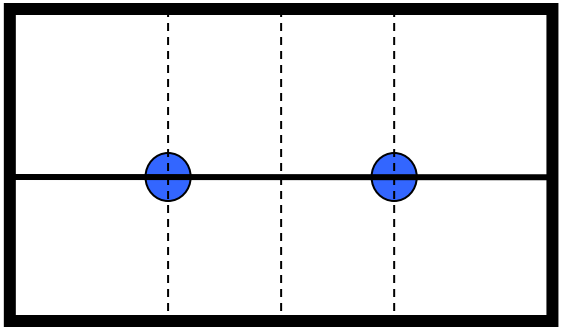
- Remote locations
- Can lift up to 250 feet or long distance
- Not portable
- Need frost protection
- Economical to operate
- Costly

Design

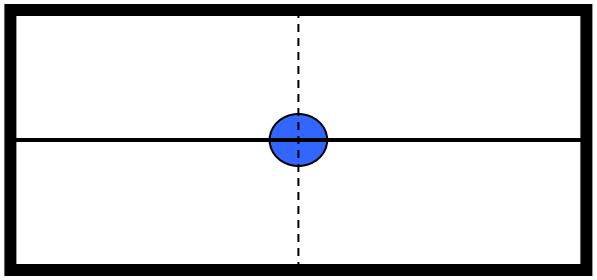
- Location
- Livestock
- Seasonal vs Annual
- Single or Multiple Troughs
- EFT
- State developed design tools


water trough #1
EL 232'
water trough #2
EL 229'
870'
480'
232'
76'
41'
intake
EL 226'
tank base
EL 248'
solar
array

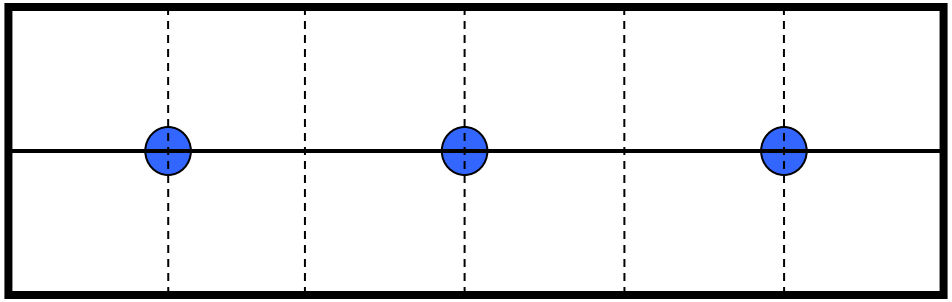

N
water trough #2
EL 3550'
water trough #3
EL 3530'
2135'
1790'
water trough #1
EL 3585'
pump
EL 3575'
1130'
tank base
EL 3600'
1330'



8 Paddocks sharing Two tanks



4 Paddocks sharing One tank



12 paddocks sharing Three tanks

Design Flow Rate

- Source Limited
  - Well or spring
- Peak Demand
  - Water the herd in a short period of time

Pipe & Pump Design

- Calculate TDH
- Size Pump

PRESSURE or HEAD
4 Main Considerations

1) To offset Elevation difference between source and delivery point

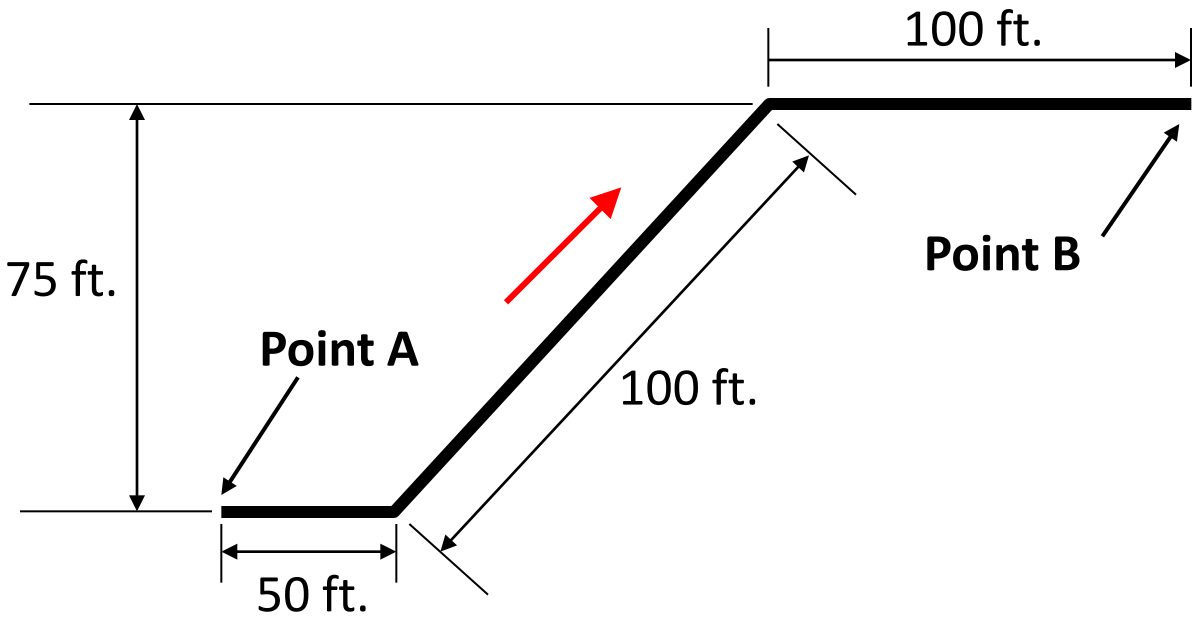
2) To compensate for Friction losses in the mainline delivery system

3) System Operational Requirements

4) Other Minor losses

Elevation & Distance

- Elevation Difference
- Distance



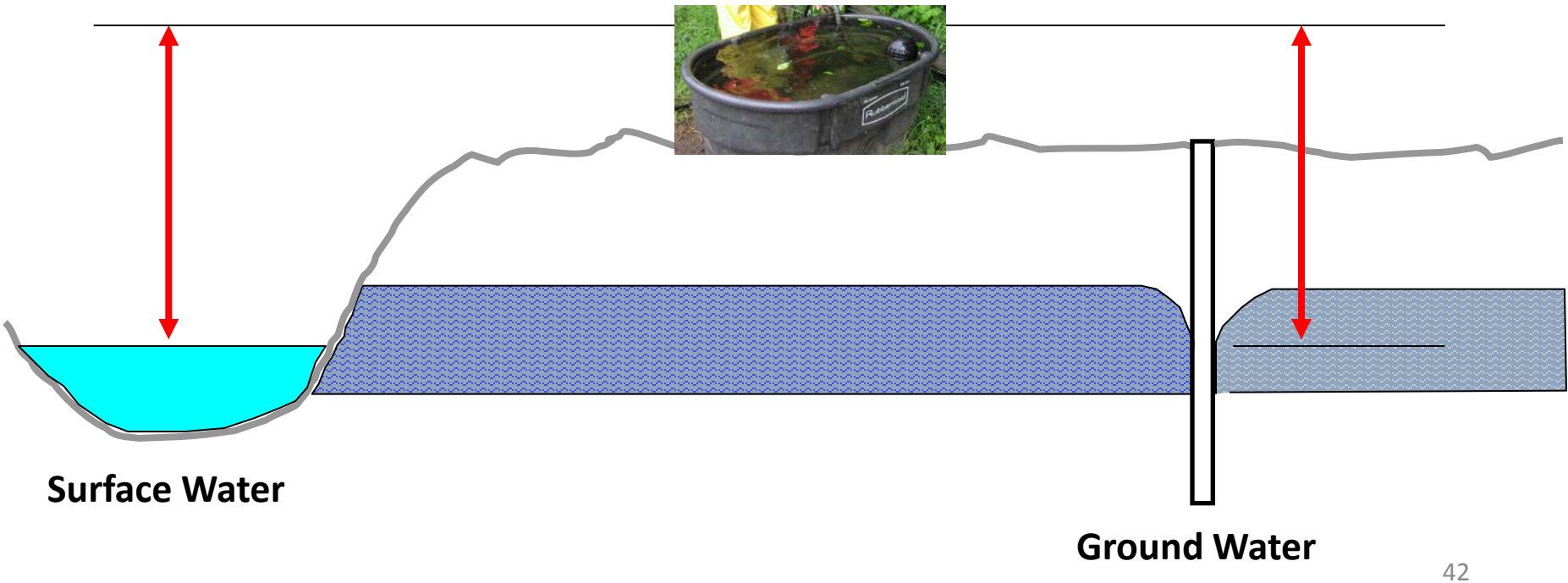
Pressure vs Elevation

- 1 foot of elevation change = 0.433 psi change
- Lack of pressure can occur going uphill
- Excessive Pressure can occur going downhill

Elevation Difference
between water source and point of distribution

Vertical distance between pumping water surface
and the field delivery point
(for troughs use the highest elevated trough position for conservative calculations)

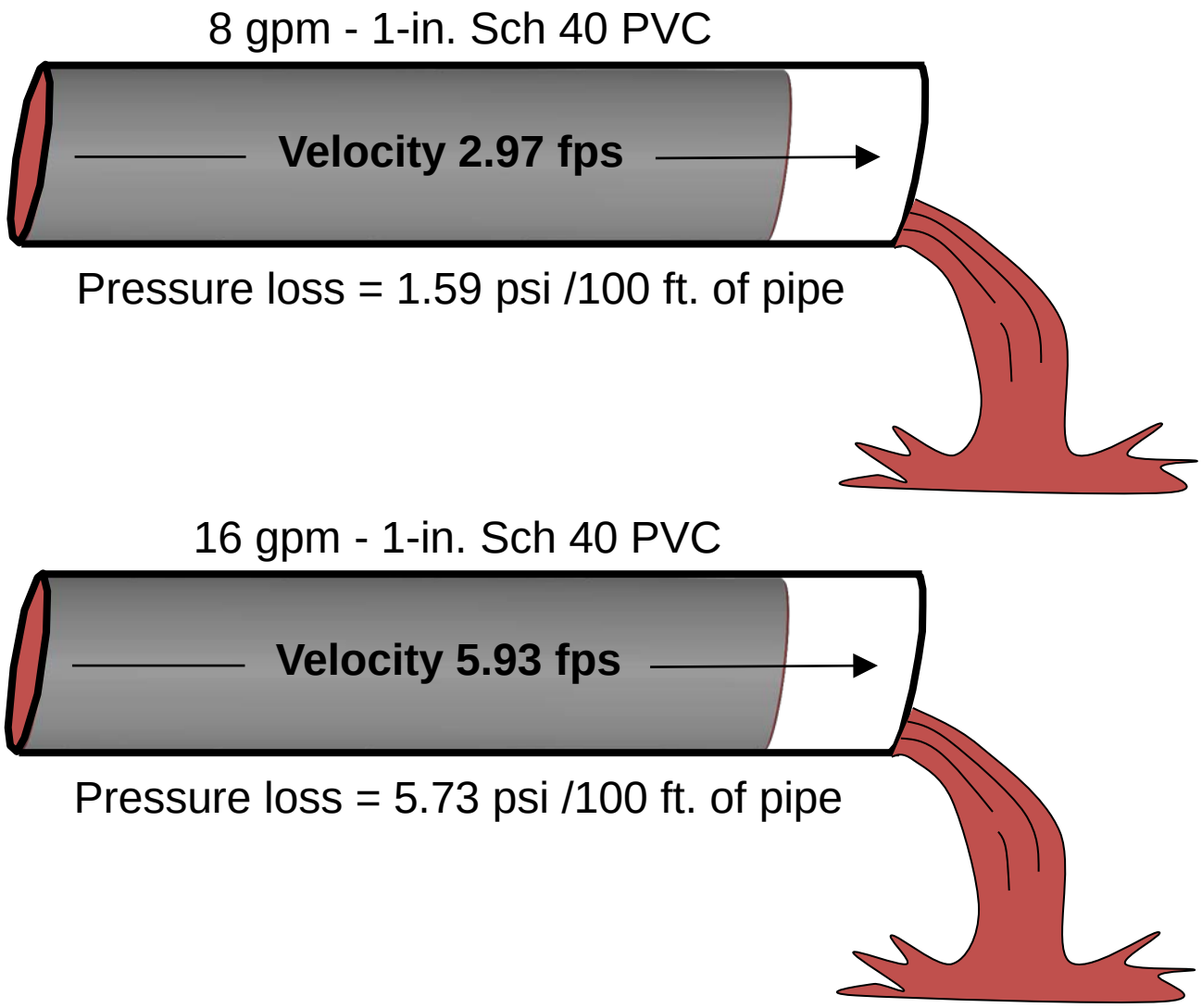
Example 50 feet



Pipeline

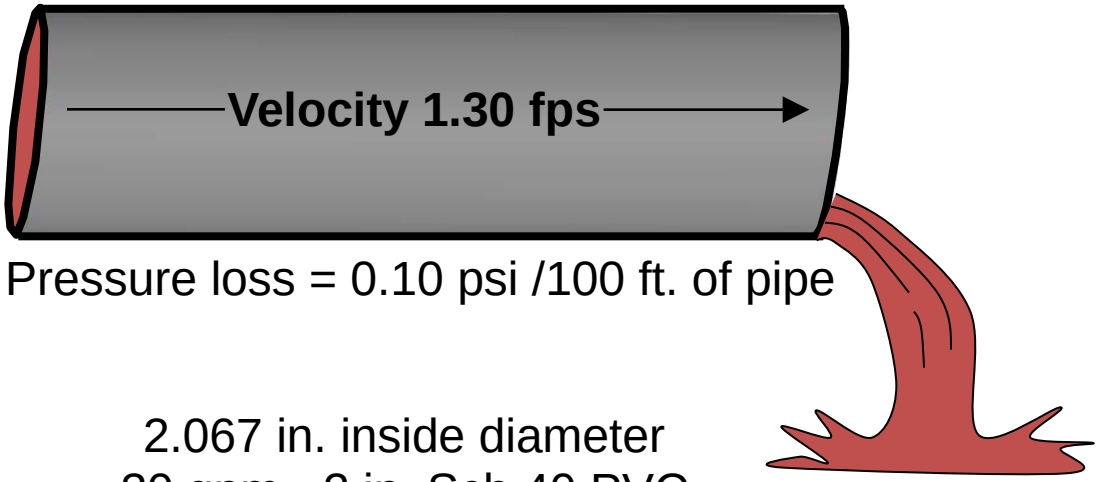
- PVC
- Steel
- HDPE

Velocity Effects on Friction Loss



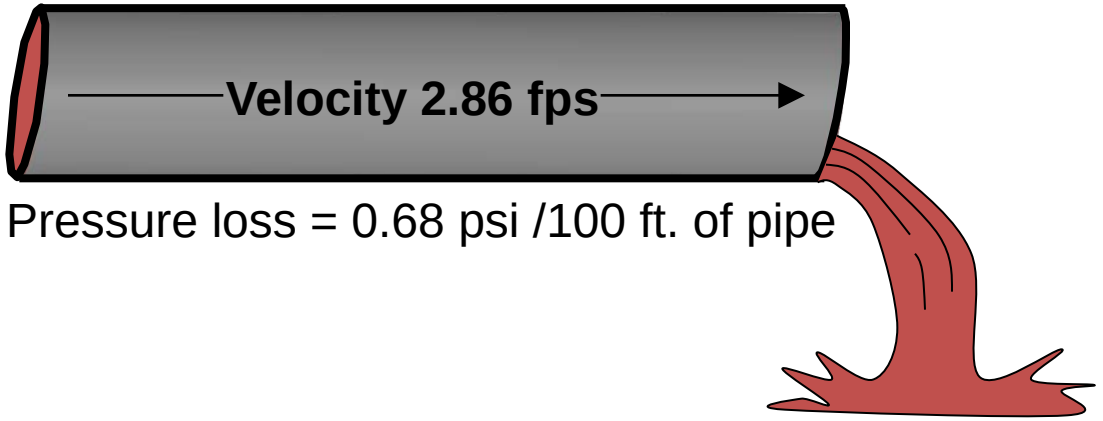
Inside Diameter Effects on Friction Loss

3.068 in. inside diameter
30 gpm – 3 in. Sch 40 PVC



Pressure loss = 0.10 psi /100 ft. of pipe

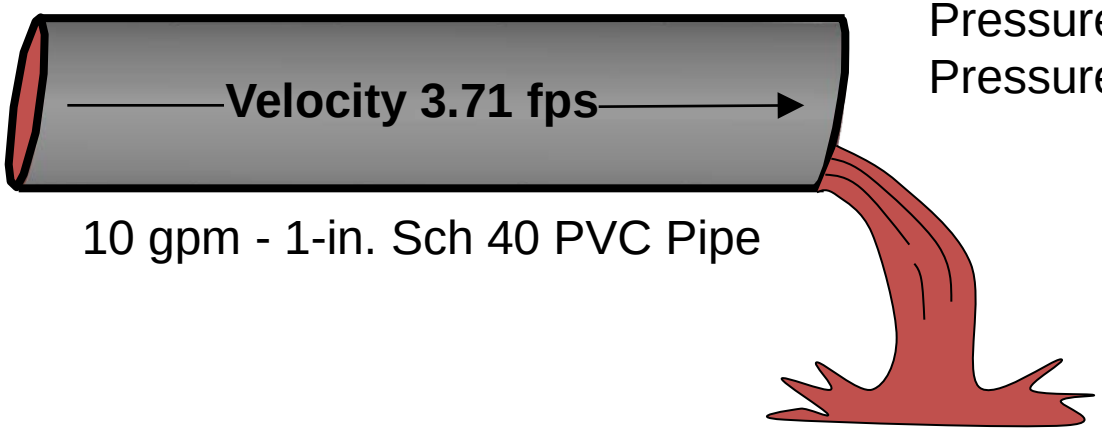
2.067 in. inside diameter
30 gpm - 2 in. Sch 40 PVC



Pressure loss = 0.68 psi /100 ft. of pipe

Length Effects on Friction Loss

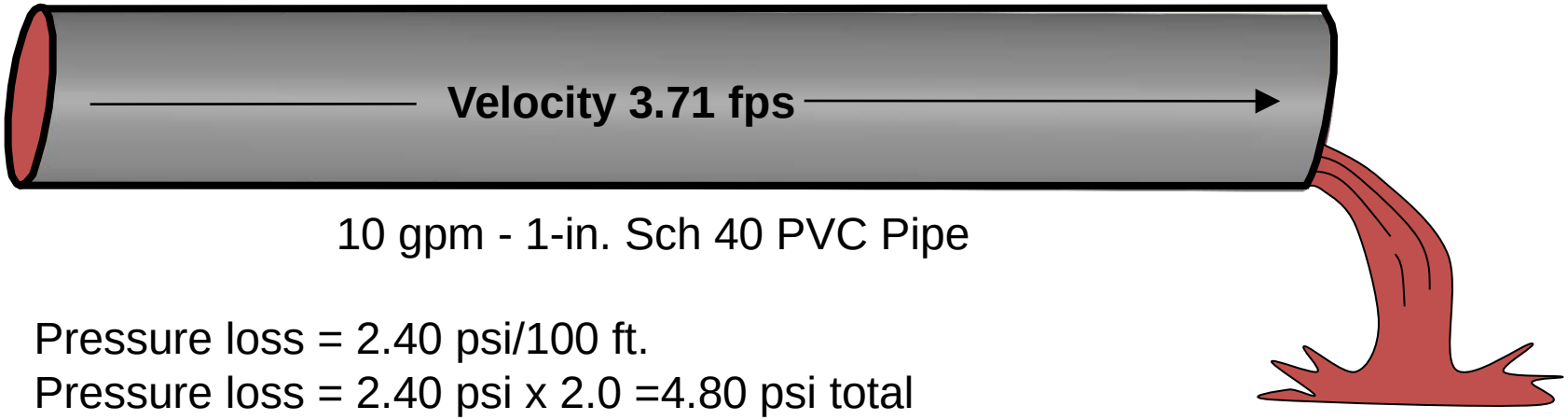
100 feet of pipe



10 gpm - 1-in. Sch 40 PVC Pipe

Pressure loss = 2.40 psi/100 ft.
Pressure loss = 2.40 x 1 = 2.40 psi total

200 feet of pipe



10 gpm - 1-in. Sch 40 PVC Pipe

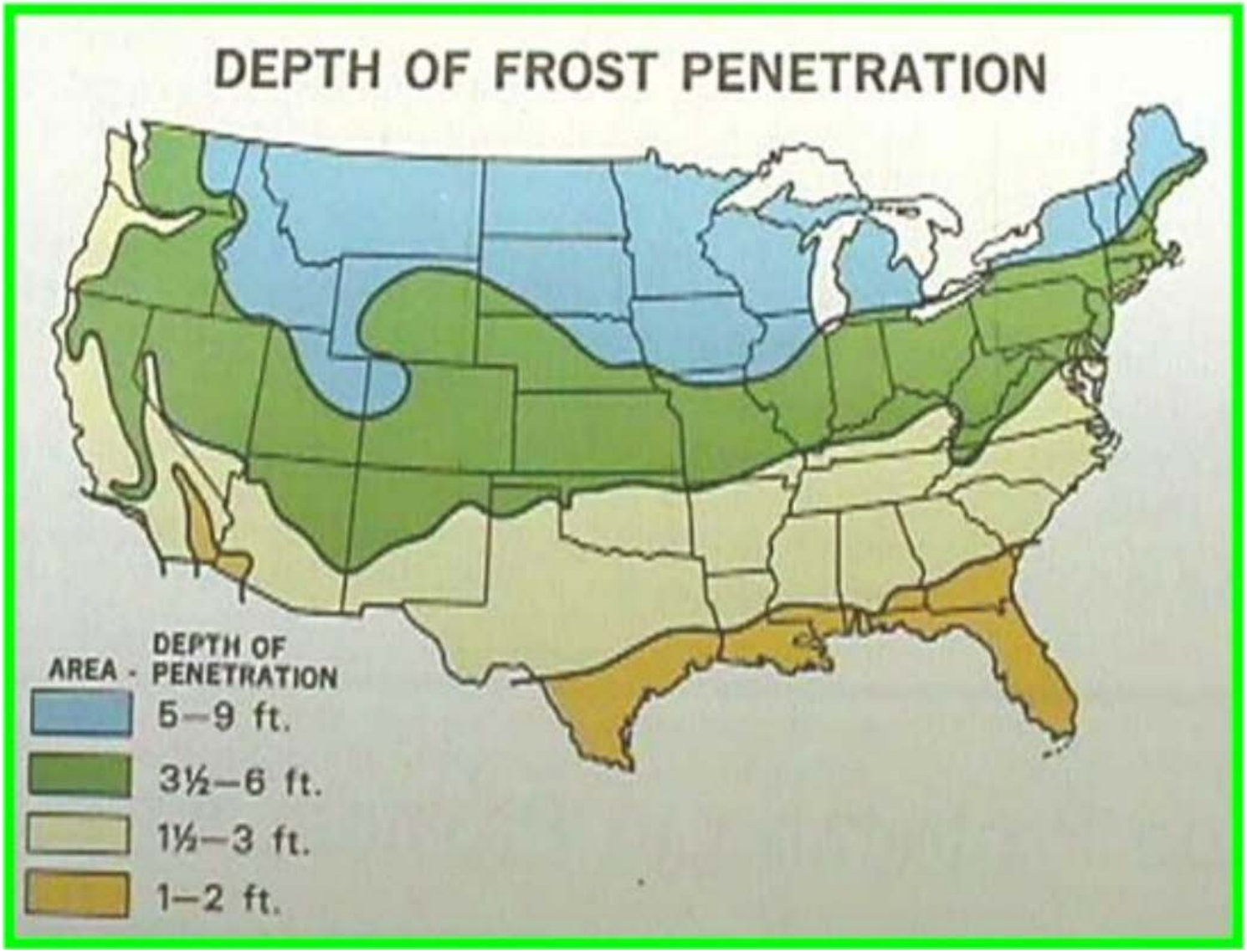
Pressure loss = 2.40 psi/100 ft.
Pressure loss = 2.40 psi x 2.0 =4.80 psi total

HDPE Pipe Strength

- 160 psi PS
- 200 psi PS
- As pipe temperature increases, the pipe loses strength


PARR 160 IPS
POLY TECHNOLOGY
PARENT
EXCEL
1-1/4"X300'
13330
160 PSI PE3408
ASTM D2239 SIDR-9
IRON PIPE SIZE
NSF
C5 SIDR 9 ASTM D-2239

Anything above frost depth, that is not completely drained, will break (HDPE is the only exception).



Installation

- HDPE expands and contracts 2-3 feet per 100 feet with temperature changes
- Provide slack in pipeline when installing
- Recommend laying out pipeline during the warmest part of the day and connecting during the coolest part of the day


1 " 100 PSI @ 73°F POLY TECHNOLOGY EXCEL PE3408 C-3 SIDR 15 ASTM D2239

Shallow-burying pipeline

Roll of pipeline for livestock watering system

Minor losses

- Add 10 – 15% to pipe length
- Or add up the loss for each fitting

Fittings

- Flow control valve
- Check valve
- Air release valve
- Low pressure drains
- Tee
- Elbow
- Pressure Reducer

Pressure Loss in Fittings

$$H = k\, v^2 / 2g$$

H = Head Loss in Feet

K = resistance coefficient

V = average velocity of liquid flow in the pipe in feet per second

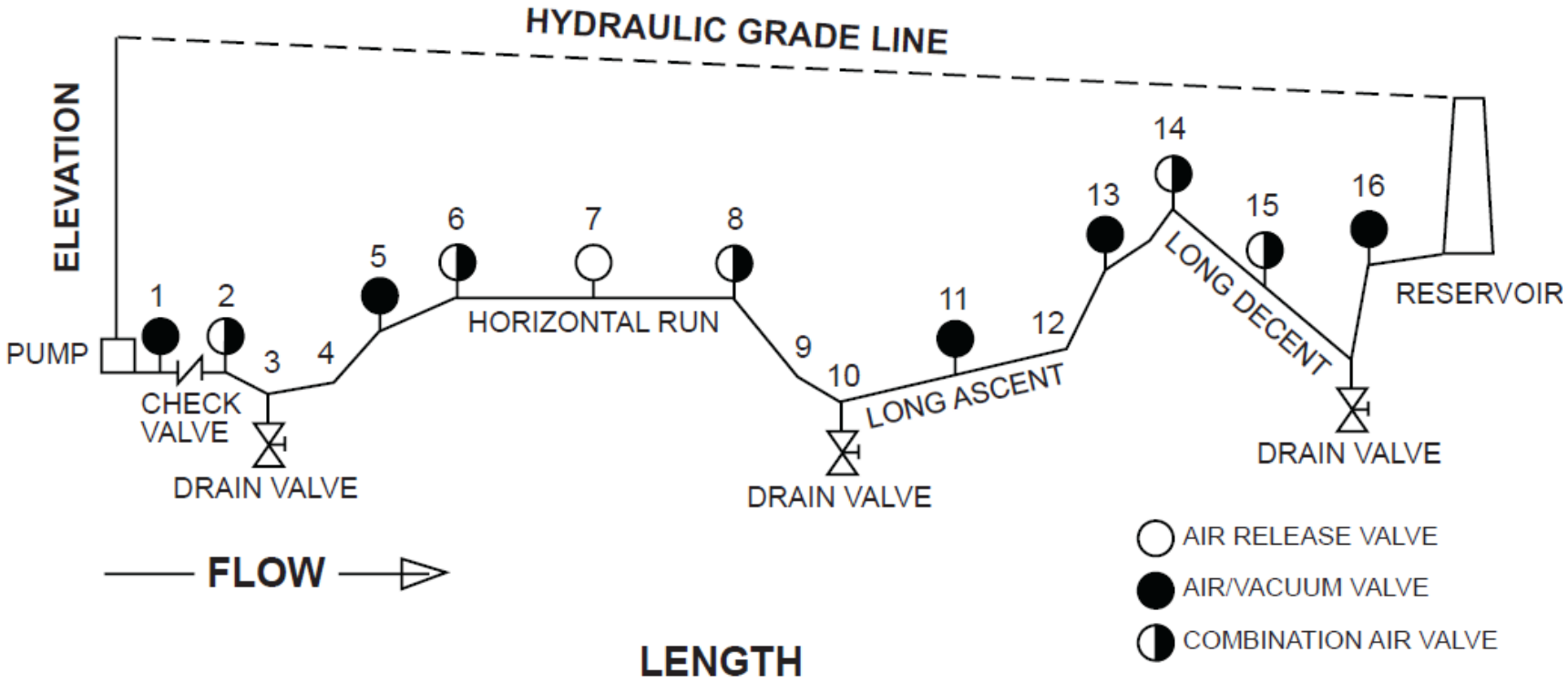
g = acceleration of gravity, 32.2 ft. per second

Head Loss Coefficients for Fittings and Special Conditions where $H = kv^2/2g$

Nature of Resistance	Recommended k
Square edge entry	0.50
Projecting pipe at entry, or re-entrant pipe	1.00
90^o large radius bends	0.25
90^o short radius bends	0.50
Tees or crosses, straight flow	0.10
Tees or crosses, angle flow	1.50
Taper reducer (refer to smaller pipe)	0.25
Taper increaser (refer to smaller pipe)	0.15
Sudden contraction (refer to smaller pipe)	0.35
Sudden enlargement (refer to smaller pipe)	0.20
Foot valve	3.00
Globe valve, open	3.00 to 15.00
Gate valve	0.10
Angle valve, open	5.00
Alfalfa valve	3.00
45^o short radius bends	0.38
Check valve[1]	3.00 to 10.00

Air in Pipelines

- Air in pressurized pipelines
  - efficiency is sacrificed
  - Pipe damage can occur
- Removal of air from a pipeline will not solve all surge and efficiency problems.
- The elimination of air can solve one of the most common causes of these problems.


HYDRAULIC GRADE LINE
ELEVATION
PUMP
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
CHECK VALVE
DRAIN VALVE
HORIZONTAL RUN
DRAIN VALVE
LONG ASCENT
LONG DECENT
DRAIN VALVE
RESERVOIR
FLOW
LENGTH
AIR RELEASE VALVE
AIR/VACUUM VALVE
COMBINATION AIR VALVE

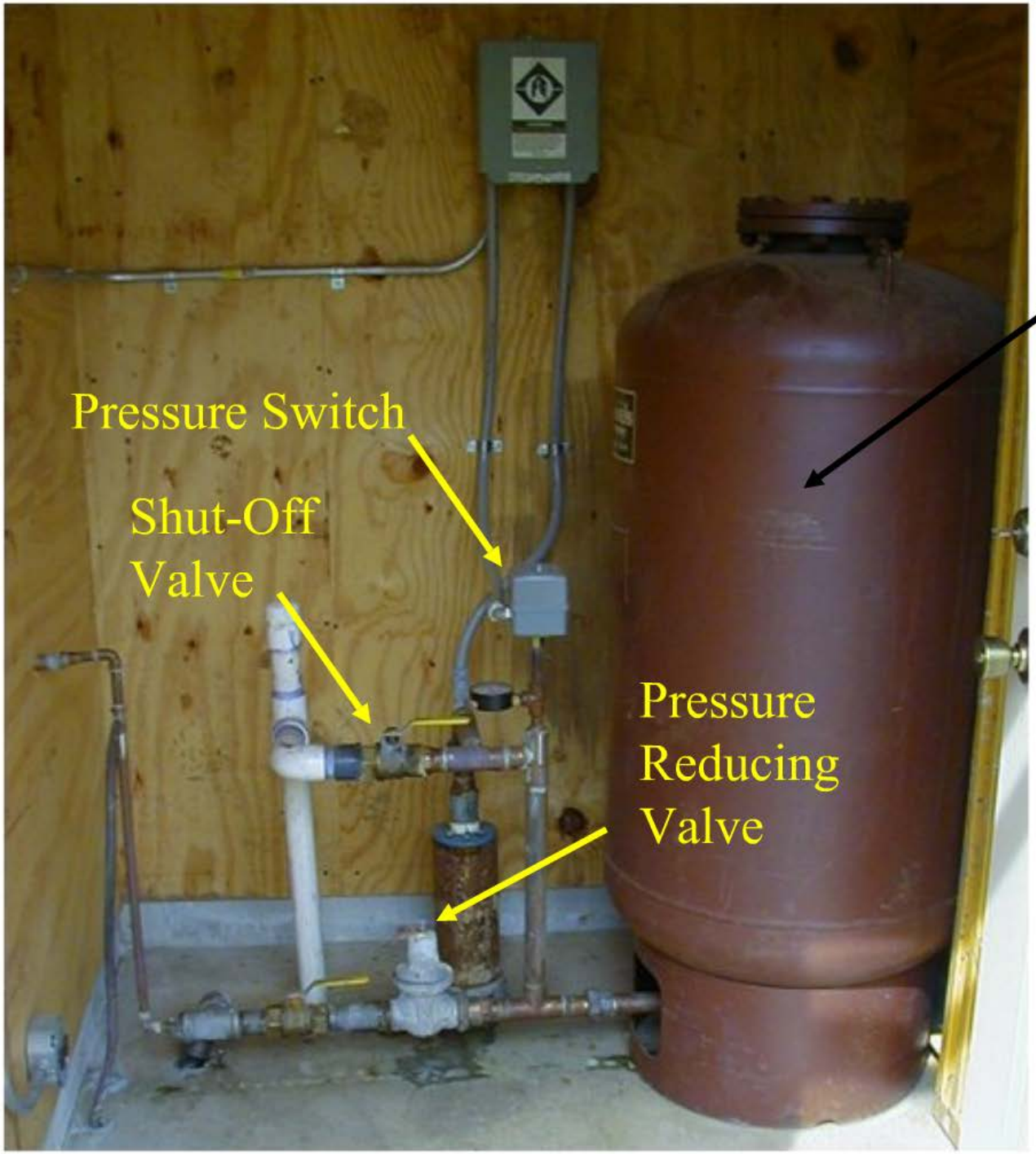
Air Release Valve

Location

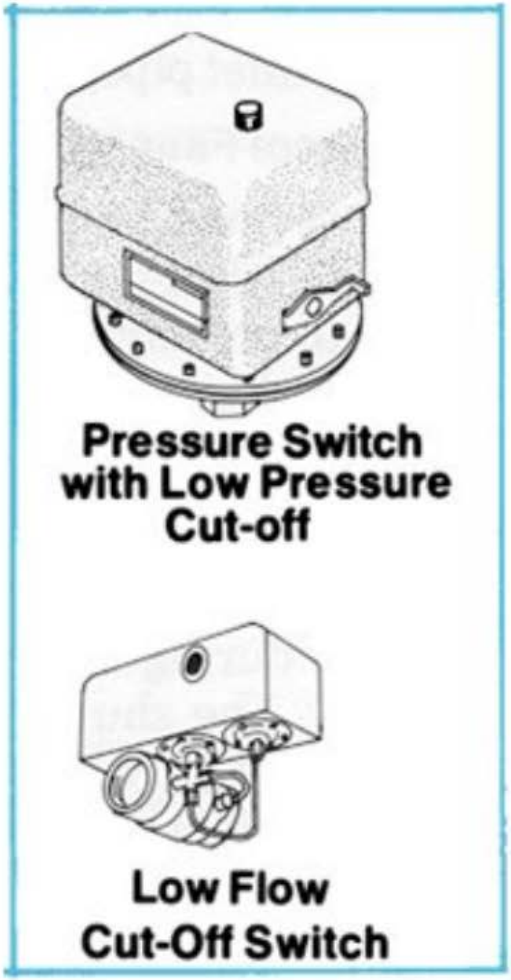
- Air Valves: high points and at 1/4 mile intervals on pipelines with constant grades.
- Air release valve at the end of the line
- Vacuum Release valves: not needed on pipelines of less than 3-inch diameter for protection from collapse; however, they may be needed to insure complete drainage of the line.

Pressure Tanks

- Tank
- Switch
- Water hammer
- Storage
- Relationship of tank size to pump capacity
- Pump cycling


Pressure Tank
Pressure Switch
Shut-Off Valve
Pressure Reducing Valve

Pressure switch



Common Pressure Switch Settings

- 20/40 psi
- 30/50 psi
- 40/60 psi


Quick coupler tank connection


Quick coupler tank connection

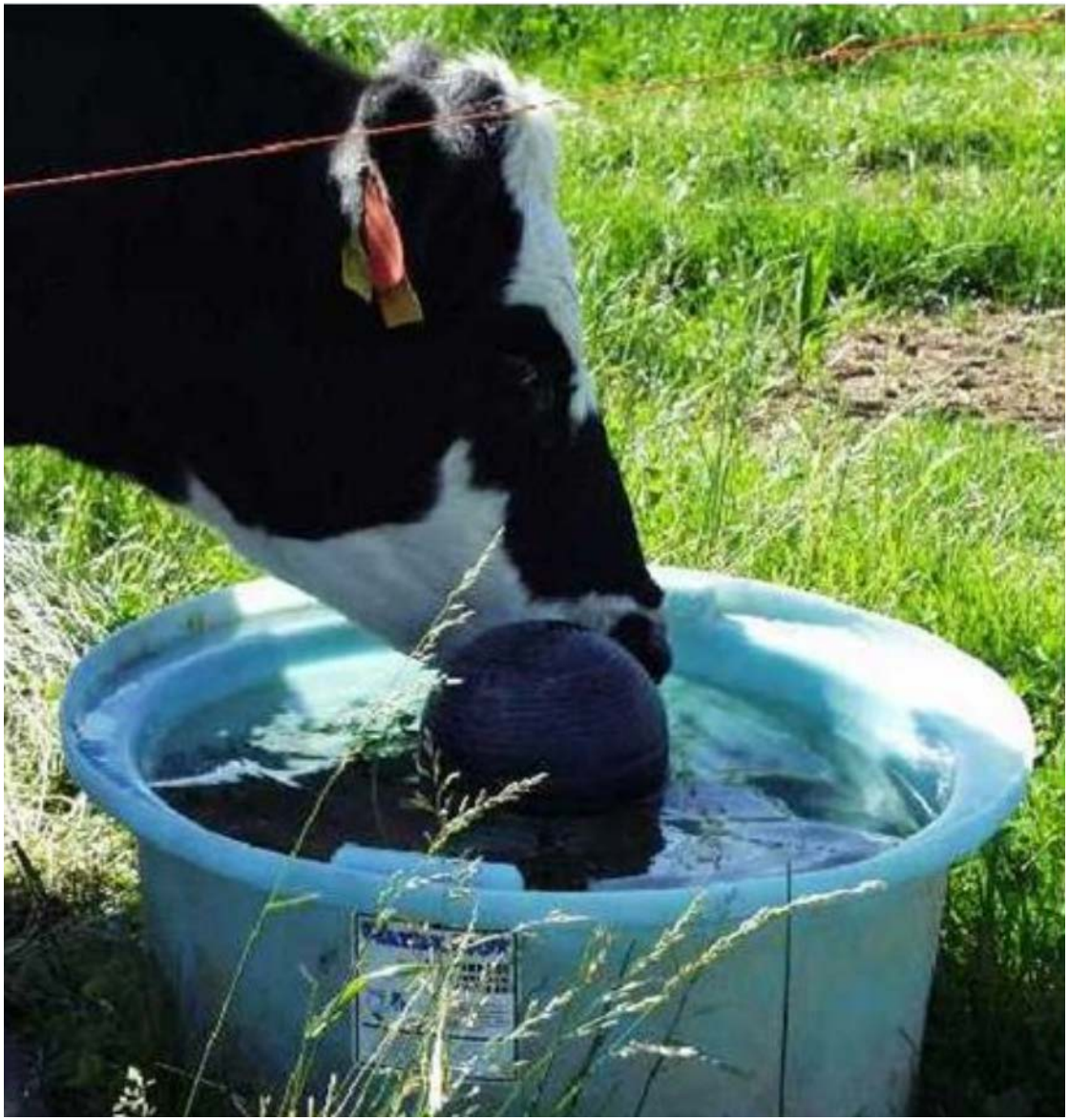

Quick coupler tank connection


Aboveground pipeline with tee connection and shut-off valve

Float Valve Pressure

- What is the minimum float valve pressure?
  - Typical 10 psi
- Maximum?

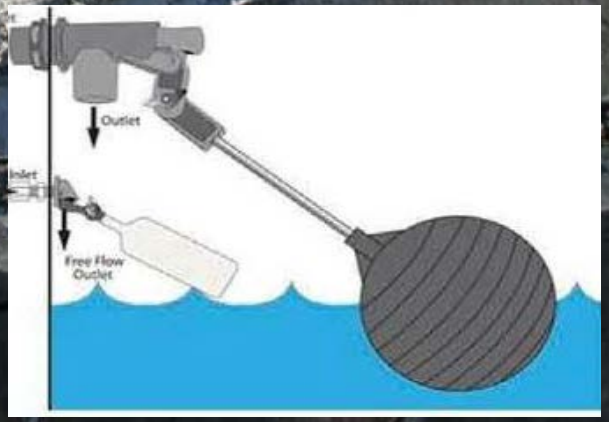
Float Valve




Tire tank with float
10 – 75 gpm
5 – 100 psi

Tire tank and valve

Orifice Size dependant




Max 4 gpm
10 – 75 psi

Pump Design

- Calculate TDH
- Size Pump

PRESSURE or HEAD
4 Main Considerations

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2) To compensate for Friction losses in the mainline delivery system

3) System Operational Requirements

4) Other Minor losses

Reference

- NEH Part 652 Irrigation Guide
  - Chapter 6
  - State Supplement – Section 5

Thanks

- Many pictures from
  - Jeff Duchene
  - Kevin Ogles
  - & Missouri and Oregon NRCS publications


Questions?
Rubbermaid