Installation Keys for Long Term Performance

FIRST DISTRICT HEALTH UNIT
Regional Public Health Agency

University of Minnesota Onsite Sewage Treatment Program

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University of Minnesota Onsite Sewage Treatment Program

- Professional Training – Designers, Inspectors, Pumpers/Maintainers, Installers, Service Providers
- Research and Demonstration
- Homeowner Operation & Maintenance
- Small Community Wastewater Solutions

Research at UMN

- Adult care facilities served by septics
- Phosphorus movement and removal technologies
- Rest stop evaluation, design and management
- Community septic system owner's guide

Presentation overview

- Material quality issues
- Installation techniques for difficult site and soil conditions

DIRTY MEDIA

Media specifications

- Installer must make sure media available meets specifications of system designer and codes!
  - Know what material to ask for
  - Get documentation that material is what you ordered
  - Know what it should look like
  - Know how to double check if needed
  - Document with pictures

Sand media

- Treatment media in:
  - Filters
  - Mounds
- Washed to be free of fines (<5%) to prevent system failure

Bucket cleaning

- When installing media in soil treatment systems & media filters a clean bucket is ***essential*** to avoid contaminating media
- Scrape out all soil before handling media

Sand quality tests

- Conduct jar test as a field check
- Verify clean sand using a sieve test

Jar test – field procedure - I

- Place two inches of sand in the bottom of a quart jar

Jar test – field procedure - II

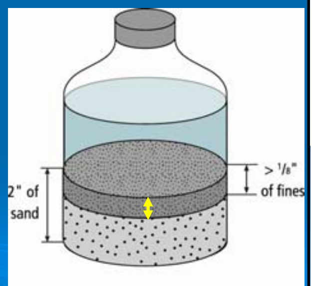
- Fill the jar 3/4 full of water
- Cover
- Shake for 1 – 2 minutes

Jar test - field procedure - III

- Allow jar to stand for 30 minutes

Jar test - field procedure - IV

- Measure layer of fines on top of sand
- Layer should measure less than 1/8”



Jar test example

- > 1/8” ~
- More then 5% fines
- Send back and request sieve analysis on next load

Fines reduce treatment performance

- Fines migrate to bottom and form a restrictive layer
  - Holds effluent and water in pore space
  - Effluent and water wicked upwards into media due to capillary action
  - Reduced pore space
    - Less air transfer
    - Less space for sloughing of biomass to move through media

Sand size characteristics

- Grain size
- Uniformity coefficient (EC)
- Effective size (ES)
- Sieve test is a method to characterize the size of the sand

Sieve analysis

- Soil sample is placed on top sieve and run through a shaker to separate different size grains

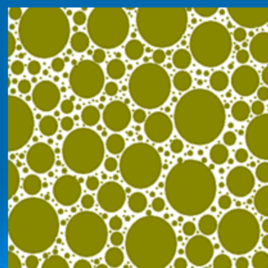
- Material collected from each sieve is weighed and the point data plotted

Example sieve analysis

Size Number	mm	Individual Retained Weight (grams)	Cumulative Percent Retained	Cumulative Percent Passing
8	2.36	127.0	18.7	81.3
16	1.18	189.5	46.5	53.5
30	0.60	140.0	67.1	32.9
50	0.30	105.0	82.5	17.5
100	0.15	93.0	96.2	3.8
200 FINES	0.075	25.5	99.9	0.1
Pan		1.00		

Uniformity Coefficient (UC)

- How well graded your sand sample is
- UC = 1 - material uniform in size
- UC > 1
  - less uniform
  - wide range of sizes
- Range of sizes of particles is important due to pore space



Does UC matter?

- Yes! Affects performance – longevity and treatment
- Ideal sands are a medium to coarse sand with UC of less than 4
- High UC sand– plugging due to reduced pore space
- Reduced ability to transport
  - Water and effluent
  - Air
  - Solids

Sand media installation

- Mounds and media filters
- Sand installed in layers/lifts of 6-8 inches
- Foot compaction and light watering to reduce volume of pore spaces
- Compaction equipment should not be used

Distribution material

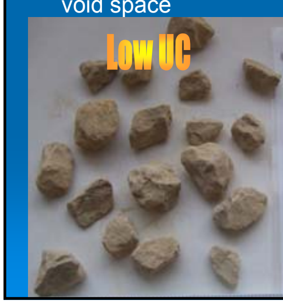
- Rock
  - Provided by quarry
  - Needs to meet specific criteria for:
    - Durability, hardness
    - Size
    - Cleanliness
  - Installer responsibility to assure material meets criteria
- Gravelless products
  - Types
    - Chambers
    - Polystyrene blocks or beads
  - Manufacture assures material meets criteria through manufacturing process

Rock characteristics - hardness

- Hardness is an important characteristic as soft rock can break into pieces reducing void capacity
- If a penny can scratch a rock without crumbing and flaking it is OK

Rock characteristics - size

- Uniform size is preferred to provide maximum void space



Rock Characteristics - size

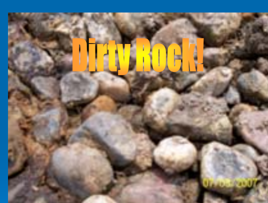
- 3/4 - 2 ½ inches
- Quarry/pit should provide gradation information
- <1% by weight of fines

Gradation Example

Sieve Size (inch)	% Passing
1.5	100
1	41
¾	10
½	0.5
#200 – fines	0.25

Rock characteristics - "clean"

- The rock must be "clean" as dirty rock has fines (silt and clay particles)
- These fines can cause system failure because they will reduce the long term acceptance rate of the underlying soil or media



Checking rock for cleanliness

- Is there a large dust cloud when the media is dumped?
- Verify quarry results to verify rock cleanliness and other characteristics
- Use field jar test to check the cleanliness of rock

Solutions for dirty media

- Monitor performance
- Remove contaminated materials and rebuild system
  - Thin zone
  - Entire system
- Build a new system in another location

Gravelless technologies

- Can be used for both gravity & pressure
- Can be used where washed rock is used
- Avoids the concerns of rock
- Have unique sizing & installation requirements
- Have their own unique precautions
- Check with manufacturer & local regulations

Chambers

- Pre-formed manufactured distribution media with an open-bottom configuration
- Varying manufacturer's
  - Size, capacity, and sizing
- Level installation
- For support, chambers should be stepped in
- Appropriate backfill is critical before *light* equipment traffic is allowed

Synthetic material

Expanded polystyrene aggregate (EPA) system

- Varying size, capacity, and sizing
- Typically covered with a geotextile material

Soil treatment area backfill

- Suitable native soil material for backfill and cover must be free of:
  - Debris
  - Clods
  - Frozen soil

ASTM 2321

Soil treatment area backfill

- Material should:
  - Allow air/oxygen to diffuse into the soil treatment system
  - Shed surface water
  - Support the growth of vegetation
- High clay content soils have reduced oxygen transfer
- High sand content soils do not support vegetation

Concerns for installation on wet sites

- Compaction and smearing are more likely
- Soil must be treated carefully
- Check weather before starting construction & be prepared

Considerations for installation on wet sites

- Excavation only when:
  - Moisture content less than the plastic limit
  - Soil is not frozen

Soil smearing

- Smearing: the spreading and smoothing of soil particles by sliding pressure.
  - Any sandy loam or finer textured soil can be susceptible to smearing if enough water is present.
  - This is why we test the plastic limit before construction

Soil compaction

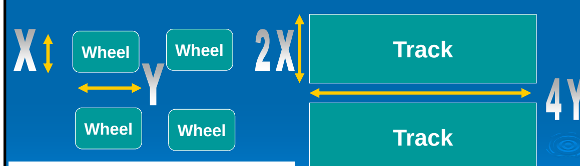
- Compaction: the effect of causing compression of the soil particles:
  - closing the pore spaces
  - Reduces pathways for water, air and roots

Soil compaction

- Ways to minimize soil compaction-
  1. avoid area
  2. protect/flag area
  3. use only tracked equipment
  4. construct only when soils are below plastic limit
  5. no cutting or fill
  6. protect site after installation

Ground pressure

- For same piece of equipment, ground pressure will be much higher with wheels



Ground pressure = 10,000 pounds / 4 wheels x (2ft x 4ft) x 144 in²/ft² *= 2.2 psi*

Ground 10,000 pounds / 2 tracks x (4ft x 16ft) x144 in²/ft² *= 0.5 psi*

Field testing of plastic limit

- Grab a ped/clump of soil
- Do not add water
- Try to roll into a pencil
- If rolled into a wire 1/8 inch in diameter and 2 inches long with out crumbling
  → Moisture content is above plastic limit
  → Construction should NOT proceed

Frozen soils

- Any frost is too much frost for an above-grade system
- For below grade trenches frost could be present, however cannot extend to the depth of the required sidewall or bottom area of the trench/bed
- Snow should be removed with caution

Frozen soil-why are they bad?

- No way to test the plastic limit
  - Wet fall
- Scarification will not work
  - Soil can be frozen solid
  - Large clumps instead of exposing natural soil structure
  - Shattering in dry frozen soils
- If scarified when frozen,
  - as the soil thaws it can "seal off" the scratched area.
- The large frozen clumps will also hamper constructability


Frozen soil-why are they bad?

- Stock piles of sandy/loamy soil material (cover) or topsoil borrow should not be allowed to freeze
- Attempting to use this material for cover will result in:
  - Uneven cover thicknesses
  - Increased erosion potential
  - Difficulties in establishing vegetative cover
  - Poor frost protection

Maintaining natural soil conditions

- Soil located at or near the soil surface is generally the best for:
  - Treatment
  - Dispersal
  - Oxygen-transfer
  - Evapotranspiration
  - Natural biological activity

Protecting exposed natural soil

- If site has been scarified, immediately cover with media to prevent
  - damage
  - contamination
- When you can't cover exposed soil immediately, protect area with tarp

Vegetation removal

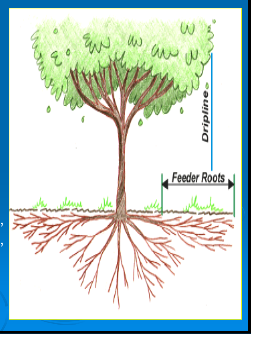
- If vegetation is removed document method/machine used
- For above-grade systems
  - Vegetation – cut to 2" or less and remove
  - Purpose - no barrier to movement of effluent
- Trees – to avoid damaging soil, cut short and leave stumps in place
  - Consult arborist for concerns about tree impacts

Stump removal

- Generally not recommended
- Large diameter stumps may need to be removed for system installation

Stump removal

- Taproots
  - Compacted ball
  - Easier to remove
    - Hickory, walnut, butternut, white oak, hornbeam
- Fibrous roots
  - Large & spread out
  - Harder to remove
    - Red oak, honey locust, basswood, sycamore, pines, birch, fir, spruce, sugar maple, cottonwood, silver maple, and hackberry

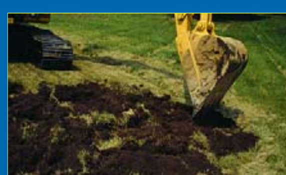


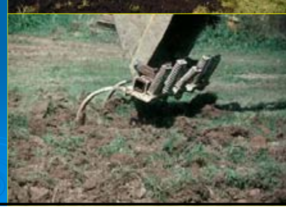
Stump removal techniques

- Stump grinding
  - Quickest method to remove upper portion of tree roots
  - May not be deep enough
- Stump removal
  - May be more effective using large equipment such as tracked backhoe/dozer
  - Be careful:
    - Who is doing clearing?
    - Limit compaction
    - *Do not* destroy site

Scarification

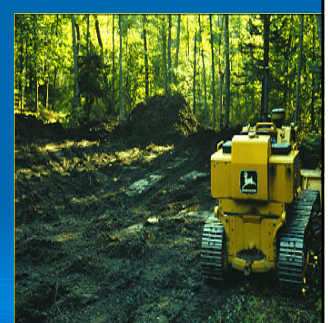
- Process of scratching the absorption area
  - Stake first
  - Proper elevations
  - Green side down
- Backhoe
  - Never drive on loosened soil
- Do not smear or compact soil
- Check if soil is too dry or wet prior to scarifying



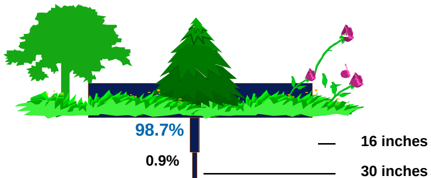


Topsoil benefits

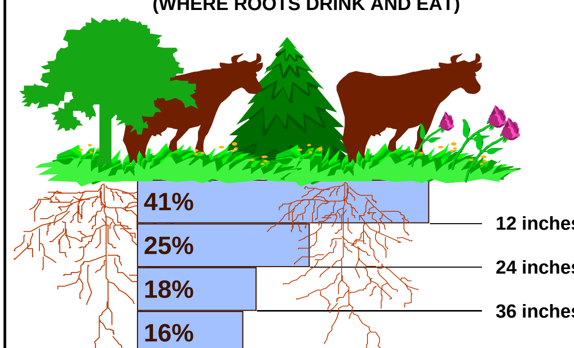
- Soil for treatment and dispersal
- Removing increases likelihood of damaging soil
- May assist with nitrogen removal process



SOIL BIOTA POPULATION
VS
SOIL DEPTH



WATER USE
(WHERE ROOTS DRINK AND EAT)



Techniques to maintain natural soil conditions of infiltrative surface

- Do not drive excavation equipment or other vehicles over
- Limit foot traffic
- Rake sidewalls of trenches and beds
- Use low ground pressure equipment
- Position equipment upslope of system when placing media

Soil Compaction

- Ways to minimize soil compaction-
  1. avoid area
  2. protect/flag area
  3. use only tracked equipment
  4. construct only when soils are below plastic limit
  5. no cutting or fill
  6. protect site after installation

Compacted site – what to do?

- Avoid compaction
- Discuss options with Designer/Local unit of government
- Determine severity
- Move system location
- Time will help
  - Freeze/thaw
  - Root activity
  - Weathering
- Experimental methods
  - Lower loading rates
  - Mechanical soil fracturing
  - Deep plowing/ripping
  - Removing & backfilling

Vegetation removal

- If vegetation is removed document method/machine used
- For above-grade systems
  - Vegetation – cut to 2 inches or less and remove
  - Purpose - no barrier to movement of effluent
- Trees – to avoid damaging soil, cut short and leave stumps in place
  - Consult arborist for concerns about tree impacts

Stump removal

- Generally not recommended
- Large diameter stumps may need to be removed for system installation

Scarification

- Scarification - process of scratching the entire absorption area
  - Stake first
  - Proper elevations
  - Green side down
- Wheeled backhoe or tracker
  - Never drive on loosened soil
- Do not smear or compact soil
- Check if soil is too wet prior

Topsoil benefits

- Soil for treatment and dispersal
- Removing increases likelihood of damaging soil
- May assist with nitrogen removal process

Final cover

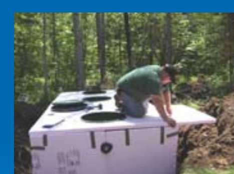
Depth – 12" minimum required
- Loamy topsoil material
- Crowned to allow for settling and shedding of surface water
- Serve as appropriate soil for vegetative growth/landscaping
- Protect system from erosion and winter freezing by using
  - Mulch
  - Sod

Construction techniques for cold climates

- Freezing may only be an issue 1 in 10 years, but better to prevent it
- Key techniques
  - Keep proper slope on pipes
  - Insulate where appropriate
  - Bed pipes properly to prevent dips

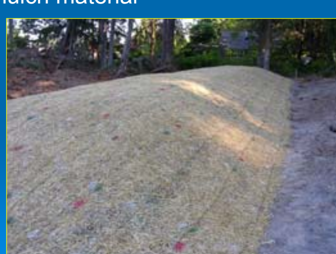
Construction techniques for cold climates

- Tanks and pretreatment units
  - Insulate when there is less than 2 feet of soil cover
- Soil treatment system
  - Limit traffic over system
  - Vegetation is a critical part of natural insulation
    - Vigorous growth in the fall is advantageous
    - Fall installations should have temporary insulation – place light mulch material



Late fall installs

- Erosion control blanket
- Light mulch material



SETTLING

Techniques for installation at the proper elevation and grade

- Concern: Many components must be installed level for the system to properly treat and disperse wastewater
  - Non-level installations can result in reduce retention times, hydraulic overload and component failure
- Critical to level components
  - Septic tanks
  - Advanced treatment

Pipe storage

- Protect from direct sunlight, excessive heat, and harmful chemicals
- UV exposure can cause brittleness
  - Store inside if possible
  - Cover with tarp if stored outside
- Stack pipes:
  - Thickest wall pipe on the bottom
  - Smaller diameter at the bottom
- Pipes stored on racks should be supported along entire length of pipe
- Rotate stock as it will become brittle over time

Impact of wall thickness & diameter

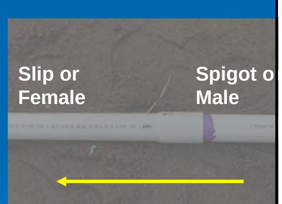
- Thinner walls - less strength
- Smaller inside diameter pipe - greater friction loss
- For example if SDR pipe was specified and Sch.40 was installed resulting in a decrease in the cross sectional area
  - Increase in
    - Velocity
    - Friction loss (TDH)
  - Specified pump may not work

Pipe installation

- PVC will expand or contract 3.36 inches for every 100 feet of pipe per every 100 degree F change in temperature
  - Typical - 5 degrees F of temp change & 1 inch of expansion/contraction
- Methods
  - Snake pipe
  - Install during cooler part of day

Pipe installation

- Install pipe label up with no bows
- Install piping so flow travels from male into female end of pipe
  - Avoid a lip which can catch material
  - **Slip:** A 'female' end – where the pipe glues into it
  - **Spigot:** A 'male' end – it glues into another fittings socket



Embedment

- Material used and compaction is critical
  - Maximum recommended rock diameter in embedment is 2.5 inches
  - Do not use organic or frozen soil for embedment of pipe
- Bed, haunch, and backfill the pipe so it is supported
- Backfill should be free of rocks and debris

Making the connection – clean pipe

- It must be clean and dry!
- Exterior and interior
- Be sure all small PVC pieces are kept out of system

Making the connection - fittings

- Needed when doing more than just joining a male and female end
- Increase friction in pipe
  - use least amount of fittings and piping necessary
  - see appendix
- Pressure fitting when required

Non-pressure

Pressure

Set time*

- Definition: the necessary time to allow before the joint can be carefully handled

Temp Range	Pipe Size ½ to 1¼ inch	Pipe Size 1½ to 3 inch
60° -100° F	15 min	30 min
40° – 60° F	1 hr	2 hr
0° – 40° F	3 hr	6 hr

**** Check label as some are fast set***

Cure time

- Definition: the necessary time to allow for full strength rating & before pressurizing the system

RELATIVE HUMIDITY 60% or Less*	Pipe Size ½” to 1¼”	Pipe Size 1½” to 3”
Temperature Range	≤ 180 psi	
60° -100° F	1 hr	2 hr
40° – 60° F	2 hr	4 hr
0° – 40° F	8 hr	16 hr

Pipe sleeving

- Application: In areas where a pipe may need additional support
- Method: place a larger diameter pipe around smaller diameter pipe to
  - help support the pipe
  - prevent bowing where debris gets caught or in cold climates wastewater can freeze

Over-excavation

- Should be avoided whenever possible by the use of a laser
- Stability is essential

Why over-excavate?

- Some site conditions require it:
  - Shallow bedrock
  - Organic peat soils
  - Large diameter trees and rocks
  - Loose fill material
  - Soil substitution
- Construction mistakes
- In these situations proper backfilling/bedding is very critical to assure components are stable

Selecting bedding materials

- Key issues are:
  - Can the material be effectively compacted?
  - Is there potential that water will collect in the area where material is being installed?
  - Note – areas with more bedding materials will settle more (A will settle more than B)

Compactable backfill material

Term	Typical Size	Description	Application
Backfill, compactable	3/8 – 1 inch minus High Uniformity Coefficient (UC)	• Compactable material with no rocks larger than 2.5 inches in diameter • Free of organic material, debris, clods, or frozen soil • Not washed, fines present	• Backfill around tanks and advance treatment units where ground and surface water is an issue

Proper backfill?

Non-compactable backfill material

Term	Description	Application
Backfill, non-compactable	• Non-compactable material with no rocks larger than 2.5 inches in diameter • Free of organic material, debris, clods, or frozen soil • Limited amounts of fines •Low uniformity coefficient (UC)	• Backfill around piping • Backfill around tanks and advanced treatment units where ground and surface water is NOT an issue

Compaction equipment

- Machine or mechanism used to reduce the volume of soil through compaction
- Two main types of compactors:
  - Plate
  - "Jumping jack"

Compactor applications

- Pipe bedding
- Tank excavation area
- Around media filter installations
- Be careful to not damage
  - Components – i.e. tanks
  - Soil treatment area

Compaction in filters and mounds systems

- Foot traffic
- Light watering
- Tracked equipment traffic after minimum base of material in place

Landscaping Importance

- Erosion protection- plants help hold topsoil in place
- Protect the system from freezing
  - Plants trap snow
  - Provide insulation
- Soften "look" of system so more aesthetically pleasing

As-built diagram - Required

- To scale is *recommended*
- Diagrams with locations, distances, elevations of
  - Benchmark
  - Manholes
  - Monitoring locations
  - Inspection pipes
- Photos are recommended

Pumps

What is our Application

- Raw sewage
  - must be able to handle solids
  - must be able to handle stringy materials
- Septic tank effluent
  - very minimal solids
- Look for literature on the pump that indicates "effluent, sewage or grinder"

Where is our Application

- Typically, Submersed in One Nasty Environment
  - very corrosive atmosphere above the water line
  - pump materials must not degrade in the liquid and gas of the our pump chamber
  - electrical connections must not short to water

Pump Specifications

- Selection of the pump is based on:
  - Solids handling capacity
  - Flow (measured in gallons per minute – gpm)
  - Total dynamic head Pressure
    - calculated by knowing
      - elevation difference
      - friction in pipes and fittings
      - required pressure at distal end
- Other important specifications
  - Electrical ratings (voltage? amperage?)

Types of pumps
(solids handling capacity)

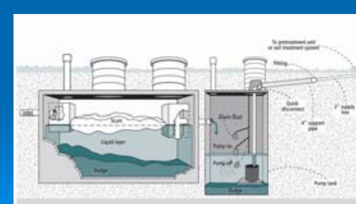
- Sewage
  - Passes up to certain diameter solids
- Effluent
  - "Clear" effluent
- Grinder
  - Grinds sewage before pumping



Every pump should be:

- Accessible
- Elevated
- Replaceable
- Operable
  - Wired
  - Controlled

Proper type
Proper size

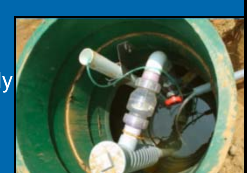


Accessible

- Access from surface
  - Under the manhole
- Reachable
  - Within 20" of the surface

Quick disconnect

- Necessary for O&M of assembly components
- Must be accessible from the surface
- Types of disconnect
  - Threaded union
  - Cam lock fitting
  - Other device that can withstand pressure



Pump is:

- Elevated
  - Storage
- Covered
  - Protection

Normal Position

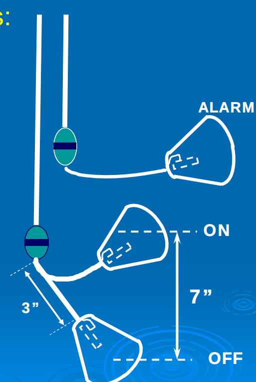
- Normal position for floats is hanging down
  - normally open floats
    - contacts are open in normal position and closed in non-normal position
  - normally closed floats
    - contacts are closed in normal position and open in non-normal position

Demand dosed settings: Single wide angle

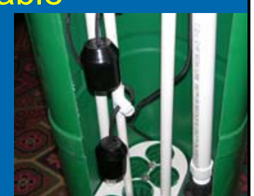
- Factory float settings must be adjusted for your installation
- Effective range for tether length is about 3 to 8″
- Drawdown is about 7 to 19″

ON/OFF separation distance
X Gallons per inch
= dose volume

7″ x 20 gpi = 140 gal.



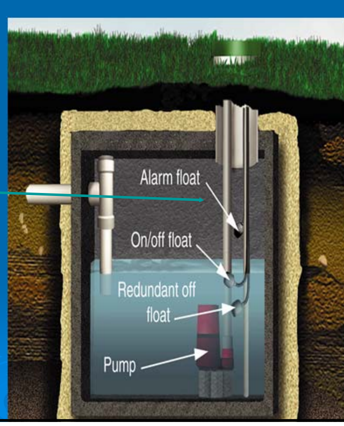
Replaceable



- Removable
  - Pump
  - Floats
  - Float tree
- Reconnecting the pump
- Reconnecting the controls
- Lifting the pump
- All secured?

Drainback?

- Check valve
- Purge hole
  - Bottom of the pipe



Float Cords

- Don’t cut them off to shorten
  - You will need the length to remove them from the basin during service
  - You can wrap them up and stow them neatly in the riser and out of the way
  - Order enough cable to traverse from tank to control panel without splice

Dose Volume (DV) recommendations to Soil Treatment Area

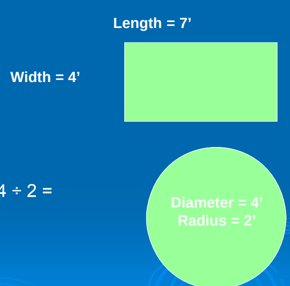
- Maximum = 25% of Design Flow
  - Daily flow ÷ 4 doses
  - Example → 600 gpd ÷ 4 = 150 gal
  - Pressure dosed gravity
- Minimum with pressure distribution = 4 times the volume of laterals
  - Example → 3 laterals, 40 feet in length, 1.5 inch in diameter
  - Known 0.10 gal/ft in 1.5 inch pipe
  - 3 laterals x 40 feet x 0.10 gal/ft = 12 gal
  - 12 gal x 4 = 48 gal
- Example = 100 gal

Dose volume

- Dose Vol
  - Drawdown in inches x gallons per inch
- GPI
  - Area in sq ft.. x 1 for cu ft.. x 7.5 (gal per cu ft).. / 12
- Setting the Floats for the System

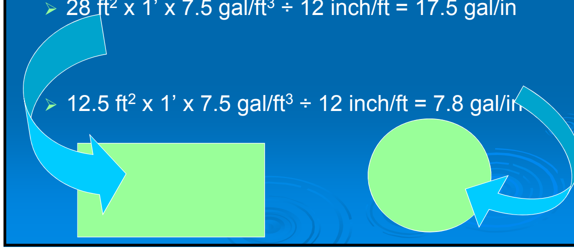
Calculating Drawdown Surface Area

- Rectangle: 4' x 7' tank
  - L x W = Area
  - 4' x 7' = 28 ft^2
- Circle: 4' diameter
  - Radius is half of diameter 4 ÷ 2 = 2'
  - Π x [radius]^2= 3.14 x r x r
  - 3.14 x 2 x 2 = 12.5 ft^2



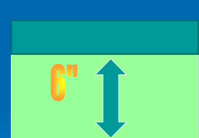
Gallons Per Inch

- Area x 1' x 7.5 gal/ft^3 ÷ 12 inch/ft = gal/inch
- 28 ft^2 x 1' x 7.5 gal/ft^3 ÷ 12 inch/ft = 17.5 gal/in
- 12.5 ft^2 x 1' x 7.5 gal/ft^3 ÷ 12 inch/ft = 7.8 gal/in



Dose Volume (DV)

- Drawdown (in) = Dose Vol. ÷ GPI
- Dose volume ~ 100 gal
- (in) = 100 gal ÷ 17 gal/in
- 6" between the floats
- Need to add in drain back
- Alarm float then set 2-3 inches above



Effect of A Large Dose in the Drainfield

eventually clogging and surfacing

allowing the wastewater to infiltrate into the soil before the next dose is applied

QUESTIONS, COPIES OF PRESENTATIONS
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