Delegated Agency Training
September 23, 2024
by Raymond Morgan, PE

Hydraulic Linear Loading Rates Calculations

Buoyancy Calculations

Cesspools vs Earth Pit Privy

ADEQ Arizona Department of Environmental Quality

Clean Air, Safe Water, Healthy Land for Everyone

Hydraulic Linear Loading Rate

- **R18-9-A312. Facility Design for Type 4 On-site Wastewater Treatment Facilities**
- **A.** General design requirements. An applicant shall ensure that the person designing an on-site wastewater treatment facility:
- 1. Signs the design documents submitted as part of the Notice of Intent to Discharge to obtain a Construction Authorization, including plans, specifications, drawings, reports, and calculations; and
- 2. Locates and designs the on-site wastewater treatment facility project using good design judgment and relies on appropriate design methods and calculations.

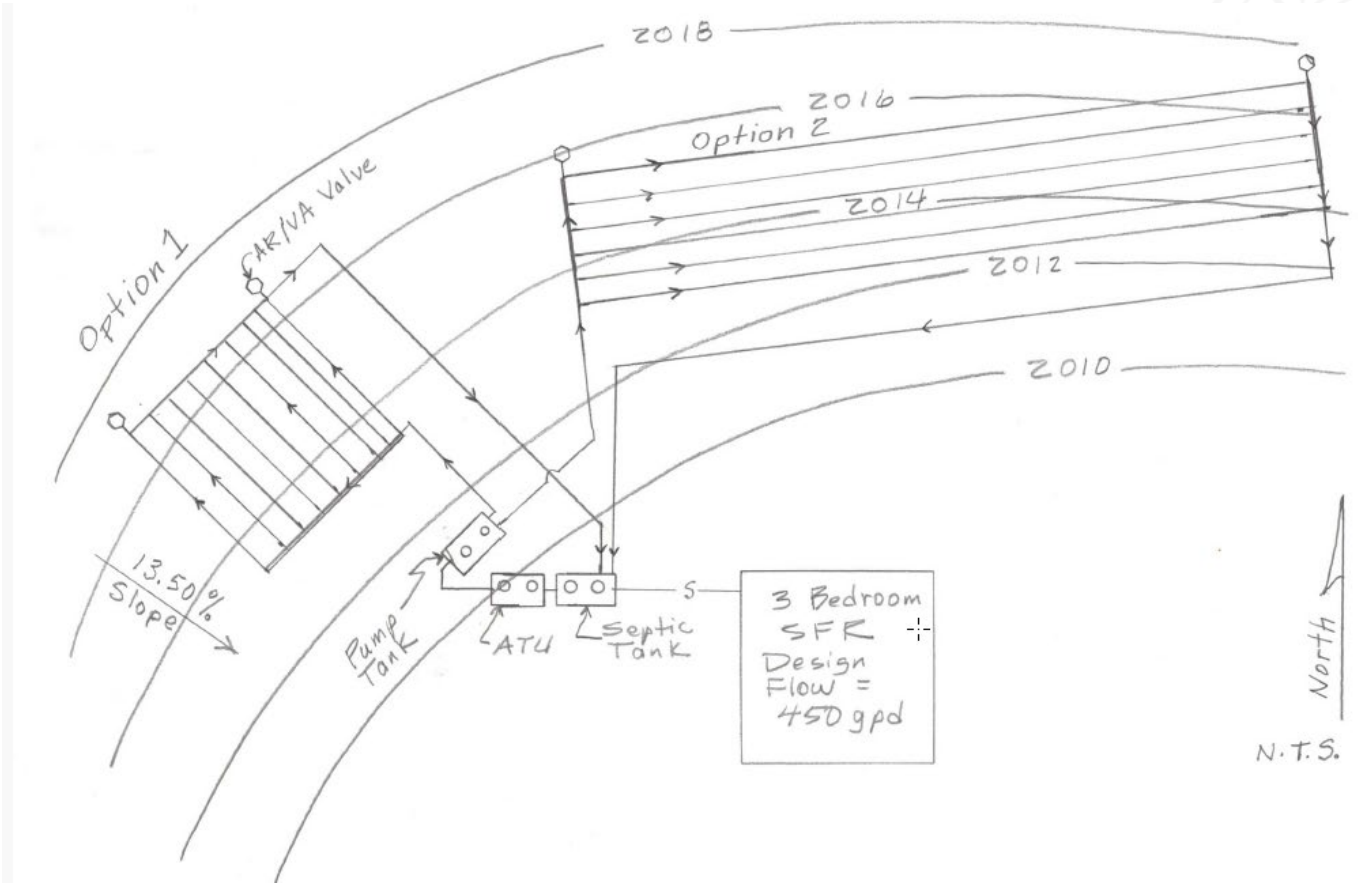
Hydraulic Linear Loading Rate

- R18-9-A312.B.4 For on-site wastewater treatment facilities permitted under R18-9-E303 through R18-9-E323, apply the following design requirements, as applicable:
- a. Include the power source and power components in construction drawings if electricity or another type of power is necessary for facility operation;
- b. If a hydraulic analysis is required under subsection (E), perform the analysis based on the location and dimensions of the bottom and sidewall surfaces of the disposal works that are identified in the design documentation;

Hydraulic Linear Loading Rate

- R18-9-A312.E.2.b Include a hydraulic analysis with the Notice of Intent to Discharge, based on the dimensions of the absorption surfaces specified in R18-9-A312(B)(4)(b), showing that the soil is sufficiently permeable to conduct wastewater downward and laterally without surfacing for the site conditions at the disposal works.

Hydraulic Linear Loading Rate



- Information for the Onsite Wastewater Treatment Facility Design (OWTF):
  - Three-bedroom single family residence
  - Design Flow = 3 bedrooms x 150 gpd/bedroom = 450 gpd
  - SAR – 0.60 gpd/sf
  - Soil Texture - Sandy Loam (SL)
  - Structure – Moderate
  - Soil Depth – 4 feet
  - SAR_a – 1.20 gpd/sf
  - BOD_5 – 15 mg/l
  - TSS – 15 mg/l
  - Allowable Hydraulic Linear Loading Rate (AHLLR) – 7 gpd/lf (from Tyler's Table 1)
  - Dripline – Drip Heads at 2' intervals
  - Drip Emitter Flow Rate – 0.60 gph

Hydraulic Linear Loading Rate

2005 Soil Absorption Rate Adjustment Calculation -

Enter Data as Follows:

BOD (Effluent Value)	TSS (Effluent Value)	Unadjusted SAR (From Site Investigation)	Design Flow (gpd)
15	15	0.60	450

2005 Soil Absorption Rate Adjustment Formula

BOD (Effluent Value)	TSS (Effluent Value)	Unadjusted SAR (From Site Investigation)	Adjusted SAR (Calculated Value)	Unadjusted Disposal Field Area (sf)	Adjusted Disposal Field Area (sf)
15	15	0.60	1.20	750	373

Hydraulic Linear Loading Rate

Soil characteristics			Infiltration loading rate, gal/da/ft^2		Hydraulic linear loading rate, gal/d/ft								
					Slope								
					0-4%			5-9%			>10%		
					Infiltration distance, inch			Infiltration distance, inch			Infiltration distance, inch		
Texture	Structure		>30 mg/L	<30 mg/L	8-12	12-	24-48	8-	12-	24-	8-	12-	24-
	Shap	Grad											
COS, S, LCOS, LS	--	0SG	0.8	1.6	4.0	5.0	6.0	5.0	6.0	7.0	6.0	7.0	8.0
FS,VFS,LFS,LVFS	--	0SG	0.4	1.0	3.5	4.5	5.5	4.0	5.0	6.0	5.0	6.0	7.0
CSL, SL	--	0M	0.2	0.6	3.0	3.5	4.0	3.6	4.1	4.6	5.0	6.0	7.0
	PL	1	0.2	0.5	3.0	3.5	4.0	3.6	4.1	4.6	4.0	5.0	6.0
		2, 3	0.0	0.0	-	-	-	-	-	-	-	-	-
	PR/BK/GR	1	0.4	0.7	3.5	4.5	5.5	4.0	5.0	6.0	5.0	6.0	7.0
		2,3	0.6	1.0	3.5	4.5	5.5	4.0	5.0	6.0	5.0	6.0	7.0
FSL, VFSL	--	0M	0.2	0.5	2.0	2.3	2.6	2.4	2.7	3.0	2.7	3.2	3.7
	PL	1,2,3	0.0	0.0	-	-	-	-	-	-	-	-	-
	PR/BK/G	1	0.2	0.6	3.0	3.5	4.0	3.3	3.8	4.3	3.6	4.1	4.6
		2,3	0.4	0.8	3.3	3.8	4.3	3.6	4.1	4.6	3.9	4.4	4.9
L	--	0M	0.2	0.5	2.0	2.3	2.6	2.4	2.7	3.0	2.7	3.2	3.7
	PL	1,2, 3	0.0	0.0	-	-	-	-	-	-	-	-	-
	PR/BK/GR	1	0.4	0.6	3.0	3.5	4.0	3.3	3.8	4.3	3.6	4.1	4.6
		2, 3	0.6	0.8	3.3	3.8	4.3	3.6	4.1	4.6	3.9	4.4	4.9
SIL	--	0M	0.0	0.2	2.0	2.5	3.0	2.2	2.7	3.2	2.4	2.9	3.4
	PL	1,2,3	0.0	0.0	-	-	-	-	-	-	-	-	-
	PR/BK/G	1	0.4	0.6	2.4	2.7	3.0	2.7	3.0	3.3	3.0	3.5	4.0
		2,3	0.6	0.8	2.7	3.0	3.3	3.0	3.5	4.0	3.3	3.8	4.3
SCL,CL SICL	--	0M	0.0	0.0	-	-	-	-	-	-	-	-	-
	PL	1,2,3	0.0	0.0	-	-	-	-	-	-	-	-	-
	PR/BK/G	1	0.2	0.3	2.0	2.5	3.0	2.2	2.7	3.2	2.4	2.9	3.4
		2,3	0.4	0.6	2.4	2.9	3.4	2.7	3.0	3.3	3.0	3.5	4.0
SC, C, SIC	--	0M	0.0	0.0	-	-	-	-	-	-	-	-	-
	PL	1,2,3	0.0	0.0	-	-	-	-	-	-	-	-	-
	PR/BK/G	1	0.0	0.0	-	-	-	-	-	-	-	-	-
		2,3	0.2	0.3	2.0	2.5	3.0	2.2	2.7	3.2	2.4	2.9	3.4

Hydraulic Wastewater Loading Rates to Soil – Table 1 by E. Jerry Tyler

Hydraulic Linear Loading Rate

- Calculations – Disposal Area on 13.5% Slope
  - Disposal Area Needed (DAN) = Design Flow/SAR_a
  - DAN = 450 gpd/1.20 gpd/sf = 375 sf
  - DAN Dimensions (option 1) = $(375)^{0.50}$ = 20’ x 20’
    - Actual HLLR = 450 gpd/20’ = 22.5 gpd/lf > 7 gpd/lf
  - DAN Dimensions (option 2) = 6’ x 65’
    - Length = Design Flow/AHLLR = 450 gpd/7 gpd/lf = 64.3’
    - Width = DAN/Length = 375 sf / 64.3’ = 5.8’

Hydraulic Linear Loading Rate

- Calculations – Disposal Area on Level Building Pad
  - Disposal Area Needed = Design Flow/SAR_a
  - DAN = 450 gpd/1.20 gpd/sf = 375 sf
  - DAN Dimensions (option 1) = $(375)^{0.50}$ = 20’ x 20’
    - Actual HLLR = 450 gpd/20’ = 22.5 gpd/lf > 5.5 gpd/lf
  - DAN Dimensions (option 2) = 6’ x 82’
    - Length = Design Flow/AHLLR = 450 gpd/5.5 gpd/lf = 81.8’
    - Width = DAN/Length = 375 sf / 81.8’ = 4.58’

Hydraulic Linear Loading Rate

- Calculations – Number of Drip Emitters & Dispersal Flow Rate
  - Number of Emitters = (# of rows (3) x 82’) /2’ (emitter spacing) = 123
  - Hourly Design Flow (HDF) = 450 gpd/24 hpd = 18.75 gph
  - Hourly Dispersal Rate (HDR) = emitter flow rate (gph/emitter) x # of emitters = 0.60 gph x 123 emitters = 73.80 gph
- Dosing Time Ratio = HDF (gph)/ HDR (gph) = .25, therefore only ¼ of the hour is needed to disperse the effluent Design Flow

Hydraulic Linear Loading Rate

- Questions?

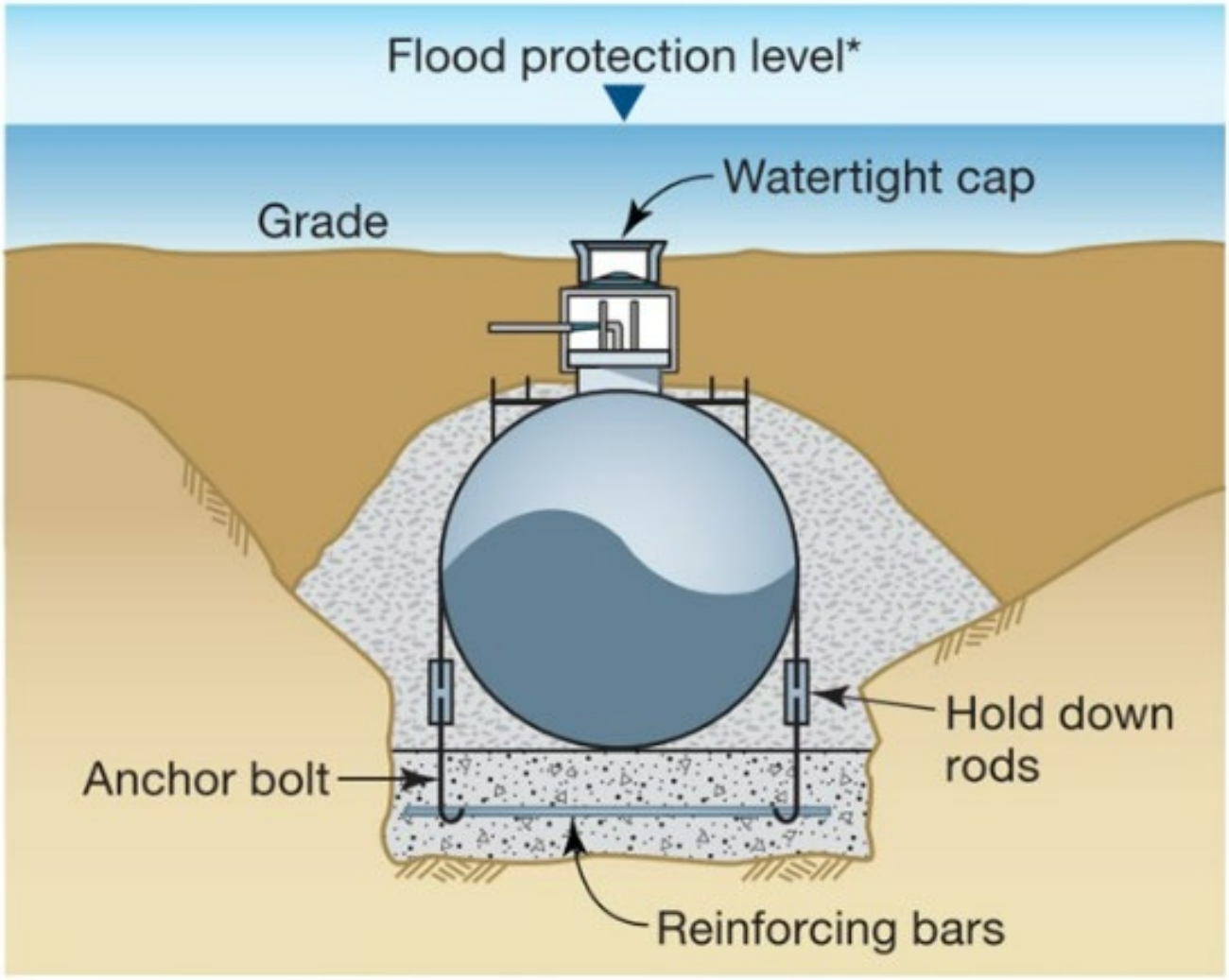
Buoyant Forces

- R18-9-A312.B.4 For on-site wastewater treatment facilities permitted under R18-9-E303 through R18-9-E323, apply the following design requirements, as applicable:
- R18-9-A312.B.4.c Design components, piping, ports, seals, and appurtenances to withstand installation loads, internal and external operational loads, and buoyant forces. Design ports for resistance against movement, and cap or cover openings for protection from damage and entry by rodents, mosquitoes, flies, or other organisms capable of transporting a disease-causing organism;

Buoyant Forces

- Archimedes' principle states that a body immersed in a liquid is subjected to a vertical buoyant force equal to the weight of the displaced liquid.

Buoyant Forces



* The flood protection level will be dictated by the ability of the submerged tank to resist depth-dependant hydrostatic pressures

Buoyant Forces

Buoyant Forces

- Given
  - Septic Tank Volume – 1,000 gallons
  - Septic Tank Dimensions – 8’2’’ (8.17’) Length x 5’8” (5.67’) Width x 5’1’’ (5.08’) Height
  - Soil Cover – 1 foot
  - Weight of Concrete – 145 pcf
  - Weight of Water – 62.4 pcf
  - Weight of Soil – 115 pcf
  - Weight of Concrete Anchor – 2,500 #
  - Weight of 1,000-gallon concrete septic tank with 3” thick walls – 8,600 #

Buoyant Forces

- Buoyancy Force
  - Buoyance Force (BF) = Volume of Displaced Liquid x weight of the displaced liquid
  - BF = (8.17’ x 5.67’ x 5.08’) x (62.4 #/cf) = 14,864 #
- Resisting Force
  - Resisting Force (RF) = Weight of Concrete + Weight of Soil + Weight of an Anchor
  - RF = 8,600 # + (1’ x 8.17’ x.5.67’ x 115 pcf) + (2 x 2,500 #)
  - RF = 8,600 # +5,327 # + 5,000 #
  - RF = 18,927 # > 14,684 #; the safety ratio = 1.29

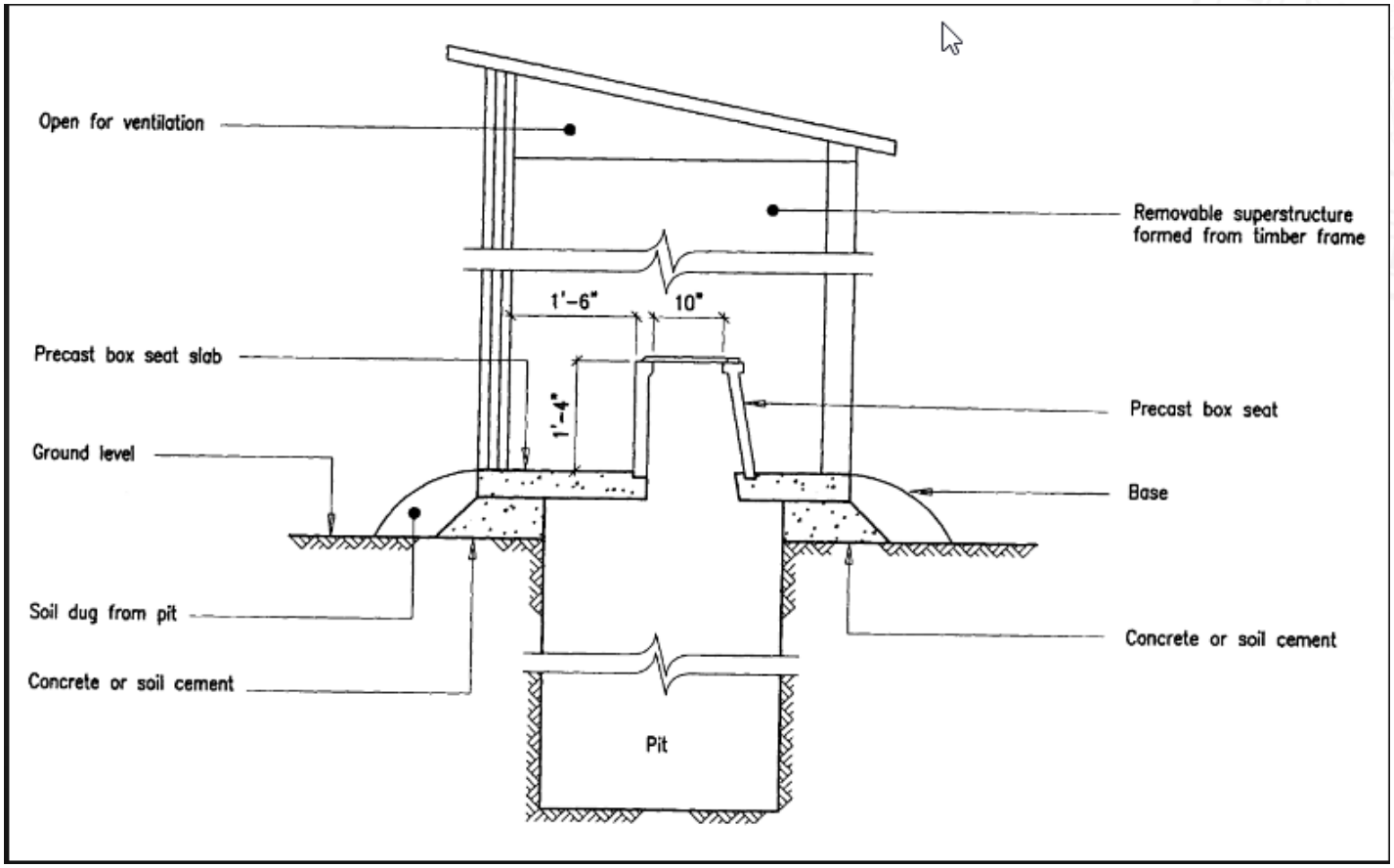
Buoyant Forces

- Questions?

Earth Pit Privy vs. Cesspool

- R18-9-A309.A.4 A person shall not use a cesspool for sewage disposal.
- R18-9-B301.H 1.08 General Permit allows for any earth pit privy, fixed or transportable chemical toilet, incinerator toilet or privy, or pail or can-type privy if allowed by a county health or environmental department under A.R.S. Title 36 or a delegation agreement under A.R.S. § 49-107.

Earth Pit Privy vs. Cesspool



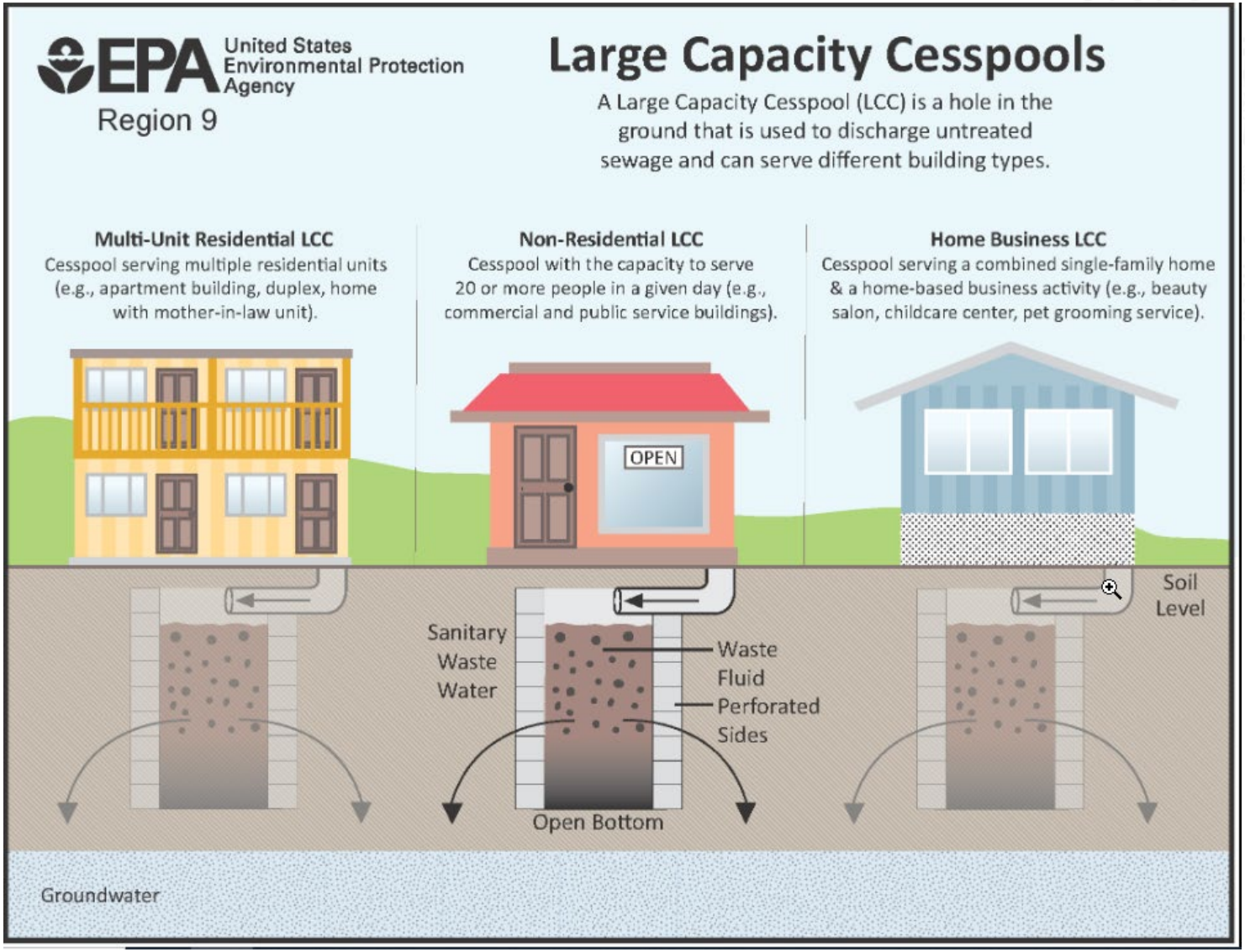
Earth Pit Privy vs. Cesspool

- R18-9-101.14 "Cesspool" means a pit, collection structure, or subsurface fluid distribution system, which may or may not be partially lined, that receives discharged sewage. A cesspool is not an on-site wastewater treatment facility, such as a septic tank, vault, or other structure permitted under Article 3 of this Chapter.

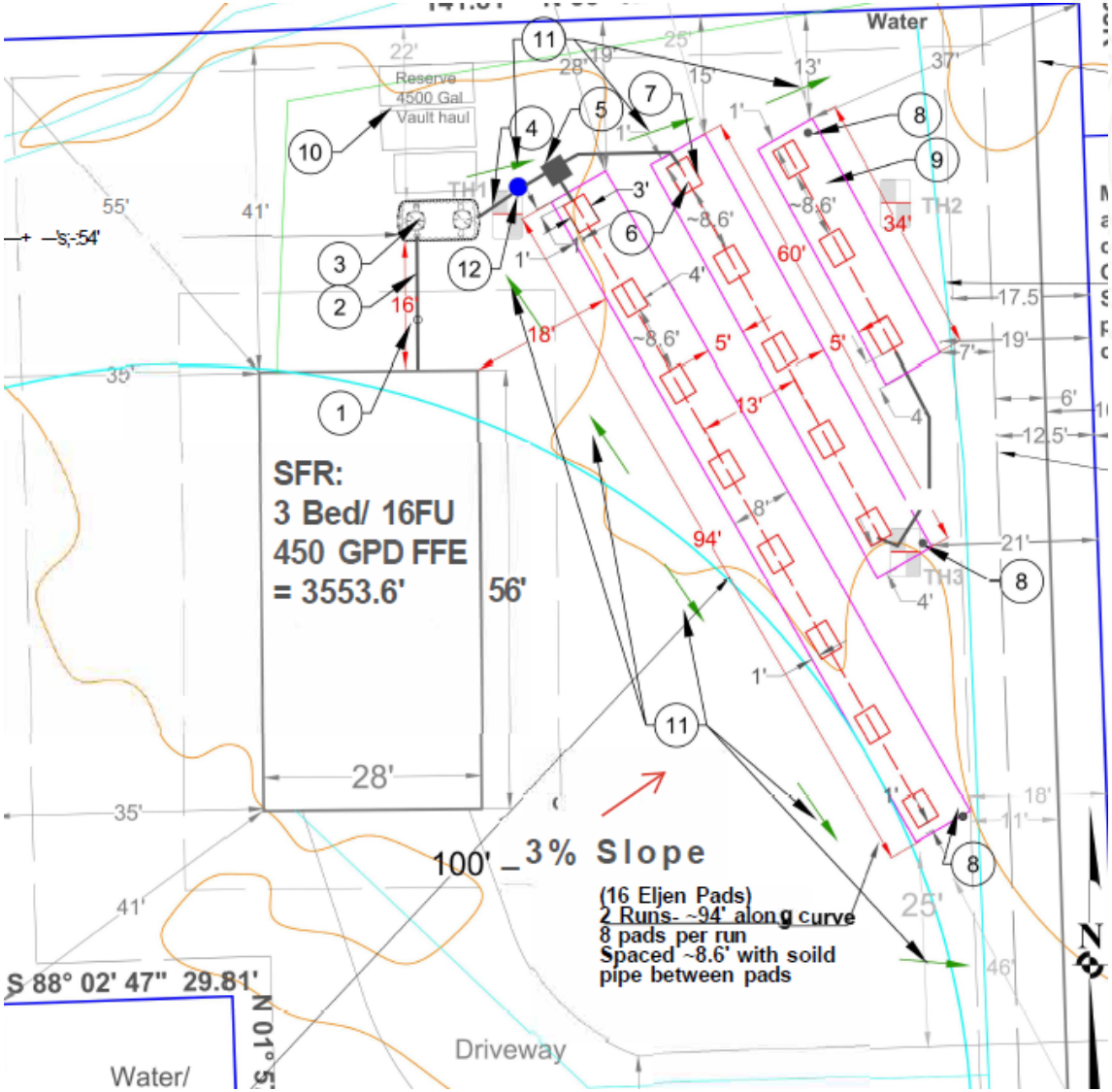
Earth Pit Privy vs. Cesspool

- R18-9-101.41 "Sewage" means untreated wastes from toilets, baths, sinks, lavatories, laundries, other plumbing fixtures, and waste pumped from septic tanks in places of human habitation, employment, or recreation. Sewage does not include gray water as defined in A.R.S. § 49-201(20), if the gray water is reused according to 18 A.A.C. 9, Article 7

Earth Pit Privy vs. Cesspool



Hydraulic Linear Loading Rate



Hydraulic Linear Loading Rate

- Analysis of a Concentrated Hydraulic Linear Loading Rate Design
  - Given:
    - Soil – Loamy Sand (SL)
    - Allowable Hydraulic Linear Loading Rate – 5.5 gpd/lf
    - Design Flow - 450 gpd
    - Design Flow per pad = 28 gpd
  - Analysis
    - Zone 1 – 10 pads = 280 gpd/34’ = 8.2gpd/lf > 5.5 gpd/lf
    - Zone 2 – 3 pads = 84 gpd/26’ = 3.2 gpd/lf < 5.5 gpd/lf
    - Zone 3 – 3 pads = 84 gpd/34’ + 2.5 gpd/lf < 5.5 gpd/lf

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Arizona Department of Environmental Quality

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