DESIGN GUIDE
MD #4

Wastewater Treatment Strip
Design Methods
For
Grass Filter Areas and Grass Filter Channels

CONSTRUCTION DETAILS

AND SPECIFICATIONS

NRCS Natural Resources Conservation Service

Maryland

May 2002

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SECTION I

General

The development of this design guide has been influenced through assistance by the Pennsylvania NRCS engineering staff. This assistance is greatly appreciated.

This guide will assist the designer in determining the size, dimensions, and application rates for wastewater treatment strips, in conformance with Maryland Conservation Practice Standard 635, Wastewater Treatment Strip. The design process is based on controlled hydraulic loading of diluted wastewater onto a vegetated soil surface. The wastewater is treated and assimilated by the plants and soil within the filter area. The intent is to treat the wastewater with filtering, deposition, plant uptake, evapotranspiration, solar exposure, adsorption to soil particles, and biological degradation. To accomplish this, the wastewater must be retained within the filter area. The hydraulic loading is designed so that there will be no surface discharge or leaching below the root zone beneath the filter. The hydraulic loading criteria come from studies that showed this to be the critical factor in the success of vegetated filters. In simple terms, it means that a filter will only work if you don't overload it. Because the design method is based on hydraulic loading, there is no accounting for nutrient accumulations. To prevent extreme nutrient build up or releases, and to avoid harming the vegetation, the wastewater must be relatively dilute.

Vegetated filters are not meant for undiluted or prolonged flows of manure, manure liquids, or silage leachate. These types of waste can only be accommodated if they are diluted (at least 1:1) with clean water or other wastewater such as milkhouse wastewater and barnyard runoff. The designer should consider increasing dilution and/or providing more than one filter area to provide extended rest periods for nutrient uptake and removal.

There shall be a minimum of 20 inches of soil depth between finished grade and bedrock and/or the seasonal high water table. When soils are classified as excessively drained or soils do not meet the above criteria the wastewater treatment strip shall be modified in accordance with recommendations from the appropriate specialists.

SECTION II

Filter Areas for Controlled Overland Flow Treatment of Liquid Wastes

These criteria apply to filter areas for wastewater from milking parlors, milking centers, waste treatment lagoons, on-farm food processing plants, silos, and waste storage facilities.

Dosing and Settling Facility Design

If suspended solids are expected in the wastewater, provide a settling facility with a minimum of two-day detention volume for floatable and settleable solids. The outlet from this settling facility shall be gravity flow. In addition a dosing tank with a minimum volume equal to 3 says storage of wastewater is required. The maximum discharge from the settling facility outlet to the dosing tank shall not exceed the maximum discharge from the dosing tank to the manifold pipe. A pump or siphon for distribution of wastewater shall be located in a dosing tank separate from the settling facility.

Design

Maximum application depth is determined using the "soil group" as shown in Table 1 to prevent exceeding the soil's water holding capacity. Deep well-drained soils will accept and hold more water than shallow poorly drained soils. The "soil group" and maximum application depth for the filter area can be determined from Table 1. This can be achieved by determining the filter areas soil drainage class and soil depth and reading right and down, respectively, on table 1. Maximum application depth is the total water volume per dose, expressed as a depth in inches over the entire filter area.

Table 1: Soil Groups and Maximum Application Depths

		Soil Depth		
	Redox Feature Depth	Deep > 40"	Mod. Deep[1] 20" – 40"	Shallow[1] < 20"
Soil Drainage Class		Soil Group/Max Application Depth		
Well drained	> 40"	1/0.5"	2/0.4"	3/0.3"
Moderately Well Drained[1]	20" - 40"	2/0.4"	3/0.3"	4/0.2"
Somewhat Poorly Drained[1]	10" - 20"	4/0.2"	5/0.1"	5/0.1"
Poorly & Very Poorly Drained[1]	< 10"	4/0.2"	5/0.1"	5/0.1"

[1] The useable soil depth in the filter area should be verified on site. If there is less than 20 inches of useable soil depth, additional useable depth will have to be provided, or the site is not acceptable. Useable soil depth can be increased by adding soil on the surface, or by providing drainage up slope of the filter area.

The hydraulic loading rate is designed to establish sheet flow ($\leq$0.5" deep) down the filter slope. Filter area dimensions are determined using hydraulic calculations to provide 15 minutes of retention time within the filter length, at a maximum constant flow depth of 0.5" throughout the length. Filter dimensions for these flow conditions are found in Table 2. (Due to infiltration, this is a conservative approach. The flow depth and velocity will actually decrease as the water flows down the slope.)

Table 2 is split into two sections that are read separately. In the top portion of the table, the slope of the filter area (%), the minimum filter length (ft) to provide 15 minute flow time, and the maximum dose rate (gal/min/ft width) per foot of filter width are related to each other. Any one of these values can be found if the other two are known.

The bottom portion of Table 2 shows the relationship among the filter slope (%) along the left side, a delivery rate (gpm) across the top, and a minimum required filter width (ft) within the body of the table. Again, any one of these values can be found based on the other two. The values used in the lower portion must agree, however, with those from the top portion of the table (i.e. the same filter slope, and the product of the maximum dose rate (gal/min/ft) times the minimum filter width (ft) must equal the delivery rate gpm).) Minimum filter widths can be interpolated from the table for delivery rates between those listed in the table, or can be calculated by dividing a desired delivery rate by the maximum dose rate (gal/min/ft of width).

The best filter area performance is achieved by intermittently dosing the filter area with a pump or siphon every three or more days. This is essential for the success of a filter area for milking center wastewater, and is encouraged for all types of filter areas. For a milking center filter, the pump or siphon should be selected to empty the dosing tank in 5 to 20 minutes. This will produce a dose rate that exceeds the soil infiltration rate, and will force surface flow down the filter slope. A delivery rate can be initially estimated by multiplying the daily wastewater volume by 3 days, and dividing by 10.

A pump's delivery rate (gpm) is taken from a pump rating curve or table provided by the manufacturer. It will be a pumping capacity for the expected total dynamic head (elevation head loss plus friction losses) on the planned installation. For an automatic siphon, the manufacturer's published average discharge is used as the delivery rate in the table. For gravity flow systems, the delivery rate is the design discharge flow from the barnyard, or a routed discharge where extra storage and a flow restricting orifice is used to limit the flow to a desired delivery rate.

The design flow depth for sheet flow through the filter area can be less than 0.5 inch to meet site constraints such as a short available slope length. This can be done using Tables 3 through 6 or Figure 1. <u>Care should be taken to not confuse the design flow depth with the maximum application depth</u>. The design flow depth must be less than or equal to 0.5 inches, regardless of the maximum application depth found in Table 1. If there are no site constraints on the dimensions of the filter area, the design flow depth should be kept at 0.5".

Tables 3 through 6 are read in the same manner as Table 2. For a given filter slope and pump rate, Tables 3 through 6 will give shorter filter lengths, greater filter widths, and larger filter areas to provide flexibility in meeting site conditions.

Figure 1 is an alternative method to Tables 2 through 6, and yields the same results. Knowing the values for any three of: the filter slope (%), filter area length (ft), design flow depth (inches), and the maximum dose rate (gal/min/ft), the fourth value can be found. The two charts in Figure 1 are related to each other by the filter slope and the design flow depth, both of which must be kept constant when reading from one chart to the other. An added step in using Figure 1 is to divide the pump rate (gpm, found in manufacturer's rating curve or table) by the dose rate (gal/min/ft) to find the minimum filter width.

As a final check on the filter dimensions, the dose volume must be compared to the maximum application depth. To do this, divide the total dose volume (gal) by 7.48 gal/ft^3, divide again by the area (ft^2) of the filter, and multiply by 12 inch/ft. This value should be no higher than the maximum application depth found in Table 1.

Figure 2 takes another approach to find the filter dimensions. Using the total dose volume (gal) and the Soil Group from Table 1, the required area (ft^2) of the filter can be found on the left chart in Figure 2. Reading across to the right chart, a filter width and length can be determined that meet the minimum area requirements. These dimensions do not automatically meet the minimum width or length requirements for a dose rate or 15 minute flow time. These dimensions must then be matched with a delivery rate (gal/min) that will not exceed the maximum dose rate (gal/min/ft). This can be done in Figure 1, using the length, the filter slope, and the design depth to find the maximum dose rate.

Figure 2 can also be used to check that the maximum application depth (inches) from Table 1 has not been exceeded. Using the total dose volume (gal) and the Soil Group from Table 1, the required area of the filter can be found at the left side of Figure 2. This area must be $\leq$ the product of the filter width and length determined from Tables 2 through 6 or Figure 1.

A final check of the filter dimensions and dose volume looks at the weekly hydraulic load on the filter area. The total allowable weekly depth, including rainfall, is two inches. The highest weekly average rainfall (highest monthly rainfall / 4) is subtracted from 2 inches. The remaining value is then multiplied by 3 days per dose, and divided by 7 days per week. This value must be $\geq$ the maximum application depth from Table 1.

Table 7 provides orifice discharge capacities over the typical range needed to handle the design discharge flow from a barnyard, and the small (< 1") diameter orifice sizes used in a perforated distribution pipe. The table can be used to select the orifice size based on the desired discharge and the head at the maximum depth over the orifice. The table can also be used to determine the discharge through a trial orifice size, with the design head over the orifice. Whenever possible, the design head should be 3 feet or more.

Table 8 provides discharge capacities of slotted riser pipes over the typical range needed to handle the design discharge flow from a barnyard. The required discharge and the maximum head over the base of the riser are used to find the open slot area needed per foot of riser pipe.

SECTION III

Filter Areas for Runoff from Concentrated Livestock Areas

These criteria apply to wastewater treatment strips for runoff from feedlots, barnyards, manure stacking facilities, and composting facilities.

Grass Filter Areas without Settling Facilities

In some situations a grass filter area can be constructed without the use of a settling facility. Minimal solids transport and even distribution of the wastewater (sheet flow) onto the grass filter area is critical to the success of these systems. The discharge outlet from the concentrated livestock area should be as wide as practical. The idea is to make the grass filter area wide and have a flow length no greater than 100 feet. This will help to keep sheet flow across the grass filter area, which will improve distribution of the wastewater and increase infiltration.

The design of the concentrated livestock area will influence solids transport from the area. When constructing a new concentrated livestock area consider the following. Minimize the flow length across the area by making the pad short in the flow direction and as long as needed to get the proper size. Construct the pad as close as possible to the contour and keep the pad slope (flow path slope) at 1.5 % or less. In addition to the above a level distribution pad, curbing or similar means can be used at the outlet to reduce the discharge velocity, improve distribution of the wastewater and reduce solids transport onto the grass filter area. Cleaning (scraping) of the concentrated livestock area is also critical.

In many situations the concentrated livestock areas already exist and a problem has developed. Why else would we be there. In situations were good management is anticipated (frequent scraping) but the concentrated livestock area doesn't comply with that shown above it may still be possible to construct an outlet that will achieve the same goal. A leveling pad, curbing or similar may be constructed at the outlet to reduce the discharge velocity, remove some solids and evenly distribute the wastewater discharge onto the grass filter area.

The grass filter area shall be sized as follows. The flow length of the grass filter area shall be equal to the maximum flow path of its drainage area but in no case less than 20 feet or greater than 100 feet. The minimum size of the grass filter area shall be equal to the size of its drainage area.

Wastewater Treatment Strips with Settling Facilities

Settling Facility Design

A settling facility shall be provided between the waste source and wastewater treatment strip if one or both of the following conditions occur:

1. When it is anticipated that a high volume of manure solids will run off the concentrated livestock area, due to infrequent cleaning or less than optimum site management;

2. When the criteria shown in the previous section cannot be met.

The settling facility shall have sufficient capacity (wet storage volume) below the overflow to store 0.5 area/inches of manure solids from the concentrated waste area. This is a volume equivalent to the drainage area in square feet multiplied by 0.042 feet (0.5 inches). In addition, the settling facility shall have capacity to store an additional 1-inch of runoff to the top of the settling facility. This is a volume equivalent to the drainage area in square feet multiplied by 0.083 feet (1.0 inches). Any basin outflow shall be disregarded in computing minimum storage.

Additional storage capacity, based on frequency of cleaning, shall be provided for manure and other solids settled within the basin. If the basin is to be cleaned after every 2-inch rainfall or when the solids storage is full, no additional storage is required. If infrequent cleaning of the basin is planned, additional storage equivalent to at least 0.5 inches runoff from the concentrated waste area shall be provided for each month between planned cleanings.

The settling facility shall be designed to completely discharge the design volume of runoff from the drainage area in no longer than 2 hours, and not produce a sustained trickle flow to the wastewater treatment strip. Minimum dimensions of the wastewater treatment strip shall be based on the design flow from the runoff discharge from the settling facility. The discharge will be controlled by pump, siphon, valve or by similar means.

Filter Area Design

When designing a grass filter area for runoff from a concentrated livestock area and a dosing distribution system will be utilized the design of the filter area will follow the method shown Section II under Filter Area Design with the exception that table 1 will not be used. An application depth of 0.5 inches will be used.

Grass filter channels require a minimum flow through time of 15 minutes based on a D retardance and a maximum depth of 0.3 feet. The filter channel shall be trapezoidal in shape and have a maximum bottom width of 20 feet. When a distribution system is used to supply the wastewater to the grass filter channel widths wider than 20 feet may be considered. Regardless of the filter channel size, provide an area adequate for a maximum application rate of 1 inch per week.

Grass filter channel dimensions are determined using hydraulic calculations to provide 15 minutes of retention time, at D retardance, within the filter length, at a maximum constant flow depth of 0.3 feet throughout the length. Filter dimensions for these flow conditions are found in Table 9. (Due to infiltration, this is a conservative approach. The flow depth and velocity will actually decrease as the water flows down the slope.)

Table 9 is split into two sections that are read separately. In the top portion of the table, the slope of the filter area (%), the minimum filter length (ft) to provide 15 minute flow time, and the maximum dose rate (gal/min/ft width) or (cubic feet/sec/ft. width) per foot of filter width are related to each other. Any one of these values can be found if the other two are known.

The bottom portion of Table 9 shows the relationship among the filter slope (%) along the left side, a delivery rate (gpm) across the top, and a minimum required filter width (ft) within the body of the table. Again, any one of these values can be found based on the other two. The values used in the lower portion must agree, however, with those from the top portion of the table (i.e. the same filter slope, and the product of the maximum dose rate (gal/min/ft) times the minimum filter width (ft) must equal the delivery rate gpm).) Minimum filter widths can be interpolated from the table for delivery rates between those listed in the table, or can be calculated by dividing a desired delivery rate by the maximum dose rate (gal/min/ft of width).

The best filter area performance is achieved by intermittently dosing the filter area with a pump, gravity or siphon every three or more days. This is essential for the success of a filter and is encouraged for all types of filter areas.

A pump's delivery rate (gpm) is taken from a pump rating curve or table provided by the manufacturer. It will be a pumping capacity for the expected total dynamic head (elevation head loss plus friction losses) on the planned installation. For an automatic siphon, the manufacturer's published average discharge is used as the delivery rate in the table. For gravity flow systems, the delivery rate is the design discharge from the wet storage volume, or a routed discharge where extra storage and a flow restricting orifice is used to limit the flow to a desired delivery rate.

The design flow depth for channel flow through the filter area can be less than 0.3 feet to meet site constraints such as a short available slope length. This can be done using Tables 10 through 15. <u>Care should be taken to not confuse the design flow depth with the maximum application depth</u>. The design flow depth must be less than or equal to 0.3 feet, regardless of the maximum application depth found in Table 1. If there are no site constraints on the dimensions of the filter area, the design flow depth should be kept at 0.3 feet.

Tables 10 through 15 are read in the same manner as Table 9. For a given filter slope and pump rate, Tables 10 through 15 will give shorter filter lengths, greater filter widths, and larger filter areas to provide flexibility in meeting site conditions.

As a final check on the filter dimensions, the dose volume must be compared to the maximum application depth. To do this, divide the total dose (wet) volume (ft^3) by the area (ft^2) of the filter, and multiply by 12 inch/ft. This value should be no higher than the maximum application depth found in Table 1. In addition the weekly hydraulic load on the filter area of 1 inch can not be exceeded.

Table 7 provides orifice discharge capacities over the typical range needed to handle the design discharge from a barnyard, and the small (< 1") diameter orifice sizes used in a perforated distribution pipe. The table can be used to select the orifice size based on the desired discharge and the head at the maximum depth over the orifice. The table can also be used to determine the discharge through a trial orifice size, with the design head over the orifice. Whenever possible, the design head should be 3 feet or more.

Table 8 provides discharge capacities of slotted riser pipes over the typical range needed to handle the design discharge flow from a barnyard. The required discharge and the maximum head over the base of the riser are used to find the open slot area needed per foot of riser pipe.

SECTION IV

Design Tables

Table 2: Filter Area Dimensions for Design Flow Depth of 0.5 Inches

Table 2: Filter Area Dimensions for Design Flow Depth of 0.5 Inches

Design Flow Depth (d=0.5")

	Filter Slope %														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Minimum Filter Length	67	95	115	135	150	164	177	188	200	211	222	232	242	251	260
gal/min/ ft. width	1.4	1.97	2.42	2.79	3.12	3.42	3.69	3.95	4.19	4.41	4.63	4.83	5.03	5.22	5.41

		Min. Filter Width @ Delivery Rate (gpm)														
		10	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**	**120**	**140**	**160**	**180**	**200**
	1		15	22	29	36	43	50	58	65	72	86	100	115	129	143
F	**2**		11	16	21	26	31	36	41	46	51	61	72	82	92	102
I	**3**		9	13	17	21	25	29	34	38	42	50	58	67	75	83
L	**4**			11	15	18	22	26	29	33	36	44	51	58	65	72
T	**5**			10	13	17	20	23	26	29	33	39	45	52	58	65
E	**6**			9	12	15	18	21	24	27	30	36	41	47	53	59
R	**7**			9	11	14	17	19	22	25	28	33	38	44	49	55
	8				11	13	16	18	21	23	26	31	36	41	46	51
S	**9**				10	12	15	17	20	22	24	29	34	39	43	48
L	**10**				10	12	14	16	19	21	23	28	32	37	41	46
O	**11**				9	11	13	16	18	20	22	26	31	35	39	44
P	**12**				9	11	13	15	17	19	21	25	29	34	38	42
E	**13**					10	12	14	16	18	20	24	28	32	36	40
	14					10	12	14	16	18	20	23	27	31	35	39
(%)	**15**					10	12	13	15	17	19	23	26	30	34	37

Table 3: Filter Area Dimensions for Design Flow Depth of 0.4 Inches

Table 3: Filter Area Dimensions for Design Flow Depth of 0.4 Inches

Design Flow Depth (d=0.4")

	Filter Slope %														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Minimum Filter Length	58	82	100	116	129	142	153	163	173	183	192	200	208	216	224
gal/min/ ft. width	0.96	1.36	1.66	1.92	2.15	2.35	2.54	2.72	2.88	3.04	3.19	3.33	3.46	3.6	3.72

		Min. Filter Width @ Delivery Rate (gpm)														
		10	20	30	40	50	60	70	80	90	100	120	140	160	180	200
	1	11	21	32	42	53	63	73	84	94	105	125	146	167	188	209
F	2		15	23	30	37	45	52	59	67	74	89	103	118	133	148
I	3		13	19	25	31	37	43	49	55	61	73	85	97	109	121
L	4		11	16	21	27	32	37	42	47	53	63	73	84	94	105
T	5			14	19	24	28	33	38	42	47	56	66	75	84	94
E	6			13	18	22	26	30	35	39	43	52	60	69	77	86
R	7			12	16	20	24	28	32	36	40	48	56	63	71	79
	8			12	15	19	23	26	30	34	37	45	52	59	67	74
S	9			11	14	18	21	25	28	32	35	42	49	56	63	70
L	10			10	14	17	20	24	27	30	33	40	47	53	60	66
O	11			10	13	16	19	22	26	29	32	38	44	51	57	63
P	12			10	13	16	19	22	25	28	31	37	43	49	55	61
E	13			9	12	15	18	21	24	27	29	35	41	47	53	58
	14			9	12	14	17	20	23	25	28	34	39	45	50	56
(%)	15			9	11	14	17	19	22	25	27	33	38	44	49	54

Table 4: Filter Area Dimensions for Design Flow Depth of 0.3 Inches

Table 4: Filter Area Dimensions for Design Flow Depth of 0.3 Inches

	Design Flow Depth (d=0.3")														
	Filter Slope (%)														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Minimum Filter Length	48	68	83	96	107	117	126	135	143	151	158	165	172	179	185
gal/min/ ft. width	0.6	0.84	1.03	1.19	1.33	1.46	1.57	1.68	1.79	1.88	1.97	2.06	2.14	2.22	2.3

		Min. Filter Width @ Delivery Rate (gpm)														
		10	20	30	40	50	60	70	80	90	100	120	140	160	180	200
	1	17	34	50	67	84	100	117	134	150	167	200	234	267	300	
F	2	12	24	36	48	60	72	84	96	108	120	143	167	191	215	239
I	3	10	20	30	39	49	59	68	78	88	98	117	136	156	175	195
L	4	9	29	26	34	43	51	59	68	76	85	101	118	135	152	169
T	5		19	23	31	38	46	53	61	68	76	91	106	121	136	151
E	6		14	21	28	35	42	48	55	62	69	83	96	110	124	137
R	7		19	20	26	32	39	45	51	58	64	77	90	102	115	128
	8		12	18	24	30	36	42	48	54	60	72	84	96	108	120
S	9		12	17	23	28	34	40	45	51	56	68	79	90	101	112
L	10		11	16	22	27	32	38	43	48	54	64	75	86	96	107
O	11		11	16	21	26	31	36	41	46	51	61	72	82	92	102
P	12		10	15	20	25	30	34	39	44	49	59	68	78	88	98
E	13		10	15	19	24	29	33	38	43	47	57	66	75	85	94
	14		10	14	19	23	28	32	37	41	46	55	64	73	82	91
(%)	15		9	14	18	22	27	31	35	40	44	53	61	70	79	87

[1] There shall be a minimum of 2 feet of soil depth between finished grade and bedrock or the seasonal high water table.

Table 5: Filter Area Dimensions for Design Flow Depth of 0.2 Inches

Design Flow Depth (d=0.2")

	Filter Slope (%)														
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Minimum Filter Length	37	52	63	73	82	89	97	103	109	115	121	126	131	136	141
gal/min/ ft. width	0.3	0.43	0.52	0.61	0.68	0.74	0.8	0.86	0.91	0.96	1	1.05	1.09	1.13	1.17

		Min. Filter Width @ Delivery Rate (gpm)														
		10	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**	**120**	**140**	**160**	**180**	**200**
	1	34	67	100	134	167	200	234	267	300						
F	**2**	24	47	70	94	117	140	163	187	210	233	280				
I	**3**	20	39	58	77	97	116	135	154	174	193	231	270			
L	**4**	17	33	50	66	82	99	115	132	148	164	197	230	263	296	
T	**5**	15	30	45	59	74	89	103	118	133	148	177	206	236	265	295
E	**6**	14	27	41	55	68	82	95	109	122	136	163	190	217	244	271
R	**7**	13	25	38	50	63	75	88	100	113	125	150	175	200	225	250
	8	12	24	35	47	59	70	82	94	105	117	140	163	187	210	233
S	**9**	11	22	33	44	55	66	77	88	99	110	132	154	176	198	220
L	**10**	11	21	32	42	53	63	73	84	94	105	125	146	167	188	209
O	**11**	10	20	30	40	50	60	70	80	90	100	120	140	160	180	200
P	**12**	10	20	29	39	48	58	67	77	86	96	115	134	153	172	191
E	**13**	10	19	28	37	46	56	65	74	83	92	111	129	147	166	184
	14	9	18	27	36	45	54	62	71	80	89	107	124	142	160	177
(%)	**15**	9	18	26	35	43	52	60	69	77	86	103	120	137	154	171

[1] There shall be a minimum of 2 feet of soil depth between finished grade and bedrock or the seasonal high water table.

Table 5: Filter Area Dimensions for Design Flow Depth of 0.2 Inches

Table 6: Filter Area Dimensions for Design Flow Depth of 0.1 Inches

Table 6: Filter Area Dimensions for Design Flow Depth of 0.1 Inches

	Design Flow Depth (d=0.1")														
	Filter Slope (%)														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Minimum Filter Length	23	32	40	46	51	56	61	65	69	73	76	79	83	86	89
gal/min/ ft. width	0.1	0.13	0.16	0.19	0.21	0.23	0.25	0.27	0.29	0.3	0.32	0.33	0.34	0.36	0.37

		Min. Filter Width @ Delivery Rate (gpm)														
		10	20	30	40	50	60	70	80	90	100	120	140	160	180	200
	1	100	200	300												
F	2	77	154	231												
I	3	63	125	188	250											
L	4	53	106	158	211	264										
T	5	48	96	143	191	239	286									
E	6	44	87	131	174	218	261									
R	7	40	80	120	160	200	240	280								
	8	38	75	112	149	186	223	260	297							
S	9	35	69	104	138	173	207	242	276							
L	10	34	67	100	134	167	200	234	267	300						
O	11	32	63	94	125	157	188	219	250	282						
P	12	31	61	91	122	152	182	213	243	273						
E	13	30	59	89	118	148	177	206	236	265	295					
	14	28	56	84	112	139	167	195	223	250	278					
(%)	15	28	55	82	109	136	163	190	217	244	271					

[1] There shall be a minimum of 2 feet of soil depth between finished grade and bedrock or the seasonal high water table.

Table 7: Orifice discharge capacity

For orifices to control flow rate through riser, or distribution manifold.

Based on:

$Q = (C)\ (A)\ (2gh)^{0.5}$ in cfs

C = orifice constant; assumed to be 0.61. The actual value varies with the type of orifice. The assumed value is conservative.

A = orifice area, ft^2

g = 32.174 ft/sec^2

h = head of orifice, ft

Diameter in.	Area ft^2	Head, ft 0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0
		Flow rate, cfs							
0.50	0.0014	0.005	0.007	0.008	0.009	0.010	0.012	0.013	0.014
0.75	0.0031	0.011	0.015	0.018	0.021	0.024	0.026	0.028	0.030
1.00	0.005	0.017	0.027	0.033	0.038	0.042	0.046	0.050	0.053
1.25	0.009	0.031	0.042	0.051	0.059	0.066	0.072	0.078	0.083
1.50	0.012	0.042	0.060	0.074	0.085	0.095	0.104	0.112	0.120
1.75	0.017	0.059	0.082	0.100	0.116	0.129	0.142	0.153	0.163
2.00	0.022	0.076	0.107	0.131	0.151	0.169	0.185	0.200	0.214
2.25	0.028	0.097	0.135	0.165	0.191	0.214	0.234	0.253	0.270
2.50	0.034	0.118	0.167	0.204	0.236	0.264	0.289	0.312	0.334
2.75	0.041	0.142	0.202	0.247	0.285	0.319	0.350	0.378	0.404
3.00	0.049	0.170	0.240	0.294	0.340	0.380	0.416	0.449	0.480
3.25	0.058	0.201	0.282	0.345	0.399	0.446	0.488	0.527	0.564
3.50	0.067	0.232	0.327	0.400	0.462	0.517	0.566	0.612	0.654
3.75	0.077	0.266	0.375	0.460	0.531	0.593	0.650	0.702	0.751
4.00	0.087	0.301	0.427	0.523	0.604	0.675	0.740	0.799	0.854
4.25	0.099	0.343	0.482	0.590	0.682	0.762	0.835	0.902	0.964
4.50	0.110	0.381	0.540	0.662	0.764	0.855	0.936	1.011	1.081
4.75	0.123	0.426	0.602	0.737	0.852	0.952	1.043	1.127	1.204
5.00	0.136	0.471	0.667	0.817	0.944	1.055	1.156	1.248	1.334
5.25	0.150	0.519	0.736	0.901	1.040	1.163	1.274	1.376	1.471
5.50	0.165	0.571	0.807	0.989	1.142	1.276	1.398	1.510	1.615
5.75	0.180	0.623	0.882	1.081	1.248	1.395	1.528	1.651	1.765
6.00	0.196	0.678	0.961	1.177	1.359	1.519	1.664	1.797	1.922
6.25	0.213	0.737	1.043	1.277	1.474	1.648	1.806	1.950	2.085
6.50	0.230	0.796	1.128	1.381	1.595	1.783	1.953	2.110	2.255
6.75	0.249	0.862	1.216	1.489	1.720	1.923	2.106	2.275	2.432
7.00	0.267	0.924	1.308	1.602	1.849	2.068	2.265	2.447	2.615
7.25	0.287	0.993	1.403	1.718	1.984	2.218	2.430	2.624	2.806
7.50	0.307	1.062	1.501	1.839	2.123	2.374	2.600	2.890	3.002
7.75	0.328	1.135	1.603	1.963	2.267	2.535	2.776	2.999	3.206
8.00	0.349	1.208	1.708	2.092	2.416	2.701	2.958	3.195	3.416

Table 8: Riser pipe outlet design.
For settling basins.

Based on:
$Q = (C)(A)(2gh)^{0.5}$ in cfs
C = slot constant; assumed to be 0.61. The actual value varies with the type of slot. The assumed value is conservative.
A = open slot area, ft^2
g = 32.174 ft/sec^2
h = head on openings, ft. The pipe height was divided into 0.5' increment. The head on all the slots in the first 0.5' increment assumed to be 0.25'. The head on the subsequent 0.5' pipe increments increase at 0.5' increments.

Open slot area/ft of pipe height in^2/ft	Head, ft 0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0
	Flowrate, cfs							
4	0.034	0.093	0.169	0.259	0.361	0.473	0.596	0.728
6	0.051	0.139	0.253	0.388	0.541	0.710	0.894	1.091
8	0.068	0.186	0.338	0.518	0.721	0.947	1.192	1.455
10	0.085	0.232	0.422	0.647	0.902	1.183	1.480	1.819
12	0.102	0.279	0.507	0.776	1.082	1.420	1.788	2.183
14	0.119	0.325	0.591	0.906	1.262	1.657	2.086	2.546
16	0.136	0.371	0.675	1.035	1.443	1.894	2.384	2.910
18	0.153	0.418	0.760	1.164	1.623	2.130	2.682	3.274
20	0.170	0.464	0.844	1.294	1.803	2.367	3.980	3.638
22	0.187	0.511	0.929	1.423	1.984	2.604	3.277	4.001
24	0.204	0.557	1.013	1.542	2.164	2.840	3.575	4.365
26	0.221	0.603	1.097	1.682	2.344	3.077	3.873	4.729
28	0.238	0.650	1.182	1.811	2.525	3.314	4.171	5.093
30	0.255	0.696	1.266	1.940	2.705	3.550	4.469	5.456
32	0.272	0.743	1.351	2.070	2.885	3.787	4.767	5.820
34	0.289	0.789	1.435	2.199	3.066	4.024	5.065	6.184
36	0.306	0.836	1.519	2.329	3.246	4.260	5.363	6.548
38	0.323	0.882	1.604	2.458	3.426	4.497	5.661	6.911
40	0.340	0.928	1.688	2.587	3.607	4.734	5.959	7.275

Figure 1: Filter Area Dimensions for Design Flow Depth of 0.5 to 0.1 Inches

Figure 1: Filter Area Dimensions for Design Flow Depths from 0.1 to 0.5 Inches

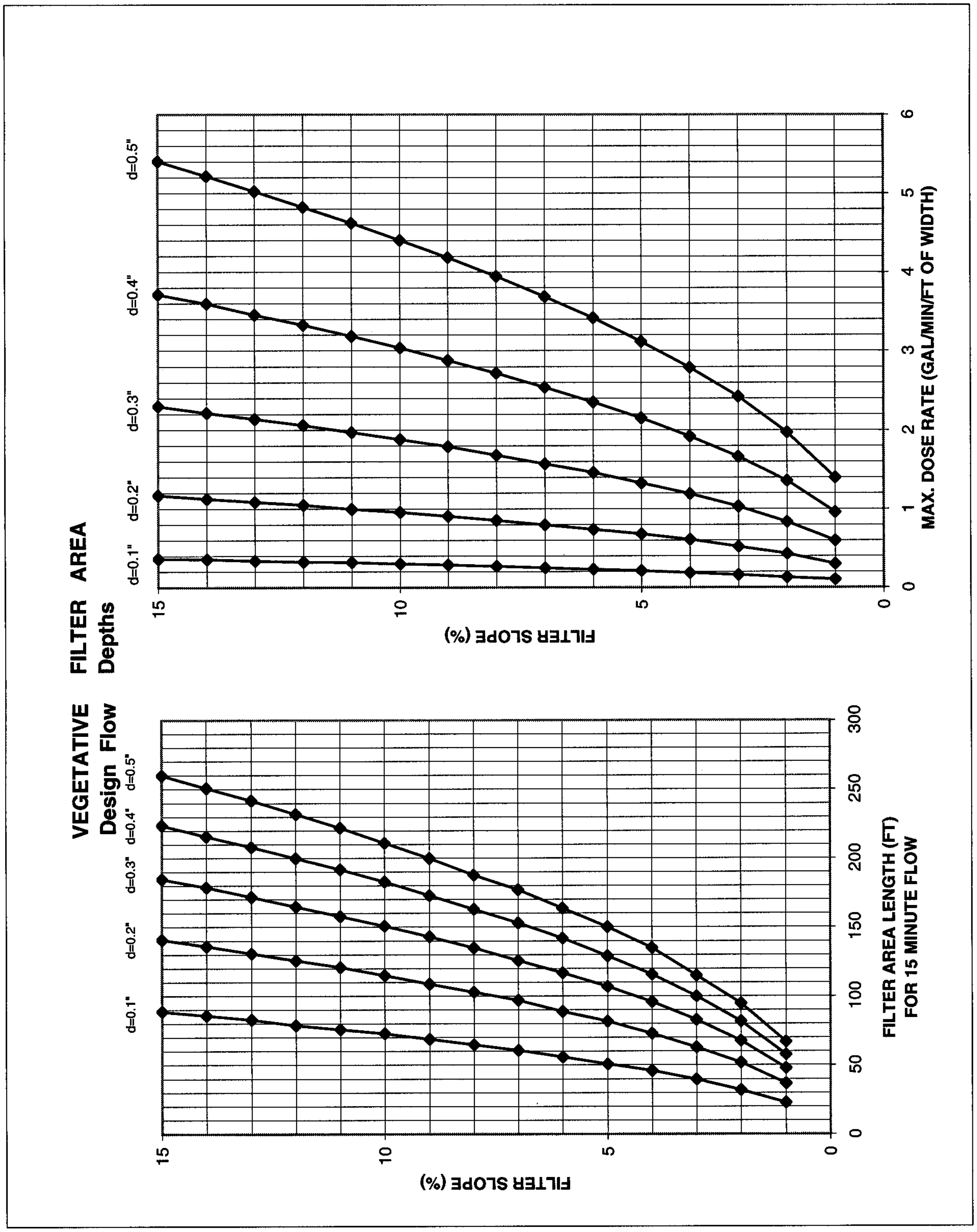


Figure 2: Filter Area Dimensions for Design Flow Depth of 0.5 to 0.1 Inches

Figure 2 Filter Area Dimensions for Design Flow Depths of 0.5 to 0.1 Inches

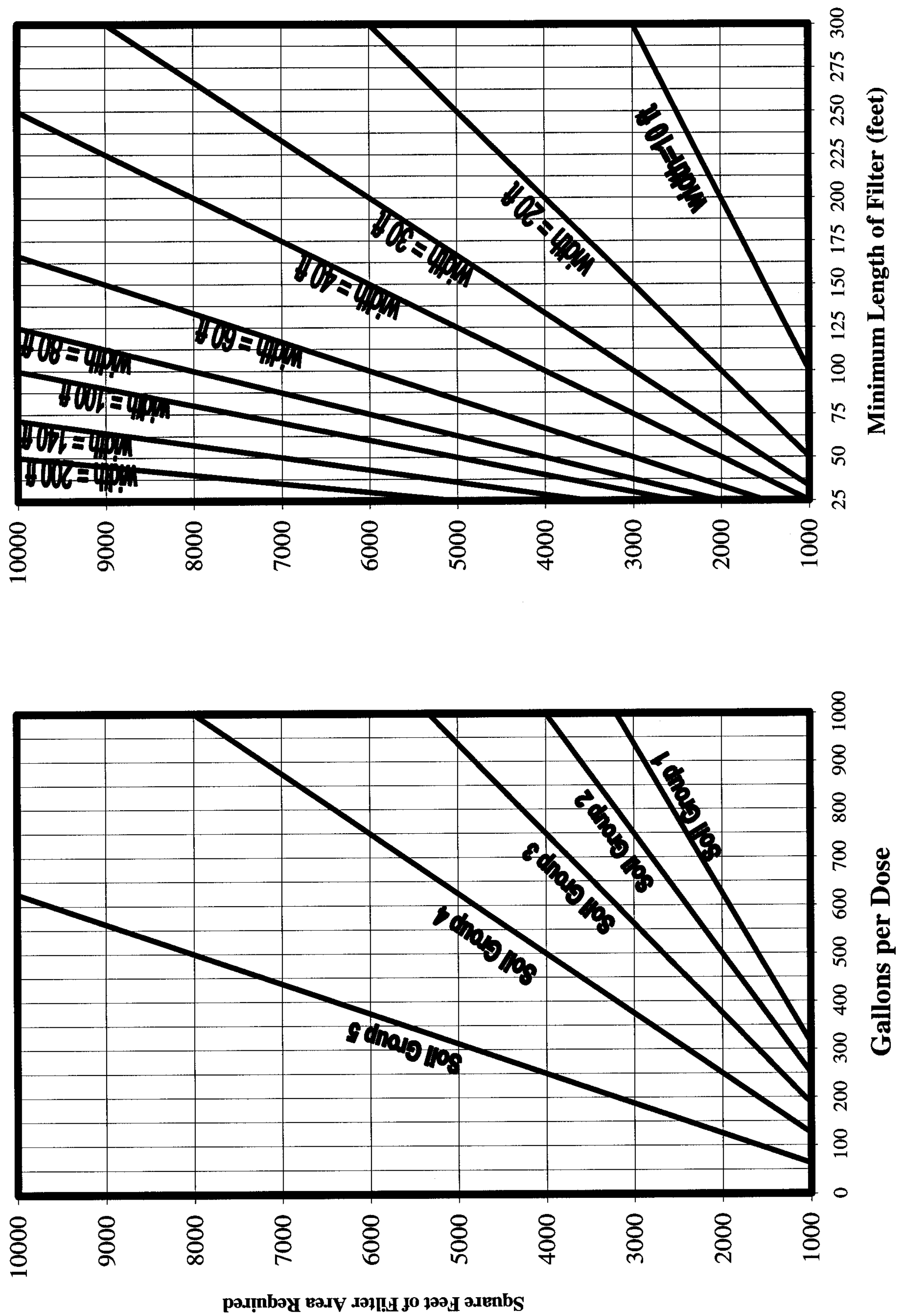


Table 9: Grass Filter Channel Dimensions for Design Flow Depth of 0.3 Feet

Table 9: Filter Channel Dimensions

Design Flow Depth (d=0.3 Feet)
15 minute flow through-time

	Filter Slope %														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Minimum Filter Length	801	1133	1387	1602	1791	1962	2119	2265	2403	2533	2656	2775	2888	2997	3102
cfs/ ft. width	0.267	0.378	0.462	0.534	0.597	0.654	0.706	0.755	0.801	0.844	0.885	0.925	0.963	0.999	1.034
gal/min/ ft. width	119.8	169.5	207.5	239.6	267.9	293.5	317.0	338.9	359.5	378.9	397.4	415.1	432.0	448.3	464.1

		Min. Filter Width @ Delivery Rate (gpm)														
		10	20	30	40	50	60	70	80	90	100	120	140	160	180	200
	1		1	1	1	1	1	1	1	1	1	2	2	2	2	2
F	2		1	1	1	1	1	1	1	1	1	1	1	1	2	2
I	3		1	1	1	1	1	1	1	1	1	1	1	1	1	1
L	4			1	1	1	1	1	1	1	1	1	1	1	1	1
T	5			1	1	1	1	1	1	1	1	1	1	1	1	1
E	6			1	1	1	1	1	1	1	1	1	1	1	1	1
R	7			1	1	1	1	1	1	1	1	1	1	1	1	1
	8				1	1	1	1	1	1	1	1	1	1	1	1
S	9				1	1	1	1	1	1	1	1	1	1	1	1
L	10				1	1	1	1	1	1	1	1	1	1	1	1
O	11				1	1	1	1	1	1	1	1	1	1	1	1
P	12				1	1	1	1	1	1	1	1	1	1	1	1
E	13					1	1	1	1	1	1	1	1	1	1	1
	14					1	1	1	1	1	1	1	1	1	1	1
(%)	15					1	1	1	1	1	1	1	1	1	1	1

Table 10: Grass Filter Channel Dimensions for Design Flow Depth of 0.2 Feet

Table 10: Grass Filter Channel Dimensions

Design Flow Depth (d=0.2 Feet)
15 minute flow through-time

	Filter Slope %														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Minimum Filter Length	382	540	662	764	854	936	1011	1080	1146	1208	1267	1323	1377	1429	1479
cfs/ ft. width	0.085	0.120	0.147	0.170	0.190	0.208	0.225	0.240	0.255	0.268	0.282	0.294	0.306	0.318	0.329
gal/min/ ft. width	38.1	53.9	66.0	76.2	85.2	93.3	100.8	107.8	114.3	120.5	126.3	132.0	137.4	142.5	147.5

		Min. Filter Width @ Delivery Rate (gpm)														
		10	20	30	40	50	60	70	80	90	100	120	140	160	180	200
	1		1	1	2	2	2	2	3	3	3	4	4	5	5	6
F	2		1	1	1	1	2	2	2	2	2	3	3	3	4	4
I	3		1	1	1	1	1	2	2	2	2	2	3	3	3	4
L	4			1	1	1	1	1	2	2	2	2	2	3	3	3
T	5			1	1	1	1	1	1	2	2	2	2	2	3	3
E	6			1	1	1	1	1	1	1	2	2	2	2	2	3
R	7			1	1	1	1	1	1	1	1	2	2	2	2	2
	8				1	1	1	1	1	1	1	2	2	2	2	2
S	9				1	1	1	1	1	1	1	2	2	2	2	2
L	10				1	1	1	1	1	1	1	1	2	2	2	2
O	11				1	1	1	1	1	1	1	1	2	2	2	2
P	12				1	1	1	1	1	1	1	1	2	2	2	2
E	13					1	1	1	1	1	1	1	2	2	2	2
	14					1	1	1	1	1	1	1	1	2	2	2
(%)	15					1	1	1	1	1	1	1	1	2	2	2

Table 11: Grass Filter Channel Dimensions for Design Flow Depth of 0.1 Feet

Table 11: Filter Area Dimensions

	Design Flow Depth (d=0.1 Feet) 15 minute flow through-time														
	Filter Slope %														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Minimum Filter Length	289	408	500	577	646	707	764	817	433	456	479	500	520	540	559
cfs/ ft. width	0.016	0.023	0.028	0.032	0.036	0.039	0.042	0.045	0.048	0.051	0.053	0.056	0.058	0.060	0.062
gal/min/ ft. width	7.2	10.2	12.5	14.4	16.1	17.6	19.0	20.4	21.6	22.8	23.9	24.9	26.0	26.9	27.9

		Min. Filter Width @ Delivery Rate (gpm)														
		10	20	30	40	50	60	70	80	90	100	120	140	160	180	200
	1		3	5	6	7	9	10	12	13	14	17	20	23	26	28
F	2		3	3	4	5	6	7	8	9	10	12	14	16	18	20
I	3		2	3	4	5	5	6	7	8	9	10	12	13	15	17
L	4			3	3	4	5	5	6	7	7	9	10	12	13	14
T	5			2	3	4	4	5	5	6	7	8	9	10	12	13
E	6			2	3	3	4	4	5	6	6	7	8	10	11	12
R	7			2	3	3	4	4	5	5	6	7	8	9	10	11
	8				2	3	3	4	4	5	5	6	7	8	9	10
S	9				2	3	3	4	4	5	5	6	7	8	9	10
L	10				2	3	3	4	4	4	5	6	7	8	8	9
O	11				2	3	3	3	4	4	5	6	6	7	8	9
P	12				2	3	3	3	4	4	5	5	6	7	8	9
E	13					2	3	3	4	4	4	5	6	7	7	8
	14					2	3	3	3	4	4	5	6	6	7	8
(%)	15					2	3	3	3	4	4	5	6	6	7	8

Table 12: Grass Filter Channel Dimensions for Design Flow Depth of 0.08 Feet

Table 12: Filter Area Dimensions

	Design Flow Depth (d=0.08 Feet) 15 minute flow through-time														
	Filter Slope %														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Minimum Filter Length	104	147	180	207	232	254	274	293	311	328	344	359	374	388	401
cfs/ ft. width	0.009	0.013	0.016	0.018	0.021	0.023	0.024	0.026	0.028	0.029	0.031	0.032	0.033	0.034	0.036
gal/min/ ft. width	4.1	5.8	7.2	8.3	9.2	10.1	10.9	11.7	12.4	13.1	13.7	14.3	14.9	15.5	16.0

		Min. Filter Width @ Delivery Rate (gpm)														
		10	20	30	40	50	60	70	80	90	100	120	140	160	180	200
	1		5	8	10	13	15	17	20	22	25	30	34	39	44	49
F	2		5	6	7	9	11	12	14	16	18	21	24	28	31	35
I	3		3	5	6	7	9	10	12	13	14	17	20	23	26	28
L	4			4	5	7	8	9	10	11	13	15	17	20	22	25
T	5			4	5	6	7	8	9	10	11	13	16	18	20	22
E	6			3	4	5	6	7	8	9	10	12	14	16	18	20
R	7			3	4	5	6	7	8	9	10	11	13	15	17	19
	8				4	5	6	6	7	8	9	11	12	14	16	18
S	9				4	5	5	6	7	8	9	10	12	13	15	17
L	10				4	4	5	6	7	7	8	10	11	13	14	16
O	11				3	4	5	6	6	7	8	9	11	12	14	15
P	12				3	4	5	5	6	7	7	9	10	12	13	14
E	13					4	5	5	6	7	7	9	10	11	13	14
	14					4	4	5	6	6	7	8	10	11	12	13
(%)	15					4	4	5	5	6	7	8	9	10	12	13

Table 13: Grass Filter Channel Dimensions for Design Flow Depth of 0.04 Feet

Table 13: Filter Channel Dimensions

Design Flow Depth (d=0.04 Feet)
15 minute flow through-time

	Filter Slope %														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Minimum Filter Length	65	92	113	131	146	160	173	185	196	206	217	226	235	244	253
cfs/ ft. width	0.003	0.004	0.005	0.006	0.006	0.007	0.008	0.008	0.009	0.009	0.010	0.010	0.010	0.011	0.011
gal/min/ ft. width	1.3	1.8	2.3	2.6	2.9	3.2	3.4	3.7	3.9	4.1	4.3	4.5	4.7	4.9	5.0

		Min. Filter Width @ Delivery Rate (gpm)														
		10	20	30	40	50	60	70	80	90	100	120	140	160	180	200
	1		16	24	31	39	47	54	62	70	77	93	108	123	139	154
F	2		16	17	22	28	33	39	44	49	55	66	77	87	98	109
I	3		9	14	18	23	27	32	36	40	45	54	63	71	80	89
L	4			12	16	20	24	27	31	35	39	47	54	62	70	77
T	5			11	14	18	21	25	28	31	35	42	49	55	62	69
E	6			10	13	16	19	22	26	29	32	38	44	51	57	63
R	7			9	12	15	18	21	24	27	30	35	41	47	53	59
	8				11	14	17	20	22	25	28	33	39	44	49	55
S	9				11	13	16	18	21	24	26	31	36	41	47	52
L	10				10	13	15	17	20	22	25	30	34	39	44	49
O	11				10	12	14	17	19	21	24	28	33	38	42	47
P	12				9	12	14	16	18	20	23	27	32	36	40	45
E	13					11	13	15	18	20	22	26	30	35	39	43
	14					11	13	15	17	19	21	25	29	33	37	42
(%)	15					10	12	14	16	18	20	24	28	32	36	40

Table 14: Grass Filter Channel Dimensions for Design Flow Depth of 0.03 Feet

Table 14: Filter Channel Dimensions

	Design Flow Depth (d=0.03 Feet)														
	15 minute flow through-time														
	Filter Slope %														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Minimum Filter Length	54	76	93	108	120	132	143	152	162	170	179	187	194	202	209
cfs/ ft. width	0.002	0.003	0.003	0.004	0.004	0.004	0.005	0.005	0.005	0.006	0.006	0.006	0.006	0.007	0.007
gal/min/ ft. width	0.8	1.1	1.4	1.6	1.8	2.0	2.1	2.3	2.4	2.5	2.7	2.8	2.9	3.0	3.1

		Min. Filter Width @ Delivery Rate (gpm)														
		10	20	30	40	50	60	70	80	90	100	120	140	160	180	200
	1		25	38	50	63	75	87	100	112	125	149	174	199	224	249
F	2		25	27	36	44	53	62	71	79	88	106	123	141	158	176
I	3		15	22	29	36	43	51	58	65	72	86	101	115	129	144
L	4			19	25	32	38	44	50	56	63	75	87	100	112	125
T	5			17	23	28	34	39	45	50	56	67	78	89	100	111
E	6			16	21	26	31	36	41	46	51	61	71	82	92	102
R	7			15	19	24	29	33	38	43	47	57	66	76	85	94
	8				18	22	27	31	36	40	44	53	62	71	79	88
S	9				17	21	25	29	34	38	42	50	58	67	75	83
L	10				16	20	24	28	32	36	40	48	55	63	71	79
O	11				15	19	23	27	30	34	38	45	53	60	68	75
P	12				15	18	22	26	29	33	36	43	51	58	65	72
E	13					18	21	25	28	31	35	42	49	56	62	69
	14					17	20	24	27	30	34	40	47	54	60	67
(%)	15					17	20	23	26	29	33	39	45	52	58	65

Table 15: Grass Filter Channel Dimensions for Design Flow Depth of 0.02 Feet

Table 15: Filter Channel Dimensions

Design Flow Depth (d=0.02 Feet)
15 minute flow through-time

	Filter Slope %														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Minimum Filter Length	41	58	71	82	92	101	109	116	123	130	136	142	148	154	159
cfs/ ft. width	0.001	0.001	0.002	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.004
gal/min/ ft. width	0.4	0.6	0.7	0.8	0.9	1.0	1.1	1.2	1.2	1.3	1.4	1.4	1.5	1.5	1.6

		Min. Filter Width @ Delivery Rate (gpm)													
		10	20	30	40	50	60	70	80	90	100	120	140	160	180	200
	1		49	74	98	122	147	171	196	220	244	293	342	391	439	488
F	2		49	52	69	87	104	121	138	156	173	207	242	276	311	345
I	3		29	43	57	71	85	99	113	127	141	169	198	226	254	282
L	4			37	49	61	74	86	98	110	122	147	171	196	220	244
T	5			33	44	55	66	77	88	99	110	131	153	175	197	219
E	6			30	40	50	60	70	80	90	100	120	140	160	180	200
R	7			28	37	47	56	65	74	83	93	111	130	148	166	185
	8				35	44	52	61	69	78	87	104	121	138	156	173
S	9				33	41	49	57	66	74	82	98	114	131	147	163
L	10				31	39	47	54	62	70	78	93	108	124	139	155
O	11				30	37	45	52	59	67	74	89	103	118	133	148
P	12				29	36	43	50	57	64	71	85	99	113	127	141
E	13					34	41	48	55	61	68	82	95	109	122	136
	14					33	40	46	53	59	66	79	92	105	118	131
(%)	15					32	38	45	51	57	63	76	89	101	114	126

SECTION V

CONSTRUCTION SPECIFICATIONS

1. All materials and construction shall be in accordance with applicable NRCS standards and construction specifications.
2. All components of the completed system shall conform to the lines, grades, elevations, dimensions and materials shown on the plans.
3. Any changes in the plans or specifications must be approved by the original plan approver prior to being made. Changes are to be reviewed by the landowner for concurrence.
4. All disturbed areas shall be fertilized, seeded, and mulched or otherwise stabilized as required on the construction plans.
5. Precast Concrete units shall comply with ACI-523 and 533.
6. Joint Sealers shall conform to the requirements for ASTM-C920 or Federal Specification SS-S-210A; except that sealers for vertical or overhead application must meet the requirements of Federal Specification TT-S-227, Type II.
7. Waterstops. Vinyl-chloride polymer types shall be tested in accordance with Federal Test Method Standard No. 601, and shall show no sign of web failure due to brittleness at a temperature of -35 degrees Fahrenheit. Colloidal waterstops shall be at least 75 percent bentonite in accordance with Federal Specification SS-S-210A.
8. Plastic Pipe and Appurtenances shall meet the following requirements, unless otherwise set forth in Section 7:
9. Appurtenances such as fittings, coupling bands, collars, end section, etc. shall be composed of the same material as the pipe and conform to the appropriate ASTM standard and specification.

   D 1785 Poly (Vinyl Chloride) (PVC) Plastic Pipe Schedules 40, 80, 120

   D 2241 Poly (Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series)

   D 2104 Polyethylene (PE) Plastic Pipe Schedule 40

   D 2239 Polyethylene (PE) Plastic Pipe, (SIDR-PR) Based on Controlled Inside Diameter

   D 2447 Polyethylene (PE) Plastic Pipe, Schedules 40 & 80, Based on Outside Diameter

   D 3035 Polyethylene (PE) Plastic Pipe, (SDR-PR) Based on Controlled Outside Diameter

   F 714 Polyethylene (PE) Plastic Pipe, (SDR-PR) Based on Outside Diameter

   D 1527 Acrylonitrile-Butadiene-Styrene (ABS) Plastic Pipe Schedules 40 & 80

D 2282 Acrylonitrile-Butadiene-Styrene (ABS) Plastic Pipe, (SDR-PR)

10. Only track mounted equipment shall be permitted on the filter area. All of the stockpiled topsoil shall be spread over the entire re-graded surface of the filter area. The topsoil shall be uniformly spread to the finished grades. The topsoil shall be dry enough that it does not adhere to the equipment tracks. Equipment traffic on the topsoil shall be kept to an absolute minimum.

11. Fill material shall be placed in maximum 8-inch lifts (before compaction). The lifts shall be compacted by the traversing of the entire surface by not less than one track of the equipment or by a minimum of four complete passes with a sheepsfoot, vibratory, or rubber tire roller. Compaction around structures shall be accomplished by placing fill in maximum 4-inch lifts and compacting by means of hand tampers or other manually directed compaction equipment. The technician shall determine if the moisture content is suitable for fill placement. The contractor shall make adjustments as directed by the technician. The method of compaction shall be approved prior to placement of fill material. Frozen material shall not be placed in the fill nor shall the fill material be placed on a frozen foundation.

12. The Soil Conservation District makes no representation as to the existence or nonexistence of any utilities at the construction site. Shown on these construction drawings are those utilities, which have been identified. It is the responsibility of the landowners or operators and contractors to assure themselves that no hazard exists or damage will occur to utilities. Miss Utility should be contacted at 1 800-257-7777.

SECTION IV

Design Examples

EXAMPLE #1 (Milk House & Parlor Wastewater Grass Filter Area System Design)

GIVEN:

Daily wastewater production = 283 Gallons (Metered) use 300 Gallon

Grass filter area size available = length 115 feet x width 200 feet

SIZE DOSING TANK:

Minimum 3 days detention = 300 gallons/day x 3 days = 900 Gallons

Tank size = Use 1250 gallon 2 piece (Check local vendors for sizes available).

PUMP:

Use Siphon from Fluid Dynamics

Average discharge = 185 Gallons/Minute

See pipeline design at end of example

FILTER AREA:

SOIL = Penn PnC2 Moderately Deep, Well Drained

Soil Group = 2 (d = 0.4”) From (Design Guide MD#4, Table 1)

Filter Area Slope = 15%

Minimum filter length = 224 Feet. (Design Guide MD#4, Table 3) w/ application depth (d) of 0.4 inches

Gal/Min/Ft. of Width = 3.72

Width = 185 GPM/3.72 = 50 Feet.

Filter Area Size Available (Length = 115 Feet. and Width = 200 Feet)

The minimum filter area length of 224 feet required, exceed that which is available. Adjust the filter area size. Reduce the application depth. This will reduce the grass filter area length and increase its width.

ADJUST FILTER AREA SIZE:

From Design Guide MD#4, Figure 1 with a filter area slope of 15% and a maximum filter area length of 115 feet use a maximum application depth (d) of 0.15 inches.

Application depth (d) @ a 115 feet = 0.15” (From Design Guide MD#4, Figure 3)

Maximum Dose Rate Gal/Min/Ft. of Width = 0.8 (From Design Guide MD#4, Figure 3)

Filter width = (185 GPM)/(0.8 Gal/Min/Ft. of Width) = 232 Feet > 200 Feet. Available (Adjust). The maximum grass filter area width available has been exceeded. Determine what the maximum allowable discharge @ with a grass filter area width of 200 feet.

Maximum discharge allowable @ 200 Feet Width = 200 (0.8) = 160 Gallon per Minutes

Restrict flow of the at the distribution line to 160 GPM

DISTRIBUTION LINE (MANIFOLD PIPE) 3" DIAMETER: (Number and size of holes)

Head at lateral = 3 FT. The pipeline will be designed to deliver 3 feet of head at the manifold pipe.

Use ¾" Holes

Q = 0.026 CFS per hole (Design Guide MD#4, Table 7)

Discharge @ 160 Gallon/Minute = (160 Gallons/Minute)/(448.83) = 0.356 CFS

Note to convert gpm to cfs divide by 448.83

Number of Holes = (0.356 cfs)/(0.026cfs/hole) = 13.7 Use 14

Spacing = 200 Feet/14 Holes = 14.3 Feet.

CHECK HYDRAULIC LOADING:

1 Inch Maximum Weekly Application Rate and a 3-day dosing interval.

(1 Inch/ week)(1 week/7 days)(3 day interval) = **0.43**" (Maximum/Dose)

Filter Strip Area 115 feet x 200 feet = 23,000 Square Feet

(935 Gallon/Dose/7.48 Gal/Cubic Feet) (12"/Foot/ 23000 Square Feet) = **0.07**" Per Dose

0.07" Dose is less than or equal to 0.43" (CHECKS)

DETERMINE THE VOLUME OF LIQUID DOSED BY A MODEL 448 SIPHON

1250 Gallon two-piece tank

Rectangular tank with inside dimensions of 90 inches x 50 inches

Area of the tank in square inches:

90" x 50" = 4,500 square inches

Volume in cubic inches (Draw down height of the siphon x The area of the tank:

48 inches x 4,500 square inches = 216,000 Cubic Inches

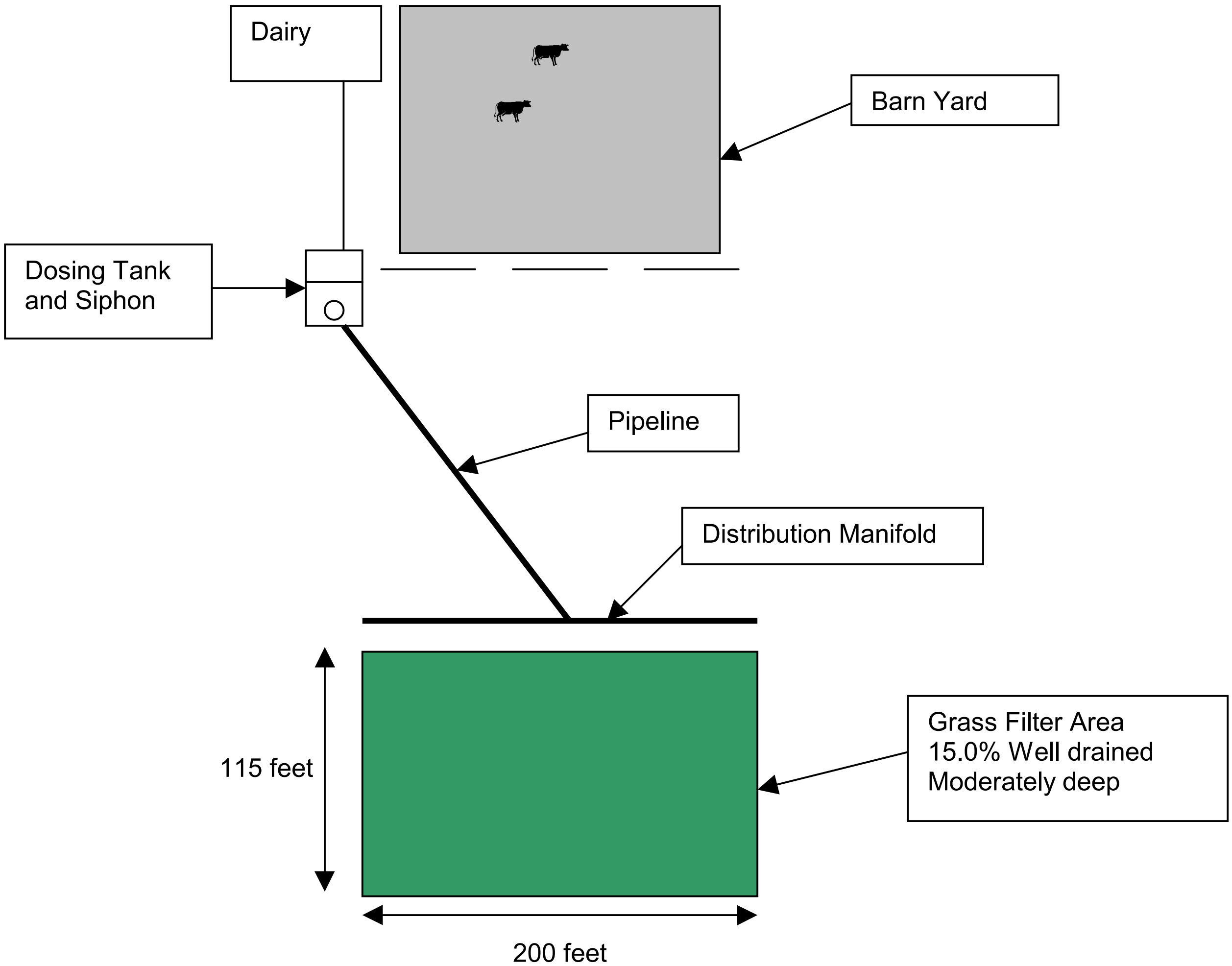
Convert to cubic feet (Divide by 1728):

216,000/1728 = 125 cu. ft.

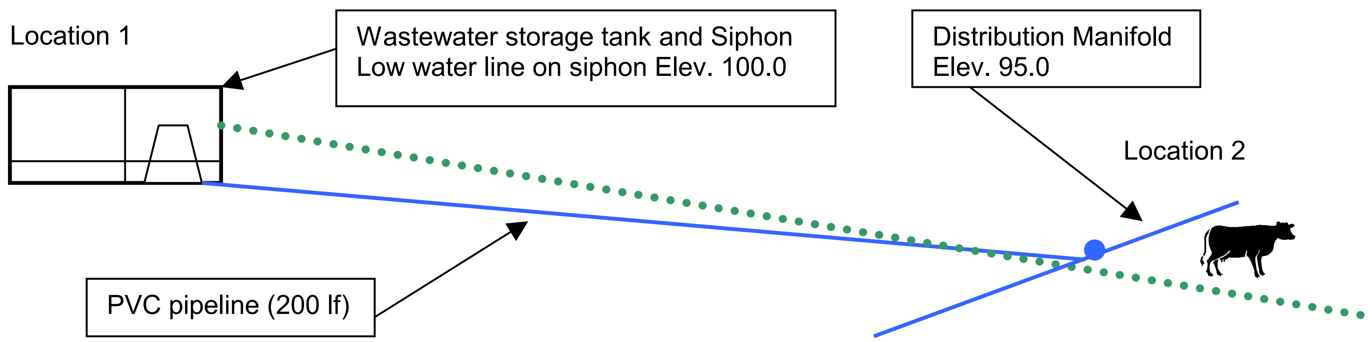
Convert cubic feet to gallons (7.48 Gallons/Cubic Feet):

(125 cu. ft.) (7.48 gal/cu. ft.) = **935 Gallons >900 required**

Example 1 Site Plan



Pipeline Design for Example #1



Given:

Need 3 feet of pressure head at the end of the distribution manifold (location 2) shown above. Size the system above to achieve 3 feet of pressure head (after losses) with an average discharge rate of 185 gallons per minute. Use a Fluid Dynamics siphon with an average discharge of 185 gallons per minute. The manifold pipe is 200 feet long with the tee connected at the center.

Analysis:

Hydraulic Head (HH) = Pressure Head (PH) + Gravity Head (EL) + Velocity Head (VH).

(From Equation 3-5, page 3-18 EFH part 650, chapter 3)

Energy equation:

$$HH_1 = HH_2 + \text{Losses}$$

$$PH_1 + EL_1 + VH_1 = PH_2 + EL_2 + VH_2 + \text{Losses}$$

The velocity of the water at the dosing tank prior to entering the siphon is considered to be equal to 0 (location 1).

$$VH_1 = 0$$

The pressure head (PH_1) at the dosing tank prior to entering the siphon is 0 (location 1).

$$PH_1 = 0$$

Therefore: $PH_1 + EL_1 + VH_1 = PH_2 + EL_2 + VH_2 + \text{Losses}$

$$0 + 100.0 + 0 = PH_2 + 95.0 + VH_2 + \text{Losses}$$

$$100.0 - 95.0 = PH_2 + VH_2 + \text{Losses}$$

Calculate Losses:

Use Fluid Dynamics siphon, Average discharge 185 gallons/minute

Losses:

$\sum K ((V_p)^2 /2g)$ Where $\sum K = K_m + K_p L$

Minor Losses:

For this example assume that there are 2 - 90° bends and 1 Tee in the pipeline. K values are shown in Exhibit 3-8 pages 3-89 and 3-90 NEH Part 650 Chapter 3

90° bend each k = 0.90	2(0.90)
Tee (1) each k = 1.80	1(1.80)

$K_p = (5087\ (n)^2)/d_i^{\ 4/3}$ From equation 3-9, page 3-21 EFH part 650 chapter 3. . An n value of 0.012 was used. Values as low as 0.010 are acceptable.

where n = 0.012 and d_i = 4 in.

$K_p = (5087\ (0.012)^2)/(4)^{4/3} = 0.116$

$\sum K_1 = 2(0.90) + 1(1.80) + 0.116(200) = 26.8$ (Where K_1 represents K value in pipeline)

$\sum K_2 = 0.116(100) = 11.6$ (Where K_2 represents K value in manifold pipe)

Therefore:

$\text{Losses} = (26.8\ (V_{p1})^2)/2(32.2) + (11.6\ (V_{p2})^2)/2(32.2)$

Where:

V_{p1} = Average velocity in the pipeline

V_{p2} = Average velocity in the manifold pipe

Find average velocities in the manifold pipe and in the pipeline. It is required to have a discharge in the pipeline = 185 gallons/minute. The discharge in the manifold pipe will be one half of the pipeline discharge since it is equally split in two directions.

To Convert gallons/minute to cubic feet/second divide by 448.8

185 gpm/448.8 = 0.412 cfs

Using the continuity equation Q = AV solve for velocity. From equation 3-4 page 3-15 EFH part 650 chapter 3.

V_{p1} = Q/A where A (area of 4" diameter pipeline) = $\pi\ r^2 = \pi\ (0.167')^2 = 0.087$ sq. ft.

V_{p1} = 0.412cfs/0.087 sq. ft. = 4.72 ft/sec.

V_{p2} = (0.5)(0.412cfs)/0.087 sq. ft. = 2.37 ft/sec.

Losses = (26.8 (4.72 ft/sec)^2) / 2(32.2) + (11.6 (2.37 ft/sec)^2) / 2(32.2)= 10.3 feet

Find average velocity head (VH_2) in the manifold discharge pipeline:

$V_2 = V_{p2}$ = 2.37 ft/sec.

$VH_2 = 2(V_2)^2/ 2(32.2) = 2(2.37)^2/ 2(32.2) = 0.17$ feet

Therefore:

PH_2 = 5.0' (gravity head) – 10.3' (losses) - 0.17' (velocity head) = -5.5 feet

Head loss of 10.3 feet is too large. Utilizing a 4-inch diameter pipe, with a discharge of 185 gpm cannot be achieved. Since the discharge cannot be reduced, increase the pipe diameter to 6 inches and recalculate the head loss.

$V_{p1} = 0.412\text{cfs}/\pi(0.25)^2$ = 2.1 ft/sec.

$V_{p2} = (0.5)(0.412\text{cfs})/\pi(0.25)^2$. = 1.1 ft/sec

$K_p = (5087\ (0.012)^2)/(6)^{4/3} = 0.068$

$\sum K_1 = 2(0.90) + 1(1.80) + 0.068(200) = 17.2$

$\sum K_2 = 0.068(100) = 6.8$

Losses = (17.2 (2.1 ft/sec)^2) / 2(32.2) + (6.8 (1.1 ft/sec)^2) / 2(32.2) = 1.31 feet

$VH_2 = (1.1)^2/ 2g = 0.02$ feet

PH_2 = 5.0' (gravity head) – 1.31' (losses) – 0.02' (velocity head) = 3.67 feet

It is desired to have 3 feet of pressure head in the manifold pipe at the orifice. This system will have 3.67 feet of pressure head at last orifice when using a 6-inch diameter PVC pipe for pipeline (size OK)

Example #2 (Milk House Wastewater and Barn Yard Runoff Filter Area System Design)

Given:

Barnyard = 3475 sq. ft.

Milkhouse discharge = 150 gallons/day or 20 cubic feet/day

One common tank and filter for all runoff and milkhouse waste

Filter area: Reaville PrA 3% slope, Moderately deep, moderately well drained – soils group 3

Design combined filter system:

1) Calculate minimum filter area

a) Milkhouse volumes

Dose volume = 3 days x 20 cu. ft./day = 60 cu. ft./dose

Weekly volume = 7 days x 20 cu. ft./day = 140 cu. ft.

b) Barnyard wet storage (runoff) volume

3475 sq. ft. x (1 inch) x (1 ft./12 in.) = 290 cubic feet

c) Storage for manure solids

3475 sq. ft. x (0.5 inch) x (1 ft./12 in.) = 145 cubic feet

d) Determine combined weekly wastewater application volume

Volume = 140 cu. ft. + 290 cu. ft. = 430 cu. ft./week

e) Minimum area of filter will be based on the larger of the filter area (based on soils) for the milkhouse or the application of the barnyard runoff. The maximum allowable weekly application rate (depth (d)) is 1 inch however when applying the barnyard runoff the application depth should not exceed 0.5 inches since the frequency of doses cannot be controlled. This will also match the maximum application depth for the milkhouse wastewater.

Determine minimum area for application of barnyard runoff.

290 cu. ft./(0.5 inch)(1 foot/12 inches) = 6960 sq. ft.

Determine minimum area for milkhouse dose based on soils.

60 cubic feet/(0.3 inches/12 in./ft.) = 2400 sq. ft. (Based on soils group 3 which allows 0.3 in./dose) (Design Guide MD#4, Table 1)

Use the larger of the two areas as a minimum grass filter area.

Use a minimum filter area size = 6960 sq. ft.

2) Calculate length and width of filter

a) Assume trial application depth of flow (d max = 0.5 inches)

Use d = 0.5”

b) Calculate velocity of flow using Manning’s formula and minimum length for 15 minutes of flow through time.

Velocity = 1.486/.24 x $R^{.667}$ x $slope^{.5}$

With:
R = depth of flow in feet = d/12

Filter Slope = 0.03 feet/feet

Velocity = 1.486/.24 x $(.5/12)^{(.667)}$ x $(.03)^{.5}$

Velocity = 0.129 feet/sec.

Determine minimum flow length (L) for flow of 15 minutes

15 min. x 60 sec./min. x .129 ft./sec. = 116 ft.

Note: This step could be replaced by going directly to Design Guide MD#4, Table 2 Design Flow Depth of 0.5 inches for a filter slope of 3.0% the minimum filter length is 115 feet.

c) Determine minimum width

Width = Area/Length = 6960 square feet/116 feet long = 60 feet

3) Pump design

Choose a pump based on anticipated friction loss, elevation change, and required head (3 ft.) on manifold. The maximum discharge rate should provide a minimum of 3 feet of head on the manifold.

The minimum application rate is based on removal of all wastewater in 2 hours or less.

(430 cubic feet)(7.48 gallons/cubic foot) = 3216 gallons

(2 hours)(60 minutes/hour) = 120 minutes

(3216 gallons/120 minutes) = 26.8 gallons/minute (Minimum Pump Delivery Rate)

The maximum discharge rate is based is based on the filter strip size and depth of flow.

From Design Guide MD#4, Table 2 Design Flow Depth of 0.5 inches with a filter strip slope of 3% the maximum discharge rate is 2.42 gallons/minute/foot width

(2.42 gallons/minute/foot width)(60 feet wide) = 145.2 gallons/minute.

4) Manifold Design (Assume a pump with a discharge delivery rate of approximately 145 gallons/minute = 0.323 cfs at the anticipated total dynamic head)

Assume a 4-inch header with 1-inch diameter discharge holes and 3 feet of head required at holes.

a) Area of each hole = $(1.0/12)^2$ x $\pi/4$ = .0055 sq. ft.

b) Discharge/hole = q = $CA(2GH)^{1/2}$

.6 x .0055 x $(2 \times 32.2 \times 3)^{1/2}$ = 0.0459 CFS

Note: Step a) and b) could be replaced by going directly to Design Guide MD#4, Table 7 Orifice Discharge Capacity with a head of 3 feet and 1.0 inch diameter orifice the flow rate = 0.046 cfs.

c) Number of holes = Q/q = (Where Q = actual pump discharge rate)

.323/.046 = 7 holes (6 spaces) Holes to be evenly spaced.

d) Hole Spacing (Width of filter = Length of manifold)

Width of filter/number of holes =

60 ft./6 spaces = 10 ft. hole spacing

5) Runoff, Solids and Dosing Tank Sizing

a) Dosing Tank - Size dosing tank to provide required dose volume (milkhouse wastewater plus drain back from system) per cycle based on tank floor area and difference in elevation between pump on and pump off levels. This volume is shown in step 1a above plus drain back volume.

b) Runoff Volume from barnyard area. Provide temporary storage for barnyard runoff as shown in step 1b above.

Volume =3475 sq. ft. x (1 inch) x (1 ft./12 in.) = 290 cubic feet

c) Solids volumes from barnyard area. Provide solids storage for solids accumulations as shown in step 1c above.

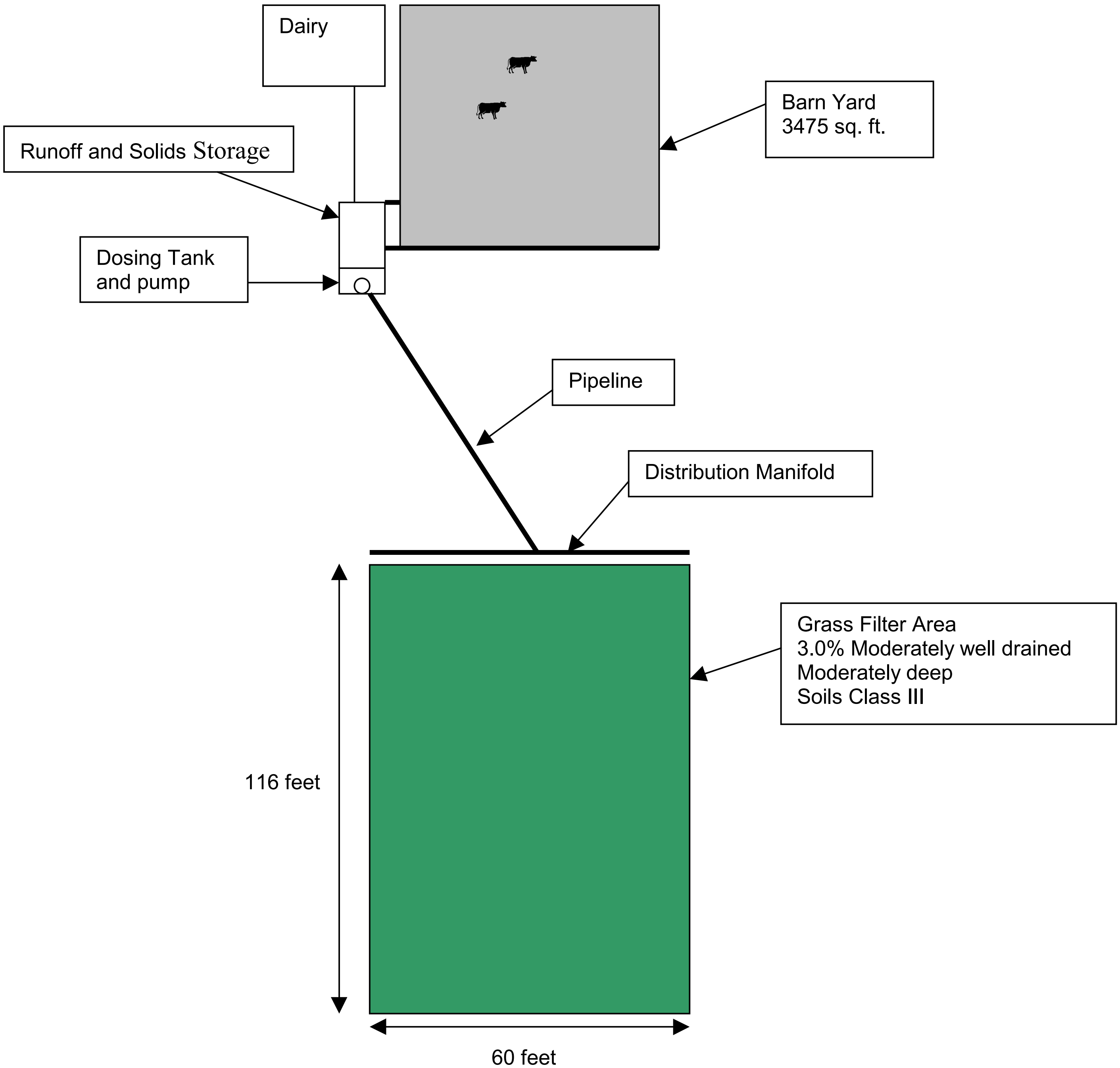
Volume = 3475 sq. ft. x (0.5 inch) x (1 ft./12 in.) = 145 cubic feet

The barnyard runoff and solids may be stored in a separate tank, solids separator, or on the barnyard or in combination of these depending on site constraints and design.

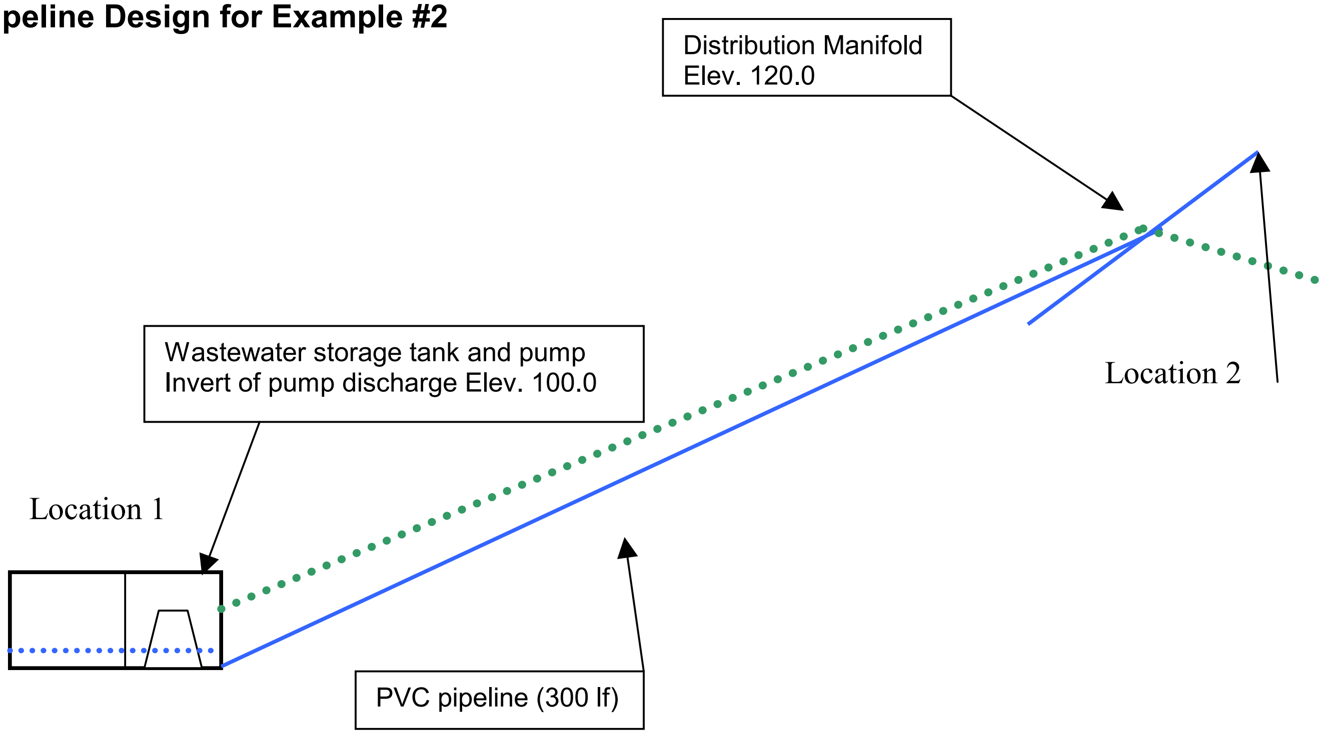
Total volume = manure solids + runoff volume

= 290 cubic feet + 145 cubic feet = 435 cubic feet

Example 2 Site Plan



Pipeline Design for Example #2



Given:

It is desired to have a minimum of 3 feet of pressure head in the manifold pipe at the end of the distribution manifold (location 2). The minimum discharge (after losses) for the pump is 2.23 gallons/minute. The maximum discharge for the pump (after losses) is 145.2 gallons/minute. The manifold pipe is 60 feet long with the tee connected at the center.

Determine pump size:

The size of the pump required is based on the maximum discharge at the manifold, the total dynamic head and size of anticipated solids that may enter the pump.

Total Dynamic Head (TDH)

The total dynamic head is based on the accumulated losses within the piping system and the gravity head at the required discharge.

Compute system losses with a discharge of 145 gallons/minute

Losses:

$\sum K ((V_2)^2 /2g)$ Where $\sum K = K_m + K_pL$

For this example assume that there are 2 - 90° bends and 1 Tee in the pipeline. K values are shown in Exhibit 3-8 pages 3-89 and 3-90 NEH Part 650 Chapter 3

90° bend (2 at pump connection) each k = 0.90 2(0.90)

Tee (1) each k = 1.80 1(1.80)

$K_p = (5087\ (n)^2)/d_i^{\ 4/3}$ From equation 3-9, page 3-21 EFH part 650 chapter 3. . An n value of 0.012 was used. Values as low as 0.010 are acceptable.

where n = 0.012 and d_i = 2 in.

$K_p = (5087\ (0.012)^2)/(2)^{4/3} = 0.291$

$\sum K_1 = 2(0.90) + 1(1.80) + 0.291(300) = 90.9$ (Where K_1 represents K value in pipeline)

$\sum K_2 = 0.291(30) = 8.73$ (Where K_2 represents K value in manifold pipe)

Therefore:

Losses = $(90.9\ (V_{p1})^2)/2(32.2) + (8.73\ (V_{p2})^2)/2(32.2)$

Where:

V_{p1} = Average velocity in the pipeline

V_{p2} = Average velocity in the manifold pipe

Find average velocities in the manifold pipe and in the pipeline. It is required to have a discharge in the pipeline = 145 gallons/minute. The discharge in the manifold pipe will be one half of the pipeline discharge since it is equally split in two directions.

To Convert gallons/minute to cubic feet/second divide by 448.8

145 gpm/448.8 = 0.323 cfs

Using the continuity equation Q = AV solve for velocity. From equation 3-4 page 3-15 EFH part 650 chapter 3.

V = Q/A where A (area of 2" diameter pipeline) = $\pi\ r^2 = \pi\ (0.083')^2 = 0.022$ sq. ft.

V_{p1} = 0.323cfs/0.022 sq. ft. = 14.68 ft/sec.

V_{p2} = (0.5)(0.323cfs)/0.022 sq. ft. = 7.34 ft/sec

Losses = $(90.9\ (14.68\ \text{ft/sec})^2)\ /\ 2(32.2) + (8.73\ (7.34\ \text{ft/sec})^2)\ /\ 2(32.2) = 311$ feet

Losses are too high, increase size of pipeline to 4-inch diameter and recalculate losses.

V = Q/A where A (area of 4" diameter pipeline) = $\pi\ r^2 = \pi\ (0.167')^2 = 0.087$ sq. ft.

V_{p1} = 0.323cfs/0.087 sq. ft. = 3.7 ft/sec.

V_{p2} = (0.5)(0.323cfs)/0.087 sq. ft. = 1.85 ft/sec

$K_p = (5087\,(n)^2)/d_i^{\,4/3}$ From equation 3-9, page 3-21 EFH part 650 chapter 3

where $n = 0.012$ and $d_i = 4$ in.

$K_p = (5087\,(0.012)^2)/(4)^{4/3} = 0.116$

$\sum K_1 = 2(0.90) + 1(1.80) + 0.116(300) = 38.4$

$\sum K_2 = 0.116(30) = 3.5$

Losses = (38.4 (3.7 ft/sec)^2) / 2(32.2) + (3.5 (1.85 ft/sec)^2) / 2(32.2) = 8.4 feet

Total dynamic head requirements for pump

Gravity head = $GH_2 - GH_1$ +3 feet(required at Manifold)

GH = 120.0 – 100.0 + 3 feet = 23 feet

Losses = 8.4 feet

VH_2 = (1.85 ft/sec)^2 / 2(32.2) = 0.05

TDH requirement = GH + VH_2 + Losses = 23 feet + 0.05 feet +8.4 feet = 31.5 feet

Utilizing a pump rating curve (supplied by pump manufacture) choose a pump that will deliver approximately 145 gallons/minute with a total dynamic head requirement of 31.5 feet.

Example #3 (Barn Yard Runoff Grass Filter Area System Design Without a Settling Facility)

Given:

Concentrated Feeding Area (40 feet x 75 feet)= 3000 sq. ft.

Runoff Slope of feed lot = 2.0%

Flow length through feed lot = 40 feet

Infrequent scraping, solids transport is anticipated from the feed lot onto the filter area.

Filter area: Mt. Airy MtB2, 3% slope, Moderately deep, well drained

Grass Filter Area Design:

The filter shall have a size equal to the drainage area of the feed lot = 3000 square feet.

The slope of the feed lot is steeper than 1.5% allowable; in addition it anticipated that manure solids would enter the grass filter area. It will be required that a leveling pad, curb or similar means to reduce the velocity and redistribute the discharge and provide some removal of solids prior to entering the grass filter area.

The distribution of the wastewater runoff must occur over the entire required width of the grass filter area of 75 feet.

The length of the filter area will be 40 feet.

Example 3 Site Plan