PURPOSE

The purpose of this guide is to assist with the estimation of the volume of a Sanitary Sewer Overflow. It has limited application, as it can be used on dry surfaces where the limits of the spill footprint can be determined and in instances when the spill is contained. It does not require that the Spill Duration and Spill Flow Rate be known. However, any and all information available should be used if it helps to make a more accurate estimate.

HOW IT WORKS

This guide contains formulas for determining the volume of some basic geometric shapes and some simple conversions that are necessary to determine volume (in gallons.) Any SSO will leave a 'wetted footprint' on the surfaces affected. This guide will help you to determine the area of the wetted footprint of the spill. The wetted footprint will not likely be a geometric shape that is easy to determine the area. You will have to be creative and find the familiar shapes within the shape. This will be demonstrated later in the guide. After determining the area contacted by the spill, the depth of the spilled sewage must be determined, which, combined with the area, will lead to the volume spilled.

CONVERSIONS

** To convert inches into feet: Divide the inches by 12.

Example: 27" / 12 = 2.25'

Or Use Chart A

Example: 1 ¾" = ?

1" (0.08') + ¾" (0.06') = 0.14'

** One Cubic Foot can contain 7.48 gallons of liquid.

Chart A

Conversion:

Inches	to	Feet
1/8"	=	0.01'
1/4"	=	0.02'
3/8"	=	0.03'
1/2"	=	0.04'
5/8"	=	0.05'
3/4"	=	0.06'
7/8"	=	0.07'
1"	=	0.08'
2"	=	0.17'
3"	=	0.25'
4"	=	0.33'
5"	=	0.42'
6"	=	0.50'
7"	=	0.58'
8"	=	0.67'
9"	=	0.75'
10"	=	0.83'
11"	=	0.92'
12"	=	1.00'

GEOMETRY

For the purposes of this guide, the unit of measurement will be in feet for formula examples.

Area is two-dimensional - represented in square feet. (Length x Width)

Volume is three-dimensional - represented in cubic feet. (Length x Width x depth) or (Diameter Squared) D^2 x 0.785 x depth.

A Note about Depth

Wet Stain on a Concrete Surface - For a stain on concrete, use 0.0026'. This number is 1/32" converted to feet. For a stain on asphalt use 0.0013' (1/64"). These were determined to be a reasonable depth to use on the respective surfaces through a process of trial and error. A known amount of water (one gallon) was poured onto both asphalt and concrete surfaces. Once the Area was determined as accurately as possible, different depths were used to determine the volume of the wetted footprint until the formula produced a result that (closely) matched the one gallon spilled. 1/32" was the most consistently accurate depth on concrete and 1/64" for asphalt. This process was repeated several times.

Sewage "Ponding" or Contained – Measure actual depth of standing sewage whenever possible. When depth varies, measure several (representative) points, determine the average and use that number in your formula to determine volume.

Area/Volume Formulas

Area is two dimensional and is represented as Square Feet (SQ/FT)

Volume is three dimensional and is represented as Cubic Feet (CU/FT)

One Cubic Foot can hold 7.48 gallons

AREA/VOLUME OF A RECTANGLE OR SQUARE

Formula: **Length x Width x Depth** = Volume in Cubic Feet

12’

Depth = 1 ¾”

25’

Length (25’) x Width (12’) x Depth (0.14’)
(0.08’+ 0.06’ = 0.14’)

25’ x 12’ x 0.14’ = <u>42 Cubic Feet</u>.

Now the Volume in Cubic Feet is known.

There are 7.48 Gallons in one Cubic Foot

So, 42 Cubic Feet x 7.48 gallons/cubic feet = **<u>314 Gallons</u>**

Chart A

Conversion:

Inches	to	Feet
1/8”	=	0.01’
1/4”	=	0.02’
3/8”	=	0.03’
1/2”	=	0.04’
5/8”	=	0.05’
3/4”	=	0.06’
7/8”	=	0.07’
1”	=	0.08’
2”	=	0.17’
3”	=	0.25’
4”	=	0.33’
5”	=	0.42’
6”	=	0.50’
7”	=	0.58’
8”	=	0.67’
9”	=	0.75’
10”	=	0.83’
11”	=	0.92’
12”	=	1.00’

AREA/VOLUME OF A RIGHT TRIANGLE

Base x Height x 0.05 x Depth = Volume in Cubic Feet

10’

Depth = 5/8”

45’

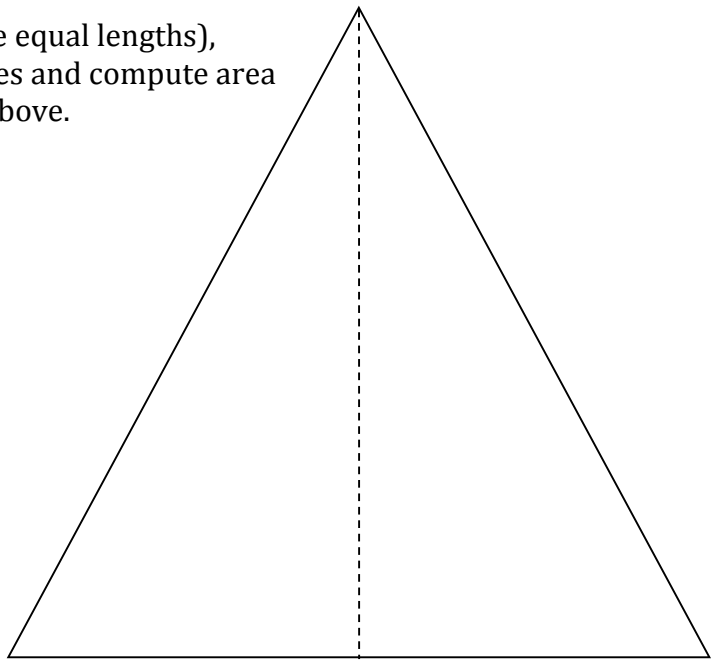
Chart A

Conversion:

Inches	to	Feet
1/8”	=	0.01’
1/4”	=	0.02’
3/8”	=	0.03’
1/2”	=	0.04’
5/8”	=	0.05’
3/4”	=	0.06’
7/8”	=	0.07’
1”	=	0.08’
2”	=	0.17’
3”	=	0.25’
4”	=	0.33’
5”	=	0.42’
6”	=	0.50’
7”	=	0.58’
8”	=	0.67’
9”	=	0.75’
10”	=	0.83’
11”	=	0.92’
12”	=	1.00’

Base (45’) x Height (10’) x 0.5 x Depth (.05’) x 7.48 gallons/cubic foot = **84 gallons**

For Isosceles Triangles (two sides are equal lengths), Break it down into two Right Triangles and compute area as you would for the Right Triangle above.



AREA/VOLUME OF A CIRCLE/CYLINDER

$D^2 \times 0.785 \times d$

Diameter Squared x 0.785 x Depth = Volume in cubic feet.

Diameter = Any straight line segment that passes through the center of a circle.

For our purposes, it is the measurement across the widest part of a circle.

D^2 x 0.785 x depth = Volume in cubic feet

Example:

27' x 27' x 0.785 x 0.03 = 17.17 cubic feet

17.17 cubic feet x 7.48 gallons/cubic feet = **<u>128 gallons</u>**

Chart - A

Conversion:
Inches to Feet

1/8"	=	0.01'
1/4"	=	0.02'
3/8"	=	0.03'
1/2"	=	0.04'
5/8"	=	0.05'
3/4"	=	0.06'
7/8"	=	0.07'
1"	=	0.08'
2"	=	0.17'
3"	=	0.25'
4"	=	0.33'
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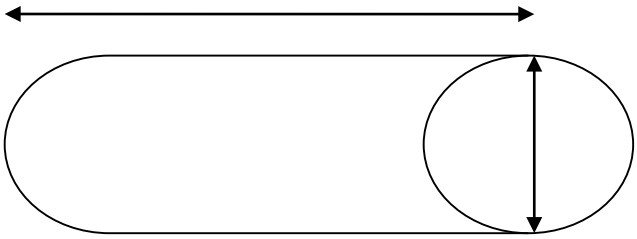
9"	=	0.75'
10"	=	0.83'
11"	=	0.92'
12"	=	1.00'

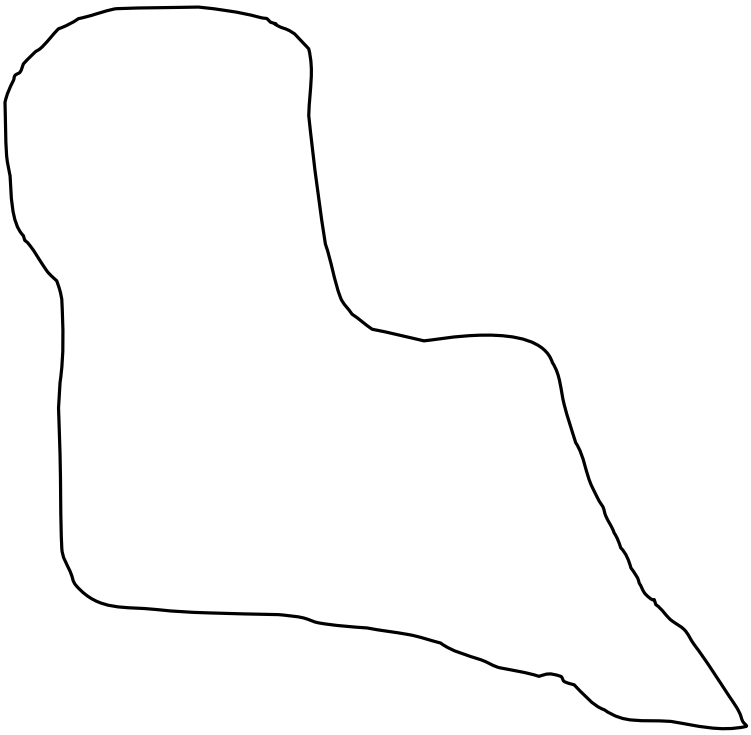


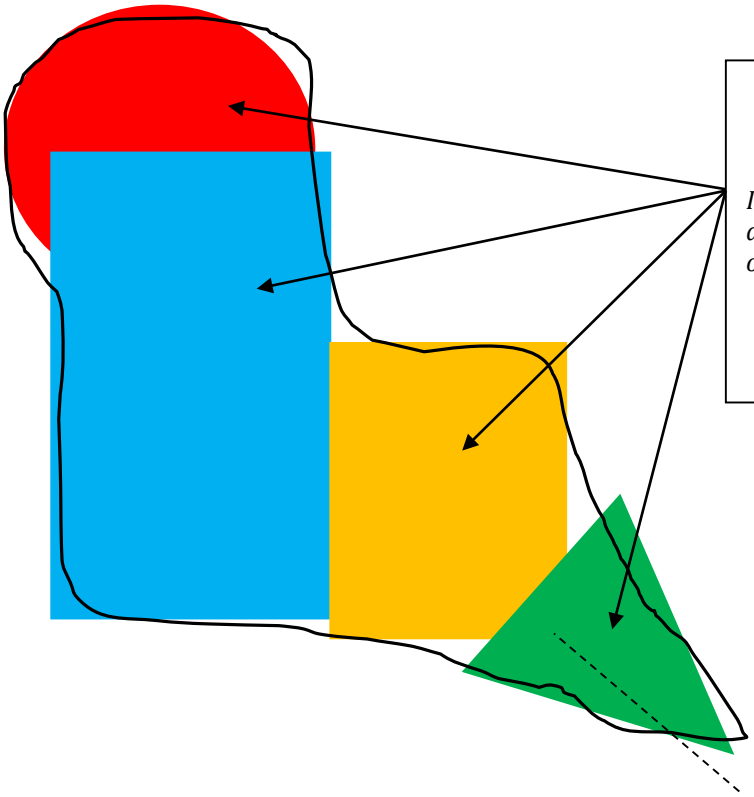
Diameter = 27'

Depth = 3/8"

Find the geometric shapes within the shape. If this was the shape of your spill, break it down, as best you can, with the shapes we know.

** As a Rule, any shape you choose to use must be 85% wet (by your best estimation) within the lines otherwise use additional shapes.





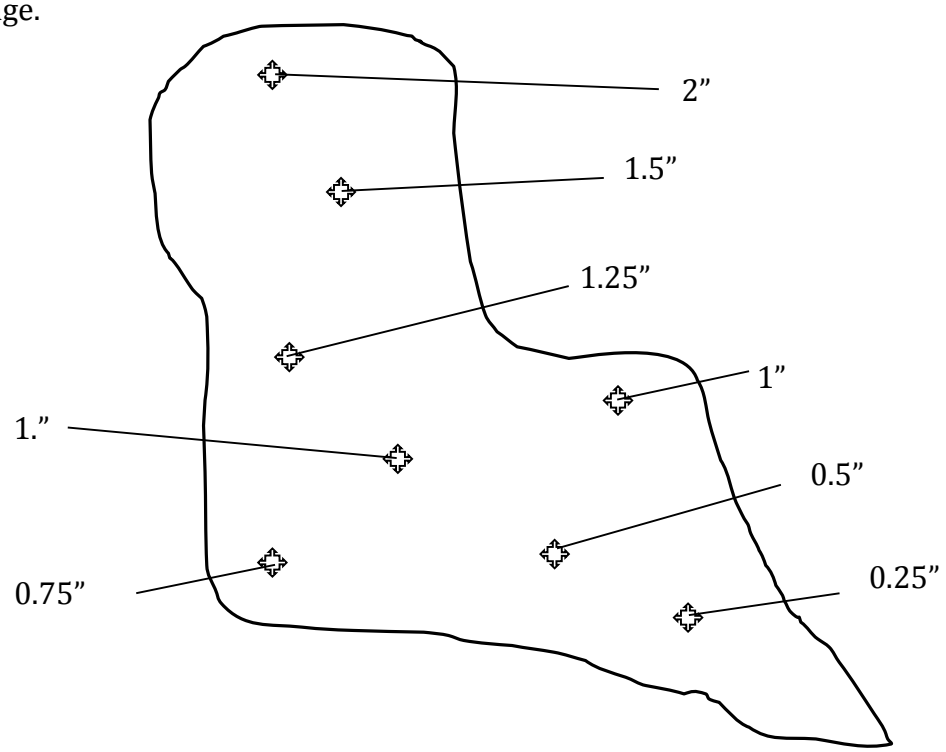
1. Determine the volumes of each shape.

In this example, after the volume of the circle is determined, multiply it by 55% (+/-) so that the overlap area won't be counted twice.

2. Add all the volumes to determine total spill volume.

When Water is "Ponding" on the ground.

If the spill depth is of varying depths, take several measurements at different depths and find the average.



2" + 1.5" + 1.25" + 1" + 1" + 0.75" + 0.5" + 0.25" = 8.25"

8.25" / 8 measurements = 1.03"

Average Depth = 1.03"

Step 1

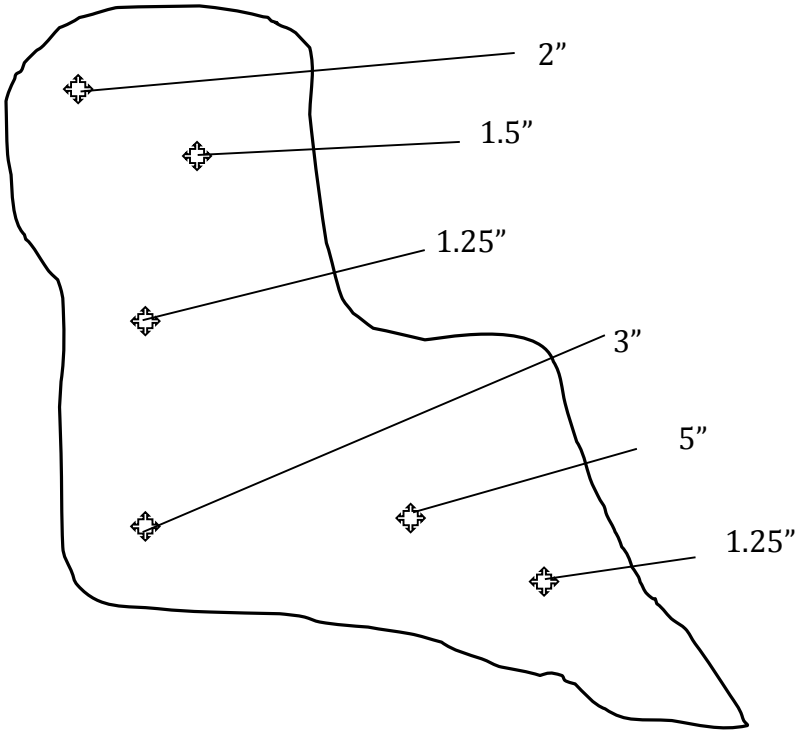
If the spill affects a dry, unimproved area such as a field or dirt parking lot, determine the Area of the wetted ground in the same manner as you would on a hard surface. Using a round-point shovel, dig down into the soil until you find dry soil. Do this in several locations within the wetted area and measure the depth of the wet soil. Average the measurement/thickness of the wet soil and determine the average depth of the wet soil.

Step 2

Take a Test Sample
(See Next Page)

NOTE: This can be used in a (Dry) dirt or grassy area that is not regularly irrigated like a field or a dirt parking lot.

Wet weather would make this method ineffective.



2” + 1.5” + 1.25” + 3” + 5” + 1.25” = <u>14.0”</u>

14.0” / 6 measurements = 2.33”

Average Depth = 2.33” (0.194’)

EXAMPLE:

If the Area of the spill was determined to be 128 Sq/Ft and the average depth of the wet soil is 2.33 inches:

128 Sq/Ft x 0.194’ = 24.83 Cu/Ft

24.83 Cu/Ft x 7.48 Gals/Cu/Ft = 185.74 gallons

185.74 x 18% = <u>33 Gallons</u> (water in soil)

(Test) SAMPLING SOIL FOR WATER CONTENT

Once you have determined the wetted footprint of the spill, you will want to determine the water (sewage) content in the soil.

1. Select an area of dry soil (near the wetted footprint of the spill) to sample.
2. Pour a known amount of water onto the soil and let it soak in for an adequate amount of time. If possible, use a form to keep the water contained to a geometric shape (circle, square, rectangle, etc.).
3. Determine the Area of the wetted footprint.
4. Using a small hand tool, dig down into the soil until dry soil is reached. Measure the depth of the wet soil. Do this in multiple locations and average the measurements.
5. Multiply the Area by the Average Depth of the wet soil to determine the volume of the wet soil.
6. Determine the water content in the soil
    a. Since you started with a known amount, you know how much water is in the soil.
    b. Divide that <u>known amount</u> by the <u>volume determined</u> in step 5 to arrive at the percent of water content in the soil.
    c. Arrive at the water content of the soil (percent)

Example:

1. Place a 2-foot diameter form onto an area of dry soil.
2. Pour one gallon of water into the form and let it soak in for 15 minutes.
3. Pull the form and measure the Area of the wetted soil (it will likely be larger than the form). Let's say 26" diameter.
4. Dig into the soil in 3 locations and measure the depth of the wetted soil.
5. Average the 3 measurements. (Let's say 2.5", 1.5" & 3.75" = 7.75". divide by 3 = <u>2.58"</u> or 0.215')
6. Determine the Area of the Circle (D^2 x 0.785) 2.16' x 2.16' x 0.785 = 3.66 Sq/Ft
7. Multiply the Area by the Average Depth to get the Volume (3.66 x 0.215' = 0.79 Cu/Ft)
8. Multiply 0.79 cubic feet by 7.48 gallons/Cu/ft = 5.9 gallons.
9. Divide 1 Gallon (known Amount) by 5.9 gallons = .17 or 17% is the water content in the soil.
10. Now you have determined that the water content in the soil is 17%. Apply this to your actual spill area by multiplying the volume of the saturated soil by the percent of water arrived at from the sample.

Appendix D

Surface: ☐ Asphalt ☐ Concrete ☐ Dirt ☐ Landscape ☐ Inside Building Other _____

(Draw / Sketch outline of Spill 'Footprint' and attach photos) Work Order Nbr: _____

~~ Breakdown the 'Footprint' into Recognizable Shapes and Determine Dimensions of Each Shape ~~

Area 1_____ % Wet _____

☐ Stain, or Depth1_____ Depth2 _____ Depth3 _____ Depth4 _____ Depth5 _____ Depth6 _____

Area 2_____ % Wet _____

☐ Stain, or Depth1_____ Depth2 _____ Depth3 _____ Depth4 _____ Depth5 _____ Depth6 _____

Area 3_____ % Wet _____

☐ Stain, or Depth1_____ Depth2 _____ Depth3 _____ Depth4 _____ Depth5 _____ Depth6 _____

Area 4_____ % Wet _____

☐ Stain, or Depth1_____ Depth2 _____ Depth3 _____ Depth4 _____ Depth5 _____ Depth6 _____

Area 5_____ % Wet _____

☐ Stain, or Depth1_____ Depth2 _____ Depth3 _____ Depth4 _____ Depth5 _____ Depth6 _____

Area 6_____ % Wet _____

☐ Stain, or Depth1_____ Depth2 _____ Depth3 _____ Depth4 _____ Depth5 _____ Depth6 _____

(To be Completed by Supervisor)

Area 1 **(A) =** Square Feet: _____ x % Wet _____ = _____ Sq/Ft

(B) = Ave Depth: _____ or ☐ Concrete 0.0026' or ☐ Asphalt 0.0013'

(A) x (B) = Volume: _____ Cu/Ft

Area 2 **(A) =** Square Feet: _____ x % Wet _____ = _____ Sq/Ft

(B) = Ave Depth: _____ or ☐ Concrete 0.0026' or ☐ Asphalt 0.0013'

(A) x (B) = Volume: _____ Cu/Ft

Area 3 **(A) =** Square Feet: _____ x % Wet _____ = _____ Sq/Ft

(B) = Ave Depth: _____ or ☐ Concrete 0.0026' or ☐ Asphalt 0.0013'

(A) x (B) = Volume: _____ Cu/Ft

Area 4 **(A) =** Square Feet: _____ x % Wet _____ = _____ Sq/Ft

(B) = Ave Depth: _____ or ☐ Concrete 0.0026' or ☐ Asphalt 0.0013'

(A) x (B) = Volume: _____ Cu/Ft

Area 5 **(A) =** Square Feet: _____ x % Wet _____ = _____ Sq/Ft

(B) = Ave Depth: _____ or ☐ Concrete 0.0026' or ☐ Asphalt 0.0013'

(A) x (B) = Volume: _____ Cu/Ft

Area 6 **(A) =** Square Feet: _____ x % Wet _____ = _____ Sq/Ft

(B) = Ave Depth: _____ or ☐ Concrete 0.0026' or ☐ Asphalt 0.0013'

(A) x (B) = Volume: _____ Cu/Ft

Total Volume: _____*Cu/Ft

Total Volume: _____ *Cu Ft x 7.48 gallons = _____ **** Gallons Spilled**

****** In order to determine volume spilled on soil, in addition to the above information, a soil sample must be obtained using the "Soil Saturation Sample Worksheet". Involve TSD for this procedure.

1. Place the Soil Sampling Ring into the soil adjacent to the spill area, press into the ground up to 1" deep, if possible.

2. Pour one gallon of water into the ring, spreading as equally as possible.

3. Let water soak into the soil for a reasonable amount of time – generally 10 to 20 minutes.

4. Dig down in 3 different locations within the ring to determine the depth of the wetted soil.
    a. If on a slope, the samples should be taken from the low side, middle, high side.

5. Determine the average of the three depths.
    a. Take Photo of Ring with dig outs
    b. Take Photo of Ring in relation to spill area (broad view)

6. The Soil Sampling Ring has an area of 3.14 sq/ft.

7. Multiply 3.14 x Average Depth to arrive at cu/ft.

8. Multiply cu/ft x 7.48 to determine gallons of saturated soil.

9. Divide the one gallon used for the sample by the gallons of saturated soil arrived at in step 8 to arrive at the percentage of water in the saturated soil.

10. Multiply the volume of saturated soil for the actual spill event by the percentage of water arrived at in step 9 and that will determine the (sewage) content in the soil.

Date Sample Was Taken _____/_____/_____ Time _____:_____ BY: _____

Weather Conditions: _____

Spill Location: _____

Depth 1 _____ + Depth 2 _____ + Depth 3 _____ = _____ / 3 = _____ Ave.

Convert inches to feet: _____ Ave. / 12 = _____ Ave.

_____ Ave. x 3.14 sq/ft = _____ cu/ft. x 7.48 = _____ gallons of saturated soil.

1 Gallon / _____ gallons of saturated soil = _____%.

Comments: _____

_____

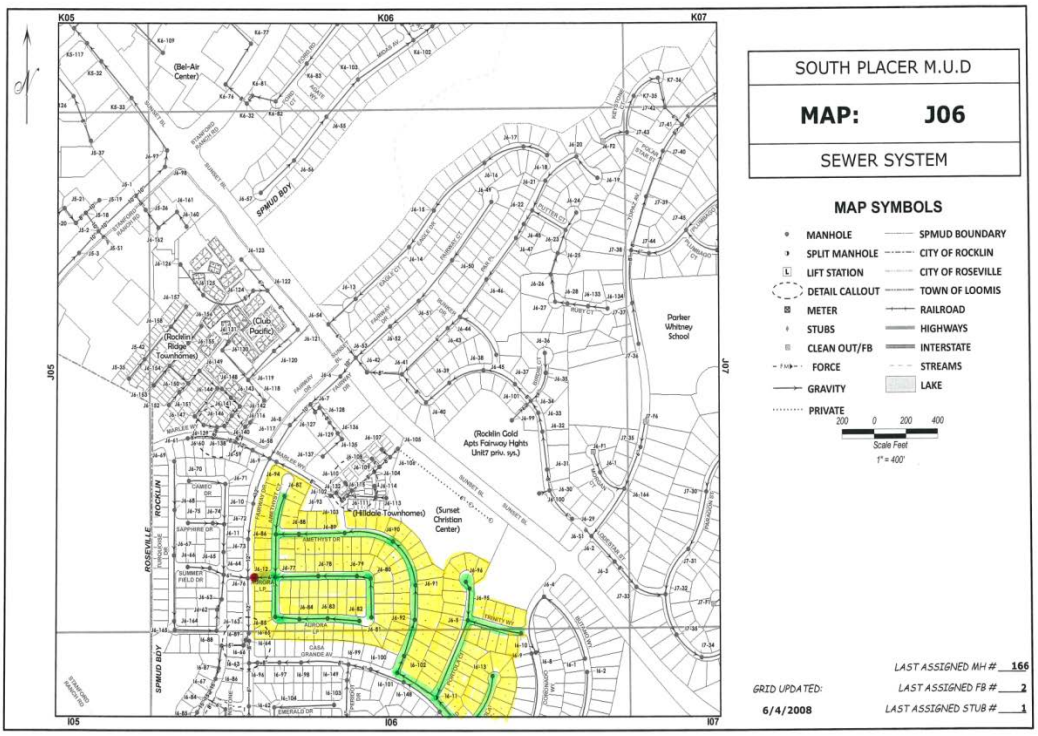
_____

This methods is dependent on establishing the spill duration. It assumes the District average (Dry Weather) flow from a building to be 150 gallons per Equivalent Dwelling Unit (EDU). This number is derived by dividing total (District-Wide) EDU's into (daily) gallons conveyed to the WWTP. During Wet Weather conditions consult the Technical Services Department (TSD) for flow characteristics based on current conditions. A residential building is typically one EDU.
For commercial buildings:

- **Refer to Service Line module in the WWMS database for actual EDU's, or**
- **Contact the District's Administration office.**
    - **Provide the Administration personnel with the address(s) and they will provide the information.**

For small portions of the collection system such as a residential neighborhood the District's Grid Map Book can be used.

1. **Locate the portion of the system in the Grid Map Book**
2. **Determine the limits of the collection system that flows through the overflowing manhole**
3. **Count the number of lots that are served by that portion of the collection system.**

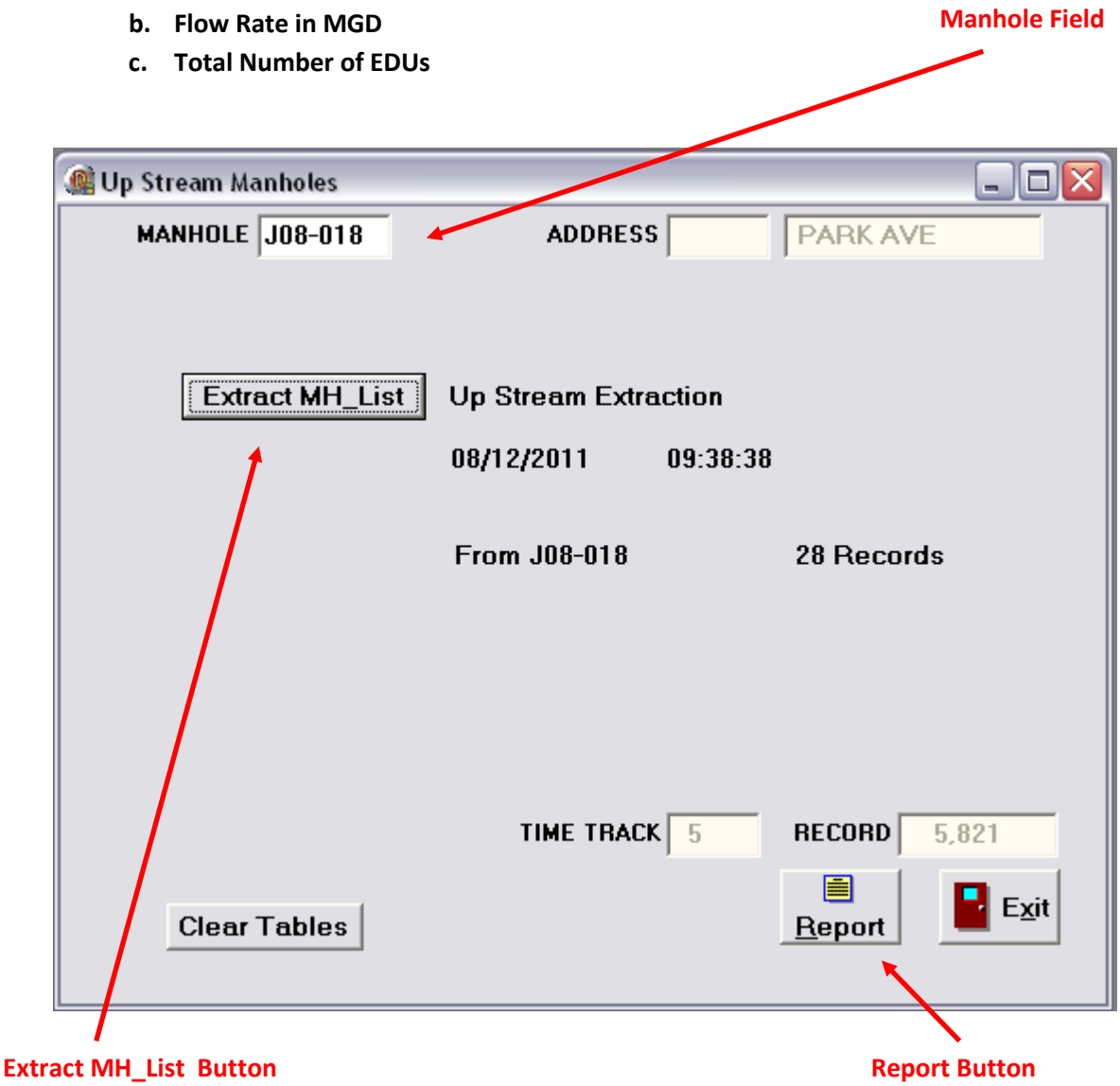


Multiply the number of lots by the appropriate Gallon/EDU and arrive at the flow rate (in GPM)

For larger portions of the collection system this method is not practical.

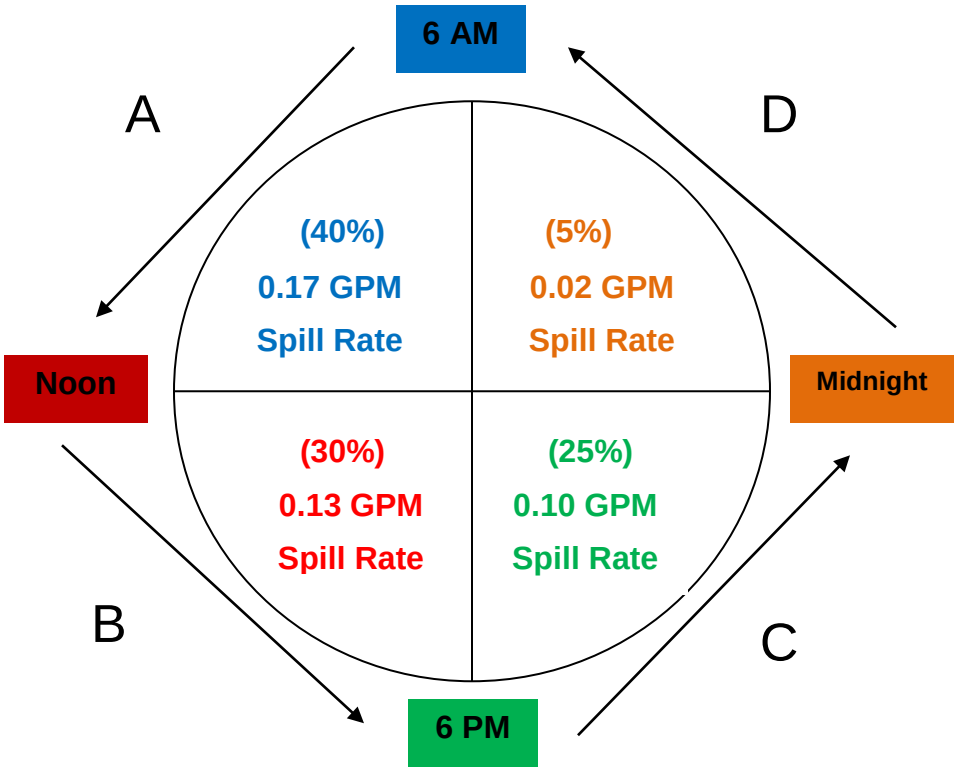
The District's WWMS database has feature for determining the flow using the Upstream Connections Method. This can be used in lieu of the above method

1. **From the Home Screen select REPORTS from the Menu Bar**
2. **From the Drop-Down window select Up Stream Manholes**
3. **Enter the Manhole ID of the overflowing manhole into the MANHOLE field**
4. **Click on the EXTRACT MH_LIST Button**
5. **When the Extraction is complete Click on the REPORT Button**
6. **The last page of the report will indicate:**
    a. **Flow Rate in GPM**
    b. **Flow Rate in MGD**
    c. **Total Number of EDUs**



150 GPD per Household

(District-wide diurnal flow patterns are applied to estimate usage during each period)



Time Period	Gals per Minute	Gals per Hour	Gals per Period
A - 6 AM to Noon	**0.17**	**10.2**	**61**
B - Noon to 6 PM	**0.13**	**7.8**	**46**
C - 6PM to Midnight	**0.10**	**6.0**	**36**
D - Midnight - 6 AM	**0.02**	**1.2**	**7**

Spill Start Time _____ - Spill End Time _____ = Spill Duration _____

Spill Duration _____ x Spill Rate _____ x EDUs _____ = Spill Volume _____

This is to be used as a guide for spill estimation for lower lateral blockages. Each six-hour period flow rate assumes a constant flow, which would not be typical in a home or business. In the absence of any other information or in conjunction with other information, this is intended to assist with spill estimations.

See Back

Here's how it works…

This estimation method works only for spills where the blockage is in the lower lateral. It assumes 150 gallons per EDU, which is based on the District-wide average as of September 2013. Single-Family Residential homes = One EDU. For Commercial buildings, the EDUs can be found in WWMS database, on the 'Service Line' screen.

Once the Spill Start Time and End Time are determined, this method can be applied. Example:

It is determined that the spill start time was 9:45 AM and the Spill End time was 1:30 (3 hours and 45 minutes)

From 9:45 to Noon (2 Hrs, 15 Minutes would be calculated using 0.17 GPM (135 minutes x 0.17 = **23.0 gallons**).

From Noon to 1:30 PM (1 Hr, 30 Minutes would be calculated using 0.13 GPM (90 minutes x 0.13 = **12.0 gallons**).

Total would be 23.0 gallons + 12.0 gallons = **35.0 gallons**.

This method involves utilizing Flow Monitoring equipment and (historical) Flow Monitoring records to assist with the determination of spill volume. It is used after-the-fact and is intended to approximate the flows during a spill event by using actual flows through the same portion of the system during the same time/days of the spill event.

During the Spill Event, the first responders are expected to inspect the first manhole downstream of the blockage, make a notation of the amount of water in the manhole channel, take a picture and measure the depth, if applicable. This is documented ion the SSO Field Check List form. Calculations of the amount of flow passing through this manhole will be documented on the Flow Calculation Worksheet. After the location of the blockage is determined, CCTV records will be used to determine the number of connections between the blockage and the downstream manhole. The flow contributed from these connections will be subtracted from the flow through the downstream manhole. In the absence of any specific information about the volume of flows from any of these connections, 180 gallons/home/24 hours will be used.

Portable Spill Monitoring Equipment

After a spill event has occurred, and as soon as possible after the event, portable flow monitoring equipment is installed in the same portion of the system the SSO occurred – if possible, the same manhole or mainline. The minimum amount of time will be 24 hours, while the maximum will (generally) be one week. This will be determined on a case-by-case basis. The goal is to collect the most representative sample.

After the flow data is collected it will be used in conjunction with:

1. Spill Start Time
2. Spill Duration
3. Flow Calculation Worksheet for downstream manhole
4. Rainfall data, when applicable

Average Flow Rate (GPM) – Downstream Manhole Flow Rate (GPM) x Duration (minutes) = Volume of Spill (gallons)

Other considerations that might suggest an adjustment to the volume as determined above would include:

1. Holidays
2. Special Events
3. Known Special Discharges upstream.

Adjustments, if any, would be determined by management personnel.

Diurnal Flow Pattern

There are times when Flow Monitoring data will be utilized to apply the Diurnal Flow Pattern to a spill. When using a photo or some instantaneous observation that represents a moment in time and the duration of the spill event is determined to be lengthy (beyond an hour) the diurnal flow pattern will be

applied to the spill rate to adjust the observed spill rate up or down to produce a more accurate estimation.

Generally, historic flow data from the District's permanent flow monitoring sites will be used for this determination. Most of these sites are located on the major trunk sewers throughout the District.

Documentation for the method will be done on the Flow Monitoring Method Worksheet.

Completed By: _____ Measuring Manhole: _____

How was Flow Rate Determined?

(Attach worksheets, reports, etc. used in determination)

☐ Flow Calculation Work Sheet; Determined Flow Rate: _____ GPM

☐ Flow Monitoring Equipment;

If Flow Monitoring Equipment:

Measuring Period: From _____/_____/_____ at _____:_____

To _____/_____/_____ at _____:_____

Average Flow Rate During Same Time of Day as Spill Occurred: _____ GPM

Flow Measured - Downstream Manhole ID: _____; Flow _____ GPM

(See SSO Response Field Check List for Downstream flow information)
(Attach Flow Calculation Worksheet)

Diurnal Flow Pattern applied: _____

_____

_____

_____

Comments: _____

_____

_____

_____

Duration: _____ x Flow Rate (GPM) _____ = Spill Volume _____ Gals

Lift Station Spill Volume Estimation

Lift stations produce several pieces if information that can be used in combination to help determine the failure time of a lift station and the volume of flow into and out of the station.

Spill Estimation Considerations:

1. Lift Station Log Sheets – Elapsed Time Meter (ETM) data
    a. These log sheets indicate the date/time District personnel were on site performing maintenance or operations checks.
    b. The hours for each pump are logged from the pump's ETM.
    c. Together with the date, time and hours run-time from the last visit to the time of failure could help to determine SSO Start Time and could assist with spill volume estimation.
2. Known pump rates
    Pump rate (GPM) data collected can be used to help determine spill volume if the spill is related to a force main failure.
3. Known influent rates
    a. In the same manner as item 2 above, the influent rates can be useful in determining spill volume when the SSO is caused by station failure. In some cases these rates are measured.
4. SCADA data
    a. Data may be available for:
        i. Pump starts & stops
        ii. Pump run times
        iii. AMP draws
        iv. Volume in pumping cycle.
    b. All of this data is used to assist estimations of failure start time, volume estimations
5. Number of Connections served by lift stations
    a. Especially for the small volume stations, counting upstream connections could help determine the influent rate and spill volume when the SSO is caused by a station failure.
6. Auto-Dialer Alarm call time/date
    a. This will provide information of failure start time and will provide milestones as the alarms progress. For example, a pump failure is followed by a high level alarm. The time between alarms, along with the volume between the two set points will help to determine influent rate.
7. Eye witness observations
    a. Interviews can help to establish spill start times.

The amount and type of information available will be different from station to station. The idea here is to gather as much information as possible, analyze it and establish the best estimation of volume as possible.