Siphonic Roof Drainage & Design Process

Presentation by

MIFAB®

HydroMax®

Leaders In Siphonic Drainage

ASPE American Society of Plumbing Engineers™

Siphonic Roof Drainage Systems

PHCC PLUMBING-HEATING-COOLING CONTRACTORS ASSOCIATION

What is Siphonic Roof Drainage?

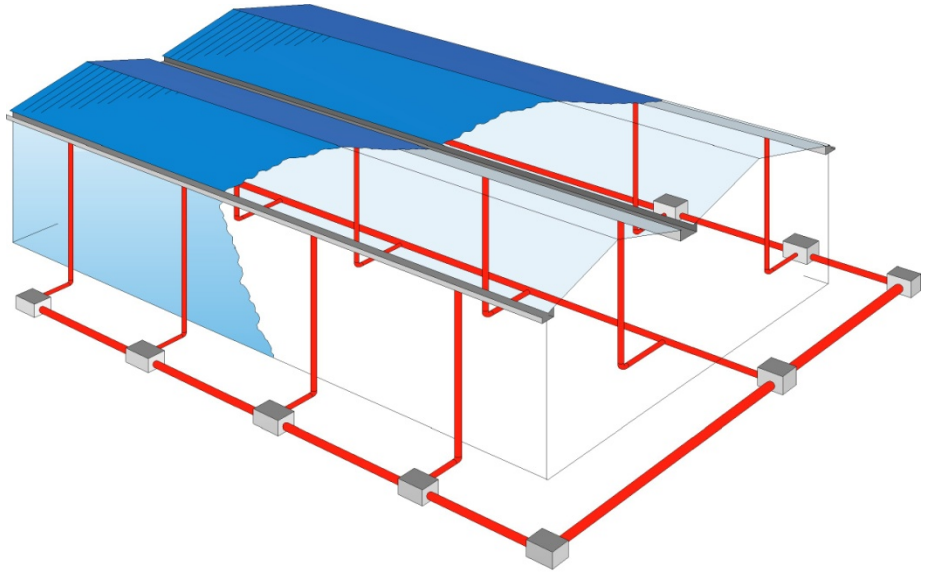
Siphonic Roof Drainage is an innovative solution which utilises the power of a natural siphon to create a high-performance roof drainage solution.

Why use Siphonic Roof Drainage?

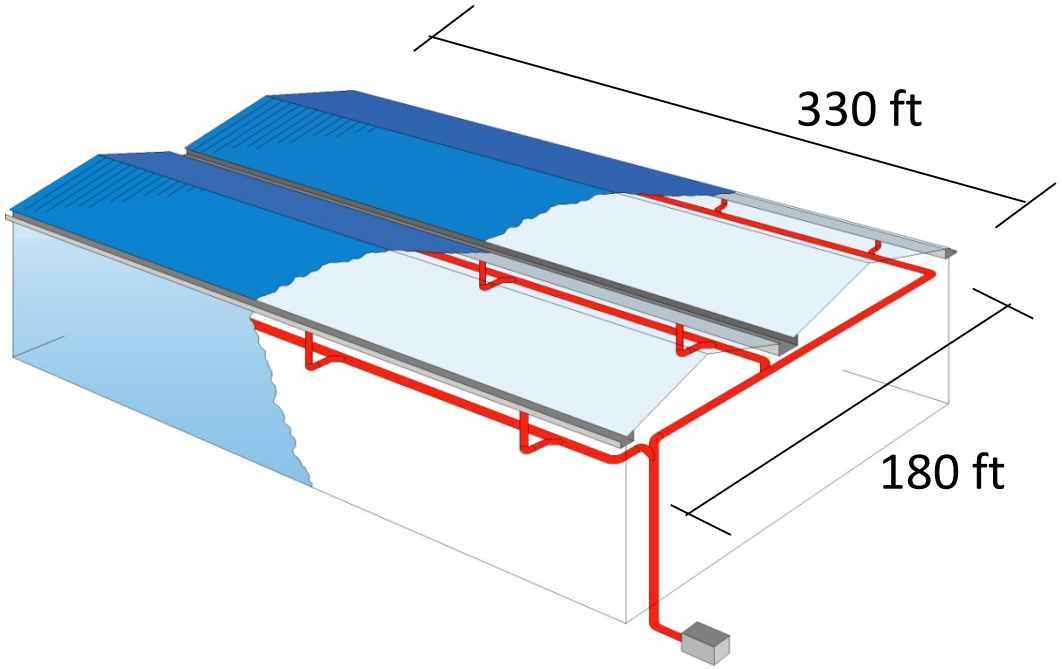
Siphonic Roof Drainage is an Engineered Solution which provides many Technical Benefits

Siphonic Roof Drainage offers **cost savings** ranging from

25% to 45%!



Traditional Gravity System
1600 feet Pipework
Diameters 6” to 18”



Siphonic Roof Drainage
Only 1000 feet Pipe
Diameters 3” to 8”

What's wrong with Traditional Gravity Drainage Systems?

Traditional Gravity drainage systems work but they are inefficient and have a number of factors restricting performance.

Restrictive Factors of Gravity Drainage

1. The water flow-rate is **dictated by ¼" pitch** when hanging the pipe, this decline also **limits the distance a pipe can travel**.

2. Multiple rainwater pipes have **location of discharge largely dictated by the gravity hydraulics** rather than design team choice of where to route.

3. Vortex formation at the gravity roof drain results in the **water being transported in an inefficient spiral motion** rather than straight into the pipe below.

4. Gravity drains/pipes require **⅔ air to transport ⅓ water** = bigger diameters required to properly flow.

5. The **driving force** is directly correlated to the **depth of ponding** ('head' of water above the roof drain).

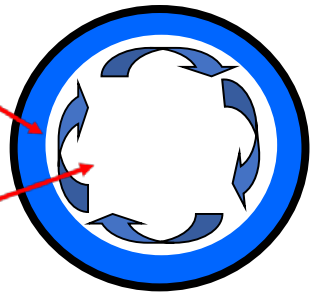
6. **No Test Standards** currently in place to test ponding flow graphs **for Gravity Drains** = **unidentified** ponding on roof.

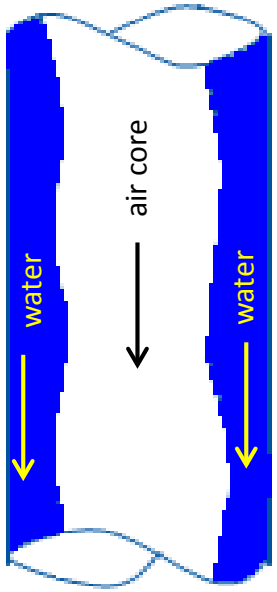
System Comparison

Traditional Gravity

⅓ water in annular flow

⅔ air core





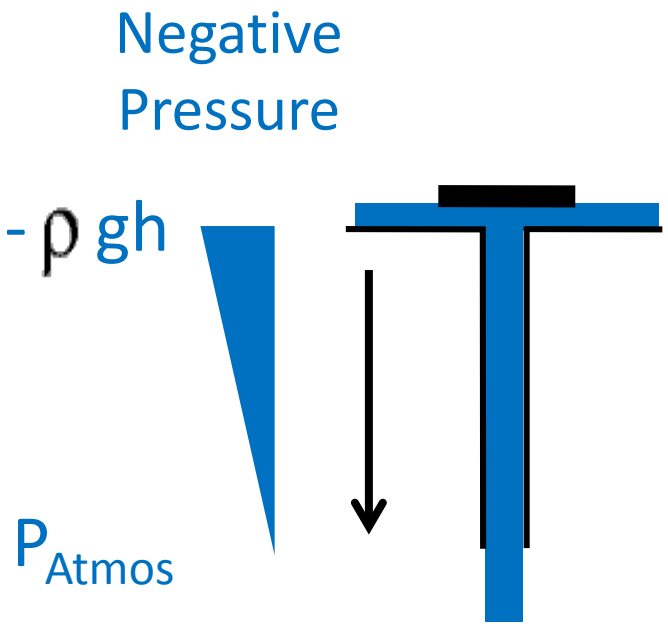
Siphonic

No Air

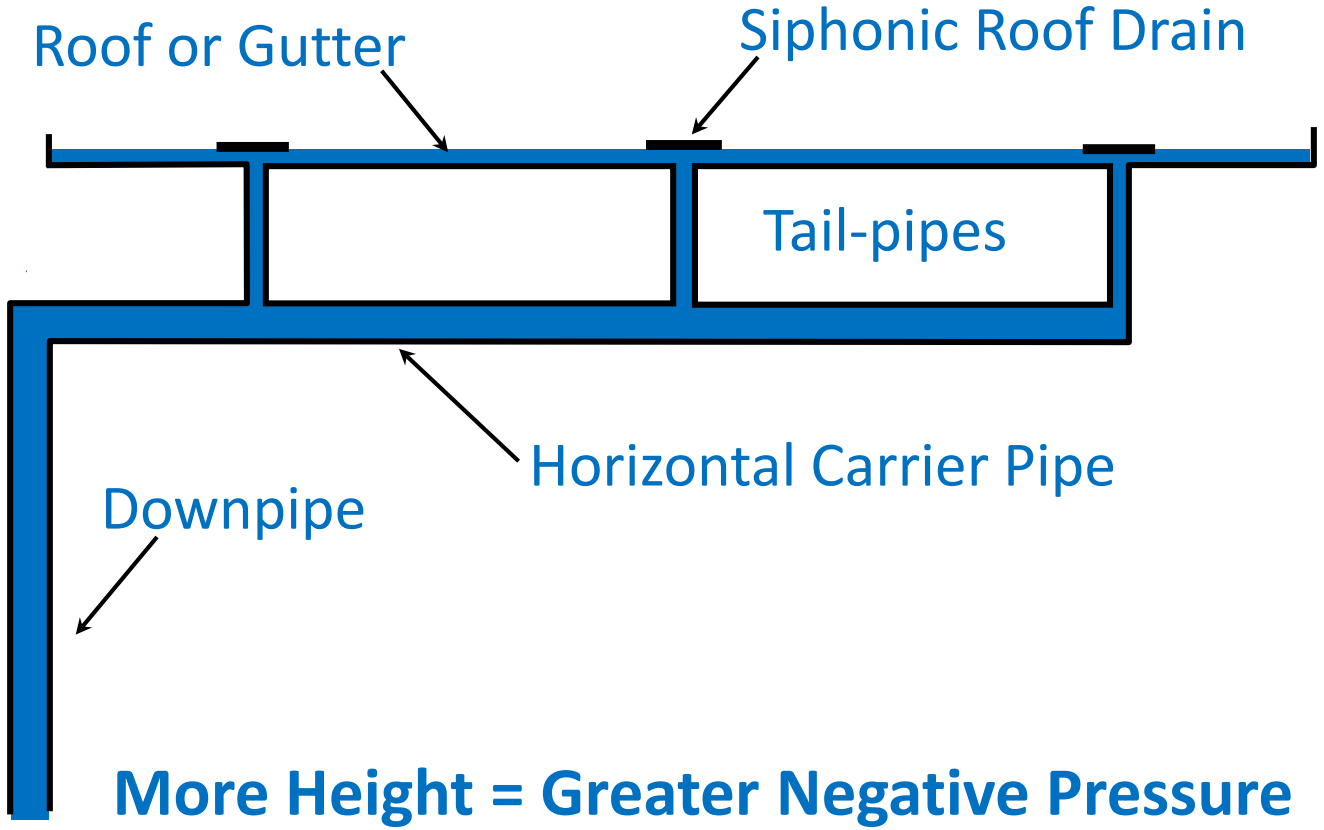
Principles of Siphonic Drainage

- The Siphonic Roof Drain eliminates air entering the pipe promoting water filled pipework
- The full bore of the pipework carries the rainwater
- **Water, without air, accelerates down the vertical downpipe, creating negative pressure** and naturally generating a high performance siphonic flow
- **The full height of the building provides the energy** for this highly efficient Rainwater Drainage Solution

Fully Primed Siphonic Drainage System



Rainwater falling down the vertical pipe accelerates, creating negative pressure



More Height = Greater Negative Pressure
Greater Negative Pressure = Higher Flow Rates

Top Technical Benefits
Siphonic Roof Drainage

- **Smaller Diameter** pipe required – approx. half the size of gravity diameter pipe size.
- Horizontal pipes are installed without **PITCH – Flat Level**.
- A significant **Reduction in Below Grade Drainage** (common range is from 20% to 60%).
- Pipes run full-bore with **self-scouring properties**.

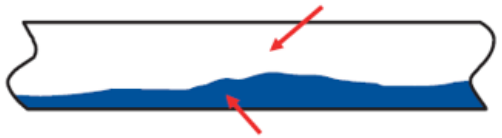
4 Stages of Flow – Self-Cleaning System

Four Flow Patterns of Siphonic Drainage

Priming of Main Pipe Work

Stage 1- Light Rainfall - Wavy or Gravity flow

Air above water



Gravity flow in pipework

Stage 2- Plug flow

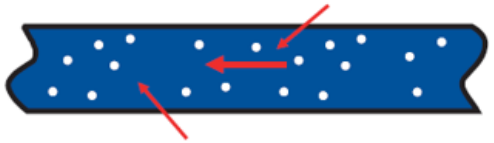
Plug of water filling whole pipe at high velocities which achieves self-cleansing.

Air pockets driven down pipework

Tests have shown that **self-cleansing** can be achieved at as low as **10% to 15%** of the design rainfall rate.

Stage 3- Bubble flow

Water filling whole pipe



Air bubbles in suspension carried at high velocity

Stage 4- Full-bore flow

No more air entry – Air within Pipe now Fully Purged

Water filling whole pipe

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Top Technical Benefits (continued)

- Rainwater down pipes **routed to the Engineer's Preferred Locations** - This frees up valuable building space.
- Routing of rainwater down pipes to the perimeter of buildings **Eliminates Below Grade Excavation Under the Building Floor**.
- Fewer pipes = **Reduced construction time and cost**.

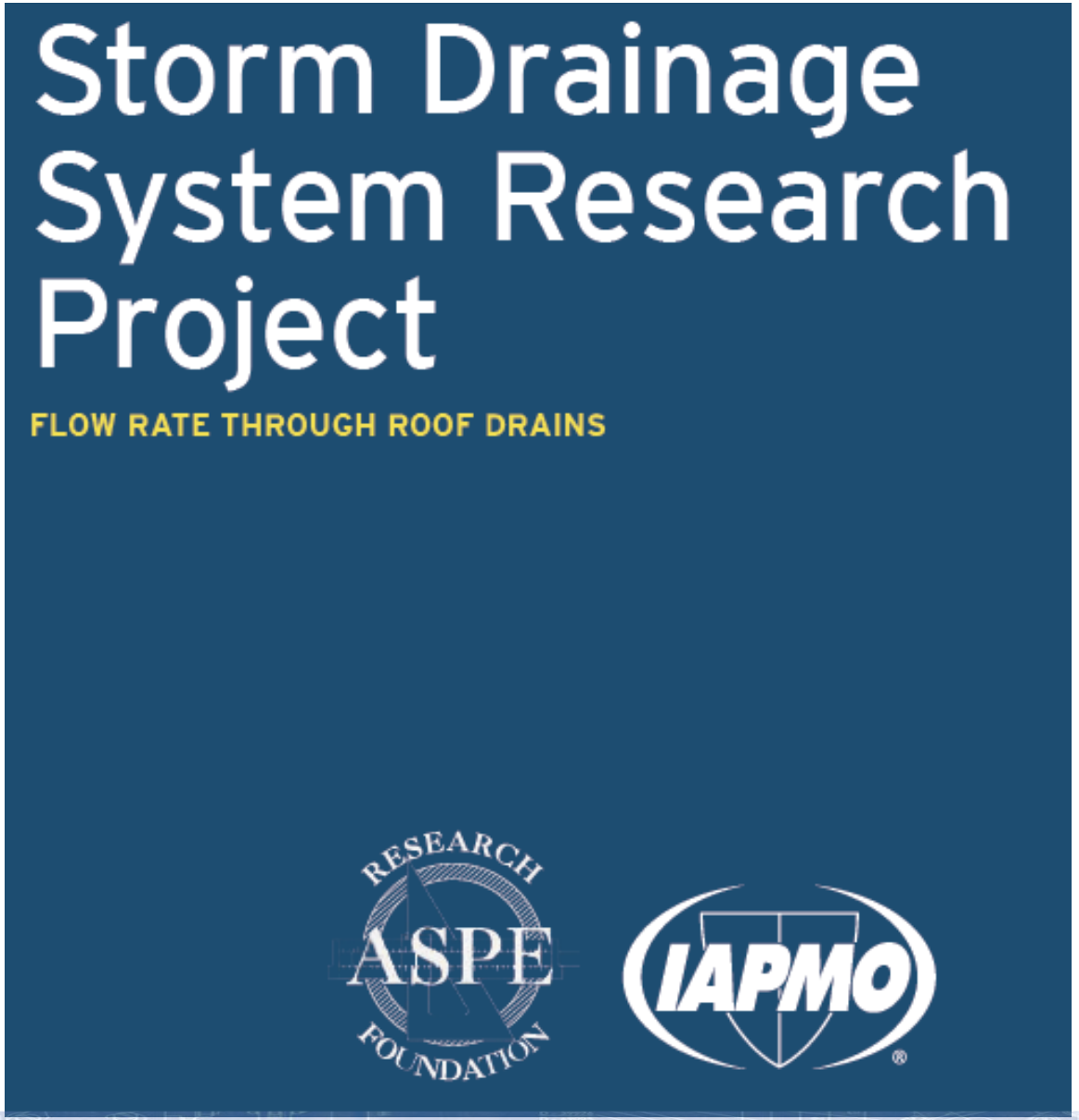
Top Technical Benefits (continued)

- Ability to route rainwater pipes to **Retention Ponds** or **Detention Basins** or **Rainwater Harvesting**.
- **Easy co-ordination** of services for BIM modeling due to pipe work running flat
- Makes **rainwater harvesting** more cost effective
- **Reduced Ponding** on the roof compared to traditional gravity drains due to efficient water discharge

Smaller Diameter Pipes running **Flat Level** allows for
Easy Co-ordination with structure and zoning of services

Top Technical Benefits

- **IPC 2015 Code Compliance** – Siphonic roof drains have performance graphs from testing to siphonic roof drains standard ASME A112.6.9



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Gravity Drain
ASPE Research Foundation Recommendation

To develop a new and proper method for sizing storm drainage based on capacity of roof drain and maximum ponding

Sizing Method Recommendation

Based on the results of the testing, the plumbing engineering profession must establish a new and proper method for sizing storm drainage systems. The new sizing method must be based on the capacity of the roof drain, the maximum amount of ponding under various storm conditions at the roof drain, and the maximum capacity of the piping system.

The archaic method of using roof area needs to be abandoned. The roof area method does not address the pitch and roughness of the roof, resulting in ponding at the roof drain. The method also does not consider the flow rate through the roof drain.

The ASME A112.6.4 standard regulates the design and construction of roof drains. An important part of this standard should include the performance of the roof drain. This would include the flow rate through the roof drain at various ponding heights.

Pipe sizing is based on tables with design rainfall rates and roof areas. The roof area x rainfall rate equates to GPM flow

TABLE 1106.3
SIZE OF HORIZONTAL STORM DRAINGE PIPING

SIZE OF HORIZONTAL PIPING (inches)	HORIZONTALLY PROJECTED ROOF AREA (square feet)					
	Rainfall rate (inches per hour)					
	1	2	3	4	5	6
1/8 unit vertical in 12 units horizontal (1-percent slope)						
3	3,288	1,644	1,096	822	657	548
4	7,520	3,760	2,506	1,800	1,504	1,253
5	13,360	6,680	4,453	3,340	2,672	2,227
6	21,400	10,700	7,133	5,350	4,280	3,566
8	46,000	23,000	15,330	11,500	9,200	7,600
10	82,800	41,400	27,600	20,700	16,580	13,800
12	133,200	66,600	44,400	33,300	26,650	22,200
15	218,000	109,000	72,800	59,500	47,600	39,650
1/4 unit vertical in 12 units horizontal (2-percent slope)						
3	4,640	2,320	1,546	1,160	928	773
4	10,600	5,300	3,533	2,650	2,120	1,766
5	18,880	9,440	6,293	4,720	3,776	3,146
6	30,200	15,100	10,066	7,550	6,040	5,033
8	65,200	32,600	21,733	16,300	13,040	10,866

10,066 sq. ft. at 3” per hour rainfall = 314 GPM

Effectively, the table says a 6” leader at ¼” per foot can take 314 GPM

Calculate Gallons per Minute to each Siphonic Roof Drain

Run-Off From Catchment Area

$$q_i = \frac{1}{43200} \times I_d \times A_i$$

q_i = Volume in Cubic feet per second
(multiply by 448.83 to convert to Gallons per Minute)

I_d = Design rainfall in inches per hour as per code

A_i = Tributary Catchment Area running to the drain

The roof area x rainfall rate equates to a GPM flow

GPM Calculator

Insert Rainfall Rate Below

	3.0	Inches per Hour Rainfall

ROOF AREA #	SQ. FEET	Q	GPM
A1	10066	0.70	314
A2	0	0.00	0.000
A3	0	0.00	0.000

10,066 sq. ft. at 3” per hour rainfall = 314 GPM

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6” Gravity Drain
(info from ASPE/IAPMO test report)

Target Flow for the 6” Leader is to Discharge 314 GPM

5. Manufacturer A, Model A-5	Head	1”	2”	3”	4”	5”	6”
6” Cast Iron Drain with Cast Iron Dome	GPM	10	185	199	238	267	218

Gravity 6” Drain at Ponding Depth = 2” can only Discharge 185 GPM

Even at 6” ponding this 6” Gravity drain can only Discharge 218 GPM

Effectively you would need 2 x 6” Gravity drains to obtain the target flow

Gravity Drain
ASPE Research Foundation Recommendation

“The archaic method of using roof areas needs to be abandoned……..method does not consider flow rate through the roof drain”

Sizing Method Recommendation

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Gravity Drain
ASPE Research Foundation Recommendation

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ASME A112.6.4 needs to add a test for flow rate through a roof drain. The testing for flow rate should utilize the test setup developed by ASPE RF. This test setup has proven to be an accurate method of testing the flow rate through roof drains.

USA Siphonic Standards

ASPE Technical Standard #45

Published in 2007 and reviewed 2012.
(HydroMax's Bill Ross was on committee)

In October 2013, having gained American National Standards Institute approval this revision was published as

ASPE/ANSI 45-2013:Siphonic Roof Drainage

Applications

- Warehouses
- Distribution Centers
- Box Stores/Malls
- Parking Decks
- Podium/Promenade Decks
- Office Buildings
- Hotels
- Hospitals
- Airports/Rail Stations

Malls & Multi Deck Parking

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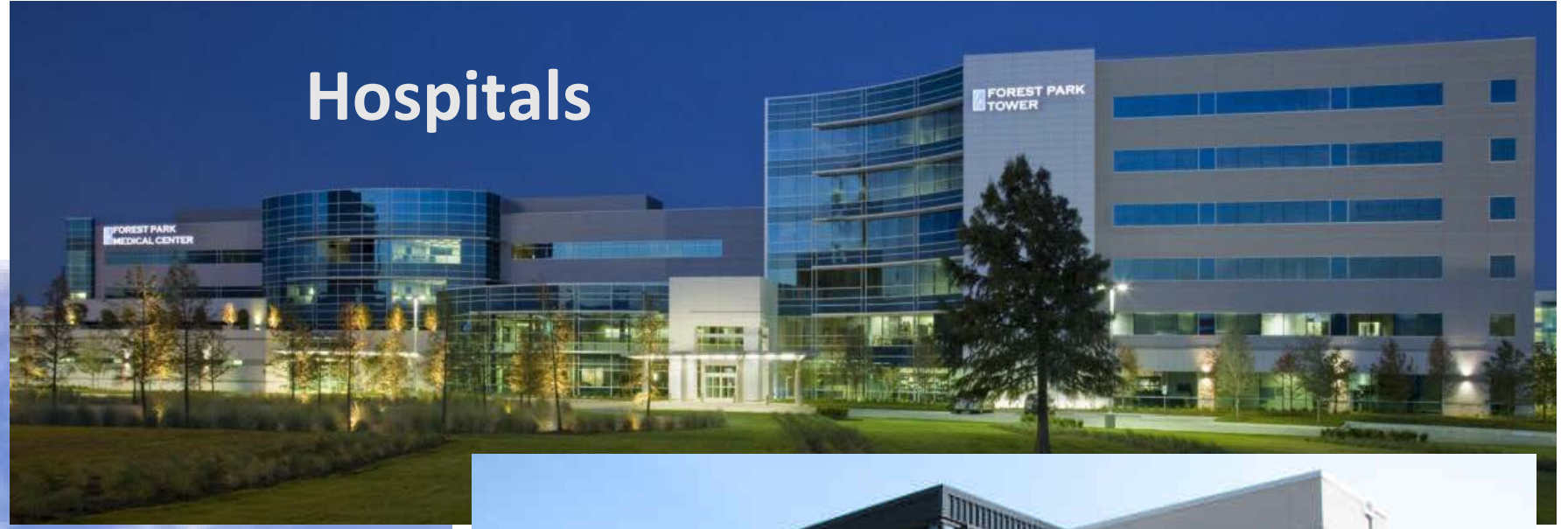

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Manufacturing

Unusual Architecture

Airports

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Understanding Savings

Warehousing & Distribution Centres

1,100,000 ft² Distribution Center Roof

Original Gravity Option

144 x 6” Roof Drains

72no. 8” Downpipe (Every 45ft)

2,600 ft. of 8” Pipe

Siphonic Solution

Only 36 x 5” Roof Drains

36no. 5” Downpipes (Every 90ft)

1300 ft. of 5” Pipe

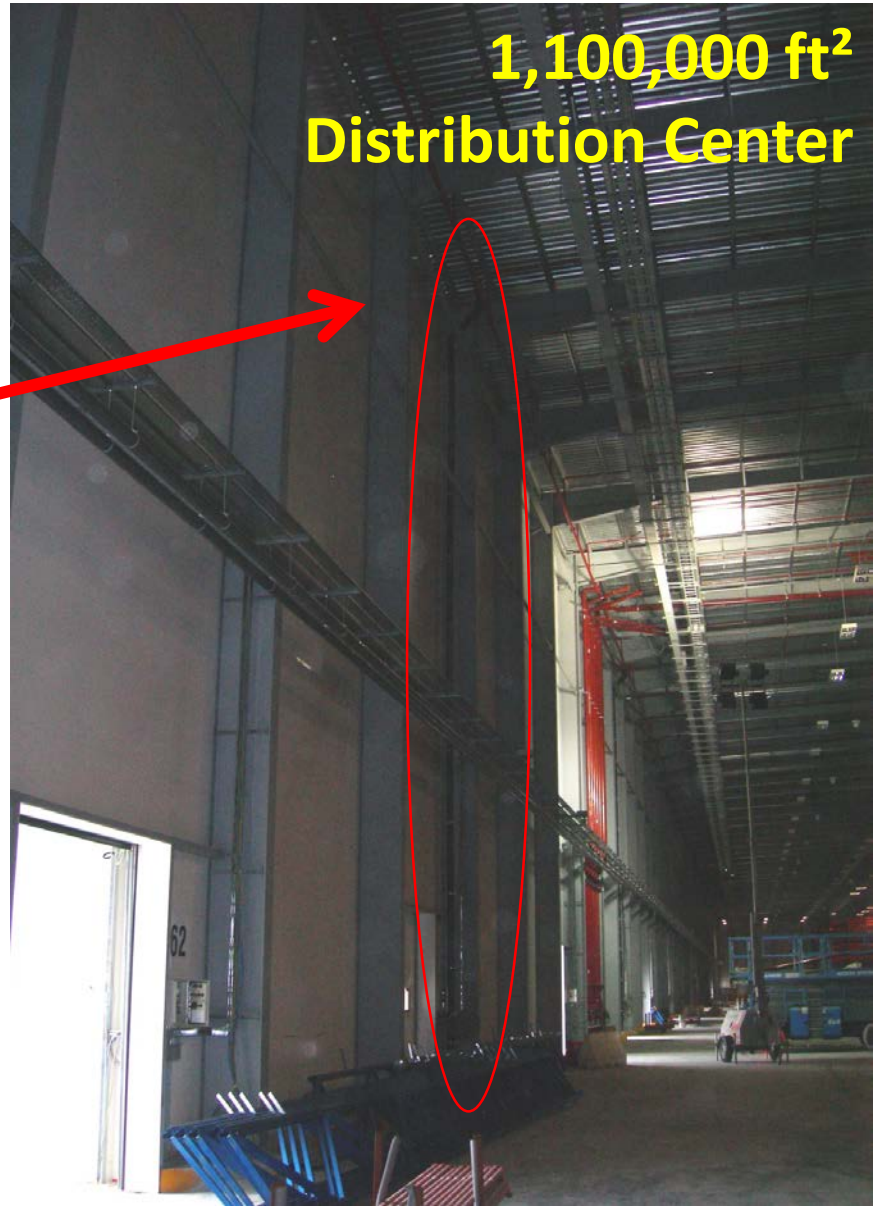
SAVINGS

108 x 6” Roof Drains & penetrations

36no. Downpipes & MH connections

1300 ft. of Pipe and reduced diameter

60% the labor cost

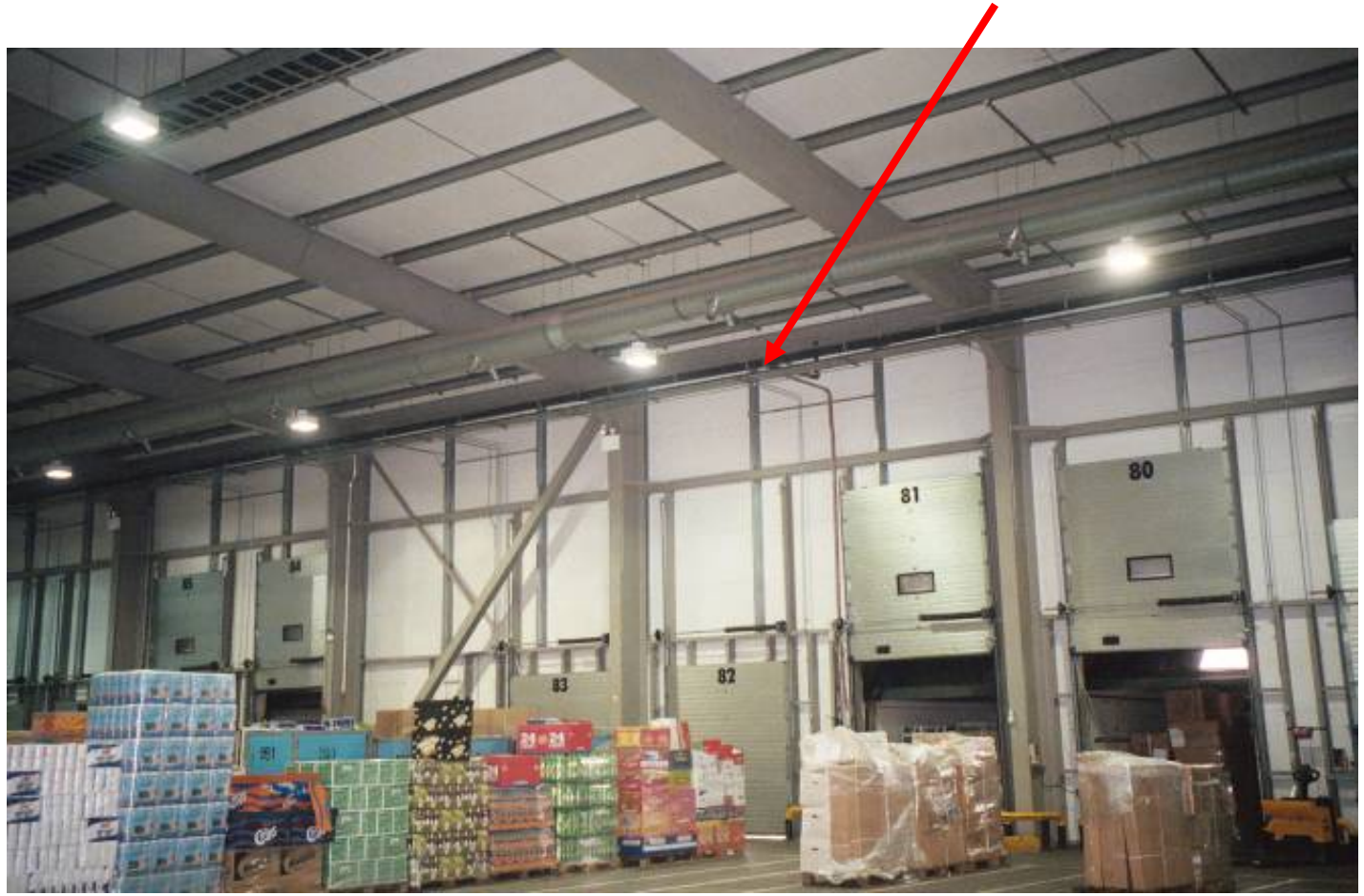


Siphonic System

600,000 ft² Roof

Only 4 Rainwater Downpipes draining the Main Roof

Siphonic horizontal Collector Pipe at High Level



No Pitch

Completely **FLAT**

2, 3”, 4”, 5” and 6” Primary Siphonic Roof Drains

All Drains should be tested to ASME/ANSI A112.6.9:2005

With IAPMO listing

Lower ‘K’ Factors =
Higher Efficiency
and
Lower Ponding Depths

Example Performance chart – K factor and min/max GPM

C.I. No-Hub Outlet	K factor	Minimum GPM Inflow	Maximum GPM Inflow
3”	0.12	23	400
4”	0.08	75	800
5”	0.04	120	1300
6”	0.04	160	2000

Factors that Affect Head Loss

K-Factor

The fittings, such as elbows, tees, strainers, valves, etc., have all been tested and assigned "K" factors based on the head loss measured through them.

1. Flow Rate
2. Inside Diameter of Pipe
3. Roughness of the Pipe Wall
4. Corrosion and Scale Deposits
5. Viscosity of the Liquid
6. Length of the Pipe
7. Fittings
8. Straightness of the Pipe

2, 3”, 4”, 5” and 6” Siphonic Overflow Roof Drains

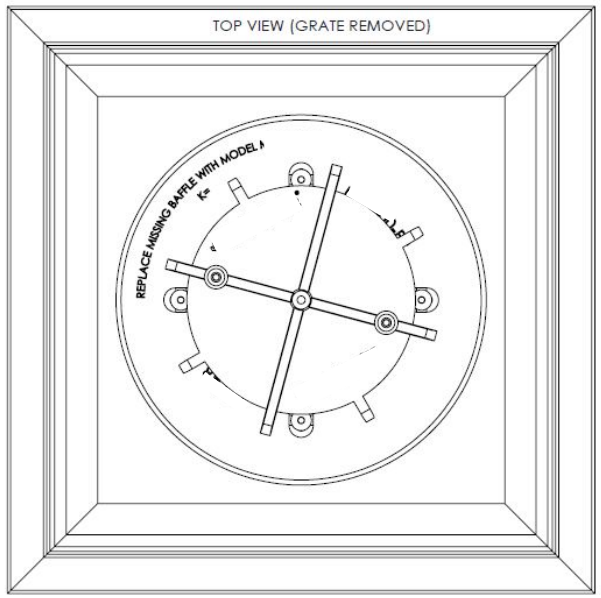
All Drains should be tested to ASME/ANSI A112.6.9:2005
With IAPMO listing

Overflow drains will have a dam to raise water inlet level.

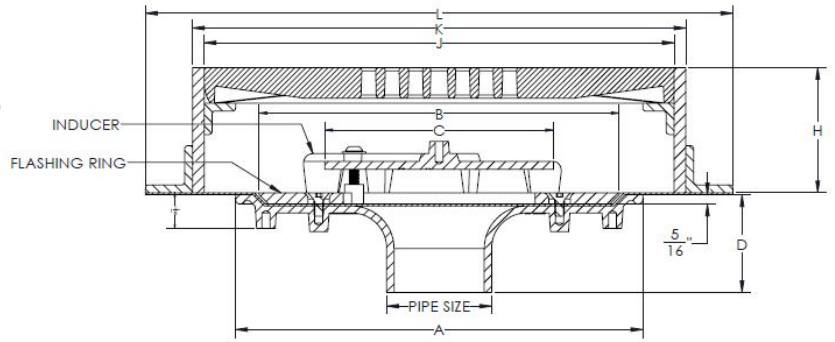
Overflow Systems must be kept separate from Primary Systems.

If they do connect together, the downstream pipework should be gravity design and vented

Podium/Promenade/Parking Deck Drains



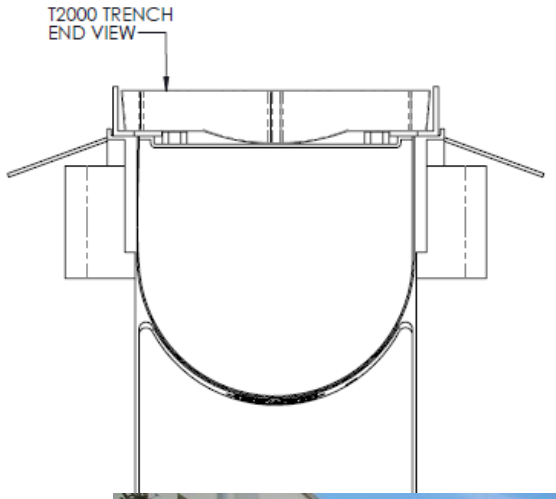
Podium/Promenade/Parking Deck Drains Using cast iron frame and grates to house the Siphonic Roof Drain



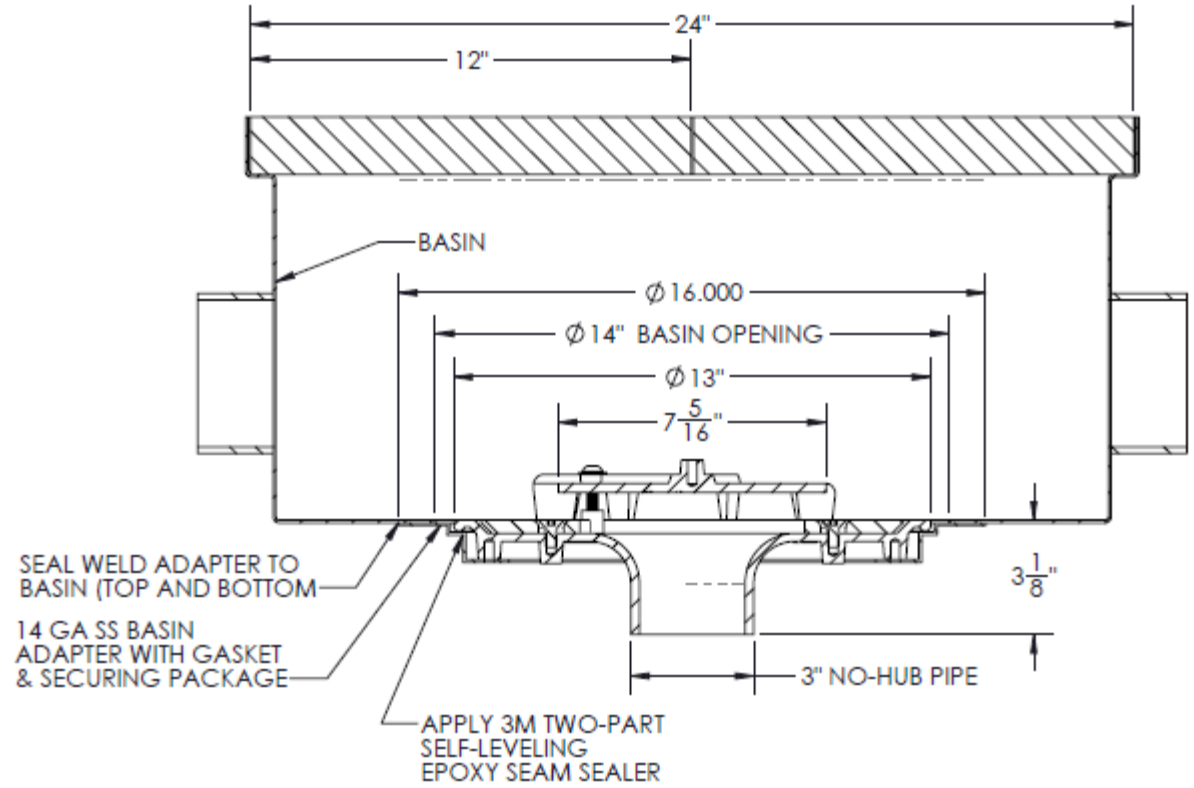
Siphonic System to Top level of Parking Deck

Pipework Installed
Absolutely Flat Level
at High level

Siphonic Roof Drains can be combined with Trench Drains on Promenade Decks



Podium Decks



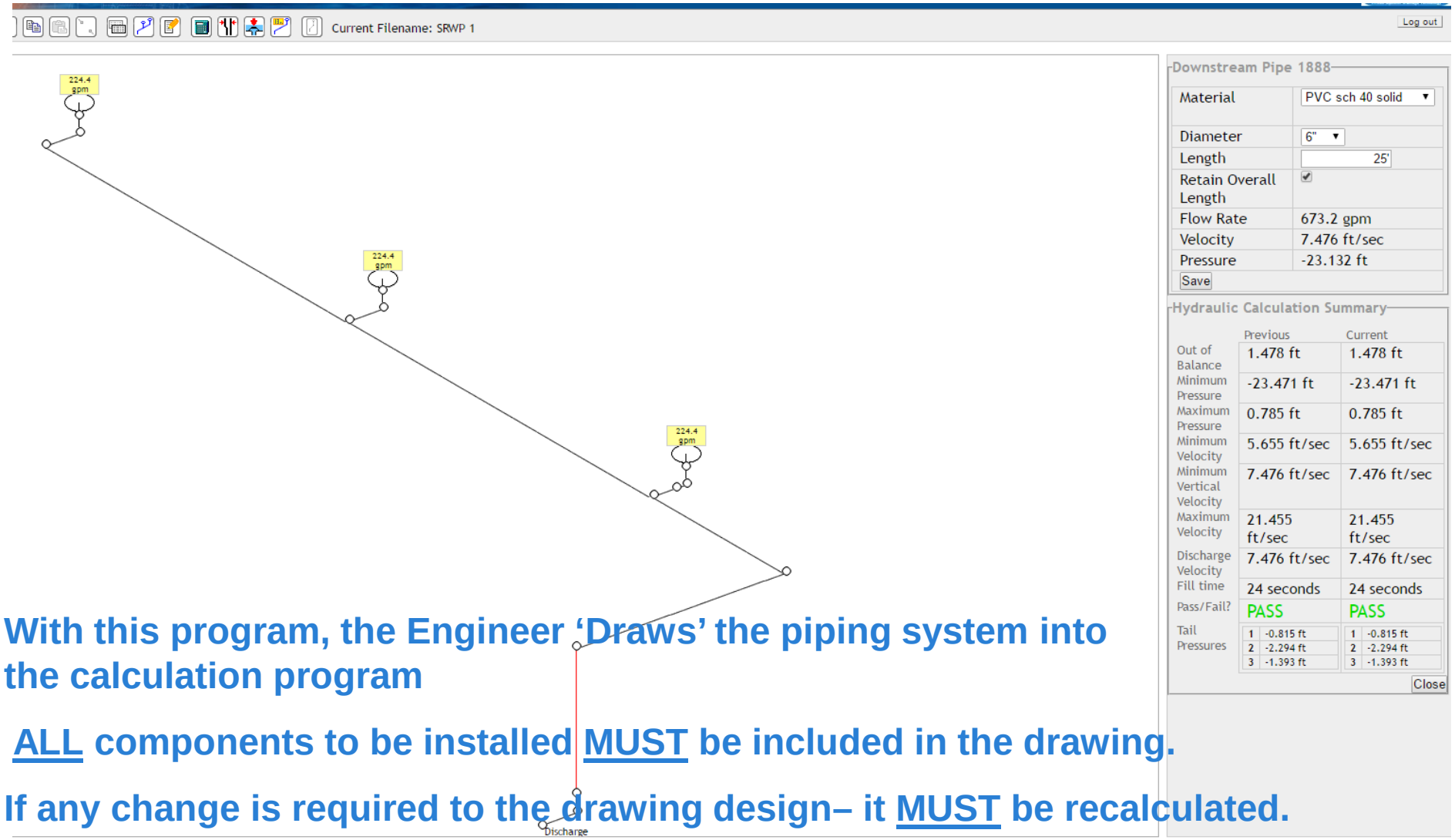
Design Process

- Siphonic Drainage is an Engineered Solution
- A Hydraulic analytical design calculation program provides the tool required for sizing pipework
- The design program should be independently tested to comply with all aspects of ASPE/ANSI 45:2013

Design Process

To calculate for compliance with ASPE/ANSI 45 standard you must first:

- Select Roof Drain placement
- Calculate GPM inflows to roof drains
  (code rainfall rate x roof area for primary and overflow)
- Select pipe material
  (commonly PVC solid wall schedule 40 or Cast Iron no-hub)
- Identify Interface with civils and determine if civils are designed to surcharge
- Provide AutoCAD or DWG Pipe layouts
- Draw schematic isometric drawing and input into calculation program



With this program, the Engineer 'Draws' the piping system into the calculation program

ALL components to be installed MUST be included in the drawing.

If any change is required to the drawing design– it MUST be recalculated.

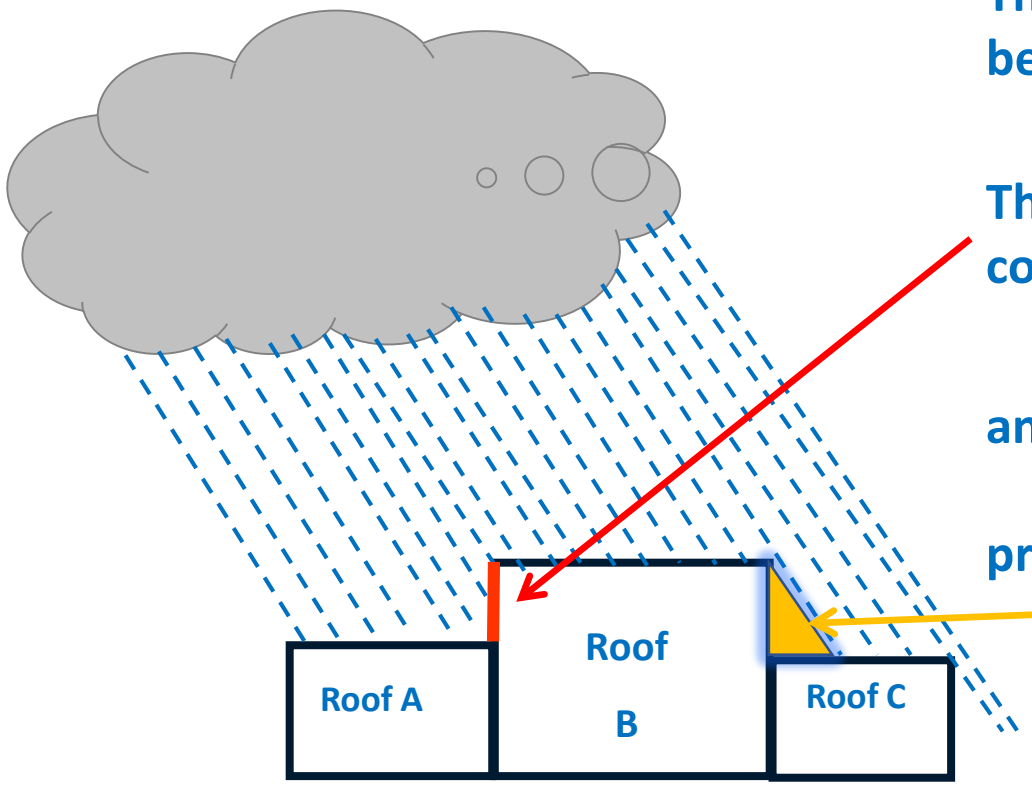
Hydraulic Calculation Summary

	Previous	Current
Out of Balance	1.899 ft	0.999 ft
Minimum Pressure	-18.961 ft	-18.961 ft
Maximum Pressure	1.605 ft	1.605 ft
Minimum Velocity	2.699 ft/sec	5.63 ft/sec
Minimum Vertical Velocity	10.98 ft/sec	10.98 ft/sec
Maximum Velocity	25.241 ft/sec	25.241 ft/sec
Discharge Velocity	13.848 ft/sec	13.848 ft/sec
Fill Time	26 seconds	26 seconds
Pass / Fail	FAIL	PASS
Tail Pressures	1 -1.142 ft 2 -1.639 ft 3 -0.809 ft 4 -0.778 ft 5 0.259 ft	1 -1.142 ft 2 -2.103 ft 3 -1.273 ft 4 -1.241 ft 5 -2.141 ft

All Hydraulic Parameters must be met.

Pipe diameters are edited to find the 'PASS' solution to meet all hydraulic parameters within ASPE/ANSI 45

Roofs at different elevations may be affected by wind driven rain.



There is a risk that Roofs A and C will be affected by wind driven rain.

This vertical surface run-off will contribute more flow to roof A

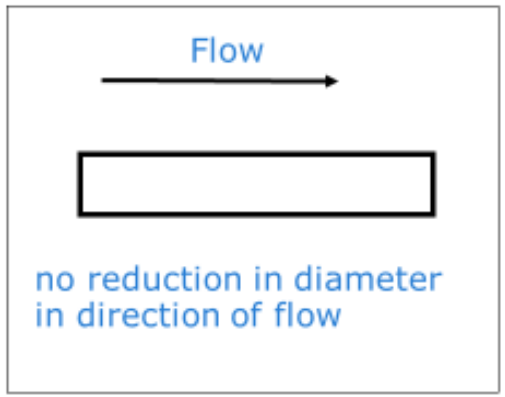
and

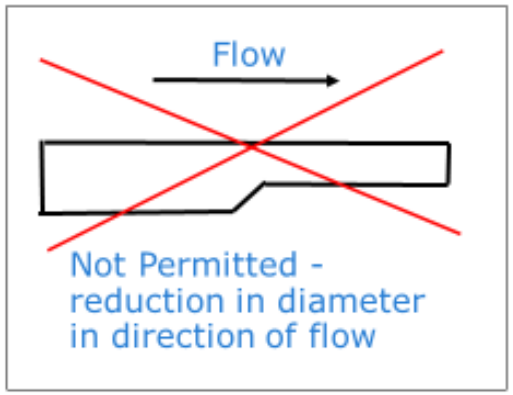
provide less flow to Roof C.

Where roofs at different elevations may be affected by wind driven rain, The Design should incorporate separate piping systems to each roof.

Piping Details

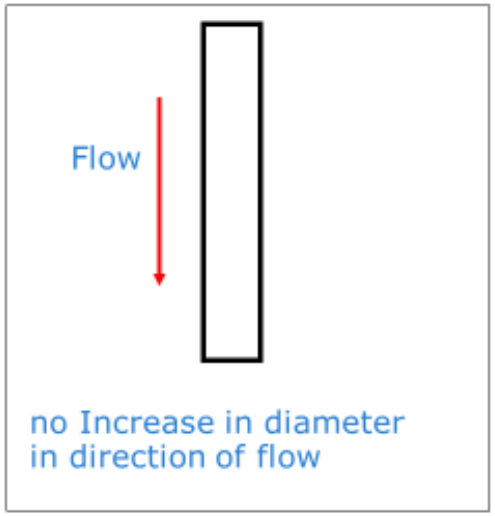
Horizontal Pipework –
No DECREASE in diameter in direction of flow

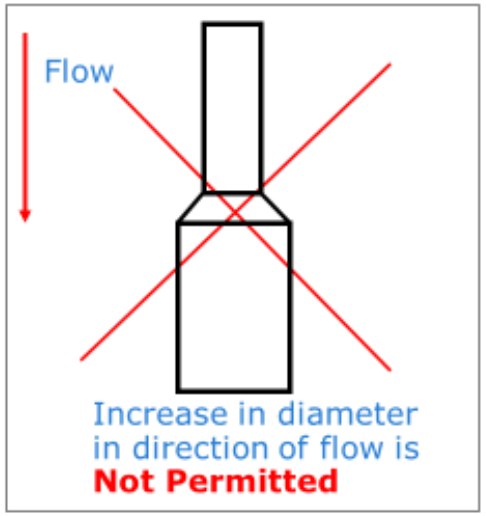




Piping Details

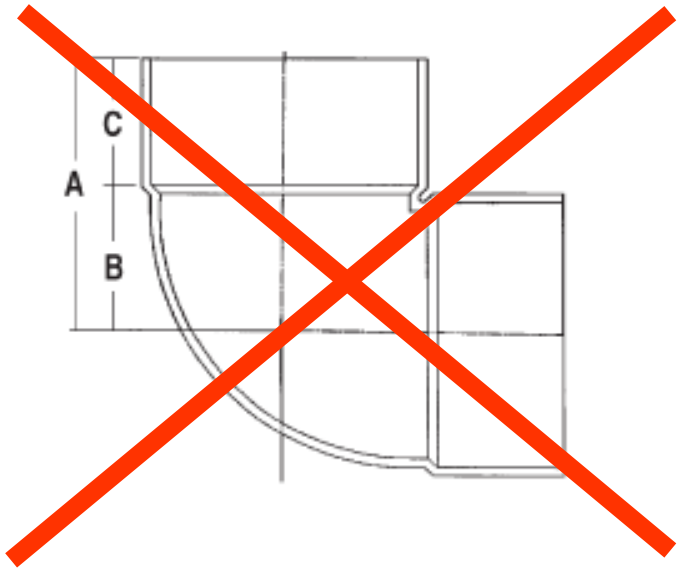
Vertical Pipework –
No INCREASE in diameter in direction of flow





A 90° bend creates turbulence forcing the vertical tailpipe to prime and create suction early on in the rainfall event.

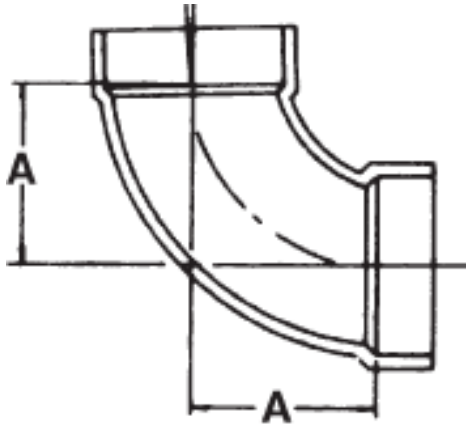
Piping Details

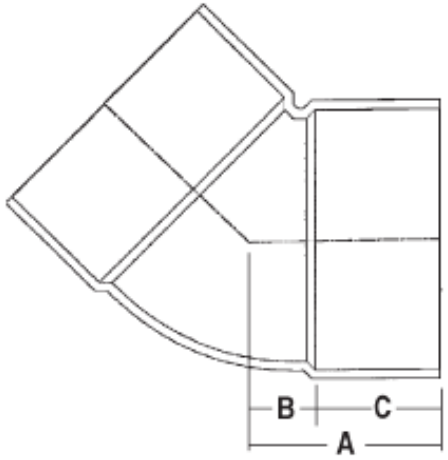


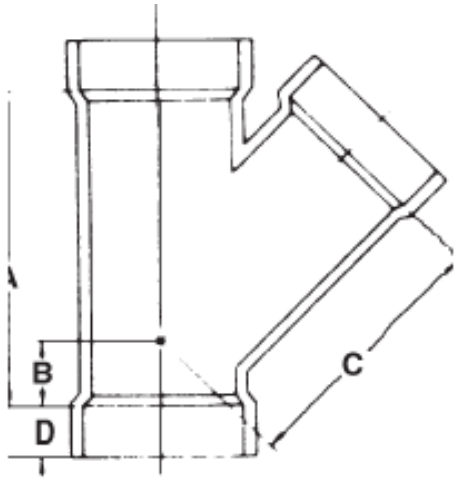
Must use Long 90's, Knuckle Bends not permitted;
Bends can be 45°

No Clean Outs

Only 45° WYE's; no double branches permitted







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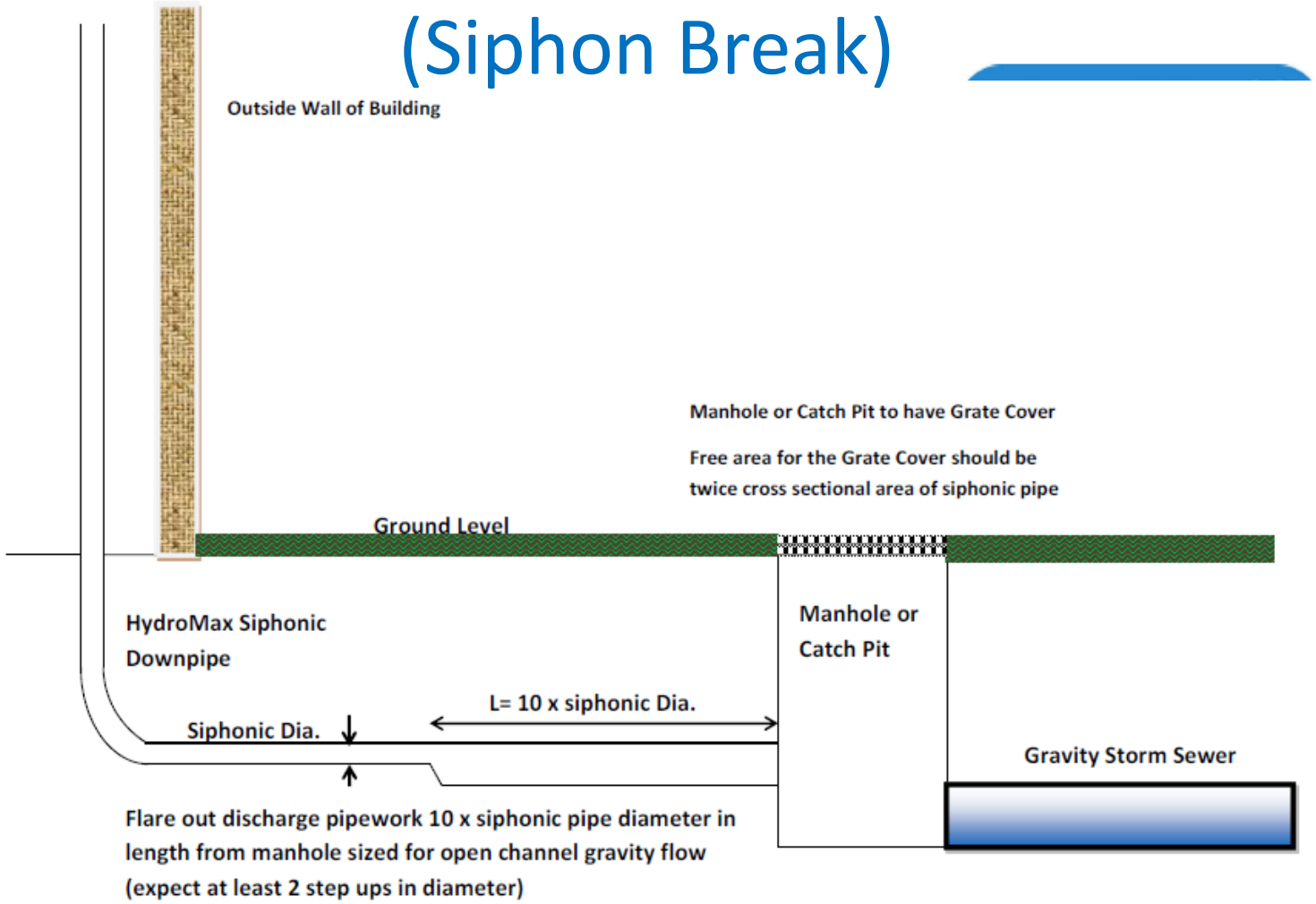
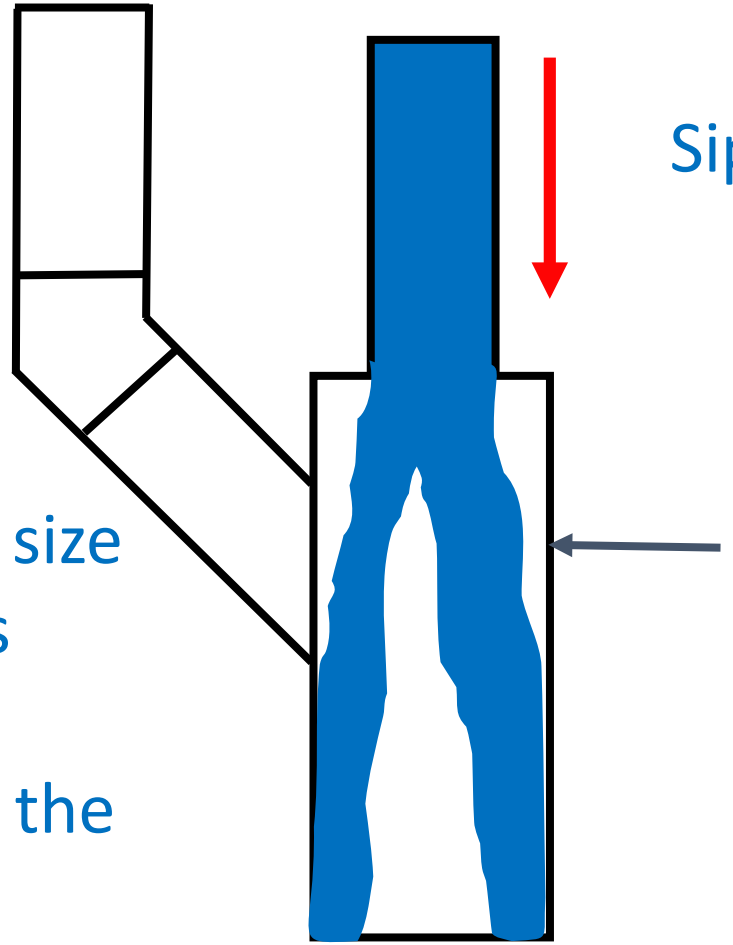
ASPE/ANSI 45 Recommended Termination Details (Siphon Break)



Mifab HydroMax™ Siphonic Drainage Termination Details (Siphon Break)

Ventilated to Atmosphere



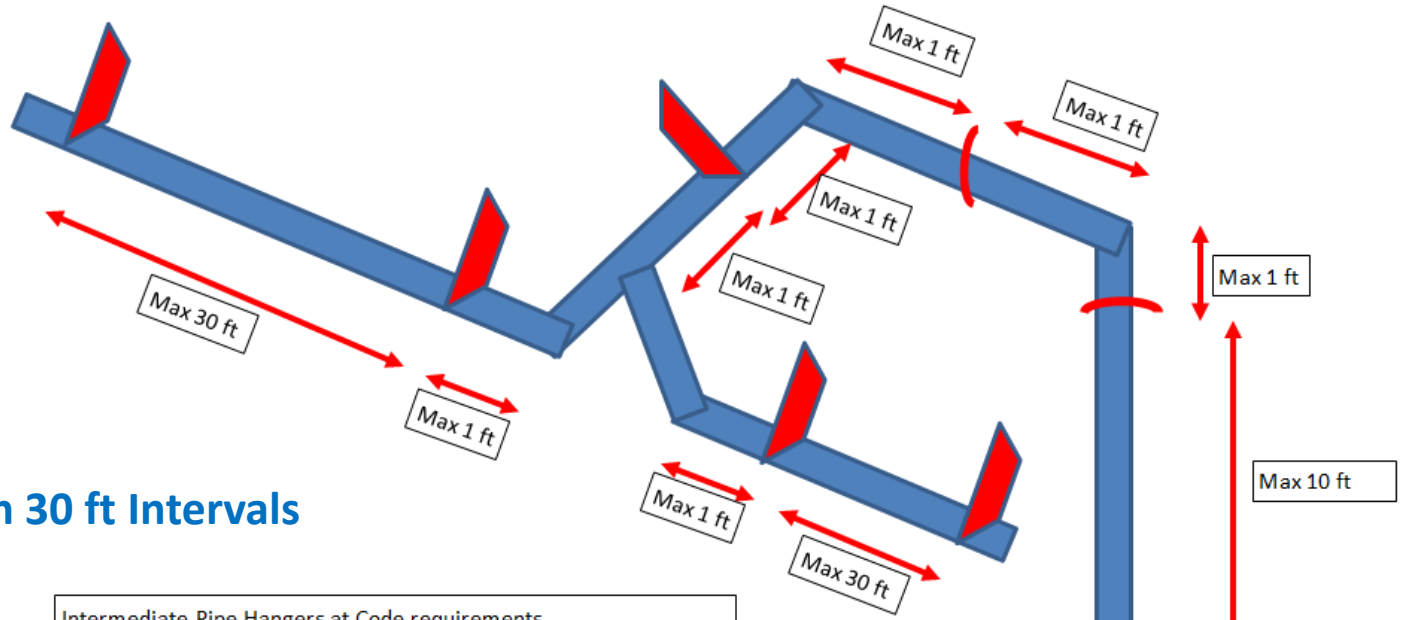
Siphonic flow

Break to Gravity flow

Recommended Vent size being Two-Thirds Gravity Pipe size (⅔ air to ⅓ water in the gravity flow)

Bracket Supports and Bracing

Recommendation – supports at each side of each change of direction



Sway Bracing at Maximum 30 ft Intervals

Intermediate Pipe Hangers at Code requirements
For PVC - Maximum 4ft Intervals
For Cast Iron - Maximum 10ft Intervals

Pipe Support Brace

Wall Clamp

Recommendation – 2 supports at a bend; 3 supports at Wye Branch.

MIFAB®

HydroMax
Leaders In Siphonic Drainage

OVER 8,000 Siphonic Roof Drain Systems

SUCCESSFULLY designed by **HydroTechnic™**

100% SUCCESS RATE

ZERO System Design Failures

TRIED - TESTED - PROVEN

ASPE American Society of Plumbing Engineers

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