# Storm Drainage System Research Project

FLOW RATE THROUGH ROOF DRAINS



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by Julius Ballanco, PE, CPD, FASPE

The American Society of Plumbing Engineers Research Foundation conducted research on the flow rates through various manufacturers' roof drains. The research produced stunning results that verified that the sizing method for storm drainage systems, as required in the plumbing codes, is inaccurate. A new approach to sizing storm drainage systems was developed based on the research test results.





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# INTRODUCTION

It was brought to the attention of the American Society of Plumbing Engineers Research Foundation (ASPE RF) that a number of failures with storm drainage systems had occurred. The types of failures included:

- Collapse of roof
- Pipe fitting separating
- Hanger pulled from prestressed concrete floor/ceiling
- Flooding of upper-level balcony decks
- Fitting component failure
- Flooding in the building on upper floors due to pipe failure

Many of these failures resulted in litigation. Of the litigation failures directly identified to ASPE RF, all of the cases were settled. Because of the settlements, the specific cases cannot be identified.

Two of the cases involved testing at SGS U.S. Testing Company (now known as QAI Laboratories Ltd.) in Tulsa, Oklahoma. A mock-up roof assembly was created to test the flow rate through various roof drains. In one set of tests, a 10-inch roof drain was tested to determine the flow rate based on the head height of water ponding around the drain. (ASME A112.6.4 regulates roof drains in 2-inch through 6-inch diameters. It is recognized that the standard does not regulate 10-inch roof drains.) In this particular series of tests, the 10-inch roof drain flowed less water than most plumbing engineers anticipated for a roof drain of this size. This accounted for the ponding around the roof drain, with the eventual collapse of the roof.

The other testing conducted, using the same test assembly, was of 4-inch roof drains. In this series of tests, the flow rate through the roof drain exceeded the anticipated flow as identified in the plumbing codes. While the plumbing codes do not identify the flow rate through a roof drain, they do identify the maximum flow rate through the storm drainage piping connected to the roof drain.

The testing on the 4-inch drain demonstrated that the flow in the storm drainage piping exceeded the flow rates for an open channel flow in the stack and horizontal building drain. The high rate of flow created pressure differentials in the piping system that far exceeded the pressures assumed for a typical storm drainage system.

With a test assembly already created, an opportunity was presented to ASPE RF to test roof drains at SGS U.S. Testing Company to determine the different flow rates through standard roof drains. ASPE RF asked roof drain manufacturers to provide roof drains for this testing. The following manufacturers made available their roof drains for testing:

- Canplas
- Froet Industries LLC
- Jay R. Smith Manufacturing Co.
- Josam Co.
- MIFAB
- Oatey
- Sioux Chief Manufacturing Co.
- Wade Drains
- Watts Water Technologies
- Zurn Engineered Water Solutions

The testing was limited to 2-inch through 6-inch roof drains. The limitation was consistent with the sizes regulated in ASME A112.6.4, which is the standard referenced in the plumbing codes for roof drains.

# **REVIEW OF AVAILABLE DATA**

Prior to any testing, ASPE RF conducted a review of the available data regarding standard roof drains and the design of storm drainage systems. Siphonic roof drains were not researched or evaluated as part of this study.

None of the manufacturers published data regarding the flow rates through their roof drains. This was not unusual since this is not required in the roof drain standard or in the plumbing codes.

#### **Plumbing Codes**

The plumbing codes reviewed were the three model plumbing codes used in the United States–IAPMO Uniform Plumbing Code (UPC), ICC International Plumbing Code (IPC), and PHCC-NA National Standard Plumbing Code (NSPC)–and the National Plumbing Code of Canada (NPCC). All three U.S. model plumbing codes and the Canadian plumbing code have similar requirements for roof drains and the design of storm drainage systems.

The U.S. model plumbing codes require the roof drains to conform to ASME A112.6.4. In addition to the reference to the ASME standard, the UPC specifies requirements for the height of the dome strainer and the opening in the dome strainer. Section 1105.2 reads:

**1105.2 Dome or Strainer for General Use.** Roof drains and overflow drains, except those draining to hanging gutters, shall be equipped with strainers extending not less than 4 inches (102 mm) above the surface of the roof immediately adjacent to the drain. Strainers shall have a minimum inlet area above the roof level not less than one and one-half times the area of the conductor or leader to which the drain is connected.

The NSPC includes requirements for the dome strainer in Section 13.5.2. The section reads:

#### 13.5.2 Dome Strainers

Roof areas shall be drained to roof drains having raised dome strainers with dome-free areas complying with ASME A112.6.4. The minimum free dome area shall be one and one-half (1-1/2) times the area of the drain outlet connection.

#### EXCEPTIONS

(1) Pitched roofs draining to hanging gutters.
 (2) Roof areas subject to pedestrian and/or vehicular traffic.

All three U.S. model plumbing codes require the storm drainage system to be sized for a storm of 60-minute (onehour) duration and a 100-year return period. The data for the rainfall rates published in the plumbing codes is consistent with the data from the National Weather Bureau.

The sizing of the storm drainage system is based on the capacity of the piping. The UPC and IPC sizing is based on a stack that is one-third full flow and horizontal piping that is flowing full. The NSPC sizing is based on a stack that is 7/24 full flow and horizontal piping that is flowing full.

Other than the difference in the stack capacity, the sizing is basically the same in the plumbing codes. Both the UPC and IPC have sizing tables for gutters.

The sizing tables in the plumbing codes use the projected roof area for sizing the pipe. The projected roof area is the roof area draining to a particular roof drain and storm drainage pipe. To establish the projected roof area, the rainfall rate is divided by the capacity of the pipe and converted to square footage. For example, if a pipe has a capacity of 110 gallons per minute (gpm) and the rainfall rate is 1 inch of rain per hour, the projected roof area equals 10,588 square feet. (1 inch per square foot per hour equates to 0.6233 gallons per hour and when divided by 60 equals 0.010388 gpm. Dividing 110 gpm by the rainfall rate equals 10,588 square feet, which is rounded up in the plumbing codes to 10,600 square feet.)

The U.S. model plumbing code tables list the projected roof area for various rainfall rates in increments of full inches. If the rainfall rate is a fraction of an inch, the projected roof area is determined by dividing the rainfall rate for 1 inch per hour by the rainfall rate. Using the same 10,600 square feet, divide by 3.1 inches per hour to establish the projected roof area for a storm drainage system in Des Plaines, Illinois. The resulting allowable projected roof area would be 3,419 square feet.

The NPCC has sizing requirements similar to the U.S. model plumbing codes. However, the sizing is based on liters of water on the roof for a 15-minute rainfall. The National Building Code of Canada specifies the rainfall rates. The liters are calculated by the roof area multiplied by the rainfall rate, resulting in cubic meters of water on the roof. Cubic meters are then converted to liters (multiplied by 1,000).

The sizing in the NPCC does not consider the flow rate through the roof drain. The sizing is based on the capacity of the storm drainage piping.

The following UPC sizing tables are shown to identify the typical method of sizing in the plumbing codes. The sizing tables from the UPC are reprinted with permission.

#### **UPC TABLE 1101.7**

SIZING OF	HORIZONTAL	RAINWATER	PIPING
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SIZE OF PIPE (inches)	FLOW (gpm at 1/8 inch per foot slope)	MAXIMUM ALLOWABLE HORIZONTAL PROJECTED ROOF AREAS AT VARIOUS RAINFALL RATES							
		1 (in/h)	2 (in/h)	3 (in/h)	4 (in/h)	5 (in/h)	6 (in/h)		
3	34	3,288	1,644	1,096	822	657	548		
4	78	7,520	3,760	2,506	1,880	1,504	1,253		
5	139	13,360	6,680	4,453	3,340	2,672	2,227		
6	222	21,400	10,700	7,133	5,350	4,280	3,566		
8	478	46,000	23,000	15,330	11,500	9,200	7,670		
10	860	82,800	41,400	27,600	20,700	16,580	13,800		
12	1,384	133,200	66,600	44,400	33,300	26,650	22,200		
15	2,473	238,000	119,000	79,333	59,500	47,600	39,650		

SIZE OF	FLOW	ΜΑΧΙΜ	MAXIMUM ALLOWABLE HORIZONTAL PROJECTED ROOF AREAS							
PIPE (inches)	(gpm at	AT VARIOUS RAINFALL RATES								
(inches)	1/4 inch	(square feet)								
	slope)	1 (in/h)	2 (in/h)	3 (in/h)	4 (in/h)	5 (in/h)	6 (in/h)			
3	48	4,640	2,320	1,546	1,160	928	773			
4	110	10,600	5,300	3,533	2,650	2,120	1,766			
5	196	18,880	9,440	6,293	4,720	3,776	3,146			
6	314	30,200	15,100	10,066	7,550	6,040	5,033			
8	677	65,200	32,600	21,733	16,300	13,040	10,866			
10	1,214	116,800	58,400	38,950	29,200	23,350	19,450			
12	1,953	188,000	94,000	62,600	47,000	37,600	31,350			
15	3,491	336,000	168,000	112,000	84,000	67,250	56,000			

SIZE OF	FLOW	MAXIMUM ALLOWABLE HORIZONTAL PROJECTED ROOF AREAS									
PIPE (inches)	(gpm at	AT VARIOUS RAINFALL RATES									
(inches)	1/2 inch per foot slope)	(square feet)									
		1 (in/h)	2 (in/h)	3 (in/h)	4 (in/h)	5 (in/h)	6 (in/h)				
3	68	6,576	3,288	2,192	1,644	1,310	1,096				
4	156	15,040	7,520	5,010	3,760	3,010	2,500				
5	278	26,720	13,360	8,900	6,680	5,320	4,450				
6	445	42,800	21,400	14,267	10,700	8,580	7,140				
8	956	92,000	46,000	30,650	23,000	18,400	15,320				
10	1,721	165,600	82,800	55,200	41,400	33,150	27,600				
12	2,768	266,400	133,200	88,800	66,600	53,200	44,400				
15	4,946	476,000	238,000	158,700	119,000	95,200	79,300				

**UPC TABLE 1101.11** 

SIZING OF ROOF DRAINS, LEADERS, AND VERTICAL RAINWATER PIPING

SIZE OF PIPE LEADER	FLOW	MAXIMUM ALLOWABLE HORIZONTAL PROJECTED ROOF AREAS AT VARIOUS RAINFALL RATES (square feet)							AS				
OR PIPE (inches)	(gpiii)	1 (in/h)	2 (in/h)	3 (in/h)	4 (in/h)	5 (in/h)	6 (in/h)	7 (in/h)	8 (in/h)	9 (in/h)	10 (in/h)	11 (in/h)	12 (in/h)
2	30	2,880	1,440	960	720	575	480	410	360	320	290	260	240
3	92	8,800	4,400	2,930	2,200	1,760	1,470	1,260	1,100	980	880	800	730
4	192	18,400	9,200	6,130	4,600	3,680	3,070	2,630	2,300	2,045	1,840	1,675	1,530
5	360	34,600	17,300	11,530	8,650	6,920	5,765	4,945	4,325	3,845	3,460	3,145	2,880
6	563	54,000	27,000	17,995	13,500	10,800	9,000	7,715	6,750	6,000	5,400	4,910	4,500
8	1,208	116,000	58,000	38,660	29,000	23,200	19,315	16,570	14,500	12,890	11,600	10,545	9,600

The UPC tables provide a column identifying the flow rate for the pipe. The NSPC also lists the flow rates for each given pipe size. The IPC sizing tables do not list the flow rate for the pipe. However, the flow rate can be derived through calculation. The resulting flow rate would be similar to the UPC.

The flow rates for leaders and vertical drains listed in the NSPC are lower than those in the UPC and IPC since they are based on a capacity of 7/24 full, as opposed to one-third full in the UPC and IPC. The stack sizing in the plumbing codes is based on the stack equation. The stack equation for cast iron pipe is:

 $Q = 27.88r^{5/3}d^{8/3}$ 

Where:

Q = capacity, gpm

r = ratio of cross-section area of sheet of water to cross-section area of the stack

d = diameter of stack, inches

When calculating the flow rate with a stack capacity of one-third full, the values vary slightly from the values in the UPC and IPC. It is not known when and why the values differed from the calculated values when using the stack equation.

The sizing of the horizontal drains in all of the plumbing codes is based on a calculation using the Manning equation, or Manning expression. The Manning equation is:

$$V = \frac{1.486 \ R^{2/3} S^{1/2}}{n}$$

Where:

V = velocity of flow, feet per second
n = coefficient of roughness
R = hydraulic radius, feet
S = hydraulic slope of surface of flow, feet per feet

The equation is also written as:

Q = 
$$\frac{666.9A R^{2/3}S^{1/2}}{n}$$

Where:

Q = flow rate, gpm

A = area, square feet

n = coefficient of roughness

R = hydraulic radius, feet

S = hydraulic slope of surface of flow, feet per feet

One of the defining factors when using the Manning equation is the "n" factor, which is the coefficient of roughness. When plumbing codes were first being developed, the "n" factor for piping was assigned a value of 0.015. This is considered fairly rough pipe. As a result, the plumbing codes use a value for sizing horizontal drains of fairly rough pipe.

Studies conducted within the last 50 years have determined that an "n" factor of 0.015 is unrealistic for modern piping materials. The roughest pipe is considered to be cast iron. The "n" factor that is used for cast iron in ASPE's *Plumbing Engineering and Design Handbook of Tables* is 0.012. If this factor was applied to the plumbing codes, the flow rate would increase by 25 percent.

The smoothest piping materials are considered to be copper tube, PVC, and ABS. The roughness factor used in the *Plumbing Engineering and Design Handbook of Tables* for these materials is 0.010. This would increase the flow rate in the plumbing codes by 50 percent.

All of the plumbing codes require a secondary or emergency roof drainage system. A secondary storm drainage system is also required by the ICC International Building Code (IBC). The requirements for a secondary roof drainage system were added to all of the plumbing codes in the 1990s. The change was based on the requirements in ASCE 7, Minimum Design Loads for Buildings and Other Structures. This standard requires roof loads to be based on the maximum amount of ponding on the roof with the primary roof drainage means blocked. If a secondary roof drain is not provided, the loading is based on the height of water to the top of the parapet.

While the plumbing codes added requirements for secondary roof drainage in the 1990s, the building codes have included such requirements since 1949. The 1949 Uniform Building Code required overflows to be installed at each roof drain at the low point.

The UPC allows the primary storm drainage and the secondary storm drainage to be combined into a common vertical downspout or leader. The IPC and NSPC require the secondary storm drainage to be piped separately to a point of disposal that is visible above or at grade. Both the IPC and UPC require the secondary storm drainage system to be sized for a rainfall occurrence of 60-minute duration and a 100-year return period. The NSPC requires the secondary storm drainage system to be sized for a rainfall occurrence of 15-minute duration and a 100-year return period. The result in the NSPC is a secondary storm drainage system that will flow a greater capacity than the primary storm drainage system.

The IBC clearly states that the roof loading must consider the primary roof drainage means blocked and the rise of water above the secondary roof drain to meet the discharge rates. This is the only code requirement that identifies loading based on the discharge rate and rise of water above the drain. However, the plumbing codes do not provide any discharge rates through secondary roof drains. The interpretation of the IBC is that calculations must be performed to determine the rise of water above the base of the drain. The IBC also requires the roof loading to be evaluated for ponding instability.

#### **Older Plumbing Codes**

The sizing tables in the UPC and IPC can be traced to ASA A40.8-1955, National Plumbing Code. This code specified storm drainage sizing requirements that are the same as those in the current plumbing codes. The tables in ASA A40.8 were slightly different, listing the values for 4 inches of rainfall. Users of the code were directed to divide the values in the table by four and multiply by the local rainfall rate.

#### **Other Reference Documents**

ASPE Plumbing Engineering Design Handbook, Volume 2: Plumbing Systems addresses storm drainage design. Chapter 4 identifies the engineering design and specification requirements for a storm drainage system. For sizing the systems, Chapter 4 references the sizing requirements in the plumbing codes. While the philosophical requirements for sizing identify the proper method of sizing, the reference to the plumbing code defers to the sizing requirements that date back to 1955.

RCIP Publication No. 02.03, Roof Drainage, published by the Roof Consultants Institute Foundation, was also reviewed. The sizing of the storm drainage system in this document references the plumbing codes. However, RCIP Publication No. 02.03 includes a method for sizing scuppers for either primary or secondary roof drainage. The sizing method includes a calculation of the height of the water at the scupper while flowing at the required rainfall rate. Many other documents regard the testing, design, and installation of siphonic roof drainage systems. However, as previously stated, this project specifically excluded siphonic roof drainage since such research has been completed with sizing methods that address all aspects of the storm drainage system.

#### **Referenced Standard**

The standard for roof drains is ASME A112.6.4. This is the consensus standard referenced in the plumbing codes. ASME A112.6.4 specifies material requirements and dimensional sizing requirements. It does not include test requirements for establishing the flow rate through the roof drain. Furthermore, it does not include drainage opening requirements.

CSA B79 is the Canadian consensus standard for drains, including roof drains. It is similar to the ASME standard in specifying material and dimension requirements.

# **ROOF DRAIN TESTING**

The testing of the roof drains was divided into two phases. The first phase of testing was a preliminary set of tests performed at SGS U.S. Testing Company in Tulsa. The second phase was a follow-up, detailed set of tests performed at IAPMO R&T Laboratories in Ontario, California.

#### **Preliminary Tests**

The preliminary tests conducted at SGS U.S. Testing Company were designed to evaluate whether a problem existed with the sizing of storm drainage systems. The cooperating manufacturers supplied a series of roof drains to be tested. Findings from the preliminary testing were published and presented at the 2010 ASPE Convention in Philadelphia.

The previously published results of the preliminary tests are not listed in this report. The preliminary testing indicated the need to do further testing on the roof drains. The additional testing would require more detailed results. To obtain these results, it was determined that different instrumentation and a different test protocol would be necessary.

#### **Testing at IAPMO R&T Laboratories**

A test protocol was developed for testing that was to be conducted at IAPMO R&T Laboratories. The test protocol was developed by ASPE RF with input from IAPMO R&T Laboratories. The final test protocol approved by the ASPE RF Board of Directors appears in Appendix A.

The test assembly identified in the protocol was constructed at IAPMO R&T Laboratories. Photographs of the test assembly are shown in Appendix B. The photographs show that the test assembly inlet piping was slightly modified from the protocol to reduce wave action in the test box. This was approved prior to the start of testing.

The roof drains were tested with three distinct piping arrangements (see Figure 1). In the first test series, the roof drain was installed without any piping connected to the drain. The intent of this test was to establish a control for the remainder of the testing.

In the second piping arrangement, the roof drain was connected to a straight section of pipe that discharged to the recirculation tank. In the third piping arrangement, the pipe was offset 90 degrees below the roof drain. The horizontal offset length ranged from 4 to 5 feet before turning downward, discharging to the recirculation tank. The third piping arrangement was intended to simulate the most common method of installing the piping connected to the roof drain.

Flow through the drain was measured by the pump flow rate once the roof ponding around the drain achieved steady state. In addition to the flow rate, the velocity of flow in the pipe was measured, as well as the pressure.

Prior to the testing of the roof drains, control tests were run without the roof drain in place. These tests were done for each size opening with a straight pipe and an offset piping arrangement.

A total of 60 roof drains were tested. The test results do not identify the manufacturer's name or model number of the drain. Each manufacturer was identified randomly with a letter designation. Each drain model was identified consecutively with the prefix being the manufacturer's letter designation.

The random order of the roof drains is identified in Table 1. These manufacturer and model identifiers are used throughout the report. Table 1 also lists a description of the roof drain and the type of strainer. While the cooperating manufacturers were previously identified in alphabetical order, the list of manufacturers in Table 1 is not in alphabetical order.

FIGURE 1



## TABLE 1 ROOF DRAINS TESTED BY IAPMO R&T LABORATORIES

Test No.	Company	No.	Model No.	Description of Roof Drain	Type of Strainer
1	Manufacturer A	1	A-1	2" cast iron drain	cast iron dome
2	Manufacturer A	2	A-2	3" cast iron drain	cast iron dome
3	Manufacturer A	3	A-3	4" cast iron drain	cast iron dome
4	Manufacturer A	4	A-4	5" cast iron drain	cast iron dome
5	Manufacturer A	5	A-5	6" cast iron drain	cast iron dome
6	Manufacturer B	1	B-1	2" cast iron drain	cast iron dome
7	Manufacturer B	2	B-2	3" cast iron drain	cast iron dome
8	Manufacturer B	3	B-3	4" cast iron drain	cast iron dome
9	Manufacturer B	4	B-4	6" cast iron drain	cast iron dome
10	Manufacturer C	1	C-1	2" cast iron drain	poly dome
11	Manufacturer C	2	C-2	3" cast iron drain	poly dome
12	Manufacturer C	3	C-3	4" cast iron drain	poly dome
13	Manufacturer C	4	C-4	5" cast iron drain	poly dome
14	Manufacturer C	5	C-5	6" cast iron drain	poly dome
15	Manufacturer D	1	D-1	2" cast iron drain	aluminum dome
16	Manufacturer D	2	D-2	3" cast iron drain	aluminum dome
17	Manufacturer D	3	D-3	4" cast iron drain	aluminum dome
18	Manufacturer D	4	D-4	6" cast iron drain	aluminum dome
19	Manufacturer E	1	E-1	2" PVC drain	poly dome
20	Manufacturer E	2	E-2	4" PVC drain	poly dome
21	Manufacturer E	3	E-3	4" PVC drain	aluminum dome
22	Manufacturer E	4	E-4	6" PVC drain	aluminum dome
23	Manufacturer E	5	E-5	4" cast iron drain	poly dome
24	Manufacturer E	6	E-6	6" cast iron drain	poly dome
25	Manufacturer E	7	E-7	4" cast iron drain	cast iron dome
26	Manufacturer E	8	E-8	6'' cast iron drain	cast iron dome
27	Manufacturer F	1	F-1	3" cast iron drain	cast iron dome
28	Manufacturer F	2	F-2	4" cast iron drain	cast iron dome
29	Manufacturer F	3	F-3	5" cast iron drain	cast iron dome
30	Manufacturer F	4	F-4	6" cast iron drain	cast iron dome
31	Manufacturer F	5	F-5	3" cast iron drain	cast iron dome
32	Manufacturer F	6	F-6	4" cast iron drain	cast iron dome
33	Manufacturer F	7	F-7	5" cast iron drain	cast iron dome
34	Manufacturer F	8	F-8	6" cast iron drain	cast iron dome
35	Manufacturer G	1	G-1	2" PVC drain	ABS dome
36	Manufacturer G	2	G-2	3" PVC drain	ABS dome
37	Manufacturer G	3	G-3	4" PVC drain	ABS dome
38	Manufacturer G	4	G-4	6" PVC drain	ABS dome
39	Manufacturer H	1	H-1	2" cast iron drain	cast iron dome
40	Manufacturer H	2	H-2	3" cast iron drain	cast iron dome
41	Manufacturer H	3	H-3	4" cast iron drain	cast iron dome

Test No.	Company	No.	Model No.	Description of Roof Drain	Type of Strainer
42	Manufacturer H	4	H-4	5" cast iron drain	cast iron dome
43	Manufacturer H	5	H-5	6" cast iron drain	cast iron dome
44	Manufacturer I	1	1-1	2" PVC drain	poly dome
45	Manufacturer I	2	I-2	3" PVC drain	poly dome
46	Manufacturer I	3	I-3	4" PVC drain	poly dome
47	Manufacturer J	1	J-1	2" cast iron drain	cast iron dome
48	Manufacturer J	2	J-2	3" cast iron drain	cast iron dome
49	Manufacturer J	3	J-3	4" cast iron drain	cast iron dome
50	Manufacturer J	4	J-4	5" cast iron drain	cast iron dome
51	Manufacturer J	5	J-5	6" cast iron drain	cast iron dome
52	Manufacturer J	6	J-6	2" cast iron drain	brass dome
53	Manufacturer J	7	J-7	3" cast iron drain	brass dome
54	Manufacturer J	8	J-8	4" cast iron drain	brass dome
55	Manufacturer J	10	J-10	5" cast iron drain	brass dome
56	Manufacturer J	11	J-11	6" cast iron drain	brass dome
57	Manufacturer J	12	J-12	2" cast iron drain	brass dome
58	Manufacturer J	13	J-13	3" cast iron drain	brass dome
59	Manufacturer J	14	J-14	4" cast iron drain	brass dome
60	Manufacturer J	15	J-15	5" cast iron drain	brass dome

#### TABLE 1 ROOF DRAINS TESTED BY IAPMO R&T LABORATORIES

#### **Test Results**

The test results for each drain are found in Appendix C. The results listed are the raw data reported by IAPMO R&T Laboratories. This is the information that was provided directly from the laboratory.

A table is provided for each drain listing the flow rate, velocity of flow, and pressure in the piping for each of the three piping arrangements. The values published in the table are an average of three tests performed for each value (run) of testing.

The test protocol required the testing to be conducted at ponding levels ranging from 1 inch to 6 inches in height, measured at the roof drain. The ponding levels were increased in increments of 1 inch. When there was no measurable flow at 1 inch of ponding, IAPMO R&T Laboratories tested the drain up to 7 inches of ponding. This was done with only a few drains that had little to no flow at 1 inch of ponding.

The first five test results listed in Appendix C are the control tests that do not have a roof drain connected. These five tests were performed only with straight pipe and the offset piping arrangement.

# **INTERPRETATION OF DATA**

The raw data was analyzed by comparing the results for roof drains of the same size. For certain sizes, the cooperating manufacturer supplied multiple drains. The data for drains of the same size from the same manufacturer were also compared.

The tables and charts prepared for interpreting the data are identified by number. The numbering scheme used for the tables and charts lists the drain size first. The second number is the test piping arrangement. The number 1 indicates no pipe connected to the drain. The number 2 indicates a straight pipe connected to the drain. The number 3 indicates an offset piping arrangement. For example, Table 4-3 is the table of results for 4-inch drains with an offset piping arrangement. Letters are used to distinguish the different charts. The letter "a" always indicates the chart with all of the drains for the given size and piping arrangement. Letters b, c, d, ... are used to identify the charts comparing drains of the same size from the same manufacturer.

For the 4-inch roof drains, there are also charts identified as 4-4 with a letter. These charts are a comparison of each drain for the three different piping arrangements. This was done only for 4-inch drains to show the differences in flow for the same drain, depending on the pipe, or lack thereof, connecting to the drain.

A total of 76 tables and charts compare the data from the tests.

#### **Predictions Prior to Testing**

With all laboratory testing, engineers attempt to predict the general results of the testing prior to conducting the test. The ASPE RF Board of Directors, in preparing the testing protocol, was no different. The Board attempted to predict, in general terms, the results they anticipated.

Some of the assumptions made regarding the test results were as follows:

- The flow through the drain with no pipe connected should have the highest value.
- The piping arrangement may not impact the flow through the roof drain.
- The drain may go siphonic during the testing.
- The flow rate should be similar for manufacturers' drains that look identical.
- The high flow rates should pressurize the pipe.

As previously stated, the purpose of testing the roof drain without any piping was to establish a control value to compare the rest of the data. However, the anticipation that the roof drain without any piping would have the highest flow rates turned out to be wrong. In reviewing the data in Appendix C, for most roof drains the flow rate without any piping connected was the lowest flow rate of the three piping arrangements. The reason for this is further discussed in the Engineering Analysis section.

The assumption that the piping arrangement would have little to no impact on the flow rate also proved to be inaccurate by testing. The drains that looked the same from different manufacturers did not have the same flow rates. This was another assumption that proved to be incorrect.

If the roof drain was subjected to a high enough head height, the flow did go siphonic, even though the roof drains were not a siphonic design. However, for most drains tested, a water head height of 6 inches did not result in the flow going siphonic.

The assumption that the system would pressurize the pipe as the flow increased also proved to be incorrect. The higher flow rates lowered the pressure in the piping. This is further discussed in the Engineering Analysis section.

#### Analysis of Testing without Roof Drain

The purpose of testing the piping system without a roof drain was to provide a control value to compare the roof drains. If the flow rates through the roof drains were higher than the opening in the roof test assembly, this would indicate that the dome of the roof drain assisted in increasing the flow rate. If the flow rates were lower, it would indicate that the dome configuration hindered flow through the roof drain. Table 2-O lists the flow rates without a roof drain in place.

Pine	Maxi	Maximum Flow Rate Through Opening without Roof Drain Based on Ponding Height (gpm)											
Size	1″		2″		3″		4''		5″		6'	,	
(inch)	Straight	Offset	Straight	Offset	Straight	Offset	Straight	Offset	Straight	Offset	Straight	Offset	
2	32	23	34	35	35	36	75	64	91	66	178	69	
3	50	37	61	64	75	79	101	100	124	129	146	161	
4	59	57	121	108	178	141	184	170	208	205	251	247	
5	113	124	137	141	199	178	257	207	249	222	318	910	
6	107	95	225	210	326	258	743	685	958	911	989	968	

#### TABLE 2-0, COMPARISON FLOW RATES WITHOUT A ROOF DRAIN

The tests without the roof drain also showed the point where the piping arrangement went from an open channel flow to a siphonic flow. This is identified with the lowering of the pressure measured in the piping and a significant increase in flow rate through the opening.

#### Analysis of No Pipe Connected Roof Drain Test

The test results shown in Tables 2-1, 3-1, 4-1, 5-1, and 6-1 as well as the associated charts of the data are of little to no value. While it was anticipated that these flow rates would be the highest and useful as control values, the flow rates were most often the lowest flow rates through the roof drain. These values cannot be used as control numbers.

The other reason these values are of little to no use is because plumbing engineers do not install roof drains without any piping connected. The standard practice in the profession is to install the roof drain and provide a piping connection to the drain on the underside of the roof.

The results of the testing with no pipe connected are reported since the testing was part of the research.

#### Analysis of Straight Pipe Compared to Pipe with an Offset

One can compare the difference between a roof drain connected to a straight pipe and a roof drain connected to an offset piping arrangement by comparing the X-2 tables to the X-3 tables. For all of the 4-inch drains, charts were prepared showing the difference between the flows for the same roof drain.

For most drains, the flow rate through a straight pipe was very similar to the flow rate through a roof drain with an offset piping arrangement for ponding heights of 3 inches or less. The exception to this is Chart 4-4a on Model A-3. At 3 inches of ponding at the roof drain, the flow in the straight pipe was more than double the flow rate through the offset piping arrangement.

For ponding heights of 4 inches and greater, the flow rate through a straight pipe exceeded the flow rate through an offset piping arrangement. Again, there were some exceptions to this. Chart 4-4e, Chart 4-4h, and Chart 4-4n show a flow slightly greater in the offset piping arrangement than in the straight pipe. This was also the case at 5 inches of ponding for Model E-5 in Chart 4-4g.

There was no consistency in the difference between flow in a straight pipe versus flow in an offset piping arrangement for ponding 3 inches and greater. For instance, in Chart 4-4a, Model A-3, the flow in the straight pipe is more than double the flow in an offset piping arrangement. By comparison, Chart 4-4n, Model J-3 indicates flow rates that are very similar between the two piping arrangements.

# **ANALYSIS OF 2-INCH ROOF DRAINS WITH STRAIGHT PIPE**

The test results show a significant difference in flow rates through different manufacturers' roof drains. With a ponding of 1 inch, two drains did not have any measurable flow rate. Excluding these two drains, the flow rates at 1 inch of ponding varied from 10 gpm (Model G-1) to a high of 61 gpm (Model B-1). The lowest flow rate, Model G-1, is a PVC drain with a poly dome. The highest flow rate, Model B-1, is a cast iron roof drain with a cast iron dome.

While the materials may initially appear to make a difference in flow rate, the second lowest flow rate was Model H-1 with a flow rate of 11 gpm. Model H-1 is a cast iron roof drain with a cast iron dome.

Comparing these two drains at 6 inches of ponding, Model G-1 had a flow rate of 177 gpm and Model B-1 had a flow rate of 202 gpm, a difference of only 14 percent. The difference between the two flow rates at 1 inch of ponding was 600 percent.

Manufacturer J submitted three 2-inch roof drains for testing. The flow rates between the different models were very similar. The greatest difference was between two of the drains at 5 inches of ponding. One drain flowed 32 percent more than the other. Interestingly, these two drains at 4 inches of ponding had basically the same flow rate.

#### TABLE 2-1

# 2" ROOF DRAIN TEST RESULTS ROOF DRAIN WITHOUT DRAIN PIPE

Test No.	Model	Description	Type of Strainer	I	Flow Ra	te (gpm)	) Based	on Hea	d Height	t
	NO.			1″	2″	3″	4″	5″	6″	7″
1	A-1	2" cast iron drain	cast iron dome	41	70	64	73	77	82	
6	B-1	2" cast iron drain	cast iron dome	53	62	64	69	71	72	
10	C-1	2" cast iron drain	poly dome	13	49	65	73	80	87	
15	D-1	2" cast iron drain	Aluminum dome	29	48	51	54	75	83	
19	E-1	2" PVC drain	poly dome	*	45	58	78	95	99	103
35	G-1	2" PVC drain	ABS dome	18	40	51	70	78	89	
39	H-1	2" cast iron drain	cast iron dome	13	52	54	65	74	88	
44	1-1	2" PVC drain	poly dome	**	38	65	75	67	66	
47	J-1	2" cast iron drain	cast iron dome	22	54	59	75	81	87	
52	J-6	2" cast iron drain	brass dome	20	49	55	65	73	82	
57	J-12	2" cast iron drain	brass dome	26	51	56	60	62	63	

\* No flow

\*\* Flow too low for sensors to record

## CHART 2-1a 2" ROOF DRAIN COMPARISON OF TEST RESULTS ROOF DRAIN WITHOUT DRAIN PIPE



CHART 2-1b

2" ROOF DRAIN COMPARISON OF TEST RESULTS ROOF DRAINS OF SAME MANUFACTURER ROOF DRAIN WITHOUT DRAIN PIPE



## TABLE 2–2 2" ROOF DRAIN TEST RESULTS ROOF DRAIN WITH STRAIGHT DRAIN PIPE

Test No.	Model No.	Description	Type of Strainer	Flow Rate (gpm) Based on Head Height							
				1″	2″	3″	4″	5″	6"	7″	
1	A-1	2" cast iron drain	cast iron dome	41	141	156	189	198	202		
6	B-1	2" cast iron drain	cast iron dome	61	110	108	148	189	202		
10	C-1	2" cast iron drain	poly dome	28	171	177	192	206	208		
15	D-1	2" cast iron drain	aluminum dome	26	76	87	109	122	165		
19	E-1	2" PVC drain	poly dome	*	52	107	176	181	203	218	
35	G-1	2" PVC drain	ABS dome	10	91	125	149	162	177		
39	H-1	2" cast iron drain	cast iron dome	11	75	139	149	191	203		
44	-1	2" PVC drain	poly dome	*	36	102	126	161	183	177	
47	J-1	2" cast iron drain	cast iron dome	19	94	113	122	131	192		
52	J-6	2" cast iron drain	brass dome	21	98	116	141	165	204		
57	J-12	2" cast iron drain	brass dome	21	86	119	125	173	206		

\* Flow too low for sensors to record

#### CHART 2-2a

2" ROOF DRAIN COMPARISON OF TEST RESULTS ROOF DRAIN WITH STRAIGHT DRAIN PIPE



# CHART 2–2b 2" ROOF DRAIN COMPARISON OF TEST RESULTS ROOF DRAINS OF SAME MANUFACTURER ROOF DRAIN WITH STRAIGHT DRAIN PIPE



# ANALYSIS OF 2-INCH ROOF DRAINS WITH OFFSET PIPING

The highest flow rate and lowest flow rate for 2-inch roof drains connected to an offset piping arrangement were the same two drains at 1 inch of ponding, Models G-1 and B-1. The flow rate through Model B-1 was almost six times greater than Model G-1 with 1 inch of ponding. At 6 inches of ponding, Models G-1 and B-1 had similar flow rates. Once the ponding reached 2 inches, the flow rates were closer with these two drains.

Chart 2-3a shows the wide variation in flow rates for the roof drains. Some roof drains discharged almost twice as much as other roof drains with the same ponding of water.

Chart 2-3b shows that the three roof drains from the same manufacturer had similar flow rates. Each drain had flows in the upper end for 2-inch roof drains.

#### TABLE 2-3

#### 2" ROOF DRAIN TEST RESULTS ROOF DRAIN WITH OFFSET DRAIN PIPE

Test No.	Model No.	Description	Type of Strainer	Flow Rate (gpm) Based on Head Height							
				1‴	2″	3″	4″	5″	6"	7″	
1	A-1	2" cast iron drain	cast iron dome	37	125	149	151	155	157		
6	B-1	2" cast iron drain	cast iron dome	59	87	85	111	134	145		
10	C-1	2" cast iron drain	poly dome	23	134	136	140	146	148		
15	D-1	2" cast iron drain	aluminum dome	28	78	85	107	119	155		
19	E-1	2" PVC drain	poly dome	*	46	119	140	157	161	158	
35	G-1	2" PVC drain	ABS dome	11	88	111	120	126	140		
39	H-1	2" cast iron drain	cast iron dome	11	79	103	114	121	139		
44	-1	2" PVC drain	poly dome	*	46	68	83	78	92	96	
47	J-1	2" cast iron drain	cast iron dome	18	88	86	116	114	143		
52	J-6	2" cast iron drain	brass dome	26	95	98	109	131	144		
57	J-12	2" cast iron drain	brass dome	28	82	80	122	133	135		

\* Flow too low for sensors to record

#### **ASPE Research Foundation**



CHART 2-3b 2" ROOF DRAIN COMPARISON OF TEST RESULTS ROOF DRAINS OF SAME MANUFACTURER ROOF DRAIN WITH OFFSET DRAIN PIPE



## CHART 2-3a 2" ROOF DRAIN COMPARISON OF TEST RESULTS ROOF DRAIN WITH OFFSET DRAIN PIPE

# **ANALYSIS OF 3-INCH ROOF DRAINS WITH STRAIGHT PIPE**

With the larger 3-inch roof drains, there is a great difference in the flow rates between the different manufacturers' roof drains. With 1 inch of ponding, the lowest flow rate was 13 gpm through Model I-2. This is a PVC drain with a poly dome.

The greatest flow rate at 1 inch of ponding was Model F-1, flowing 105 gpm. Model F-1 is a cast iron drain with a cast iron dome. The Model F-1 flow rate is more than eight times more than the flow rate of Model I-2. With 4 and 5 inches of ponding, the Model I-2 flow rate exceeded the Model F-1 flow rate.

At 6 inches of ponding, the lowest flow rate was 429 gpm for two models. The highest flow rate was 522 gpm for three different models. The greater difference was at 5 inches of ponding. The lowest flow rate was 186 gpm, while the highest flow rate was 490 gpm, more than 2-1/2 times the lowest flow rate.

Two charts show the same manufacturer's drains of the same size. The two models from Manufacturer F did not have similar flow rates. Model F-1's flows at 1 inch, 2 inches, and 6 inches of ponding exceed the flow rates of Model F-5, while Model F-5 had greater flows at 3 inches through 5 inches of ponding.

Manufacturer J has three 3-inch roof drains. Models J-2, J-7, and J-13 were similar at 1 and 2 inches of ponding. The flow rates between the drains varied significantly for the other ponding levels of 3 through 5 inches. At 6 inches of ponding, the flow rates were similar.

#### TABLE 3-1

#### 3" ROOF DRAIN TEST RESULTS ROOF DRAIN WITHOUT DRAIN PIPE

Test No.	Model	Description	Type of Strainer	Flow	Flow Rate (gpm) Based on Head Height						
				1″	2"	3"	4″	5″	6"		
2	A-2	3" cast iron drain	cast iron dome	13	101	108	114	126	151		
7	B-2	3" cast iron drain	cast iron dome	48	106	126	144	149	165		
11	C-2	3" cast iron drain	poly dome	18	122	151	161	178	187		
16	D-2	3" cast iron drain	aluminum dome	46	99	132	162	164	210		
27	F-1	3" cast iron drain	cast iron dome	120	168	225	212	244	313		
31	F-5	3" cast iron drain	cast iron dome	39	89	94	108	114	123		
36	G-2	3" PVC drain	ABS dome	9	94	126	144	166	187		
40	H-2	3" cast iron drain	cast iron dome	18	90	101	172	178	300		
45	I-2	3" PVC drain	poly dome	12	93	147	233	292	340		
48	J-2	3" cast iron drain	cast iron dome	29	55	124	152	165	172		
53	J-7	3" cast iron drain	brass dome	42	118	190	200	221	236		
58	J-13	3" cast iron drain	brass dome	49	93	143	155	161	179		

## CHART 3-1a 3" ROOF DRAIN COMPARISON OF TEST RESULTS ROOF DRAIN WITHOUT DRAIN PIPE



CHART 3-1b 3" ROOF DRAIN COMPARISON OF TEST RESULTS ROOF DRAINS OF SAME MANUFACTURER ROOF DRAIN WITHOUT DRAIN PIPE



# CHART 3-1c 3" ROOF DRAIN COMPARISON OF TEST RESULTS ROOF DRAINS OF SAME MANUFACTURER ROOF DRAIN WITHOUT DRAIN PIPE



## TABLE 3–2 3" ROOF DRAIN TEST RESULTS ROOF DRAIN WITH STRAIGHT DRAIN PIPE

Test No.	Model No.	Description	Type of Strainer	Flow Rate (gpm) Based on Head Height						
				1″	2″	3″	4''	5″	6″	
2	A-2	3" cast iron drain	cast iron dome	41	135	405	414	418	429	
7	B-2	3" cast iron drain	cast iron dome	58	152	202	414	448	467	
11	C-2	3" cast iron drain	poly dome	27	181	415	468	485	495	
16	D-2	3" cast iron drain	aluminum dome	25	101	149	171	490	522	
27	F-1	3" cast iron drain	cast iron dome	105	220	137	157	261	522	
31	F-5	3" cast iron drain	cast iron dome	47	133	266	398	411	429	
36	G-2	3" PVC drain	ABS dome	16	95	140	195	475	500	
40	H-2	3" cast iron drain	cast iron dome	16	91	208	226	239	498	
45	I-2	3" PVC drain	poly dome	13	50	119	188	379	474	
48	J-2	3" cast iron drain	cast iron dome	32	65	388	462	485	493	
53	J-7	3" cast iron drain	brass dome	38	114	179	249	453	487	
58	J-13	3" cast iron drain	brass dome	22	100	165	162	186	522	

## CHART 3-2a 3" ROOF DRAIN COMPARISON OF TEST RESULTS ROOF DRAIN WITH STRAIGHT DRAIN PIPE



CHART 3-2b 3" ROOF DRAIN COMPARISON OF TEST RESULTS ROOF DRAINS OF SAME MANUFACTURER ROOF DRAIN WITH STRAIGHT DRAIN PIPE



# CHART 3-2c 3" ROOF DRAIN COMPARISON OF TEST RESULTS ROOF DRAINS OF SAME MANUFACTURER ROOF DRAIN WITH STRAIGHT DRAIN PIPE



# ANALYSIS OF 3-INCH ROOF DRAINS WITH OFFSET PIPING

The great difference in the flow rates between the different manufacturers' roof drains continues with 3-inch roof drains connected to an offset piping arrangement. With 1 inch of ponding, the lowest flow rate was 14 gpm through Model I-2. This is a higher value, by 1 gpm, than the drain flow through straight pipe.

The greatest flow rate at 1 inch of ponding was Model F-1, flowing 118 gpm. That is more than eight times the flow rate of Model I-2. Models F-1 and I-2 did not have similar flows until the ponding reached 5 inches.

Even with 6 inches of ponding, there was a significant difference between the highest flow rate and the lowest flow rate. Model J-2 had a flow of only 195 gpm, while Model F-1 had a flow rate of 423 gpm. That amounts to more than 217 percent greater flow through Model F-1 compared to Model J-2.

Two charts show the same manufacturer's drains of the same size. The two drains from Manufacturer F had similar flow rates. Although there were slight differences, the differences were not consistent. Model F-1 flows were higher at 1 inch, 2 inches, and 6 inches of ponding, while Model F-5 had greater flows at 3 inches through 5 inches of ponding.

Chart 3-3c compares the three roof drains from Manufacturer J. Models J-2 and J-13 were similar through 5 inches of ponding. At 6 inches of ponding, Model J-13 had a significantly higher flow rate than Model J-2, 195 gpm versus 358 gpm.

## TABLE 3-3 3" ROOF DRAIN TEST RESULTS ROOF DRAIN WITH OFFSET DRAIN PIPE

Test No.	Model No.	Description	Type of Strainer	Flow Rate (gpm) Based on Head Height							
				1″	2″	3″	4″	5″	6″		
2	A-2	3" cast iron drain	cast iron dome	49	155	318	333	340	350		
7	B-2	3" cast iron drain	cast iron dome	52	161	174	262	371	402		
11	C-2	3" cast iron drain	poly dome	18	185	351	347	363	371		
16	D-2	3" cast iron drain	aluminum dome	55	106	146	167	337	402		
27	F-1	3" cast iron drain	cast iron dome	118	154	221	261	287	423		
31	F-5	3" cast iron drain	cast iron dome	49	136	271	293	330	327		
36	G-2	3" PVC drain	ABS dome	22	102	205	260	384	409		
40	H-2	3" cast iron drain	cast iron dome	20	104	231	262	332	410		
45	I-2	3" PVC drain	poly dome	14	49	118	215	298	399		
48	J-2	3" cast iron drain	cast iron dome	29	77	147	152	176	195		
53	J-7	3" cast iron drain	brass dome	41	126	187	200	215	408		
58	J-13	3" cast iron drain	brass dome	28	99	137	161	178	358		

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CHART 3-3b 3" ROOF DRAIN COMPARISON OF TEST RESULTS ROOF DRAINS OF SAME MANUFACTURER ROOF DRAIN WITH OFFSET DRAIN PIPE



# CHART 3-3a 3" ROOF DRAIN COMPARISON OF TEST RESULTS ROOF DRAIN WITH OFFSET DRAIN PIPE

# CHART 3-3c 3" ROOF DRAIN COMPARISON OF TEST RESULTS ROOF DRAINS OF SAME MANUFACTURER ROOF DRAIN WITH OFFSET DRAIN PIPE



# ANALYSIS OF 4-INCH ROOF DRAINS WITH STRAIGHT PIPE

The difference in flow rates continued for 4-inch roof drains. With 1 inch of ponding, the lowest flow rate was 16 gpm for two drains, Models E-5 and I-3. Model E-5 is a cast iron drain with a poly dome, and Model I-3 is a PVC drain with a poly dome.

The highest flow rate at 1 inch of ponding was Model F-2 with 117 gpm. Model F-2 is a cast iron drain with a cast iron dome.

Model E-5 has lower flow rates than most of the drains through 5 inches of ponding. At 6 inches of ponding, the flow rate more than triples from 5 inches of ponding.

Model I-3 had similar lower flow rates through 4 inches of ponding. At 5 inches of ponding, the flow rate more than doubled the flow rate at 4 inches. Similarly, at 6 inches of ponding, the flow rate more than doubled again from 5 inches of ponding.

At 6 inches of ponding, the greatest flow rate was 889 gpm though Model C-3. The lowest flow rate was 628 gpm though Model J-3.

Three manufacturers submitted multiple 4-inch roof drains. One roof drain from Manufacturer E had a flow rate of 657 gpm with 5 inches of ponding, while another one of its drains had a flow rate of only 215 gpm. This is the greatest difference in flow rates for a single manufacturer with the same size drains.

TABLE 4-1

4" ROOF DRAIN TEST RESULTS ROOF DRAIN WITHOUT DRAIN PIPE

Test No.	Model	Description	Type of Strainer	Flow Rate (gpm) Based on Head Height						
				1″	2″	3″	4"	5″	6"	
3	A-3	4" cast iron drain	cast iron dome	48	129	166	177	184	191	
8	B-3	4" cast iron drain	cast iron dome	72	198	275	240	304	348	
12	C-3	4" cast iron drain	poly dome	38	197	292	323	350	383	
17	D-3	4" cast iron drain	aluminum dome	58	140	215	226	305	355	
20	E-2	4" PVC drain	poly dome	58	113	166	210	270	302	
21	E-3	4" PVC drain	aluminum dome	26	90	189	230	242	257	
23	E-5	4" cast iron drain	poly dome	17	76	162	180	215	296	
25	E-7	4" cast iron drain	cast iron dome	72	180	253	225	295	360	
28	F-2	4" cast iron drain	cast iron dome	83	155	240	306	334	367	
32	F-6	4" cast iron drain	cast iron dome	43	150	130	190	229	248	
37	G-3	4" PVC drain	ABS dome	16	118	247	265	289	314	
41	H-3	4" cast iron drain	cast iron dome	16	102	245	239	281	300	
46	I -3	4" PVC drain	poly dome	12	93	147	233	292	340	
49	J-3	4" cast iron drain	cast iron dome	17	78	179	172	255	301	
54	J-8	4" cast iron drain	brass dome	67	130	210	217	299	271	
59	J-14	4" cast iron drain	brass dome	95	138	180	215	251	298	



CHART 4–1b 4" ROOF DRAIN COMPARISON OF TEST RESULTS ROOF DRAINS OF SAME MANUFACTURER ROOF DRAIN WITHOUT DRAIN PIPE



# CHART 4-1a 4" ROOF DRAIN COMPARISON OF TEST RESULTS ROOF DRAIN WITHOUT DRAIN PIPE

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CHART 4-1d 4" ROOF DRAIN COMPARISON OF TEST RESULTS ROOF DRAINS OF SAME MANUFACTURER ROOF DRAIN WITHOUT DRAIN PIPE



# CHART 4-1c 4" ROOF DRAIN COMPARISON OF TEST RESULTS ROOF DRAINS OF SAME MANUFACTURER ROOF DRAIN WITHOUT DRAIN PIPE

# TABLE 4–2 4" ROOF DRAIN TEST RESULTS ROOF DRAIN WITH STRAIGHT DRAIN PIPE

Test	Model	Description	Type of Strainer	Flow Rate (gpm) Based on Head Height						
				1″	2"	3″	4"	5″	6"	
3	A-3	4" cast iron drain	cast iron dome	41	172	538	585	612	673	
8	B-3	4" cast iron drain	cast iron dome	68	184	242	608	768	790	
12	C-3	4" cast iron drain	poly dome	40	217	442	754	865	889	
17	D-3	4" cast iron drain	aluminum dome	46	147	205	341	610	710	
20	E-2	4" PVC drain	poly dome	61	101	170	200	498	830	
21	E-3	4" PVC drain	aluminum dome	34	100	184	280	472	703	
23	E-5	4" cast iron drain	poly dome	16	117	185	188	215	692	
25	E-7	4" cast iron drain	cast iron dome	56	190	275	301	657	856	
28	F-2	4" cast iron drain	cast iron dome	117	187	254	312	497	671	
32	F-6	4" cast iron drain	cast iron dome	45	152	317	545	680	773	
37	G-3	4" PVC drain	ABS dome	24	103	258	480	745	847	
41	H-3	4" cast iron drain	cast iron dome	50	110	234	468	642	813	
46	-3	4" PVC drain	poly dome	16	92	142	180	434	835	
49	J-3	4" cast iron drain	cast iron dome	19	69	169	206	478	628	
54	J-8	4" cast iron drain	brass dome	69	130	221	370	547	860	
59	J-14	4" cast iron drain	brass dome	67	128	169	257	677	830	


CHART 4–2b 4" ROOF DRAIN COMPARISON OF TEST RESULTS ROOF DRAINS OF SAME MANUFACTURER ROOF DRAIN WITH STRAIGHT DRAIN PIPE



## CHART 4-2a 4" ROOF DRAIN COMPARISON OF TEST RESULTS ROOF DRAIN WITH STRAIGHT DRAIN PIPE

# CHART 4-2c 4" ROOF DRAIN COMPARISON OF TEST RESULTS ROOF DRAINS OF SAME MANUFACTURER ROOF DRAIN WITH STRAIGHT DRAIN PIPE



## CHART 4–2d 4" ROOF DRAIN COMPARISON OF TEST RESULTS ROOF DRAINS OF SAME MANUFACTURER ROOF DRAIN WITH STRAIGHT DRAIN PIPE



# **ANALYSIS OF 4-INCH ROOF DRAINS WITH OFFSET PIPING**

Model F-2 remained the highest and Model I-3 remained the lowest flow rate when connected to an offset piping arrangement with 1 inch of ponding. The lowest flow rate was 14 gpm, and the highest was 118 gpm.

The flow rate trend lines were similar to the straight pipe connection for the 4-inch roof drains connected to an offset piping arrangement. However, the flow rates were lower.

The lowest flow rate with 6 inches of ponding was 423 gpm for Model E-5. The highest flow rate was 710 gpm for Model B-3.

# TABLE 4-34" ROOF DRAIN TEST RESULTSROOF DRAIN WITH OFFSET DRAIN PIPE

Test	Model	Description	Type of Strainer	Flow Rate (gpm) Based on Head Heigh						
				1"	2″	3″	4″	5″	6″	
3	A-3	4" cast iron drain	cast iron dome	49	134	225	250	262	285	
8	B-3	4" cast iron drain	cast iron dome	67	195	296	587	668	710	
12	C-3	4" cast iron drain	poly dome	45	203	445	615	625	645	
17	D-3	4" cast iron drain	aluminum dome	52	144	196	225	556	655	
20	E-2	4" PVC drain	poly dome	51	70	142	250	445	640	
21	E-3	4" PVC drain	aluminum dome	44	125	186	276	434	606	
23	E-5	4" cast iron drain	poly dome	47	110	168	172	362	423	
25	E-7	4" cast iron drain	cast iron dome	80	210	235	332	618	665	
28	F-2	4" cast iron drain	cast iron dome	118	166	239	286	470	558	
32	F-6	4" cast iron drain	cast iron dome	78	142	285	503	545	611	
37	G-3	4" PVC drain	ABS dome	22	113	253	460	598	567	
41	H-3	4" cast iron drain	cast iron dome	46	111	234	456	640	682	
46	I -3	4" PVC drain	poly dome	14	59	125	190	422	622	
49	J-3	4" cast iron drain	cast iron dome	21	81	163	244	472	564	
54	J-8	4" cast iron drain	brass dome	35	158	217	284	491	562	
59	J-14	4" cast iron drain	brass dome	66	103	192	235	520	574	



CHART 4–3b 4" ROOF DRAIN COMPARISON OF TEST RESULTS ROOF DRAINS OF SAME MANUFACTURER ROOF DRAIN WITH OFFSET DRAIN PIPE



CHART 4-3a 4" ROOF DRAIN COMPARISON OF TEST RESULTS ROOF DRAIN WITH OFFSET DRAIN PIPE

# CHART 4-3c 4" ROOF DRAIN COMPARISON OF TEST RESULTS ROOF DRAINS OF SAME MANUFACTURER ROOF DRAIN WITH OFFSET DRAIN PIPE



CHART 4-3d 4" ROOF DRAIN COMPARISON OF TEST RESULTS ROOF DRAINS OF SAME MANUFACTURER ROOF DRAIN WITH OFFSET DRAIN PIPE



# **ANALYSIS OF PERFORMANCE OF INDIVIDUAL 4-INCH ROOF DRAINS**

As previously stated, a chart (identified as 4-4 with a letter) compares the flow rates of the three piping arrangements for each 4-inch roof drain. Since the flow rates for the roof drain with no piping connected provided no useful information, the trend line for this flow rate can be ignored on these charts. The two trend lines that need to be compared are the trend line for a roof drain connected to a straight pipe and a roof drain connected to an offset piping arrangement.

With lower ponding heights, the difference in flow rate between a straight pipe and an offset piping arrangement is not significant. As the ponding increases, the flow in the straight pipe is greater than the offset piping arrangement. This tends to occur at 4 inches or greater of ponding. However, there are exceptions with certain roof drains.

#### CHART 4-4a

4" ROOF DRAIN MODEL A-3 COMPARISON OF TEST RESULTS



# CHART 4-4b 4" ROOF DRAIN MODEL B-3 COMPARISON OF TEST RESULTS



## CHART 4-4c 4" ROOF DRAIN MODEL C-3 COMPARISON OF TEST RESULTS



# CHART 4-4d 4" ROOF DRAIN MODEL D-3 COMPARISON OF TEST RESULTS



CHART 4-4e 4" ROOF DRAIN MODEL E-2 COMPARISON OF TEST RESULTS



# CHART 4-4f 4" ROOF DRAIN MODEL E-3 COMPARISON OF TEST RESULTS



CHART 4-4g 4" ROOF DRAIN MODEL E-5 COMPARISON OF TEST RESULTS



# CHART 4-4h 4" ROOF DRAIN MODEL E-7 COMPARISON OF TEST RESULTS



CHART 4-4i 4" ROOF DRAIN MODEL F-2 COMPARISON OF TEST RESULTS



# CHART 4-4j 4" ROOF DRAIN MODEL F-6 COMPARISON OF TEST RESULTS



CHART 4-4k 4" ROOF DRAIN MODEL G-3 COMPARISON OF TEST RESULTS



# CHART 4-4I 4" ROOF DRAIN MODEL H-3 COMPARISON OF TEST RESULTS



CHART 4-4m 4" ROOF DRAIN MODEL I-3 COMPARISON OF TEST RESULTS



# CHART 4-4n 4" ROOF DRAIN MODEL J-3 COMPARISON OF TEST RESULTS



CHART 4-40 4" ROOF DRAIN MODEL J-8 COMPARISON OF TEST RESULTS



# CHART 4-4p 4" ROOF DRAIN MODEL J-14 COMPARISON OF TEST RESULTS



# **ANALYSIS OF 5-INCH ROOF DRAINS WITH STRAIGHT PIPE**

The fewest number of roof drains for testing were 5 inches in size-only eight roof drains from five manufacturers.

The 5-inch roof drains with the lowest and highest flow rates at 1 inch of ponding were from the same manufacturer, Manufacturer J. Model J-10 had the lowest flow rate at 97 gpm, while Model J-4 had the highest flow rate at 162 gpm. Model J-4 is a cast iron drain with a cast iron dome. Model J-10 is a cast iron drain with a brass dome.

With 6 inches of ponding, the highest flow rate was 1,267 gpm through Model C-4. The lowest flow rate was Model J-4 at 651 gpm. At 1 inch of ponding, Model J-4 had the highest flow rate. At 6 inches of ponding, it had the lowest flow rate.

The comparison between the Manufacturer J models is shown in Chart 5-3b. The trend lines in this chart appear similar to the trend lines for Manufacturer J's 4-inch roof drains.

## TABLE 5–1 5" ROOF DRAIN TEST RESULTS ROOF DRAIN WITHOUT DRAIN PIPE

Test No.	Model No.	Description	Type of Strainer	Flow	Rate	Head H	leight		
				1″	2″	3″	4''	5″	6''
4	A-4	5" cast iron drain	cast iron dome	107	243	405	435	427	470
13	C-4	5" cast iron drain	poly dome	108	185	335	368	357	387
29	F-3	5" cast iron drain	cast iron dome	93	174	394	476	568	588
33	F-7	5" cast iron drain	cast iron dome	127	169	299	320	332	347
42	H-4	5" cast iron drain	cast iron dome	160	155	340	365	458	494
50	J-4	5" cast iron drain	cast iron dome	78	108	168	307	388	469
55	J-10	5" cast iron drain	brass dome	116	195	273	369	460	492
60	J-15	5" cast iron drain	brass dome	123	156	196	262	395	440



CHART 5-1b 5" ROOF DRAIN COMPARISON OF TEST RESULTS ROOF DRAINS OF SAME MANUFACTURER ROOF DRAIN WITHOUT DRAIN PIPE



## CHART 5-1a 5" ROOF DRAIN COMPARISON OF TEST RESULTS ROOF DRAIN WITHOUT DRAIN PIPE

## TABLE 5-2 5" ROOF DRAIN TEST RESULTS ROOF DRAIN WITH STRAIGHT DRAIN PIPE

Test No.	Model No.	Description	Type of Strainer	Flow	/ Rate (	Head Height			
				1″	2″	3″	4''	5″	6″
4	A-4	5" cast iron drain	cast iron dome	109	220	617	1,203	1,125	1,042
13	C-4	5" cast iron drain	poly dome	118	199	402	745	1,060	1,267
29	F-3	5" cast iron drain	cast iron dome	134	204	392	476	642	848
33	F-7	5" cast iron drain	cast iron dome	119	149	333	556	756	982
42	H-4	5" cast iron drain	cast iron dome	128	184	264	484	716	1,016
50	J-4	5" cast iron drain	cast iron dome	162	222	322	408	575	651
55	J-10	5" cast iron drain	brass dome	97	152	236	371	646	1,012
60	J-15	5" cast iron drain	brass dome	112	171	229	257	787	866

# CHART 5-2a 5" ROOF DRAIN COMPARISON OF TEST RESULTS ROOF DRAIN WITH STRAIGHT DRAIN PIPE



# CHART 5-2b 5" ROOF DRAIN COMPARISON OF TEST RESULTS ROOF DRAINS OF SAME MANUFACTURER ROOF DRAIN WITH STRAIGHT DRAIN PIPE



# **ANALYSIS OF 5-INCH ROOF DRAINS WITH OFFSET PIPING**

The lowest flow rate with 1 inch of ponding and an offset piping arrangement was Model F-3 with a flow rate of 25 gpm. This is significantly less than the flow in the same drain with straight pipe. That flow rate was 134 gpm. Model F-3 is a cast iron drain with a cast iron dome.

The highest flow rate at 1 inch of ponding was Model F-7 with 148 gpm. This is another case where the same manufacturer has the highest and lowest flow rate for two different models.

With 6 inches of ponding, J-4 remains the lowest flow rate with 618 gpm. The highest flow rate was still Model C-4 with 973 gpm.

The comparison of Manufacturer J's roof drains shows similar trend lines to the straight piping flow rates.

#### TABLE 5-3

5" ROOF DRAIN TEST RESULTS ROOF DRAIN WITH OFFSET DRAIN PIPE

Test No.	Model No.	Description	Type of Strainer	Flov	/ Rate	ased on	n Head Height		
				1″	2″	3″	4''	5″	6"
4	A-4	5" cast iron drain	cast iron dome	133	258	641	867	834	850
13	C-4	5" cast iron drain	poly dome	117	219	432	755	947	973
29	F-3	5" cast iron drain	cast iron dome	25	216	383	467	642	808
33	F-7	5" cast iron drain	cast iron dome	148	181	346	528	769	915
42	H-4	5" cast iron drain	cast iron dome	40	125	270	447	675	874
50	J-4	5" cast iron drain	cast iron dome	138	187	256	367	514	618
55	J-10	5" cast iron drain	brass dome	95	161	238	362	553	874
60	J-15	5" cast iron drain	brass dome	69	123	203	292	776	799



CHART 5-3b 5" ROOF DRAIN COMPARISON OF TEST RESULTS ROOF DRAINS OF SAME MANUFACTURER ROOF DRAIN WITH OFFSET DRAIN PIPE



# CHART 5-3a 5" ROOF DRAIN COMPARISON OF TEST RESULTS ROOF DRAIN WITH OFFSET DRAIN PIPE

# **ANALYSIS OF 6-INCH ROOF DRAINS WITH STRAIGHT PIPE**

The roof drain with the lowest flow rate with 1 inch of ponding was Model E-4, with a flow rate of 20 gpm. Model E-4 is a PVC drain with an aluminum dome.

The highest flow rate with 1 inch of ponding was Model F-8 with 153 gpm. Model F-8 is a cast iron drain with a cast iron dome. The difference is more than seven times between the highest and the lowest.

With 6 inches of ponding, the highest flow rate was Model B-4 with a flow rate of 1,520 gpm. Model B-4 is a cast iron drain with a cast iron dome. The lowest flow rate is Model J-5 with a flow rate of 668 gpm, less than half the highest flow rate. Model J-5 is a cast iron drain with a cast iron dome.

#### TABLE 6-1

6" ROOF DRAIN TEST RESULTS ROOF DRAIN WITHOUT DRAIN PIPE

Test	Model	Description	Type of Strainer	Flow Rate (gpm) Based on Head Height						
				1″	2"	3"	4"	5"	6"	
5	A-5	6" cast iron drain	cast iron dome	10	185	199	238	267	218	
9	B-4	6" cast iron drain	cast iron dome	180	212	379	528	573	608	
14	C-5	6" cast iron drain	poly dome	150	195	438	591	634	732	
18	D-4	6" cast iron drain	aluminum dome	78	167	310	452	602	741	
22	E-4	6" PVC drain	aluminum dome	10	144	232	294	407	520	
24	E-6	6" cast iron drain	poly dome	126	213	264	329	425	508	
26	E-8	6" cast iron drain	cast iron dome	98	185	358	574	663	788	
30	F-4	6" cast iron drain	cast iron dome	118	202	402	616	714	870	
34	F-8	6" cast iron drain	cast iron dome	133	228	371	537	427	551	
38	G-4	6" PVC drain	ABS dome	92	112	217	432	690	804	
43	H-5	6" cast iron drain	cast iron dome	12	128	243	460	609	647	
51	J-5	6" cast iron drain	cast iron dome	48	111	214	293	475	602	
56	J-11	6" cast iron drain	brass dome	87	126	191	371	519	551	



CHART 6-1b 6" ROOF DRAIN COMPARISON OF TEST RESULTS ROOF DRAINS OF SAME MANUFACTURER ROOF DRAIN WITHOUT DRAIN PIPE



## CHART 6-1a 6" ROOF DRAIN COMPARISON OF TEST RESULTS ROOF DRAIN WITHOUT DRAIN PIPE

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CHART 6-1d 6" ROOF DRAIN COMPARISON OF TEST RESULTS ROOF DRAINS OF SAME MANUFACTURER ROOF DRAIN WITHOUT DRAIN PIPE



# CHART 6-1c 6" ROOF DRAIN COMPARISON OF TEST RESULTS ROOF DRAINS OF SAME MANUFACTURER ROOF DRAIN WITHOUT DRAIN PIPE

## TABLE 6-2 6" ROOF DRAIN TEST RESULTS ROOF DRAIN WITH STRAIGHT DRAIN PIPE

Test No.	Model	Description	Type of Strainer	Flow Rate (gpm) Based on Head Height						
				1″	2"	3″	4″	5″	6"	
5	A-5	6" cast iron drain	cast iron dome	122	169	744	979	1,162	1,188	
9	B-4	6" cast iron drain	cast iron dome	111	188	382	629	1,034	1,520	
14	C-5	6" cast iron drain	poly dome	150	231	449	798	1,167	1,630	
18	D-4	6" cast iron drain	aluminum dome	38	128	249	435	595	720	
22	E-4	6" PVC drain	aluminum dome	20	126	233	315	438	851	
24	E-6	6" cast iron drain	poly dome	150	135	211	281	418	873	
26	E-8	6" cast iron drain	cast iron dome	91	262	392	564	864	1,471	
30	F-4	6" cast iron drain	cast iron dome	120	192	397	604	704	866	
34	F-8	6" cast iron drain	cast iron dome	153	156	347	534	803	1,062	
38	G-4	6" PVC drain	ABS dome	118	112	240	462	764	1,142	
43	H-5	6" cast iron drain	cast iron dome	28	128	298	491	753	1,134	
51	J-5	6" cast iron drain	cast iron dome	67	108	160	276	509	668	
56	J-11	6" cast iron drain	brass dome	94	117	227	393	613	1,147	

CHART 6-2a

6" ROOF DRAIN COMPARISON OF TEST RESULTS

**ROOF DRAIN WITH STRAIGHT DRAIN PIPE** 



# CHART 6-2b 6" ROOF DRAIN COMPARISON OF TEST RESULTS ROOF DRAINS OF SAME MANUFACTURER ROOF DRAIN WITH STRAIGHT DRAIN PIPE



CHART 6-2c 6" ROOF DRAIN COMPARISON OF TEST RESULTS ROOF DRAINS OF SAME MANUFACTURER ROOF DRAIN WITH STRAIGHT DRAIN PIPE



# CHART 6-2d 6" ROOF DRAIN COMPARISON OF TEST RESULTS ROOF DRAINS OF SAME MANUFACTURER ROOF DRAIN WITH STRAIGHT DRAIN PIPE



# ANALYSIS OF 6-INCH ROOF DRAINS WITH OFFSET PIPING

The roof drain with the lowest flow rate with 1 inch of ponding was Model H-5, with a flow rate of 10 gpm. Model H-5 is a cast iron drain with a cast iron dome. This compares to a flow rate of 28 gpm with a straight pipe connecting.

The highest flow rate with 1 inch of ponding was Model A-5 with 228 gpm. Model A-5 is a cast iron drain with a cast iron dome. This flow rate is 22 times greater than the lowest flow rate. The flow rate is higher than the flow rate for straight pipe for this roof drain.

With 6 inches of ponding, the highest flow rate was Model C-5 with a flow rate of 1,380 gpm. Model C-5 is a cast iron drain with a poly dome. The lowest flow rate is still Model J-5 with a flow rate of 639 gpm, again less than half the highest flow rate.

# TABLE 6-3 6" ROOF DRAIN TEST RESULTS ROOF DRAIN WITH OFFSET DRAIN PIPE

Test	Model	Description	Type of Strainer	Flow Rate (gpm) Based on Head Heigh						
110.				1″	2″	3″	4"	5″	6"	
5	A-5	6" cast iron drain	cast iron dome	228	240	549	1,008	1,014	1,026	
9	B-4	6" cast iron drain	cast iron dome	115	194	367	598	1,011	1,265	
14	C-5	6" cast iron drain	poly dome	146	208	408	778	1,157	1,380	
18	D-4	6" cast iron drain	aluminum dome	36	194	301	408	624	650	
22	E-4	6" PVC drain	aluminum dome	17	96	215	286	397	693	
24	E-6	6" cast iron drain	poly dome	145	138	238	257	376	712	
26	E-8	6" cast iron drain	cast iron dome	186	233	409	511	754	1,258	
30	F-4	6" cast iron drain	cast iron dome	117	210	401	596	916	1,164	
34	F-8	6" cast iron drain	cast iron dome	122	208	339	526	731	975	
38	G-4	6" PVC drain	ABS dome	101	108	248	450	718	1,120	
43	H-5	6" cast iron drain	cast iron dome	10	124	274	487	668	1,012	
51	J-5	6" cast iron drain	cast iron dome	53	94	198	283	494	639	
56	J-11	6" cast iron drain	brass dome	89	107	231	370	546	879	



CHART 6-3b 6" ROOF DRAIN COMPARISON OF TEST RESULTS ROOF DRAINS OF SAME MANUFACTURER ROOF DRAIN WITH OFFSET DRAIN PIPE



## CHART 6-3a 6" ROOF DRAIN COMPARISON OF TEST RESULTS ROOF DRAIN WITH OFFSET DRAIN PIPE



CHART 6-3d 6" ROOF DRAIN COMPARISON OF TEST RESULTS ROOF DRAINS OF SAME MANUFACTURER ROOF DRAIN WITH OFFSET DRAIN PIPE



CHART 6-3c 6" ROOF DRAIN COMPARISON OF TEST RESULTS ROOF DRAINS OF SAME MANUFACTURER ROOF DRAIN WITH OFFSET DRAIN PIPE

# **ENGINEERING ANALYSIS**

The test results show a wide variety of flows through roof drains. The flow rates exhibited no consistency or pattern.

Before the study started, ASPE RF asked the manufacturers what the flow rates were through their roof drains. None of the manufacturers knew. The response was the same: "The roof drains are designed to meet the standard." All of the roof drains were listed to ASME A112.6.4, thus meeting the requirements of the standard. However, the standard does not specify any flow requirements.

The sizing method in the plumbing codes relies on a consistent flow through the roof drains. The plumbing codes assume that as the water reaches the roof drain, the water simply proceeds down the storm drain pipe. However, that is not the case.

Another fallacy in the sizing method listed in the plumbing codes is that the roof drains will only discharge the amount of water to meet the maximum capacity of the storm drainage pipe. Without some means of restricting the flow into a roof drain, the drain will flow the amount of water based on the head height of ponding around the drain. However, the head height of ponding will vary depending on the slope of the roof, the location of the roof drain, and the amount of rainfall.

Structural engineers and architects specify a minimum slope of 1/4 inch per foot on flat roofs. Many roofs are pitched greater than this amount. The greater the pitch of the roof, the faster the water arrives at the roof drain. The faster the water arrives, the greater the depth of ponding at the roof drain. Finally, the greater the depth of ponding, the greater the flow rate through the roof drain.

If the flow exceeds the maximum capacity of the storm drainage pipe, open channel flow cannot be guaranteed. When the flow is no longer open channel flow, the pressure excursions in the piping system can be significant. The storm drainage piping system is designed and installed for open channel flow. Hence, if open channel flow is exceeded, the piping system can be damaged from a high pressure differential. This would be the most likely reason for hangers being ripped from reinforced concrete floors, pipe bursting apart, water running out on balcony decks, and components in the piping system being destroyed.

Table 7 shows the maximum flow rate measured through roof drains at a given level of ponding. Column 2 lists the maximum allowable flows through a vertical storm drain of the same diameter. The numbers in column 2 are taken from the *Plumbing Engineering and Design Handbook of Tables*.

As can be seen in the table, 83 percent of the maximum flow rates exceeds the flow rate in the piping of the same size. A heavy black line in the table distinguishes the allowable flows in the drain from the flows that are too high. For 2-inch and 3-inch roof drains, every maximum flow rate from 1 inch of ponding through 6 inches of ponding exceeds the allowable flow in a vertical pipe of the same size.

Pipe Size (inches)	Vertical		Maximum Flow Rate Through Roof Drain Based on Ponding Height (gpm)												
	Drain (gpm)	1	"	2		3	"	4		5	"	6	»''		
		Straight	Offset	Straight	Offset	Straight	Offset	Straight	Offset	Straight	Offset	Straight	Offset		
2	34	61	59	171	134	177	149	192	151	206	157	208	161		
3	87	105	118	220	185	415	351	468	347	490	384	522	410		
4	180	117	118	217	210	538	445	754	615	865	668	889	710		
5	311	162	148	222	258	617	641	1203	867	1,125	947	1,267	973		
6	538	153	228	262	240	744	549	979	1,008	1,167	1,157	1,630	1,380		

#### TABLE 7, COMPARISON OF ROOF DRAIN FLOW RATES TO VERTICAL DRAIN CAPACITY

It is recognized that there are lower flow rates for the various drains tested. Table 7 merely shows that the maximum flow rates for most of the drains allow too much flow into a vertical pipe of the same diameter.

Using the maximum allowable flow rate in column 2 of Table 7, a 2-inch roof drain with 1 inch of ponding would have to connect to a 3-inch vertical storm drain. Similarly, a 3-inch roof drain with 1 inch of ponding would have to connect to a 4-inch vertical storm drain.

If you increase the ponding to 2 inches, a 2-inch roof drain would have to connect to a 4-inch storm drain. A 3-inch roof drain would have to connect to a 5-inch drain.

The values in Table 7 can be compared to the controlled measurements of the test assembly without any roof drain connected. Table 8 provides a comparison of the opening without a roof drain to the maximum flow rate measured through the roof drains that were tested.

TABLE	TABLE 8, COMPARISON OF OPENING FLOW RATES TO MAXIMUM ROOF DRAIN FLOW RATES												
Pipe Size (inches)	Vertical Drain (gpm)	Maximum Flow Rate Through Roof Drain Based on Ponding Height (								(gpm)			
		1		2		3		4		5		6	)''
		Straight	Offset	Straight	Offset	Straight	Offset	Straight	Offset	Straight	Offset	Straight	Offset
2	Open	32	23	34	35	35	36	75	64	91	66	178	69
2	Drain	61	59	171	134	177	149	192	151	206	157	208	161
3	Open	50	37	61	64	75	79	101	100	124	129	146	161
3	Drain	105	118	220	185	415	351	468	347	490	384	522	410
4	Open	59	57	121	108	178	141	184	170	208	205	251	247
4	Drain	117	118	217	210	538	445	754	615	865	668	889	710
5	Open	113	124	137	141	199	178	257	207	249	222	318	910
5	Drain	162	148	222	258	617	641	1,203	867	1,125	947	1,267	973
6	Open	107	95	225	210	326	258	743	685	958	911	989	968
6	Drain	153	228	262	240	744	549	979	1,008	1,167	1,157	1,630	1,380

Comparing every value, the flow rate through the roof drain exceeds the flow rate through an opening without a roof drain. For maximum flow rate conditions, this indicates that the dome and shape of the roof drain assist in the removal of water off the roof. While the table appears to validate all roof drains, the statement made regarding the performance of the roof drain cannot be made for every roof drain tested. Some roof drains had values that were lower than an opening without a roof drain.

It was decided not to include the trend line for the test of the opening without a roof drain. If the trend line was added to charts 2-1a through 6-3d, it would get lost somewhere along the bottom of the chart. To demonstrate the location of the no roof drain flow rate to the roof drains, Chart 8-2 duplicates the 5-inch roof drain with straight pipe chart with the open pipe added.

#### CHART 8-2, 5" ROOF DRAIN STRAIGHT PIPE WITH OPEN PIPE INCLUDED



The trend line for the open drain is the lowest line at 6 inches of ponding. Following the line across the chart, a few drains discharge a lower flow rate than the opening in the roof assembly with 1 inch or less of ponding.

One of the benefits of the testing without a roof drain is that these flow rates can be used when sizing the secondary or emergency storm drainage system. Most secondary storm drainage systems are an open pipe without a roof drain or dome strainer.

When using the test results, it should be noted that the flow rates for many flows are siphonic. If the secondary storm drain opens to atmosphere aboveground, the listed flow rates can be used. Both the IPC and NSPC require the secondary storm drainage to terminate atmospherically above grade.

If the secondary storm drainage system connects to the public storm sewer, the flow rates may not be accurate. Testing was not performed to determine if the flow in the piping becomes siphonic when connected to a public storm sewer system. Additional testing would be necessary to determine the flow rates to use for open pipe connected to a public storm sewer.

The result of the testing illustrates that the sizing method in the plumbing codes is incorrect. In some instances, the sizing may be off by two pipe diameters.

Knowing the inadequacy of the storm drainage sizing in the plumbing codes, the question becomes: Why haven't more storm drainage systems failed on commercial buildings?

There are many answers to this question. The first reason is because the rainfall rate for the design of storm drainage systems is a 60-minute storm with a 100-year return period. These rainfalls do not occur very often. However, it should be noted that some storm drainage systems have failed during a microburst, or a heavy downpour in a very short period, giving credence to adding a second calculation for the ponding of water that occurs during a five-minute storm with a 10-year return period or a 15-minute storm with a 100-year return period. This is the rainfall rate that would occur during a microburst. While not a lot of water in inches falls on the ground, for a steeper slope roof, a lot of water can arrive at the roof drain quickly.

Another reason for not having a significant number of failures is the plumbing engineering community oversizing storm drainage systems. It is not unusual for a storm drainage piping design to result in the pipe being two pipe diameters larger than is required by the plumbing codes. The larger pipe can handle the higher flows through the roof drains when ponding around the drain occurs.

Structural engineers are also known for over-designing the roof to handle great roof loads. This has also prevented a significant number of roof failures.

With the increase in value engineering, storm drainage systems are being redesigned for small pipe sizes. Some of the failures that have occurred were in systems that were value engineered. This should not be considered a condemnation of value engineering. Value engineering always has its place in engineering design. Value engineering merely revealed the problems with the sizing methods in the plumbing codes.

Since the 1990s, secondary roof drains have been installed on a regular basis, and they even have been installed on some buildings dating back to 1949. In many instances, the secondary roof drainage system prevented the primary roof drainage system from exceeding its capacity.

Finally, the piping systems are typically more robust than is necessary for open channel flow storm drainage systems. The piping systems have been able to withstand the pressure excursions that have occurred in the system.

#### Pressure Measured in the Piping System

During the testing of the roof drains, the pressure in the piping system was measured. This is reported in Appendix C. Not much has been written about the pressure measurements in the analysis of the test. The reason for not mentioning the pressure is because of the invalidity of the results.

After the testing was completed and the data analyzed, it was realized that the test setup did not facilitate the measuring of pressure in the piping system. Most of the pressure readings were negative numbers or vacuum pressures.

When there is open channel flow in a vertical pipe, the top of the stack will have negative pressure. The greater the flow, the higher the negative pressure. This was verified many years ago during testing at the National Bureau of Standards.

When you exceed the capacity of flow for open channel flow, the piping system either converts to pressurized flow or siphonic flow. For most storm drainage systems, it is anticipated that the flow switches to pressure flow. This may or may not be the case since this was not tested.

The problem with the test setup was that the piping terminated above the recirculation tank. With a termination to atmosphere, above the water level in the tank, the system induced siphonage. All of the pressure readings for the higher flows in the roof drains indicate pressures associated with siphonic flow.

For valid pressure readings to be made, the pipe would have to connect to an underground storm drain, storm sewer, and public sewer. For testing purposes, this would result in a tremendous waste of test water due to the lack of recirculation.

An alternative to connecting the piping to an underground storm sewer would be termination below the water level at a point that equates to a long run of piping to a public storm sewer. It should be noted that both pressure flows and siphonic flows allow a greater flow rate though the piping than open channel flow.

#### 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.

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.

Testing of both straight pipe connections and offset piping must be performed. While one might argue that only an offset piping arrangement needs to be used for testing purposes, if a straight piping arrangement is installed in a building, the flow in the storm drainage pipe could exceed the capacity of the piping system. The design would be inaccurate.

Each manufacturer must publish the flow rates through their roof drains based on head height of ponding. While ASPE RF used 1-inch increments, manufacturers can choose to use smaller increments. ASPE RF is of the opinion that a 1-inch increment is the largest increment that should be used. A maximum ponding height of 6 inches for testing is not unreasonable. However, a manufacturer could always test for a greater amount of ponding.

#### Recommended Change to ASME Standard

The following test protocol is recommended to be added to ASME A112.6.4:

#### 7.2 Flow test

**7.2.1** Each roof drain model shall be tested for the flow rate through the drain at 1 inch to 6 inches of ponding water.

**7.2.2 Test Assembly.** A test assembly shall be constructed as shown in Figure 10 and Figure 11. The piping from the test box shall be the same pipe size as the roof drain being tested.

A flow meter or data acquisition system shall measure flow rates to an accuracy of ±5 gpm.

**7.2.3 Test Protocol.** Connect the roof drain to the opening in the test pan. For each roof drain, complete the testing in accordance with paragraph 7.2.3.1 and 7.2.3.2.

**7.2.3.1 Straight Pipe Test.** Connect a minimum of a 10-foot length of drain pipe to the pan with the pipe directed vertically downward. The pipe shall extend to below the water line in the recirculation tank. There shall be no fitting at the bottom of the pipe. With water flowing into the pan, the level of the water shall be controlled to be set above the opening at 1-inch intervals. Begin with a water head of 1 inch, and increase at 1-inch increment up to 6 inches. Achieve a steady state to record the flow of water. Steady state is defined as the condition in which the head height is maintained within +/-0.1 inch of the head height for a period of five minutes. At each head increment, record the flow rate through the roof drain.

**7.2.3.2 Offset Piping Arrangement Test.** Connect the roof drain to a 1-foot length of pipe that connects to a 90-degree elbow. Connect a 5-foot section of pipe to the elbow, with the pipe pitched 1/4 inch per foot down from the elbow. Connect a second elbow to the 5-foot section of pipe with the elbow facing downward. Connect a minimum of a 9-foot section of pipe to the elbow and allow it to discharge downward without a fitting on the other end. The pipe shall extend to below the water line in the recirculation tank. With water flowing into the pan, the level of the water shall be controlled to be above the opening at 1-inch intervals. Begin with a water head of 1 inch, and increase at 1-inch increments up to 6 inches. Achieve a steady state to record the flow of water. Steady state is defined as the condition in which the head height is maintained within +/-O.1 inch of the head height for a period of five minutes. At each head increment, record the flow rate through the roof drain.

**7.2.4 Test results.** Manufacturer shall publish the flow rates for each roof drain based on the piping arrangement (straight pipe/offset piping arrangement) and the head height of ponding.

Overhead View






Once the flow rate data is published by the roof drain manufacturers, plumbing engineers will have the data necessary to design the storm drainage system. The remaining information required for the design is the rainfall rate and the capacity of the piping system.

#### **Recommended Change to Plumbing Codes**

The plumbing codes must be modified to add new sizing requirements for storm drainage systems. The new sizing method should include sizing based on two rainfall rates. The 60-minute storm with a 100-year return period should remain the design criteria for storm drainage systems. In addition, a five-minute storm with a 10-year return period should be added to the plumbing codes. The sizing of the system should include calculations for the maximum ponding at the roof drain based on these two storms. It is recognized that only one storm will regulate the size. However, without knowing the configuration of the roof, it is impossible to determine which storm will result in the greatest amount of ponding at the roof drain.

The recommended language that should be added to the plumbing codes for sizing a storm drainage system is as follows:

**Roof drain flow rate.** The flow rate capacity of the roof drain shall be published based on the head height of water at the roof drain. The roof drain flow rate shall be used to size the storm drainage system. The flow rate used for sizing the storm drainage piping shall be based on the maximum anticipated ponding at the roof drain based on a rainfall rate of a 60-minute storm with a 100-year return period and a five-minute storm with a 10-year return period.

**Sizing storm drain piping.** Vertical and horizontal storm drain pipe shall be sized based on the flow rate through the roof drain. Storm drain pipes shall not exceed the flow rate specified in Table A.

TABLE A					
STORM D	RAIN PIPE SIZ	ING			
		Maximum	Permitted Flow F	Rate (gpm)	
(inchos)	Vartical Drain		Horizontal Drain	Based on Pitch	
(inches)	vertical Drain	1/16 in/ft	1/8 in/ft	1/4 in/ft	1/2 in/ft
2	34	15	22	31	44
3	87	39	55	79	111
4	180	81	115	163	231
5	311	117	165	234	331
6	538	243	344	487	689
8	1,117	505	714	1,010	1,429
10	2,050	927	1,311	1,855	2,623
12	3,272	1,480	2,093	2,960	4,187
15	5,543	2,508	3,546	5,016	7,093

Note: The values in the table are taken from the *Plumbing Engineering and Design Handbook of Tables*.

**Sizing vertical gutters.** Vertical gutters shall be sized based on the flow rate from the horizontal gutters or through the roof drain. Vertical storm drain gutters shall not exceed the flow rate specified in Table B.

TABLE B VERTICAL GU	TTER SIZING
Size of Leader (inches)	Maximum Permitted Flow Rate (gpm)
2	30
2 x 2	30
1 <sup>1</sup> / <sub>2</sub> x 2 <sup>1</sup> / <sub>2</sub>	30
2 <sup>1</sup> / <sub>2</sub>	54
2 <sup>1</sup> / <sub>2</sub> x 2 <sup>1</sup> / <sub>2</sub>	54
3	92
2 x 4	92
2 <sup>1</sup> / <sub>2</sub> x 3	92
4	192
3 x 4 <sup>1</sup> / <sub>2</sub>	192
3 <sup>1</sup> / <sub>2</sub> x 4	192
5	360
4 x 5	360
4 <sup>1</sup> / <sub>2</sub> x 4 <sup>1</sup> / <sub>2</sub>	360
6	563
5 x 6	563
5 <sup>1</sup> / <sub>2</sub> x 5 <sup>1</sup> / <sub>2</sub>	563
8	1,208
6 x 8	1,208

Note: Single-digit numbers are diameters; other values are square of rectangular shapes. The values in the table are taken from the *Plumbing Engineering and Design Handbook of Tables*. **Size of horizontal gutters.** Horizontal gutters shall be sized based on the flow rate from the roof surface. Horizontal storm drain gutters shall not exceed the flow rate specified in Table C.

TABLE C		
HORIZONTAL	GUTTER SI	ZING
Diameter of Gutter (inches)	Slope (in/ft)	Capacity (gpm)
1 <sup>1</sup> / <sub>2</sub> x 2 <sup>1</sup> / <sub>2</sub>	1/4	26
1 <sup>1</sup> / <sub>2</sub> x 2 <sup>1</sup> / <sub>2</sub>	1/2	40
4	1/8	39
2 <sup>1</sup> / <sub>2</sub> x 3	1/4	55
2 <sup>1</sup> / <sub>2</sub> x 3	1/2	87
5	1/8	74
4 x 2 <sup>1</sup> / <sub>2</sub>	1/4	106
3 x 3 <sup>1</sup> / <sub>2</sub>	1/2	156
6	1/8	110
3 x 5	1/4	157
3 x 5	1/2	225
8	1/16	172
8	1/8	247
4 <sup>1</sup> / <sub>2</sub> x 6	1/4	348
4 <sup>1</sup> / <sub>2</sub> x 6	1/2	494
10	1/16	331
10	1/8	472
5 x 8	1/4	651
4 x 10	1/2	1,055

Note: Single-digit numbers are diameters; other values are square of rectangular shapes. The values in the table are taken from the ASPE *Plumbing Engineering and Design Handbook of Tables*.

# APPENDIX A TEST PROTOCOL DEVELOPED BY ASPE RESEARCH FOUNDATION

#### 1.0 Purpose:

(a) To engage in scientific research and to produce and disseminate to the general public educational and technical materials devoted to the advancement of plumbing technology and design.

(b) To determine the flow rates through roof drains based on the head height of water at the roof drain.

(c) To determine the velocity of flow in the vertical drain connected to a roof drain based on the discharge through the roof drain.

#### 2.0 Product to be tested:

Roof Drains: The American Society of Plumbing Engineers Research Foundation provided roof drains in sizes 2 inches through 6 inches from various manufacturers.

#### 3.0 Test Assembly:

#### See below figures.

The piping from the test box shall be regular PVC of the same pipe size as the roof drain being tested. Standard PVC fittings (white in color) were used for joining the pipe sections.

A data acquisition system was used in collaboration with visual observation to record all measurements.

#### 4.0 Test Protocol:

Prior to testing the roof drains of a given size, two control tests, as described in sections 4.1 and 4.2, were conducted. A total of 12 control tests (pipe only) were performed. The control test protocol was as follows:

- 4.1 Connect the pipe to the test box without a roof drain in place. Have the connection sealed to the bottom of the box with a flange to allow full flow into the pipe. Connect a drain pipe of 10 feet in length to the box with the pipe directed vertically downward. There was no fitting at the bottom of the pipe. With water flowing into the box, the level of the water was set above the opening at 1-inch intervals. Begin with a water head of 1 inch, and increase at 1-inch increments up to 6 inches. Achieve a steady state to record the flow of water. At each head increment, record the following information:
  - 4.1.1 Head height of the water
  - 4.1.2 Flow rate of water into the box
  - 4.1.3 Velocity of flow in the stack
  - 4.1.4 Pressure in the stack

The velocity and pressure measurement in the stack shall be taken at three separate locations. Steady state is defined as the condition in which the head height is maintained within +/- 0.1 inch of the head height for a period of five minutes.

- **4.2** Repeat the testing with a modified piping arrangement. Connect the drain to the flange with a 1-foot section of pipe that connects to a 90-degree elbow. Connect a 5-foot section of pipe to the elbow, with the pipe pitched 1/4 inch per foot down from the elbow. Connect a second elbow to the 5-foot section of pipe with the elbow facing downward. Connect a 9-foot section of pipe to the elbow and allow it to discharge downward without a fitting on the other end. Do not have any fitting at the bottom of the pipe. With water flowing into the box, set the level of the water above the opening at 1-inch intervals. Begin with a water head of 1 inch, and increase at 1-inch increments up to 6 inches. Achieve a steady state to record the flow of water. At each head increment, record the following information:
  - 4.2.1 Head height of the water
  - 4.2.2 Flow rate of water into the box
  - 4.2.3 Discharge flow rate
  - 4.2.4 Velocity of flow in the stack, horizontal pipe, and the second stack

4.2.5 Pressure in the stack, horizontal pipe and the second stack

Steady state is defined as the condition in which the head height is maintained within +/- 0.1 inch of the head height for a period of five minutes.

For each drain, the following three tests need to be done:

- (a) Drain-only test
- (b) Drain stack configuration
- (c) Drain alternate configuration

The control protocol shall be as follows:

- **4.3 Drain Only Test:** Connect the roof drain to the opening in the test box. No piping was connected to the test box. With water flowing into the box, set the level of the water above the opening at 1-inch intervals. Begin with a water head of 1 inch, and increase at 1-inch increments up to 6 inches. Achieve a steady state to record the flow of water. At each head increment, record the following information:
  - 4.3.1 Head height of the water
  - 4.3.2 Flow rate of water into the box
  - 4.3.3 Discharge flow rate
  - 4.3.4 Velocity of flow
  - 4.3.5 Pressure

Steady state is defined as the condition in which the head height is maintained within +/- 0.1 inch of the head height for a period of five minutes.

- **4.4 Drain Stack Configuration:** Connect the roof drain to the opening in the test box. Connect 10 feet of pipe to the bottom of the roof drain with the pipe directed vertically downward. Do not have any fitting at the bottom of the pipe. With water flowing into the box, set the level of the water above the opening at 1-inch intervals. Begin with a water head of 1 inch, and increase at 1-inch increments up to 6 inches. Achieve a steady state to record the flow of water. At each head increment, record the following information:
  - 4.4.1 Head height of the water
  - 4.4.2 Flow rate of water into the box
  - 4.4.3 Discharge flow rate
  - 4.4.4 Velocity of flow in the stack, horizontal pipe, and the second stack
  - 4.4.5 Pressure in the stack, horizontal pipe, and the second stack

Steady state is defined as the condition in which the head height is maintained within +/- 0.1 inch of the head height for a period of five minutes.

4.5 Drain Alternate Configuration: Repeat the testing described in section 4.4 with a modified piping arrangement. Connect the roof drain to a 1-foot section of pipe that connects to a 90-degree elbow. Connect a 5-foot section of pipe to the elbow, with the pipe pitched 1/4 inch per foot down from the elbow. Connect a second elbow to the 5-foot section of pipe with the elbow facing downward. Connect a 9-foot section of pipe to the elbow and allow it to discharge downward without a fitting on the other end. With water flowing into the box, set the level of the water above the opening at 1-inch intervals. Begin with a water head of 1 inch, and increase at 1-inch increments up to 6 inches. Achieve a steady state to record the flow of water. At each head increment, record the following information:

- 4.5.1 Head height of the water
- 4.5.2 Flow rate of water into the box
- 4.5.3 Discharge flow rate
- 4.5.4 Velocity of flow in the stack, horizontal pipe, and the second stack
- 4.5.5 Pressure in the stack, horizontal pipe, and the second stack

Steady state is defined as the condition in which the head height is maintained within +/- 0.1 inch of the head height for a period of five minutes.



Overhead View (Figure 1)

## Side View (Figure 2)



# **APPENDIX B TEST ASSEMBLY PHOTOS**



























# **APPENDIX C TEST RESULTS OF ROOF DRAINS**

		NO E	RAIN WIT	H 10-FT	PIPE	
Water head (inch)	1″	2″	3″	4″	5″	6″
Flow of water into box (gpm)	32	34	35	75	91	178
Velocity in drain pipe (ft/s)	5.4	5.7	6.3	6.8	7.8	9.0
Pressure in drain pipe (in. W.C.)	0.4	0.0	0.0	0.4	0.5	0.4
		DRAI	N WITH M	ODIFIED F	PIPES	
Water head (inch)	1″	2″	3″	4''	5″	6"
Flow of water into box (gpm)	23	35	36	64	66	69
Velocity in 1st stack (ft/s)	3.4	3.7	4.0	5.4	4.5	6.3
Velocity in horizontal pipe (ft/s)	2.3	2.7	2.7	5.0	3.5	6.2
Velocity in 2nd stack (ft/s)	7.2	7.3	7.9	8.1	8.5	8.1
Pressure in 1st stack (in. W.C.)	0.2	0.3	0.4	-15	-16	-17
Pressure in horizontal pipe (in. W.C.)	2.6	2.4	2.1	-23	-24	-26
Pressure in 2nd stack (in. W.C.)	-0.9	-0.9	-1.2	-32	-31	-31

#### TEST 0-2, 2" OPENING WITHOUT A ROOF DRAIN

#### TEST 0-3, 3" OPENING WITHOUT A ROOF DRAIN

		NO E	RAIN WIT	H 10-FT	PIPE	
Water head (inch)	1′′	2″	3″	4″	5″	6″
Flow of water into box (gpm)	50	61	75	101	124	146
Velocity in drain pipe (ft/s)	7.1	7.0	6.2	7.8	8.1	8.2
Pressure in drain pipe (in. W.C.)	-0.3	-8.1	-19.4	-39.8	-40.1	-42.2
		DRAI	N WITH M	ODIFIED F	PIPES	
Water head (inch)	1″	2″	3″	4″	5″	6''
Flow of water into box (gpm)	37	64	79	100	129	161
Velocity in 1st stack (ft/s)	3.4	4.7	5.0	8.4	8.5	8.3
Velocity in horizontal pipe (ft/s)	2.3	4.7	4.7	9.0	9.5	9.2
Velocity in 2nd stack (ft/s)	7.2	7.3	7.9	8.1	8.9	8.1
Pressure in 1st stack (in. W.C.)	-0.3	-10.5	-31.5	-40.1	-41.3	-40.1
Pressure in horizontal pipe (in. W.C.)	-1.5	-11.2	-41.4	-40.4	-42.6	-43.4
Pressure in 2nd stack (in. W.C.)	-2.6	-22.4	-43.8	-42.9	-43.8	-44.1

# TEST 0-4, 4" OPENING WITHOUT A ROOF DRAIN

		NOE	RAIN WIT	H 10-FT	PIPE	
Water head (inch)	1″	2″	3″	4''	5″	6"
Flow of water into box (gpm)	59	121	178	184	208	251
Velocity in drain pipe (ft/s)	4.3	6.4	6.6	7.7	7.8	7.9
Pressure in drain pipe (in. W.C.)	-0.1	-2.7	-2.1	-1.9	-3.4	-3.9
		DRAI	<mark>N WITH M</mark>	ODIFIED F	PIPES	
Water head (inch)	1″	2″	3″	4″	5″	6"
Flow of water into box (gpm)	57	108	141	170	205	247
Velocity in 1st stack (ft/s)	3.4	3.7	4.1	4.3	4.6	4.7
Velocity in horizontal pipe (ft/s)	3.0	4.1	3.8	3.5	3.5	4.1
Velocity in 2nd stack (ft/s)	4.6	6.0	6.3	6.9	6.1	6.6
Pressure in 1st stack (in. W.C.)	0.7	-0.1	-0.5	-0.7	-0.9	-1.4
Pressure in horizontal pipe (in. W.C.)	-0.3	-0.4	-2.1	-0.3	-1.1	-2.3
Pressure in 2nd stack (in. W.C.)	-4.2	-1.8	-3.6	-5.1	-6.7	-7.2

# TEST 0-5, 5" OPENING WITHOUT A ROOF DRAIN

		NO E	RAIN WIT	H 10-FT	PIPE	
Water head (inch)	1″	2″	3″	4″	5″	6"
Flow of water into box (gpm)	113	137	199	257	249	318
Velocity in drain pipe (ft/s)	6.2	6.9	7.5	7.6	7.4	8.2
Pressure in drain pipe (in. W.C.)	0.7	0.6	-0.1	-0.1	-0.3	-2.3
		DRAI	<mark>N WITH M</mark>	ODIFIED F	PIPES	
Water head (inch)	1″	2″	3″	4″	5″	6"
Flow of water into box (gpm)	124	141	178	207	222	910
Velocity in 1st stack (ft/s)	2.1	3.0	3.0	2.1	3.5	8.3
Velocity in horizontal pipe (ft/s)	2.6	4.0	4.1	4.6	4.7	6.6
Velocity in 2nd stack (ft/s)	7.5	7.9	8.2	8.7	7.9	7.7
Pressure in 1st stack (in. W.C.)	0.7	-0.2	-0.8	-0.8	-0.8	-36.6
Pressure in horizontal pipe (in. W.C.)	-2.8	-3.0	-3.0	-1.9	-2.5	-54.3
Pressure in 2nd stack (in. W.C.)	-7.1	-8.9	-9.5	-10.4	-11.8	-51.1

# TEST 0-6, 6" OPENING WITHOUT A ROOF DRAIN

		NOE	RAIN WIT	H 10-FT	PIPE	
Water head (inch)	1″	2″	3″	4"	5″	6"
Flow of water into box (gpm)	107	225	326	743	958	989
Velocity in drain pipe (ft/s)	5.3	6.5	7.6	7.8	9.9	10.1
Pressure in drain pipe (in. W.C.)	-0.6	-1.6	-2.3	-16.3	-34.4	-37.7
		DRAI	<mark>N WITH M</mark>	ODIFIED F	PIPES	
Water head (inch)	1″	2″	3″	4″	5″	6"
Flow of water into box (gpm)	95	210	258	685	911	968
Velocity in 1st stack (ft/s)	2.6	2.4	2.5	5.7	5.9	6.9
Velocity in horizontal pipe (ft/s)	2.4	3.2	4.2	8.4	8.1	8.7
Velocity in 2nd stack (ft/s)	5.1	5.4	6.4	9.2	8.6	8.9
Pressure in 1st stack (in. W.C.)	0.8	0.7	0.5	-13.4	-27.8	-22.2
Pressure in horizontal pipe (in. W.C.)	0.3	-0.4	-2.1	-15.0	-33.3	-45.1
Pressure in 2nd stack (in. W.C.)	0.4	-0.3	-5.0	-4.3	-49.8	-50.3

# 1. MANUFACTURER A, MODEL A-1

2" CAST IRON DRAIN WITH CAST IRON DOME

		DRAIN	WITHOU	JT DRAI	N PIPE	
Water head (inch)	1″	2″	3″	4"	5″	6''
Flow of water into box (gpm)	41	70	64	73	77	82
Velocity of flow (ft/s)	2.8	4.5	4.8	5.1	5.2	5.4
		DRA	IN WITH	10-FT I	PIPE	
Water head (inch)	1″	2″	3″	4"	5″	6''
Flow of water into box (gpm)	41	141	156	189	198	202
Velocity in drain pipe (ft/s)	8.7	9.0	9.0	9.0	9.0	9.0
Pressure in drain pipe (in. W.C.)	-3.8	-40.1	-55.1	-56.8	-55.0	-54.4
		DRAIN	<b>WITH M</b>	ODIFIED	PIPES	
Water head (inch)	1"	DRAIN 2"	<b>WITH M</b> 3"	ODIFIED 4"	<b>PIPES</b> 5"	6''
Water head (inch) Flow of water into box (gpm)	1″ 37	<b>DRAIN</b> 2'' 125	<b>WITH M</b> 3″ 149	ODIFIED 4'' 151	<b>PIPES</b> 5'' 155	6'' 157
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s)	1″ 37 3.9	<b>DRAIN</b> 2'' 125 7.8	<b>WITH M</b> 3" 149 7.9	<b>ODIFIED</b> 4'' 151 8.0	<b>PIPES</b> 5'' 155 8.2	6'' 157 8.3
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s)	1" 37 3.9 3.8	DRAIN 2" 125 7.8 8.7	<b>WITH M</b> 3″ 149 7.9 8.7	<b>ODIFIED</b> 4" 151 8.0 8.7	<b>PIPES</b> 5" 155 8.2 8.8	6" 157 8.3 8.7
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s)	1" 37 3.9 3.8 8.3	<b>DRAIN</b> 2" 125 7.8 8.7 8.6	WITH M 3" 149 7.9 8.7 8.7	ODIFIED 4'' 151 8.0 8.7 8.7	PIPES 5" 155 8.2 8.8 8.8	6'' 157 8.3 8.7 8.7
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.)	1″ 37 3.9 3.8 8.3 -1.4	<b>DRAIN</b> 2" 125 7.8 8.7 8.6 -22.4	WITH M 3" 149 7.9 8.7 8.7 -21.0	ODIFIED 4" 151 8.0 8.7 8.7 8.7 -20.6	PIPES 5" 155 8.2 8.8 8.8 -19.0	6'' 157 8.3 8.7 8.7 8.7 -19.4
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.) Pressure in horizontal pipe (in. W.C.)	1" 37 3.9 3.8 8.3 -1.4 -3.0	<b>DRAIN</b> 2" 125 7.8 8.7 8.6 -22.4 -43.8	WITH M 3" 149 7.9 8.7 8.7 -21.0 -45.5	ODIFIED 4'' 151 8.0 8.7 8.7 -20.6 -43.5	PIPES 5" 155 8.2 8.8 8.8 -19.0 -44.6	6'' 157 8.3 8.7 8.7 -19.4 -45.0

## 2. MANUFACTURER A, MODEL A-2

		DRAIN		JT DRAI		
Water head (inch)	1″	2″	3″	4"	5″	6''
Flow of water into box (gpm)	13	101	108	114	126	151
Velocity of flow (ft/s)	0.7	4.1	4.9	5.1	5.3	5.5
		DRA		10-FT I	PIPE	
Water head (inch)	1″	2″	3″	4"	5″	6''
Flow of water into box (gpm)	41	135	405	414	418	429
Velocity in drain pipe (ft/s)	3.2	7.7	8.1	8.9	10.1	10.6
Pressure in drain pipe (in. W.C.)	-1.3	-3.8	-24.1	-38.7	-40.8	-43.1
		DRAIN	<mark>і                                    </mark>	ODIFIED	PIPES	
Water head (inch)	1″	DRAIN 2"	і <b>WITH M</b> З″	<mark>ODIFIED</mark> 4"	<b>PIPES</b> 5"	6''
Water head (inch) Flow of water into box (gpm)	1'' 49	<b>DRAIN</b> 2" 155	3'' 318	ODIFIED 4'' 333	<b>PIPES</b> 5'' 340	6'' 350
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s)	1″ 49 2.5	<b>DRAIN</b> 2'' 155 3.1	3" 318 3.6	<b>ODIFIED</b> 4'' 333 5.6	<b>PIPES</b> 5″ 340 7.1	6'' 350 7.8
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s)	1″ 49 2.5 3.2	DRAIN 2" 155 3.1 3.8	3" 318 3.6 4.0	<b>ODIFIED</b> 4'' 333 5.6 4.5	<b>PIPES</b> 5" 340 7.1 6.3	6'' 350 7.8 7.6
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s)	1'' 49 2.5 3.2 6.7	<b>DRAIN</b> 2" 155 3.1 3.8 6.8	3'' 318 3.6 4.0 7.1	ODIFIED 4" 333 5.6 4.5 7.2	<b>PIPES</b> 5" 340 7.1 6.3 7.4	6'' 350 7.8 7.6 7.9
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.)	1" 49 2.5 3.2 6.7 -1.7	<b>DRAIN</b> 2" 155 3.1 3.8 6.8 -4.4	3" 318 3.6 4.0 7.1 -39.4	ODIFIED 4" 333 5.6 4.5 7.2 -40.5	<b>PIPES</b> 5" 340 7.1 6.3 7.4 -39.3	6'' 350 7.8 7.6 7.9 -38.3
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.) Pressure in horizontal pipe (in. W.C.)	1" 49 2.5 3.2 6.7 -1.7 -0.3	<b>DRAIN</b> 2" 155 3.1 3.8 6.8 -4.4 -7.6	3'' 318 3.6 4.0 7.1 -39.4 -45.6	ODIFIED 4" 333 5.6 4.5 7.2 -40.5 -48.9	<b>PIPES</b> 5" 340 7.1 6.3 7.4 -39.3 -49.1	6" 350 7.8 7.6 7.9 -38.3 -48.5

#### 3. MANUFACTURER A, MODEL A-3 4" CAST IRON DRAIN WITH CAST IRON DOME

		DRAIN	ι <mark>ωιτ</mark> Ηοι	JT DRAII		
Water head (inch)	1″	2″	3″	4''	5″	6''
Flow of water into box (gpm)	48	129	166	177	184	191
Velocity of flow (ft/s)	1.1	3.8	4.4	4.7	4.7	5.1
		DRA	IN WITH	10-FT F	PIPE	
Water head (inch)	1″	2″	3″	4″	5″	6"
Flow of water into box (gpm)	41	172	538	585	612	673
Velocity in drain pipe (ft/s)	4.3	6.4	8.5	9.1	9.1	9.1
Pressure in drain pipe (in. W.C.)	-0.4	-2.4	-37.8	-54.2	-54.2	-54.6
		DRAIN	<b>WITH M</b>	ODIFIED	PIPES	
Water head (inch)	1″	2″	3″	4''	5″	6''
Flow of water into box (gpm)	49	134	225	250	262	285
Velocity in 1st stack (ft/s)	2.3	3.3	4.4	4.0	4.7	4.5
Velocity in horizontal pipe (ft/s)	2.4	3.5	4.3	5.0	4.9	5.1
Velocity in 2nd stack (ft/s)	5.0	6.6	6.7	6.8	6.9	5.9
Pressure in 1st stack (in. W.C.)	0.4	0.1	-2.4	-2.8	-4.3	-5.5
Pressure in horizontal pipe (in. W.C.)	-0.1	-2.4	-4.6	-4.9	-7.3	-7.3

#### 4. MANUFACTURER A, MODEL A-4

		DRAIN	ι <mark>ωιτ</mark> Ηοι	JT DRAII	N PIPE	
Water head (inch)	1′′	2″	3″	4"	5″	6''
Flow of water into box (gpm)	107	243	405	435	427	470
Velocity of flow (ft/s)	0.1	2.7	3.2	3.6	3.7	4.0
		DRA	IN WITH	10-FT I	PIPE	
Water head (inch)	1′′	2″	3″	4"	5″	6''
Flow of water into box (gpm)	109	220	617	1203	1125	1042
Velocity in drain pipe (ft/s)	2.8	7.8	8.8	9.1	9.3	8.9
Pressure in drain pipe (in. W.C.)	-8.6	-9.6	-24.2	-33.1	-23.0	-24.7
		DRAIN	<b>WITH M</b>	ODIFIED	PIPES	
Water head (inch)	1″	DRAIN 2"	<b>WITH M</b> 3″	ODIFIED 4''	<b>PIPES</b> 5"	6″
Water head (inch) Flow of water into box (gpm)	1'' 133	<b>DRAIN</b> 2" 258	<b>WITH M</b> 3'' 641	<mark>ODIFIED</mark> 4'' 867	<b>PIPES</b> 5'' 834	6'' 850
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s)	1″ 133 2.5	<b>DRAIN</b> 2" 258 4.0	3'' 641 7.3	<b>ODIFIED</b> 4'' 867 7.9	<b>PIPES</b> 5'' 834 8.3	6'' 850 8.1
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s)	1'' 133 2.5 2.1	DRAIN 2" 258 4.0 3.8	3'' 641 7.3 6.1	<b>ODIFIED</b> 4'' 867 7.9 7.3	<b>PIPES</b> 5" 834 8.3 7.3	6'' 850 8.1 7.3
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s)	1" 133 2.5 2.1 7.4	<b>DRAIN</b> 2" 258 4.0 3.8 7.2	<b>WITH M</b> 3″ 641 7.3 6.1 8.2	ODIFIED 4'' 867 7.9 7.3 7.5	<b>PIPES</b> 5" 834 8.3 7.3 7.4	6'' 850 8.1 7.3 7.9
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.)	1'' 133 2.5 2.1 7.4 0.9	<b>DRAIN</b> 2" 258 4.0 3.8 7.2 -2.3	<b>WITH M</b> 3″ 641 7.3 6.1 8.2 -18.9	ODIFIED 4" 867 7.9 7.3 7.5 -34.8	<b>PIPES</b> 5" 834 8.3 7.3 7.4 -34.4	6'' 850 8.1 7.3 7.9 -29.4
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.) Pressure in horizontal pipe (in. W.C.)	1" 133 2.5 2.1 7.4 0.9 -0.8	<b>DRAIN</b> 2" 258 4.0 3.8 7.2 -2.3 -2.8	WITH M 3" 641 7.3 6.1 8.2 -18.9 -44.1	ODIFIED 4" 867 7.9 7.3 7.5 -34.8 -57.7	PIPES 5" 834 8.3 7.3 7.4 -34.4 -58.9	6" 850 8.1 7.3 7.9 -29.4 -60.6

#### 5. MANUFACTURER A, MODEL A-5 6" CAST IRON DRAIN WITH CAST IRON DOME

		DRAIN	ι <mark>ωιτ</mark> Ηοι	JT DRAII		
Water head (inch)	1‴	2″	3″	4''	5″	6''
Flow of water into box (gpm)	10	185	199	238	267	218
Velocity of flow (ft/s)	0.9	2.0	2.4	2.5	2.4	2.8
		DRA	IN WITH	10-FT F	PIPE	
Water head (inch)	1″	2"	3″	4″	5″	6''
Flow of water into box (gpm)	122	169	744	979	1162	1188
Velocity in drain pipe (ft/s)	0.2	3.0	5.7	6.2	5.9	6.2
Pressure in drain pipe (in. W.C.)	0.8	-0.1	-28.9	-50.4	-50.8	-50.2
		DRAIN	WITH M	ODIFIED	PIPES	
Water head (inch)	1″	2"	3″	4″	5″	6''
Flow of water into box (gpm)	228	240	549	1008	1014	1026
Velocity in 1st stack (ft/s)	0.4	1.9	3.4	5.0	4.1	4.6
Velocity in horizontal pipe (ft/s)	1.9	36	49	6.3	5.9	6.0
		0.0		0.0		
Velocity in 2nd stack (ft/s)	4.0	6.4	8.4	5.7	5.4	5.2
Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.)	4.0 0.6	6.4 -0.6	8.4 -19.9	5.7 -63.8	5.4 -67.7	5.2 -68.8
Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.) Pressure in horizontal pipe (in. W.C.)	4.0 0.6 0.1	6.4 -0.6 -0.5	8.4 -19.9 -28.8	5.7 -63.8 -72.1	5.4 -67.7 -73.7	5.2 -68.8 -76.0

## 6. MANUFACTURER B, MODEL B-1

		DRAIN	<b>WITHOU</b>	JT DRAII		
Water head (inch)	1′′	2″	3″	4″	5″	6''
Flow of water into box (gpm)	53	62	64	69	71	72
Velocity of flow (ft/s)	2.3	2.4	3.3	3.5	3.7	4.1
		DRA	і <mark>н </mark> ытн	10-FT F	PIPE	
Water head (inch)	1′′	2″	3″	4"	5″	6''
Flow of water into box (gpm)	61	110	108	148	189	202
Velocity in drain pipe (ft/s)	8.6	9.0	9.0	9.0	9.0	9.0
Pressure in drain pipe (in. W.C.)	-8.2	-34.5	-37.8	-43.6	-55.8	-55.8
		DRAIN	<b>WITH M</b>	ODIFIED	PIPES	
Water head (inch)	1″	DRAIN 2"	<b>WITH M</b> 3″	<mark>ODIFIED</mark> 4"	<b>PIPES</b> 5"	6″
Water head (inch) Flow of water into box (gpm)	1" 59	<b>DRAIN</b> 2'' 87	<b>WITH M</b> 3″ 85	<b>ODIFIED</b> 4'' 111	<b>PIPES</b> 5'' 134	6'' 145
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s)	1'' 59 5.4	<b>DRAIN</b> 2'' 87 5.4	<b>WITH M</b> 3'' 85 9.1	<b>ODIFIED</b> 4'' 111 9.1	<b>PIPES</b> 5'' 134 8.1	6'' 145 8.2
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s)	1″ 59 5.4 5.7	<b>DRAIN</b> 2'' 87 5.4 7.0	<b>WITH M</b> 3″ 85 9.1 7.5	<b>ODIFIED</b> 4'' 111 9.1 7.0	<b>PIPES</b> 5" 134 8.1 9.0	6'' 145 8.2 9.0
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s)	1'' 59 5.4 5.7 7.2	<b>DRAIN</b> 2" 87 5.4 7.0 7.7	WITH M 3″ 85 9.1 7.5 7.6	ODIFIED 4" 111 9.1 7.0 7.2	<b>PIPES</b> 5″ 134 8.1 9.0 8.7	6'' 145 8.2 9.0 8.6
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.)	1'' 59 5.4 5.7 7.2 -10.4	<b>DRAIN</b> 2" 87 5.4 7.0 7.7 -5.9	WITH M 3″ 85 9.1 7.5 7.6 -5.8	ODIFIED 4" 111 9.1 7.0 7.2 -15.5	PIPES 5" 134 8.1 9.0 8.7 -20.8	6'' 145 8.2 9.0 8.6 -18.4
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.) Pressure in horizontal pipe (in. W.C.)	1" 59 5.4 5.7 7.2 -10.4 -13.6	<b>DRAIN</b> 2" 87 5.4 7.0 7.7 -5.9 -30.5	WITH M 3″ 85 9.1 7.5 7.6 -5.8 -14.5	ODIFIED 4" 111 9.1 7.0 7.2 -15.5 -24.8	PIPES 5" 134 8.1 9.0 8.7 -20.8 -43.9	6" 145 8.2 9.0 8.6 -18.4 -44.1

#### 7. MANUFACTURER B, MODEL B-2 3" CAST IRON DRAIN WITH CAST IRON DOME

		DRAIN	WITHOU	JT DRAII		
Water head (inch)	1″	2″	3″	4"	5″	6''
Flow of water into box (gpm)	48	106	126	144	149	165
Velocity of flow (ft/s)	0.8	3.8	4.3	4.7	4.9	5.1
		DRA	IN WITH	10-FT F	PIPE	
Water head (inch)	1″	2″	3″	4"	5″	6''
Flow of water into box (gpm)	58	152	202	414	448	467
Velocity in drain pipe (ft/s)	3.2	7.7	7.9	9.7	10.1	10.3
Pressure in drain pipe (in. W.C.)	-1.7	-13.6	-25.4	-27.3	-37.2	-38.1
		DRAIN	<b>WITH M</b>	ODIFIED	PIPES	
Water head (inch)	1"	DRAIN 2"	<b>WITH M</b> 3"	ODIFIED 4''	<b>PIPES</b> 5"	6"
Water head (inch) Flow of water into box (gpm)	1″ 52	<b>DRAIN</b> 2'' 161	<b>WITH M</b> 3″ 174	<mark>ODIFIED</mark> 4'' 262	<b>PIPES</b> 5'' 371	6'' 402
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s)	1″ 52 3.2	<b>DRAIN</b> 2'' 161 4.6	<b>WITH M</b> 3″ 174 5.0	<b>ODIFIED</b> 4'' 262 8.0	<b>PIPES</b> 5'' 371 8.3	6'' 402 7.8
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s)	1" 52 3.2 3.1	<b>DRAIN</b> 2'' 161 4.6 4.6	<b>WITH M</b> 3″ 174 5.0 4.5	ODIFIED 4" 262 8.0 9.5	<b>PIPES</b> 5" 371 8.3 9.4	6'' 402 7.8 9.7
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s)	1" 52 3.2 3.1 6.6	<b>DRAIN</b> 2'' 161 4.6 4.6 6.7	WITH M 3" 174 5.0 4.5 7.2	ODIFIED 4'' 262 8.0 9.5 7.8	<b>PIPES</b> 5" 371 8.3 9.4 8.1	6'' 402 7.8 9.7 7.9
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.)	1" 52 3.2 3.1 6.6 -0.3	<b>DRAIN</b> 2'' 161 4.6 4.6 6.7 -15.7	WITH M 3" 174 5.0 4.5 7.2 -0.4	ODIFIED 4'' 262 8.0 9.5 7.8 -16.5	<b>PIPES</b> 5" 371 8.3 9.4 8.1 -29.9	6'' 402 7.8 9.7 7.9 -29.7
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.) Pressure in horizontal pipe (in. W.C.)	1" 52 3.2 3.1 6.6 -0.3 -1.2	<b>DRAIN</b> 2'' 161 4.6 4.6 6.7 -15.7 -27.8	WITH M 3" 174 5.0 4.5 7.2 -0.4 -2.6	ODIFIED 4'' 262 8.0 9.5 7.8 -16.5 -27.2	PIPES 5" 371 8.3 9.4 8.1 -29.9 -46.1	6'' 402 7.8 9.7 7.9 -29.7 -44.9

## 8. MANUFACTURER B, MODEL B-3

		DRAIN		UT DRAII		
Water head (inch)	1″	2″	3″	4″	5″	6''
Flow of water into box (gpm)	72	198	275	240	304	348
Velocity of flow (ft/s)	1.5	2.8	4.1	4.3	5.3	6
		DRA	IN WITH	10-FT F	PIPE	
Water head (inch)	1″	2″	3″	4"	5″	6''
Flow of water into box (gpm)	68	184	242	608	768	790
Velocity in drain pipe (ft/s)	4.1	7.5	8.5	9.2	9.8	10.3
Pressure in drain pipe (in. W.C.)	-1.1	-2.9	-2.8	-46.8	-55.9	-56.5
		DRAIN	WITH M	ODIFIED	PIPES	
Water head (inch)	1″	DRAIN 2"	<b>WITH M</b> 3"	ODIFIED 4"	<b>PIPES</b> 5"	6"
Water head (inch) Flow of water into box (gpm)	1″ 67	<b>DRAIN</b> 2'' 195	WITH M 3" 296	ODIFIED 4'' 587	<b>PIPES</b> 5'' 668	6'' 710
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s)	1'' 67 2.6	<b>DRAIN</b> 2'' 195 4.2	WITH M 3" 296 6.3	<b>ODIFIED</b> 4'' 587 8.6	<b>PIPES</b> 5'' 668 9.1	6'' 710 8.5
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s)	1'' 67 2.6 2.6	DRAIN 2'' 195 4.2 4.3	<b>WITH M</b> 3" 296 6.3 4.6	<b>ODIFIED</b> 4'' 587 8.6 9.5	<b>PIPES</b> 5'' 668 9.1 9.9	6'' 710 8.5 10.0
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s)	1'' 67 2.6 2.6 5.4	<b>DRAIN</b> 2" 195 4.2 4.3 6.8	WITH M 3" 296 6.3 4.6 6.7	<b>ODIFIED</b> 4" 587 8.6 9.5 7.9	<b>PIPES</b> 5″ 668 9.1 9.9 7.7	6'' 710 8.5 10.0 7.9
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.)	1" 67 2.6 2.6 5.4 1.4	<b>DRAIN</b> 2" 195 4.2 4.3 6.8 -2.2	WITH M 3" 296 6.3 4.6 6.7 -1.2	<b>ODIFIED</b> 4" 587 8.6 9.5 7.9 -23.1	<b>PIPES</b> 5″ 668 9.1 9.9 7.7 -31.3	6" 710 8.5 10.0 7.9 -30.3
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.) Pressure in horizontal pipe (in. W.C.)	1" 67 2.6 2.6 5.4 1.4 -0.1	<b>DRAIN</b> 2" 195 4.2 4.3 6.8 -2.2 -6.8	WITH M 3" 296 6.3 4.6 6.7 -1.2 -4.8	<b>ODIFIED</b> 4'' 587 8.6 9.5 7.9 -23.1 -56.4	PIPES 5" 668 9.1 9.9 7.7 -31.3 -56.7	6" 710 8.5 10.0 7.9 -30.3 -58.5

#### 9. MANUFACTURER B, MODEL B-4 6" CAST IRON DRAIN WITH CAST IRON DOME

		DRAIN		JT DRAI	N PIPE	
Water head (inch)	1″	2″	3″	4″	5″	6"
Flow of water into box (gpm)	180	212	379	528	573	608
Velocity of flow (ft/s)	1.0	1.7	4.4	5.4	5.4	5.8
		DRA	IN WITH	10-FT	PIPE	
Water head (inch)	1″	2″	3″	4"	5″	6"
Flow of water into box (gpm)	111	188	382	629	1034	1520
Velocity in drain pipe (ft/s)	0.8	6.0	8.0	8.3	9.1	10.3
Pressure in drain pipe (in. W.C.)	0.9	1.2	-1.8	-8.7	-20.2	-31.4
		DRAIN	WITH M	ODIFIED	PIPES	
Water head (inch)	1"	DRAIN 2"	<b>WITH M</b> 3"	<mark>ODIFIED</mark> 4''	<b>PIPES</b> 5"	6"
Water head (inch) Flow of water into box (gpm)	1″ 115	<b>DRAIN</b> 2'' 194	<b>WITH M</b> 3" 367	<mark>ODIFIED</mark> 4'' 598	<b>PIPES</b> 5'' 1011	6'' 1265
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s)	1″ 115 1.2	<b>DRAIN</b> 2'' 194 2.7	<b>WITH M</b> 3" 367 3.7	<b>ODIFIED</b> 4'' 598 3.3	<b>PIPES</b> 5'' 1011 6.6	6'' 1265 5.7
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s)	1" 115 1.2 2.0	DRAIN 2" 194 2.7 2.7	<b>WITH M</b> 3" 367 3.7 4.1	<b>ODIFIED</b> 4" 598 3.3 5.4	<b>PIPES</b> 5" 1011 6.6 8.9	6'' 1265 5.7 8.3
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s)	1″ 115 1.2 2.0 4.1	<b>DRAIN</b> 2" 194 2.7 2.7 6.6	WITH M 3" 367 3.7 4.1 7.4	ODIFIED 4'' 598 3.3 5.4 7.9	<b>PIPES</b> 5" 1011 6.6 8.9 7.8	6'' 1265 5.7 8.3 7.7
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.)	1" 115 1.2 2.0 4.1 0.8	<b>DRAIN</b> 2" 194 2.7 2.7 6.6 1.2	WITH M 3" 367 3.7 4.1 7.4 0.7	ODIFIED 4" 598 3.3 5.4 7.9 -5.4	<b>PIPES</b> 5" 1011 6.6 8.9 7.8 -24.7	6'' 1265 5.7 8.3 7.7 -29.1
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.) Pressure in horizontal pipe (in. W.C.)	1" 115 1.2 2.0 4.1 0.8 0.1	<b>DRAIN</b> 2" 194 2.7 2.7 6.6 1.2 3.9	WITH M 3" 367 3.7 4.1 7.4 0.7 -6.9	ODIFIED 4" 598 3.3 5.4 7.9 -5.4 -8.3	<b>PIPES</b> 5" 1011 6.6 8.9 7.8 -24.7 -34.8	6'' 1265 5.7 8.3 7.7 -29.1 -51.6

## **10. MANUFACTURER C, MODEL C-1**

		DRAIN	<b>WITHO</b>	JT DRAII		
Water head (inch)	1″	2″	3″	4''	5″	6''
Flow of water into box (gpm)	13	49	65	73	80	87
Velocity of flow (ft/s)	0.7	3.8	4.1	4.3	4.6	4.8
		DRA	ін шітн	10-FT I	PIPE	
Water head (inch)	1″	2″	3″	4″	5″	6''
Flow of water into box (gpm)	28	171	177	192	206	208
Velocity in drain pipe (ft/s)	8.1	9.0	9.0	9.0	9.0	9.0
Pressure in drain pipe (in. W.C.)	-5.2	-53.8	-53.4	-53.7	-52.9	-53.0
		DRAIN	<b>WITH M</b>	ODIFIED	PIPES	
Water head (inch)	1″	DRAIN 2"	<b>WITH M</b> 3"	ODIFIED 4''	<b>PIPES</b> 5"	6″
Water head (inch) Flow of water into box (gpm)	1″ 23	<b>DRAIN</b> 2'' 134	<b>WITH M</b> 3″ 136	<mark>ODIFIED</mark> 4'' 140	<b>PIPES</b> 5'' 146	6'' 148
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s)	1'' 23 2.5	<b>DRAIN</b> 2'' 134 8.1	<b>WITH M</b> 3″ 136 8.1	<b>ODIFIED</b> 4'' 140 8.4	<b>PIPES</b> 5″ 146 8.7	6'' 148 8.5
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s)	1″ 23 2.5 3.0	DRAIN 2" 134 8.1 8.6	<b>WITH M</b> 3" 136 8.1 8.7	<b>ODIFIED</b> 4'' 140 8.4 8.8	<b>PIPES</b> 5″ 146 8.7 9.0	6" 148 8.5 9.0
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s)	1" 23 2.5 3.0 7.3	<b>DRAIN</b> 2" 134 8.1 8.6 8.5	WITH M 3" 136 8.1 8.7 8.6	ODIFIED 4'' 140 8.4 8.8 8.8 8.7	<b>PIPES</b> 5″ 146 8.7 9.0 8.7	6'' 148 8.5 9.0 8.7
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.)	1" 23 2.5 3.0 7.3 0.3	<b>DRAIN</b> 2" 134 8.1 8.6 8.5 -21.8	WITH M 3" 136 8.1 8.7 8.6 -19.4	0DIFIED 4" 140 8.4 8.8 8.7 -19.6	<b>PIPES</b> 5'' 146 8.7 9.0 8.7 -18.7	6'' 148 8.5 9.0 8.7 -18.3
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.) Pressure in horizontal pipe (in. W.C.)	1" 23 2.5 3.0 7.3 0.3 0.2	<b>DRAIN</b> 2" 134 8.1 8.6 8.5 -21.8 -46.1	WITH M 3" 136 8.1 8.7 8.6 -19.4 -45.3	<b>ODIFIED</b> 4'' 140 8.4 8.8 8.7 -19.6 -45.4	PIPES 5" 146 8.7 9.0 8.7 -18.7 -43.8	6" 148 8.5 9.0 8.7 -18.3 -43.3

#### 11. MANUFACTURER C, MODEL C-2 3" CAST IRON DRAIN WITH POLY DOME

		DRAIN	WITHOU	JT DRAII		
Water head (inch)	1″	2″	3″	4″	5″	6''
Flow of water into box (gpm)	18	122	151	161	178	187
Velocity of flow (ft/s)	0.6	4.1	4.9	5.2	5.4	5.4
		DRA	IN WITH	10-FT F	PIPE	
Water head (inch)	1′′	2″	3″	4"	5″	6''
Flow of water into box (gpm)	27	181	415	468	485	495
Velocity in drain pipe (ft/s)	3.4	7.8	8.4	9.7	10.1	10.6
Pressure in drain pipe (in. W.C.)	-1.2	-8.3	-36.8	-38.9	-39.4	-39.1
		DRAIN	<b>WITH M</b>	ODIFIED	PIPES	
Water head (inch)	1″	DRAIN 2"	<b>WITH M</b> 3"	ODIFIED 4''	<b>PIPES</b> 5"	6"
Water head (inch) Flow of water into box (gpm)	1″ 18	<b>DRAIN</b> 2'' 185	<b>WITH M</b> 3″ 351	<mark>ODIFIED</mark> 4'' 347	<b>PIPES</b> 5'' 363	6'' 371
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s)	1″ 18 1.6	<b>DRAIN</b> 2'' 185 3.7	<b>WITH M</b> 3″ 351 4.5	<b>ODIFIED</b> 4'' 347 6.1	<b>PIPES</b> 5'' 363 6.9	6'' 371 7.4
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s)	1″ 18 1.6 2.2	DRAIN 2" 185 3.7 3.6	<b>WITH M</b> 3″ 351 4.5 4.2	<b>ODIFIED</b> 4'' 347 6.1 4.9	<b>PIPES</b> 5" 363 6.9 8.7	6" 371 7.4 8.9
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s)	1″ 18 1.6 2.2 6.5	<b>DRAIN</b> 2" 185 3.7 3.6 6.9	WITH M 3" 351 4.5 4.2 7.1	ODIFIED 4'' 347 6.1 4.9 7.8	<b>PIPES</b> 5" 363 6.9 8.7 8.0	6'' 371 7.4 8.9 8.1
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.)	1" 18 1.6 2.2 6.5 1.2	<b>DRAIN</b> 2" 185 3.7 3.6 6.9 -6.3	WITH M 3″ 351 4.5 4.2 7.1 -30.2	ODIFIED 4'' 347 6.1 4.9 7.8 -29.2	PIPES 5" 363 6.9 8.7 8.0 -28.9	6'' 371 7.4 8.9 8.1 -27.9
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.) Pressure in horizontal pipe (in. W.C.)	1" 18 1.6 2.2 6.5 1.2 0.1	<b>DRAIN</b> 2" 185 3.7 3.6 6.9 -6.3 -8.5	WITH M 3" 351 4.5 4.2 7.1 -30.2 -39.7	ODIFIED 4'' 347 6.1 4.9 7.8 -29.2 -46.8	PIPES 5" 363 6.9 8.7 8.0 -28.9 -43.7	6'' 371 7.4 8.9 8.1 -27.9 -44.6

## 12. MANUFACTURER C, MODEL C-3

		DRAIN	ι <mark>ωιτ</mark> Ηοι	JT DRAII		
Water head (inch)	1″	2″	3″	4''	5″	6''
Flow of water into box (gpm)	38	197	292	323	350	383
Velocity of flow (ft/s)	0.7	3.0	4.3	4.3	4.3	5.0
		DRA	IN WITH	10-FT F	PIPE	
Water head (inch)	1′′	2″	3″	4''	5″	6''
Flow of water into box (gpm)	40	217	442	754	865	889
Velocity in drain pipe (ft/s)	1.2	6.8	7.4	9.3	10.5	10.4
Pressure in drain pipe (in. W.C.)	0.4	-3.1	-22.7	-48.1	-55.9	-55.6
		DRAIN	<b>WITH M</b>	ODIFIED	PIPES	
Water head (inch)	1′′	DRAIN 2"	<b>WITH M</b> 3″	<mark>ODIFIED</mark> 4''	<b>PIPES</b> 5"	6"
Water head (inch) Flow of water into box (gpm)	1'' 45	<b>DRAIN</b> 2'' 203	<b>WITH M</b> 3″ 445	ODIFIED 4'' 615	<b>PIPES</b> 5'' 625	6'' 645
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s)	1'' 45 3.4	DRAIN 2" 203 3.9	<b>WITH M</b> 3″ 445 7.0	<b>ODIFIED</b> 4'' 615 8.7	<b>PIPES</b> 5'' 625 8.7	6'' 645 8.9
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s)	1'' 45 3.4 0.1	DRAIN 2" 203 3.9 3.6	<b>WITH M</b> 3″ 445 7.0 9.0	<b>ODIFIED</b> 4'' 615 8.7 9.6	<b>PIPES</b> 5" 625 8.7 9.5	6" 645 8.9 9.8
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s)	1'' 45 3.4 0.1 0.3	<b>DRAIN</b> 2" 203 3.9 3.6 7.1	WITH M 3″ 445 7.0 9.0 6.8	ODIFIED 4'' 615 8.7 9.6 8.0	<b>PIPES</b> 5" 625 8.7 9.5 7.9	6'' 645 8.9 9.8 7.8
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.)	1" 45 3.4 0.1 0.3 0.2	<b>DRAIN</b> 2" 203 3.9 3.6 7.1 -2.4	WITH M 3″ 445 7.0 9.0 6.8 -21.2	ODIFIED 4" 615 8.7 9.6 8.0 -31.5	<b>PIPES</b> 5" 625 8.7 9.5 7.9 -30.7	6'' 645 8.9 9.8 7.8 -30.7
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.) Pressure in horizontal pipe (in. W.C.)	1" 45 3.4 0.1 0.3 0.2 3.1	<b>DRAIN</b> 2" 203 3.9 3.6 7.1 -2.4 -12.4	WITH M 3" 445 7.0 9.0 6.8 -21.2 -42.9	<b>ODIFIED</b> 4'' 615 8.7 9.6 8.0 -31.5 -56.8	PIPES 5" 625 8.7 9.5 7.9 -30.7 -30.7	6'' 645 8.9 9.8 7.8 -30.7 -57.0

#### 13. MANUFACTURER C, MODEL C-4 5" CAST IRON DRAIN WITH POLY DOME

		DRAIN	WITHOU	JT DRAII	N PIPE	
Water head (inch)	1″	2″	3″	4"	5"	6"
Flow of water into box (gpm)	108	185	335	368	357	387
Velocity of flow (ft/s)	1.3	1.1	2.7	3.5	3.5	3.7
		DRA	IN WITH	10-FT I	PIPE	
Water head (inch)	1‴	2″	3″	4"	5″	6″
Flow of water into box (gpm)	118	199	402	745	1060	1267
Velocity in drain pipe (ft/s)	5.0	5.8	8.3	7.7	8.8	9.5
Pressure in drain pipe (in. W.C.)	0.4	-0.7	-6.2	-23.9	-21.8	-18.2
		DRAIN	<b>WITH M</b>	ODIFIED	PIPES	
Water head (inch)	1″	DRAIN 2"	<b>WITH M</b> 3"	<mark>ODIFIED</mark> 4"	<b>PIPES</b> 5"	6''
Water head (inch) Flow of water into box (gpm)	1'' 117	<b>DRAIN</b> 2'' 219	<b>WITH M</b> 3'' 432	<mark>ODIFIED</mark> 4'' 755	<b>PIPES</b> 5'' 947	6'' 973
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s)	1″ 117 2.5	DRAIN 2" 219 3.1	WITH M 3" 432 4.9	<mark>ODIFIED</mark> 4'' 755 5.8	<b>PIPES</b> 5'' 947 8.8	6'' 973 8.5
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s)	1″ 117 2.5 1.7	DRAIN 2" 219 3.1 3.7	<b>WITH M</b> 3" 432 4.9 4.7	ODIFIED 4'' 755 5.8 8.3	<b>PIPES</b> 5'' 947 8.8 7.2	6'' 973 8.5 7.3
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s)	1″ 117 2.5 1.7 7.1	<b>DRAIN</b> 2" 219 3.1 3.7 8.3	WITH M 3" 432 4.9 4.7 8.3	ODIFIED 4'' 755 5.8 8.3 7.3	PIPES 5" 947 8.8 7.2 7.7	6" 973 8.5 7.3 7.8
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.)	1" 117 2.5 1.7 7.1 1.0	<b>DRAIN</b> 2" 219 3.1 3.7 8.3 -0.4	WITH M 3" 432 4.9 4.7 8.3 -1.4	ODIFIED 4" 755 5.8 8.3 7.3 -30.6	PIPES 5" 947 8.8 7.2 7.7 -26.7	6" 973 8.5 7.3 7.8 -26.2
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.) Pressure in horizontal pipe (in. W.C.)	1" 117 2.5 1.7 7.1 1.0 -1.0	<b>DRAIN</b> 2" 219 3.1 3.7 8.3 -0.4 -1.6	WITH M 3" 432 4.9 4.7 8.3 -1.4 -8.5	ODIFIED 4'' 755 5.8 8.3 7.3 -30.6 -57.8	PIPES 5" 947 8.8 7.2 7.7 -26.7 -26.7	6" 973 8.5 7.3 7.8 -26.2 -53.8

#### 14. MANUFACTURER C, MODEL C-5

		DRAIN	<b>WITHO</b>	JT DRAI		
Water head (inch)	1′′	2″	3″	4″	5″	6''
Flow of water into box (gpm)	150	195	438	591	634	732
Velocity of flow (ft/s)	1.0	2.8	3.9	5.6	5.9	6.2
		DRA	IN WITH	10-FT I	PIPE	
Water head (inch)	1′′	2″	3″	4″	5″	6''
Flow of water into box (gpm)	150	231	449	798	1167	1630
Velocity in drain pipe (ft/s)	0.8	5.6	8.0	7.7	9.1	9.6
Pressure in drain pipe (in. W.C.)	2.7	3.4	2.8	-9.8	-30.9	-38.1
		DRAIN	<b>WITH M</b>	ODIFIED	PIPES	
Water head (inch)	1″	DRAIN 2"	<b>WITH M</b> 3"	ODIFIED 4''	<b>PIPES</b> 5"	6"
Water head (inch) Flow of water into box (gpm)	1'' 146	<b>DRAIN</b> 2'' 208	<b>WITH M</b> 3" 408	<mark>ODIFIED</mark> 4'' 778	<b>PIPES</b> 5'' 1157	6'' 1380
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s)	1'' 146 1.3	<b>DRAIN</b> 2'' 208 1.3	<b>WITH M</b> 3" 408 3.7	<b>ODIFIED</b> 4'' 778 5.4	<b>PIPES</b> 5'' 1157 6.0	6'' 1380 7.1
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s)	1″ 146 1.3 1.9	DRAIN 2" 208 1.3 2.0	WITH M 3" 408 3.7 2.9	<b>ODIFIED</b> 4'' 778 5.4 6.7	<b>PIPES</b> 5″ 1157 6.0 9.3	6'' 1380 7.1 9.4
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s)	1'' 146 1.3 1.9 6.5	<b>DRAIN</b> 2" 208 1.3 2.0 6.1	WITH M 3" 408 3.7 2.9 7.1	ODIFIED 4" 778 5.4 6.7 7.9	<b>PIPES</b> 5″ 1157 6.0 9.3 8.1	6'' 1380 7.1 9.4 7.6
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.)	1″ 146 1.3 1.9 6.5 1.5	<b>DRAIN</b> 2" 208 1.3 2.0 6.1 1.9	WITH M 3" 408 3.7 2.9 7.1 0.7	ODIFIED 4" 778 5.4 6.7 7.9 -10.5	<b>PIPES</b> 5″ 1157 6.0 9.3 8.1 -11.5	6" 1380 7.1 9.4 7.6 -14.9
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.) Pressure in horizontal pipe (in. W.C.)	1" 146 1.3 1.9 6.5 1.5 -0.6	<b>DRAIN</b> 2" 208 1.3 2.0 6.1 1.9 -0.8	WITH M 3" 408 3.7 2.9 7.1 0.7 -5.5	ODIFIED 4" 778 5.4 6.7 7.9 -10.5 -28.4	<b>PIPES</b> 5" 1157 6.0 9.3 8.1 -11.5 -53.6	6" 1380 7.1 9.4 7.6 -14.9 -56.0

#### 15. MANUFACTURER D, MODEL D-1 2" CAST IRON DRAIN WITH ALUMINUM DOME

		DRAIN	<b>WITHOU</b>	JT DRAII		
Water head (inch)	1″	2″	3″	4''	5″	6''
Flow of water into box (gpm)	29	48	51	54	75	83
Velocity of flow (ft/s)	2.2	3.6	3.2	3.8	4.4	4.7
		DRA	IN WITH	10-FT F	PIPE	
Water head (inch)	1′′	2″	3″	4''	5″	6''
Flow of water into box (gpm)	26	76	87	109	122	165
Velocity in drain pipe (ft/s)	8.6	9.0	9.0	9.0	9.0	9.0
Pressure in drain pipe (in. W.C.)	-2.3	-43.2	-49.6	-54.6	-48.6	-53.2
		DRAIN	WITH M	ODIFIED	PIPES	
Water head (inch)	1″	DRAIN 2"	<b>WITH M</b> 3"	ODIFIED 4"	<b>PIPES</b> 5"	6"
Water head (inch) Flow of water into box (gpm)	1″ 28	<b>DRAIN</b> 2'' 78	<b>WITH M</b> 3″ 85	<mark>ODIFIED</mark> 4'' 107	<b>PIPES</b> 5'' 119	6'' 155
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s)	1'' 28 3.0	<b>DRAIN</b> 2'' 78 7.2	<b>WITH M</b> 3″ 85 8.7	<b>ODIFIED</b> 4'' 107 8.2	<b>PIPES</b> 5'' 119 8.6	6'' 155 8.6
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s)	1″ 28 3.0 3.1	<b>DRAIN</b> 2" 78 7.2 5.9	WITH M 3″ 85 8.7 5.9	<b>ODIFIED</b> 4'' 107 8.2 6.5	<b>PIPES</b> 5″ 119 8.6 8.8	6'' 155 8.6 8.6
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s)	1" 28 3.0 3.1 7.8	<b>DRAIN</b> 2" 78 7.2 5.9 7.7	WITH M 3″ 85 8.7 5.9 7.8	0DIFIED 4" 107 8.2 6.5 7.3	<b>PIPES</b> 5″ 119 8.6 8.8 8.8	6'' 155 8.6 8.6 8.5
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.)	1'' 28 3.0 3.1 7.8 -6.3	<b>DRAIN</b> 2" 78 7.2 5.9 7.7 -8.8	WITH M 3″ 85 8.7 5.9 7.8 -14.7	<b>ODIFIED</b> 4" 107 8.2 6.5 7.3 -2.4	PIPES 5″ 119 8.6 8.8 8.6 -17.6	6'' 155 8.6 8.6 8.5 -19.3
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.) Pressure in horizontal pipe (in. W.C.)	1" 28 3.0 3.1 7.8 -6.3 -2.1	<b>DRAIN</b> 2" 78 7.2 5.9 7.7 -8.8 -33.3	WITH M 3" 85 8.7 5.9 7.8 -14.7 -11.3	<b>ODIFIED</b> 4" 107 8.2 6.5 7.3 -2.4 -6.6	PIPES 5" 119 8.6 8.8 8.6 -17.6 -45.4	6'' 155 8.6 8.6 8.5 -19.3 -43.7

## 16. MANUFACTURER D, MODEL D-2

3" CAST IRON DRAIN WITH ALUMINUM DOME

		DRAIN	I WITHOU	JT DRAI	N PIPE	
Water head (inch)	1′′	2″	3″	4″	5″	6''
Flow of water into box (gpm)	46	99	132	162	164	210
Velocity of flow (ft/s)	0.9	3.9	4.5	4.9	5.4	5.3
		DRA	IN WITH	10-FT	PIPE	
Water head (inch)	1′′	2″	3″	4″	5″	6''
Flow of water into box (gpm)	25	101	149	171	490	522
Velocity in drain pipe (ft/s)	5.4	8.4	8.5	9.4	11.7	11.4
Pressure in drain pipe (in. W.C.)	-0.8	-1.2	-1.6	-1.5	-34.7	-35.9
		DRAIN	<b>WITH M</b>	ODIFIED	PIPES	
Water head (inch)	1′′	DRAIN 2"	<b>WITH M</b> 3"	ODIFIED 4"	<b>PIPES</b> 5"	6"
Water head (inch) Flow of water into box (gpm)	1'' 55	<b>DRAIN</b> 2'' 106	<b>WITH M</b> 3″ 146	<mark>ODIFIED</mark> 4'' 167	<b>PIPES</b> 5'' 337	6'' 402
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s)	1'' 55 2.2	<b>DRAIN</b> 2'' 106 3.7	<b>WITH M</b> 3″ 146 3.7	<b>ODIFIED</b> 4'' 167 4.2	<b>PIPES</b> 5'' 337 4.6	6'' 402 7.3
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s)	1'' 55 2.2 3.1	<b>DRAIN</b> 2" 106 3.7 3.4	<b>WITH M</b> 3″ 146 3.7 3.8	<b>ODIFIED</b> 4'' 167 4.2 4.9	<b>PIPES</b> 5'' 337 4.6 4.7	6'' 402 7.3 7.2
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s)	1'' 55 2.2 3.1 6.4	<b>DRAIN</b> 2" 106 3.7 3.4 6.6	WITH M 3″ 146 3.7 3.8 6.9	ODIFIED 4" 167 4.2 4.9 6.9	<b>PIPES</b> 5″ 337 4.6 4.7 6.9	6'' 402 7.3 7.2 7.9
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.)	1" 55 2.2 3.1 6.4 -1.7	<b>DRAIN</b> 2" 106 3.7 3.4 6.6 -1.4	WITH M 3" 146 3.7 3.8 6.9 -1.3	ODIFIED 4" 167 4.2 4.9 6.9 -11.3	<b>PIPES</b> 5″ 337 4.6 4.7 6.9 -31.0	6" 402 7.3 7.2 7.9 -35.9
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.) Pressure in horizontal pipe (in. W.C.)	1" 55 2.2 3.1 6.4 -1.7 -1.2	<b>DRAIN</b> 2" 106 3.7 3.4 6.6 -1.4 -2.9	WITH M 3" 146 3.7 3.8 6.9 -1.3 -3.6	ODIFIED 4" 167 4.2 4.9 6.9 -11.3 -13.4	<b>PIPES</b> 5" 337 4.6 4.7 6.9 -31.0 -45.5	6" 402 7.3 7.2 7.9 -35.9 -46.1

#### 17. MANUFACTURER D, MODEL D-3 4" CAST IRON DRAIN WITH ALUMINUM DOME

		DRAIN	ωιτηοι	JT DRAI	N PIPE	
Water head (inch)	1‴	2″	3″	4″	5″	6"
Flow of water into box (gpm)	58	140	215	226	305	355
Velocity of flow (ft/s)	0.8	3.3	1.8	4.3	5.1	5.6
		DRAI	<mark>N WIT</mark> H	10-FT	PIPE	
Water head (inch)	1‴	2″	3″	4″	5″	6"
Flow of water into box (gpm)	46	147	205	341	610	710
Velocity in drain pipe (ft/s)	1.1	6.6	7.8	9.5	9.5	9.1
Pressure in drain pipe (in. W.C.)	1.6	0.5	0.5	-18.6	-33.4	-46.0
		DRAIN		ODIFIED	PIPES	
Water head (inch)	1″	DRAIN 2"	<mark>WITH M</mark> 3″	ODIFIED 4"	<b>PIPES</b> 5"	6"
Water head (inch) Flow of water into box (gpm)	1″ 52	<b>DRAIN</b> 2" 144	<mark>WITH М</mark> 3″ 196	<b>ODIFIED</b> 4'' 225	<b>PIPES</b> 5" 556	6'' 655
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s)	1″ 52 0.7	<b>DRAIN</b> 2" 144 3.3	WITH M 3'' 196 4.7	<b>ODIFIED</b> 4'' 225 5.3	577 556 8.9	6'' 655 9.1
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s)	1'' 52 0.7 2.7	<b>DRAIN</b> 2" 144 3.3 3.4	WITH M 3'' 196 4.7 3.6	0 <b>DIFIED</b> 4'' 225 5.3 4.8	577 556 8.9 9.5	6" 655 9.1 8.6
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s)	1″ 52 0.7 2.7 3.2	<b>DRAIN</b> 2'' 144 3.3 3.4 5.9	WITH M 3'' 196 4.7 3.6 6.9	0DIFIED 4" 225 5.3 4.8 7.0	<b>PIPES</b> 5" 556 8.9 9.5 7.8	6'' 655 9.1 8.6 7.3
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.)	1" 52 0.7 2.7 3.2 1.1	2" 144 3.3 3.4 5.9 0.4	WITH M 3″ 196 4.7 3.6 6.9 0.9	4" 225 5.3 4.8 7.0 0.7	<b>PIPES</b> 5" 556 8.9 9.5 7.8 -32.3	6'' 655 9.1 8.6 7.3 -33.6
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.) Pressure in horizontal pipe (in. W.C.)	1" 52 0.7 2.7 3.2 1.1 -1.6	<b>DRAIN</b> 2" 144 3.3 3.4 5.9 0.4 -2.8	WITH M 3" 196 4.7 3.6 6.9 0.9 -2.8	0DIFIED 4" 225 5.3 4.8 7.0 0.7 -3.7	<b>PIPES</b> 5" 556 8.9 9.5 7.8 -32.3 -53.8	6'' 655 9.1 8.6 7.3 -33.6 -58.0

#### 18. MANUFACTURER D, MODEL D-4

6" CAST IRON DRAIN WITH ALUMINUM DOME

		DRAIN	WITHOU	JT DRAI	N PIPE	
Water head (inch)	1′′	2″	3″	4″	5″	6''
Flow of water into box (gpm)	78	167	310	452	602	741
Velocity of flow (ft/s)	0.2	2.2	3.3	5.1	4.8	5.3
		DRA	IN WITH	10-FT	PIPE	
Water head (inch)	1′′	2″	3″	4″	5″	6''
Flow of water into box (gpm)	38	128	249	435	595	720
Velocity in drain pipe (ft/s)	0.7	4.8	6.6	7.1	7.1	8.2
Pressure in drain pipe (in. W.C.)	1.9	1.4	2.7	-2.3	-5.3	-13.7
		DRAIN	<b>WITH M</b>	ODIFIED	PIPES	
Water head (inch)	1′′	DRAIN 2"	<b>WITH М</b> 3″	ODIFIED 4"	<b>PIPES</b> 5"	6″
Water head (inch) Flow of water into box (gpm)	1'' 36	<b>DRAIN</b> 2'' 194	<b>WITH M</b> 3" 301	<mark>ODIFIED</mark> 4'' 408	<b>PIPES</b> 5'' 624	6'' 650
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s)	1'' 36 0.6	<b>DRAIN</b> 2'' 194 1.3	<b>WITH M</b> 3″ 301 3.0	<b>ODIFIED</b> 4'' 408 3.0	<b>PIPES</b> 5'' 624 4.8	6'' 650 5.2
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s)	1" 36 0.6 1.3	DRAIN 2" 194 1.3 1.9	<b>WITH M</b> 3" 301 3.0 3.3	<b>ODIFIED</b> 4" 408 3.0 4.3	<b>PIPES</b> 5'' 624 4.8 5.8	6'' 650 5.2 6.1
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s)	1" 36 0.6 1.3 2.2	<b>DRAIN</b> 2" 194 1.3 1.9 6.5	WITH M 3" 301 3.0 3.3 6.8	ODIFIED 4" 408 3.0 4.3 7.0	<b>PIPES</b> 5" 624 4.8 5.8 7.8	6'' 650 5.2 6.1 8.6
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.)	1" 36 0.6 1.3 2.2 3.2	<b>DRAIN</b> 2" 194 1.3 1.9 6.5 1.4	WITH M 3" 301 3.0 3.3 6.8 5.6	ODIFIED 4" 408 3.0 4.3 7.0 6.8	<b>PIPES</b> 5" 624 4.8 5.8 7.8 -2.4	6'' 650 5.2 6.1 8.6 -9.8
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.) Pressure in horizontal pipe (in. W.C.)	1" 36 0.6 1.3 2.2 3.2 -0.5	<b>DRAIN</b> 2" 194 1.3 1.9 6.5 1.4 -0.6	WITH M 3" 301 3.0 3.3 6.8 5.6 -0.6	ODIFIED 4'' 408 3.0 4.3 7.0 6.8 -4.7	PIPES 5" 624 4.8 5.8 7.8 -2.4 -13.2	6" 650 5.2 6.1 8.6 -9.8 -18.4

#### 19. MANUFACTURER E, MODEL E-1 2" PVC DRAIN WITH POLY DOME

		DRAIN	I WITHOU	JT DRAII			
Water head (inch)	1″	2″	3″	4''	5″	6''	7″
Flow of water into box (gpm)	*	45	58	78	95	99	103
Velocity of flow (ft/s)	*	2.8	3.7	3.9	4.0	4.1	4.4
		DRA	IN WITH	10-FT F	PIPE		
Water head (inch)	1″	2″	3″	4″	5″	6''	
Flow of water into box (gpm)	*	52	107	176	181	203	218
Velocity in drain pipe (ft/s)	*	8.1	9.0	9.0	9.0	9.0	9.0
Pressure in drain pipe (in. W.C.)	*	-2.2	-23.1	-24.3	-26.7	-27.9	-29.0
		DRAIN	<b>WITH M</b>	ODIFIED	PIPES		
Water head (inch)	1″	DRAIN 2"	<b>WITH M</b> 3"	<mark>ODIFIED</mark> 4''	<b>PIPES</b> 5"	6″	
Water head (inch) Flow of water into box (gpm)	1″ *	<b>DRAIN</b> 2" 46	<b>WITH M</b> 3" 119	<b>ODIFIED</b> 4'' 140	<b>PIPES</b> 5'' 157	6'' 161	158
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s)	1″ * *	<b>DRAIN</b> 2'' 46 4.7	<b>WITH M</b> 3" 119 7.2	<b>ODIFIED</b> 4'' 140 7.8	<b>PIPES</b> 5'' 157 8.0	6'' 161 8.0	158 8.1
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s)	1″ * *	<b>DRAIN</b> 2" 46 4.7 4.4	<b>WITH M</b> 3" 119 7.2 7.5	<b>ODIFIED</b> 4'' 140 7.8 8.6	<b>PIPES</b> 5″ 157 8.0 7.8	6'' 161 8.0 7.8	158 8.1 8.9
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s)	1″ * * *	<b>DRAIN</b> 2" 46 4.7 4.4 7.9	WITH M 3" 119 7.2 7.5 7.8	ODIFIED 4'' 140 7.8 8.6 8.5	<b>PIPES</b> 5" 157 8.0 7.8 8.9	6'' 161 8.0 7.8 8.7	158 8.1 8.9 8.7
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.)	1″ * * * *	<b>DRAIN</b> 2" 46 4.7 4.4 7.9 -3.1	WITH M 3" 119 7.2 7.5 7.8 -14.6	ODIFIED 4" 140 7.8 8.6 8.5 -21.9	PIPES 5" 157 8.0 7.8 8.9 -20.2	6'' 161 8.0 7.8 8.7 -18.3	158 8.1 8.9 8.7 -18.9
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.) Pressure in horizontal pipe (in. W.C.)	1″ * * * *	<b>DRAIN</b> 2" 46 4.7 4.4 7.9 -3.1 -4.8	WITH M 3" 119 7.2 7.5 7.8 -14.6 -29.3	<b>ODIFIED</b> 4" 140 7.8 8.6 8.5 -21.9 -44.8	PIPES 5" 157 8.0 7.8 8.9 -20.2 -44.6	6" 161 8.0 7.8 8.7 -18.3 -44.7	158 8.1 8.9 8.7 -18.9 -45.5

\* Water flows were too small for the sensors to read.

#### 20. MANUFACTURER E, MODEL E-2 4" PVC DRAIN WITH POLY DOME

		DRAIN	WITHOU	JT DRAI	N PIPE	
Water head (inch)	1″	2″	3″	4''	5″	6''
Flow of water into box (gpm)	58	113	166	210	270	302
Velocity of flow (ft/s)	0.8	1.7	3.2	3.5	3.7	4.0
		DRA	ін штн	10-FT	PIPE	
Water head (inch)	1′′	2″	3″	4''	5″	6''
Flow of water into box (gpm)	61	101	170	200	498	830
Velocity in drain pipe (ft/s)	1.1	4.9	5.8	7.6	8.0	9.5
Pressure in drain pipe (in. W.C.)	0.1	0.3	-0.8	-0.1	-29.6	-55.5
		DRAIN	<b>WITH M</b>	ODIFIED	PIPES	
Water head (inch)	1″	DRAIN 2"	<b>WITH M</b> 3″	ODIFIED 4"	<b>PIPES</b> 5"	6"
Water head (inch) Flow of water into box (gpm)	1″ 51	<b>DRAIN</b> 2'' 70	<b>WITH M</b> 3'' 142	<mark>ODIFIED</mark> 4'' 250	<b>PIPES</b> 5'' 445	6'' 640
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s)	1" 51 0.9	<b>DRAIN</b> 2'' 70 1.2	<b>WITH M</b> 3″ 142 4.5	<b>ODIFIED</b> 4'' 250 4.8	<b>PIPES</b> 5'' 445 6.9	6'' 640 7.4
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s)	1″ 51 0.9 1.6	<b>DRAIN</b> 2" 70 1.2 3.0	<b>WITH M</b> 3" 142 4.5 3.2	<b>ODIFIED</b> 4" 250 4.8 4.1	<b>PIPES</b> 5" 445 6.9 9.0	6'' 640 7.4 9.4
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s)	1'' 51 0.9 1.6 3.3	<b>DRAIN</b> 2" 70 1.2 3.0 5.2	WITH M 3" 142 4.5 3.2 6.6	ODIFIED 4" 250 4.8 4.1 6.5	<b>PIPES</b> 5″ 445 6.9 9.0 5.8	6'' 640 7.4 9.4 7.8
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.)	1" 51 0.9 1.6 3.3 1.7	<b>DRAIN</b> 2" 70 1.2 3.0 5.2 1.8	WITH M 3" 142 4.5 3.2 6.6 0.7	ODIFIED 4" 250 4.8 4.1 6.5 -4.3	<b>PIPES</b> 5″ 445 6.9 9.0 5.8 -19.1	6'' 640 7.4 9.4 7.8 -34.4
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.) Pressure in horizontal pipe (in. W.C.)	1" 51 0.9 1.6 3.3 1.7 -0.1	<b>DRAIN</b> 2" 70 1.2 3.0 5.2 1.8 -0.1	WITH M 3" 142 4.5 3.2 6.6 0.7 0.9	ODIFIED 4" 250 4.8 4.1 6.5 -4.3 -6.3	<b>PIPES</b> 5" 445 6.9 9.0 5.8 -19.1 -38.8	6" 640 7.4 9.4 7.8 -34.4 -61.4

# 21. MANUFACTURER E, MODEL E-3

4" PVC DRAIN WITH ALUMINUM DOME

		DRAIN	<b>WITHO</b>	JT DRAII	N PIPE				
Water head (inch)	1″	2″	3″	4″	5″	6''			
Flow of water into box (gpm)	26	90	189	230	242	257			
Velocity of flow (ft/s)	1.1	2.4	1.9	2.9	3.0	3.6			
	DRAIN WITH 10-FT PIPE								
Water head (inch)	1″	2″	3″	4"	5″	6"			
Flow of water into box (gpm)	34	100	184	280	472	703			
Velocity in drain pipe (ft/s)	2.3	6.0	7.5	8.1	8.5	9.1			
Pressure in drain pipe (in. W.C.)	-0.1	-0.4	-0.5	-1.5	-17.4	-50.4			
		DRAIN	<b>WITH M</b>	ODIFIED	PIPES				
Water head (inch)	1″	DRAIN 2"	<b>WITH M</b> 3"	<mark>ODIFIED</mark> 4"	<b>PIPES</b> 5"	6"			
Water head (inch) Flow of water into box (gpm)	1'' 44	<b>DRAIN</b> 2'' 125	<b>WITH M</b> 3" 186	ODIFIED 4'' 276	<b>PIPES</b> 5'' 434	6'' 606			
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s)	1'' 44 1.1	DRAIN 2'' 125 3.7	<b>WITH M</b> 3" 186 4.0	<b>ODIFIED</b> 4'' 276 6.6	<b>PIPES</b> 5'' 434 7.4	6'' 606 7.2			
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s)	1'' 44 1.1 1.9	<b>DRAIN</b> 2" 125 3.7 3.1	<b>WITH M</b> 3" 186 4.0 4.2	<b>ODIFIED</b> 4" 276 6.6 6.5	<b>PIPES</b> 5" 434 7.4 7.9	6" 606 7.2 9.2			
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s)	1″ 44 1.1 1.9 3.2	<b>DRAIN</b> 2" 125 3.7 3.1 4.8	WITH M 3" 186 4.0 4.2 6.0	ODIFIED 4" 276 6.6 6.5 7.0	<b>PIPES</b> 5'' 434 7.4 7.9 6.2	6'' 606 7.2 9.2 7.5			
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.)	1" 44 1.1 1.9 3.2 0.6	<b>DRAIN</b> 2" 125 3.7 3.1 4.8 0.5	WITH M 3" 186 4.0 4.2 6.0 -0.1	<b>ODIFIED</b> 4" 276 6.6 6.5 7.0 -14.4	<b>PIPES</b> 5'' 434 7.4 7.9 6.2 -27.8	6'' 606 7.2 9.2 7.5 -43.3			
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.) Pressure in horizontal pipe (in. W.C.)	1" 44 1.1 1.9 3.2 0.6 0.1	<b>DRAIN</b> 2" 125 3.7 3.1 4.8 0.5 0.2	WITH M 3" 186 4.0 4.2 6.0 -0.1 -0.3	ODIFIED 4'' 276 6.6 6.5 7.0 -14.4 -33.8	PIPES 5'' 434 7.4 7.9 6.2 -27.8 -48.3	6'' 606 7.2 9.2 7.5 -43.3 -63.0			

# 22. MANUFACTURER E, MODEL E-4

6" PVC DRAIN WITH ALUMINUM DOME

		DRAIN		JT DRAI	N PIPE	
Water head (inch)	1″	2″	3″	4″	5″	6''
Flow of water into box (gpm)	10	144	232	294	407	520
Velocity of flow (ft/s)	0.5	1.2	2.7	2.6	4.5	3.7
		DRA	IN WITH	10-FT I	PIPE	
Water head (inch)	1″	2″	3″	4''	5″	6''
Flow of water into box (gpm)	20	126	233	315	438	851
Velocity in drain pipe (ft/s)	0.2	2.8	5.6	5.5	5.8	7.8
Pressure in drain pipe (in. W.C.)	1.7	1.8	2.4	2.0	-2.8	-18.3
		DRAIN	WITH M	ODIFIED	PIPES	
Water head (inch)	1″	DRAIN 2"	<b>WITH M</b> 3"	ODIFIED 4''	<b>PIPES</b> 5"	6"
Water head (inch) Flow of water into box (gpm)	1'' 17	<b>DRAIN</b> 2" 96	<b>WITH M</b> 3" 215	ODIFIED 4'' 286	<b>PIPES</b> 5'' 397	6'' 693
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s)	1'' 17 0.2	<b>DRAIN</b> 2'' 96 2.4	<b>WITH M</b> 3" 215 2.6	<b>ODIFIED</b> 4'' 286 2.3	<b>PIPES</b> 5'' 397 1.3	6'' 693 4.3
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s)	1″ 17 0.2 0.9	DRAIN 2" 96 2.4 2.9	<b>WITH M</b> 3" 215 2.6 3.8	<b>ODIFIED</b> 4" 286 2.3 3.4	<b>PIPES</b> 5'' 397 1.3 3.3	6'' 693 4.3 6.4
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s)	1'' 17 0.2 0.9 1.4	<b>DRAIN</b> 2" 96 2.4 2.9 6.6	WITH M 3" 215 2.6 3.8 5.5	ODIFIED 4" 286 2.3 3.4 7.4	<b>PIPES</b> 5" 397 1.3 3.3 6.1	6" 693 4.3 6.4 7.7
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.)	1" 17 0.2 0.9 1.4 4.9	<b>DRAIN</b> 2" 96 2.4 2.9 6.6 4.5	WITH M 3" 215 2.6 3.8 5.5 5.8	ODIFIED 4" 286 2.3 3.4 7.4 7.9	<b>PIPES</b> 5" 397 1.3 3.3 6.1 -2.8	6" 693 4.3 6.4 7.7 -4.9
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.) Pressure in horizontal pipe (in. W.C.)	1" 17 0.2 0.9 1.4 4.9 -1.6	DRAIN 2" 96 2.4 2.9 6.6 4.5 -3.5	WITH M 3" 215 2.6 3.8 5.5 5.8 -3.6	ODIFIED 4" 286 2.3 3.4 7.4 7.9 -3.1	<b>PIPES</b> 5" 397 1.3 3.3 6.1 -2.8 -7.0	6" 693 4.3 6.4 7.7 -4.9 -22.1

# 23. MANUFACTURER E, MODEL E-5 4" CAST IRON DRAIN WITH POLY DOME

		DRAIN		UT DRAI	N PIPE				
Water head (inch)	1″	2″	3″	4''	5″	6''			
Flow of water into box (gpm)	17	76	162	180	215	296			
Velocity of flow (ft/s)	0.2	2.9	3.0	4.0	4.1	4.3			
	DRAIN WITH 10-FT PIPE								
Water head (inch)	1″	2″	3″	4''	5″	6''			
Flow of water into box (gpm)	16	117	185	188	215	692			
Velocity in drain pipe (ft/s)	1.4	5.8	7.0	7.5	8.0	9.4			
Pressure in drain pipe (in. W.C.)	0.1	0.3	-4.9	0.6	0.5	38.6			
		DRAIN	і	ODIFIED	PIPES				
Water head (inch)	1″	<b>DRAIN</b> 2"	<b>I WITH M</b> 3''	ODIFIED 4''	5"	6"			
Water head (inch) Flow of water into box (gpm)	1'' 47	<b>DRAIN</b> 2" 110	3'' 168	<b>ODIFIEC</b> 4'' 172	5" 362	6'' 423			
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s)	1″ 47 0.9	<b>DRAIN</b> 2'' 110 3.2	3'' 168 4.4	4'' 172 4.6	5" 362 7.1	6'' 423 8.1			
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s)	1'' 47 0.9 2.1	2" 110 3.2 3.1	3'' 168 4.4 4.6	4'' 172 4.6 4.2	5" 362 7.1 7.7	6" 423 8.1 9.2			
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s)	1'' 47 0.9 2.1 2.7	2" 110 3.2 3.1 5.7	3'' 168 4.4 4.6 7.1	4'' 172 4.6 4.2 5.1	5" 362 7.1 7.7 7.0	6'' 423 8.1 9.2 7.4			
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.)	1" 47 0.9 2.1 2.7 0.6	2" 110 3.2 3.1 5.7 0.5	3'' 168 4.4 4.6 7.1 -1.3	4" 172 4.6 4.2 5.1 0.1	5" 362 7.1 7.7 7.0 -22.9	6" 423 8.1 9.2 7.4 -34.7			
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.) Pressure in horizontal pipe (in. W.C.)	1" 47 0.9 2.1 2.7 0.6 0.2	<b>DRAIN</b> 2" 110 3.2 3.1 5.7 0.5 0.4	3'' 168 4.4 4.6 7.1 -1.3 0.6	4" 172 4.6 4.2 5.1 0.1 -1.6	5" 362 7.1 7.7 7.0 -22.9 -44.8	6" 423 8.1 9.2 7.4 -34.7 -59.4			

#### 24. MANUFACTURER E, MODEL E-6

		DRAIN	и withou	JT DRAII	N PIPE	
Water head (inch)	1″	2″	3″	4″	5″	6''
Flow of water into box (gpm)	126	213	264	329	425	508
Velocity of flow (ft/s)	0.7	1.1	4.0	2.2	3.6	3.5
		DRA	IN WITH	10-FT I	PIPE	
Water head (inch)	1″	2″	3″	4″	5″	6''
Flow of water into box (gpm)	150	135	211	281	418	873
Velocity in drain pipe (ft/s)	1.1	1.8	5.1	7.1	5.6	7.6
Pressure in drain pipe (in. W.C.)	-1.4	-1.2	-0.7	-0.5	-3.2	-17.1
		DDAIN			DIDEC	
		DRAIN			FIFES	
Water head (inch)	1″	2"	3″	4"	5"	6"
Water head (inch) Flow of water into box (gpm)	1'' 145	2" 138	3" 238	4" 257	5″ 376	6'' 712
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s)	1'' 145 1.1	2" 138 1.9	3'' 238 2.6	4'' 257 3.5	5″ 376 2.9	6'' 712 4.7
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s)	1'' 145 1.1 1.2	2" 138 1.9 2.1	3" 238 2.6 2.2	4" 257 3.5 2.8	5" 376 2.9 3.6	6'' 712 4.7 7.0
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s)	1" 145 1.1 1.2 3.2	2" 138 1.9 2.1 6.3	3" 238 2.6 2.2 6.3	4" 257 3.5 2.8 6.8	5" 376 2.9 3.6 6.5	6'' 712 4.7 7.0 7.6
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.)	1" 145 1.1 1.2 3.2 1.5	2" 138 1.9 2.1 6.3 1.3	3" 238 2.6 2.2 6.3 1.6	4" 257 3.5 2.8 6.8 3.5	5" 376 2.9 3.6 6.5 -2.5	6'' 712 4.7 7.0 7.6 -11.0
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.) Pressure in horizontal pipe (in. W.C.)	1" 145 1.1 1.2 3.2 1.5 -2.1	2" 138 1.9 2.1 6.3 1.3 -2.1	3" 238 2.6 2.2 6.3 1.6 -1.5	4" 257 3.5 2.8 6.8 3.5 -0.3	5" 376 2.9 3.6 6.5 -2.5 -2.7	6" 712 4.7 7.0 7.6 -11.0 -24.0

#### 25. MANUFACTURER E, MODEL E-7 4" CAST IRON DRAIN WITH CAST IRON DOME

		DRAIN		JT DRAII					
Water head (inch)	1″	2″	3″	4″	5″	6''			
Flow of water into box (gpm)	72	180	253	225	295	360			
Velocity of flow (ft/s)	1	3.5	4.5	3.8	5.3	5.6			
	DRAIN WITH 10-FT PIPE								
Water head (inch)	1″	2″	3″	4''	5″	6''			
Flow of water into box (gpm)	56	190	275	301	657	856			
Velocity in drain pipe (ft/s)	1.9	7.7	7.4	7.9	10.4	10.5			
Pressure in drain pipe (in. W.C.)	0.2	0.7	-12.6	-13.7	-37.4	-53.3			
	0.2 0.7 -12.6 -13.7 -37.4 -53.3								
		DRAIN	<b>WITH M</b>	ODIFIED	PIPES				
Water head (inch)	1''	DRAIN 2"	<b>WITH M</b> 3"	<mark>ODIFIED</mark> 4''	<b>PIPES</b> 5''	6"			
Water head (inch) Flow of water into box (gpm)	1″ 80	<b>DRAIN</b> 2'' 210	<b>WITH M</b> 3" 235	<mark>ODIFIED</mark> 4'' 332	<b>PIPES</b> 5'' 618	6'' 665			
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s)	1'' 80 2.6	<b>DRAIN</b> 2" 210 4.6	WITH M 3" 235 4.4	<mark>ODIFIED</mark> 4'' 332 6.9	<b>PIPES</b> 5" 618 8.7	6'' 665 9.0			
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s)	1'' 80 2.6 2.8	DRAIN 2" 210 4.6 4.2	<b>WITH M</b> 3″ 235 4.4 4.0	ODIFIED 4'' 332 6.9 7.7	<b>PIPES</b> 5″ 618 8.7 9.2	6'' 665 9.0 9.0			
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s)	1″ 80 2.6 2.8 5.6	<b>DRAIN</b> 2'' 210 4.6 4.2 6.8	WITH M 3" 235 4.4 4.0 4.4	ODIFIED 4'' 332 6.9 7.7 6.8	<b>PIPES</b> 5" 618 8.7 9.2 7.7	6'' 665 9.0 9.0 7.7			
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.)	1" 80 2.6 2.8 5.6 0.8	<b>DRAIN</b> 2" 210 4.6 4.2 6.8 -3.6	WITH M 3" 235 4.4 4.0 4.4 0.5	ODIFIED 4'' 332 6.9 7.7 6.8 -4.0	PIPES 5" 618 8.7 9.2 7.7 -31.7	6'' 665 9.0 9.0 7.7 -32.2			
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.) Pressure in horizontal pipe (in. W.C.)	1" 80 2.6 2.8 5.6 0.8 0.3	<b>DRAIN</b> 2" 210 4.6 4.2 6.8 -3.6 2.1	WITH M 3" 235 4.4 4.0 4.4 0.5 -41.6	ODIFIED 4'' 332 6.9 7.7 6.8 -4.0 -27.5	PIPES 5" 618 8.7 9.2 7.7 -31.7 -57.5	6'' 665 9.0 9.0 7.7 -32.2 -57.9			

#### 26. MANUFACTURER E, MODEL E-8

		DRAIN	ωιτηοι	JT DRAI	N PIPE	
Water head (inch)	1″	2″	3″	4″	5″	6"
Flow of water into box (gpm)	98	185	358	574	663	788
Velocity of flow (ft/s)	0.5	2.9	4.3	4.9	4.9	5.0
		DRAI	<mark>N WIT</mark> H	10-FT	PIPE	
Water head (inch)	1″	2″	3″	4"	5″	6"
Flow of water into box (gpm)	91	262	392	564	864	1471
Velocity in drain pipe (ft/s)	1.5	6.4	7.0	8.0	7.4	10.8
Pressure in drain pipe (in. W.C.)	1.7	2.0	2.5	-5.7	-15.4	-31.0
		DRAIN	<b>М НТІМ</b>	ODIFIED	PIPES	
Water head (inch)	1″	DRAIN 2"	<b>WITH М</b> 3″	ODIFIED 4"	<b>PIPES</b> 5"	6"
Water head (inch) Flow of water into box (gpm)	1'' 186	<b>DRAIN</b> 2'' 233	<mark>WITH М</mark> 3'' 409	<b>ODIFIED</b> 4'' 511	<b>PIPES</b> 5" 754	6'' 1258
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s)	1'' 186 1.6	<b>DRAIN</b> 2" 233 1.9	WITH M 3" 409 3.1	<b>ODIFIED</b> 4'' 511 3.6	<b>PIPES</b> 5'' 754 5.1	6'' 1258 6.9
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s)	1'' 186 1.6 2.2	<b>DRAIN</b> 2" 233 1.9 3.0	WITH M 3″ 409 3.1 3.7	0 <b>DIFIED</b> 4'' 511 3.6 5.0	5" 554 5.1 6.2	6'' 1258 6.9 9.1
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s)	1" 186 1.6 2.2 6.7	<b>DRAIN</b> 2" 233 1.9 3.0 5.8	WITH M 3″ 409 3.1 3.7 6.3	4" 511 3.6 5.0 7.8	<b>PIPES</b> 5" 754 5.1 6.2 8.5	6'' 1258 6.9 9.1 7.9
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.)	1'' 186 1.6 2.2 6.7 1.9	<b>DRAIN</b> 2" 233 1.9 3.0 5.8 4.6	WITH M 3" 409 3.1 3.7 6.3 5.6	4" 511 3.6 5.0 7.8 -3.2	<b>PIPES</b> 5" 754 5.1 6.2 8.5 -8.0	6'' 1258 6.9 9.1 7.9 -18.2
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.) Pressure in horizontal pipe (in. W.C.)	1" 186 1.6 2.2 6.7 1.9 -1.6	<b>DRAIN</b> 2" 233 1.9 3.0 5.8 4.6 -1.6	WITH M 3" 409 3.1 3.7 6.3 5.6 -3.2	4" 511 3.6 5.0 7.8 -3.2 -8.5	<b>PIPES</b> 5" 754 5.1 6.2 8.5 -8.0 -27.5	6" 1258 6.9 9.1 7.9 -18.2 -56.1

## 27. MANUFACTURER F, MODEL F-1 3" CAST IRON DRAIN WITH CAST IRON DOME

		DRAIN	<b>WITHOU</b>	JT DRAI	N PIPE	
Water head (inch)	1′′	2″	3″	4''	5″	6"
Flow of water into box (gpm)	120	168	225	212	244	313
Velocity of flow (ft/s)	4.3	4.0	4.5	4.4	5.1	5.3
		DRA	IN WITH	10-FT	PIPE	
Water head (inch)	1′′	2″	3″	4''	5″	6''
Flow of water into box (gpm)	105	220	137	157	261	522
Velocity in drain pipe (ft/s)	8.0	8.9	8.9	8.8	8.7	9.3
Pressure in drain pipe (in. W.C.)	9.0	7.4	5.8	-4.2	-7.4	-24.8
		DRAIN	<b>WITH M</b>	ODIFIED	PIPES	
Water head (inch)	1″	DRAIN 2"	<b>WITH M</b> 3"	ODIFIED 4"	<b>PIPES</b> 5"	6"
Water head (inch) Flow of water into box (gpm)	1'' 118	<b>DRAIN</b> 2'' 154	<b>WITH M</b> 3'' 221	ODIFIED 4'' 261	<b>PIPES</b> 5'' 287	6" 423
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s)	1″ 118 3.8	<b>DRAIN</b> 2'' 154 6.0	<b>WITH M</b> 3" 221 6.0	<b>ODIFIED</b> 4'' 261 6.0	<b>PIPES</b> 5'' 287 7.1	6" 423 8.6
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s)	1″ 118 3.8 5.5	<b>DRAIN</b> 2" 154 6.0 5.8	<b>WITH M</b> 3" 221 6.0 6.0	<b>ODIFIED</b> 4'' 261 6.0 5.7	<b>PIPES</b> 5" 287 7.1 7.6	6'' 423 8.6 8.3
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s)	1" 118 3.8 5.5 6.4	<b>DRAIN</b> 2" 154 6.0 5.8 6.9	WITH M 3" 221 6.0 6.0 7.2	<b>ODIFIED</b> 4'' 261 6.0 5.7 7.0	<b>PIPES</b> 5" 287 7.1 7.6 6.9	6" 423 8.6 8.3 7.8
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.)	1" 118 3.8 5.5 6.4 6.8	<b>DRAIN</b> 2" 154 6.0 5.8 6.9 2.6	WITH M 3" 221 6.0 6.0 7.2 5.0	<b>ODIFIED</b> 4'' 261 6.0 5.7 7.0 -4.0	<b>PIPES</b> 5″ 287 7.1 7.6 6.9 -14.7	6'' 423 8.6 8.3 7.8 -16.9
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.) Pressure in horizontal pipe (in. W.C.)	1" 118 3.8 5.5 6.4 6.8 -13.0	<b>DRAIN</b> 2" 154 6.0 5.8 6.9 2.6 -12.2	WITH M 3" 221 6.0 6.0 7.2 5.0 -12.0	ODIFIED 4'' 261 6.0 5.7 7.0 -4.0 -11.8	<b>PIPES</b> 5" 287 7.1 7.6 6.9 -14.7 -10.2	6" 423 8.6 8.3 7.8 -16.9 -9.1

## 28. MANUFACTURER F, MODEL F-2

		DRAIN	<b>WITHOU</b>	JT DRAI	N PIPE	
Water head (inch)	1′′	2″	3″	4″	5″	6''
Flow of water into box (gpm)	83	155	240	306	334	367
Velocity of flow (ft/s)	3.5	4.3	5.7	6.2	5.7	6.1
		DRA	IN WITH	10-FT	PIPE	
Water head (inch)	1′′	2″	3″	4″	5″	6''
Flow of water into box (gpm)	117	187	254	312	497	671
Velocity in drain pipe (ft/s)	4.3	7.0	7.2	7.8	8.5	8.9
Pressure in drain pipe (in. W.C.)	5.5	5.2	4.4	1.2	-15.6	-29.6
		DRAIN	<b>WITH M</b>	ODIFIED	PIPES	
Water head (inch)	1″	DRAIN 2"	<b>WITH M</b> 3"	<mark>ODIFIED</mark> 4"	<b>PIPES</b> 5"	6"
Water head (inch) Flow of water into box (gpm)	1″ 118	<b>DRAIN</b> 2'' 166	<b>WITH M</b> 3'' 239	<mark>ODIFIED</mark> 4'' 286	<b>PIPES</b> 5'' 470	6" 558
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s)	1'' 118 3.8	<b>DRAIN</b> 2'' 166 3.5	<b>WITH M</b> 3″ 239 5.1	<b>ODIFIED</b> 4'' 286 5.4	<b>PIPES</b> 5'' 470 7.9	6'' 558 7.9
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s)	1″ 118 3.8 2.3	DRAIN 2" 166 3.5 3.8	<b>WITH M</b> 3" 239 5.1 3.7	<b>ODIFIED</b> 4'' 286 5.4 6.9	<b>PIPES</b> 5'' 470 7.9 8.6	6'' 558 7.9 8.8
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s)	1'' 118 3.8 2.3 5.1	<b>DRAIN</b> 2" 166 3.5 3.8 6.0	WITH M 3" 239 5.1 3.7 6.8	ODIFIED 4" 286 5.4 6.9 5.7	<b>PIPES</b> 5″ 470 7.9 8.6 7.0	6'' 558 7.9 8.8 7.1
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.)	1" 118 3.8 2.3 5.1 4.1	<b>DRAIN</b> 2" 166 3.5 3.8 6.0 3.9	WITH M 3" 239 5.1 3.7 6.8 2.0	ODIFIED 4" 286 5.4 6.9 5.7 3.3	<b>PIPES</b> 5" 470 7.9 8.6 7.0 -15.1	6'' 558 7.9 8.8 7.1 -28.7
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.) Pressure in horizontal pipe (in. W.C.)	1" 118 3.8 2.3 5.1 4.1 -13.2	<b>DRAIN</b> 2" 166 3.5 3.8 6.0 3.9 -13.0	WITH M 3" 239 5.1 3.7 6.8 2.0 -13.2	ODIFIED 4'' 286 5.4 6.9 5.7 3.3 -11.8	<b>PIPES</b> 5" 470 7.9 8.6 7.0 -15.1 -8.4	6'' 558 7.9 8.8 7.1 -28.7 -18.7

## 29. MANUFACTURER F, MODEL F-3 5" CAST IRON DRAIN WITH CAST IRON DOME

	DRAIN WITHOUT DRAIN PIPE							
Water head (inch)	1′′	2″	3″	4''	5″	6''		
Flow of water into box (gpm)	93	174	394	476	568	588		
Velocity of flow (ft/s)	1.6	4.3	6.3	6.3	5.9	5.8		
	DRAIN WITH 10-FT PIPE							
Water head (inch)	1″	2″	3″	4″	5″	6"		
Flow of water into box (gpm)	134	204	392	476	642	848		
Velocity in drain pipe (ft/s)	5.0	7.3	8.3	9.0	10.3	9.7		
Pressure in drain pipe (in. W.C.)	-14.7	-52.2	-52.7	-54.2	-62.1	-73.0		
	DRAIN WITH MODIFIED PIPES							
		DRAIN	<b>WITH M</b>	ODIFIED	PIPES			
Water head (inch)	1″	DRAIN 2"	<b>WITH M</b> 3"	ODIFIED 4"	<b>PIPES</b> 5"	6"		
Water head (inch) Flow of water into box (gpm)	1'' 25	<b>DRAIN</b> 2'' 216	<b>WITH M</b> 3" 383	<mark>ODIFIED</mark> 4'' 467	<b>PIPES</b> 5'' 642	6'' 808		
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s)	1″ 25 2.5	<b>DRAIN</b> 2'' 216 4.0	<b>WITH M</b> 3″ 383 4.6	<b>ODIFIED</b> 4'' 467 7.5	<b>PIPES</b> 5'' 642 8.7	6'' 808 9.1		
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s)	1'' 25 2.5 4.3	<b>DRAIN</b> 2" 216 4.0 4.8	<b>WITH M</b> 3″ 383 4.6 6.1	<b>ODIFIED</b> 4'' 467 7.5 6.4	<b>PIPES</b> 5″ 642 8.7 5.3	6'' 808 9.1 7.6		
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s)	1" 25 2.5 4.3 7.2	<b>DRAIN</b> 2" 216 4.0 4.8 7.6	WITH M 3" 383 4.6 6.1 9.2	<b>ODIFIED</b> 4" 467 7.5 6.4 8.8	<b>PIPES</b> 5" 642 8.7 5.3 8.1	6'' 808 9.1 7.6 8.6		
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.)	1" 25 2.5 4.3 7.2 2.3	<b>DRAIN</b> 2" 216 4.0 4.8 7.6 2.2	WITH M 3" 383 4.6 6.1 9.2 1.2	<b>ODIFIED</b> 4'' 467 7.5 6.4 8.8 -1.7	<b>PIPES</b> 5'' 642 8.7 5.3 8.1 -8.7	6'' 808 9.1 7.6 8.6 -20.7		
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.) Pressure in horizontal pipe (in. W.C.)	1" 25 2.5 4.3 7.2 2.3 -0.9	<b>DRAIN</b> 2" 216 4.0 4.8 7.6 2.2 -2.4	WITH M 3" 383 4.6 6.1 9.2 1.2 -22.0	<b>ODIFIED</b> 4" 467 7.5 6.4 8.8 -1.7 -23.0	PIPES 5" 642 8.7 5.3 8.1 -8.7 -29.9	6'' 808 9.1 7.6 8.6 -20.7 -38.6		

## **30. MANUFACTURER F, MODEL F-4**

	DRAIN WITHOUT DRAIN PIPE							
Water head (inch)	1′′	2″	3″	4″	5″	6''		
Flow of water into box (gpm)	118	202	402	616	714	870		
Velocity of flow (ft/s)	1.8	4.5	6.2	7.8	3.3	3.2		
	DRAIN WITH 10-FT PIPE							
Water head (inch)	1′′	2″	3″	4"	5″	6''		
Flow of water into box (gpm)	120	192	397	604	704	866		
Velocity in drain pipe (ft/s)	2.4	3.2	8.2	8.8	8.9	8.6		
Pressure in drain pipe (in. W.C.)	7.4	7.6	6.9	5.5	5.3	5.6		
		DRAIN	<b>WITH M</b>	ODIFIED	PIPES			
Water head (inch)	1″	2"	3"	4''	5″	6″		
	•	-	0		5			
Flow of water into box (gpm)	117	210	401	596	916	1164		
Flow of water into box (gpm) Velocity in 1st stack (ft/s)	117 3.2	210 2.9	401 4.2	596 5.0	916 7.0	1164 8.6		
Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s)	117 3.2 0.5	210 2.9 3.2	401 4.2 5.2	596 5.0 6.5	916 7.0 7.3	1164 8.6 6.9		
Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s)	117 3.2 0.5 4.2	210 2.9 3.2 5.9	401 4.2 5.2 6.4	596 5.0 6.5 8.0	916 7.0 7.3 8.9	1164 8.6 6.9 7.9		
Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.)	117 3.2 0.5 4.2 15.5	210 2.9 3.2 5.9 17.6	401 4.2 5.2 6.4 17.3	596 5.0 6.5 8.0 18.1	916 7.0 7.3 8.9 14.2	1164 8.6 6.9 7.9 -5.4		
Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.) Pressure in horizontal pipe (in. W.C.)	117 3.2 0.5 4.2 15.5 -13.2	210 2.9 3.2 5.9 17.6 -13.2	401 4.2 5.2 6.4 17.3 -13.3	596 5.0 6.5 8.0 18.1 -13.8	916 7.0 7.3 8.9 14.2 -11.7	1164 8.6 6.9 7.9 -5.4 -10.6		

#### 31. MANUFACTURER F, MODEL F-5 3" CAST IRON DRAIN WITH CAST IRON DOME

	DRAIN WITHOUT DRAIN PIPE							
Water head (inch)	1″	2″	3″	4"	5″	6"		
Flow of water into box (gpm)	39	89	94	108	114	123		
Velocity of flow (ft/s)	0.5	4.8	5.2	5.6	5.6	5.8		
	DRAIN WITH 10-FT PIPE							
Water head (inch)	1″	2"	3″	4"	5″	6″		
Flow of water into box (gpm)	47	133	266	398	411	429		
Velocity in drain pipe (ft/s)	3.6	7.3	7.8	10.1	10.3	10.7		
Pressure in drain pipe (in. W.C.)	-0.6	-3.3	-21.8	-39.3	-40.8	-41.3		
	DRAIN WITH MODIFIED PIPES							
		DRAIN	<b>WITH M</b>	ODIFIED	PIPES			
Water head (inch)	1″	DRAIN 2"	<b>WITH M</b> 3"	<mark>ODIFIED</mark> 4''	<b>PIPES</b> 5"	6"		
Water head (inch) Flow of water into box (gpm)	1'' 49	<b>DRAIN</b> 2'' 136	<b>WITH M</b> 3″ 271	<mark>ODIFIED</mark> 4'' 293	<b>PIPES</b> 5'' 330	6'' 327		
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s)	1'' 49 2.5	<b>DRAIN</b> 2" 136 3.1	<b>WITH M</b> 3" 271 3.7	<mark>ODIFIED</mark> 4'' 293 4.2	<b>PIPES</b> 5" 330 6.5	6'' 327 7.4		
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s)	1'' 49 2.5 3.1	<b>DRAIN</b> 2" 136 3.1 3.6	<b>WITH M</b> 3″ 271 3.7 3.9	ODIFIED 4'' 293 4.2 5.1	<b>PIPES</b> 5″ 330 6.5 5.8	6'' 327 7.4 7.3		
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s)	1" 49 2.5 3.1 6.4	<b>DRAIN</b> 2" 136 3.1 3.6 6.8	WITH M 3" 271 3.7 3.9 7.0	ODIFIED 4'' 293 4.2 5.1 7.0	<b>PIPES</b> 5" 330 6.5 5.8 7.3	6'' 327 7.4 7.3 7.9		
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.)	1" 49 2.5 3.1 6.4 -1.1	<b>DRAIN</b> 2" 136 3.1 3.6 6.8 -10.9	WITH M 3" 271 3.7 3.9 7.0 -28.4	ODIFIED 4'' 293 4.2 5.1 7.0 -37.1	PIPES 5" 330 6.5 5.8 7.3 -39.1	6'' 327 7.4 7.3 7.9 -37.7		
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.) Pressure in hor. pipe (in. W.C.)	1" 49 2.5 3.1 6.4 -1.1 -1.6	<b>DRAIN</b> 2" 136 3.1 3.6 6.8 -10.9 -14.6	WITH M 3" 271 3.7 3.9 7.0 -28.4 -37.2	ODIFIED 4'' 293 4.2 5.1 7.0 -37.1 -38.7	PIPES 5" 330 6.5 5.8 7.3 -39.1 -48.5	6'' 327 7.4 7.3 7.9 -37.7 -47.5		

## 32. MANUFACTURER F, MODEL F-6

	DRAIN WITHOUT DRAIN PIPE							
Water head (inch)	1″	2″	3″	4″	5″	6''		
Flow of water into box (gpm)	43	150	130	190	229	248		
Velocity of flow (ft/s)	0.9	3.5	3.1	4.0	4.5	5.0		
	DRAIN WITH 10-FT PIPE							
Water head (inch)	1″	2″	3″	4″	5″	6''		
Flow of water into box (gpm)	45	152	317	545	680	773		
Velocity in drain pipe (ft/s)	1.5	4.6	8.5	8.6	8.9	9.3		
Pressure in drain pipe (in. W.C.)	0.3	-1.7	-12.7	-32.7	-40.8	-50.9		
	DRAIN WITH MODIFIED PIPES							
		DRAIN	<b>WITH M</b>	ODIFIED	PIPES			
Water head (inch)	1″	DRAIN 2"	<b>WITH M</b> 3"	ODIFIED 4"	<b>PIPES</b> 5"	6"		
Water head (inch) Flow of water into box (gpm)	1″ 78	<b>DRAIN</b> 2" 142	<b>WITH M</b> 3" 285	ODIFIED 4'' 503	<b>PIPES</b> 5'' 545	6'' 611		
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s)	1'' 78 0.3	<b>DRAIN</b> 2'' 142 3.6	<b>WITH M</b> 3" 285 5.4	<b>ODIFIED</b> 4'' 503 7.7	<b>PIPES</b> 5'' 545 7.8	6'' 611 7.4		
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s)	1" 78 0.3 2.8	DRAIN 2" 142 3.6 3.3	<b>WITH M</b> 3" 285 5.4 6.2	<b>ODIFIED</b> 4'' 503 7.7 8.7	<b>PIPES</b> 5" 545 7.8 9.2	6'' 611 7.4 8.9		
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s)	1" 78 0.3 2.8 5.0	<b>DRAIN</b> 2" 142 3.6 3.3 6.5	WITH M 3″ 285 5.4 6.2 6.7	ODIFIED 4" 503 7.7 8.7 7.2	<b>PIPES</b> 5″ 545 7.8 9.2 7.7	6'' 611 7.4 8.9 7.7		
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.)	1" 78 0.3 2.8 5.0 0.8	<b>DRAIN</b> 2" 142 3.6 3.3 6.5 -0.8	WITH M 3" 285 5.4 6.2 6.7 -18.3	ODIFIED 4" 503 7.7 8.7 7.2 -37.0	PIPES 5″ 545 7.8 9.2 7.7 -39.6	6" 611 7.4 8.9 7.7 -38.9		
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.) Pressure in hor. pipe (in. W.C.)	1" 78 0.3 2.8 5.0 0.8 0.3	<b>DRAIN</b> 2" 142 3.6 3.3 6.5 -0.8 -5.2	WITH M 3" 285 5.4 6.2 6.7 -18.3 -29.1	ODIFIED 4" 503 7.7 8.7 7.2 -37.0 -56.4	PIPES 5" 545 7.8 9.2 7.7 -39.6 -61.3	6" 611 7.4 8.9 7.7 -38.9 -61.2		

#### 33. MANUFACTURER F, MODEL F-7 5" CAST IRON DRAIN WITH CAST IRON DOME

	DRAIN WITHOUT DRAIN PIPE							
Water head (inch)	1″	2″	3″	4"	5″	6''		
Flow of water into box (gpm)	127	169	299	320	332	347		
Velocity of flow (ft/s)	0.2	1.8	4.1	4.6	5.1	5.5		
		DRA	IN WITH	10-FT	PIPE			
Water head (inch)	1′′	2″	3″	4"	5″	6"		
Flow of water into box (gpm)	119	149	333	556	756	982		
Velocity in drain pipe (ft/s)	4.9	5.8	7.9	9.3	9.2	9.2		
Pressure in drain pipe (in. W.C.)	1.3	-0.2	-0.8	-14.2	-27.4	-23.7		
	DRAIN WITH MODIFIED PIPES							
		DRAIN	<b>WITH M</b>	ODIFIED	PIPES			
Water head (inch)	1″	<b>DRAIN</b> 2"	<b>WITH M</b> 3"	<mark>ODIFIED</mark> 4''	<b>PIPES</b> 5"	6"		
Water head (inch) Flow of water into box (gpm)	1'' 148	<b>DRAIN</b> 2'' 181	<b>WITH M</b> 3" 346	<mark>ODIFIED</mark> 4" 528	<b>PIPES</b> 5'' 769	6'' 915		
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s)	1'' 148 2.0	<b>DRAIN</b> 2'' 181 2.3	<b>WITH M</b> 3″ 346 2.9	<b>ODIFIED</b> 4'' 528 5.6	<b>PIPES</b> 5'' 769 5.7	6'' 915 8.1		
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s)	1″ 148 2.0 1.1	<b>DRAIN</b> 2" 181 2.3 0.7	WITH M 3" 346 2.9 3.7	<b>ODIFIED</b> 4" 528 5.6 5.5	<b>PIPES</b> 5" 769 5.7 8.9	6" 915 8.1 6.0		
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s)	1″ 148 2.0 1.1 7.8	<b>DRAIN</b> 2'' 181 2.3 0.7 7.8	WITH M 3" 346 2.9 3.7 8.2	ODIFIED 4'' 528 5.6 5.5 8.7	<b>PIPES</b> 5" 769 5.7 8.9 7.5	6'' 915 8.1 6.0 7.0		
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.)	1'' 148 2.0 1.1 7.8 1.0	<b>DRAIN</b> 2" 181 2.3 0.7 7.8 -0.4	WITH M 3" 346 2.9 3.7 8.2 -2.5	0DIFIED 4'' 528 5.6 5.5 8.7 -12.2	PIPES 5" 769 5.7 8.9 7.5 -36.8	6" 915 8.1 6.0 7.0 -28.5		
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.) Pressure in hor. pipe (in. W.C.)	1" 148 2.0 1.1 7.8 1.0 -1.0	DRAIN 2" 181 2.3 0.7 7.8 -0.4 -1.2	WITH M 3" 346 2.9 3.7 8.2 -2.5 -9.0	ODIFIED 4'' 528 5.6 5.5 8.7 -12.2 -36.0	PIPES 5" 769 5.7 8.9 7.5 -36.8 -35.6	6" 915 8.1 6.0 7.0 -28.5 -61.2		

#### 34. MANUFACTURER F, MODEL F-8

	DRAIN WITHOUT DRAIN PIPE							
Water head (inch)	1″	2″	3″	4″	5″	6''		
Flow of water into box (gpm)	133	228	371	537	427	551		
Velocity of flow (ft/s)	0.4	0.5	1.6	3.2	2.4	3.0		
		DRA	IN WITH	10-FT	PIPE			
Water head (inch)	1″	2″	3″	4″	5″	6''		
Flow of water into box (gpm)	153	156	347	534	803	1062		
Velocity in drain pipe (ft/s)	0.4	2.1	5.3	6.8	7.2	7.3		
Pressure in drain pipe (in. W.C.)	1.2	1.0	-0.8	-5.8	-14.2	-31.9		
	DRAIN WITH MODIFIED PIPES							
		DRAIN	<b>WITH M</b>	ODIFIED	PIPES			
Water head (inch)	1″	DRAIN 2"	<b>WITH M</b> 3"	ODIFIED 4"	<b>PIPES</b> 5"	6"		
Water head (inch) Flow of water into box (gpm)	1'' 122	<b>DRAIN</b> 2" 208	<b>WITH M</b> 3'' 339	<mark>ODIFIED</mark> 4'' 526	<b>PIPES</b> 5'' 731	6'' 975		
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s)	1'' 122 0.5	DRAIN 2" 208 0.9	<b>WITH M</b> 3" 339 1.7	<b>ODIFIED</b> 4'' 526 3.3	<b>PIPES</b> 5'' 731 5.5	6'' 975 7.5		
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s)	1″ 122 0.5 2.4	DRAIN 2" 208 0.9 1.8	WITH M 3" 339 1.7 3.4	<b>ODIFIED</b> 4" 526 3.3 4.6	<b>PIPES</b> 5" 731 5.5 5.6	6'' 975 7.5 6.9		
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s)	1" 122 0.5 2.4 5.5	DRAIN 2" 208 0.9 1.8 7.2	WITH M 3" 339 1.7 3.4 6.6	ODIFIED 4'' 526 3.3 4.6 7.5	<b>PIPES</b> 5" 731 5.5 5.6 8.5	6'' 975 7.5 6.9 8.8		
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.)	1" 122 0.5 2.4 5.5 1.0	DRAIN 2" 208 0.9 1.8 7.2 1.8	WITH M 3" 339 1.7 3.4 6.6 0.9	ODIFIED 4" 526 3.3 4.6 7.5 -1.5	<b>PIPES</b> 5" 731 5.5 5.6 8.5 -12.1	6'' 975 7.5 6.9 8.8 -31.5		
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.) Pressure in hor. pipe (in. W.C.)	1" 122 0.5 2.4 5.5 1.0 -2.3	DRAIN 2" 208 0.9 1.8 7.2 1.8 -2.1	WITH M 3" 339 1.7 3.4 6.6 0.9 -1.6	ODIFIED 4'' 526 3.3 4.6 7.5 -1.5 -9.2	PIPES 5" 731 5.5 5.6 8.5 -12.1 -21.2	6" 975 7.5 6.9 8.8 -31.5 -44.0		
	DRAIN WITHOUT DRAIN PIPE							
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Water head (inch)	1″	2″	3″	4″	5″	6''		
Flow of water into box (gpm)	18	40	51	70	78	89		
Velocity of flow (ft/s)	1.2*	4.3	4.7	4.8	4.3	4.6		
		DRA	IN WITH	10-FT I	PIPE			
Water head (inch)	1″	2"	3″	4"	5″	6''		
Flow of water into box (gpm)	10	91	125	149	162	177		
Velocity in drain pipe (ft/s)	2.4	9.0	9.0	9.0	9.0	9.0		
Pressure in drain pipe (in. W.C.)	1.3	1.2	0.9	0.8	0.7	0.8		
	1.3 1.2 0.9 0.8 0.7 0.8							
		DRAIN	<b>WITH M</b>	ODIFIED	PIPES			
Water head (inch)	1″	<b>DRAIN</b> 2"	<b>WITH M</b> 3"	<mark>ODIFIED</mark> 4''	<b>PIPES</b> 5"	6''		
Water head (inch) Flow of water into box (gpm)	1'' 11	<b>DRAIN</b> 2" 88	<b>WITH M</b> З″ 111	<mark>ODIFIED</mark> 4'' 120	<b>PIPES</b> 5'' 126	6'' 140		
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s)	1'' 11 2.8	DRAIN 2" 88 3.2	<b>WITH M</b> 3'' 111 7.7	<b>ODIFIED</b> 4'' 120 7.2	<b>PIPES</b> 5'' 126 8.1	6'' 140 8.1		
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s)	1″ 11 2.8 1.4	DRAIN 2" 88 3.2 7.3	WITH M 3" 111 7.7 8.7	<b>ODIFIED</b> 4'' 120 7.2 7.5	<b>PIPES</b> 5" 126 8.1 8.8	6'' 140 8.1 9.0		
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s)	1" 11 2.8 1.4 1.2	DRAIN 2'' 88 3.2 7.3 7.1	WITH M 3" 111 7.7 8.7 8.6	0DIFIED 4'' 120 7.2 7.5 7.4	<b>PIPES</b> 5" 126 8.1 8.8 8.6	6'' 140 8.1 9.0 8.7		
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.)	1" 11 2.8 1.4 1.2 0.5	DRAIN 2" 88 3.2 7.3 7.1 -17.0	WITH M 3" 111 7.7 8.7 8.6 -22.5	ODIFIED 4'' 120 7.2 7.5 7.4 -21.0	PIPES 5" 126 8.1 8.8 8.6 -21.0	6'' 140 8.1 9.0 8.7 -20.4		
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.) Pressure in hor. pipe (in. W.C.)	1" 11 2.8 1.4 1.2 0.5 0.3	DRAIN 2" 88 3.2 7.3 7.1 -17.0 -28.0	WITH M 3" 111 7.7 8.7 8.6 -22.5 -41.6	ODIFIED 4" 120 7.2 7.5 7.4 -21.0 -30.3	PIPES 5" 126 8.1 8.8 8.6 -21.0 -44.3	6" 140 8.1 9.0 8.7 -20.4 -43.3		

\* Water flow was too small for the sensor to read consistently. This was an approximate number.

#### 36. MANUFACTURER G, MODEL G-2 3" PVC DRAIN WITH ABS DOME

		DRAIN		JT DRAI	N PIPE	
Water head (inch)	1″	2″	3″	4″	5″	6''
Flow of water into box (gpm)	9	94	126	144	166	187
Velocity of flow (ft/s)	0.5	4.8	5.1	5.5	5.4	5.3
		DRA	IN WITH	10-FT	PIPE	
Water head (inch)	1‴	2″	3″	4"	5″	6''
Flow of water into box (gpm)	16	95	140	195	475	500
Velocity in drain pipe (ft/s)	3.6	8.2	8.4	10.2	10.5	10.7
Pressure in drain pipe (in. W.C.)	-1.8	-17.1	-19.8	-24.3	-38.9	-39.7
		DRAIN	<b>WITH M</b>	ODIFIED	PIPES	
Water head (inch)	1‴	2″	3″	4"	5″	6''
Flow of water into box (gpm)	22	102	205	260	384	409
Velocity in 1st stack (ft/s)	0.5	4.3	4.3	6.9	7.5	7.6
Velocity in horizontal pipe (ft/s)	2.2	4.5	4.2	5.4	8.9	9.1
Velocity in 2nd stack (ft/s)	3.5	7.2	7.2	6.8	7.7	7.8
Pressure in 1st stack (in. W.C.)	0.1	-4.4	-10.7	-11.0	-27.7	-34.3
Pressure in hor nine (in $WC$ )		1 7	~ 7	<u></u>	47.0	40.0
	0.2	-1.7	-2.1	-23.4	-47.9	-40.9

### 37. MANUFACTURER G, MODEL G-3 4" PVC DRAIN WITH ABS DOME

		DRAIN	и wітно	JT DRAII		
Water head (inch)	1″	2″	3″	4"	5″	6''
Flow of water into box (gpm)	16	118	247	265	289	314
Velocity of flow (ft/s)	0.8	2.9	4.6	5.4	6.0	5.2
		DRA	IN WITH	10-FT	PIPE	
Water head (inch)	1″	2″	3″	4"	5″	6''
Flow of water into box (gpm)	24	103	258	480	745	847
Velocity in drain pipe (ft/s)	1.6	4.9	7.9	8.0	9.3	10.1
Pressure in drain pipe (in. W.C.)	0.1	-0.5	-7.8	-29.8	-46.9	-51.3
		DRAIN	<b>WITH M</b>	ODIFIED	PIPES	
Water head (inch)	1″	2″	3″	4"	5″	6''
Flow of water into box (gpm)	22	113	253	460	598	567
Velocity in 1st stack (ft/s)	1.2	4.5	5.6	7.4	7.5	7.7
Velocity in horizontal pipe (ft/s)	1.4	2.8	5.4	8.7	9.3	9.4
Velocity in 2nd stack (ft/s)	2.8	6.8	6.8	7.1	7.7	7.7
Pressure in 1st stack (in. W.C.)	0.1	-1.3	-8.1	-25.7	-36.7	-36.0
Pressure in hor. pipe (in. W.C.)	0.3	-1.6	-15.8	-45.7	-59.6	-59.1
Pressure in 2nd stack (in. W.C.)	-0.5	-1.0	-10.5	-49.1	-49.4	-50.8

# 38. MANUFACTURER G, MODEL G-4

6" PVC DRAIN WITH ABS DOME

		DRAIN		JT DRAI	N PIPE	
Water head (inch)	1″	2″	3″	4″	5″	6''
Flow of water into box (gpm)	92	112	217	432	690	804
Velocity of flow (ft/s)	0.2	1.1	2.9	4.4	4.5	4.5
		DRA	IN WITH	10-FT	PIPE	
Water head (inch)	1″	2″	3″	4″	5″	6''
Flow of water into box (gpm)	118	112	240	462	764	1142
Velocity in drain pipe (ft/s)	0.1	0.5	6.1	8.1	7.3	9.1
Pressure in drain pipe (in. W.C.)	1.5	2.1	2.6	2.2	-9.3	-25.0
		DRAIN	<b>WITH M</b>	ODIFIED	PIPES	
Water head (inch)	1″	2″	3″	4''	5″	6''
Flow of water into box (gpm)	101	108	248	450	718	1120
Velocity in 1st stack (ft/s)	0.2	0.1	3.4	3.7	5.2	7.2
Velocity in horizontal pipe (ft/s)	1.4	1.1	2.1	3.7	5.6	8.7
Velocity in 2nd stack (ft/s)	3.7	5.7	6.0	6.5	7.9	8.2
Pressure in 1st stack (in. W.C.)	0.7	-0.3	3.9	5.8	-1.3	-18.1
Pressure in hor. pipe (in. W.C.)	-2.1	-2.0	-2.2	-0.3	-15.0	-35.6
Pressure in 2nd stack (in WC)	0.9	0.9	-0.2	-7.0	-25.4	-50.7

#### 39. MANUFACTURER H, MODEL H-1 2" CAST IRON DRAIN WITH CAST IRON DOME

		DRAIN		UT DRAI		
Water head (inch)	1″	2″	3″	4''	5″	6''
Flow of water into box (gpm)	13	52	54	65	74	88
Velocity of flow (ft/s)	0.7*	3.0	3.5	3.7	3.9	4.2
		DRA	AIN WITH	10-FT	PIPE	
Water head (inch)	1″	2″	3″	4''	5″	6"
Flow of water into box (gpm)	11	75	139	149	191	203
Velocity in drain pipe (ft/s)	0.8*	9.0	8.6	9.0	9.0	9.0
Pressure in drain pipe (in. W.C.)	1.7	-12.3	-36.7	-28.3	-28.1	-37.3
		DRAIN	і <mark></mark> ітн м	ODIFIED	PIPES	
Water head (inch)	1″	2″	3″	4''	5″	6"
Flow of water into box (gpm)	11	79	103	114	121	139
Velocity in 1st stack (ft/s)	1.4	6.3	8.1	8.1	8.1	8.1
Velocity in horizontal pipe (ft/s)	1.5	6.7	8.9	8.1	7.7	9.0
Velocity in 2nd stack (ft/s)	4.2	6.9	8.5	7.6	7.7	8.6
Pressure in 1st stack (in. W.C.)	-1.2	-5.6	-8.7	-18.5	-16.7	-18.6
Pressure in hor. pipe (in. W.C.)	-2.4	-12.4	-18.9	-18.9	-35.6	-44.7
Pressure in 2nd stack (in WC)	-2.1	-10 5	-22 /	-20 E	- 10 2	- 17 2

\* Water flows were too small for the sensor to read consistently. These are approximate numbers.

# 40. MANUFACTURER H, MODEL H-2

	DRAIN WITHOUT DRAIN PIPE							
Water head (inch)	1′′	2″	3″	4''	5″	6''		
Flow of water into box (gpm)	18	90	101	172	178	300		
Velocity of flow (ft/s)	0.9	2.9	3.1	4.1	6.4	6.4		
		DRA	IN WITH	10-FT I	PIPE			
Water head (inch)	1″	2″	3″	4"	5″	6''		
Flow of water into box (gpm)	16	91	208	226	239	498		
Velocity in drain pipe (ft/s)	2.6	7.9	8.8	9.1	10.8	10.9		
Pressure in drain pipe (in. W.C.)	0.9	-0.6	-19.6	-30.1	-32.8	-35.4		
	0.9 -0.6 -19.6 -30.1 -32.8 -35.4							
		DRAIN	WITH M	ODIFIED	PIPES			
Water head (inch)	1″	DRAIN 2"	<b>WITH M</b> 3"	<mark>ODIFIED</mark> 4''	<b>PIPES</b> 5"	6"		
Water head (inch) Flow of water into box (gpm)	1'' 20	<b>DRAIN</b> 2'' 104	<b>WITH M</b> 3'' 231	ODIFIED 4'' 262	<b>PIPES</b> 5'' 332	6'' 410		
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s)	1'' 20 0.9	<b>DRAIN</b> 2" 104 4.3	<b>WITH M</b> 3″ 231 7.5	<b>ODIFIED</b> 4" 262 8.2	<b>PIPES</b> 5'' 332 8.3	6'' 410 8.3		
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s)	1″ 20 0.9 1.5	DRAIN 2" 104 4.3 4.8	<b>WITH M</b> 3" 231 7.5 7.9	<b>ODIFIED</b> 4'' 262 8.2 8.1	<b>PIPES</b> 5" 332 8.3 8.4	6'' 410 8.3 9.5		
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s)	1" 20 0.9 1.5 2.0	DRAIN 2" 104 4.3 4.8 7.1	WITH M 3" 231 7.5 7.9 6.7	ODIFIED 4" 262 8.2 8.1 7.3	<b>PIPES</b> 5" 332 8.3 8.4 8.0	6'' 410 8.3 9.5 8.0		
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.)	1" 20 0.9 1.5 2.0 0.5	DRAIN 2" 104 4.3 4.8 7.1 -3.8	WITH M 3" 231 7.5 7.9 6.7 -22.0	ODIFIED 4" 262 8.2 8.1 7.3 -31.3	<b>PIPES</b> 5" 332 8.3 8.4 8.0 -29.8	6" 410 8.3 9.5 8.0 -28.5		
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.) Pressure in hor. pipe (in. W.C.)	1" 20 0.9 1.5 2.0 0.5 0.5	DRAIN 2" 104 4.3 4.8 7.1 -3.8 -2.4	WITH M 3" 231 7.5 7.9 6.7 -22.0 -26.7	ODIFIED 4'' 262 8.2 8.1 7.3 -31.3 -29.8	<b>PIPES</b> 5" 332 8.3 8.4 8.0 -29.8 -45.2	6" 410 8.3 9.5 8.0 -28.5 -42.7		

### 41. MANUFACTURER H, MODEL H-3 4" CAST IRON DRAIN WITH CAST IRON DOME

		DRAIN		UT DRAI	N PIPE	
Water head (inch)	1″	2″	3″	4''	5″	6''
Flow of water into box (gpm)	16	102	245	239	281	300
Velocity of flow (ft/s)	0.9	1.7	4.5	4.5	4.9	5.5
		DRA	IN WITH	10-FT I	PIPE	
Water head (inch)	1″	2″	3″	4''	5″	6''
Flow of water into box (gpm)	50	110	234	468	642	813
Velocity in drain pipe (ft/s)	1.3	4.4	7.9	8.8	8.8	9.6
Pressure in drain pipe (in. W.C.)	0.4	-1.2	-1.6	-26.1	-35.8	-54.5
		DRAIN	WITH M	ODIFIED	PIPES	
Water head (inch)	1″	DRAIN 2"	<b>WITH M</b> 3"	ODIFIED 4"	<b>PIPES</b> 5"	6"
Water head (inch) Flow of water into box (gpm)	1'' 46	<b>DRAIN</b> 2'' 111	<b>WITH M</b> 3" 234	<mark>ODIFIED</mark> 4'' 456	<b>PIPES</b> 5'' 640	6'' 682
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s)	1'' 46 1.8	<b>DRAIN</b> 2'' 111 3.0	<b>WITH M</b> 3" 234 4.9	<b>ODIFIED</b> 4'' 456 5.8	<b>PIPES</b> 5'' 640 7.5	6'' 682 7.6
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s)	1″ 46 1.8 2.1	<b>DRAIN</b> 2" 111 3.0 3.1	<b>WITH M</b> 3" 234 4.9 4.7	<b>ODIFIED</b> 4'' 456 5.8 8.4	<b>PIPES</b> 5'' 640 7.5 9.7	6'' 682 7.6 9.5
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s)	1" 46 1.8 2.1 2.9	<b>DRAIN</b> 2" 111 3.0 3.1 6.1	WITH M 3" 234 4.9 4.7 6.2	ODIFIED 4'' 456 5.8 8.4 7.1	<b>PIPES</b> 5" 640 7.5 9.7 8.0	6'' 682 7.6 9.5 7.7
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.)	1'' 46 1.8 2.1 2.9 0.1	<b>DRAIN</b> 2" 111 3.0 3.1 6.1 -0.5	WITH M 3" 234 4.9 4.7 6.2 -1.0	ODIFIED 4" 456 5.8 8.4 7.1 -24.6	<b>PIPES</b> 5" 640 7.5 9.7 8.0 -35.5	6'' 682 7.6 9.5 7.7 -35.4
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.) Pressure in hor. pipe (in. W.C.)	1" 46 1.8 2.1 2.9 0.1 -0.3	<b>DRAIN</b> 2" 111 3.0 3.1 6.1 -0.5 -0.8	WITH M 3" 234 4.9 4.7 6.2 -1.0 -6.8	ODIFIED 4'' 5.8 8.4 7.1 -24.6 -48.2	<b>PIPES</b> 5" 640 7.5 9.7 8.0 -35.5 -59.0	6'' 682 7.6 9.5 7.7 -35.4 -57.7

#### 42. MANUFACTURER H, MODEL H-4

		DRAIN	WITHOU	JT DRAI	N PIPE	
Water head (inch)	1″	2″	3″	4″	5″	6''
Flow of water into box (gpm)	160	155	340	365	458	494
Velocity of flow (ft/s)	0.7	1.8	3.1	4.8	4.9	5.3
		DRA	N WITH	10-FT	PIPE	
Water head (inch)	1″	2″	3″	4″	5″	6″
Flow of water into box (gpm)	128	184	264	484	716	1016
Velocity in drain pipe (ft/s)	2.2	6.2	7.1	8.6	9.3	9.5
Pressure in drain pipe (in. W.C.)	1.6	1.1	-0.8	-9.6	-20.6	-21.1
		DRAIN	<b>WITH M</b>	ODIFIED	PIPES	
Water head (inch)	1″	<b>DRAIN</b> 2"	<b>WITH М</b> 3″	ODIFIED 4"	<b>PIPES</b> 5"	6''
Water head (inch) Flow of water into box (gpm)	1'' 40	<b>DRAIN</b> 2'' 125	<mark>WITH М</mark> 3″ 270	<b>ODIFIED</b> 4'' 447	<b>PIPES</b> 5'' 675	6'' 874
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s)	1'' 40 1.7	<b>DRAIN</b> 2" 125 2.7	<mark>WITH M</mark> 3" 270 4.6	<b>ODIFIED</b> 4'' 447 5.9	5" 675 5.9	6'' 874 7.5
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s)	1'' 40 1.7 0.4	<b>DRAIN</b> 2″ 125 2.7 1.9	WITH M 3" 270 4.6 3.1	0 <b>DIFIEC</b> 4'' 447 5.9 5.7	5" 575 5.9 6.4	6'' 874 7.5 7.0
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s)	1" 40 1.7 0.4 7.1	<b>DRAIN</b> 2" 125 2.7 1.9 7.9	WITH M 3″ 270 4.6 3.1 8.0	0 <b>DIFIEC</b> 4'' 447 5.9 5.7 8.2	<b>PIPES</b> 5" 675 5.9 6.4 8.0	6'' 874 7.5 7.0 7.5
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.)	1'' 40 1.7 0.4 7.1 1.1	<b>DRAIN</b> 2" 125 2.7 1.9 7.9 1.2	WITH M 3" 270 4.6 3.1 8.0 -2.3	4" 447 5.9 5.7 8.2 -11.0	<b>PIPES</b> 5" 675 5.9 6.4 8.0 -18.2	6'' 874 7.5 7.0 7.5 -25.9
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.) Pressure in hor. pipe (in. W.C.)	1" 40 1.7 0.4 7.1 1.1 -1.0	<b>DRAIN</b> 2" 125 2.7 1.9 7.9 1.2 -0.9	WITH M 3″ 270 4.6 3.1 8.0 -2.3 -11.8	4'' 447 5.9 5.7 8.2 -11.0 -19.4	<b>PIPES</b> 5" 675 5.9 6.4 8.0 -18.2 -50.1	6" 874 7.5 7.0 7.5 -25.9 -59.1

### 43. MANUFACTURER H, MODEL H-5 6" CAST IRON DRAIN WITH CAST IRON DOME

		DRAIN	и жітно	JT DRAI		
Water head (inch)	1″	2″	3″	4"	5″	6''
Flow of water into box (gpm)	12	128	243	460	609	647
Velocity of flow (ft/s)	0.6	1.2	2.0	2.3	3.8	4.6
		DRA	IN WITH	10-FT I	PIPE	
Water head (inch)	1″	2″	3″	4″	5″	6''
Flow of water into box (gpm)	28	128	298	491	753	1134
Velocity in drain pipe (ft/s)	0.5	3.1	7.2	7.4	7.2	8.7
Pressure in drain pipe (in. W.C.)	1.2	1.5	2.5	-1.8	-9.0	-29.5
		DRAIN	<b>WITH M</b>	ODIFIED	PIPES	
Water head (inch)		<b>.</b>	2"	<i>\\</i> ''	E''	6''
water neau (inch)	1″	2"	3	-	Э	0
Flow of water into box (gpm)	1″ 10	2" 124	3 274	487	5 668	1012
Flow of water into box (gpm) Velocity in 1st stack (ft/s)	1″ 10 0.5	2‴ 124 0.7	3 274 3.2	487 3.2	5 668 3.5	1012 5.9
Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s)	1″ 10 0.5 1.5	2" 124 0.7 1.3	3 274 3.2 3.0	487 3.2 4.8	5 668 3.5 5.7	1012 5.9 9.5
Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s)	1″ 10 0.5 1.5 3.0	2" 124 0.7 1.3 6.5	3 274 3.2 3.0 5.3	487 3.2 4.8 7.0	5 668 3.5 5.7 8.3	1012 5.9 9.5 8.9
Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.)	1" 10 0.5 1.5 3.0 1.3	2 <sup>27</sup> 124 0.7 1.3 6.5 1.2	3 274 3.2 3.0 5.3 1.0	487 3.2 4.8 7.0 -0.5	5 668 3.5 5.7 8.3 -6.7	1012 5.9 9.5 8.9 -20.2
Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.) Pressure in hor. pipe (in. W.C.)	1" 10 0.5 1.5 3.0 1.3 -1.8	2" 124 0.7 1.3 6.5 1.2 -1.9	3 274 3.2 3.0 5.3 1.0 -2.4	487 3.2 4.8 7.0 -0.5 -5.0	5 668 3.5 5.7 8.3 -6.7 -22.8	1012 5.9 9.5 8.9 -20.2 -45.0

#### 44. MANUFACTURER I, MODEL I-1 2" PVC DRAIN WITH POLY DOME

		DRAIN	ι <mark>ωιτ</mark> Ηοι	JT DRAII			
Water head (inch)	1″	2″	3″	4″	5″	6''	
Flow of water into box (gpm)	*	38	65	75	67	66	
Velocity of flow (ft/s)	*	2.2	3.7	3.0	3.5	4.1	
		DRA	IN WITH	10-FT F	PIPE		
Water head (inch)	1″	2″	3″	4″	5″	6''	7″
Flow of water into box (gpm)	*	36	102	126	161	183	177
Velocity in drain pipe (ft/s)	*	8.1	9.0	9.0	9.0	9.0	9.0
Pressure in drain pipe (in, W.C.)	*	-1.2	-16.8	-37.4	-50.1	-50.9	-51.8
		DRAIN	WITH M	ODIFIED	PIPES		
Water head (inch)	1″	DRAIN 2"	<b>WITH M</b> 3"	<mark>ODIFIED</mark> 4''	<b>PIPES</b> 5"	6"	7"
Water head (inch) Flow of water into box (gpm)	1″ *	<b>DRAIN</b> 2'' 46	<b>WITH M</b> 3″ 68	<mark>ODIFIED</mark> 4'' 83	<b>PIPES</b> 5" 78	6'' 92	7'' 96
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s)	1'' * *	<b>DRAIN</b> 2" 46 4.1	<b>WITH M</b> 3" 68 6.3	<b>ODIFIED</b> 4'' 83 4.7	<b>PIPES</b> 5'' 78 5.6	6" 92 5.1	7'' 96 5.1
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s)	1″ * *	<b>DRAIN</b> 2" 46 4.1 3.5	<b>WITH M</b> 3" 68 6.3 5.2	<b>ODIFIED</b> 4'' 83 4.7 5.2	<b>PIPES</b> 5'' 78 5.6 6.0	6'' 92 5.1 5.4	7'' 96 5.1 5.8
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s)	1″ * * *	<b>DRAIN</b> 2" 46 4.1 3.5 8.5	WITH M 3" 68 6.3 5.2 7.8	ODIFIED 4" 83 4.7 5.2 7.2	<b>PIPES</b> 5" 78 5.6 6.0 7.1	6" 92 5.1 5.4 7.3	7'' 96 5.1 5.8 7.2
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.)	1'' * * *	DRAIN 2" 46 4.1 3.5 8.5 -1.8	WITH M 3" 68 6.3 5.2 7.8 -6.2	0DIFIED 4" 83 4.7 5.2 7.2 -1.2	<b>PIPES</b> 5" 78 5.6 6.0 7.1 -3.7	6" 92 5.1 5.4 7.3 -1.3	7'' 96 5.1 5.8 7.2 -2.8
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.) Pressure in hor. pipe (in. W.C.)	1'' * * * *	DRAIN 2" 46 4.1 3.5 8.5 -1.8 -5.8	WITH M 3" 68 6.3 5.2 7.8 -6.2 -9.0	ODIFIED 4'' 83 4.7 5.2 7.2 -1.2 -7.9	<b>PIPES</b> 5" 78 5.6 6.0 7.1 -3.7 -11.0	6" 92 5.1 5.4 7.3 -1.3 -10.0	7'' 96 5.1 5.8 7.2 -2.8 -4.5

\* Water flows were too small for sensor to read.

### 45. MANUFACTURER I, MODEL I-2 3" PVC DRAIN WITH POLY DOME

		DRAIN	ι <mark></mark>	JT DRAI	N PIPE	
Water head (inch)	1″	2″	3″	4″	5″	6''
Flow of water into box (gpm)	12	93	147	233	292	340
Velocity of flow (ft/s)	0.7	2.8	4.8	5.1	5.4	6.1
		DRA	IN WITH	10-FT	PIPE	
Water head (inch)	1′′	2″	3″	4''	5″	6''
Flow of water into box (gpm)	13	50	119	188	379	474
Velocity in drain pipe (ft/s)	2.1	6.9	7.6	9.8	9.9	10.3
Pressure in drain pipe (in. W.C.)	2.1	6.9	7.6	9.8	9.9	10.3
		DRAIN	<b>WITH M</b>	ODIFIED	PIPES	
Water head (inch)	1′′	2″	3″	4''	5″	6''
Flow of water into box (gpm)	14	49	118	215	298	399
Velocity in 1st stack (ft/s)	0.0	3.8	4.9	7.2	8.0	7.5
Velocity in horizontal pipe (ft/s)	1.7	2.7	5.4	6.4	8.8	9.3
Velocity in 2nd stack (ft/s)	2.6	6.9	6.9	6.5	7.3	7.7
Pressure in 1st stack (in. W.C.)	1.1	0.3	-6.6	-16.6	-31.8	-33.8
Pressure in hor. pipe (in. W.C.)	-0.1	-0.3	-16.1	-20.1	-46.0	-47.4

### 46. MANUFACTURER I, MODEL I-3

4" PVC DRAIN WITH POLY DOME

	DRAIN WITHOUT DRAIN PIPE								
Water head (inch)	1″	2″	3″	4″	5″	6''			
Flow of water into box (gpm)	12	93	147	233	292	340			
Velocity of flow (ft/s)	0.7	1.6	4.0	4.0	5.7	5.6			
		DRA	IN WITH	10-FT	PIPE				
Water head (inch)	1″	2″	3″	4″	5″	6''			
Flow of water into box (gpm)	16	92	142	180	434	835			
Velocity in drain pipe (ft/s)	1.1	3.3	5.3	6.4	7.3	9.8			
Pressure in drain pipe (in. W.C.)	-2.6	-18.3	-24.5	-30.1	-39.5	-50.4			
		DRAIN	WITH M	ODIFIED	PIPES				
Water head (inch)	1″	<b>DRAIN</b> 2"	<b>WITH M</b> 3"	<mark>ODIFIED</mark> 4''	<b>PIPES</b> 5"	6″			
Water head (inch) Flow of water into box (gpm)	1″ 14	<b>DRAIN</b> 2" 59	<b>WITH M</b> 3'' 125	<mark>ODIFIED</mark> 4'' 190	<b>PIPES</b> 5'' 422	6'' 622			
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s)	1'' 14 0.8	<b>DRAIN</b> 2'' 59 2.2	<b>WITH M</b> 3" 125 4.9	<mark>ODIFIED</mark> 4'' 190 5.5	<b>PIPES</b> 5'' 422 6.9	6'' 622 8.3			
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s)	1″ 14 0.8 1.3	DRAIN 2" 59 2.2 2.3	WITH M 3″ 125 4.9 3.1	<b>ODIFIED</b> 4" 190 5.5 4.2	<b>PIPES</b> 5" 422 6.9 9.0	6'' 622 8.3 9.4			
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s)	1″ 14 0.8 1.3 2.7	<b>DRAIN</b> 2" 59 2.2 2.3 5.9	WITH M 3" 125 4.9 3.1 5.9	0DIFIED 4'' 190 5.5 4.2 5.3	<b>PIPES</b> 5" 422 6.9 9.0 6.8	6" 622 8.3 9.4 7.7			
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.)	1'' 14 0.8 1.3 2.7 0.8	<b>DRAIN</b> 2" 59 2.2 2.3 5.9 0.7	WITH M 3" 125 4.9 3.1 5.9 -0.3	0DIFIED 4" 190 5.5 4.2 5.3 -1.5	PIPES       5"       422       6.9       9.0       6.8       -15.0	6'' 622 8.3 9.4 7.7 -34.9			
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.) Pressure in hor. pipe (in. W.C.)	1" 14 0.8 1.3 2.7 0.8 0.1	<b>DRAIN</b> 2" 59 2.2 2.3 5.9 0.7 0.1	WITH M 3" 125 4.9 3.1 5.9 -0.3 1.7	0DIFIED 4" 190 5.5 4.2 5.3 -1.5 -1.7	<b>PIPES</b> 5" 422 6.9 9.0 6.8 -15.0 -38.2	6" 622 8.3 9.4 7.7 -34.9 -59.3			

### 47. MANUFACTURER J, MODEL J-1 2" CAST IRON DRAIN WITH CAST IRON DOME

		DRAIN	WITHOU	JT DRAII	N PIPE			
Water head (inch)	1″	2″	3″	4″	5″	6''		
Flow of water into box (gpm)	22	54	59	75	81	87		
Velocity of flow (ft/s)	1.7	3.3	3.6	3.9	4.2	4.2		
		DRA	IN WITH	10-FT I	PIPE			
Water head (inch)	1″	2″	3″	4''	5″	6''		
Flow of water into box (gpm)	19	94	113	122	131	192		
Velocity in drain pipe (ft/s)	6.1	9.0	9.0	9.0	9.0	9.0		
Pressure in drain pipe (in. W.C.)	-2.6	-18.3	-24.5	-30.1	-39.5	-50.4		
	-2.6 -18.3 -24.5 -30.1 -39.5 -50.4							
		DRAIN	WITH M	ODIFIED	PIPES			
Water head (inch)	1″	DRAIN 2"	<b>WITH M</b> 3"	ODIFIED 4''	<b>PIPES</b> 5"	6"		
Water head (inch) Flow of water into box (gpm)	1″ 18	<b>DRAIN</b> 2" 88	<b>WITH M</b> 3" 86	<mark>ODIFIED</mark> 4'' 116	<b>PIPES</b> 5'' 114	6'' 143		
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s)	1″ 18 2.3	<b>DRAIN</b> 2'' 88 7.7	<b>WITH M</b> 3'' 86 7.7	<b>ODIFIED</b> 4'' 116 7.8	<b>PIPES</b> 5″ 114 8.1	6'' 143 8.4		
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s)	1″ 18 2.3 2.5	DRAIN 2" 88 7.7 7.9	WITH M 3″ 86 7.7 8.0	ODIFIED 4'' 116 7.8 6.9	<b>PIPES</b> 5" 114 8.1 8.4	6" 143 8.4 8.5		
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s)	1″ 18 2.3 2.5 6.5	<b>DRAIN</b> 2" 88 7.7 7.9 7.7	WITH M 3" 86 7.7 8.0 8.1	0DIFIED 4'' 116 7.8 6.9 7.3	<b>PIPES</b> 5" 114 8.1 8.4 8.5	6'' 143 8.4 8.5 8.6		
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.)	1" 18 2.3 2.5 6.5 0.4	<b>DRAIN</b> 2" 88 7.7 7.9 7.7 -17.2	WITH M 3" 86 7.7 8.0 8.1 -21.2	0DIFIED 4" 116 7.8 6.9 7.3 -21.8	<b>PIPES</b> 5" 114 8.1 8.4 8.5 -13.4	6" 143 8.4 8.5 8.6 -19.8		
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.) Pressure in hor. pipe (in. W.C.)	1" 18 2.3 2.5 6.5 0.4 0.3	<b>DRAIN</b> 2" 88 7.7 7.9 7.7 -17.2 -32.8	WITH M 3" 86 7.7 8.0 8.1 -21.2 -36.1	<b>ODIFIED</b> 4'' 116 7.8 6.9 7.3 -21.8 -44.1	PIPES 5" 114 8.1 8.4 8.5 -13.4 -28.2	6'' 143 8.4 8.5 8.6 -19.8 -43.4		

# 48. MANUFACTURER J, MODEL J-2

		DRAIN	ι <mark>ωιτ</mark> Ηοι	JT DRAII		
Water head (inch)	1″	2″	3″	4″	5″	6''
Flow of water into box (gpm)	29	55	124	152	165	172
Velocity of flow (ft/s)	0.8	3.8	4.3	4.7	4.9	5.2
		DRA	IN WITH	10-FT F	PIPE	
Water head (inch)	1″	2″	3″	4''	5″	6''
Flow of water into box (gpm)	32	65	388	462	485	493
Velocity in drain pipe (ft/s)	3.8	7.7	8.9	9.4	9.6	10.4
Pressure in drain pipe (in. W.C.)	-1.1	-1.2	-33.7	-35.9	-38.1	-39.8
		DRAIN	<b>WITH M</b>	ODIFIED	PIPES	
Water head (inch)	1″	DRAIN 2"	<b>WITH M</b> 3″	<mark>ODIFIED</mark> 4''	<b>PIPES</b> 5"	6"
Water head (inch) Flow of water into box (gpm)	1'' 29	<b>DRAIN</b> 2" 77	<b>WITH M</b> 3″ 147	<mark>ODIFIED</mark> 4'' 152	<b>PIPES</b> 5'' 176	6'' 195
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s)	1″ 29 2.3	<b>DRAIN</b> 2'' 77 3.9	<b>WITH M</b> 3" 147 4.3	<b>ODIFIED</b> 4'' 152 4.7	<b>PIPES</b> 5'' 176 7.1	6'' 195 8.2
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s)	1″ 29 2.3 3.1	DRAIN 2" 77 3.9 4.4	<b>WITH M</b> 3″ 147 4.3 4.5	<b>ODIFIED</b> 4'' 152 4.7 4.9	<b>PIPES</b> 5'' 176 7.1 7.8	6'' 195 8.2 8.4
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s)	1" 29 2.3 3.1 4.1	<b>DRAIN</b> 2" 77 3.9 4.4 5.7	WITH M 3″ 147 4.3 4.5 6.8	0DIFIED 4'' 152 4.7 4.9 6.9	<b>PIPES</b> 5" 176 7.1 7.8 7.2	6'' 195 8.2 8.4 7.6
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.)	1" 29 2.3 3.1 4.1 -0.4	<b>DRAIN</b> 2" 77 3.9 4.4 5.7 -3.4	WITH M 3″ 147 4.3 4.5 6.8 -11.3	ODIFIED 4" 152 4.7 4.9 6.9 -12.1	<b>PIPES</b> 5″ 176 7.1 7.8 7.2 -18.4	6" 195 8.2 8.4 7.6 -29.3
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.) Pressure in hor. pipe (in. W.C.)	1" 29 2.3 3.1 4.1 -0.4 -1.5	<b>DRAIN</b> 2" 77 3.9 4.4 5.7 -3.4 -6.8	WITH M 3" 147 4.3 4.5 6.8 -11.3 -16.4	ODIFIED 4'' 152 4.7 4.9 6.9 -12.1 -15.3	<b>PIPES</b> 5" 176 7.1 7.8 7.2 -18.4 -14.3	6'' 195 8.2 8.4 7.6 -29.3 -43.4

### 49. MANUFACTURER J, MODEL J-3 4" CAST IRON DRAIN WITH CAST IRON DOME

		DRAIN	I WITHOU	JT DRAI	N PIPE	
Water head (inch)	1″	2″	3″	4''	5″	6''
Flow of water into box (gpm)	17	78	179	172	255	301
Velocity of flow (ft/s)	0.5	1.5	3.3	4.1	4.5	4.9
		DRA	IN WITH	10-FT	PIPE	
Water head (inch)	1″	2″	3″	4''	5″	6''
Flow of water into box (gpm)	19	69	169	206	478	628
Velocity in drain pipe (ft/s)	1.4	4.4	7.8	7.7	8.6	9.3
Pressure in drain pipe (in. W.C.)	0.1	-0.2	-3.4	0.2	-25.2	-33.9
		DRAIN	<b>WITH M</b>	ODIFIED	PIPES	
Water head (inch)	1″	2″	3″	4''	5″	6''
Flow of water into box (gpm)	21	81	163	244	472	564
Velocity in 1st stack (ft/s)	0.8	2.7	4.6	4.4	7.6	8.1
Velocity in horizontal pipe (ft/s)	2.4	2.9	3.4	3.9	8.6	9.5
Velocity in 2nd stack (ft/s)	2.9	6.9	6.2	6.6	7.2	7.7
Pressure in 1st stack (in. W.C.)	0.3	-0.5	-0.1	-2.5	-25.2	-28.7
Pressure in hor. pipe (in. W.C.)	-0.2	-0.4	-1.5	-3.6	-47.9	-56.0
Pressure in 2nd stack (in. W.C.)	-0.3	-1.2	-8.0	-11.2	-49.2	-47.6

# 50. MANUFACTURER J, MODEL J-4

		DRAIN				
Water head (inch)	1″	2″	3″	4″	5″	6''
Flow of water into box (gpm)	78	108	168	307	388	469
Velocity of flow (ft/s)	1.1	1.6	3.3	3.9	4.3	4.9
		DRA	IN WITH	10-FT	PIPE	
Water head (inch)	1″	2″	3″	4″	5″	6''
Flow of water into box (gpm)	162	222	322	408	575	651
Velocity in drain pipe (ft/s)	2.5	7.3	7.5	8.0	7.2	9.3
Pressure in drain pipe (in. W.C.)	1.7	3.0	-3.0	-7.3	-13.0	-19.6
		DRAIN	WITH M	ODIFIED	PIPES	
Water head (inch)	1″	DRAIN 2"	<b>WITH M</b> 3"	ODIFIED 4"	<b>PIPES</b> 5"	6"
Water head (inch) Flow of water into box (gpm)	1″ 138	<b>DRAIN</b> 2" 187	<b>WITH M</b> 3" 256	<b>ODIFIED</b> 4'' 367	<b>PIPES</b> 5'' 514	6'' 618
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s)	1'' 138 1.5	DRAIN 2'' 187 2.2	3" 256 2.9	<b>ODIFIED</b> 4'' 367 4.7	<b>PIPES</b> 5'' 514 6.7	6'' 618 7.0
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s)	1'' 138 1.5 0.2	DRAIN 2" 187 2.2 1.7	3" 256 2.9 3.5	<b>ODIFIED</b> 4'' 367 4.7 4.5	<b>PIPES</b> 5'' 514 6.7 5.1	6'' 618 7.0 5.8
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s)	1″ 138 1.5 0.2 7.5	<b>DRAIN</b> 2" 187 2.2 1.7 7.6	WITH M 3" 256 2.9 3.5 8.3	4" 367 4.7 4.5 9.1	<b>PIPES</b> 5" 514 6.7 5.1 9.2	6'' 618 7.0 5.8 8.6
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.)	1" 138 1.5 0.2 7.5 1.0	DRAIN 2" 187 2.2 1.7 7.6 1.1	WITH M 3" 256 2.9 3.5 8.3 0.8	4" 367 4.7 4.5 9.1 -0.4	<b>PIPES</b> 5" 514 6.7 5.1 9.2 -15.1	6'' 618 7.0 5.8 8.6 -14.6
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.) Pressure in hor. pipe (in. W.C.)	1" 138 1.5 0.2 7.5 1.0 -0.9	DRAIN 2" 187 2.2 1.7 7.6 1.1 -1.0	WITH M 3" 256 2.9 3.5 8.3 0.8 -0.2	4" 367 4.7 4.5 9.1 -0.4 -10.4	<b>PIPES</b> 5" 514 6.7 5.1 9.2 -15.1 -25.5	6" 618 7.0 5.8 8.6 -14.6 -37.3

### 51. MANUFACTURER J, MODEL J-5 6" CAST IRON DRAIN WITH CAST IRON DOME

			WITUO			
		DRAIN	WITHOU	JI DRAI		
Water head (inch)	1″	2″	3″	4″	5″	6″
Flow of water into box (gpm)	48	111	214	293	475	602
Velocity of flow (ft/s)	0.6	0.9	1.1	3.7	4.0	4.3
		DRA	IN WITH	10-FT	PIPE	
Water head (inch)	1″	2″	3″	4″	5″	6''
Flow of water into box (gpm)	67	108	160	276	509	668
Velocity in drain pipe (ft/s)	0.7	1.3	6.2	6.8	7.7	7.5
Pressure in drain pipe (in. W.C.)	1.4	1.2	1.3	1.3	-3.9	-5.4
		DRAIN	WITH M	ODIFIED	PIPES	
Water head (inch)	1″	DRAIN 2"	<b>WITH M</b> 3"	ODIFIED 4"	<b>PIPES</b> 5"	6"
Water head (inch) Flow of water into box (gpm)	1″ 53	<b>DRAIN</b> 2'' 94	<b>WITH M</b> 3″ 198	<b>ODIFIED</b> 4'' 283	<b>PIPES</b> 5'' 494	6'' 639
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s)	1″ 53 0.8	<b>DRAIN</b> 2'' 94 1.4	WITH M 3" 198 2.9	ODIFIED 4" 283 3.4	<b>PIPES</b> 5" 494 3.8	6'' 639 3.8
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s)	1″ 53 0.8 1.2	<b>DRAIN</b> 2'' 94 1.4 2.2	<b>WITH M</b> 3" 198 2.9 3.0	ODIFIED 4'' 283 3.4 2.6	<b>PIPES</b> 5" 494 3.8 4.4	6'' 639 3.8 5.8
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s)	1″ 53 0.8 1.2 1.9	DRAIN 2" 94 1.4 2.2 5.3	WITH M 3" 198 2.9 3.0 5.5	ODIFIED 4" 283 3.4 2.6 6.3	<b>PIPES</b> 5" 494 3.8 4.4 6.9	6'' 639 3.8 5.8 7.8
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.)	1" 53 0.8 1.2 1.9 1.9	DRAIN 2" 94 1.4 2.2 5.3 2.9	WITH M 3" 198 2.9 3.0 5.5 4.6	ODIFIED 4" 283 3.4 2.6 6.3 7.0	<b>PIPES</b> 5" 494 3.8 4.4 6.9 3.4	6" 639 3.8 5.8 7.8 -2.9
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.) Pressure in hor. pipe (in. W.C.)	1" 53 0.8 1.2 1.9 1.9 -2.5	DRAIN 2" 94 1.4 2.2 5.3 2.9 -2.6	WITH M 3" 198 2.9 3.0 5.5 4.6 -3.1	ODIFIED 4" 283 3.4 2.6 6.3 7.0 -2.4	PIPES 5" 494 3.8 4.4 6.9 3.4 -9.2	6" 639 3.8 5.8 7.8 -2.9 -11.8

#### 52. MANUFACTURER J, MODEL J-6

2" CAST IRON DRAIN WITH BRASS DOME

		DRAIN	<b>WITHOU</b>			
Water head (inch)	1″	2″	3″	4″	5″	6''
Flow of water into box (gpm)	20	49	55	65	73	82
Velocity of flow (ft/s)	1.0*	2.8	3.7	3.8	4.2	4.4
		DRA	ін <mark></mark> ітн	10-FT I	PIPE	
Water head (inch)	1″	2″	3″	4″	5″	6''
Flow of water into box (gpm)	21	98	116	141	165	204
Velocity in drain pipe (ft/s)	4.9	9.0	9.0	9.0	9.0	9.0
Pressure in drain pipe (in. W.C.)	-0.9	-35.5	-37.5	-42.6	-48.6	-55.4
		DRAIN	WITH M	ODIFIED	PIPES	
Water head (inch)	1″	DRAIN 2"	<b>WITH M</b> 3″	ODIFIED 4"	<b>PIPES</b> 5"	6"
Water head (inch) Flow of water into box (gpm)	1'' 26	<b>DRAIN</b> 2'' 95	<b>WITH M</b> З″ 98	<mark>ODIFIED</mark> 4'' 109	<b>PIPES</b> 5'' 131	6'' 144
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s)	1'' 26 4.0	<b>DRAIN</b> 2'' 95 7.2	<b>WITH M</b> 3'' 98 7.7	<b>ODIFIED</b> 4'' 109 7.9	<b>PIPES</b> 5'' 131 8.7	6'' 144 8.0
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s)	1″ 26 4.0 2.7	DRAIN 2'' 95 7.2 7.7	WITH M 3" 98 7.7 8.1	<b>ODIFIED</b> 4'' 109 7.9 7.5	<b>PIPES</b> 5" 131 8.7 9.0	6" 144 8.0 9.0
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s)	1'' 26 4.0 2.7 8.1	<b>DRAIN</b> 2'' 95 7.2 7.7 8.0	WITH M 3" 98 7.7 8.1 8.5	<b>ODIFIED</b> 4'' 109 7.9 7.5 7.6	<b>PIPES</b> 5" 131 8.7 9.0 8.7	6'' 144 8.0 9.0 8.7
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.)	1'' 26 4.0 2.7 8.1 0.4	<b>DRAIN</b> 2" 95 7.2 7.7 8.0 -12.3	WITH M 3" 98 7.7 8.1 8.5 -19.4	ODIFIED 4" 109 7.9 7.5 7.6 -13.1	<b>PIPES</b> 5" 131 8.7 9.0 8.7 -17.3	6'' 144 8.0 9.0 8.7 -17.4
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.) Pressure in hor. pipe (in. W.C.)	1" 26 4.0 2.7 8.1 0.4 -0.3	DRAIN 2" 95 7.2 7.7 8.0 -12.3 -43.8	WITH M 3" 98 7.7 8.1 8.5 -19.4 -45.1	<b>ODIFIED</b> 4'' 109 7.9 7.5 7.6 -13.1 -33.4	<b>PIPES</b> 5" 131 8.7 9.0 8.7 -17.3 -44.5	6" 144 8.0 9.0 8.7 -17.4 -44.1

\* Note: Water flow was too small for the sensor to read consistently. This was an approximate number.

### 53. MANUFACTURER J, MODEL J-7 3" CAST IRON DRAIN WITH BRASS DOME

		DRAIN	I WITHOU	JT DRAII		
Water head (inch)	1″	2″	3″	4″	5″	6''
Flow of water into box (gpm)	42	118	190	200	221	236
Velocity of flow (ft/s)	1.8	3.7	4.2	4.9	5.2	5.4
		DRA	IN WITH	10-FT I	PIPE	
Water head (inch)	1″	2″	3″	4"	5″	6''
Flow of water into box (gpm)	38	114	179	249	453	487
Velocity in drain pipe (ft/s)	6.2	8.6	9.1	9.2	10.7	11.6
Pressure in drain pipe (in. W.C.)	-1.1	-4.3	-22.8	-30.5	-49.8	-48.3
		DRAIN	<b>WITH M</b>	ODIFIED	PIPES	
Water head (inch)	1″	DRAIN 2"	<b>WITH M</b> 3"	<mark>ODIFIED</mark> 4''	<b>PIPES</b> 5"	6"
Water head (inch) Flow of water into box (gpm)	1'' 41	<b>DRAIN</b> 2'' 126	<b>WITH M</b> 3″ 187	<mark>ODIFIED</mark> 4'' 200	<b>PIPES</b> 5'' 215	6'' 408
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s)	1'' 41 0.1	<b>DRAIN</b> 2'' 126 4.9	<b>WITH M</b> 3″ 187 5.1	<b>ODIFIED</b> 4'' 200 5.1	PIPES       5"       215       7.0	6'' 408 7.9
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s)	1" 41 0.1 3.4	DRAIN 2" 126 4.9 4.7	<b>WITH M</b> 3″ 187 5.1 4.8	<b>ODIFIED</b> 4'' 200 5.1 5.5	<b>PIPES</b> 5" 215 7.0 6.9	6" 408 7.9 9.4
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s)	1" 41 0.1 3.4 6.2	DRAIN 2" 126 4.9 4.7 7.1	WITH M 3" 187 5.1 4.8 6.2	0DIFIED 4'' 200 5.1 5.5 6.7	<b>PIPES</b> 5" 215 7.0 6.9 6.9	6'' 408 7.9 9.4 7.7
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.)	1" 41 0.1 3.4 6.2 0.1	DRAIN 2" 126 4.9 4.7 7.1 -4.4	WITH M 3" 187 5.1 4.8 6.2 -10.8	0DIFIED 4'' 200 5.1 5.5 6.7 -14.9	PIPES 5" 215 7.0 6.9 6.9 -18.8	6'' 408 7.9 9.4 7.7 -28.3
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.) Pressure in hor. pipe (in. W.C.)	1" 41 0.1 3.4 6.2 0.1 0.1	DRAIN 2" 126 4.9 4.7 7.1 -4.4 -8.1	WITH M 3" 187 5.1 4.8 6.2 -10.8 -13.9	<b>ODIFIED</b> 4" 200 5.1 5.5 6.7 -14.9 -43.1	PIPES 5" 215 7.0 6.9 6.9 -18.8 -26.2	6'' 408 7.9 9.4 7.7 -28.3 -43.2

# 54. MANUFACTURER J, MODEL J-8

		DRAIN	<b>WITHOU</b>	JT DRAI	N PIPE	
Water head (inch)	1″	2″	3″	4″	5″	6''
Flow of water into box (gpm)	67	130	210	217	299	271
Velocity of flow (ft/s)	1.8	3.4	4.2	4.6	5.2	5.7
		DRA	IN WITH	10-FT	PIPE	
Water head (inch)	1″	2″	3″	4″	5″	6''
Flow of water into box (gpm)	69	130	221	370	547	860
Velocity in drain pipe (ft/s)	1.9	6.1	7.5	8.4	9.4	10.0
Pressure in drain pipe (in. W.C.)	0.3	0.3	0.3	-8.2	-33.4	-51.5
		DRAIN	<b>WITH M</b>	ODIFIED	PIPES	
Water head (inch)	1″	DRAIN 2"	<b>WITH M</b> 3"	<mark>ODIFIED</mark> 4"	<b>PIPES</b> 5"	6″
Water head (inch) Flow of water into box (gpm)	1″ 35	<b>DRAIN</b> 2" 158	<b>WITH M</b> 3'' 217	<mark>ODIFIED</mark> 4'' 284	<b>PIPES</b> 5'' 491	6'' 562
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s)	1″ 35 1.3	<b>DRAIN</b> 2'' 158 4.0	<b>WITH M</b> 3" 217 4.7	<mark>ODIFIED</mark> 4'' 284 5.1	<b>PIPES</b> 5'' 491 8.4	6'' 562 9.1
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s)	1" 35 1.3 3.1	<b>DRAIN</b> 2" 158 4.0 3.5	<b>WITH M</b> 3'' 217 4.7 6.2	ODIFIED 4" 284 5.1 5.1	<b>PIPES</b> 5" 491 8.4 9.1	6'' 562 9.1 9.1
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s)	1″ 35 1.3 3.1 2.8	<b>DRAIN</b> 2'' 158 4.0 3.5 6.0	WITH M 3" 217 4.7 6.2 6.6	ODIFIED 4'' 284 5.1 5.1 5.4	<b>PIPES</b> 5" 491 8.4 9.1 7.6	6" 562 9.1 9.1 7.6
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.)	1" 35 1.3 3.1 2.8 0.4	<b>DRAIN</b> 2" 158 4.0 3.5 6.0 0.4	<b>WITH M</b> 3" 217 4.7 6.2 6.6 -2.5	0DIFIED 4" 284 5.1 5.1 5.4 -8.2	<b>PIPES</b> 5" 491 8.4 9.1 7.6 -27.1	6" 562 9.1 9.1 7.6 -32.2
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.) Pressure in hor. pipe (in. W.C.)	1" 35 1.3 3.1 2.8 0.4 0.2	DRAIN 2" 158 4.0 3.5 6.0 0.4 -0.8	WITH M 3" 217 4.7 6.2 6.6 -2.5 -8.3	ODIFIED 4" 284 5.1 5.1 5.4 -8.2 -12.1	<b>PIPES</b> 5"         491         8.4         9.1         7.6         -27.1         -53.9	6" 562 9.1 9.1 7.6 -32.2 -56.6

### 55. MANUFACTURER J, MODEL J-9 5" CAST IRON DRAIN WITH BRASS DOME

		DRAIN	<b>WITHO</b>	JT DRAII		
Water head (inch)	1″	2″	3″	4″	5″	6''
Flow of water into box (gpm)	116	195	273	369	460	492
Velocity of flow (ft/s)	0.9	3.2	4.3	5.3	4.2	4.5
		DRA	IN WITH	10-FT I	PIPE	
Water head (inch)	1″	2″	3″	4″	5″	6''
Flow of water into box (gpm)	97	152	236	371	646	1012
Velocity in drain pipe (ft/s)	1.7	7.0	8.4	8.9	9.3	9.7
Pressure in drain pipe (in. W.C.)	1.8	1.7	-1.6	0.3	-17.6	-26.4
		DRAIN	<b>WITH M</b>	ODIFIED	PIPES	
Water head (inch)	1″	2″	3″	4"	5″	6"
Flow of water into box (gpm)	95	161	238	362	553	874
Velocity in 1st stack (ft/s)	1.8	2.7	2.8	4.8	7.7	7.8
Velocity in horizontal pipe (ft/s)	1.3	2.2	3.4	4.5	4.8	7.3
Velocity in 2nd stack (ft/s)	7.7	7.8	8.4	9.0	8.7	7.5
Pressure in 1st stack (in. W.C.)	1.1	-0.4	-0.3	-3.9	-16.8	-29.6
Pressure in hor. pipe (in. W.C.)	-1.3	-1.8	-2.2	-15.2	-27.2	-57.0
Dressure in 2nd steek (in WC)						

### 56. MANUFACTURER J, MODEL J-10

		DRAIN	<b>WITHO</b>	JT DRAI	N PIPE	
Water head (inch)	1″	2″	3″	4''	5″	6''
Flow of water into box (gpm)	87	126	191	371	519	551
Velocity of flow (ft/s)	0.9	1.3	1.5	3.0	2.5	2.3
		DRA	IN WITH	10-FT	PIPE	
Water head (inch)	1′′	2″	3″	4''	5″	6''
Flow of water into box (gpm)	94	117	227	393	613	1147
Velocity in drain pipe (ft/s)	0.9	1.9	6.0	7.8	7.4	8.8
Pressure in drain pipe (in. W.C.)	1.1	1.2	1.1	-0.9	-6.7	-23.4
		DRAIN	<b>WITH M</b>	ODIFIED	PIPES	
Water head (inch)	1″	<b>DRAIN</b> 2"	<b>WITH M</b> 3"	ODIFIED 4"	<b>PIPES</b> 5"	6"
Water head (inch) Flow of water into box (gpm)	1'' 89	<b>DRAIN</b> 2'' 107	<b>WITH M</b> 3″ 231	ODIFIED 4'' 370	<b>PIPES</b> 5'' 546	6'' 879
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s)	1'' 89 1.1	<b>DRAIN</b> 2'' 107 2.4	<b>WITH M</b> 3" 231 2.9	<b>ODIFIED</b> 4'' 370 3.1	<b>PIPES</b> 5'' 546 5.5	6'' 879 5.0
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s)	1″ 89 1.1 1.8	<b>DRAIN</b> 2" 107 2.4 1.8	<b>WITH M</b> 3″ 231 2.9 2.9	<b>ODIFIED</b> 4" 370 3.1 3.6	<b>PIPES</b> 5" 546 5.5 4.9	6'' 879 5.0 7.2
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s)	1″ 89 1.1 1.8 5.5	<b>DRAIN</b> 2'' 107 2.4 1.8 6.4	WITH M 3" 231 2.9 2.9 6.2	ODIFIED 4" 370 3.1 3.6 6.8	<b>PIPES</b> 5" 546 5.5 4.9 7.8	6" 879 5.0 7.2 7.3
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.)	1" 89 1.1 1.8 5.5 1.3	<b>DRAIN</b> 2" 107 2.4 1.8 6.4 1.8	WITH M 3" 231 2.9 2.9 6.2 1.4	ODIFIED 4" 370 3.1 3.6 6.8 8.1	<b>PIPES</b> 5″ 546 5.5 4.9 7.8 5.5	6" 879 5.0 7.2 7.3 -8.2
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.) Pressure in hor. pipe (in. W.C.)	1" 89 1.1 1.8 5.5 1.3 -0.3	DRAIN 2" 107 2.4 1.8 6.4 1.8 -0.4	WITH M 3" 231 2.9 6.2 1.4 -0.5	ODIFIED 4" 370 3.1 3.6 6.8 8.1 -2.0	<b>PIPES</b> 5" 546 5.5 4.9 7.8 5.5 5.5	6" 879 5.0 7.2 7.3 -8.2 -44.7

### 57. MANUFACTURER J, MODEL J-12 2" CAST IRON DRAIN WITH BRASS DOME

		DRAIN	и <b>мітно</b>	JT DRAII		
Water head (inch)	1″	2″	3″	4″	5″	6''
Flow of water into box (gpm)	26	51	56	60	62	63
Velocity of flow (ft/s)	1.4	2.6	3.2	3.4	3.6	3.8
		DRA	IN WITH	10-FT F	PIPE	
Water head (inch)	1″	2″	3″	4″	5″	6''
Flow of water into box (gpm)	21	86	119	125	173	206
Velocity in drain pipe (ft/s)	7.6	9.0	9.0	9.0	9.0	9.0
Pressure in drain pipe (in. W.C.)	-3.5	-31.1	-50.2	-43.8	-54.7	-55.0
		DRAIN	<b>WITH M</b>	ODIFIED	PIPES	
Water head (inch)	1″	DRAIN 2"	<b>WITH M</b> 3"	<mark>ODIFIED</mark> 4''	<b>PIPES</b> 5"	6"
Water head (inch) Flow of water into box (gpm)	1″ 28	<b>DRAIN</b> 2" 82	<b>WITH M</b> 3" 80	<mark>ODIFIED</mark> 4'' 122	<b>PIPES</b> 5" 133	6'' 135
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s)	1'' 28 3.9	DRAIN 2" 82 7.2	WITH M 3" 80 6.3	ODIFIED 4'' 122 8.1	<b>PIPES</b> 5'' 133 8.7	6'' 135 8.6
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s)	1" 28 3.9 3.1	DRAIN 2'' 82 7.2 7.1	<b>WITH M</b> 3″ 80 6.3 6.5	ODIFIED 4'' 122 8.1 8.4	<b>PIPES</b> 5'' 133 8.7 9.0	6'' 135 8.6 9.0
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s)	1" 28 3.9 3.1 8.0	DRAIN 2'' 82 7.2 7.1 7.2	WITH M 3" 80 6.3 6.5 7.5	ODIFIED 4'' 122 8.1 8.4 8.3	<b>PIPES</b> 5" 133 8.7 9.0 8.9	6'' 135 8.6 9.0 8.8
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.)	1" 28 3.9 3.1 8.0 -0.9	DRAIN 2" 82 7.2 7.1 7.2 -15.0	WITH M 3" 80 6.3 6.5 7.5 -23.9	ODIFIED 4'' 122 8.1 8.4 8.3 -29.8	PIPES 5" 133 8.7 9.0 8.9 -23.6	6" 135 8.6 9.0 8.8 -23.0
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.) Pressure in hor. pipe (in. W.C.)	1" 28 3.9 3.1 8.0 -0.9 -0.8	DRAIN 2" 82 7.2 7.1 7.2 -15.0 -30.4	WITH M 3" 80 6.3 6.5 7.5 -23.9 -36.7	ODIFIED 4'' 122 8.1 8.4 8.3 -29.8 -39.1	PIPES 5" 133 8.7 9.0 8.9 -23.6 -244.7	6'' 135 8.6 9.0 8.8 -23.0 -43.9

### 58. MANUFACTURER J, MODEL J-13

		DRAIN	ι <mark>ωιτ</mark> Ηοι					
Water head (inch)	1″	2″	3″	4"	5″	6''		
Flow of water into box (gpm)	49	93	143	155	161	179		
Velocity of flow (ft/s)	1.4	1.9	2.3	3.3	3.9	4.5		
		DRA	IN WITH	10-FT	PIPE			
Water head (inch)	1″	2″	3″	4″	5″	6''		
Flow of water into box (gpm)	22	100	165	162	186	522		
Velocity in drain pipe (ft/s)	5.3	8.0	8.3	8.7	8.9	11.0		
Pressure in drain pipe (in. W.C.)	0.6	-2.4	-4.3	-0.2	-2.3	-46.4		
	0.6 -2.4 -4.3 -0.2 -2.3 -46.4							
		DRAIN	WITH M	ODIFIED	PIPES			
Water head (inch)	1″	<b>DRAIN</b> 2"	<b>WITH M</b> 3"	<mark>ODIFIED</mark> 4"	<b>PIPES</b> 5"	6"		
Water head (inch) Flow of water into box (gpm)	1″ 28	<b>DRAIN</b> 2" 99	<b>WITH M</b> 3'' 137	ODIFIED 4'' 161	<b>PIPES</b> 5'' 178	6'' 358		
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s)	1'' 28 3.0	<b>DRAIN</b> 2'' 99 4.6	<b>WITH M</b> 3″ 137 6.0	<b>ODIFIED</b> 4'' 161 4.8	<b>PIPES</b> 5'' 178 6.7	6'' 358 8.9		
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s)	1" 28 3.0 2.6	<b>DRAIN</b> 2" 99 4.6 5.1	<b>WITH M</b> 3" 137 6.0 6.6	ODIFIED 4'' 161 4.8 4.8	<b>PIPES</b> 5″ 178 6.7 7.8	6" 358 8.9 9.4		
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s)	1'' 28 3.0 2.6 6.1	<b>DRAIN</b> 2" 99 4.6 5.1 7.1	WITH M 3" 137 6.0 6.6 6.5	ODIFIED 4'' 161 4.8 4.8 6.7	<b>PIPES</b> 5″ 178 6.7 7.8 6.5	6" 358 8.9 9.4 7.8		
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.)	1" 28 3.0 2.6 6.1 0.2	<b>DRAIN</b> 2" 99 4.6 5.1 7.1 -2.9	WITH M 3″ 137 6.0 6.6 6.5 -12.1	ODIFIED 4" 161 4.8 4.8 6.7 -5.7	<b>PIPES</b> 5″ 178 6.7 7.8 6.5 -11.4	6" 358 8.9 9.4 7.8 -30.7		
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.) Pressure in hor. pipe (in. W.C.)	1" 28 3.0 2.6 6.1 0.2 -0.2	<b>DRAIN</b> 2" 99 4.6 5.1 7.1 -2.9 -5.8	WITH M 3" 137 6.0 6.6 6.5 -12.1 -13.2	ODIFIED 4'' 161 4.8 4.8 6.7 -5.7 -5.8	<b>PIPES</b> 5" 178 6.7 7.8 6.5 -11.4 -15.6	6" 358 8.9 9.4 7.8 -30.7 -45.1		

### 59. MANUFACTURER J, MODEL J-14 4" CAST IRON DRAIN WITH BRASS DOME

	DRAIN WITHOUT DRAIN PIPE							
Water head (inch)	1″	2″	3″	4″	5″	6''		
Flow of water into box (gpm)	95	138	180	215	251	298		
Velocity of flow (ft/s)	2.0	1.9	3.4	3.5	4.1	5.0		
	DRAIN WITH 10-FT PIPE							
Water head (inch)	1′′	2″	3″	4″	5″	6''		
Flow of water into box (gpm)	67	128	169	257	677	830		
Velocity in drain pipe (ft/s)	4.4	6.1	7.0	7.9	8.6	9.7		
Pressure in drain pipe (in. W.C.)	0.2	0.4	0.8	-4.5	-45.2	-50.6		
	DRAIN WITH MODIFIED PIPES							
		DRAIN	WITH M	ODIFIED	PIPES			
Water head (inch)	1″	<b>DRAIN</b> 2"	<b>WITH M</b> 3"	ODIFIED 4''	<b>PIPES</b> 5"	6"		
Water head (inch) Flow of water into box (gpm)	1'' 66	<b>DRAIN</b> 2" 103	<b>WITH M</b> 3" 192	<b>ODIFIED</b> 4'' 235	<b>PIPES</b> 5" 520	6'' 574		
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s)	1'' 66 3.5	<b>DRAIN</b> 2" 103 3.6	<b>WITH M</b> 3'' 192 4.5	<b>ODIFIED</b> 4'' 235 5.1	<b>PIPES</b> 5" 520 7.7	6'' 574 8.1		
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s)	1'' 66 3.5 2.2	2" 103 3.6 3.5	<b>WITH M</b> 3" 192 4.5 4.2	ODIFIED 4" 235 5.1 5.4	<b>PIPES</b> 5" 520 7.7 9.2	6'' 574 8.1 9.4		
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s)	1" 66 3.5 2.2 4.5	DRAIN 2" 103 3.6 3.5 5.9	WITH M 3" 192 4.5 4.2 5.7	0DIFIED 4" 235 5.1 5.4 7.3	<b>PIPES</b> 5" 520 7.7 9.2 7.3	6'' 574 8.1 9.4 7.5		
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.)	1" 66 3.5 2.2 4.5 0.7	DRAIN 2" 103 3.6 3.5 5.9 0.4	WITH M 3" 192 4.5 4.2 5.7 -0.2	ODIFIED 4" 235 5.1 5.4 7.3 -2.4	<b>PIPES</b> 5" 520 7.7 9.2 7.3 -30.5	6" 574 8.1 9.4 7.5 -30.7		
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.) Pressure in hor. pipe (in. W.C.)	1" 66 3.5 2.2 4.5 0.7 0.2	DRAIN 2" 103 3.6 3.5 5.9 0.4 -0.7	WITH M 3" 192 4.5 4.2 5.7 -0.2 -2.6	ODIFIED 4" 235 5.1 5.4 7.3 -2.4 -12.6	<b>PIPES</b> 5" 520 7.7 9.2 7.3 -30.5 -58.5	6" 574 8.1 9.4 7.5 -30.7 -60.6		

# 60. MANUFACTURER J, MODEL J-15

	DRAIN WITHOUT DRAIN PIPE							
Water head (inch)	1″	2″	3″	4''	5″	6''		
Flow of water into box (gpm)	123	156	196	262	395	440		
Velocity of flow (ft/s)	1.2	1.7	1.9	2.5	3.9	5.8		
	DRAIN WITH 10-FT PIPE							
Water head (inch)	1′′	2″	3″	4''	5″	6''		
Flow of water into box (gpm)	112	171	229	257	787	866		
Velocity in drain pipe (ft/s)	6.3	6.7	7.2	7.4	7.5	7.9		
Pressure in drain pipe (in. W.C.)	2.5	2.3	2.4	1.6	-23.9	-27.9		
		DRAIN	<b>WITH M</b>	ODIFIED	PIPES			
Water head (inch)	1″	DRAIN 2"	<b>WITH M</b> 3"	ODIFIED 4"	<b>PIPES</b> 5"	6"		
Water head (inch) Flow of water into box (gpm)	1″ 69	<b>DRAIN</b> 2'' 123	<b>WITH M</b> 3" 203	ODIFIED 4'' 292	<b>PIPES</b> 5'' 776	6'' 799		
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s)	1'' 69 2.1	<b>DRAIN</b> 2'' 123 2.3	<b>WITH M</b> 3″ 203 2.7	<b>ODIFIED</b> 4'' 292 3.4	<b>PIPES</b> 5'' 776 7.9	6'' 799 7.5		
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s)	1'' 69 2.1 2.7	DRAIN 2" 123 2.3 3.1	<b>WITH M</b> 3" 203 2.7 3.7	ODIFIED 4'' 292 3.4 4.1	5" 576 7.9 5.7	6'' 799 7.5 5.5		
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s)	1" 69 2.1 2.7 6.6	DRAIN 2" 123 2.3 3.1 7.6	WITH M 3" 203 2.7 3.7 8.0	ODIFIED 4'' 292 3.4 4.1 8.3	<b>PIPES</b> 5" 776 7.9 5.7 8.8	6'' 799 7.5 5.5 7.3		
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.)	1'' 69 2.1 2.7 6.6 0.4	DRAIN 2" 123 2.3 3.1 7.6 -0.2	WITH M 3" 203 2.7 3.7 8.0 -0.7	ODIFIED 4" 292 3.4 4.1 8.3 -1.5	<b>PIPES</b> 5" 776 7.9 5.7 8.8 -25.9	6'' 799 7.5 5.5 7.3 -23.9		
Water head (inch) Flow of water into box (gpm) Velocity in 1st stack (ft/s) Velocity in horizontal pipe (ft/s) Velocity in 2nd stack (ft/s) Pressure in 1st stack (in. W.C.) Pressure in hor. pipe (in. W.C.)	1" 69 2.1 2.7 6.6 0.4 -1.0	DRAIN 2" 123 2.3 3.1 7.6 -0.2 -1.3	WITH M 3" 203 2.7 3.7 8.0 -0.7 -1.9	ODIFIED 4'' 292 3.4 4.1 8.3 -1.5 -3.2	<b>PIPES</b> 5" 776 7.9 5.7 8.8 -25.9 -62.3	6" 799 7.5 5.5 7.3 -23.9 -46.7		