Design Manual

Triton Underground Chamber System for Stormwater Management and Rainwater Harvesting

4/8/2021

Power over Water®

1.0 Background

Triton Stormwater Solutions provides a line of underground stormwater storage chambers that prove useful in many development and redevelopment projects. The Triton system's greatest benefit is at sites where high land value or simply a lack of space make above-ground stormwater best management practices infeasible. Project owners and designers throughout the world have realized the benefits of the Triton stormwater management system in this regard and have installed countless Triton systems with great success. This manual is intended to assist the site designer to implement the Triton system on his or her specific site.

2.0 Purpose

The purpose of this manual is to:

1) Briefly describe initial considerations (Section 3.0) required for the designer to establish the following system design parameters:

   - Location - Horizontal and vertical
   - Size – Chamber selection, system footprint, and storage volume

2) Describe a process to assist designers in preparing a system design (Section 4.0), including a layout and cross section detail, suitable for bidding and construction.

3.0 Initial Design Considerations

Sections 3.1 – 3.3 describe initial considerations required for the designer to establish system size and location.

3.1 Intended Use

Before a system's size and location can be determined, the designer must first consider the intended use of the Triton system for their project. The intended use is usually known before the design process begins, so this section is included only to provide a brief description of the various Triton stormwater management system applications. Triton systems are typically used in the following applications:

1) <u>To meet stormwater quality and quantity regulations</u>. The standard Triton stormwater management system is designed to provide stormwater detention (**Appendix E**) and/or infiltration (**Appendix A**) to meet target stormwater runoff rates, volume control, and water quality requirements. These systems can also be modified to provide sand filtration for water quality treatment in areas where infiltration is infeasible. Impermeable liners can also be used with Triton systems for sites with contaminated soils or in areas with high potential for groundwater contamination.

2) To provide storage for stormwater capture and reuse. In combination with an impermeable liner, Triton stormwater management systems can be designed to capture stormwater runoff for reuse in greywater applications such as irrigation.

3.2 Regulatory Requirements

Local regulatory requirements typically drive the need for a Triton stormwater management system and may also dictate its size, location and configuration. During the design process, the designer may need to consider regulatory requirements for the following reasons:

System sizing
Local regulatory requirements may dictate the amount of storage volume required within the Triton system. These may include requirements related to stormwater runoff rate control, stormwater infiltration, and detention or retention volume.

System location
Local regulatory requirements may dictate system placement on a given project site. Depending on local regulations, contaminated soils may have to be avoided and the system may have to be placed a certain distance above the groundwater table.

System configuration
As stated in Section 3.1, regulatory requirements can drive the intended use, and in turn the system components/configuration. For example, local regulations may require that a Triton system incorporate an impermeable liner due to the project site being located in an area with a high potential for groundwater contamination.

3.3 Site Constraints

In order to select an appropriate location for the Triton system, existing site constraints must be considered. Site constraints can act as a vertical constraint, a horizontal constraint or both. Horizontal site constraints control feasible locations to construct the Triton system. Vertical site constraints control the system's total build depth, maximum and minimum elevations, and size of chamber that can be selected. Commonly encountered site constraints are described below.

Storm\Water infrastructure
Existing or proposed stormwater infrastructure may heavily influence the location of the Triton system depending on its intended use. The Triton system may have to be placed horizontally in a location ideal for connecting to existing or proposed storm sewer. The depth and slope of storm sewer inlets or outlets to the Triton system also have to be considered when determining the system depth and maximum and minimum system elevations.

Site grading and drainage

Site grading may play a part in both horizontal and vertical location of the Triton system. Grading will influence the drainage system design. The Triton system(s) will typically need to be located near an outlet location for the site, and will need to be located to receive runoff from the site. (See above section, "Stormwater infrastructure). Triton systems also require a minimum cover depth (See Cross Section Details, **Appendix A & B**), so site grading will determine the maximum elevation of the system.

Other site utilities

Existing or proposed site utilities such as water, gas, electric, fiber-optic and sanitary sewer may have to be avoided.

Ground\Water table

Shallow groundwater table elevations may require a relatively shallow system design. Local regulations may also require a minimum amount of separation between infiltration best management practices (BMPs) like the Triton system and the groundwater table elevation (See Section 3.2). If an impermeable liner is utilized with a Triton system, the groundwater table must also be considered to ensure that floatation of the system will not occur.

Aboveground structures

Existing or proposed aboveground structures can easily be designed around with the flexibility of the Triton system. Large structures with footings and/or large loads should be avoided. These structures include buildings, light poles or bollards with footings that extend into the system, etc. Triton systems can be installed below some structures such as curb islands, cart corrals, footings of dumpster corrals, light poles, bollards, etc. Systems should also be designed around trees as root structures can damage underground structures over time. Minimum distances from building footings or basements may also be required in your locality.

Underlying soils

FOUNDATION REQUIREMENTS Triton chamber systems and embedment stone may be installed in various native soil types. The subgrade bearing capacity and chamber cover height determine the required depth of clean, crushed, angular stone for the chamber foundation. The chamber foundation is the clean, crushed, angular stone placed between the subgrade soils and the feet of the chamber. As cover height increases (top of chamber to top of finished grade) the chambers foundation requirements increase. Foundation strength is the product of the subgrade soils bearing capacity and the depth of clean, crushed, angular stone below the chamber foot. Table 1 for the S29, S22, C10 AND M6 specify the required minimum foundation depth for varying cover heights and subgrade bearing capacities.

WEAKER SOILS For sub-grade soils with allowable bearing capacity less than 2000 pounds per square foot [(2.0 ksf) (96 kPa)], a geotechnical engineer should evaluate the specific conditions. These soils are often highly variable, may contain organic materials and could be more sensitive to moisture. A geotechnical engineer's recommendations may include increasing the stone foundation, improving the bearing capacity of the sub-grade soils through compaction, replacement, or other remedial measures including the use of geogrids. The use of a thermoplastic liner may also be considered for systems installed in subgrade soils that are highly affected by moisture. The project engineer is responsible for ensuring overall site settlement is within acceptable limits. A geotechnical engineer should always review installation of Triton chambers on organic soils.

CHAMBER SPACING OPTION Triton always requires a minimum of 7.5" (190mm) for the S29 chamber system and 6" (150 mm) clear spacing between the feet of chambers rows for the S22, C10 AND M6. However, increasing the spacing between chamber rows may allow the application of Triton chambers with either less foundation stone or with weaker subgrade soils. This may be a good option where a vertical restriction on site prevents the use of a deeper foundation. Contact Triton for more information on this option. In all cases, Triton recommends consulting a geotechnical engineer for subgrade soils with a bearing capacity less than 2.0 ksf (96 kPa).

The designer should ensure that soils underlying the Triton system are suitably strong to support the system. The Project Civil/Design Engineer is solely responsible for assessing the bearing resistance (Allowable Bearing Capacity) of the Subgrade soils and determining the depth of the foundation stone. Subgrade bearing resistance should be assessed with consideration for the range of soil moisture conditions expected under a stormwater system. Depending on the intended use, the underlying soils must also have adequate infiltration capacity.

Table 1 (Imperial):

		S29, S22, C10, M6 - Recommended Depth of Base Stone (inches) - HGV Areas (allowing 50kPa imposed load)																						
		Minimum required Allowable Bearing Capacity ksf/kPa																						
Cover Depth		4.1	4	3.9	3.8	3.7	3.6	3.5	3.4	3.3	3.2	3.1	3.1	3	2.9	2.8	2.7	2.6	2.5	2.4	2.3	2.2	2.1	2
ft	m	*196*	*192*	*187*	*182*	*177*	*172*	*168*	*163*	*158*	*153*	*148*	*148*	*144*	*139*	*134*	*129*	*124*	*120*	*115*	*110*	*105*	*101*	*96*
1.5	0.46	6	6	9	9	9	9	9	9	9	9	9	9	9	9	9	9	12	12	12	12	12	12	12
2	0.61	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	12	12	12	12	12	12	12	15
2.5	0.76	9	9	9	9	9	9	9	9	9	9	9	9	9	12	12	12	12	12	12	12	12	15	15
3	0.91	9	9	9	9	9	9	9	9	9	9	9	9	12	12	12	12	12	12	12	12	15	15	15
3.5	1.07	9	9	9	9	9	9	9	9	9	9	12	12	12	12	12	12	12	12	12	15	15	15	15
4	1.22	9	9	9	9	9	9	9	9	12	12	12	12	12	12	12	12	12	12	15	15	15	15	15
4.5	1.37	9	9	9	9	9	9	9	12	12	12	12	12	12	12	12	12	12	15	15	15	15	15	18
5	1.52	9	9	9	9	9	9	12	12	12	12	12	12	12	12	12	12	15	15	15	15	15	18	18
5.5	1.68	9	9	9	9	12	12	12	12	12	12	12	12	12	12	12	15	15	15	15	15	18	18	18
6	1.83	9	9	9	12	12	12	12	12	12	12	12	12	12	12	15	15	15	15	15	18	18	18	18
6.5	1.98	9	9	12	12	12	12	12	12	12	12	12	12	12	15	15	15	15	15	15	18	18	18	18
7	2.13	12	12	12	12	12	12	12	12	12	12	12	12	15	15	15	15	15	15	18	18	18	18	21
7.5	2.29	12	12	12	12	12	12	12	12	12	12	15	15	15	15	15	15	15	18	18	18	18	21	21
8	2.44	12	12	12	12	12	12	12	12	12	15	15	15	15	15	15	15	18	18	18	18	18	21	21
8.5	2.59	12	12	12	12	12	12	12	15	15	15	15	15	15	15	15	18	18	18	18	18	21	21	21
9	2.74	12	12	12	12	12	12	15	15	15	15	15	15	15	15	18	18	18	18	18	21	21	21	24
9.5	2.90	12	12	12	12	12	15	15	15	15	15	15	15	15	15	18	18	18	18	21	21	21	21	24
10	3.05	12	12	12	12	15	15	15	15	15	15	15	15	15	18	18	18	18	18	21	21	21	24	24

NOTE: The design engineer is solely responsible for assessing the bearing resistance (allowable bearing capacity) of the subgrade soils and determining the depth of foundation stone. Subgrade bearing resistance should be assessed with consideration for the range of soil moisture conditions expected under a stormwater system.

Table 1 (Metric):

		S29, S22, C10, M6 - Recommended Depth of Base Stone (mm) - HGV Areas (allowing 50kPa imposed load)																						
		Minimum required Allowable Bearing Capacity ksf/kPa																						
Cover Dept		4.1	4	3.9	3.8	3.7	3.6	3.5	3.4	3.3	3.2	3.1	3.1	3	2.9	2.8	2.7	2.6	2.5	2.4	2.3	2.2	2.1	2
ft	m	196	192	187	182	177	172	168	163	158	153	148	148	144	139	134	129	124	120	115	110	105	101	96
1.5	0.46	0.150	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.250	0.250	0.250	0.250	0.250	0.250	0.300	0.300	0.300	0.300	0.350
2	0.61	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.300	0.300	0.300	0.300	0.350	0.350
2.5	0.76	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.300	0.300	0.300	0.300	0.350	0.350	0.350
3	0.91	0.200	0.200	0.200	0.200	0.200	0.200	0.200	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.300	0.300	0.300	0.300	0.350	0.350	0.350	0.350
3.5	1.07	0.200	0.200	0.200	0.200	0.200	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.300	0.300	0.300	0.300	0.300	0.350	0.350	0.350	0.350	0.400
4	1.22	0.200	0.200	0.200	0.200	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.300	0.300	0.300	0.300	0.300	0.350	0.350	0.350	0.350	0.400	0.400
4.5	1.37	0.200	0.200	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.300	0.300	0.300	0.300	0.300	0.300	0.350	0.350	0.350	0.350	0.400	0.400	0.400
5	1.52	0.200	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.300	0.300	0.300	0.300	0.300	0.300	0.350	0.350	0.350	0.350	0.400	0.400	0.400	0.450
5.5	1.68	0.250	0.250	0.250	0.250	0.250	0.250	0.250	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.350	0.350	0.350	0.350	0.400	0.400	0.400	0.450	0.450
6	1.83	0.250	0.250	0.250	0.250	0.250	0.250	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.350	0.350	0.350	0.350	0.400	0.400	0.400	0.450	0.450	0.450
6.5	1.98	0.250	0.250	0.250	0.250	0.250	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.350	0.350	0.350	0.350	0.400	0.400	0.400	0.400	0.450	0.450	0.500
7	2.13	0.250	0.250	0.250	0.250	0.300	0.300	0.300	0.300	0.300	0.300	0.350	0.350	0.350	0.350	0.350	0.350	0.400	0.400	0.400	0.450	0.450	0.450	0.500
7.5	2.29	0.250	0.250	0.250	0.300	0.300	0.300	0.300	0.300	0.300	0.350	0.350	0.350	0.350	0.350	0.350	0.400	0.400	0.400	0.450	0.450	0.450	0.500	0.500
8	2.44	0.250	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.350	0.350	0.350	0.350	0.350	0.350	0.400	0.400	0.400	0.450	0.450	0.450	0.500	0.500	0.550
8.5	2.59	0.300	0.300	0.300	0.300	0.300	0.300	0.300	0.350	0.350	0.350	0.350	0.350	0.350	0.400	0.400	0.400	0.400	0.450	0.450	0.500	0.500	0.500	0.550
9	2.74	0.300	0.300	0.300	0.300	0.300	0.300	0.350	0.350	0.350	0.350	0.350	0.350	0.400	0.400	0.400	0.400	0.450	0.450	0.450	0.500	0.500	0.550	0.550
9.5	2.90	0.300	0.300	0.300	0.300	0.300	0.350	0.350	0.350	0.350	0.350	0.400	0.400	0.400	0.400	0.400	0.450	0.450	0.450	0.500	0.500	0.500	0.550	0.550
10	3.05	0.300	0.300	0.300	0.300	0.350	0.350	0.350	0.350	0.350	0.400	0.400	0.400	0.400	0.400	0.450	0.450	0.450	0.500	0.500	0.500	0.550	0.550	0.600

NOTE: The design engineer is solely responsible for assessing the bearing resistance (allowable bearing capacity) of the subgrade soils and determining the depth of foundation stone. Subgrade bearing resistance should be assessed with consideration for the range of soil moisture conditions expected under a stormwater system.

4.0 System Design

At this point in the design, a system size and location should be determined (see Section 3.0, Initial Design Considerations). The sections below describe the design process in more detail, allowing for the designer to layout each of the system's specific components.

4.1 Chamber Selection

Chamber selection will be driven by the regional availability of Triton products and any vertical size or location restrictions on the Triton system. Table 1 summarizes chamber length, width and height, minimum cross section height (chamber height plus minimum 6" cover and 6" base, and storage volume per chamber when including typical surrounding stone and stone voids of 40% and neglecting volume included in the system perimeter stone.

Table 1: Chamber Dimensions and Storage Volumes:

(1)	(2)	(3)	(4)	(5)	(6)
Chamber Type	Chamber Length (in/mm)	Chamber Width (in/mm)	Standard Installed Cross Section Height (in/mm)	Min. Chamber Spacing (in/mm)	Storage Volume per Installed Chamber (ft^3/m^3)
M-6	29.6/ 752	33.6 / 854	29.5 / 749	6/152.4	11.4 / 0.323
C-10	29.6/ 752	39.7 / 1,009	37.0 / 940	6/152.4	17.5 / 0.496
S-22	27.7 / 703	55.0 / 1,397	47.0 / 1,194	6/152.4	31.3 / .886
S-29	33.4 / 848	59.0 / 1,499	48.0 / 1,219	7.5/190.5	40.4 / 1.145

4.2 Preliminary System Sizing

Once the required volume and horizontal and vertical location of a Triton system is known and a chamber for the system has been selected, preliminary system sizing should be performed to determine the number of chambers and rows required. There are three methods generally employed to perform preliminary system sizing: 1) estimating using a storage table, 2) the Triton Site Calculator and 3) HydroCAD.

4.2.1 Estimating Using a Storage Table

Referring to Table 1, the designer can select a chamber type and given required storage volume, and divide the required storage volume by column (5) to determine the minimum number of chambers required. The designer must then decide how many rows and chambers per row are needed to provide the minimum number of chambers required to provide the storage volume. When determining the number of rows and chambers per row, use the following equations to determine the footprint length and width: Width = (# of Rows)·(Chamber Width) + (# of Rows — 1)·(Row Spacing) + 2·(12"/305mm)

Length = (# of Chambers per Row)·(Chamber Length) + 3·(12"/305mm)

4.2.2 Triton Site Calculator

The Triton Site Calculator is available at https://tritonsws.com/calculator The Site Calculator is straightforward and self-explanatory, only requiring the following input parameters:

- Storage Volume
- Product Selection
- Header Row Position
- Fill Over Embedment Stone
- Controlling Horizontal Dimension of the System (Left or Right)

The calculator will output the number of chambers and rows, as well as other system parameters including horizontal dimensions of the system and stone volume. The advantages to the calculator are it does not require any special storm water modeling software and is freely available on the internet. One drawback of the site calculator is its inflexibility to modify the number of main header rows and their orientation to the storage rows. The site calculator assumes one or two header rows oriented perpendicular to the storage rows. See Section 4.3.1.1 below for more discussion on header row orientation.

4.2.2 HydroCAD

HydroCAD is another option available to the designer to size a Triton system. Within HydroCAD, there are two methods available to perform sizing. The advantages of using HydroCAD are greater flexibility and ability for the designer to design a system within an already modeled scenario to create the most efficient design. The disadvantage is that HydroCAD is not free so not everyone has access to this software. See PAGE 18 for HydroCAD tutorial specific to Triton sizing. For more details about the Hydrocad program please visit: http://www.hydrocad.net

4.2.3 Triton Incremental Storage Calculator

The Triton incremental calculator is a flexible spreadsheet available upon request by emailing us at sales@tritonsws.com The incremental calculator can be used to preliminarily size rectangular and non-rectangular systems and perform final calculations once a system is designed. The calculator will compute cumulative chamber and end cap, stone and total system storage as a function of system elevation. Detailed instructions for using the calculator are available in the spreadsheet.

4.3 Layout Design

Before beginning the layout design, the designer should first determine the best location for the underground system in relation to utilities like light posts, gas lines and other items that could impact the underground system.

Next, the designer should decide whether a detention or retention system will be used. A Triton detention system is defined as a system allowing infiltration into surrounding native soils. This is the default design for the majority of cases. However, in cases where the designer wishes to retain all or some of the storm water in a system, a retention system can be used. See **Appendix A** for a standard detail of a Triton single layer chamber retention system.

Finally, the designer should consider the location of the system inlet(s) and outlet(s).The inlets and outlet will guide the position and orientation of the Triton Header Row(s) and storage rows and is the third step in the preliminary layout design.

4.3.1 Determine Position and Orientation of the Header Row(s)

4.3.1.1 Header Row Purpose and Function

The Triton Header Row is used to inexpensively provide Total Suspended Solids (TSS) removal and provide access to the Triton system for inspection and maintenance.

The Header Row is comprised of several Triton chambers that sit on interconnecting sediment floors or woven geotextile fabric and is typically connected to a nearby manhole. The Header Row feeds the storage rows via connector pipes (Figure 1). The connector pipes are elevated above the bottom of chambers to capture sediment in the Header Row. The Header Row protects the storage rows from sediment accumulation. This preserves the infiltration capacity of the native soils below the storage rows, allowing the system to perform at the rate for which it was designed. An inspection port can be installed into the Header Row as shown in **Appendix F OR G.**

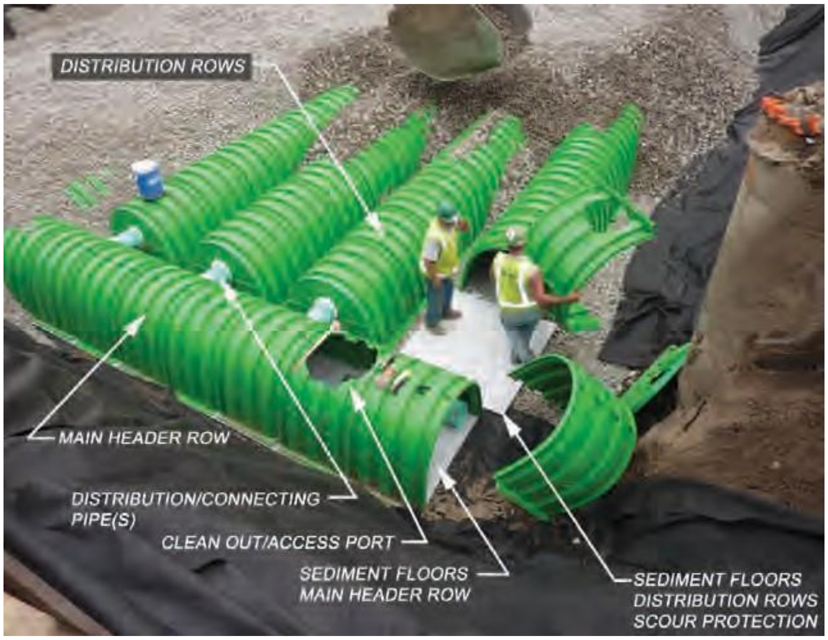
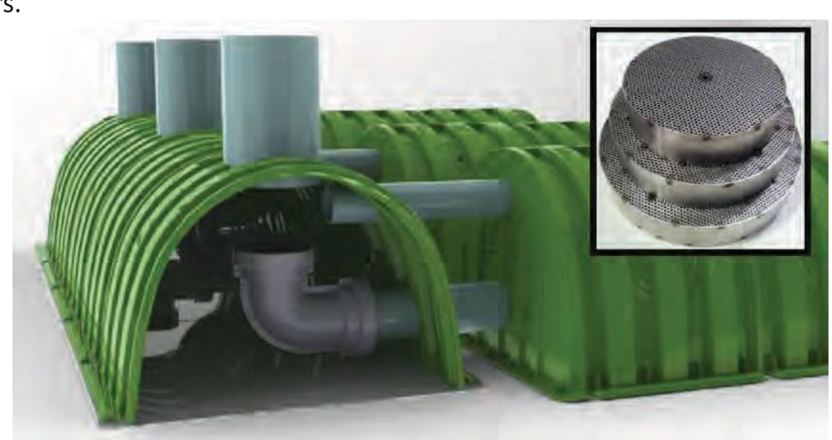


Figure 1

The sediment floors or woven geotextile fabric beneath the Header Row is used to contain sediment and prevent scouring of the underlying stone during operation and maintenance. The sediment floors lock together and mate with the chambers so they will remain intact during very high flow events and during high pressure cleaning. Cleaning typically consists of jetting of the Header Row using water under high pressure and vacuuming of the sediment and water slurry, and is typically performed from a single maintenance point using a Jet-Vak truck.
The designer may wish to enhance pollutant removal in the Main Header Row before storm water flows into the storage rows by replacing the connector pipes with a Filter Elbow and Filter Media Puck. The reusable stainless steel Filter Media Puck allows developers to pre-treat a wide range of pollutants by filling the Filter Media Puck with any type of filter media to treat any type of pollutant that might be found in the stormwater before it enters the stormwater storage chambers.



In combination with the main Header Row, featuring advanced sediment control, the Filter Media Puck allows for the most efficient handling, storage and filtration of stormwater available. The designer can refer to the Triton product listing on Triton's website at http://www.tritonsws.com/products for more information on the filter elbow and media puck.

The Header Row may also be part of a treatment train. By treating storm water prior to entry into the Header Row, service life can be extended and pollutants, such as hydrocarbons, can be captured. Pre-treatment best management practices can be as simple as deep sump catch basins or innovative proprietary storm water treatment devices. The design of the treatment train and selection of pre-treatment devices by the design engineer are often driven by regulatory requirements. Whether pre-treatment is required or not, the Header Row is recommended by Triton Engineering as an effective means of preserving the system functionality. If further treatment is required then Triton would recommend the use of the patented Triton Elbows and Filter Pucks. Refer to **Appendix G** for more details.

Figure 2-Main Header Row Option if a large inlet pipe is required that exceeds the recommended pipe size listed in Table 3 below.

4.3.1.2 Header Row Position and Orientation

The following criteria should be used to design the location and orientation of the Header Row(s):

The Header Row should be located and oriented to accept all system inlets.
All system inlets should be routed into the Header Row(s). For the majority of systems, this can be accomplished using a single Header Row. On larger systems, with many system inlets, multiple Header Rows may be used. System inlets can be connected to the Header Row in the following ways:

A. Side connection into side of Chamber
Inlet pipes can be directly connected to the side of a Triton Header Row chamber (Figure 1 & 2). Use of this connection method will require that a Triton Header Row is oriented on the outside edge of the Triton System. A given Header Row chamber should only accept one side connection oriented horizontally in the center of the chamber. Avoid side connections into the overlap between two chambers to maintain chamber strength. A minimum distance of 1 inch (25mm) from the bottom of the chamber and the outside diameter of an inlet pipe should also be

accommodated to maintain chamber strength. Triton Engineering recommends that inlet pipes directly connected into the side of a chamber are restricted to the sizes listed in Table 2.

Table 2 – Maximum Recommended PVC Pipe Sizes for Side Connections

Chamber Model	Maximum Pipe Size for Side Connection (in/mm)
M-6	8 in / 200mm
C-10	12 in / 300mm
S-22	18 in / 450mm
S-29	18 in / 450mm

B. End connection into End Cap

Inlet pipes can be directly connected to the end of a Triton Header Row chamber through the chamber end cap (Figures 2 & 3). A given Header Row end cap should only accept one end connection with a minimum distance of 1 inch (25mm) from the bottom of the end cap and 3 inches (75 mm) from the top of the end cap to the outside diameter of an inlet pipe to avoid chamber corrugations and maintain end cap strength. The end connection should be centered horizontally. Triton Engineering recommends that inlet pipes directly connected into the end of a chamber through the end cap are restricted to the sizes listed in Table 3.

Table 3 – Maximum Recommended Pipe Sizes for End Connections

Chamber Model	Maximum Pipe Outside Diameter for End Connection (in/mm)
M-6	14 in / 350mm
C-10	20 in / 500mm
S-22	30 in / 760mm
S-29	32 in / 810mm

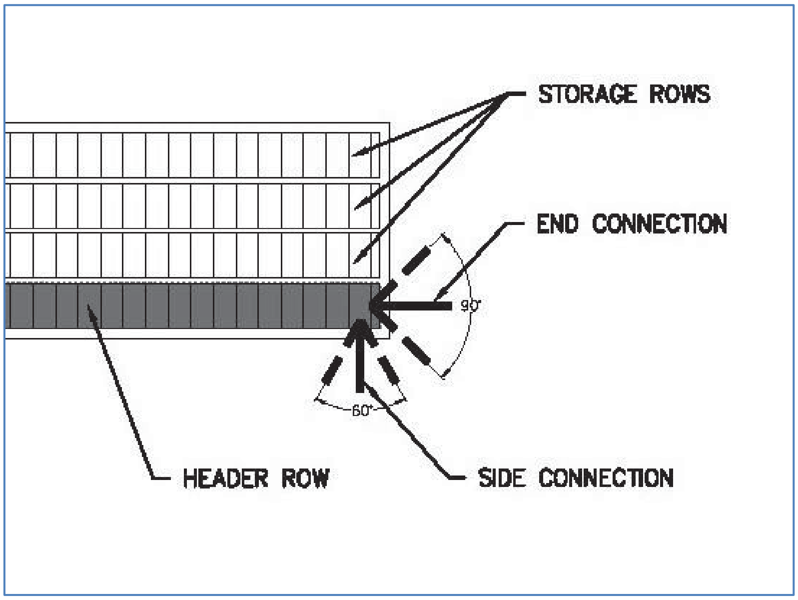


Figure 3 – Side and End Connection Schematic

C. Top connection

Inlet pipes can be directly connected to the top of a Triton Header Row chamber (Figure 3). Typically, top connections should are used when the Triton system is located directly beneath a trench drain or catch basin. A given Header Row chamber should only accept one top connection oriented in the center of the chamber. Top connections into the overlap between two chambers should be avoided so as not to compromise chamber strength. Triton Engineering recommends that inlet pipes directly connected into the top of a chamber are restricted to the sizes listed in Table 4 and **Appendix E.**

Table 4 – Maximum Recommended Pipe Sizes for Top Connections

Chamber Model	Maximum Pipe Size for Top Connection (in/mm)
M-6	12 in / 300mm
C-10	18 in / 450mm
S-22	24 in / 600mm
S-29	24 in / 600mm

Figure 4 – Triton Header Row with direct chamber connection for maintenance and inspection (Top Access), end connection and inlet top/side connections.

D. Connector Pipes (for flow distribution and system equalization)

Connector pipes are used to distribute flow from the Header Rows, and ensure adequate equalization within the system. When sizing connector pipes to distribute flow from a Header Row, the designer should keep the connections as small as possible while still providing sufficient conveyance capacity of the peak flow into the Header Row. Table 5, below, can be used to help determine an adequate connector pipe size and/or number of connector pipes required. Perpendicular Header Rows typically have connections to each adjacent storage row, but are only required as necessary to convey the influent peak flow. Parallel Header Rows typically have connector pipes located towards the end of the Header Row as necessary.

Flow equalization within the system is provided within the voids of the embedment stone, and via connector pipes. The number and size of connector pipes used to augment the stone void equalization is determined by the designer. At a minimum, connector pipes should be designed to convey the effluent peak flow.

The designer can reference Table 2 and 5 to size connector pipes.

Table 5 – Design flow capacities for connector pipes

Pipe Diameter (in/mm)	Design Flow Capacity (cfs/lps)
4/100	0.15 / 4.2
6/150	0.40 / 11
8/200	0.85 / 24
10/250	1.5 / 42
12/300	2.5 / 71
15/375	4.6 / 130
18/450	7.5 / 210

4.3.1.3 Provide maintenance and inspection access for each Header Row.

Under most circumstances, with the exception of a side connection, the Header Row inlet connections described above can double as a Header Row access. The designer must consider the most efficient way to provide access using the options described below for an individual site.

1) **Manhole Connection (End Access)**

The "manhole connection" is the most common and easiest to construct Header Row access option (Figure 5). This option requires placement of a manhole at either end of a Header Row and adjacent to the Triton system. The manhole is connected to the Header Row End Cap with a pipe of the maximum size listed in Table 3 (End Connection table) and following the other pipe connection recommendations described above in the **End Connection section**. Depending on manhole and system inlet diameter size and system inlet orientation, system inlets can also be routed into the manhole allowing this access option to double as a system inlet point. A detail showing the standard Manhole Connection is provided in **Appendix B**.

Figure 5 – Triton Header Row with manhole connection for maintenance and inspection (End Access)

2) **Direct Chamber Connection (Top Access)**
A Direct Chamber Connection can also be utilized to provide Header Row maintenance and inspection access (Figure 4). This option is generally less preferred than the Manhole Connection option described above because it typically requires exact placement of the Triton Header Row during construction. However, this option can be more desirable when space constraints restrict placement of a manhole at the end of a Header Row. This option consists of provided access directly above the Header Row by connecting a top slab and casting to the top of a Header Row chamber with a pipe of the maximum size listed in Table 4 (Top Connection table) and following the other pipe connection recommendations described above in the **Top Connection section.** A sump is usually provided beneath the chamber to allow for easier maintenance. A detail showing the Direct Chamber Connection is provided in **Appendix C**.

Figure 6 - Chamber direct connection option

3. **Orient Header Row(s) either parallel or perpendicular to the system distribution rows.** Depending on the number of Header Rows, the relationship of the inlets and outlet to the Header Row, and other horizontal constraints, the Header Row should be oriented either parallel or perpendicular to the system storage rows. In general, if there is only a single Header Row, it can be oriented either perpendicular (Figures 7) or parallel to the system storage rows (Figure 8). If there are multiple Header Rows, they are typically oriented parallel to the system storage rows (Figure 9).

   Note: When there is less than a foot between the chamber invert and a pipe invert (an inlet pipe, outlet pipe, or connector pipe), scour protection in the form of sediment floors or woven geotextile should be installed. Oftentimes, the only location in a system where this will occur is at the header row. However, in some cases, this will occur at a storage row.

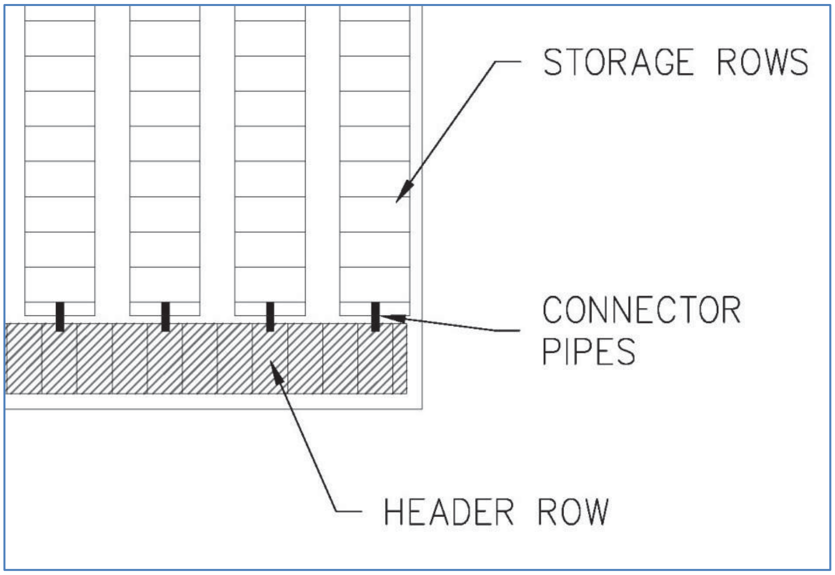


Figure 7 – Single Header Row oriented perpendicular to storage rows

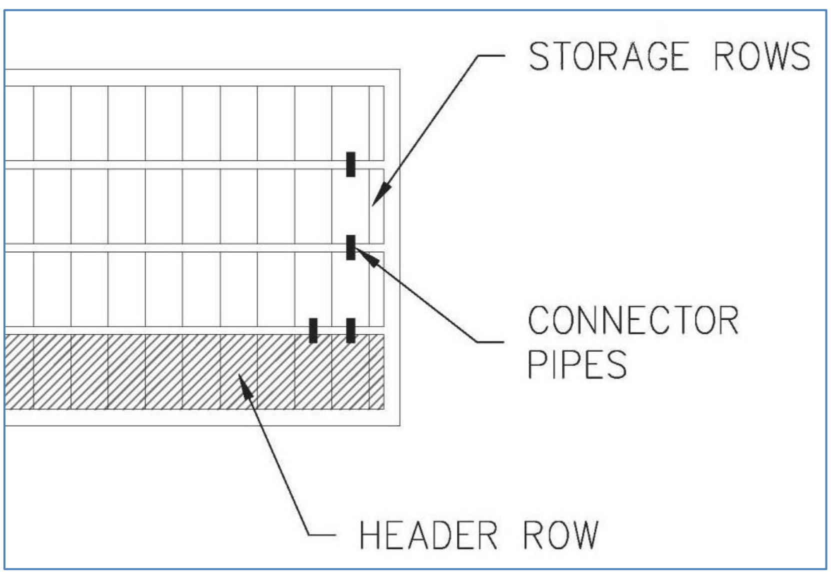


Figure 8 – Single Header Row oriented parallel to storage rows

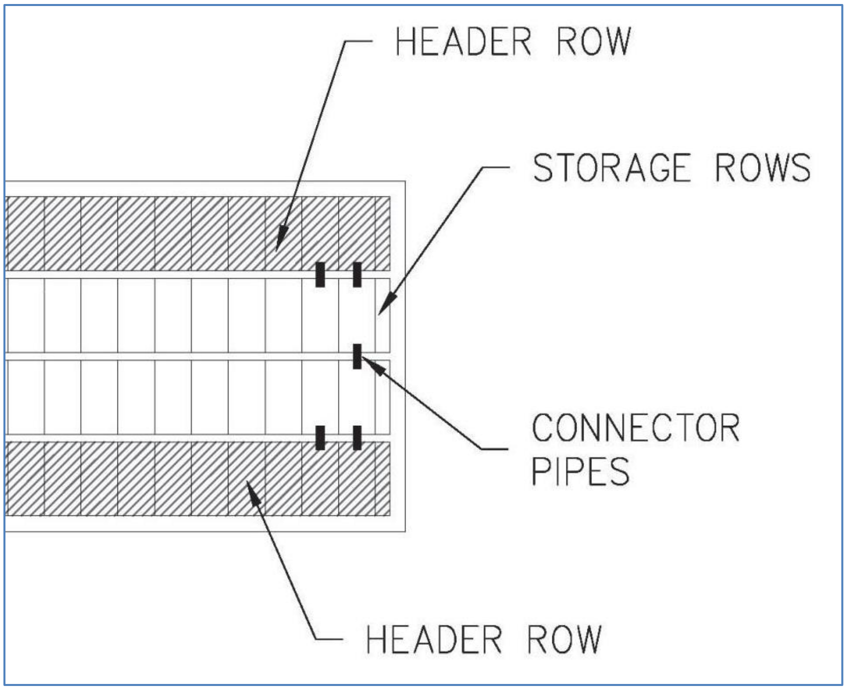


Figure 9 – Multiple Header Rows oriented parallel to storage rows

4. **System Ventilation**

For a typical design, venting of the system is likely not necessary as the system is vented by the inlet and outlet pipes, with the remainder of the system volume located above the inlet and outlet pipe crowns being dispersed to the surrounding soils. If there is concern that the surrounding soils do not have capacity to absorb air from the system or there is a large amount of storage above the inlet and outlet, then venting is recommended. Venting can be accomplished by simply running drain tile in the cover stone to an adjacent inlet or outlet MH that includes a grated, or sufficiently vented manhole covers.

HydroCAD Tutorial Method 1:

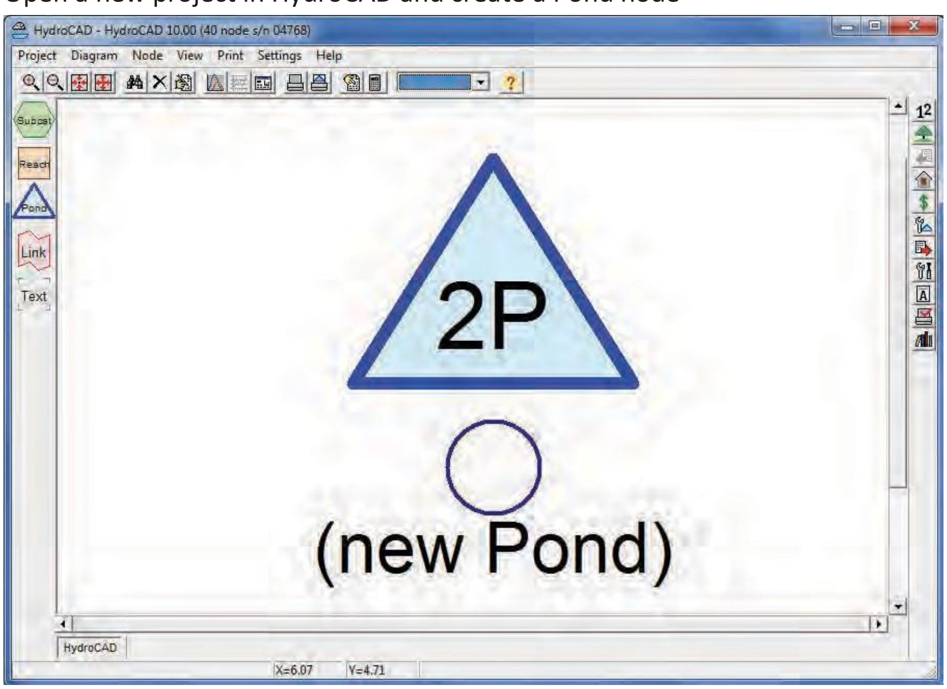
Chamber Wizard

The chamber wizard is recommended to preliminarily size a system for both the case when there are header rows parallel to the storage rows (or include no header rows) or for a very rough estimate of a system with a header row perpendicular to storage rows. This is because the chamber wizard does not allow for perpendicular rows. In this case, if the chamber wizard were used to preliminarily size a system, the designer would have to create an initial layout, and then check the storage volume using Method 2. If the storage volume were less than the required volume, the designer would have to add additional chambers and/or rows and continue rechecking the system volume using Method 2.

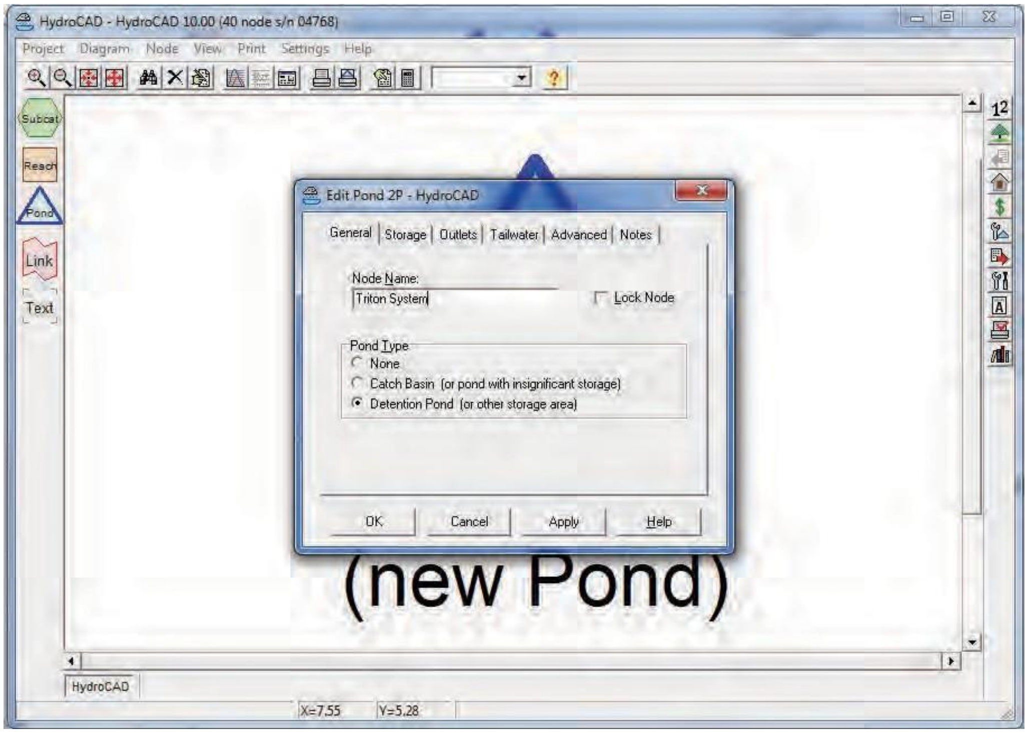
Following is a case study of sizing a system with the following requirements:

- S-29 Chambers
- 2,500 cubic feet of required storage
- 1 header row parallel to the storage rows
- Must fit within a 30' x 35' footprint
- 4 foot rock section from elevation 833.0 to 837.0
- 40% Stone Void Volume (Typical)

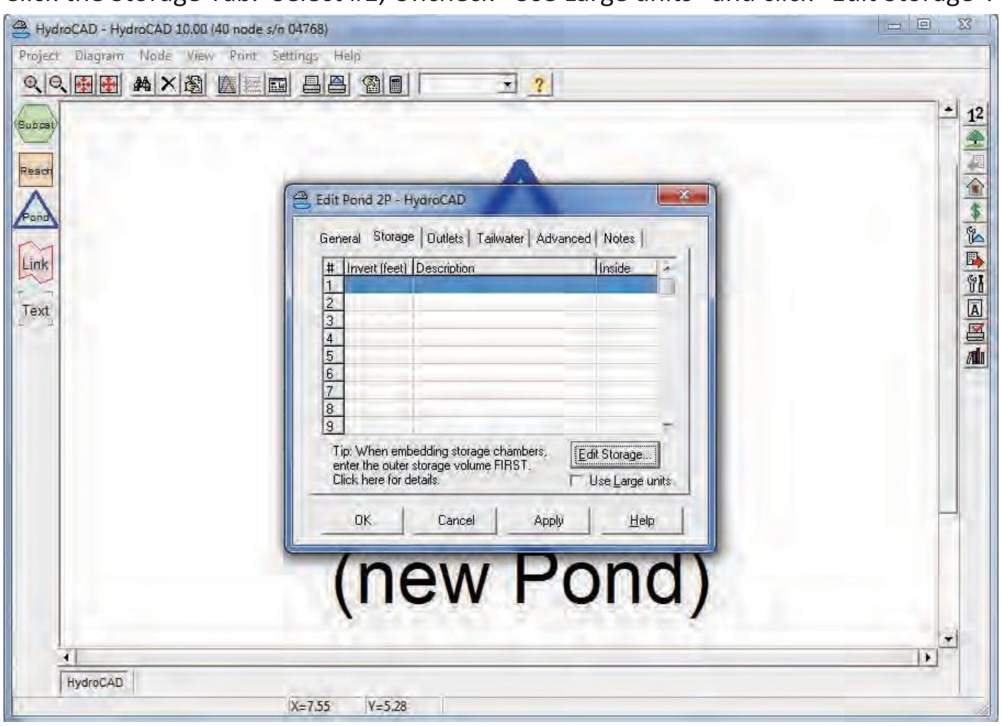
1) Open a new project in HydroCAD and create a Pond node



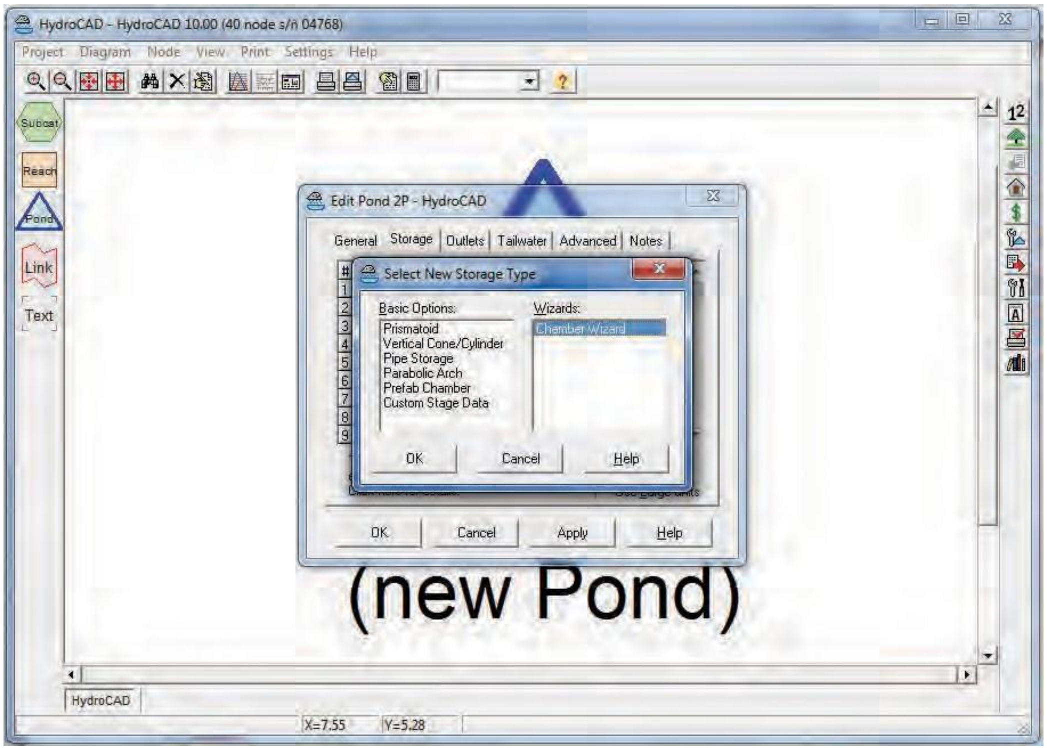
2) Open the Pond node. Rename the Pond and select "Detention Pond" under "Pond Type"



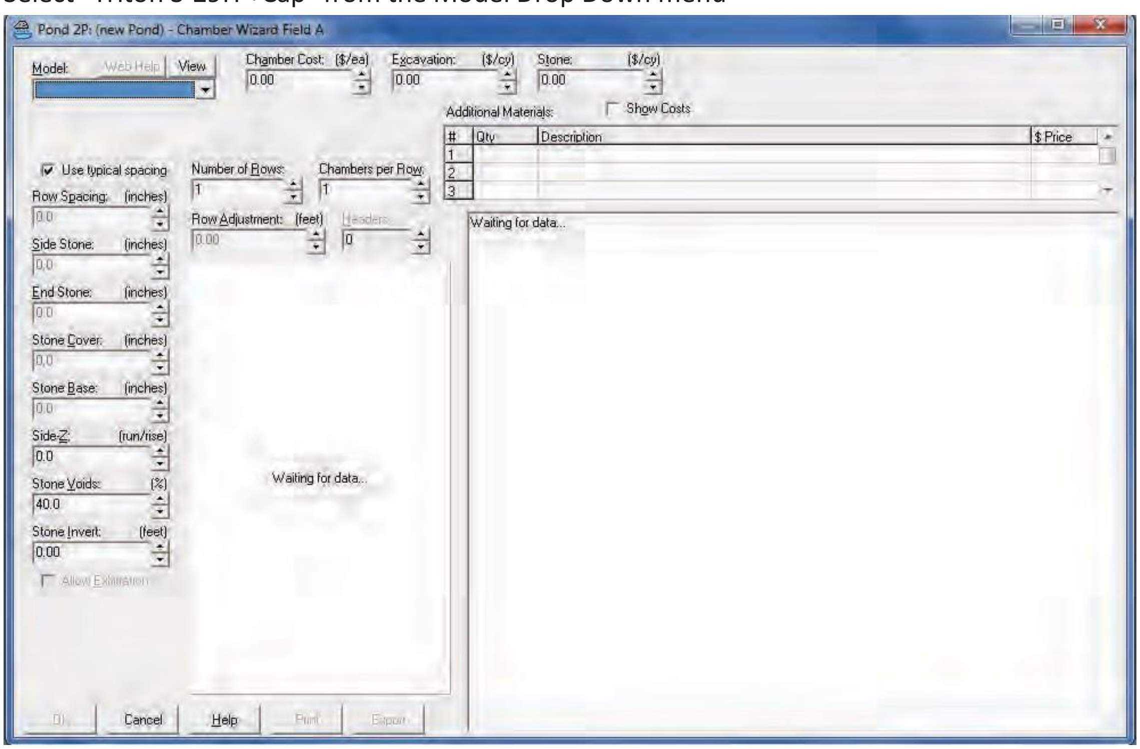
3) Click the Storage Tab. Select #1, Uncheck "Use Large units" and click "Edit Storage".



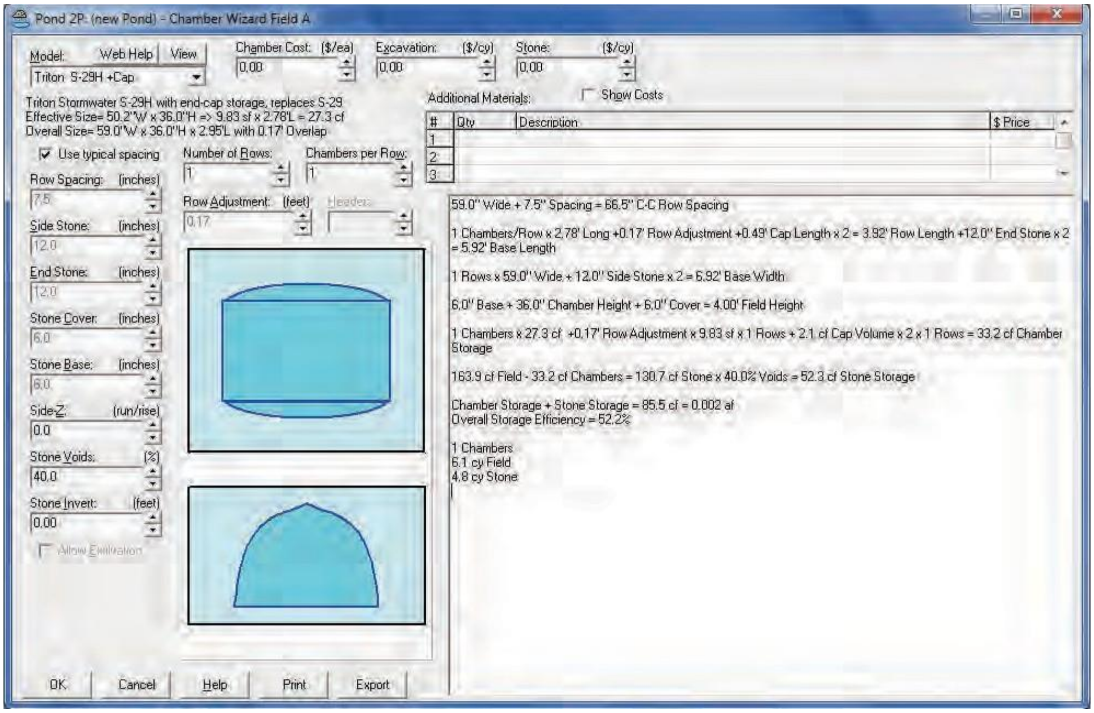
4) Select the Chamber Wizard and hit OK.



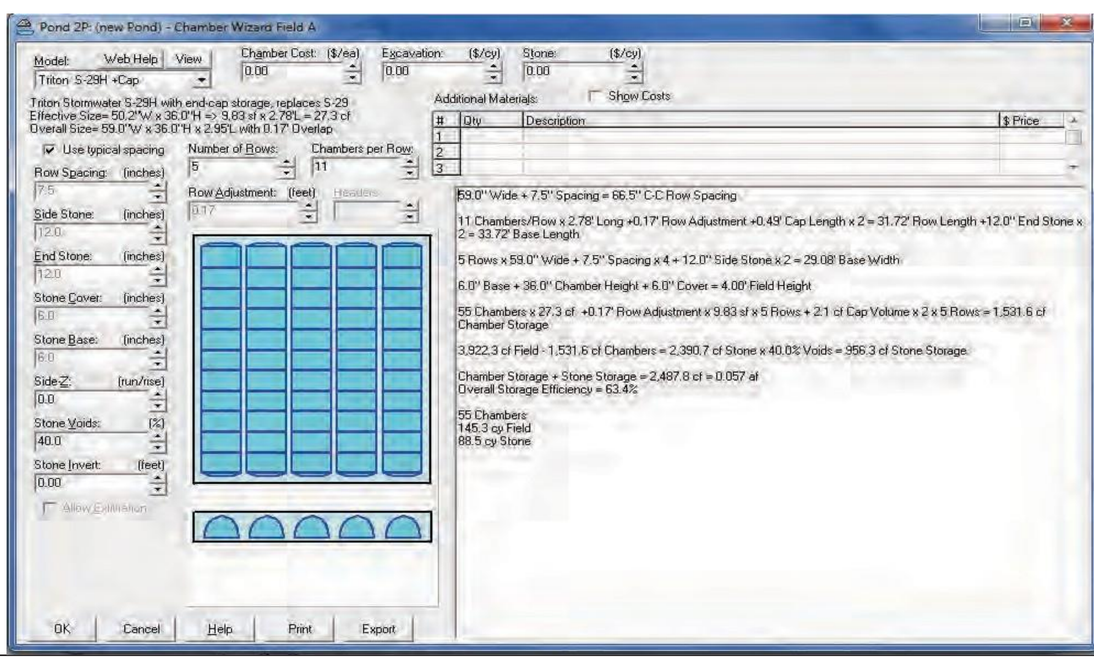
5) Select "Triton S-29H +Cap" from the Model Drop Down menu



6) Change the Stone Invert to 833.0 and change the "Number of Rows" and "Chambers per Row" to 5 and 11, respectively.



7) Note that the "Chamber Storage + Stone Storage" is 2,487.8 cubic feet, less than the required storage of 2,500 cubic feet. Adding an additional "Chamber per Row" or "Row" will result in a footprint greater than 30 x 35.



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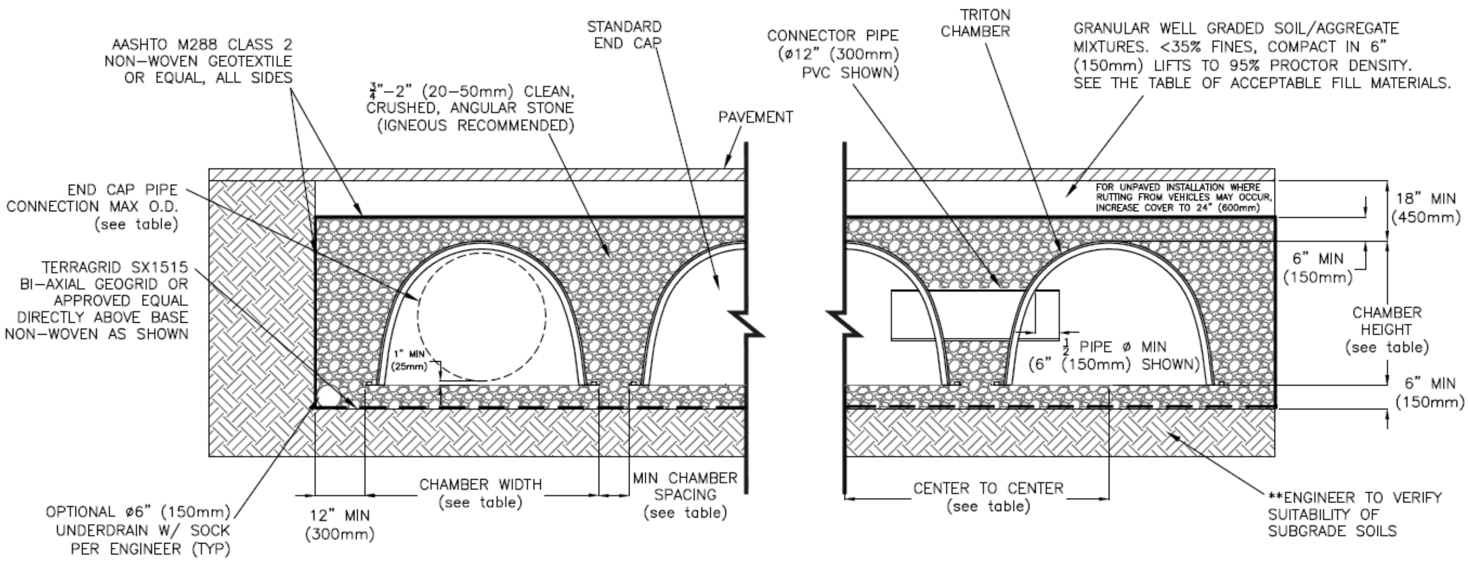
APPENDIX A



	CHAMBER WIDTH	CHAMBER SPACING	CENTER TO CENTER	CHAMBER HEIGHT	MAX END CAP CONNECTION
S29	59" (1499mm)	6.0" (150mm) *7.5" (190mm)	65.0" (1651mm) *66.5" (1690mm)	36" (914mm)	32" (813mm)
S22	55" (1397mm)	6.0" (150mm)	61.0" (1549mm)	35" (889mm)	30" (762mm)
C10	39.7" (1008mm)	6.0" (150mm)	45.7" (1161mm)	25" (635mm)	20" (508mm)
M6	33.6" (853mm)	6.0" (150mm)	39.6" (1006mm)	17.5" (445mm)	14" (356mm)

*7.5" (190mm) SPACING OF DISTRIBUTION ROWS IS REQUIRED ONLY WHEN A PERPENDICULAR MAIN HEADER ROW IS USED. IF AN INLINE MAIN HEADER ROW IS USED, THEN MIN SPACING CAN BE 6" (150mm)

** THE DESIGN ENGINEER IS SOLELY RESPONSIBLE FOR ASSESSING THE BEARING RESISTANCE (ALLOWABLE BEARING CAPACITY) OF THE SUBGRADE SOILS AND DETERMINING THE DEPTH OF FOUNDATION STONE. SUBGRADE BEARING RESISTANCE SHOULD BE ASSESSED WITH CONSIDERATION FOR THE RANGE OF SOIL MOISTURE CONDITIONS EXPECTED UNDER A STORMWATER SYSTEM.

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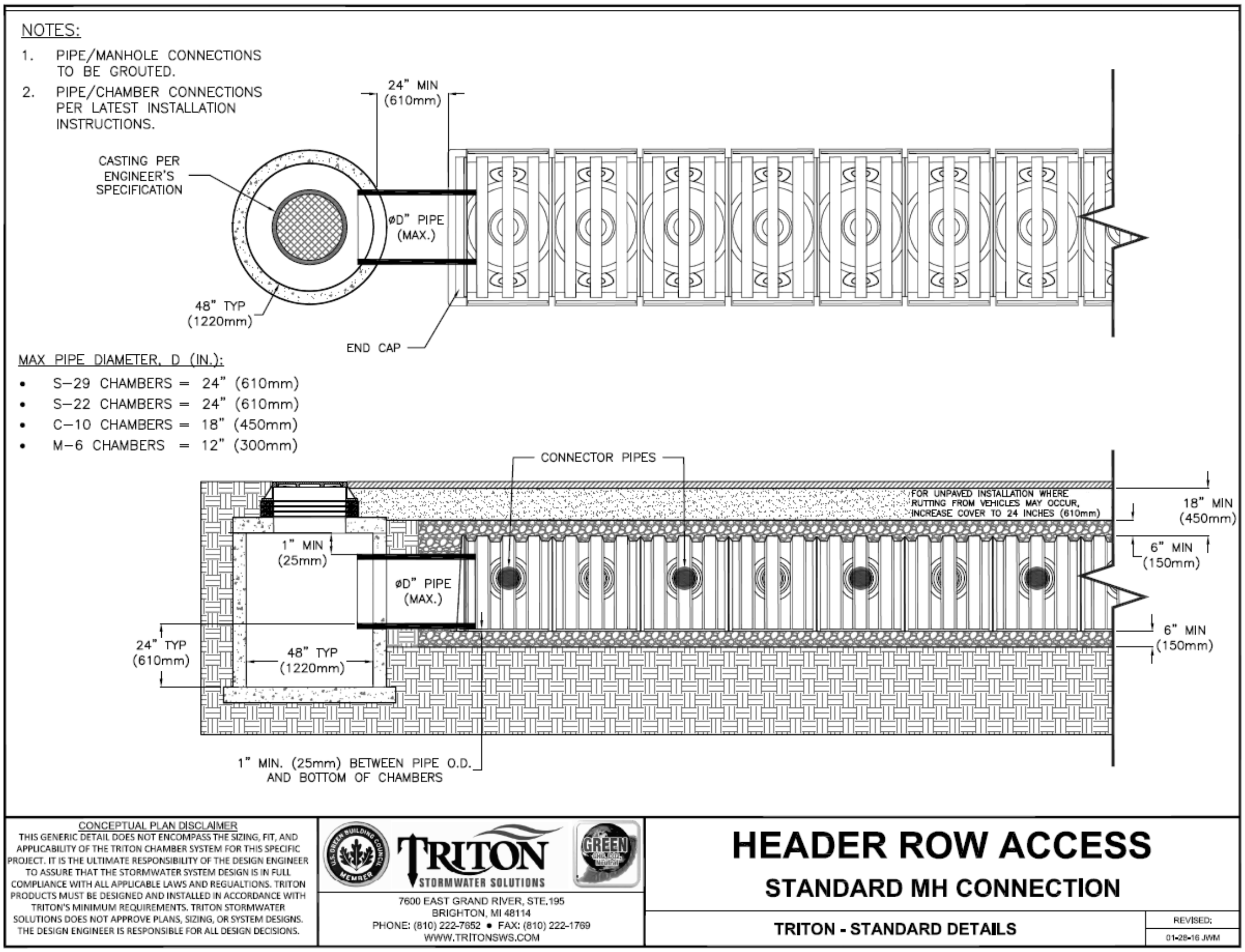
CHAMBER CROSS SECTION
INFILTRATION

TRITON - STANDARD DETAILS

REVISED: 04-09-20 JWM

APPENDIX B


NOTES:
1. PIPE/MANHOLE CONNECTIONS TO BE GROUTED.
2. PIPE/CHAMBER CONNECTIONS PER LATEST INSTALLATION INSTRUCTIONS.
24" MIN (610mm)
CASTING PER ENGINEER'S SPECIFICATION
øD" PIPE (MAX.)
48" TYP (1220mm)
END CAP
MAX PIPE DIAMETER, D (IN.):
• S-29 CHAMBERS = 24" (610mm)
• S-22 CHAMBERS = 24" (610mm)
• C-10 CHAMBERS = 18" (450mm)
• M-6 CHAMBERS = 12" (300mm)
CONNECTOR PIPES
FOR UNPAVED INSTALLATION WHERE RUTTING FROM VEHICLES MAY OCCUR, INCREASE COVER TO 24 INCHES (610mm)
18" MIN (450mm)
6" MIN (150mm)
1" MIN (25mm)
øD" PIPE (MAX.)
24" TYP (610mm)
48" TYP (1220mm)
6" MIN (150mm)
1" MIN. (25mm) BETWEEN PIPE O.D. AND BOTTOM OF CHAMBERS
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HEADER ROW ACCESS
STANDARD MH CONNECTION
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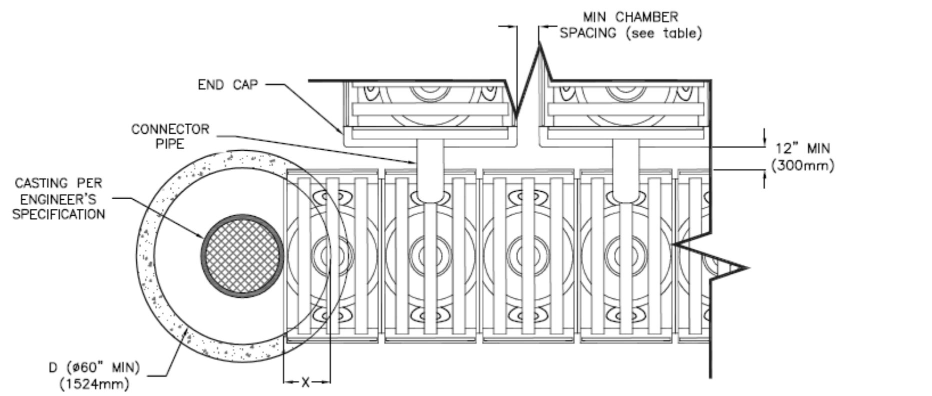
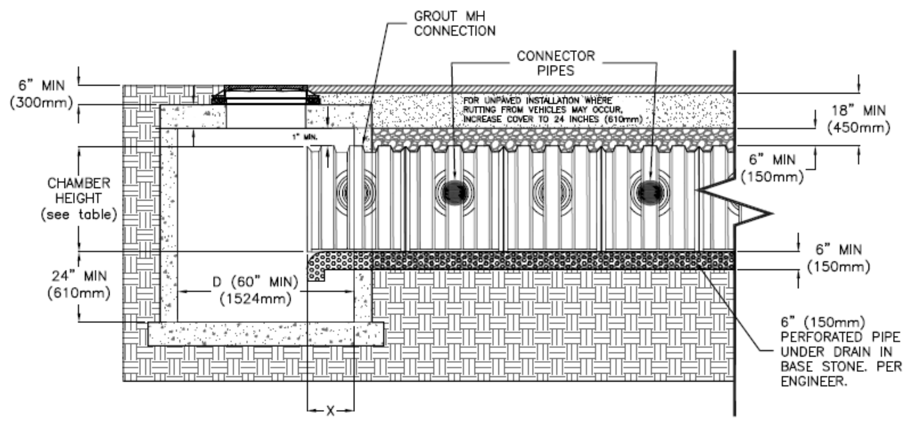
REVISED:
01-28-16 JWM

APPENDIX C

MANHOLE DIAMETER, D	TOP SLAB THICKNESS, T (TYP.)	CHAMBER INSERTION DISTANCE, X (MIN.)
60"	8"	16"
72"	8"	12"
84"	8"	10"
96"	8"	9"
≥108"	12"	8"





	MAX DIAMETER FOR CONNECTOR PIPE	CHAMBER SPACING	CHAMBER HEIGHT
S29	18" (450mm)	6.0" (150mm) *7.5" (190mm)	36" (914mm)
S22	18" (450mm)	6" (150mm)	35" (889mm)
C10	12" (300mm)	6" (150mm)	25" (635mm)
M6	8" (200mm)	6" (150mm)	17.5" (445mm)

*7.5" (190mm) SPACING OF DISTRIBUTION ROWS IS REQUIRED ONLY WHEN A PERPENDICULAR MAIN HEADER ROW IS USED. IF AN INLINE MAIN HEADER ROW IS USED, THEN MIN SPACING CAN BE 6" (150mm)

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HEADER ROW ACCESS

DIRECT MH CONNECTION

TRITON - STANDARD DETAILS

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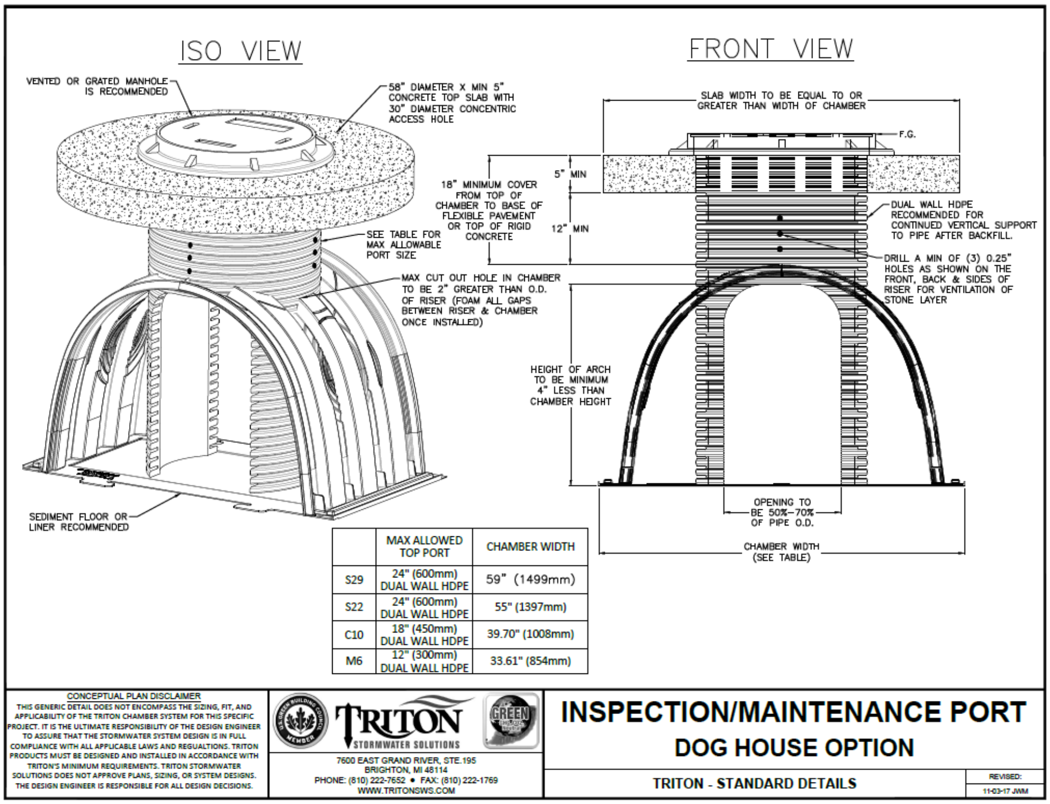
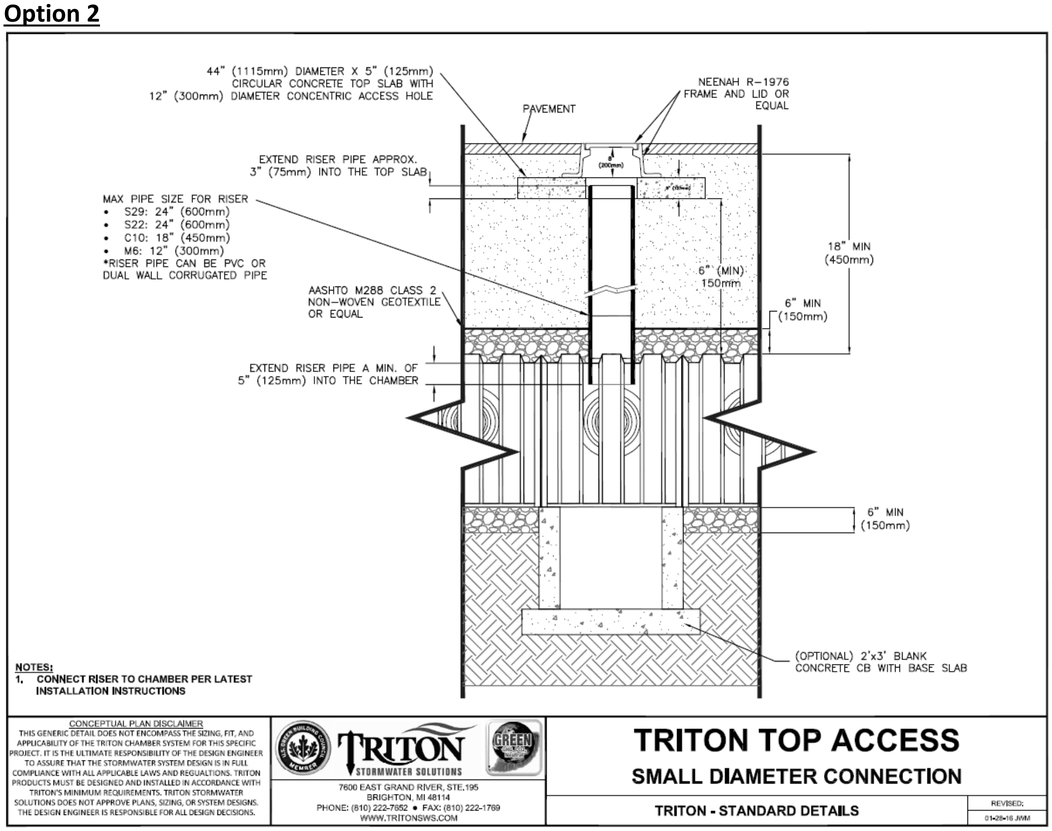
APPENDIX D

Option 1



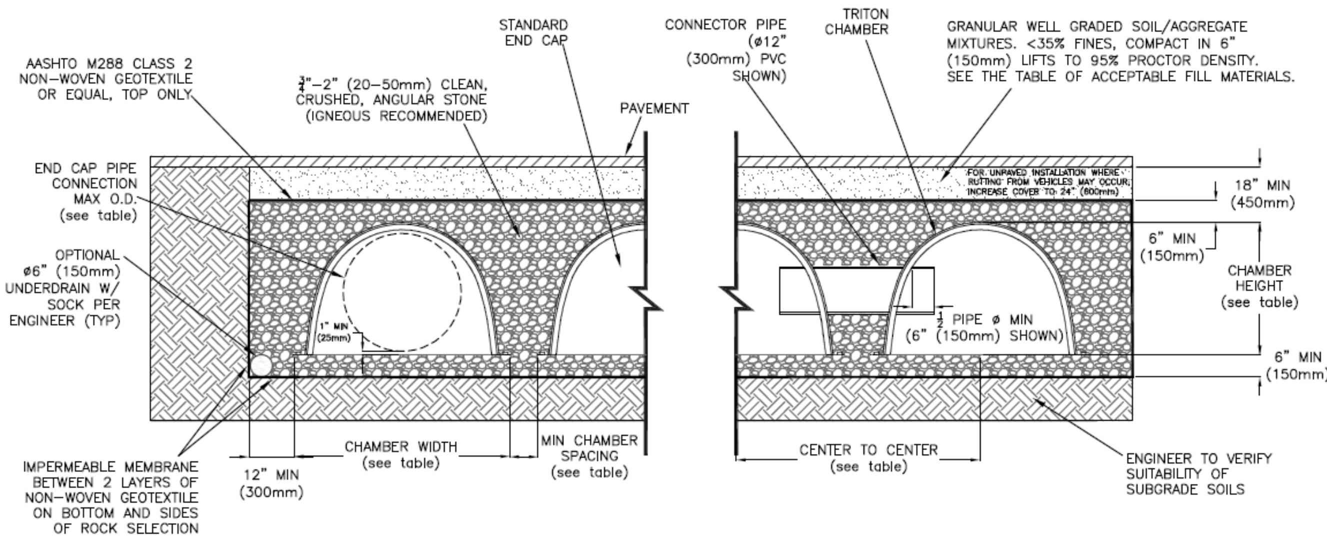
	MAX ALLOWED TOP PORT	CHAMBER WIDTH
S29	24" (600mm) DUAL WALL HDPE	59" (1499mm)
S22	24" (600mm) DUAL WALL HDPE	55" (1397mm)
C10	18" (450mm) DUAL WALL HDPE	39.70" (1008mm)
M6	12" (300mm) DUAL WALL HDPE	33.61" (854mm)

Option 2



APPENDIX E

NOTE: IF USED FOR WATER HARVESTING SYSTEM, FILL THE TRENCH WITH WATER AFTER THE FABRIC AND LINER HAVE BEEN INSTALLED TO ENSURE THERE ARE NO LEAKS IN THE LINER PRIOR TO INSTALLING THE STONE, CHAMBER AND BACKFILL.



	CHAMBER WIDTH	CHAMBER SPACING	CENTER TO CENTER	CHAMBER HEIGHT	MAX END CAP CONNECTION
S29	59" (1499mm)	6.0" (150mm) *7.5" (190mm)	65.0" (1651mm) *66.5" (1690mm)	36" (914mm)	32" (813mm)
S22	55" (1397mm)	6.0" (150mm)	61.0" (1549mm)	35" (889mm)	30" (762mm)
C10	39.7" (1008mm)	6.0" (150mm)	45.7" (1161mm)	25" (635mm)	20" (508mm)
M6	33.6" (853mm)	6.0" (150mm)	39.6" (1006mm)	17.5" (445mm)	14" (356mm)

*7.5" (190mm) SPACING OF DISTRIBUTION ROWS IS REQUIRED ONLY WHEN A PERPENDICULAR MAIN HEADER ROW IS USED. IF AN INLINE MAIN HEADER ROW IS USED, THEN MIN SPACING CAN BE 6" (150mm)

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CHAMBER CROSS SECTION

RETENTION - WITH IMPERMEABLE LINER

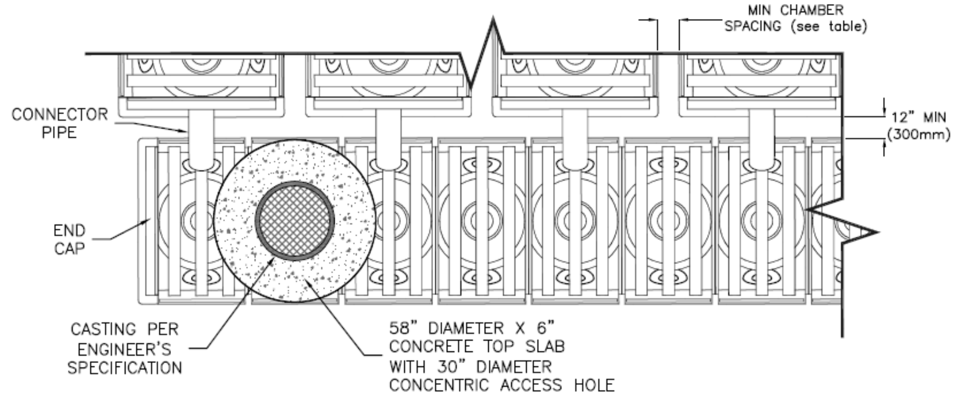
TRITON - STANDARD DETAILS

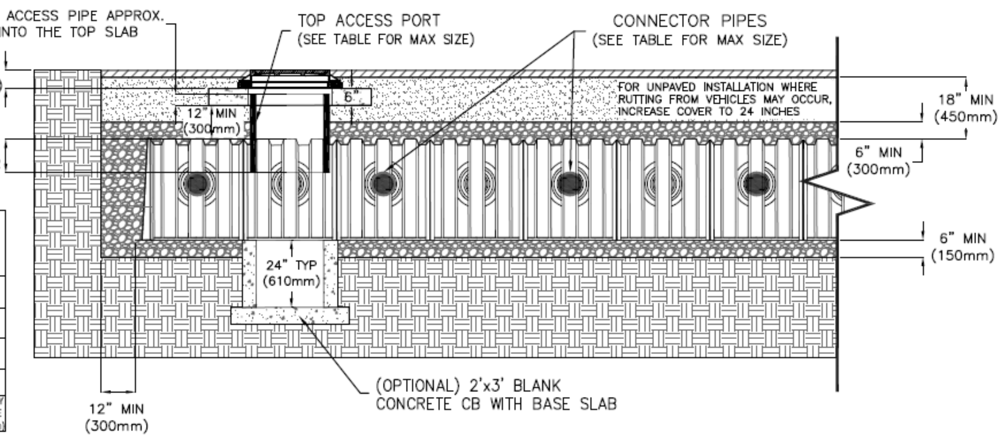
REVISED: 10-19-16 JWM

APPENDIX F

NOTES:

1. 24" (610mm) MINIMUM DEPTH REQUIRED BETWEEN CASTING RIM AND TOP OF CHAMBERS (ASSUMING 4" (102mm) LOW-PROFILE CASTING WITH 1 ADJUSTING RING).
2. CONNECT STANDPIPE TO CHAMBER PER LATEST INSTALLATION INSTRUCTIONS.
3. CONNECTION OF THE STANDPIPE TO THE TOP SLAB IS TYPICALLY NOT NECESSARY. IF A CONNECTION IS DETERMINED TO BE NECESSARY, A FLEXIBLE CONNECTION IS REQUIRED.





	MAX DIAMETER FOR:		CHAMBER SPACING
	TOP ACCESS PORT	CONNECTOR PIPE	
S29	24" (600mm)	18" (450mm)	6.0" (150mm) *7.5" (190mm)
S22	24" (600mm)	18" (450mm)	6" (150mm)
C10	18" (450mm)	12" (300mm)	6" (150mm)
M6	12" (300mm)	8" (200mm)	6" (150mm)

*7.5" (190mm) SPACING OF DISTRIBUTION ROWS IS REQUIRED ONLY WHEN A PERPENDICULAR MAIN HEADER ROW IS USED. IF AN INLINE MAIN HEADER ROW IS USED, THEN MIN SPACING CAN BE 6" (150mm)

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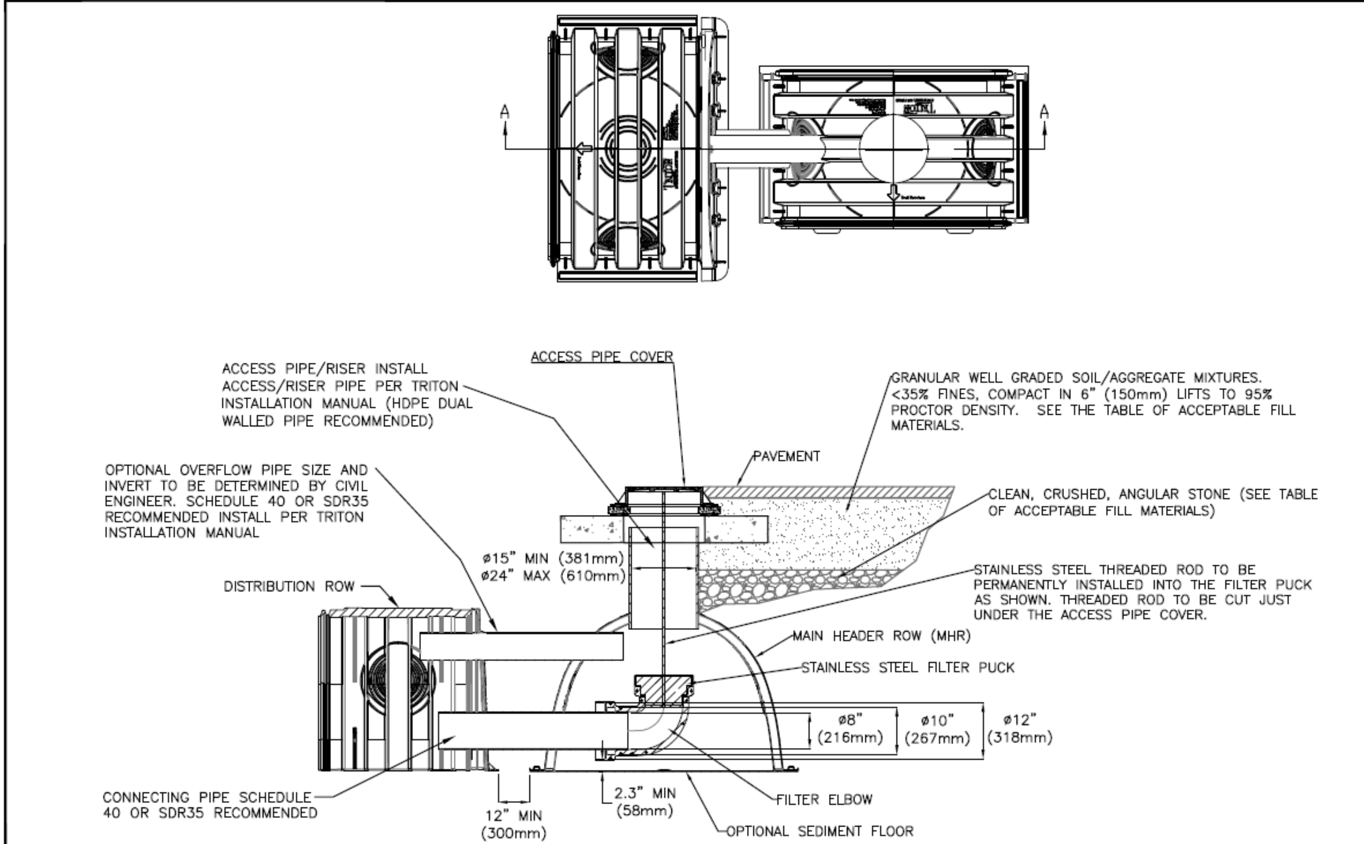
HEADER ROW ACCESS

INSPECTION/DIRECT TOP MH CONNECTION

TRITON - STANDARD DETAILS

REVISED: 09-27-16 JWM

APPENDIX G



SECTION A–A

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TRITON FILTER PUCK

UPRIGHT ORIENTATION - S29 & S22 CHAMBERS

TRITON - STANDARD DETAILS

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06-22-16 JWM