

2.0 SMARTDITCH PRODUCT INFORMATION

2.1 Product Data

The SmartDitch system is a corrugated section of HDPE sheet formed in a predetermined shape. In the thermoforming process, the plastic sheet is heated to forming temperatures, allowing it to conform to the mold. The minimum formed thickness in all of the channels is 55 mil.

The versatility of this manufacturing process provides Penda with unmatched in-house forming capabilities that enable us to deliver greater production efficiency on a full range of projects.

Penda supports your operation at every level, right from the start. Our world-class design/engineering capabilities allow us to partner with you to meet virtually any need.

2.1.1 Product Attributes, Dimensions & Weights

SmartDitch offers water management channels in the following specific depth/sizes:

- Trapezoidal design
 - 12" depth series
 - 24" depth series
- Semi-circular design
 - 24" depth series

See *Figures 1 and 2* for basic SmartDitch product dimensions and weights.

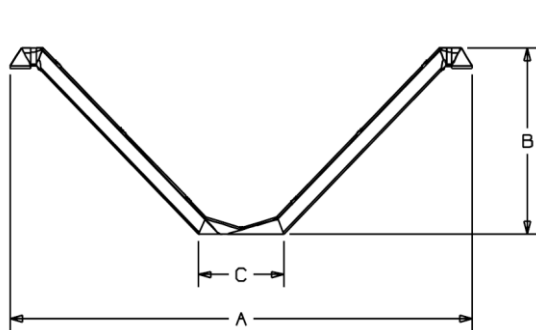


Figure 1

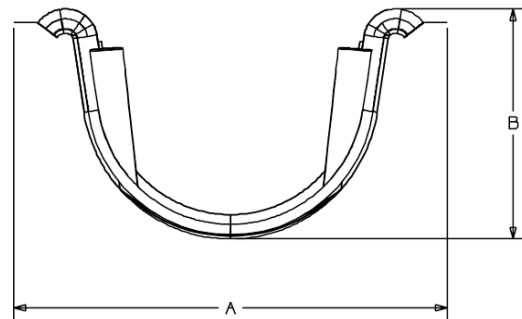
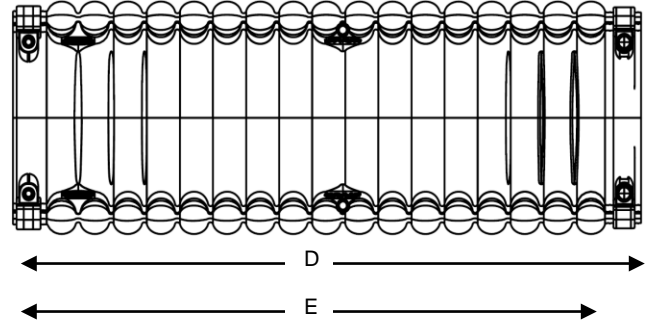
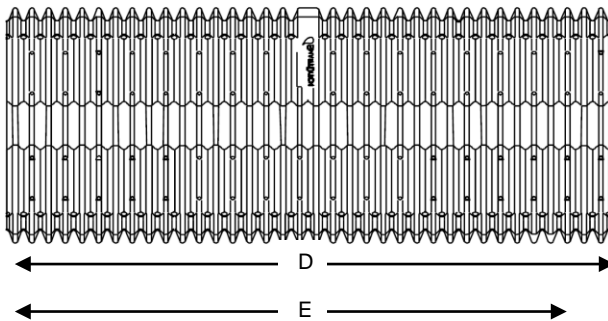


Figure 2



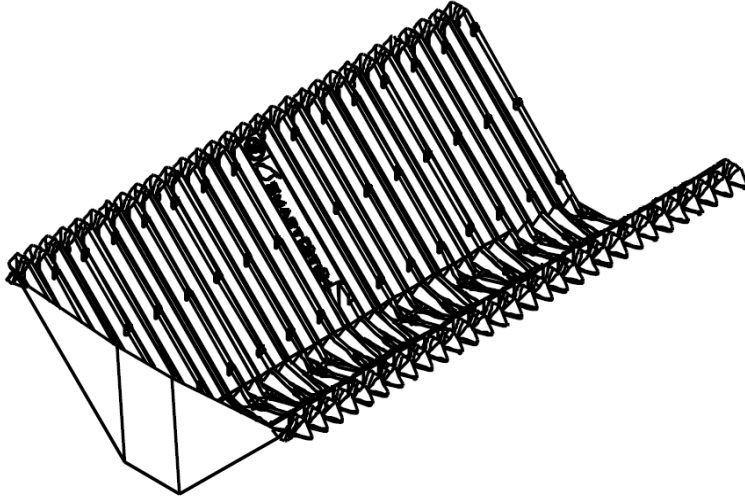
Item Description	Item #	12" Depth Trapezoidal	24" Depth Trapezoidal	24" Depth Semi-Circular
Overall exterior width	A	50.00 in / 1270.00 mm	76.00 in / 1930.40 mm	39.00 in / 990.60 mm
Overall exterior height	B	16.25 in / 412.75 mm	29.50 in / 749.30 mm	19.00 in / 482.60 mm
Bottom channel exterior width	C	10.00 in / 254.00 mm	14.00 in / 355.60 mm	N/A (Rounded Bottom)
Overall exterior length	D	120.00 in / 3048.00 mm	113.00 in / 2870.20 mm	93.00 in / 2362.20 mm
Lay length	E	112.00 in / 2844.80 mm	100.00 in / 2540.00 mm	88.00 in / 2235.20 mm
Weight per part	N/A	52.00 lb / 23.59 kg	89.00 lb / 40.37 kg	36.00 lb / 16.33 kg

Note: measurements above are overall part dimensions and are not representative of actual flow areas or earthen fill area.

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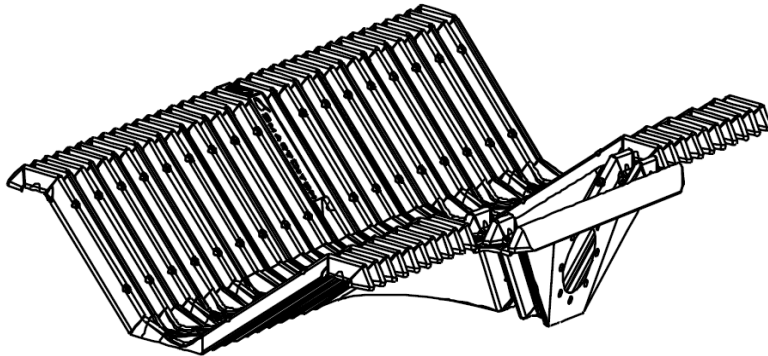
2.1.2 SmartDitch Fittings

SmartDitch offers the following fittings for both our 12" depth and 24" depth series products:



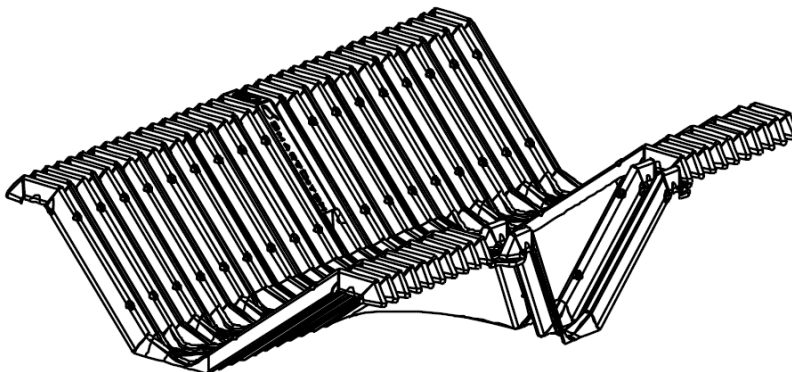
Straight Bulkheads

- Available with or without openings.
- Maximum diameter openings:
 - 12" depth trapezoidal = 6" diameter
 - 24" depth trapezoidal = 12" diameter
 - 24" depth semi-circular = 12" diameter
- Opening configurations include:
 - Circular openings
 - Flange connections
 - Square/rectangular openings
- Bulkhead closure located on downstream portion of straight channel.



Left / Right Bulkheads

- Available with or without openings.
- Maximum diameter openings:
 - 12" depth trapezoidal = 6" diameter
 - 24" depth trapezoidal = 12" diameter
 - 24" depth semi-circular = 12" diameter
- Opening configurations include:
 - Circular openings
 - Flange connections
 - Square/rectangular openings
- Multi-directional design for ease of installation/usage.

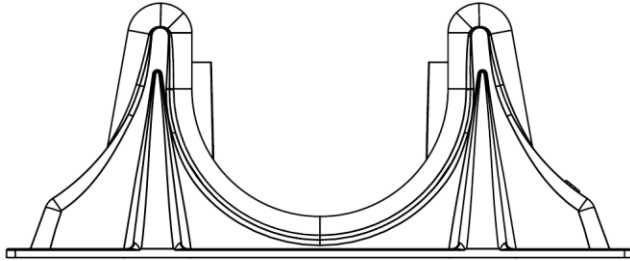


Multi-directional Tee Sections

- Multi-directional design for ease of installation/usage.
- Well suited fitting for radial turns (see the **2.7 Joint Angular Deflection** section on page 12 for additional information).

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2.1.2 SmartDitch Fittings (cont.)



Saddles

- For use with semi-circular channels only.
- Designed for usage in above-ground installations.
- Keeps semi-circular channels upright and stationary.
- Well suited application for temporary transfer of water.

2.1.3 Joint System

The SmartDitch joint system connects standard and fitting sections alike through the use of the following components (see Figure 3).

Joint system components consist of the following elements:

- **Screws:**
 - **Trapezoidal:** 1022 steel hard case screws, black dorken finish
 - **Semi-circular:** Black nylon ratchet clips
- **Gaskets:** Closed cell EPDM sponge seal meets
 - ASTM D 1056 B3Z1Z2
- **Anchoring System:** Earth anchor with attached cable
 - 1100 lb. capacity tensile resistant earth anchor
 - 3/32 stainless steel 7x7 cable attached with crimp sleeve

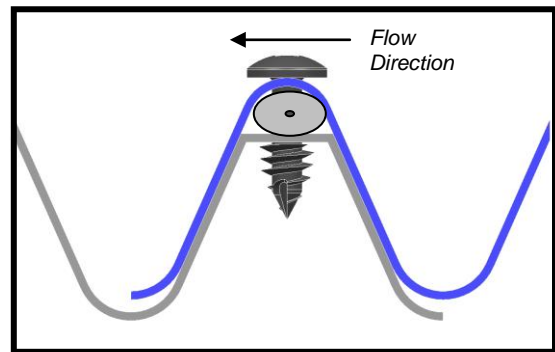


Figure 3

2.1.4 Raw Materials

Raw materials used on all SmartDitch channels and joint systems are delivered with vendor certification demonstrating their compliance with Penda's quality requirements.

In addition, all raw materials are sample tested prior to their use. These tests ensure that the pipe materials comply with the specifications as stated.

2.1.5 Physical Properties

On a sampling basis of each production run, SmartDitch sections are subjected to both visual and dimensional inspections as quality control checks.

During these inspections, the following factors are reviewed and held to established internal audit standards.

- Channel length
- Channel width
- Sidewall thickness
- Rib thickness
- Overall finishing quality

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2.2 Engineering Properties

SmartDitch is manufactured with a HDPE resin that provides excellent mechanical properties. These properties are instrumental in providing a premier, flexible, thermoformed plastic ditch-lining system.

The following table highlights some of the more important design properties of SmartDitch. Please contact your SmartDitch sales representative if additional design data is required.

Property	Unit	Value	Test Method
Tensile Yield Strength 2" per min.	psi	3000 (min)	ASTM D638, Type IV
Ultimate Elongation 2" per min.	%	500 (min)	ASTM D638, Type IV
Environmental Stress Crack Resistance (ESCR) Condition A (100% Igepal), F ₅₀ Condition B (10% Igepal), F ₅₀	h h	250 (min) 100 (min)	ASTM D1693
Flexural Modulus	psi	110,000 (min)	ASTM D790
Density	g/cc	0.946 (min)	ASTM D1505
Brittleness Temperature	°F	131 (max)	ASTM D746
Impact Resistance	Lbs force-ft	2060	ASTM D5420
Coefficient of Linear Thermal Expansion	in/in/°F	0.00007 (nominal)	ASTM D696
Cell Classification	n/a	445430	ASTM D3350

2.3 Flow Data

2.3.1 Flow Attributes

The Manning's "n" coefficient of friction for the SmartDitch system is n=0.022. This Manning's coefficient can be used for all calculations required to determine maximum capacity and flow velocities for a lined ditch.

2.3.2 Flow Velocity

The minimum flow velocity to maintain self scouring is 2 ft/sec. Maximum velocities will vary dependent upon the slope of existing ditches. The minimum slope of 0.005 (½%) is recommended to maintain the self-cleansing velocity of the SmartDitch lining system.

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2.3.3 Flow Calculations

Flow rate calculations for the channel system are based on the standard hydraulic flow formula:

$$Q = (1.49/n) A R^{2/3} S^{1/2}$$

Where:

- Q = Total Flow
- N = Manning's Coefficient of Friction (0.022)
- A = area (sf)
- R = hydraulic radius (ft) [R = A / wetted perimeter]
- S = slope (%)

To calculate the hydraulic flow area & radius of each SmartDitch size, dimensions are provided in **Figure 4**.

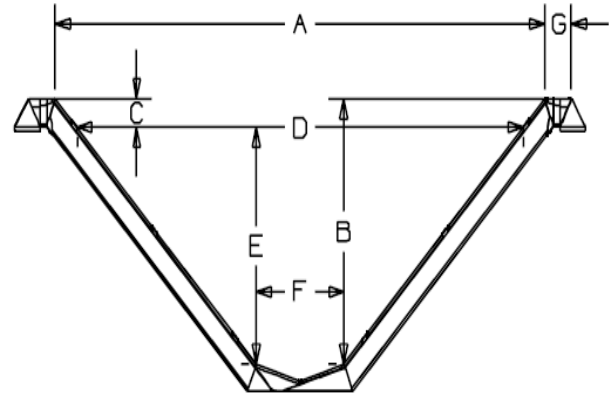
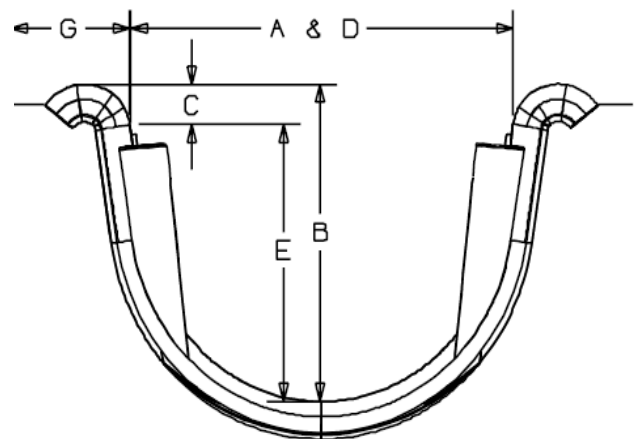


Figure 4

Item Description	Item #	12" Depth Trapezoid – in (mm)	24" Depth Trapezoid – in (mm)	24" Depth Semi-circular – in (mm)
Channel top width	A	37.50 (952.50)	65.00 (1651.00)	24.00 (609.60)
Channel height (interior)	B	14.50 (368.30)	27.00 (685.80)	16.00 (406.40)
Minimum freeboard	C	1.00 (25.40)	2.00 (50.80)	2.00 (50.80)
Maximum flow area top width	D	34.50 (876.30)	59.50 (1511.30)	24.00 (609.60)
Maximum flow depth	E	13.50 (342.90)	25.00 (635.00)	14.00 (355.60)
Bottom channel width (interior)	F	8.00 (203.20)	12.00 (304.80)	N/A (Rounded Bottom)
Top shoulder width (w/out knuckle)	G	4.50 (114.30)	3.50 (88.90)	5.00 (127.00)



2.4 Leakage

The average leakage rate for the SmartDitch system is 0.039 cubic feet / second /1000 ft.

2.5 UV Resistance

There is no evidence to suggest that ultraviolet degradation is a factor affecting the long-term service life of SmartDitch. The outermost surface will be affected with discoloring. The resins used in SmartDitch have a high content of UV stabilizers that inhibit the physical and chemical process of UV-induced degradation.

2.6 Abrasion Resistance

SmartDitch has excellent abrasion resistance. Abrasion from stones or debris is one of the most common durability concerns for SmartDitch – especially when the effluent flows at high velocities. While there are no widely standardized testing procedures, various types of test results have shown that it takes longer to abrade through HDPE than concrete or metallic surfaces.

The extent of abrasion in the invert of the SmartDitch channel sections will depend upon the type of abrasive, frequency that the material is in the channel, and velocity of flow.

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2.7 Joint Angular Deflection

Maximum angular deflection (turn) at each joint, considering both combined vertical and horizontal, must not exceed the amounts given in table below. The channel sections must be joined in straight alignment and thereafter deflected angularly as required.

For alignment deflections beyond those stated in the table below, a fitting is recommended.

Angular Deflection at the SmartDitch Joint

Nominal Product Size	Min. Radius of Curvature	Max. Angle of Deflection
12"-depth trapezoidal channel	10 feet (3.048 meters)	42°
24"-depth trapezoidal channel	75 feet (22.86 meters)	19°
24"-depth semi-circular channel	80 feet (24.38 meters)	15°



*SmartDitch 12"-depth
Straight Channel Curvature*

2.8 Temperature Expansion/Contraction Coefficients

The thermal coefficient of axial expansion and contraction for SmartDitch is 7×10^{-5} inch/inch/degree F.

SmartDitch's plastic corrugated design allows it to easily withstand freeze-thaw cycles. The effect of low temperatures on polyethylene materials is unique, the modulus of elasticity increases as temperatures are lowered. In effect, the material becomes stiffer but retains its ductile qualities. The actual low temperature embrittlement for the HDPE resin used in manufacturing SmartDitch is -131°F.

The coefficient of linear expansion for unrestrained HDPE is approximately ten times that of metal or concrete. While the potential for expansion (or contraction) is large when compared with that of metal or concrete, note that the modulus of elasticity for polyethylene is substantially lower than that of alternative materials (less rigid).

This implies that the degree of movement associated with a specific temperature change may be higher for the polyethylene, but the stress associated with restraint of this movement is significantly less. This means that SmartDitch will therefore move with the freeze/thaw movements associated with the ground heaves without damage.

2.9 Flammability

Basic ditch upkeep like burning weeds along the bank will not ignite SmartDitch; the polyethylene material utilized has flame retardant stabilizers added to it that make the material difficult to ignite and it will not continue burning in the absence of an external ignition source.

2.10 Lifespan

SmartDitch is made of HDPE (high-density polyethylene) enhanced with UV inhibitors that have a projected minimum lifespan of 20 years.

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2.11 Chemical Resistance

SmartDitch is manufactured from HDPE – one of the most chemically inert materials available. Normal ground water, storm water, salt water, or agricultural run-off typically has no effect on SmartDitch channels.

Some regions of the country have naturally occurring conditions which cause unusually low (acidic) or high (alkaline) pH in the soil and ground water. SmartDitch is ideal for both acid and alkali environments.

The heavy use fertilizers on golf courses and in agriculture can detrimentally affect the pH and chemical composition of run-off water. High concentrations of phosphates and nitrates can be common in these situations. SmartDitch is not affected by these conditions.

In a salt water environment, galvanic/electro-chemical attack can occur to more traditional materials such as metal or steel reinforced concrete. As HDPE is an insulator, SmartDitch is not affected by galvanic attack.

For a review of chemical resistance of polyethylene material to common selected substances*, see the chart to the right.

Chemical Resistance Chart – Common Substances

Chemical or Substance	Polyethylene Material (73° F / 23° C)
Alcohol, ethyl	R
Antifreeze agents, vehicle	R
Bleaching solution, 12.5% active chlorine	R
Bleaching solution, 5.5% active chlorine	R
Brake fluid	R
Diesel fuel	R
Diesel fuel / oil	R
Ethane	R
Fertilizer salts, aqueous	R
Fuel oil	R
Gasoline	R to C
Hydraulic fluid / oil	R
Hydrogen peroxide, aqueous 10% - 90%	R
Jet fuels	R
Mercury, liquid	R
Methanol, pure	R
Motor oil	R
Nitric acid, 0% - 30%	R
Nitric acid, >30% - 50%	R to C
Petroleum, sour, refined	R
Sea water	R
Sewage, residential	R
Soap solutions, aqueous	R
Sulfuric acid, 70% - 90%	R
Two stroke engine oil	R

R = Material is generally resistant (Specimen swells <3% or has weight loss of <0.5% and elongation at break is not significantly changed).

C = Material has limited resistant only and may be suitable for some conditions (Specimen swells 3% - 8% at weight and loss of 0.5% - 5% and/or elongation at break decreased by <50%).

* Information gathered from *Chemical & Abrasion Resistance of Corrugated Polyethylene Pipe*, Corrugated Polyethylene Pipe Association. Though different in physical design, SmartDitch maintains the same resin cell classification as the samples in this report. A more complete listing of polyethylene's chemical resistance can be obtained by contacting the Corrugated Polyethylene Pipe Association.