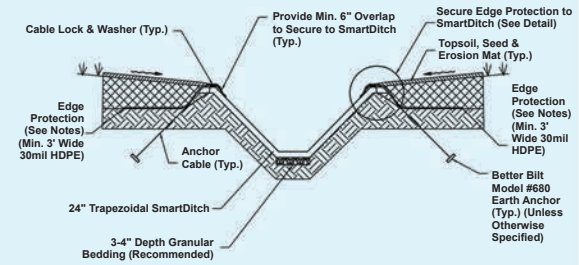
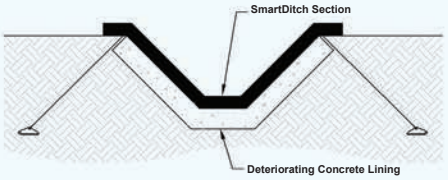
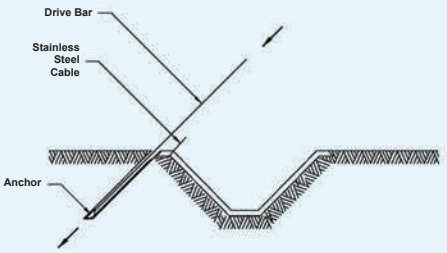
SmartDitch®

Finally, Smarter Solutions in Water Management.®







Tech Manual

Guidelines

Product, Technical & Installation

November 2013

PENDAFORM

SMARTDITCH TECHNICAL MANUAL REGISTRATION FORM

In order to forward you technical data and updates to our manual, we request that you register your manual with **PendaForm**. Please fill out the following information and return the document to either your SmartDitch representative or our corporate office:

PendaForm
P.O. Box 449
Portage, WI 53901-0449
Attention: Premier Customer Service

Or fax to: 608-745-6064

Name	
Company Name	
Address	
City	
State	
Zip Code	
Phone Number	
Fax Number	
E-mail Address	
Type of manual holder	❑ Engineer ❑ Contractor ❑ Municipality Representative ❑ Supplier ❑ Other (specify) _____
Date manual received	
Would you like to receive manual updates?	❑ Yes ❑ No

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1.0 OVERVIEW

1.1 INTRODUCTION

For too long, the challenges inherent to water conveyance have seemed insurmountable. Water in the wrong amounts or in the wrong places. Valuable water lost to leaky channel linings. Flow rates that are too high or too low and erosion problems caused by the drainage flow shear force against the channel. Until now traditional approaches and technologies in channel and ditch construction simply haven't delivered what's needed most: a safe, economical, easily installed and maintained, long-lasting and environmentally sound way to manage water flow.

The solution to these problems is SmartDitch; a flexible, thermoformed plastic HDPE channel system from **PendaForm**. While traditional water management products deteriorate and fail, the SmartDitch system guarantees a stronger, longer-lasting solution that can be used for new construction or rehabilitation. SmartDitch can be installed far more easily and quickly than traditional products, and offers significantly lower maintenance costs combined with versatility.

***PendaForm** is located in Portage, Wisconsin and operates 250,000 SF (23,230 SM), ISO certified facility.*

1.2 PENDAFORM

PendaForm Green Technologies is a strategic business unit of **PendaForm**, located in Portage, WI. For more than 40 years, **PendaForm** has been North America's largest and most advanced thermoforming plastics operations. **PendaForm** offers a wide array of quality manufacturing process and materials – from HDPE to ABS plastics, thermal plastic olefin (TPO) to co-extruded sheets using cap-stock layers, and textured surfaces to high-gloss molded in color. Our manufacturing expertise has made **PendaForm** the global leader for pick-up truck bedliners and the preferred supplier to the world's largest automotive manufacturers.

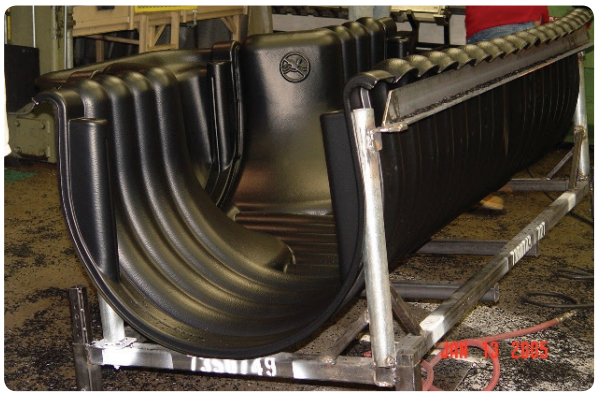
***PendaForm** is the largest heavy-gauge thermoformer in North America.*

PendaForm utilizes our globally recognized expertise in materials research, product development, and manufacturing to deliver unmatched product benefits and customer service.

PendaForm has 13 in-house, rotary sheet-fed, four-station vacuum formers. Our leading in-house forming capabilities enable us to deliver greater production efficiency on a full range of products. Every member of our team is committed to the total satisfaction of each of our thousands of customers worldwide. The proof of that commitment is seen in the many awards and recognitions our products have earned.

1.3 WATER MANAGEMENT VISION

PendaForm's vision in bringing SmartDitch to the market is to provide its customers with sustainable solutions in a smarter way. **PendaForm**'s guiding principles are to be Safe, Smart, and Successful in the products that we provide and how we conduct business. **PendaForm** is dedicated to bringing to market products that fulfill these guiding principles and provide our customers with solutions to their water and critical fluid management needs.



SmartDitch semi-circular tee-section channel in trim fixture.

1.4 SMARTDITCH APPLICATIONS

The SmartDitch channel lining system developed by **PendaForm** is a reliable, easy to install, high performance way to manage water conveyance and critical fluids. Manufactured with HDPE, SmartDitch is durable, corrosion resistant and unaffected by acidic or alkaline soils and chemicals. SmartDitch offers many advantages over traditional water conveyance products.

Growing awareness of the benefits provided by SmartDitch has resulted in widespread use in the following applications:

- Irrigation / agriculture
- Drainage applications (Stormwater, flow control)
- Erosion / sediment control
- Land development applications
- Landfill
- Mining
- Oil and Gas
- Ski Industry
- On-site water clarification
- Industrial site drainage

Replacing other materials SmartDitch delivers a long, effective service life with low operating and maintenance costs. Where can SmartDitch work for you?

SMARTDITCH DRAINAGE
SmartDitch narrows the performance gap between what traditional drainage channels provide and what today's engineers demand. Available in a trapezoidal configuration, SmartDitch is quickly replacing concrete channels, riprap and vegetated channels as a preferred product for drainage applications. Designed for predictable hydraulics, durability, structural integrity and easy installation, SmartDitch provides excellent value and cost effective performance.

SmartDitch's hydraulic characteristics remain constant over time providing maximum drainage over the life of the system. The toughness of polyethylene withstands abrasive flows, corrosion, and even the most aggressive chemical attacks. SmartDitch prevents unwanted vegetation growth and the corrugated wall design produces a self scouring action that minimizes silt build up in the flowline.

When designing drainage projects with difficult access, remote locations, uneven terrain, and steep slopes with high velocities, SmartDitch's lightweight rugged construction allows for a quick installation in the most difficult situations.

Product Benefits
- Hydraulic characteristics constant over time
- Reduces runoff velocities.
- Excellent abrasion resistance
- Withstands corrosion and chemical attacks
- Reduces maintenance costs

Portage, WI Before:
Riprap continued to fail at this DOT drainage outfall.

Portage, WI After:
SmartDitch replaced the old Riprap, improved drainage, and eliminated erosion.

1.4 SMARTDITCH APPLICATIONS (CONT.)

SMARTDITCH EROSION / SEDIMENT CONTROL

SmartDitch can be used to form defined ditches that can control erosion, catch sediment, and provide superior drainage. Storm water runoff channels help prevent erosion, reduce the risks of structural instability and provide critical drainage for roadways. SmartDitch meets all of these challenges.

High flows in drainage ditches can deteriorate the side walls and flow lines. SmartDitch's rugged HDPE construction resists the hydraulic forces of the flow and provides a stable channel that will provide years of maintenance free service.

As a slope or terrace drain, SmartDitch can be used to reduce erosion and be designed as a collector and outlet for the drainage system. SmartDitch's lightweight design makes it the perfect product to install on these difficult sites.

Applications

- Landfill erosion and control
- Public Works and Municipal drainage projects
- Highway and transportation erosion control
- Residential drainage and stormwater flow control
- Industrial site stormwater and spill control
- Irrigation and water conservation district drainage programs
- Construction site stormwater treatment
- Mining site run off applications
- Dewatering efforts to meet EPA recharge regeneration

Benefits

- Excellent flow properties
- Eliminates sidewall erosion and the subsequent sediment that can end up in the ditch
- Does not erode, crack or corrode when exposed to weather, erosion, or freeze / thaw cycles
- Engineered with self-scouring rib design that helps keep channels clear and reduces ditch maintenance
- The HDPE material withstands abrasive flows, corrosion and even the most aggressive chemical attacks
- Ease of installation - no special tools required
- A light-duty backhoe is all that is needed for longer trench runs
- Light weight and easy to transport
- Use in lieu of earthen ditch, rip rap or concrete
- Provides years of maintenance free service
- Can be used to rehabilitate existing concrete ditches
- Manufactured in the USA

Sediment and soil erosion were perpetual problems at this industrial location.

SmartDitch captures and controls the flow of sediment filled stormwater and carries it to a settling tank.

1.4 SMARTDITCH APPLICATIONS (CONT.)

SMARTDITCH LAND DEVELOPMENT

The demand for more developable land continues to grow every day requiring engineers and developers to look for innovative means to utilize ground previously thought as unusable. SmartDitch can be installed to control drainage and erosion on sites with uneven terrain, steep slopes, on property susceptible to flooding or bordering run-offs or spillways.

As part of development's stormwater drainage system, SmartDitch's hydraulic characteristics remain constant over time providing maximum drainage over the life of the system. The toughness of polyethylene withstands abrasive flows, corrosion, and even the most aggressive chemical attacks. SmartDitch prevents unwanted vegetation growth and the corrugated wall design produces a self scouring action that minimizes silt build up in the flowline.

As a slope or terrace drain, SmartDitch can be used to reduce erosion and be designed as a collector and outlet for the drainage system. SmartDitch's lightweight design makes it the perfect product to install on these difficult sites.

Project Applications

- Subdivision stormwater drainage
- Drainage for retail and business developments
- Edge and slope drainage
- Flood control
- Private dam spillways and low flow channels

Product Benefits

- Eco-friendly material and colors
- Hydraulic characteristics constant over time
- Flexible construction practices for difficult development sites
- Reduced maintenance costs
- Durable, Long-Life Material

This residential stormwater channel would flood during heavy rainfall events.

SmartDitch replaced the poor performing channel, improved flow, and required less space.

1.4 SMARTDITCH APPLICATIONS (CONT.)

SMARTDITCH IRRIGATION / AGRICULTURE

Agriculture in many parts of the country depends on the availability of irrigation water and channels are typically used to transport water from the sources to end users. Over time these channels can deteriorate due to erosion, ground movement caused by freeze / thaw cycles, or corrosion of the building materials. SmartDitch provides a durable solution to these problems and can increase water distribution in irrigation systems by as much as 90 percent.

SmartDitch's hydraulic characteristics remain constant over time providing maximum flow of water over the life of the system. The product's HDPE material withstands abrasive flows, corrosion, and even the most aggressive chemical attacks. SmartDitch also prevents unwanted vegetation growth and the corrugated wall design produces a self scouring action that minimizes silt build up in the flowline.

SmartDitch liners are easily installed in new construction applications or as slip liners in failed concrete or earthen channels, greatly reducing long term maintenance costs. SmartDitch's lightweight design makes it the perfect product to install in remote sites where accessibility is an issue.

Project Applications
- Irrigation Channels
- Flood Irrigation
- Drainage Channels
- Rehabilitation of Concrete and / or Earthen Channels

Product Benefits
- Hydraulic characteristics constant over time
- Resistant to Abrasion, Punctures, and Freeze / Thaw
- Reduces water loss through seepage
- Low Maintenance Costs
- Cost-effective Design Life Costs

Cracked concrete irrigation ditches present major problems in rural farming communities.

SmartDitch delivers more than 90% of all water from the original source.

1.4 SMARTDITCH APPLICATIONS (CONT.)

SMARTDITCH SOLID WASTE

SmartDitch is the perfect solution to protect engineered landfill covers from the effects of erosion. SmartDitch may be used to line diversion channels and downlope flumes to safely route runoff off of the landfill.

SmartDitch's flexible characteristics help resist the effects of differential settlement that is typically observed on landfill covers. The low leakage rate prevents water from infiltrating into landfill covers that can lead to instability.

Project Applications
- Diversion channels
- Downslope flumes
- Perimeter Ditches

Product Benefits
- Hydraulic characteristics constant over time
- Resistant to Abrasion, Punctures, and Freeze / Thaw
- Reduces water loss through seepage
- Low Maintenance Costs
- Cost-effective Design Life Costs

SMARTDITCH HYDRAULIC FRACTURING AND MINING

Hydraulic fracturing for oil and gas drilling requires containment and a solid working platform. SmartDitch can provide both. SmartDitch chemical resistance is well suited for mining applications.

Project Applications
- Containment
- Channel Lining
- Stable working surfaces

Product Benefits
- Low leakage rate
- Chemical Resistance
- Flexible
- Resistant to Abrasion, Punctures, and Freeze / Thaw
- Reduces water loss through seepage
- Reusable

SmartDitch controls stormwater overflow coming from landfill caps.

Vegitation grows up to the side of SmartDitch to minimize erosion.

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. Starting thickness of the sheet varies by product line from .100" (2.5 mm) - .350" (8.9 mm).

The versatility of this manufacturing process provides **PendaForm** with unmatched in-house sheet and thermoforming capabilities that enable us to deliver greater production efficiency on a full range of designs.

PendaForm 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 project need.

2.1.1 PRODUCT ATTRIBUTES, DIMENSIONS AND WEIGHTS

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

- Trapezoidal design
  - – 12" depth series
  - – 24" depth series
- Semi-circular design (Above Ground)
  - – 24" depth series

NOTE: The semi-circular design is for above ground installations only by use of saddles. The vertical HDPE walls offer limited resistance to lateral earthen forces.

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

Figure 1

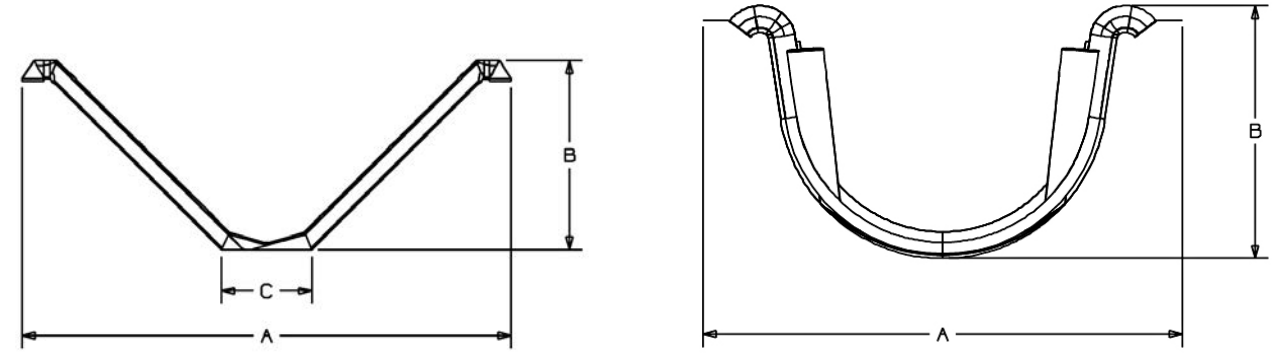
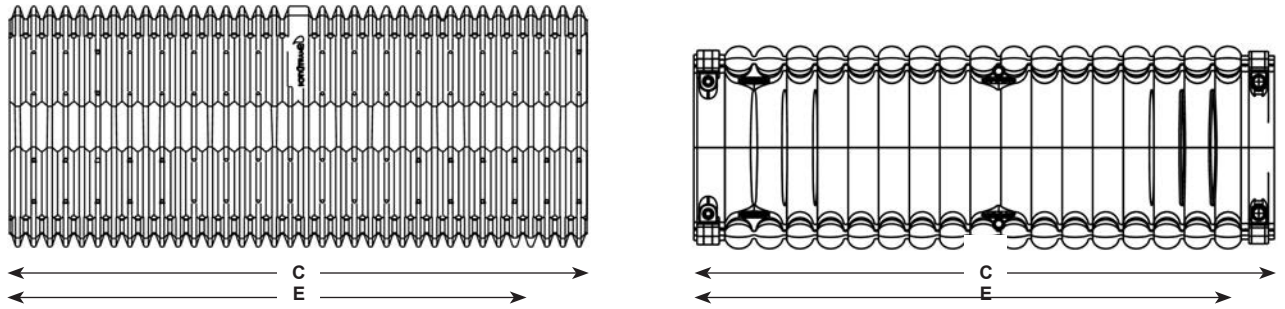


Figure 2



ITEM DESCRIPTION	ITEM #	12" DEPTH TRAPEZOIDAL	24" DEPTH TRAPEZOIDAL	24" DEPTH SEMI-CIRCULAR
Overall exterior width	A	50.00 in (1270.00 mm)	80.00 in (2032 mm)	39.00 in (990.60 mm)
Overall exterior height	B	16.25 in (412.75 mm)	30.00 in (762 mm)	19.00 in (482.60 mm)
Bottom channel exterior width	C	10.00 in (254.00 mm)	15.25 in (387 mm)	N/A (Rounded Bottom)
Overall exterior length	D	120.00 in (3048.00 mm)	97.00 in (2463 mm)	93.00 in (2362.20 mm)
Lay length	E	112.00 in (2844.80 mm)	92.75 in (2356 mm)	88.00 in (2235.20 mm)
Weight Per Part	N/A	48.00 lb (21.77 kg)	79.00 lb (35.83 kg)	42.00 lb (19.05 kg)

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

2.1.2 SMARTDITCH FITTINGS

SmartDitch offers the following fittings for both our 12" (305 mm) depth and 24" (610 mm) depth series products:

- Bulkheads
  - – straight
  - – upstream / downstream
  - – left / right
  - – directional (call for details)
- Directional Gates
  - – left / right
- Tees
  - – left / right
  - – corners (left / right)
- Transition Sections
  - – 12" (305 mm) - 24" (610 mm) trapezoidal
  - – 24" (610 mm) - 12" (305 mm) trapezoidal
- Flared End Sections
  - – inlet / outlet

For complete details, see Appendix. 5.3 (Channel & Fittings Dimension Shop Drawings)

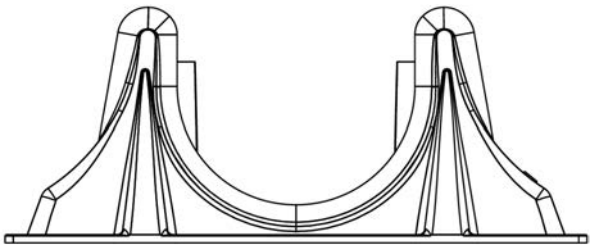
NOTE: Some fittings are fabricated and made to order. If you do not see a fitting to meet your need, please call our Engineering Hotline at 1-866-576-2783 to discuss your specific needs with one of our engineers.

SmartDitch flared-end section helps disperse flow at the end of the line.

Multi-directional tee-section adds versatility to any SmartDitch system.

SmartDitch bulkhead section can be field cut to fit drainage pipe and outlets.

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

Straight bulkheads and multidirectional tee sections may be assembled together to make 90 degree bends.

2.1.3 SMARTDITCH TRANSITIONS

The following options are available to transition from SmartDitch to the stormwater transmission system:

1. Pipe to SmartDitch transitions can be made using a bulkhead and HDPE reinforcing sheet with mastic (see detail).

2. Quick changes in vertical slope can be made by removing a knuckle on each side and bending the SmartDitch section up or down as required. An anchor should be installed on each side of the removed knuckle along with edge protection (see detail).

3. Culvert with rip rap upstream of SmartDitch, extend the culvert into the SmartDitch a minimum of 1' (305 mm).

4. A drop pipe can be installed on the bottom of a 24" (610 mm) bulkhead sections (left or right). Water will drop vertically from above, at a retaining wall or hillside.

For additional information, contact SmartDitch.

2.1.4 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

2.1.5 RAW MATERIALS

PendaForm is one of the largest buyers of recycled polyethylene in North America. Our state-of-the-art Reclaim and Recycle system ensures the utmost material quality and testing prior to thermo-forming any product.

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.

2.1.6 PHYSICAL PROPERTIES

As part of our quality control procedures, sample SmartDitch sections from each production run are subjected to visual and dimensional inspections.

During these inspections the following factors are reviewed and held to established internal audit standards:
- Application length
- Application width
- Sidewall thickness
- Rib thickness
- Overall finishing quality

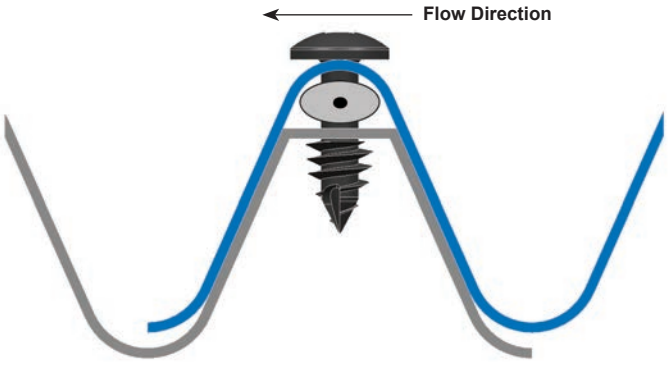


Figure 3

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	TEST METHOD	*NOMINAL VALUES (SI)	*NOMINAL VALUES (ENGLISH)
Density	ASTM D1505	0.949 g/cm^3	0.949 g/cm^3
Melt Mass Flow Rate	ASTM D1238	10 g/10 min	10 g/10 min
Environmental Stress Crack Resistance (ESCR) Condition A (100% Igepal), F50 Condition B (10% Igepal), F50	 ASTM D1693A ASTM D1693B	 600 hr 600 hr	 600 hr 600 hr
Tensile Yield Strength 2" / min, 51 mm / min	ASTM D638, Type IV	24.8 MPa	3600 psi
Tensile Elongation 2" / min	ASTM D638, Type IV	600%	600%
Flexural Modulus (compression molded)	ASTM D790	1170 MPa	170,000
Brittleness Temperature	ASTM D746	-90°C	<-130°F
Tensile Impact Strength	ASTM D1822	84.1 KJ/m^2	40.2 ft-lb/in^2
Coefficient of Linear Thermal Expansion	ASTM D696	N/A	7 x 10^{-5} in / in / °F
Cell Classification	ASTM D3350	445540	N/A

** Nominal values are intended to serve as a guide only, and not assumed as the specification limit.*
Some of the results are based on test specimens and may not reflect the ultimate performance of a full ditch lining system.

2.3 FLOW DATA

2.3.1 FLOW ATTRIBUTES

The Manning's "n" coefficient of friction for the SmartDitch system is n=0.022 for laminar flow and 0.029 for turbulent flow. 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 properties is 2' (610 mm) / sec. Maximum velocities will vary dependent upon the slope of existing ditches.

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 (%)

* A Manning's coefficient of 0.029 is used when the velocity exceeds 4 fps and flow becomes turbulent.

The designer of record must review the project hydraulics to determine the required channel freeboard.

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

ITEM DESCRIPTION	ITEM #	12" (305 MM) DEPTH TRAPEZOIDAL – IN (MM)	24" (610 MM) DEPTH TRAPEZOIDAL – IN (MM)	24" (610 MM) DEPTH SEMI-CIRCULAR – IN (MM)
Channel top width	A	37.50 (952.50)	64.25 (1632)	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 width across top	D	34.50 (876.30)	60.00 (1524)	16.00 (406.40)
Maximum flow depth	E	13.50 (342.90)	24.75 (629)	14.00 (355.60)
Bottom channel width (interior)	F	8.00 (203.20)	11.50 (292)	N/A (Rounded Bottom)
Top shoulder width (w / out knuckle)	G	4.50 (114.30)	5.25 (133)	5.00 (127.00)

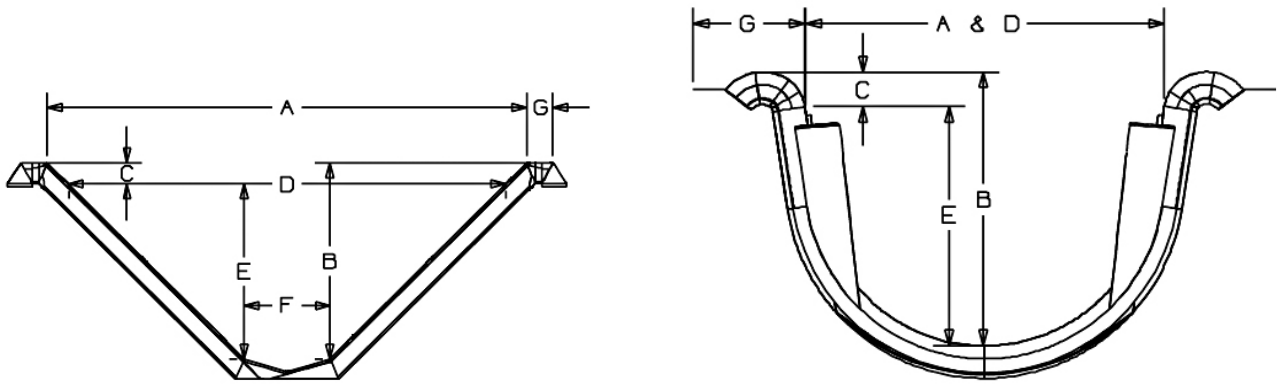


Figure 4

2.4 LEAKAGE

The average leakage rate for the SmartDitch system is 0.039 cubic feet / second / 1000' (1.1 L / second / 305 m).

2.5 UV RESISTANCE

The inherent properties of HDPE resin, combined with UV stabilizers, inhibit the physical and chemical process of ultraviolet degradation.

2.6 ABRASION RESISTANCE

SmartDitch has excellent abrasion resistance. Abrasion from stones or debris is one of the most common durability concerns 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.

2.7 INSTALLATION ON A CURVE

This minimum radius of curvature must not be less than the amounts given in the table below. The channel sections must be joined in straight alignment and thereafter deflected angularly as required. In some instances, it may be necessary to remove a few “upper knuckles” for the 24" (610 mm) trapezoidal sections (under **PendaForm** supervision) to achieve the radius of curvature shown in detail below.

Quick Installation Steps:

- Cut out the upper knuckles as indicated in the Detail Drawing
- Place the 24" (610 mm) trapezoidal section in the trench and install the self-tapping screws
- Bend the 24" (610 mm) trapezoidal section to the trench curve and install anchors on each side of the removed knuckle
- Install edge protection over the removed knuckles

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
12" (305 mm) depth trapezoidal application	10 feet (3.048 meters)
24" (610 mm) depth trapezoidal application	75 feet (22.86 meters)
24" (610 mm) depth semi-circular application	N/A (ridged design for above ground use)

SmartDitch 12" (305 mm) depth Straight Application Curvature

2.8 TEMPERATURE EXPANSION / CONTRACTION COEFFICIENTS

The thermal coefficient of axial expansion and contraction for SmartDitch is 7x10 -5 inch / inch / ºF (1.25x10 -4 mm / mm / ºC).

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 -131ºF (91ºC).

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).

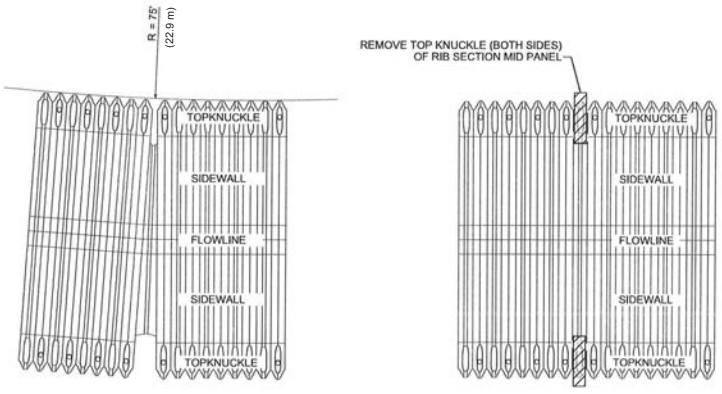
Our ribbed design has been engineered to help minimize expansion / contraction with the ribs. Therefore, weather fluctuations are easily endured without noticeable change. This implies that the degree of movement associated with a specific temperature change may be higher for the polyethylene, but the 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

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 have a projected minimum lifespan of 20 years.



Curve Installation Detail

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 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 of 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 is 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.

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.

3.1 NEW CONSTRUCTION INSTALLATION PRACTICES

A long service life and excellent performance characteristics of the SmartDitch system can only be achieved by proper handling and installation of the sections. It is important for the owner, engineer, and contractor to understand that the HDPE SmartDitch system is designed to utilize the bedding and surrounding soil for support that will result from recommended installation procedures. Engineers have found through considerable experience that properly compacted materials or properly cut undisturbed soil are ideal for installing the sections. Together, the sections with anchors and surrounding soil form a high performance "anchoring system" that will provide years of stability.

The following is a partial review of installation procedures; it is not intended to replace the installation specifications provided by the engineer or owner. See **Appendices** for detailed cross sectional shop drawings.

3.1.1 SUBGRADE / DITCH PREPARATION

Excavate to the desired line and grade for ditch installation. Grade the subgrade so that the SmartDitch sections can be laid without sags or humps. Grade the ditch cross section to match the SmartDitch cross sectional shape. A tilting bucket (see **Figure 5** below) or a modified backhoe bucket (see **Figure 6** below) works well but is not necessary.

Prepare the subgrade to be firm, smooth, and free of debris, rocks, and sharp objects. Trim and remove any tree roots. Remove unstable soils and replace with compacted soil fill.

Figure 5

Figure 6

3.1.2 BEDDING AND BACKFILL MATERIALS

The ditch subgrade, of suitable material, should provide uniform and continuous support against the SmartDitch walls. Bedding backfill and general installation requirements shall be in accordance with project plans and specifications and manufacturer's recommendations. Stabilized existing soil is preferred.

Care must be taken to choose foundation, bedding, and haunching materials that are compatible to minimize migration or loss of bedding or haunching support into the surrounding soils.

To ensure a satisfactory SmartDitch channel-soil system, correct backfill material must be used. Most coarse grained soils (as classified by the Unified Soils Classification System) are acceptable bedding backfill material.

If compaction of the subgrade is required, it should be performed prior to placement of the SmartDitch to the maximum extent possible. Avoid mechanical compaction immediately adjacent to the SmartDitch as it may force soil into the SmartDitch causing bowing and deformation.

3.1.3 SUITABLE SOIL TYPES

The SmartDitch system is suitable for installation in soils that can be excavated and remain unsupported with a cross section that matches the SmartDitch cross sectional shape. Typical suitable soil types include the following:

SMARTDITCH SECTION SIDEWALL SLOPE	OSHA SOIL TYPE	USCS SOIL GROUP SYMBOL	AASHTO Classification
1H:1V (1 horizontal to 1 vertical)	Type A or B – stiff clays, silts, dense silty or clayey sands, angular gravels	Stiff CL or CH, ML, MH, SM, SC, SC-SM, GM, GC, GC-GM, angular, GP or GW	Angular A-1, A-2, stiff A-4, A-5, A-6 or A-7

Soils that will not remain unsupported at a sidewall slope of 1H: 1V may not be suitable for SmartDitch channel section installation. These soils may include very soft clays and very loose clean sands. Installation in these soils may be possible by over-excavating the unsuitable soil and replacing it with compacted soil fill meeting one of the typical suitable soil types listed in the table above. Alternately, it may be possible to stabilize localized areas of unsuitable soil by treating the soil with quicklime (calcium oxide, do not use pulverized limestone or "ag lime") or fly ash prior to SmartDitch channel installation. **NOTE: It is the responsibility of the designing engineer to ensure proper bedding and soil types are available and utilized.**

Where the specifications permit the use of native soil as backfill, care should be taken to ensure that the material does not the include rocks, sharp objects, soil clumps, debris, frozen or organic material.

Backfill between the sections and the ditch using material free of debris, rocks and sharp objects. Bedding backfill and general installation requirements shall be in accordance with project plans and specifications and manufacturer's recommendations.

3.0 GENERAL INSTALLATION PRACTICES

3.1.4 UNSTABLE SOIL CONDITIONS

Where the trench bottom has soft, loose or highly expansive soils, it is regarded as unstable. An unstable trench bottom must be stabilized before laying SmartDitch sections or a foundation must be constructed to minimize differential settlement or undermining of the trench bottom. A well-graded sandy gravel compacted to 90% density, or crushed stone is recommended for use in foundation layers.

The depth of the sandy gravel or crushed stone material used for foundation depends upon the severity of the trench bottom soil conditions. When crushed rock is used the use of filter cloth to completely surround the foundation material will prevent foundation and bedding materials from migrating into one another which could cause loss of bottom support. Filter cloth is not needed if the same material is used for foundation and bed, or if graded sandy gravel is used for the foundation.

Cement-stabilized backfill may also be used to achieve a high stiffness without the need for significant compaction. **Installation in an unstabilized environment or without adequate side slope protection could result in channel failure.**

3.1.5 SMARTDITCH INSTALLATION

SmartDitch sections are typically laid end-to-end along the bank. Ensure that the ditch bank is free of tripping hazards and is level for connecting the ditch sections. *NOTE: connect no more than 3 sections together prior to placement into the ditch.* Sections are typically laid into the ditch flow lines by hand (see Figure 7).

Actual lay lengths and weights for each application can be found in **2.1.1 Physical Dimensions & Weights** table on page 9 of this document.

3.1.6 JOINT ASSEMBLY

NOTE: A complete set of joint assembly instructions, with diagrams is located in the APPENDIX section 5.4.

Multiple sections of SmartDitch can be assembled at the top of the trench and lowered into prepared ditch or trench. Each section is approximately 8' - 10' (2.44 m - 3.05 m) in length, depending on the project.

Ensure that the ditch has been cleared of all sharp objects, rocks and debris prior to placing the SmartDitch sections into the ditch.

Place sealing strip on top of flat end rib (See **Figure 8**):
- 12" (305 mm) Trapezoid — 50" (1270 mm) pre-cut strip per joint
- 24" (610 mm) Trapezoid — 85" (2159 mm) pre-cut strip per joint

Overlap sections ensuring that the upstream (rounded) section covers the down-stream (flat) section (See **Figure 9**).

Figure 7

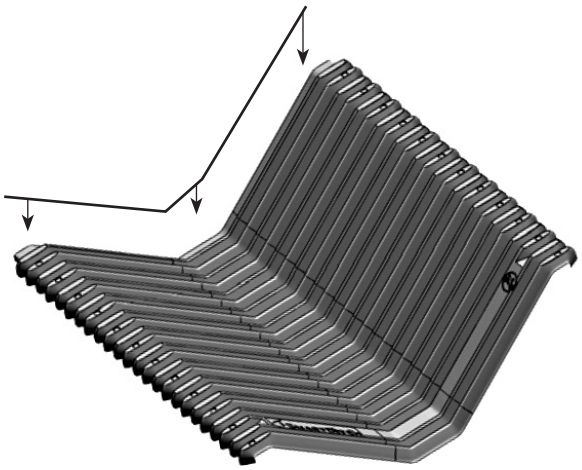


Figure 8

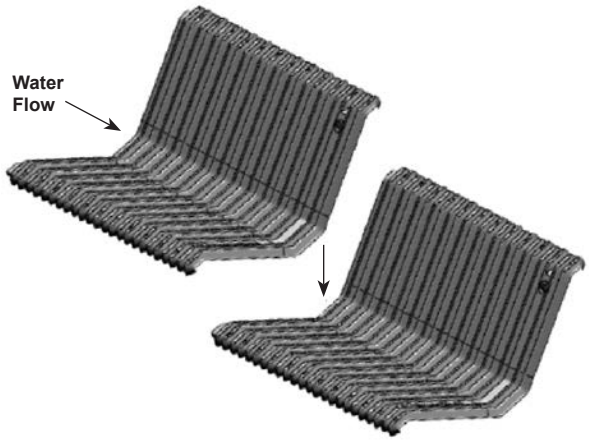


Figure 9

3.1.6 JOINT ASSEMBLY (CONT.)

NOTE: Visually inspect backside of connected channels to ensure that screws have pushed through and secured overlapped channels.

Self-tapping screws hold the channel together.

3.1.7 BACKFILL AND TAMPING

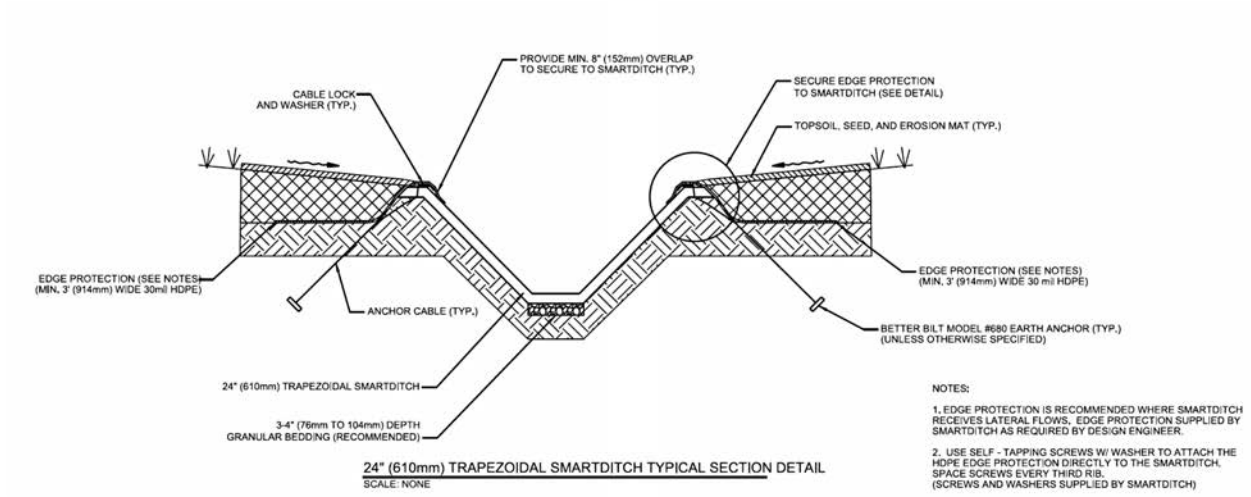
The subgrade should be constructed so that only a minimal amount of backfilling is necessary. If present, voids between the subgrade and SmartDitch should then be backfilled with coarse grained material and compacted by hand.

3.1.8 EDGE PROTECTION

Edge protection should always be specified where lateral runoff is present. This is typically seen where SmartDitch or MegaDitch is installed near adjacent hillsides and slopes.

Edge Protection will prevent the lateral flow from undermining the channels and will eliminate erosion.

Edge protection prevents soil erosion from lateral flow.



Typical edge protection detail

3.0 GENERAL INSTALLATION PRACTICES

3.1.9 ANCHORING

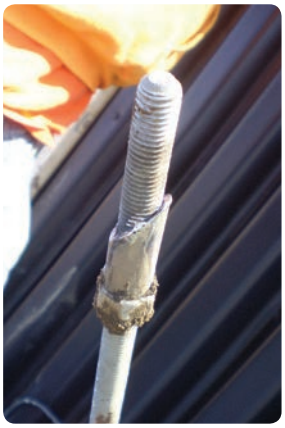
Drill 1/2" (13 mm) holes through both joined channels at the shoulder section of the sections. A recessed indentation is provided to pre-mark the location.

Drive cable anchor into ground at desired location close to the recessed pockets. The anchor should be driven to the minimum 30" (762 mm) depth. If there is not significant resistance driving the anchor at the depth identified in section 3.2, the anchor should be driven deeper until there is sufficient resistance. An impact hammer may be used to drive anchors when anchors cannot be driven to the proper depth manually. If the 1/2" (13 mm) steel drive rod pounds through the end of the anchor, a steel collar can be welded on the drive rod as indicated on the Drive Rod Detail to prevent damage to the anchor. A pilot hole may be required in rocky soils. Pull up on cable with enough force to engage anchor horizontally. After the sections have been placed in the ditch; anchor first section in place. Pull on unanchored end of last section to straighten connected sections tight. Anchor each section. See **Figure 10** for details.

Thread loose end of cable anchor up through 1/2" (13 mm) holes drilled in section shoulder. Slide the washer over the cable and into the recessed indentation. Take a cable lock and thread the cable up through the hole in the cable lock. Slide the cable lock down snugly against the washer and tighten the 7/16" (11 mm)cable lock bolt to a minimum 100 in-lbs (1143 mm-kg) of torque. If significant upward force or lateral earth force is anticipated, additional crimping may be required to prevent the cable lock from slipping. *NOTE: Do not over extend cable anchors such that the section connection is bowed out (see **Figure 11** and **Figure 12** for details).*

For a more detailed view of cable lock and washer connection, see **Figure 13**.

Using pliers, grip the cable securely and tighten the cable lock until cable anchor is taut. Trim excess cable leaving 2" (51 mm) above the cable lock. Repeat process at all joints. Additional anchoring may be added as needed.



For particularly hard soils, adding a custom collar to the drive rod can prevent the rod from punching through the anchor.

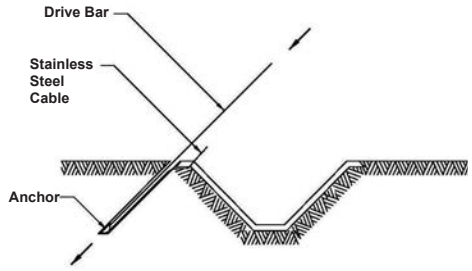


Figure 10

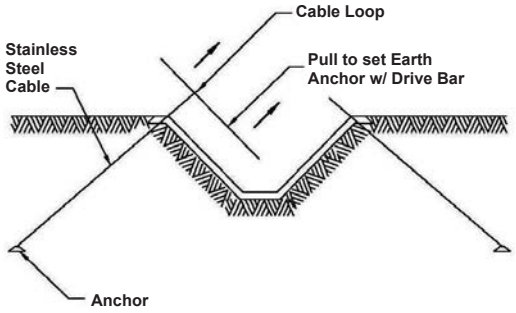


Figure 11

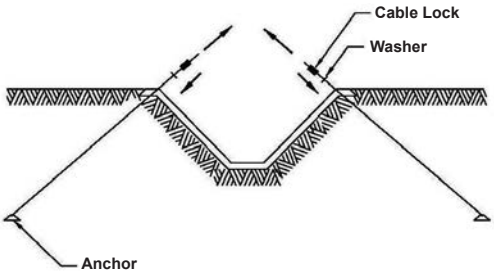


Figure 12

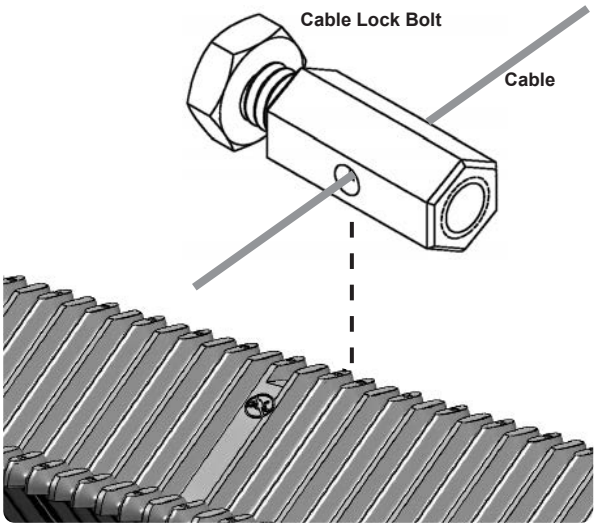


Figure 13

3.2 ANCHOR CAPACITY

The approximate capacity of the Model 680 anchor provided with SmartDitch is 1,100 pounds (499 kg).

The cable lock has a capacity of 800 pounds (363 kg), which is used to determine the anchor requirements.

The holding capacity for the anchor is for average soil conditions (Class 5 as listed in the table, right). Site soils will need to be evaluated. Soils in a higher class will have a lower holding capacity.

3.3 SOIL CLASSIFICATIONS AND ANCHOR CAPACITY

Soils can be highly variable. For applications on steep slopes, where uplift forces are anticipated, or where high energy flows are anticipated, pull tests should be performed to ensure adequate holding capacity. A pull test can be performed by installing a Model #680 anchor, connecting the cable to the backhoe with a scale. the scale should indicate an anchor holding capacity of at least 800 lbs (363 kg). If adequate holding capacity is not measured, another anchor should be installed deeper and pull tested to determine the required site depth. An engineering analysis should be performed to determine if additional anchors, or higher capacity anchors are necessary.

3.3.1 CLASSIFICATIONS

The information listed in the table below is an estimate / based on typical conditions. We recommend you perform a pull test to ensure that the anchor will meet project needs under site conditions. We strongly recommend soil tests be conducted prior to SmartDitch installion to ensure proper anchoring.

CLASS	DESCRIPTION
1	Solid bedrock
2	Dense clay; compact gravel; dense fine sand; laminated rock; slate; schist; sand stone
3	Shale; broken bedrock; hardpan; compact gravel; clay mixtures
4	Gravel; compact gravel and sand; claypen
5	Medium-firm clay; loose standard gravel; compact coarse sand
6	Medium-firm clay; loose coarse sand; clayey silt; compact fine sand
7	Fill; loose fine sand; wet clays; silt
8	Swamp; marsh; saturated silt; humus

3.3.2 ANCHORING STABILITY – STEEP SLOPES

The primary force that will prevent the SmartDitch system from sliding on a slope is frictional resistance. The frictional force must exceed the shear stress created at the channel interface. The frictional resistance can be calculated using the following equation:

$$f = N\tan F$$

Where:

f = frictional force
N = normal force acting on the channel
F = friction angle of the channel-soil interface

The friction angle is dependent upon the soil that is in contact with the SmartDitch. A typical average friction angle between HDPE and sand is 18°. A typical average friction angle between clay and HDPE is 15°.

3.3.2 ANCHORING STABILITY – STEEP SLOPES (CONT.)

The primary force acting on the channel-soil interface is shear stress. Shear stress can be calculated using the following equation.

$$t = gdS$$

Where:

- t = shear stress
- g = unit weight of water
- d = depth of water in channel
- S = slope of channel

Good contact between the SmartDitch system and the surrounding soil is essential in developing the maximum frictional resistance. The anchors supplied with the SmartDitch system will also provide resistance to sliding and help maintain good contact between soil and channel.

Because of the multiple factors present in any given installation, there is no rule of thumb for how steep of slope to which the SmartDitch system can be installed. Each installation will need to be evaluated individually.

NOTE: Please contact SmartDitch engineering with any questions.

3.4 LATERAL FLOW EROSION AND UNDERMINING

Lateral flow from an adjacent parallel hillside or side slope may cause erosion of the soil along the SmartDitch sections or undermine them. Erosion control practices that may be implemented to reduce the probability of undermining, along the sides of the SmartDitch section,include installing 30 mil HDPE as illustrated in **Figure 14**. Edge protection kits are available from **PendaForm** and include one 3' x 560' (914 mm x 171 m) 30 mil HDPE roll, 400 self tapping screws and 400 washers.

NOTE: Control of side erosion and undermining will need to be designed for site-specific conditions by an engineer.

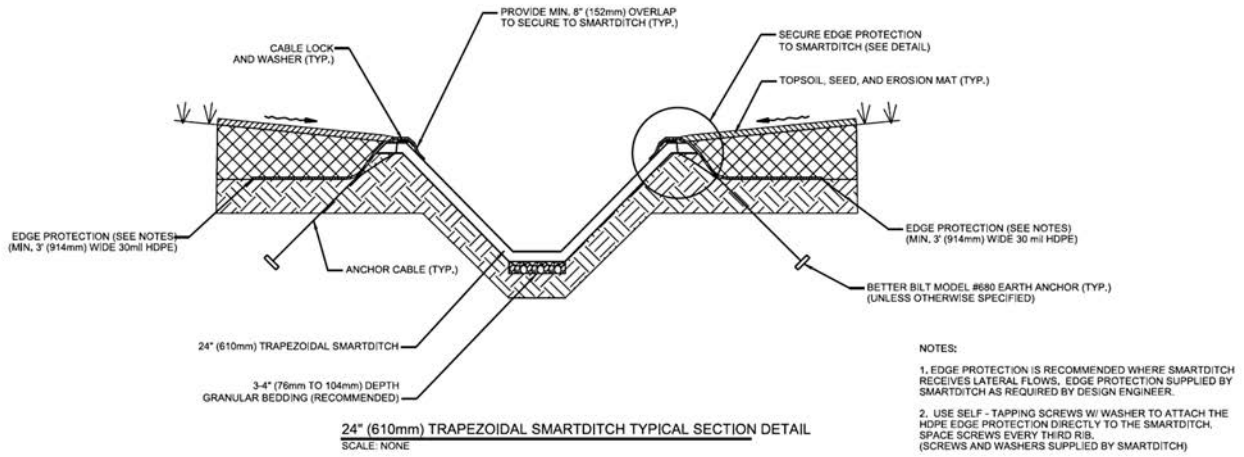


Figure 14

3.5 FITTINGS

PendaForm has created a standardized line of SmartDitch fittings that are molded or fabricated using the same materials that are used to produce SmartDitch channel sections. One of the core attributes of **PendaForm** is the ability to fabricate a wide assortment of fittings, standard as well as non-standard. For a complete listing of our standard fittings with dimensions, please contact **PendaForm**. Refer to the **Appendix: 5.3 Channel & Fittings Dimension Shop Drawings** for additional details.

3.6 TRAFFIC LOADING CONDITIONS

SmartDitch sections are not designed to support vehicular traffic. Foot traffic on the sections by people or animals will not damage or affect the performance of the sections.

3.7 RELINING EXISTING DITCHES

SmartDitch can be used to rehabilitate existing concrete and earthen ditches. Installation procedures are similar to those used in new construction.

The existing ditch subgrade of the concrete or earthen ditch should provide uniform and continuous support against the SmartDitch walls. Prepare the subgrade to be firm, smooth, and free of debris, rocks, and sharp objects. Trim and remove any tree roots. Remove unstable sections of concrete and replace with compacted soil fill.

The soil adjacent to the sections should be graded flush with the top of the concrete ditch prior to installation of the SmartDitch Sections. SmartDitch sections are typically laid end-to-end along the bank. Ensure that the ditch bank is free of tripping hazards and is level for connecting the ditch sections. *(Connect no more than 3 sections together prior to placement into the ditch.)*

Three inches of sand bedding is recommended, but not required. Bedding backfill and general installation requirements shall be in accordance with project plans and specifications and manufacturer's recommendations. See **Figure 15** and **Figure 16** below for details.

Joint assembly and anchoring of SmartDitch sections for relining are similar to the new installation practices.

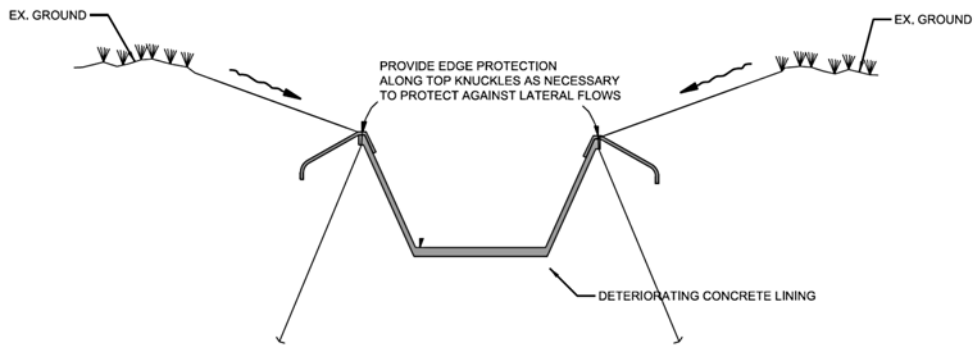


Figure 15

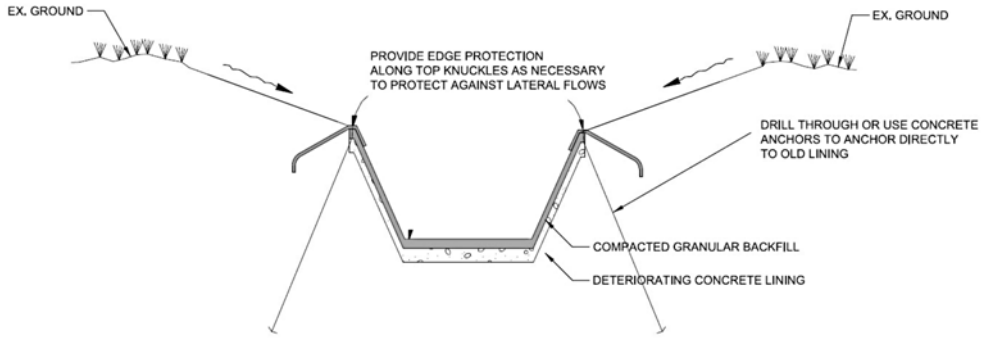


Figure 16

3.0 GENERAL INSTALLATION PRACTICES

3.8 POST INSTALLATION PRACTICES

Once the installation of SmartDitch® and MegaDitch® channels is complete, a comprehensive review of all components and materials should be conducted. Based on existing inspection cycles, review the following elements on visual and functional levels:

- Location review
  - Backfill bedding does not disturb grade or alignment and voids are not present (see the see the **Backfill and Tamping** section on page 17 for details).
- Straight / bulkhead channel review
  - Water moves freely at predetermined flow rates (see the **Flow Attributes, Flow Velocity** and **Flow Calculations** sections on pages 11 and 12 for details).
- Joint connection review
  - Screws are locked in place at drill dimple locations (see the **Joint Assembly Instructions** on pages 16 and 17 for details).
  - Water is not leaking beyond expressed rates (see the **Leakage** section on page 12 for details).
- Anchoring review
  - Anchor number per channel is appropriate for flow demands (see the **Anchoring** section on page 18 for details).
  - Anchor cables are taught and pull-tested to appropriate soil levels; loose cable is not visible (see the **Anchoring** and **Soil Classifications and Anchor Capacity** sections on pages 18-20 for details).

3.9 HANDLING / SHIPPING / STORAGE GUIDELINES

Utilize the following guidelines when handling, shipping or storing SmartDitch channels and installation elements:

Follow all applicable safety guidelines.

- Do not drop the sections from delivery truck into an open trench or onto uneven surfaces.
- Inspect all sections prior to installation.
- Temperature extremes have minimal effect on the strength or handling characteristics of SmartDitch. SmartDitch remains highly impact resistant even in subzero conditions.
- Hot weather especially when coupled with direct sunlight, will raise the sections temperature, but will not significantly affect handling or installation behavior.
- Avoid driving over the sections.
- SmartDitch sections should be stored on a flat surface on the original shipping pallets.
- Carbon black is added to polyethylene to protect against UV degradation. Some discoloration may occur if stored uncovered over an extended time period.

3.10 CLEANING, MAINTENANCE AND REPAIR

Inspect SmartDitch® and MegaDitch® lined ditches, laterals, or other components of the water distribution system regularly to ensure proper operation and delivery and or drainage of water. Remove any rocks, debris, or other obstructions from sections to ensure maximum flow and efficiency. Provide any necessary maintenance and timely repair any damage to any products and related components. In the event of discovery of any HDPE product defect, provide prompt written notice to **PendaForm.**

In low flow situations or during the dry season some sediment may accumulate in between the corrugations. To minimize potential problems, flow should be maintained at a minimum, or self-cleansing, velocity. When utilizing SmartDitch, a minimum slope of 0.005 (0.5%) is recommended to maintain the self-cleansing velocity. This minimizes the accumulation of sediments and the likely hood of vegetation starting to grow. If vegetation does grow is can be easily cleaned out with hand tools.

SmartDitch will self-cleanse itself of minor sediment build-up during a typical rain event.

DISCLAIMER:
Although the utmost care has been taken to ensure the accuracy of the contents of this brochure, **PendaForm** and its subsidiaries do not accept liability for errors or omissions in this publication. Customers must satisfy themselves of the suitability of a given product supplied or manufactured by **PendaForm** or its subsidiaries before using the same.

4.1 PRODUCT DATA

The MegaDitch™ system is a corrugated section of HDPE sheet formed into base and side wall sections that can be cut and assembled into the required drainage channel dimensions for large flow capacity. MegaDitch is made by using the same thermoforming process as the SmartDitch® products described in Section 2.0.

MegaDitch is specifically designed to convey larger volumes of water and can be used for the rehabilitation of large concrete-lined and earthen ditches and canals. Earth anchors, similar to the SmartDitch system are used to hold MegaDitch in place. Side-wall slope is available in 115° (2 vertical to 1 horizontal - normally used in existing concrete lined channels), and 135° (1 vertical to 1 horizontal). The side-wall angle is measured from the base.

4.1.1 PRODUCT ATTRIBUTES, DIMENSIONS AND WEIGHTS

Figure 17 shows a one base wide and one wall high (135°) MegaDitch cross-section. **Figure 18** shows a two base wide and two wall high (135°) MegaDitch cross section. The base and wall sections can be trimmed by **PendaForm** to create any combination of sections to provide the required channel size.

Figure 17

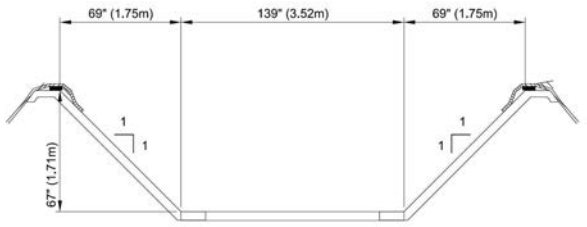


Figure 18

4.1.2 MEGADITCH™ FITTINGS

MegaDitch does not offer fittings due to the size of the product, but the flexibility of making the product conform to project requirements can be discussed with SmartDitch Engineering. Tees can be field fabricated under **PendaForm** supervision. Sharper curves are also field fabricated by cutting out one to three ribs, per section in a pie shape, and installing HDPE sheet material as indicated in the “MegaDitch Curve Fabrication” PowerPoint presentation available from **PendaForm**.

Gradual curves can be made by bending the MegaDitch around a curve as indicated in the MegaDitch Curve Fabrication PowerPoint available from **PendaForm**.

Curve fabrication pictures are available from **PendaForm**. Please contact our Engineering team at 1-866-576-2783.

4.1.3 MEGADITCH™ INSTALLATION

IMPORTANT NOTE: ***PendaForm*** *will not design a MegaDitch® system without soil samples, provided by the customer, to determine the best method of design.*

Installation practices for MegaDitch are similar to the practices described for SmartDitch® in Section 3.0 for the following items:

- 3.1.1 Subgrade Preparation
- 3.1.2 Bedding and Backfill Materials
- 3.1.3 Suitable Soil Types
- 3.1.4 Unsuitable Soil Types
- 3.1.7 Backfilling and Tamping
- 3.1.8 Anchoring (Site specific and requires assistance from SmartDitch Engineering.)
- 3.2 Anchoring Capacity
- 3.3 Soil Classifications and Anchor Capacity
- 3.4 Lateral Flow Erosion / Undermining
- 3.6 Traffic Loading Conditions
- 3.7 Relining Applications
- 3.8 Post Installation Inspection
- 3.9 Handling / Shipping / Storage Guidelines
- 3.10 Cleaning

A presentation is available from **PendaForm**.

MegaDitch sections are installed by spreading several base sections out along the bottom of the ditch. Align the sections based upon the markings under the end rib of each section. The upstream rib (marked Large Downstream) should be positioned over the top of the downstream rib (marked Small Upstream). The rib pattern should overlap side to side in accordance with the specific site specifications.

Install the anchoring system in accordance with the site specific recommendations. **Figure 19** shows a typical installation drawing. Use a jackhammer to pre-drill an anchor hole when in rocky soil or dense clay. Install the anchor and leave the cable loose. If installing multiple bases, overlap sections side to side and fasten the sections together. Install self-tapping screws in accordance with the site specific recommendations.

NOTE: Do not fasten the last ribs on the overlapped base sections at this time.

Place a vice grips on the last overlapped rib sections to hold in place. Lay a gasket over the small rib and over the overlap crease. Make sure the gasket completely covers the entire rib length. Drill a 1/2" (13 mm) hole for the earth anchor. The hole must go through both base sections. Pull the anchor cable through the drilled holes. Install the washer and gripper onto the end of the anchor cable, pull the cable tight with vice grips and slide the gripper and washer against the MegaDitch. Install one extra self tapping screw next to the anchor. Install three self tapping screws for each base section, spaced about 18" (457 mm) apart across the length of the rib.

NOTE: Do not place screws in the area where the side walls will overlap the base section.

Locate the correct side wall sections. Side walls should have left and right stamps on the underside of the section in the middle of the outermost rib. Left and right orientations correspond to looking in the MegaDitch flow direction.

Position the first side wall two ribs downstream for proper overlap across the base section. Push the side-wall up against the trench side wall and use two people to hold in place. Install self-tapping screws to connect the side wall and base sections. Install one screw in each rib valley approximately one inch from the overlap. If installing on concrete, use self-tapping concrete screws in the rib valleys. Install additional screws on the rib apex if the gap exceeds 1/4" (6 mm).

Apply a gasket to the small upstream rib, up to the top edge of the knuckle section. Note that there are no fasteners in the rib with the gasket. Overlap the next upstream side wall section one rib and install two screws at the base of the overlapping side wall sections approximately three inches apart. Install four more screws evenly spaced along the overlap section approximately 18" (457 mm) apart. Install the last screw on top of the knuckle. Install one extra screw at the side wall base, two ribs upstream of the side wall overlap.

Install the wall anchors. Drill 1/2" (13 mm) holes through both side-wallsections at the area where the two sections overlap. Indentations on the side-wall sections indicate where the holes should be drilled. Install the anchors as indicated above. Backfill around the MegaDitch.

Sealant should be applied, during suitable weather conditions, to the side-wall and base section overlaps where a gasket is not present to restrict seepage. Prepare the area to be sealed by quickly sweeping the area or blow it off with compressed air. Sections should be dry and clear of debris. Lay a long continuous bead over the overlapped sections. Also seal around the base section washers and cable grippers. Screw heads may be sealed if desired.

Restoration along the top of the product is required. Area must be maintained and vegetated if possible to minimize erosion along the product. If significant lateral flow is anticipated, install edge protection as indicated in **Figure 19**.

Installation of two side wall high channels requires additional anchoring or geotextile fabric. Contact SmartDitch Engineering for support services.

4.1.4 HEADWALLS AND ENDWALLS

Design requirements for water entering the MegaDitch at the beginning of the channel vary and several options are available. The following methods have been successfully used on previous projects:

Headwall:

- Concrete cutoff wall that can be used with or without the culvert, see **Figure 20**.
- Storm sewer culvert with rip rap, see **Figure 21**.
- Buried MegaDitch extensions, see **Figure 22**.

Endwall:

- Concrete wall
- Rip rap
- Extended base sections with rip rap.

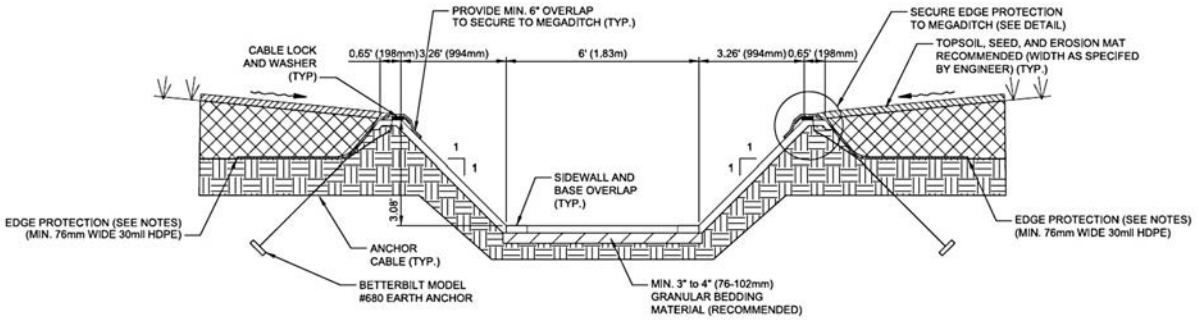


Figure 19

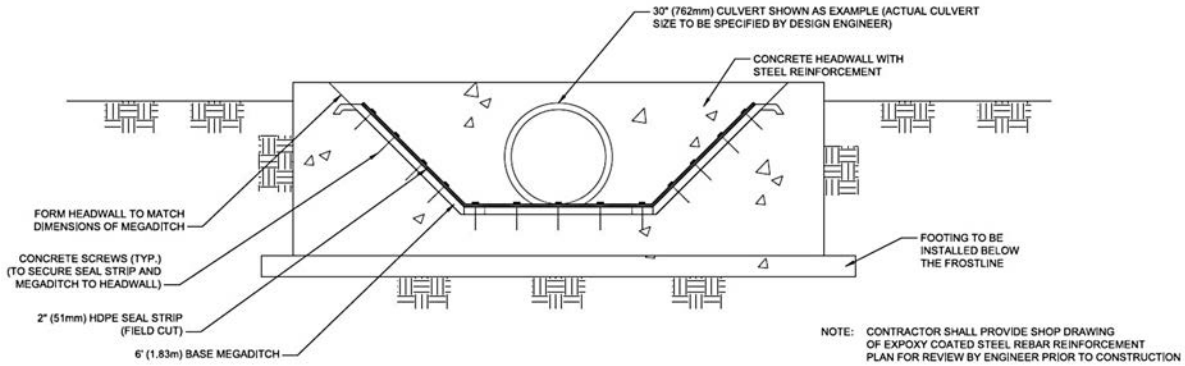


Figure 20

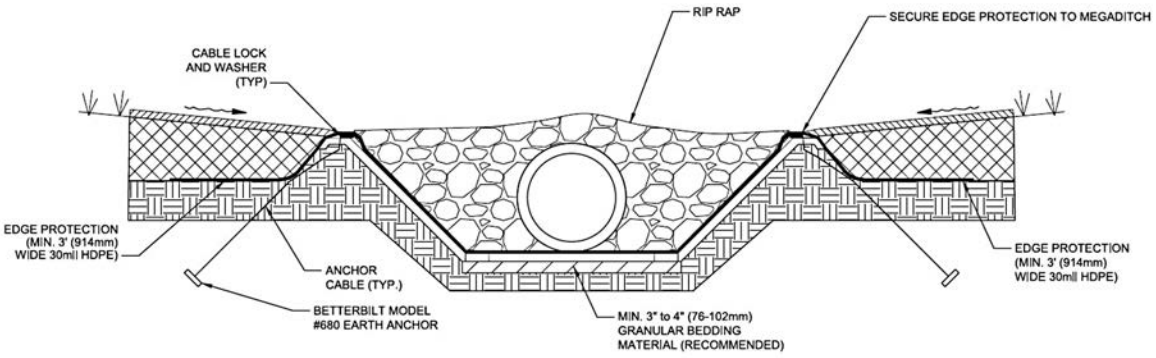


Figure 21

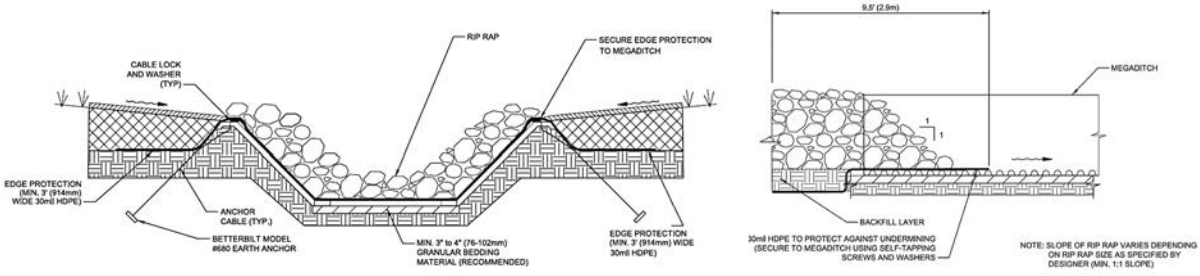


Figure 22

Appendix

SmartDitch Product Specifications
SmartDitch Flow Calculations
Channel & Fittings Dimension Shop Drawings
Installation / Assembly Instructions
Edge Protection Guidelines
Warranty Information

5.1 SMARTDITCH PRODUCT SPECIFICATIONS

SECTION I - GENERAL

A. Description: SmartDitch Channel / Lining Systems are designed to improve reliable water flow, reduce water loss, and reduce maintenance requirements for earthen irrigation ditches utilized for storm water management and public works, erosion and sediment control, and agriculture / irrigation applications.

B. Reference Specifications: There currently is not an ASTM standard for the SmartDitch Lining System. The following documents can be referenced to Indicate specific manufacturing and material performance capabilities:

ASTM

D618	Practice for Conditioning Plastics for Testing
D638	Test Method for Tensile Properties of Plastics
D746	Test Method for Brittleness Temperature of Plastics and Elastomers by Impact
D883	Terminology Relating to Plastics
D1238	Test Method for Melt Flow Rates of Thermoplastics by Extrusion Plastometer
D1505	Test Method for Density of Plastics by the Density-Gradient Technique
D1506	Test Method for Carbon Black – Ash Content
D1693	Test Method for Environmental Stress Cracking of Ethylene Plastics
D5420	Standard Test Method for Impact Resistance of Flat, Rigid Plastic Specimen by Means of a Striker Impacted by a Falling Weight

SECTION II – MATERIAL PROPERTIES

A. Liner Segments are manufactured from high molecular weight high density polyethylene. (HDPE)

B. Additives: Resin additives, such as curing agents, pigments, dyes, fillers, thixotrophic agents, etc., when used, shall not detrimentally effect the performance of the product.

C. Foam Gaskets: The foam gaskets shall be supplied by qualified gasket manufacturers and be suitable for the service intended.

SECTION III – MANUFACTURE

A. The liner segments shall be manufactured using vacuum thermoforming.

B. Fittings: All fittings shall be fabricated from material meeting the requirements of these standards.

C. Acceptable Manufacturer or Supplier: **PendaForm**

SECTION IV – NOMINAL DIMENSIONS

A. Nominal Dimensions shall be per the manufacturer's design.

B. Lengths: Liner Sections shall be supplied in nominal lengths per the manufacturer's design. Shorter and custom lengths will be supplied as defined by the project requirements.

C. Wall Thickness: The average wall thickness shall be per the manufacturer's design.

SECTION V – MATERIAL TESTING

A. Segments shall be manufactured and tested in accordance with applicable ASTM standards.

SECTION VI – DESIGN CRITERIA

A. Capacity: Lined ditch shall have enough capacity to meet the requirements as part of the planned irrigation water distribution / conveyance system without overflow. The minimum Manning's coefficient of friction for the lining system is n=0.022 for laminar flow and 0.029 for turbulent flow.

B. Velocity: The velocity in ditches lined with the liner shall be sufficient to carry the required flow. Velocity may vary dependent on slope of existing ditch, lateral, or other water work. Minimum slope requirement for installation of SmartDitch liner system is 1/2 percent.

C. Side Slopes / Bottom: Side slopes and bottom of the earthen ditch shall be free of debris, rocks and other sharp objects that may damage the liner system once installed.

D. Leak Rate: The average exfiltration rate shall not exceed 0.039 cfs / 1000' (1.1 L / s / 305 m).

SECTION VII – INSTALLATION PROCEDURES

A. Bedding backfill and general installation requirements shall be in accordance with project plans and specifications and manufacturer's recommendations.

SECTION VIII – MAINTENANCE

A. Field Inspect lined irrigation ditches, laterals, or other components of the water distribution system regularly to ensure proper operation and delivery of water. Remove any rocks, debris, or other obstructions from liner system to ensure maximum flow and efficiency.

5.0 APPENDIX

5.2 SMARTDITCH FLOW CALCULATIONS

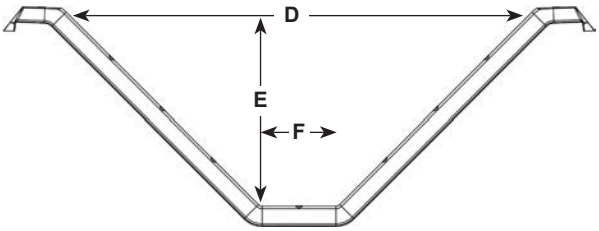
Flow rate calculations for the channel system are based on the standard hydraulic flow formula:

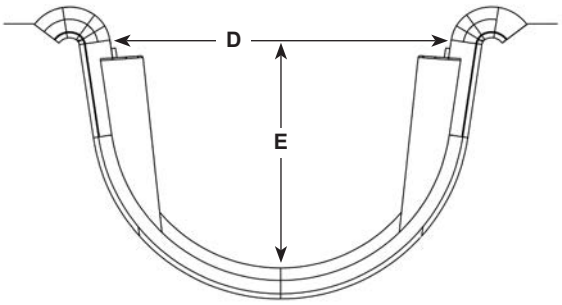
$Q = (1.49/n)\ A\ R^{2/3}\ S^{1/2}$

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 (%)

The designer of record must review the project hydraulics to determine the required channel freeboard.





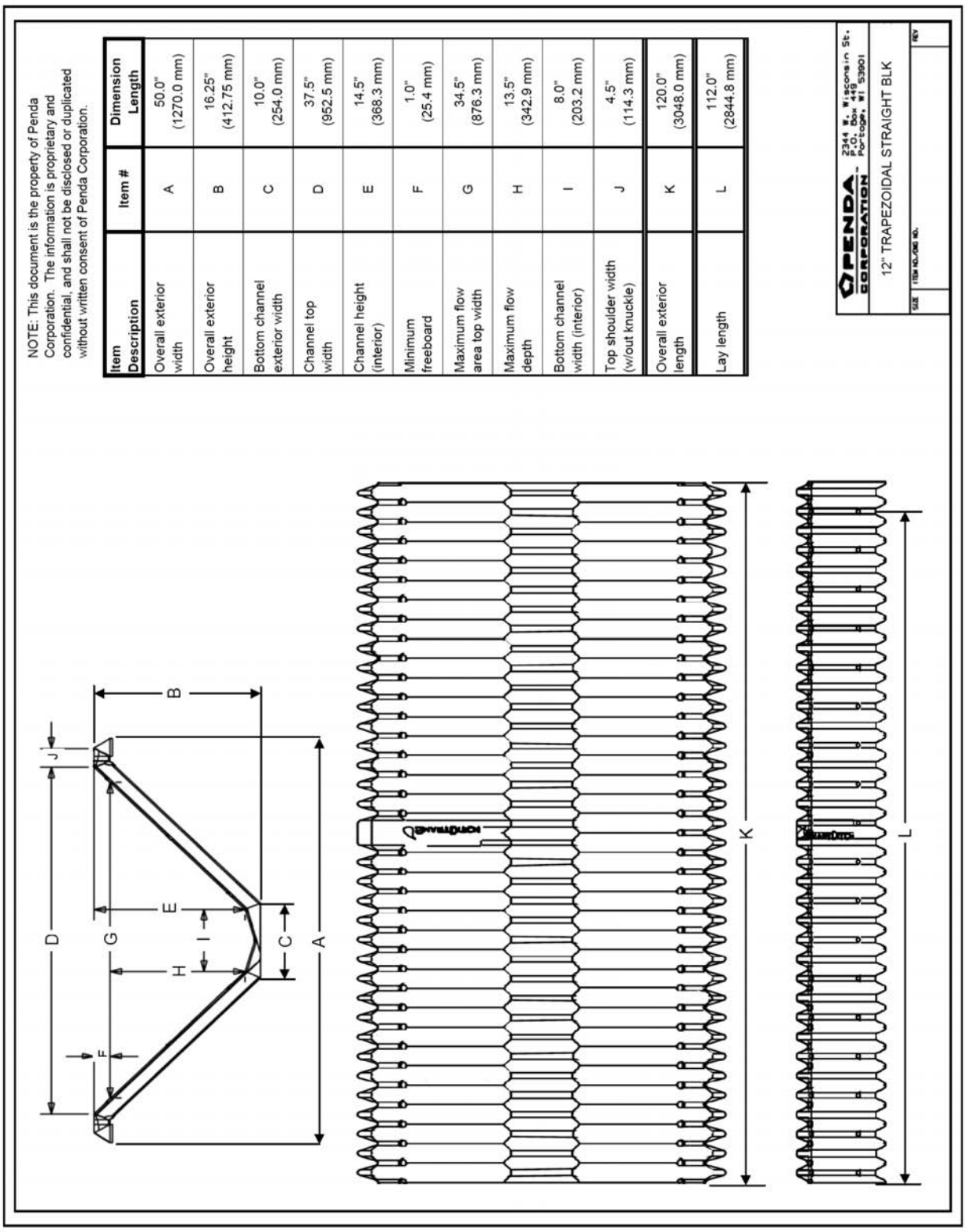
	12" (305 MM) TRAPEZOID	24" (610 MM) TRAPEZOID	24" (610 MM) SEMI-CIRCULAR
D:	**Max Flow Area Top: 34.5" (876 mm)**	**Max Flow Width Across Top: 59.5" (1511 mm)**	**Max Flow Width Across Top: 24" (610 mm)**
E:	Max Flow Depth: 13.5" (340 mm)	Max Flow Depth: 25" (635 mm)	Max Flow Depth: 14" (356 mm)
F:	Bottom Channel Width (interior): 8" (203 mm)	Bottom Channel Width (interior): 12" (305 mm)	Bottom Channel Width (interior): N/A
	Mannings: 0.022*	Mannings: 0.022*	Mannings: 0.022*

Slope %	Flow cfs / m^3/s	Velocity fps / mps	Flow cfs / m^3/s	Velocity fps / mps	Flow cfs / m^3/s	Velocity fps / mps
0.50%	6.15 / 0.17	3.09 / 0.94	28.04 / 0.79	4.52 / 1.38	5.41 / 0.15	3.10 / 0.95
1.00%	8.70 / 0.25	4.37 / 1.33	30.50 / 0.86	4.91 / 1.50	7.66 / 0.22	4.38 / 1.34
2.50%	10.61 / 0.30	5.32 / 1.62	48.23 / 1.37	7.77 / 2.37	9.31 / 0.26	5.33 / 1.63
5.00%	15.00 / 0.43	7.53 / 2.30	68.20 / 1.93	10.99 / 3.35	13.17 / 0.37	7.53 / 2.30
7.50%	18.37 / 0.52	9.22 / 2.81	85.53 / 2.42	13.46 / 4.10	16.13 / 0.46	9.23 / 2.81
10.00%	21.21 / 0.60	10.65 / 3.25	96.46 / 2.73	15.54 / 4.74	18.62 / 0.53	10.66 / 3.25
15.00%	25.98 / 0.74	13.04 / 3.98	118.13 / 3.35	19.03 / 5.80	22.81 / 0.65	13.05 / 3.98
20.00%	30.00 / 0.85	15.06 / 4.59	136.41 / 3.87	21.98 / 6.70	26.34 / 0.75	15.07 / 4.59

** A mannings coefficient of 0.029 is used when the velocity exceeds 1.22 mps and flow becomes turbulent.*

5.3 CHANNEL & FITTINGS DIMENSION SHOP DRAWINGS

12" (305 MM) DEPTH TRAPEZOIDAL STANDARD STRAIGHT CHANNEL



NOTE: This document is the property of Penda Corporation. The information is proprietary and confidential, and shall not be disclosed or duplicated without written consent of Penda Corporation.

Item Description	Item #	Dimension Length
Overall exterior width	A	50.0" (1270.0 mm)
Overall exterior height	B	16.25" (412.75 mm)
Bottom channel exterior width	C	10.0" (254.0 mm)
Channel top width	D	37.5" (952.5 mm)
Channel height (interior)	E	14.5" (368.3 mm)
Minimum freeboard	F	1.0" (25.4 mm)
Maximum flow area top width	G	34.5" (876.3 mm)
Maximum flow depth	H	13.5" (342.9 mm)
Bottom channel width (interior)	I	8.0" (203.2 mm)
Top shoulder width (w/out knuckle)	J	4.5" (114.3 mm)
Overall exterior length	K	120.0" (3048.0 mm)
Lay length	L	112.0" (2844.8 mm)

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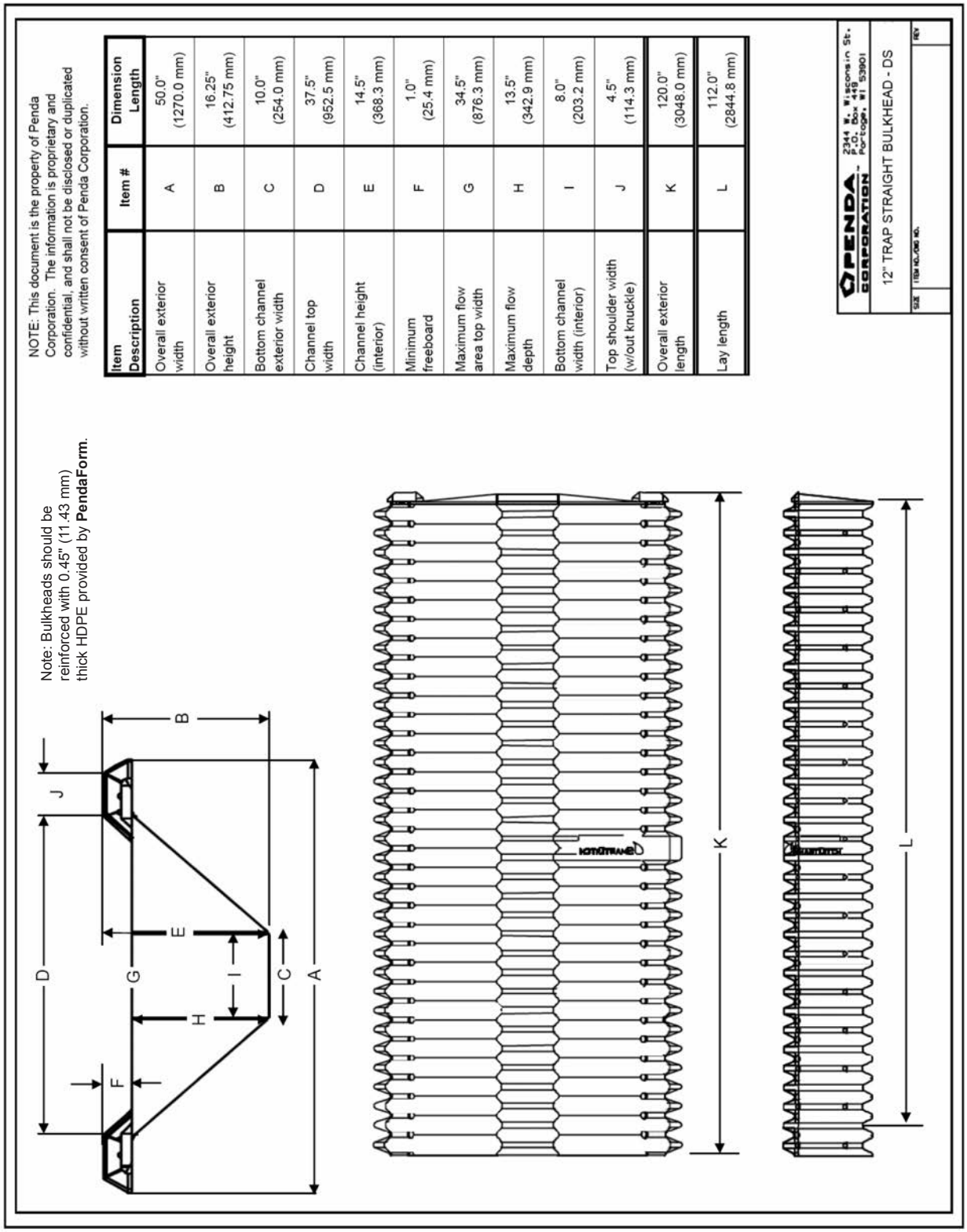
12" TRAPEZOIDAL STRAIGHT BLK

SIZE | ITEM NO./DWG NO. | REV

5.0 APPENDIX

5.3 CHANNEL & FITTINGS DIMENSION SHOP DRAWINGS

12" (305 MM) DEPTH TRAP STRAIGHT BULKHEAD – DOWNSTREAM

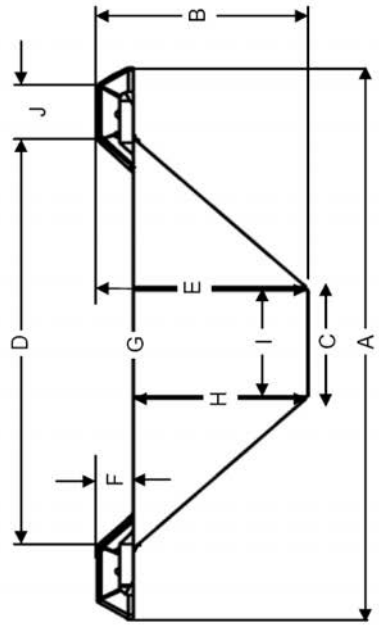


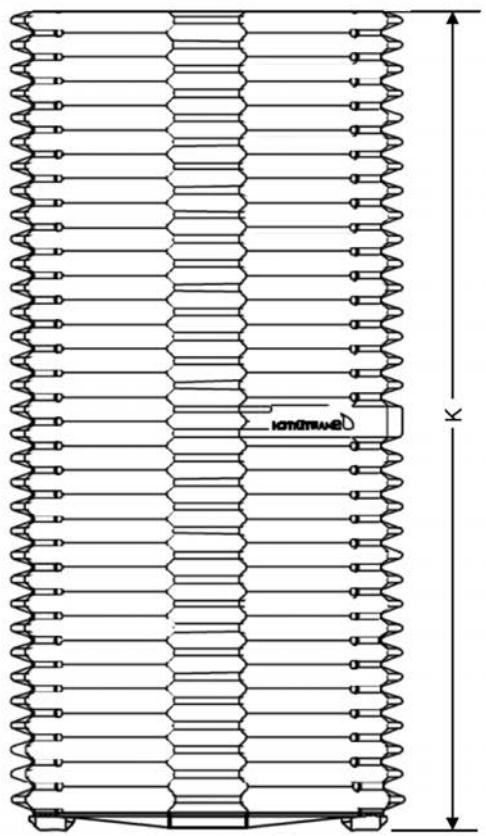
5.3 CHANNEL & FITTINGS DIMENSION SHOP DRAWINGS

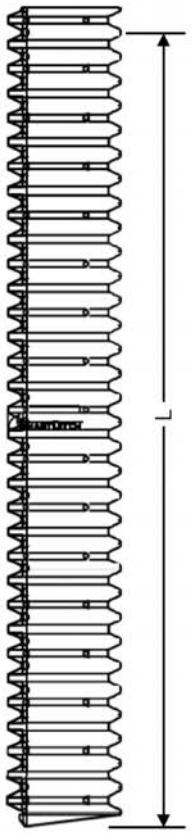
12" (305 MM) DEPTH TRAP STRAIGHT BULKHEAD – UPSTREAM

Item Description	Item #	Dimension Length
Overall exterior width	A	50.0" (1270.0 mm)
Overall exterior height	B	16.25" (412.75 mm)
Bottom channel exterior width	C	10.0" (254.0 mm)
Channel top width	D	37.5" (952.5 mm)
Channel height (interior)	E	14.5" (368.3 mm)
Minimum freeboard	F	1.0" (25.4 mm)
Maximum flow area top width	G	34.5" (876.3 mm)
Maximum flow depth	H	13.5" (342.9 mm)
Bottom channel width (interior)	I	8.0" (203.2 mm)
Top shoulder width (w/out knuckle)	J	4.5" (114.3 mm)
Overall exterior length	K	114.0" (2895.6 mm)
Lay length	L	106.0" (2692.4 mm)

Note: Bulkheads should be reinforced with 0.45" (11.43 mm) thick HDPE provided by **PendaForm**.







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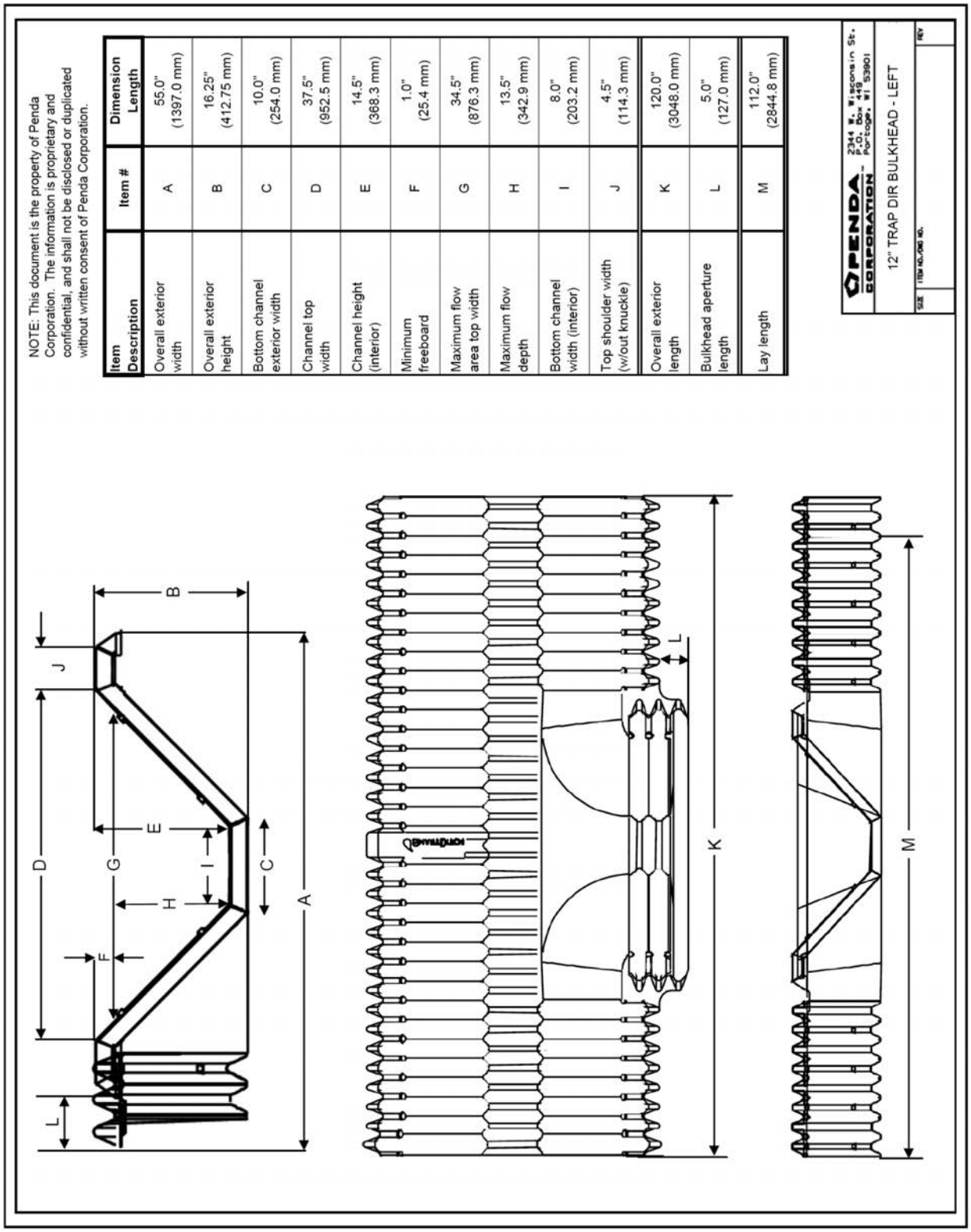
12" TRAP STRAIGHT BULKHEAD - US

SIZE | ITEM NO./DWG NO. | REV

5.0 APPENDIX

5.3 CHANNEL & FITTINGS DIMENSION SHOP DRAWINGS

12" (305 MM) DEPTH TRAP DIRECTIONAL BULKHEAD – LEFT



NOTE: This document is the property of Penda Corporation. The information is proprietary and confidential, and shall not be disclosed or duplicated without written consent of Penda Corporation.

Item Description	Item #	Dimension Length
Overall exterior width	A	55.0" (1397.0 mm)
Overall exterior height	B	16.25" (412.75 mm)
Bottom channel exterior width	C	10.0" (254.0 mm)
Channel top width	D	37.5" (952.5 mm)
Channel height (interior)	E	14.5" (368.3 mm)
Minimum freeboard	F	1.0" (25.4 mm)
Maximum flow area top width	G	34.5" (876.3 mm)
Maximum flow depth	H	13.5" (342.9 mm)
Bottom channel width (interior)	I	8.0" (203.2 mm)
Top shoulder width (w/out knuckle)	J	4.5" (114.3 mm)
Overall exterior length	K	120.0" (3048.0 mm)
Bulkhead aperture length	L	5.0" (127.0 mm)
Lay length	M	112.0" (2844.8 mm)

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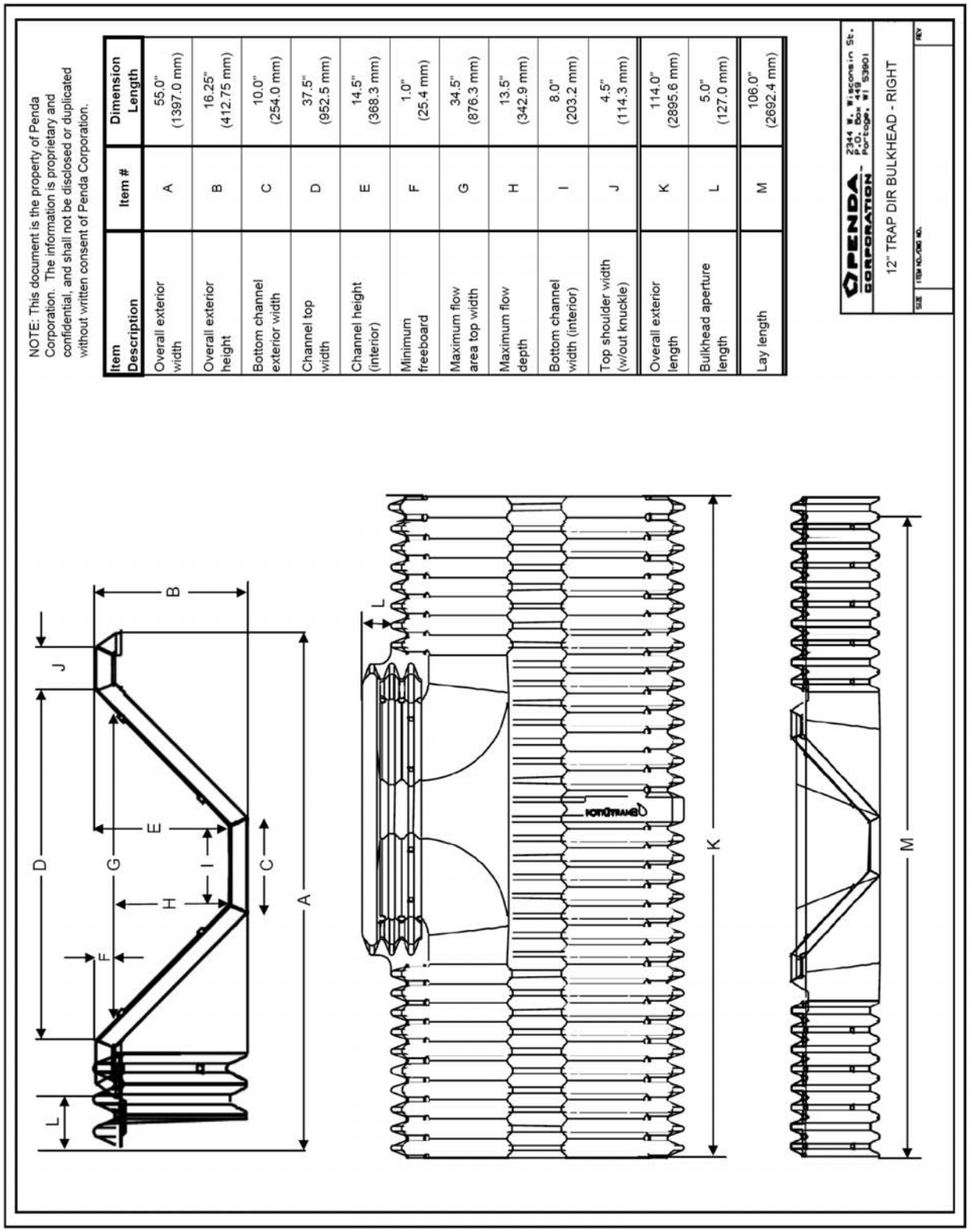
12" TRAP DIR BULKHEAD - LEFT

SIZE | ITEM NO./DWG NO. | REV

5.3 CHANNEL & FITTINGS DIMENSION SHOP DRAWINGS

12" (305 MM) DEPTH TRAP DIRECTIONAL BULKHEAD – RIGHT

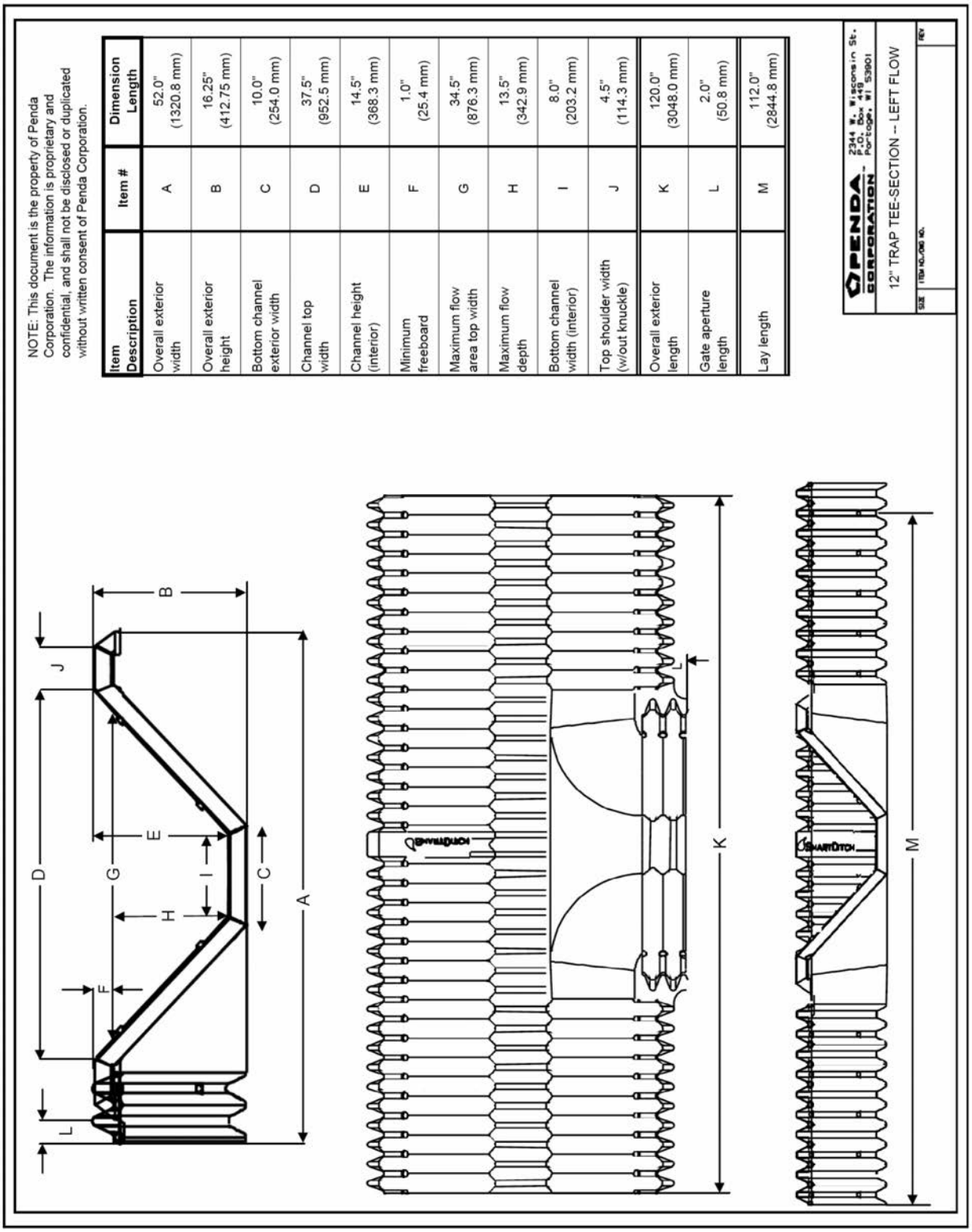


Item Description	Item #	Dimension Length
Overall exterior width	A	55.0" (1397.0 mm)
Overall exterior height	B	16.25" (412.75 mm)
Bottom channel exterior width	C	10.0" (254.0 mm)
Channel top width	D	37.5" (952.5 mm)
Channel height (interior)	E	14.5" (368.3 mm)
Minimum freeboard	F	1.0" (25.4 mm)
Maximum flow area top width	G	34.5" (876.3 mm)
Maximum flow depth	H	13.5" (342.9 mm)
Bottom channel width (interior)	I	8.0" (203.2 mm)
Top shoulder width (w/out knuckle)	J	4.5" (114.3 mm)
Overall exterior length	K	114.0" (2895.6 mm)
Bulkhead aperture length	L	5.0" (127.0 mm)
Lay length	M	106.0" (2692.4 mm)

5.0 APPENDIX

5.3 CHANNEL & FITTINGS DIMENSION SHOP DRAWINGS

12" (305 MM) DEPTH TRAP DIRECTIONAL TEE SECTION – LEFT FLOW



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Item Description	Item #	Dimension Length
Overall exterior width	A	52.0" (1320.8 mm)
Overall exterior height	B	16.25" (412.75 mm)
Bottom channel exterior width	C	10.0" (254.0 mm)
Channel top width	D	37.5" (952.5 mm)
Channel height (interior)	E	14.5" (368.3 mm)
Minimum freeboard	F	1.0" (25.4 mm)
Maximum flow area top width	G	34.5" (876.3 mm)
Maximum flow depth	H	13.5" (342.9 mm)
Bottom channel width (interior)	I	8.0" (203.2 mm)
Top shoulder width (w/out knuckle)	J	4.5" (114.3 mm)
Overall exterior length	K	120.0" (3048.0 mm)
Gate aperture length	L	2.0" (50.8 mm)
Lay length	M	112.0" (2844.8 mm)

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12" TRAP TEE-SECTION -- LEFT FLOW

SIZE | ITEM NO./DWG NO. | REV

5.3 CHANNEL & FITTINGS DIMENSION SHOP DRAWINGS

12" (305 MM) DEPTH TRAP DIRECTIONAL TEE SECTION – RIGHT FLOW

Item Description	Item #	Dimension Length
Overall exterior width	A	52.0" (1320.8 mm)
Overall exterior height	B	16.25" (412.75 mm)
Bottom channel exterior width	C	10.0" (254.0 mm)
Channel top width	D	37.5" (952.5 mm)
Channel height (interior)	E	14.5" (368.3 mm)
Minimum freeboard	F	1.0" (25.4 mm)
Maximum flow area top width	G	34.5" (876.3 mm)
Maximum flow depth	H	13.5" (342.9 mm)
Bottom channel width (interior)	I	8.0" (203.2 mm)
Top shoulder width (w/out knuckle)	J	4.5" (114.3 mm)
Overall exterior length	K	114.0" (2895.6 mm)
Gate aperture length	L	2.0" (50.8 mm)
Lay length	M	106.0" (2692.4 mm)

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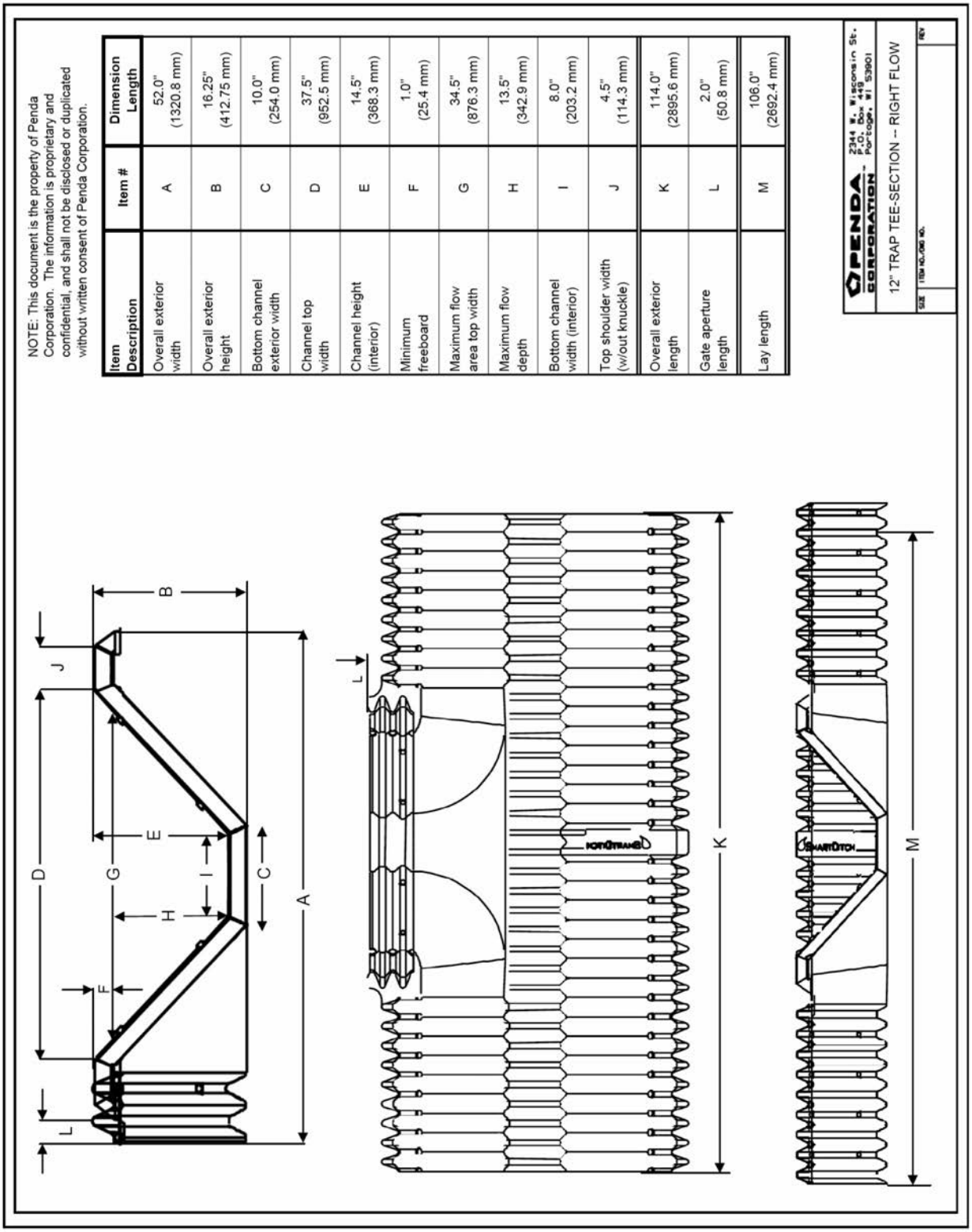
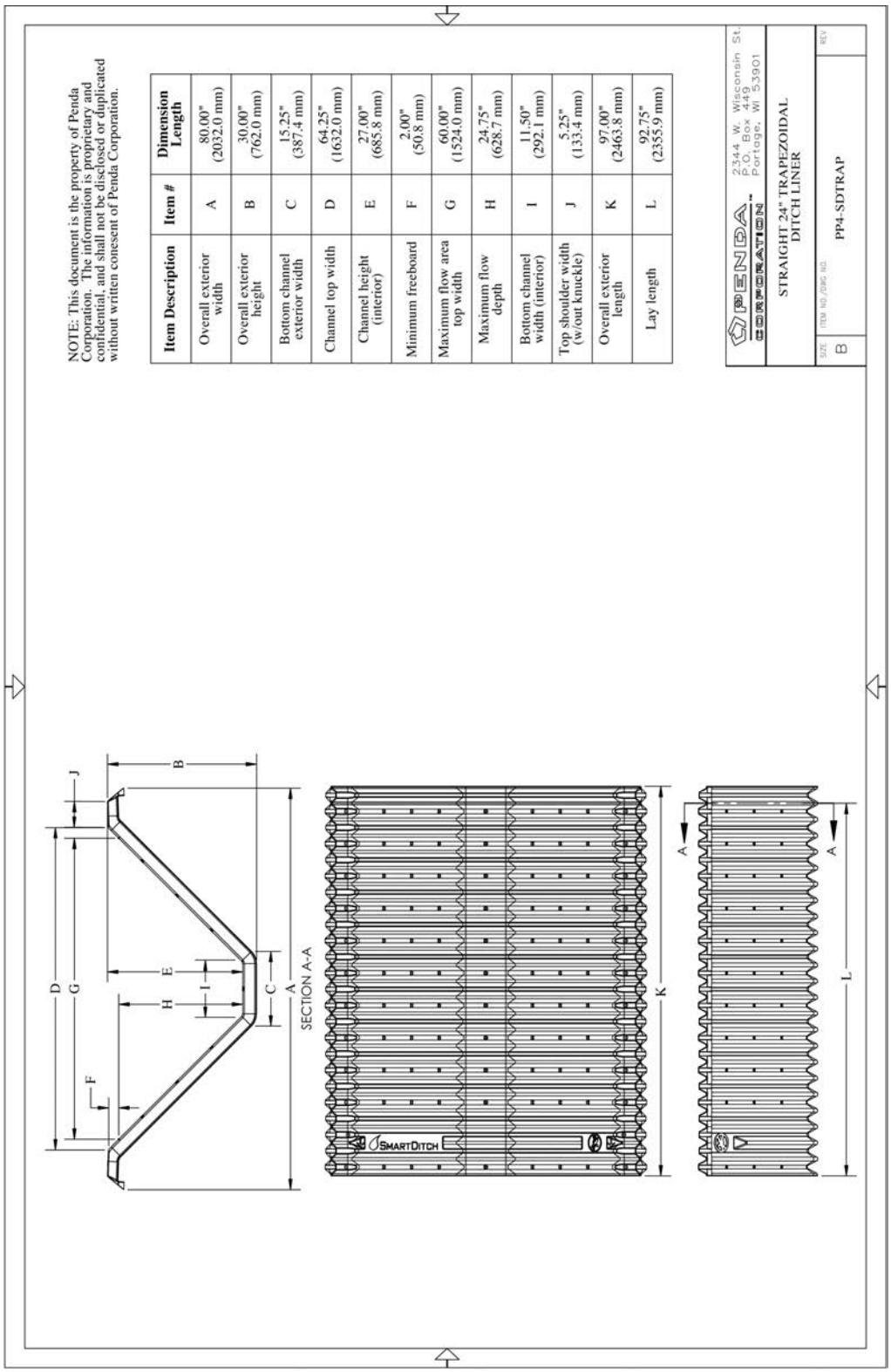
12" TRAP TEE-SECTION -- RIGHT FLOW

SIZE ITEM NO./DWG NO. REV



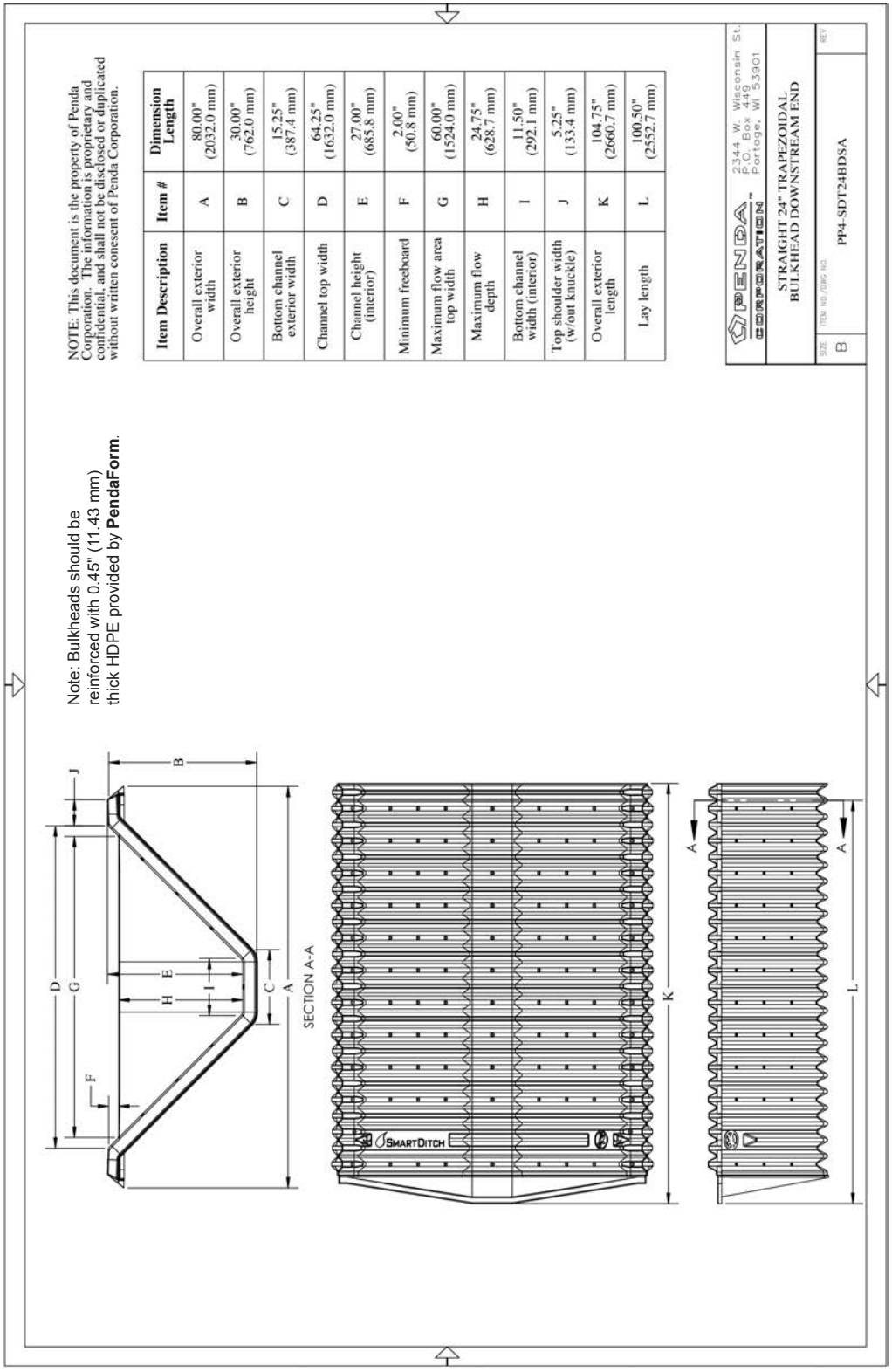
5.0 APPENDIX

5.3 CHANNEL & FITTINGS DIMENSION SHOP DRAWINGS

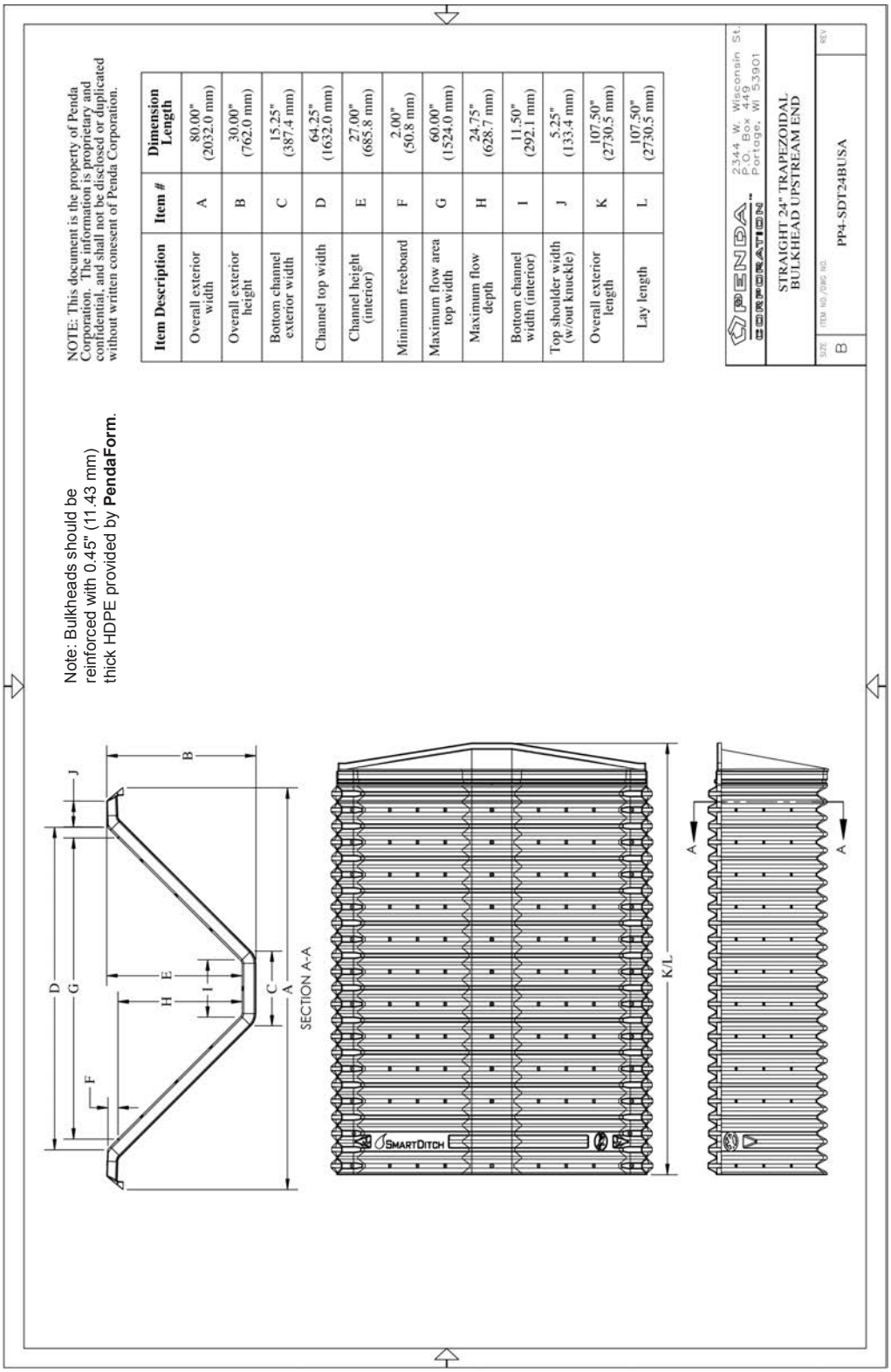


5.3 CHANNEL & FITTINGS DIMENSION SHOP DRAWINGS

STRAIGHT 24" (610 MM) TRAPEZOIDAL BULKHEAD DOWNSTREAM END

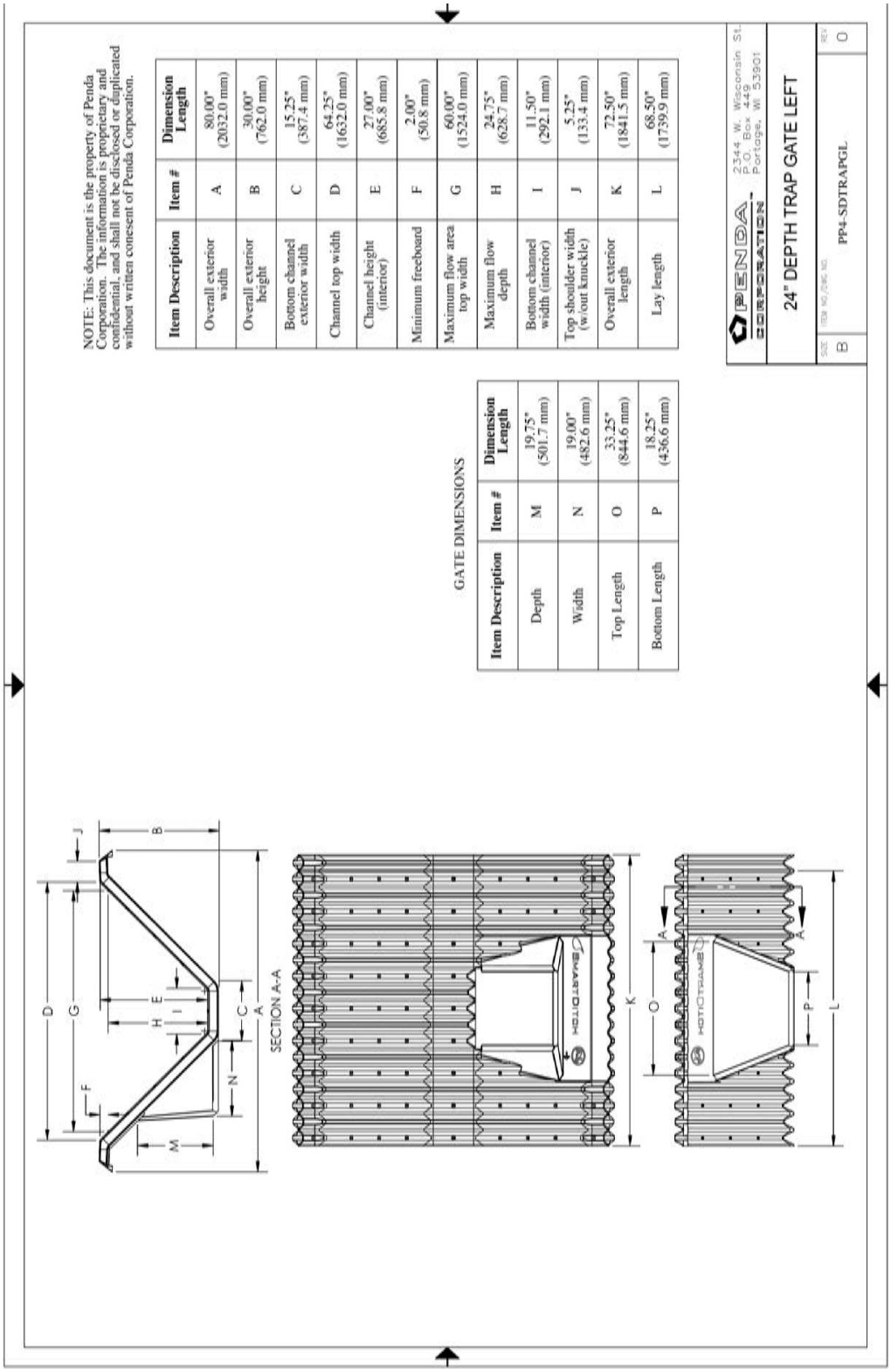


5.3 CHANNEL & FITTINGS DIMENSION SHOP DRAWINGS

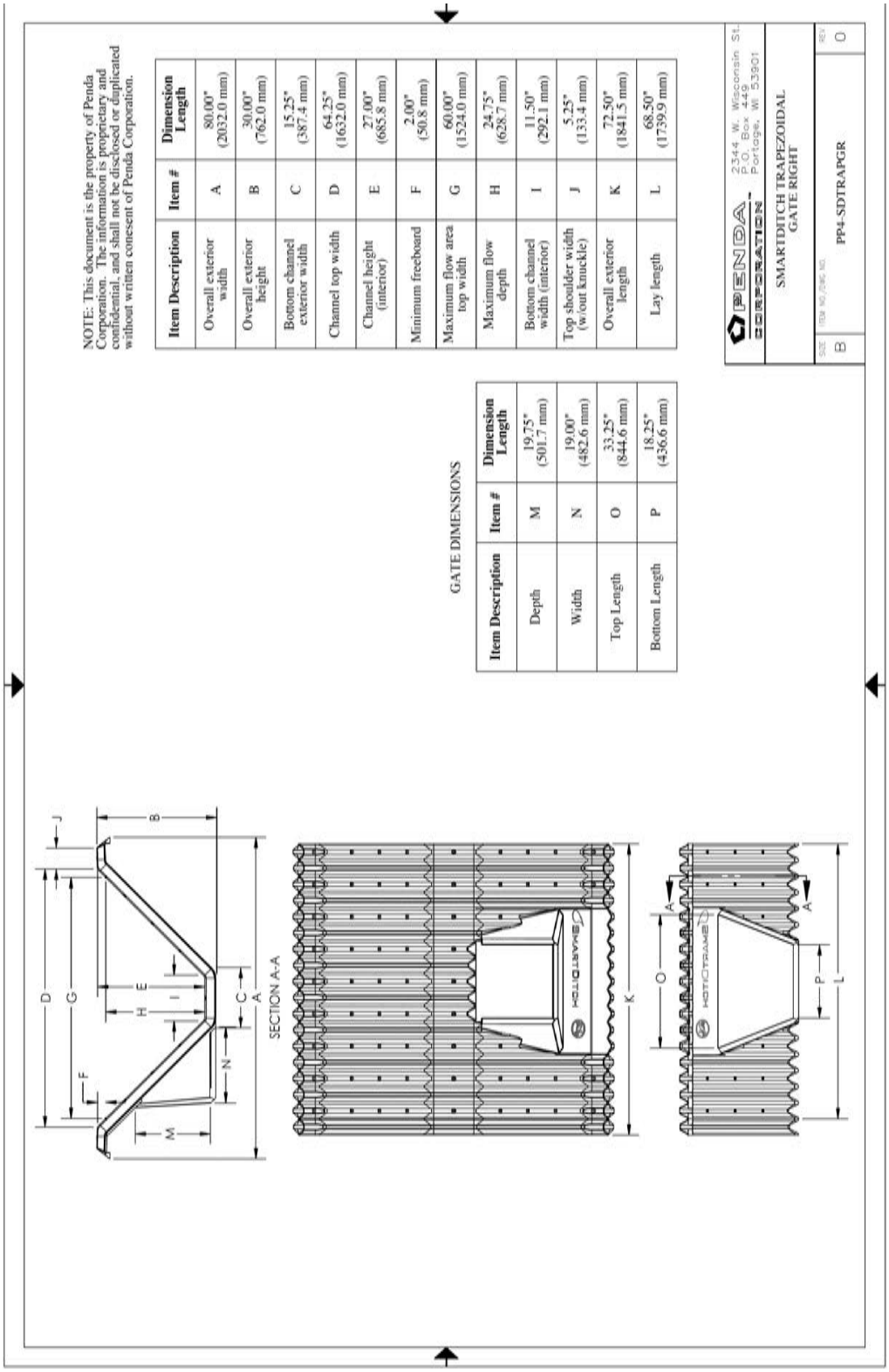


5.3 CHANNEL & FITTINGS DIMENSION SHOP DRAWINGS

24" (610 MM) DEPTH TRAP GATE LEFT



5.3 CHANNEL & FITTINGS DIMENSION SHOP DRAWINGS



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Item Description	Item #	Dimension Length
Overall exterior width	A	80.00" (2032.0 mm)
Overall exterior height	B	30.00" (762.0 mm)
Bottom channel exterior width	C	15.25" (387.4 mm)
Channel top width	D	64.25" (1632.0 mm)
Channel height (interior)	E	27.00" (685.8 mm)
Minimum freeboard	F	2.00" (50.8 mm)
Maximum flow area top width	G	60.00" (1524.0 mm)
Maximum flow depth	H	24.75" (628.7 mm)
Bottom channel width (interior)	I	11.50" (292.1 mm)
Top shoulder width (w/out knuckle)	J	5.25" (133.4 mm)
Overall exterior length	K	72.50" (1841.5 mm)
Lay length	L	68.50" (1739.9 mm)

GATE DIMENSIONS

Item Description	Item #	Dimension Length
Depth	M	19.75" (501.7 mm)
Width	N	19.00" (482.6 mm)
Top Length	O	33.25" (844.6 mm)
Bottom Length	P	18.25" (436.6 mm)

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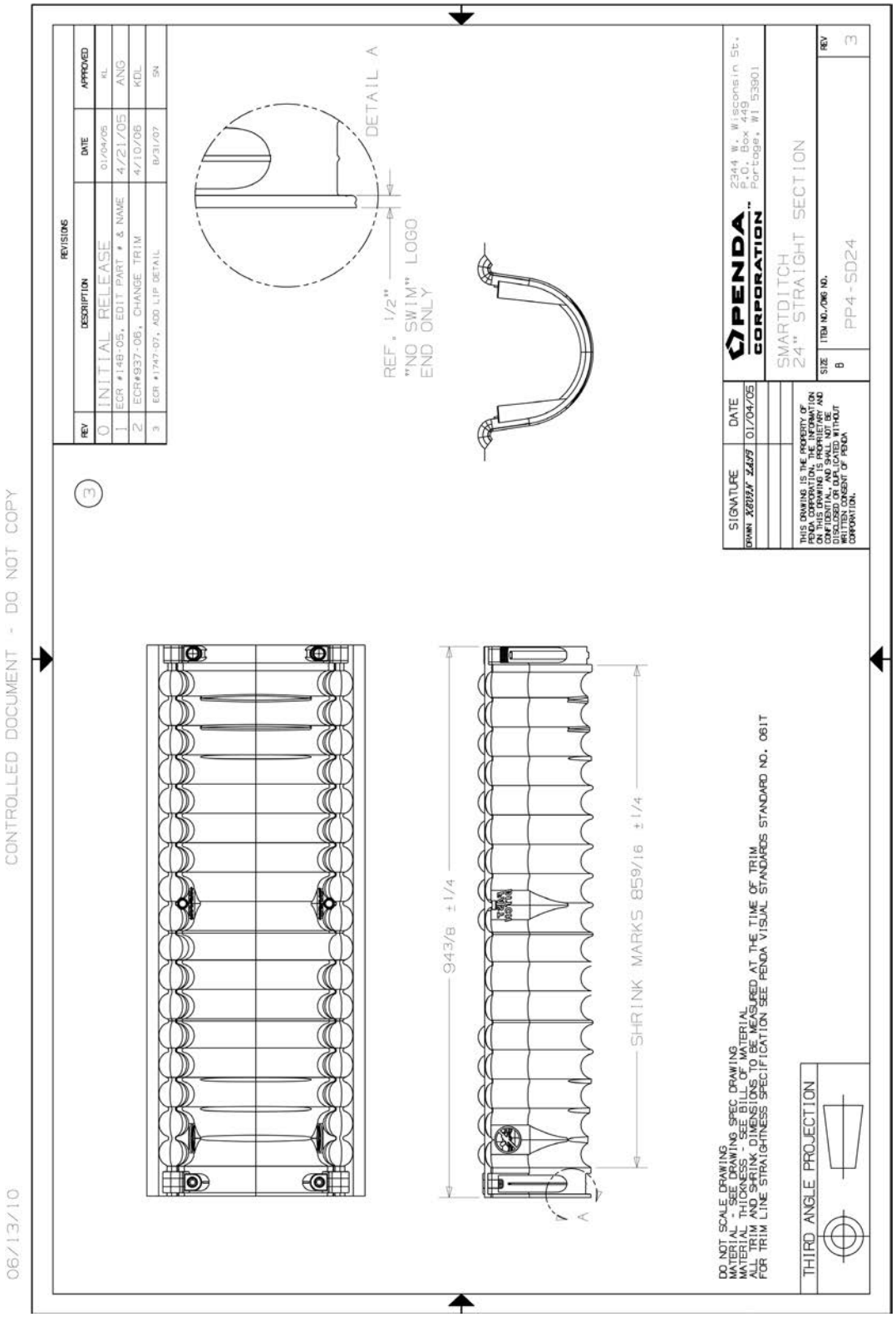
SMARTDITCH TRAPEZOIDAL GATE RIGHT

SIZE B | ITEM NO./DWG. NO. PP4-SDTRAPGR | REV O

SECTION A-A

5.3 CHANNEL & FITTINGS DIMENSION SHOP DRAWINGS

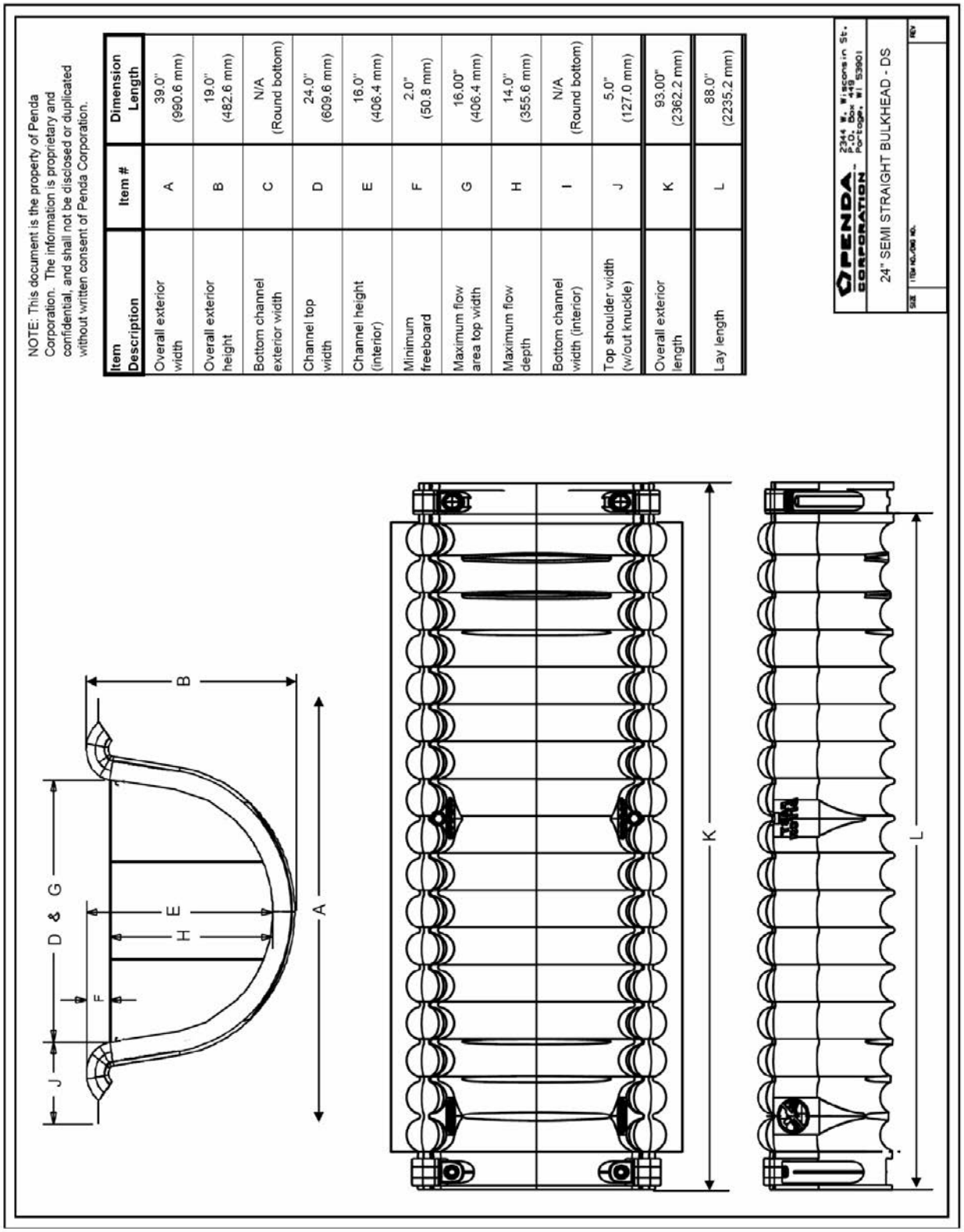
24" (610 MM) SEMI-CIRCULAR STRAIGHT CHANNEL



5.0 APPENDIX

5.3 CHANNEL & FITTINGS DIMENSION SHOP DRAWINGS

24" (610 MM) DEPTH SEMI STRAIGHT BULKHEAD – DOWNSTREAM



NOTE: This document is the property of Penda Corporation. The information is proprietary and confidential, and shall not be disclosed or duplicated without written consent of Penda Corporation.

Item Description	Item #	Dimension Length
Overall exterior width	A	39.0" (990.6 mm)
Overall exterior height	B	19.0" (482.6 mm)
Bottom channel exterior width	C	N/A (Round bottom)
Channel top width	D	24.0" (609.6 mm)
Channel height (interior)	E	16.0" (406.4 mm)
Minimum freeboard	F	2.0" (50.8 mm)
Maximum flow area top width	G	16.00" (406.4 mm)
Maximum flow depth	H	14.0" (355.6 mm)
Bottom channel width (interior)	I	N/A (Round bottom)
Top shoulder width (w/out knuckle)	J	5.0" (127.0 mm)
Overall exterior length	K	93.00" (2362.2 mm)
Lay length	L	88.0" (2235.2 mm)

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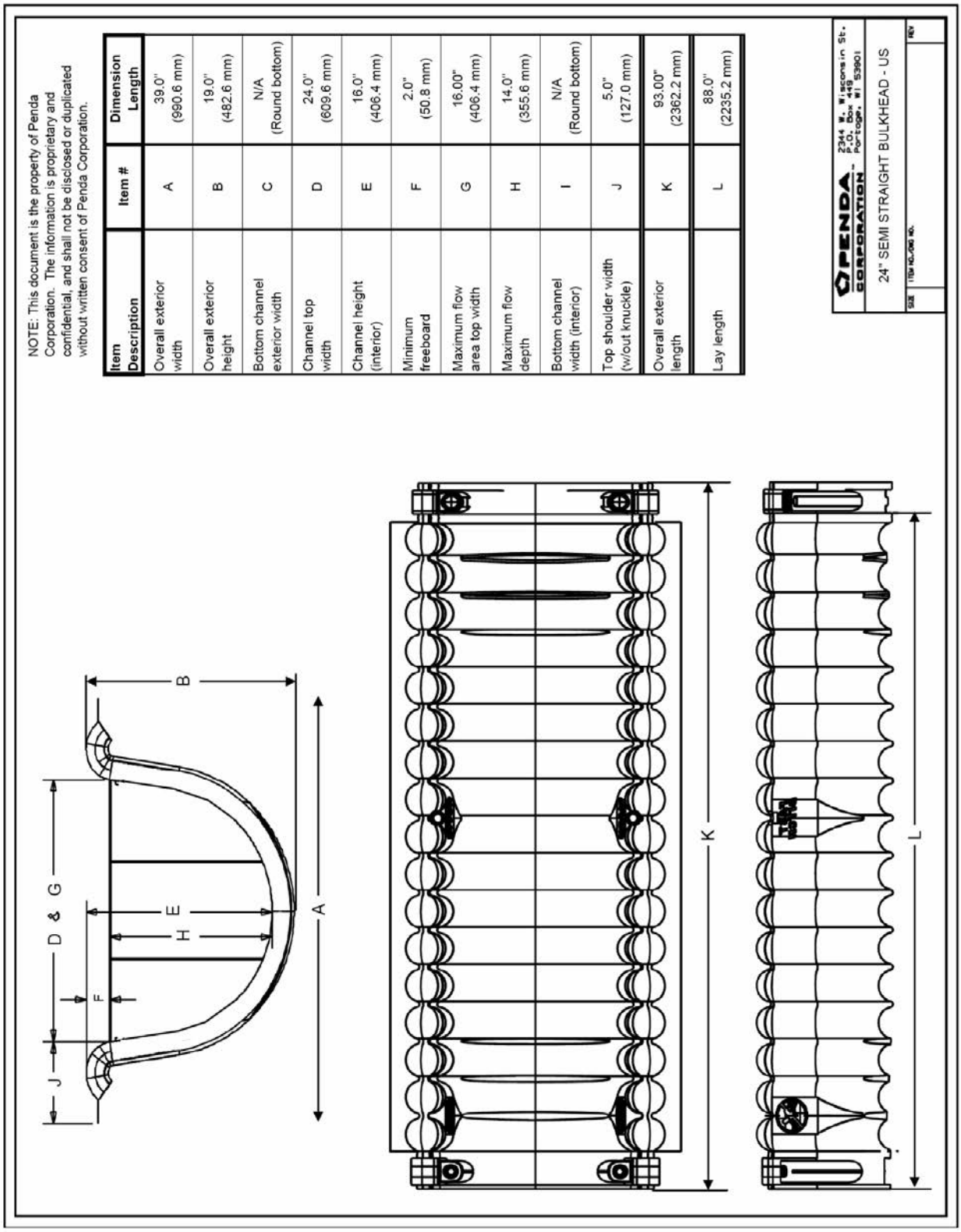
Portage, WI 53901

24" SEMI STRAIGHT BULKHEAD - DS

SIZE | ITEM NO./DWG NO. | REV

5.3 CHANNEL & FITTINGS DIMENSION SHOP DRAWINGS

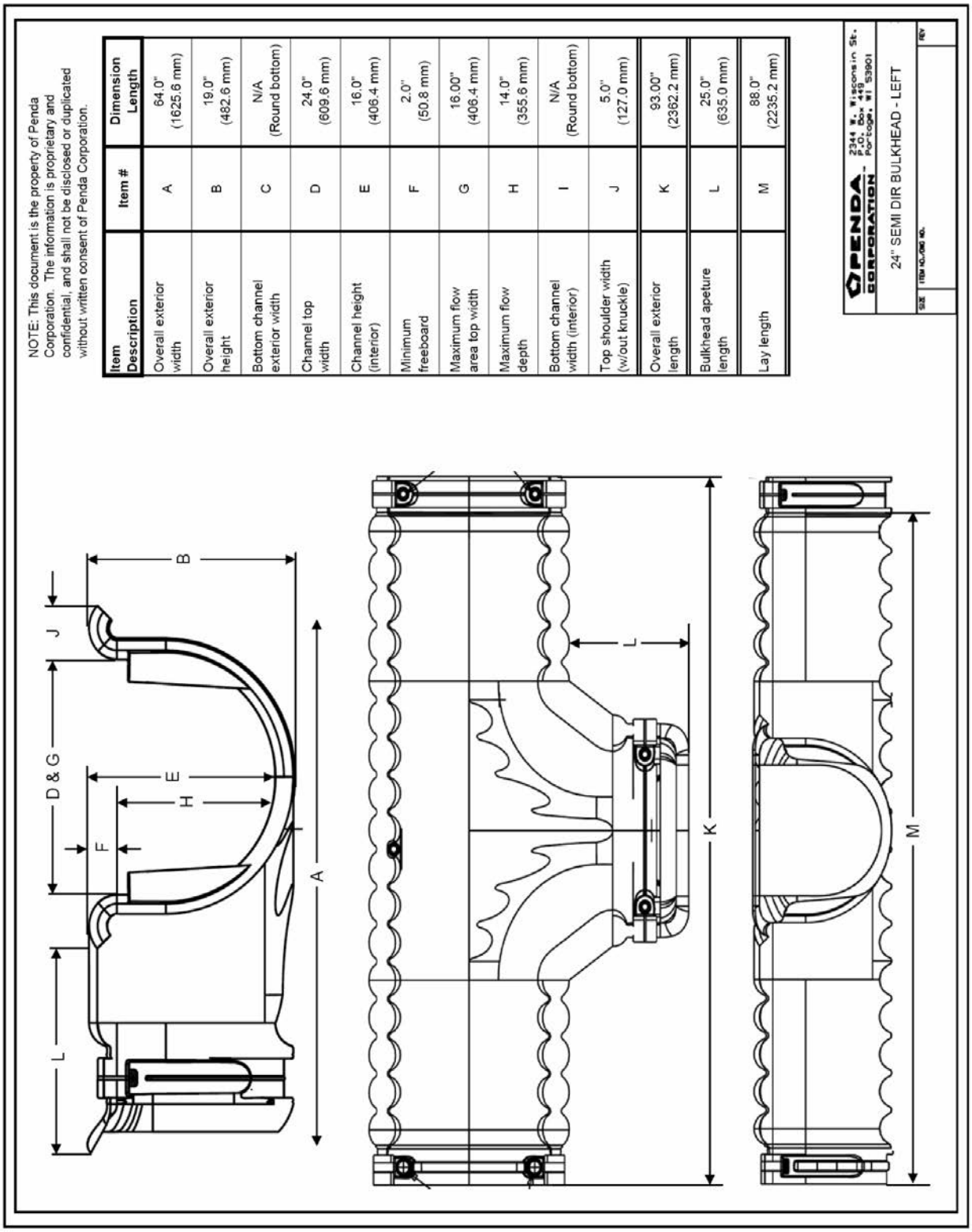
24" (610 MM) DEPTH SEMI STRAIGHT BULKHEAD – UPSTREAM



5.0 APPENDIX

5.3 CHANNEL & FITTINGS DIMENSION SHOP DRAWINGS

24" (610 MM) DEPTH SEMI DIRECTIONAL BULKHEAD – LEFT



NOTE: This document is the property of Penda Corporation. The information is proprietary and confidential, and shall not be disclosed or duplicated without written consent of Penda Corporation.

Item Description	Item #	Dimension Length
Overall exterior width	A	64.0" (1625.6 mm)
Overall exterior height	B	19.0" (482.6 mm)
Bottom channel exterior width	C	N/A (Round bottom)
Channel top width	D	24.0" (609.6 mm)
Channel height (interior)	E	16.0" (406.4 mm)
Minimum freeboard	F	2.0" (50.8 mm)
Maximum flow area top width	G	16.00" (406.4 mm)
Maximum flow depth	H	14.0" (355.6 mm)
Bottom channel width (interior)	I	N/A (Round bottom)
Top shoulder width (w/out knuckle)	J	5.0" (127.0 mm)
Overall exterior length	K	93.00" (2362.2 mm)
Bulkhead apeture length	L	25.0" (635.0 mm)
Lay length	M	88.0" (2235.2 mm)

PENDA CORPORATION
2344 W. Wisconsin St.
P.O. Box 448
Portage, WI 53901

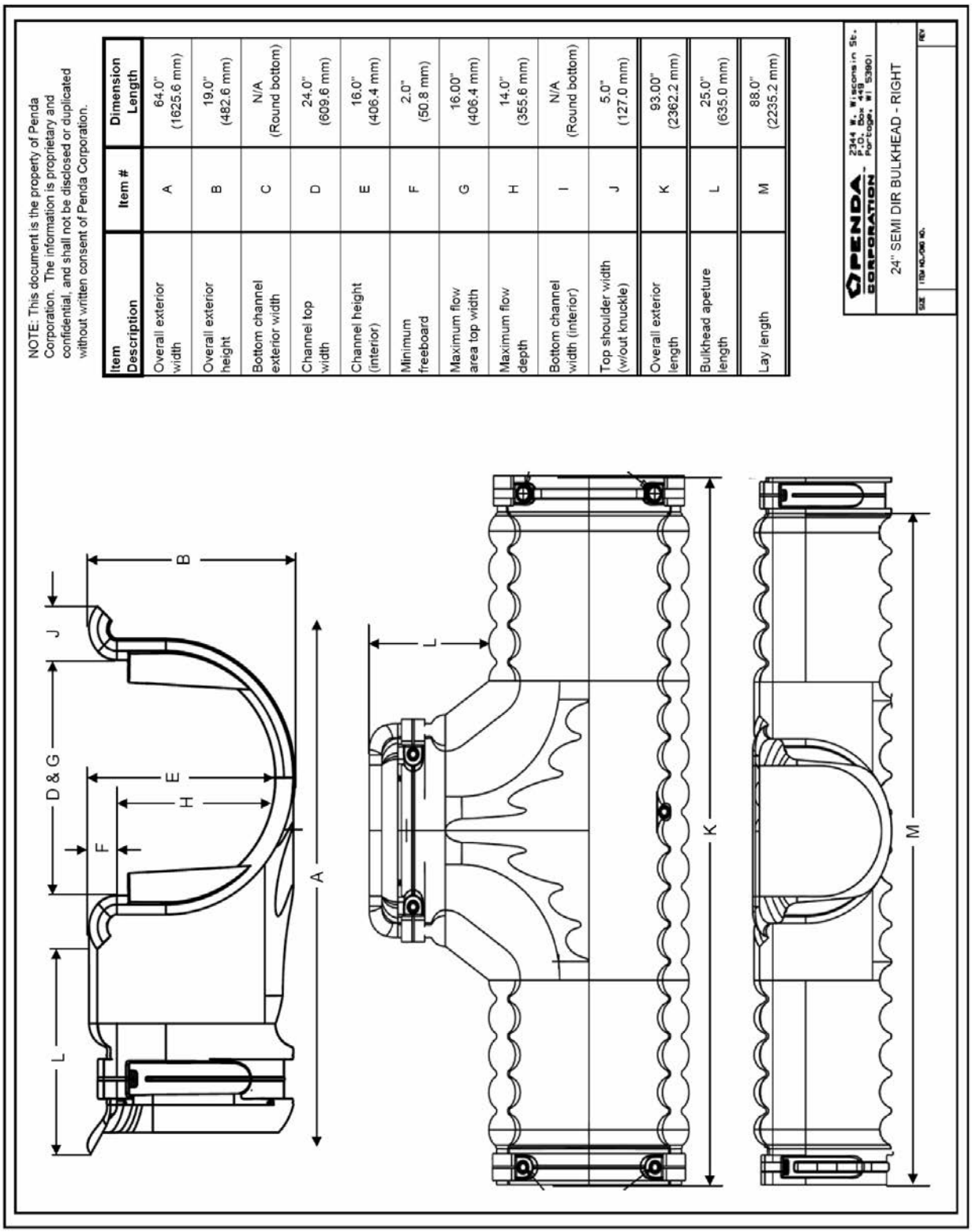
24" SEMI DIR BULKHEAD - LEFT

SIZE | ITEM NO./DWG NO. | REV

5.3 CHANNEL & FITTINGS DIMENSION SHOP DRAWINGS

24" (610 MM) DEPTH SEMI DIRECTIONAL BULKHEAD – RIGHT

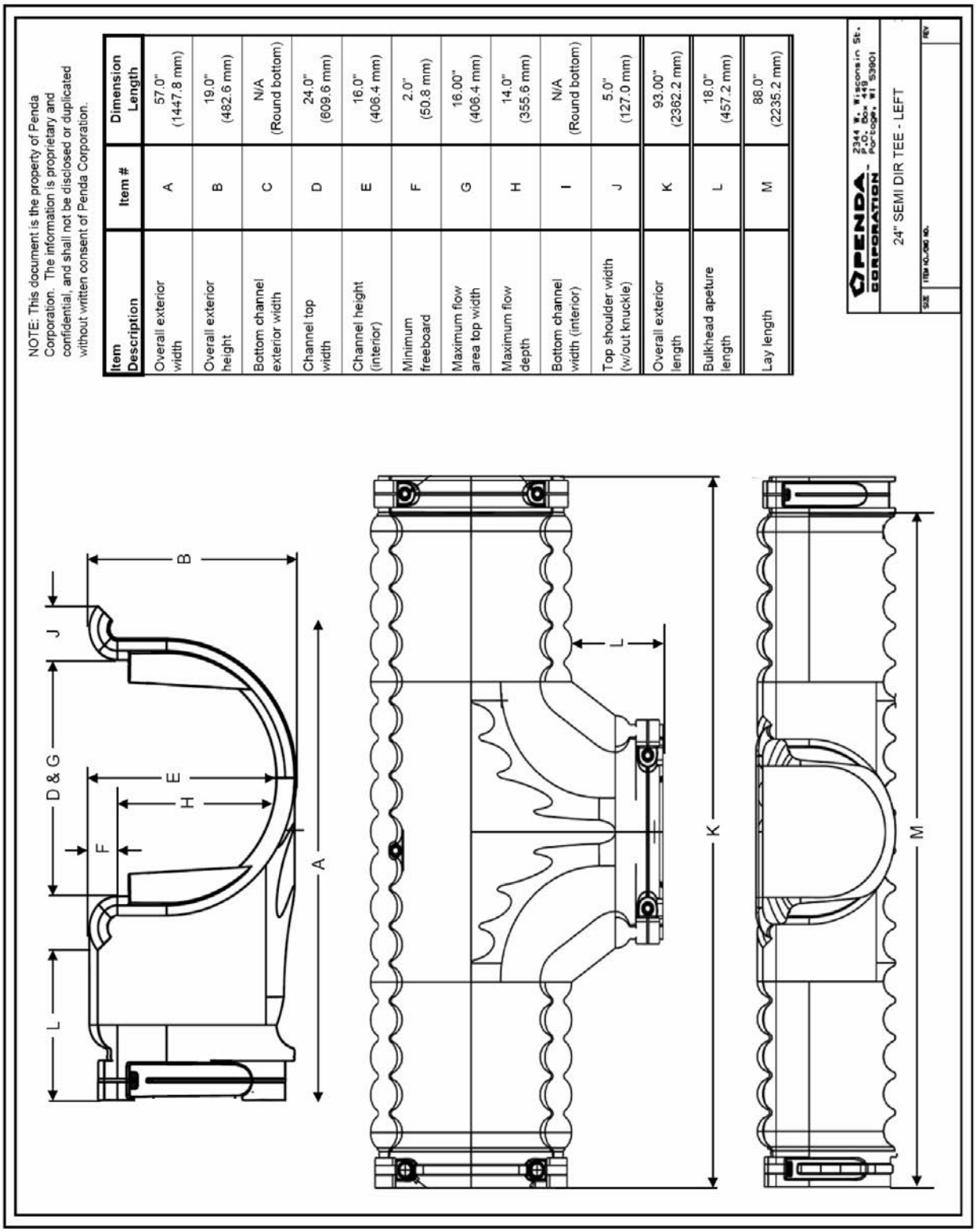
Item Description	Item #	Dimension Length
Overall exterior width	A	64.0" (1625.6 mm)
Overall exterior height	B	19.0" (482.6 mm)
Bottom channel exterior width	C	N/A (Round bottom)
Channel top width	D	24.0" (609.6 mm)
Channel height (interior)	E	16.0" (406.4 mm)
Minimum freeboard	F	2.0" (50.8 mm)
Maximum flow area top width	G	16.00" (406.4 mm)
Maximum flow depth	H	14.0" (355.6 mm)
Bottom channel width (interior)	I	N/A (Round bottom)
Top shoulder width (w/out knuckle)	J	5.0" (127.0 mm)
Overall exterior length	K	93.00" (2362.2 mm)
Bulkhead apeture length	L	25.0" (635.0 mm)
Lay length	M	88.0" (2235.2 mm)



5.0 APPENDIX

5.3 CHANNEL & FITTINGS DIMENSION SHOP DRAWINGS

24" (610 MM) DEPTH SEMI DIRECTIONAL TEE SECTION – LEFT FLOW



NOTE: This document is the property of Penda Corporation. The information is proprietary and confidential, and shall not be disclosed or duplicated without written consent of Penda Corporation.

Item Description	Item #	Dimension Length
Overall exterior width	A	57.0" (1447.8 mm)
Overall exterior height	B	19.0" (482.6 mm)
Bottom channel exterior width	C	N/A (Round bottom)
Channel top width	D	24.0" (609.6 mm)
Channel height (interior)	E	16.0" (406.4 mm)
Minimum freeboard	F	2.0" (50.8 mm)
Maximum flow area top width	G	16.00" (406.4 mm)
Maximum flow depth	H	14.0" (355.6 mm)
Bottom channel width (interior)	I	N/A (Round bottom)
Top shoulder width (w/out knuckle)	J	5.0" (127.0 mm)
Overall exterior length	K	93.00" (2362.2 mm)
Bulkhead apeture length	L	18.0" (457.2 mm)
Lay length	M	88.0" (2235.2 mm)

PENDA CORPORATION 2344 E. Wisconsin St. P.O. Box 449 Portage, WI 53901

24" SEMI DIR TEE - LEFT

SIZE ITEM NO./DWG NO. REV

5.3 CHANNEL & FITTINGS DIMENSION SHOP DRAWINGS

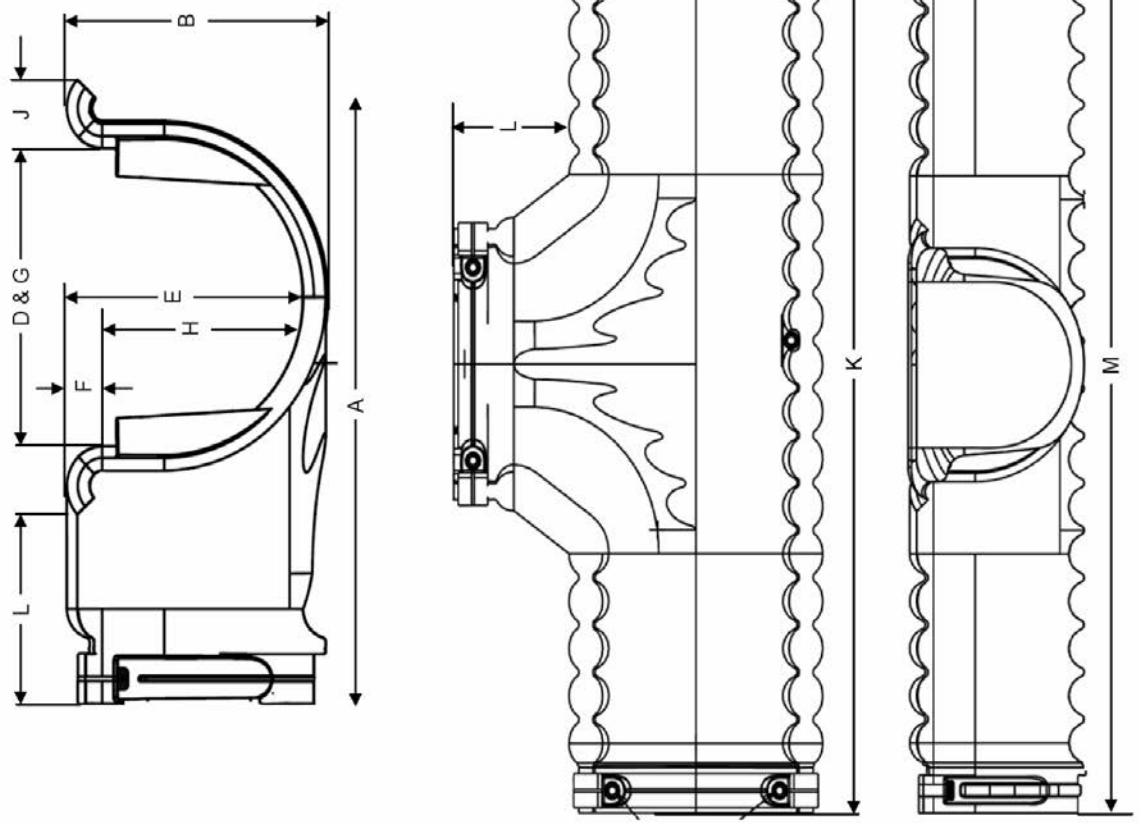
24" (610 MM) DEPTH SEMI DIRECTIONAL TEE SECTION – RIGHT FLOW

Item Description	Item #	Dimension Length
Overall exterior width	A	57.0" (1447.8 mm)
Overall exterior height	B	19.0" (482.6 mm)
Bottom channel exterior width	C	N/A (Round bottom)
Channel top width	D	24.0" (609.6 mm)
Channel height (interior)	E	16.0" (406.4 mm)
Minimum freeboard	F	2.0" (50.8 mm)
Maximum flow area top width	G	16.00" (406.4 mm)
Maximum flow depth	H	14.0" (355.6 mm)
Bottom channel width (interior)	I	N/A (Round bottom)
Top shoulder width (w/out knuckle)	J	5.0" (127.0 mm)
Overall exterior length	K	93.00" (2362.2 mm)
Bulkhead apeture length	L	18.0" (457.2 mm)
Lay length	M	88.0" (2235.2 mm)

PENDA CORPORATION
2344 W. Wisconsin St.
P.O. Box 449
Portage, WI 53901

24" SEMI DIR TEE - RIGHT

SIZE | ITEM NO./DWG NO. | REV



5.3 CHANNEL & FITTINGS DIMENSION SHOP DRAWINGS

24" (610 MM) DEPTH SEMI-CIRCULAR SADDLE

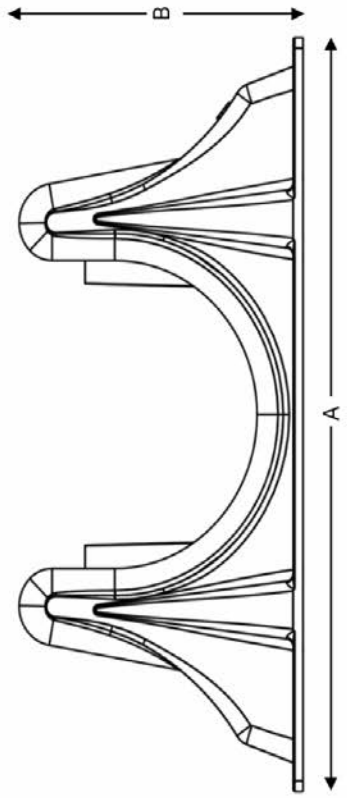
NOTE: This document is the property of Penda Corporation. The information is proprietary and confidential, and shall not be disclosed or duplicated without written consent of Penda Corporation.

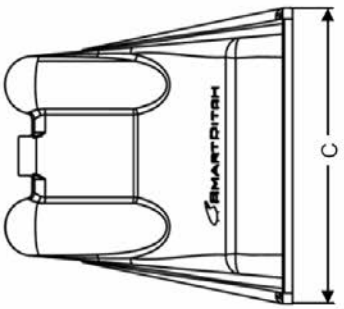
Item Description	Item #	Dimension Length
Overall exterior width	A	54.2" (1376.7 mm)
Overall exterior height	B	22.0" (558.8 mm)
Overall exterior length	C	21.0" (533.4 mm)

PENDA CORPORATION
2344 W. Wisconsin St.
P.O. Box 449
Portage, WI 53901

24" SEMI-CIRCULAR SADDLE

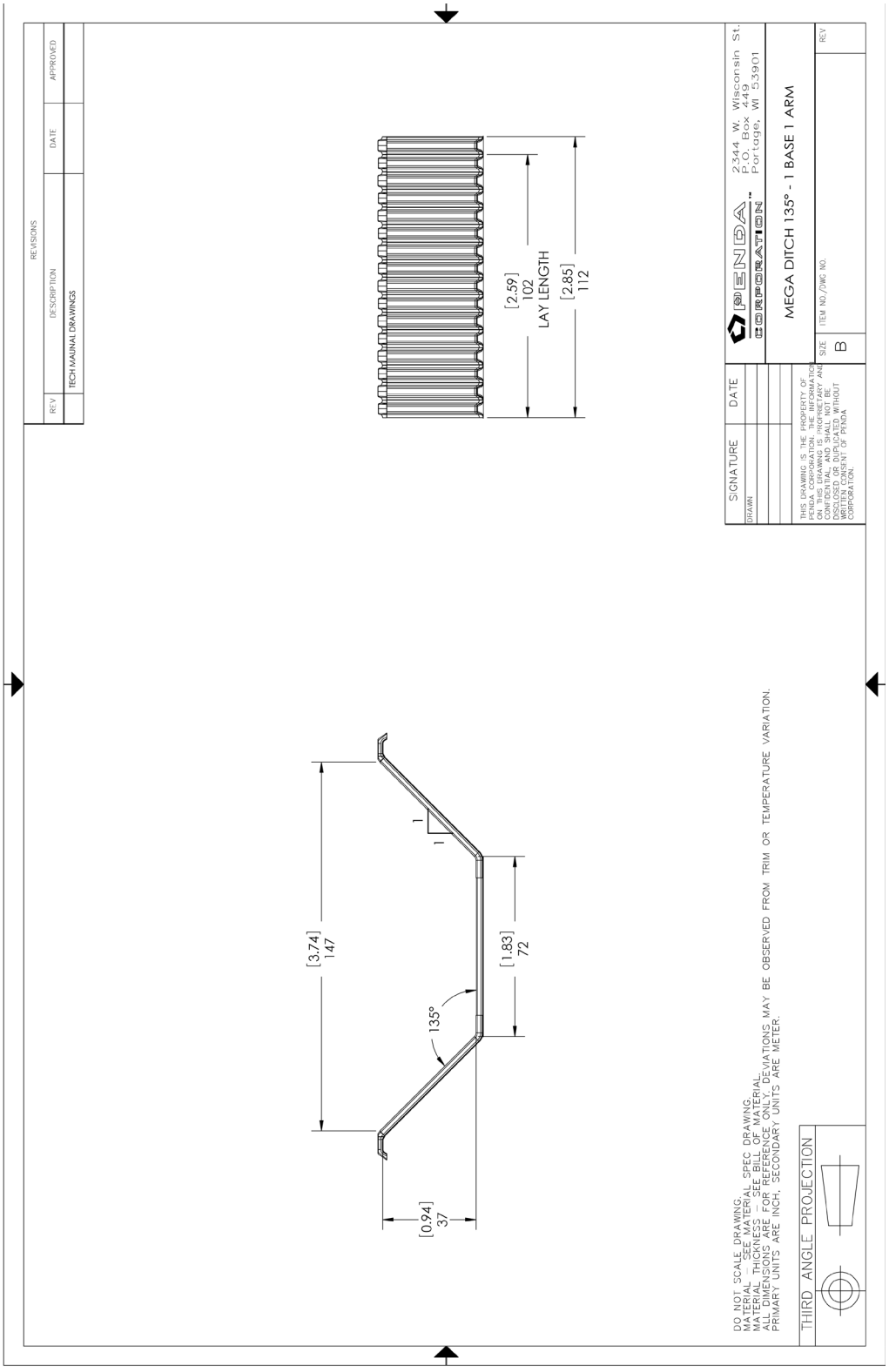
SIZE | ITEM NO./DWG NO. | REV





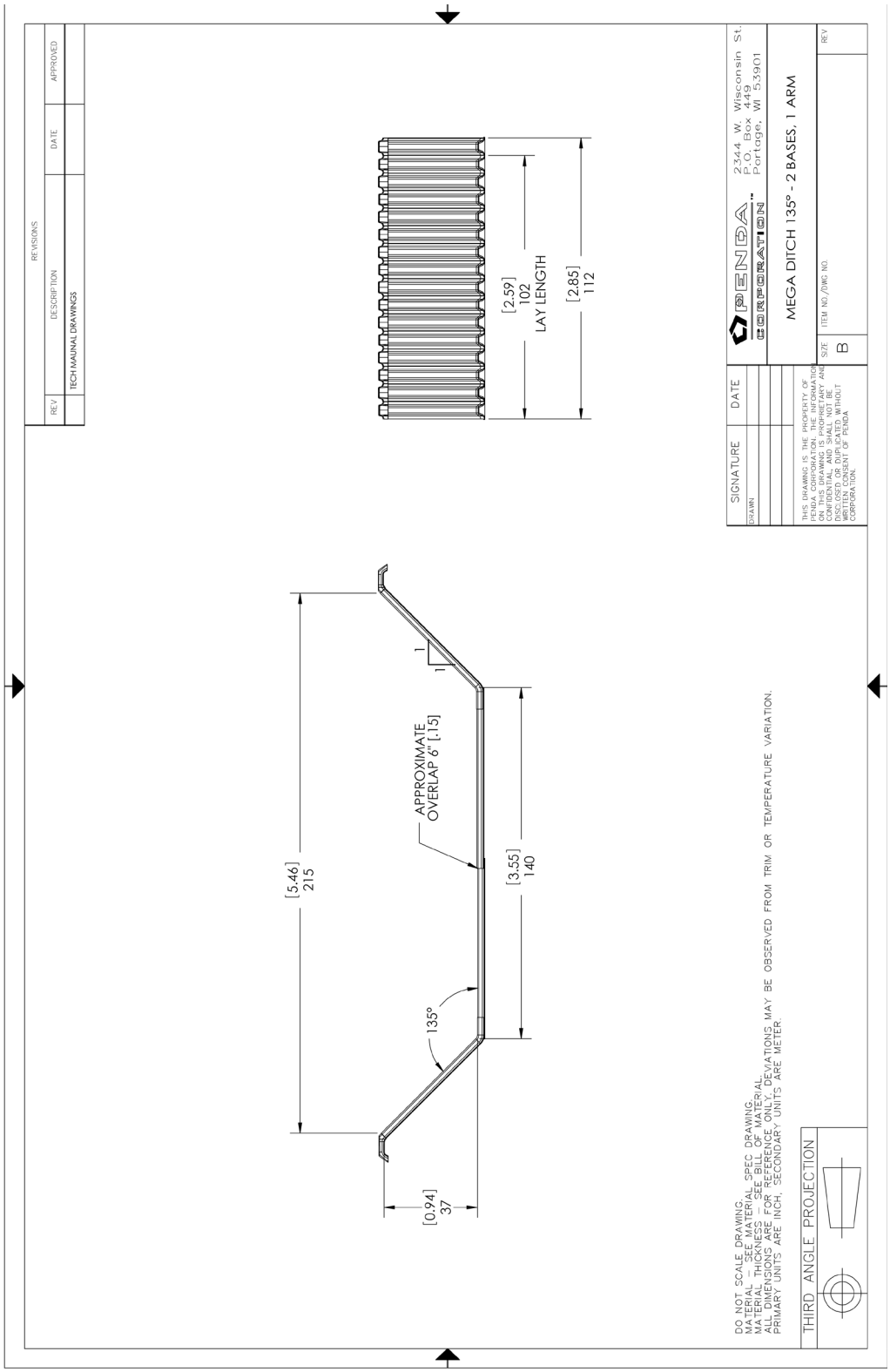
5.3 CHANNEL & FITTINGS DIMENSION SHOP DRAWINGS

MEGADITCH® 135° - 1 BASE 1 ARM



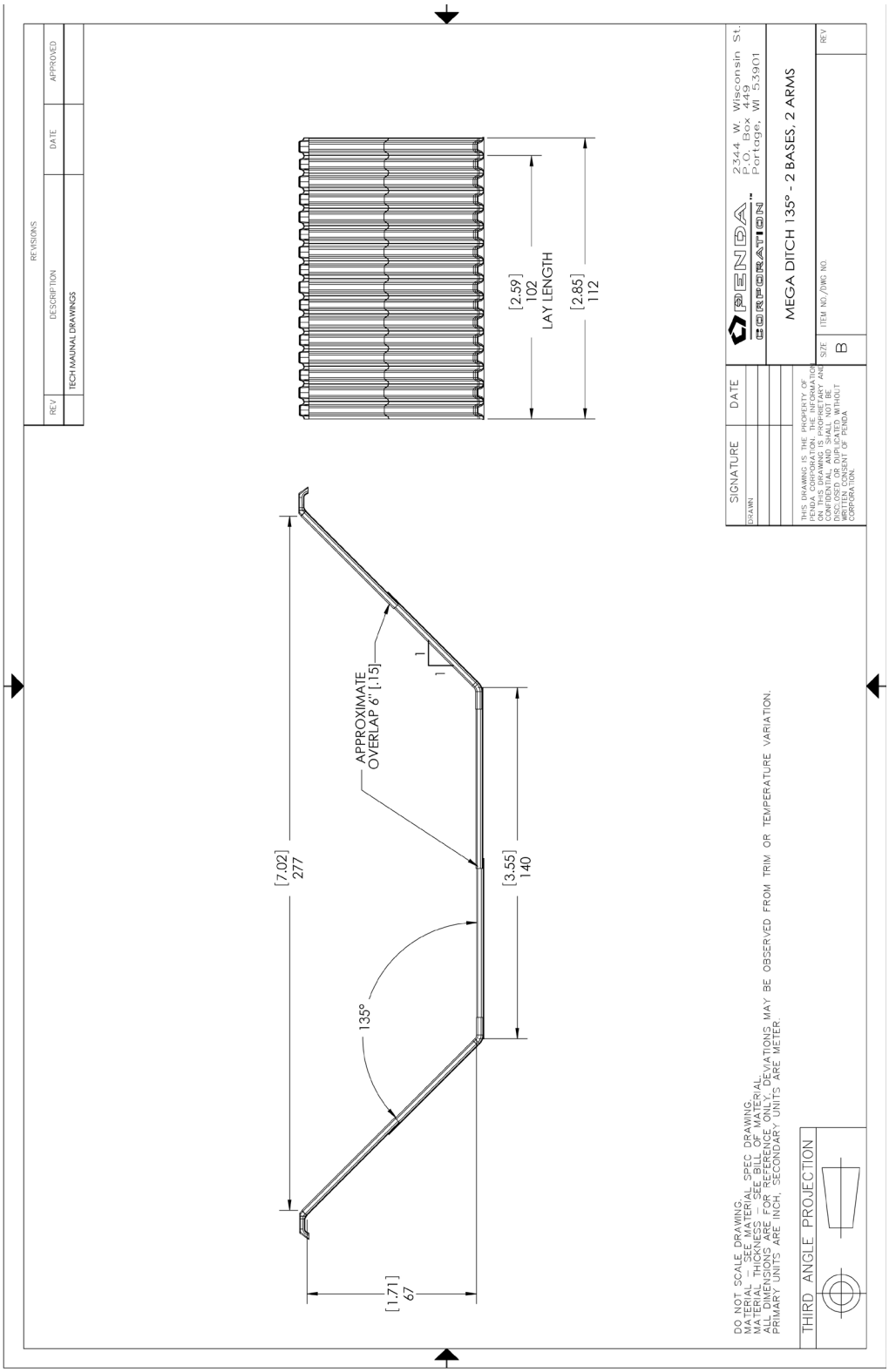
5.3 CHANNEL & FITTINGS DIMENSION SHOP DRAWINGS

MEGADITCH 135° - 2 BASES, 1 ARM



5.3 CHANNEL & FITTINGS DIMENSION SHOP DRAWINGS

MEGADITCH 135° - 2 BASES, 2 ARMS



5.4 INSTALLATION / ASSEMBLY INSTRUCTIONS

SMARTDITCH
FINALLY, SMARTER SOLUTIONS IN WATER MANAGEMENT.®

TRAPEZOIDAL SECTION ASSEMBLY INSTRUCTIONS

1. Assembly Preparation - Visually inspect liners for damage.

Assembly Kit Includes:

Sealing strips, anchors (with cables), coated screws, washers, cable locks, installation sheet.

Tools/Supplies Required:

Leather work gloves, battery operated hand-held drill,1/2" (13 mm) drill bit, pliers, 7/16" (11 mm) wrench, #3 square driver or phillips, electric powered hammer (with 3/4" (19 mm) sleeve bit), anchor driving rod (1/2" (13 mm) x 32" (813 mm) rod).

READ ALL INSTRUCTIONS THOROUGHLY BEFORE STARTING.

ALWAYS DO WORK SAFELY. ENSURE THAT THE PROPER SAFETY EQUIPMENT IS USED.
REFERENCE TECHNICAL MANUAL FOR COMPREHENSIVE INSTALLATION INSTRUCTIONS.

2. Assembly

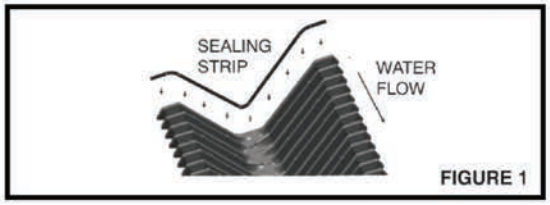


FIGURE 1

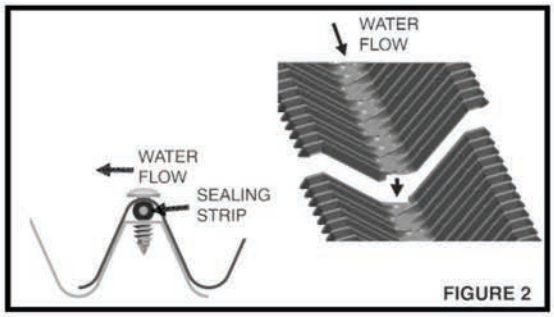


FIGURE 2

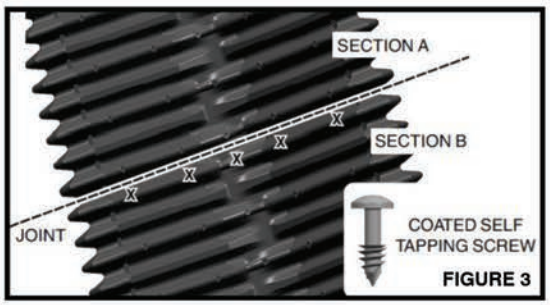


FIGURE 3

STEP 1

Ensure that the ditch has been cleared of all sharp objects, rocks and debris prior to placing the SmartDitch® sections into the ditch.

STEP 2

Place sealing strip on top of flat end rib (See FIGURE 1):

- 12" (305 mm) Trapezoid — 50" (1270 mm) pre-cut strip per joint
- 24" (610 mm) Trapezoid — 85" (2159 mm) pre-cut strip per joint

STEP 3

Overlap sections ensuring that the upstream (rounded) section covers the down-stream (flat) section (See FIGURE 2).

STEP 4

Drill screws through both liners at the dimples on the sides of the overlapped ribs. For 24" (610 mm) system, leave top dimples open for the anchoring system. (See FIGURE 3):

- 12" (305 mm) Trapezoid — 5 screws
- 24" (610 mm) Trapezoid — 7 screws

STEP 5

Visually inspect the sections to ensure the fastener screws have securely joined the sections.

5.4 INSTALLATION / ASSEMBLY INSTRUCTIONS

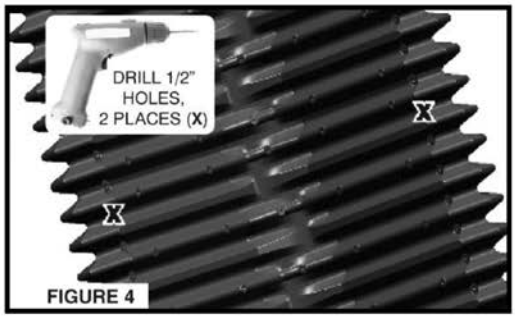


FIGURE 4

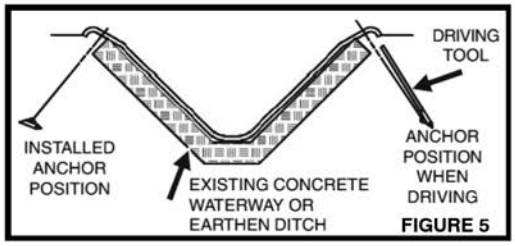


FIGURE 5

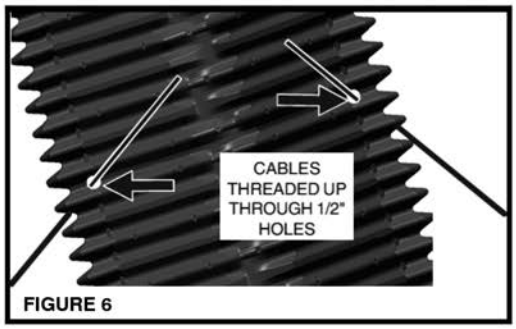


FIGURE 6

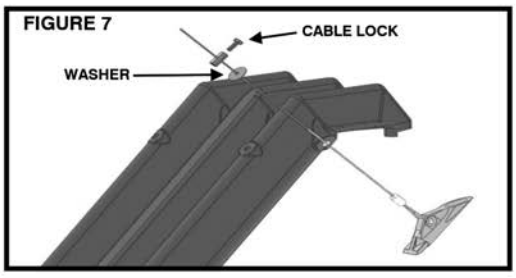


FIGURE 7

STEP 6

Drill 1/2" (13 mm) holes through sections at the dimples on top of the parts. Also drill dimples at mid-length of sections (See FIGURE 8 for recommended anchoring locations).

- 12" (305 mm) Trapezoid — Drill out dimples between the ribs closest to the overlap.
- 24" (610 mm) Trapezoid — Drill out dimples on top of overlapped ribs.

STEP 7

Drive anchors at overlapped joints and at the middle of the sections (See FIGURE 8).

Place driving rod into anchor and place anchor on soil surface. Hold driving rod and anchor cable into position and drive rod to required depth. Pull cable to engage anchor horizontally (See FIGURE 5).

STEP 8

Thread cable through drilled holes. Slide washer, and then cable lock, over the anchor cable (See FIGURE 7).

STEP 9

Use pliers to grip cable lock body. Firmly tighten the cable lock by engaging the set screw. Make sure the SmartDitch® section is tight to the earth. Trim excess cable.

Do not tighten the cable locks in a position where the SmartDitch® section is either bowed or splayed out.

Repeat the process for all sections.

Inspect cable lock seasonally and tighten as necessary.

STEP 10

It is important to use appropriate backfill material. Perform layered compaction based on the backfill material type. Do not over compact and deform trench lining. Ensure that compaction is substantial enough to support maximum flow capacity.

Please refer to technical manual for comprehensive installation instructions.

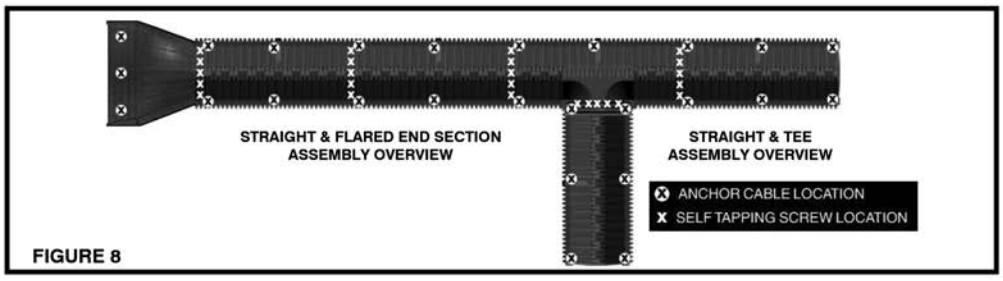


FIGURE 8

5.4 INSTALLATION / ASSEMBLY INSTRUCTIONS

SMARTDITCH
FINALLY, SMARTER SOLUTIONS IN WATER MANAGEMENT.®

SEMI-CIRCULAR SECTION ASSEMBLY INSTRUCTIONS

1. Assembly Preparation - Visually inspect sections for damage.

Assembly Kit Includes:

Sealing strips, anchors (with cables), lag bolts, washers, cable locks, installation sheet.

Tools/Supplies Required:

Leather work gloves, battery operated handheld drill, 1/2" (13mm) drill bit, pliers, vise grip (2), 7/16" (11mm) & 1/2" (13mm) socket & wrench or impact driver, electric powered hammer (with 3/4" (19mm) sleeve bit), anchor driving rod (1/2" (13mm) x 32" (813mm) rod).

PLEASE REFER TO TECHNICAL MANUAL FOR COMPREHENSIVE INSTALLATION INSTRUCTIONS. READ ALL INSTRUCTIONS THOROUGHLY BEFORE STARTING.

ALWAYS DO WORK SAFELY. ENSURE THAT THE PROPER SAFETY EQUIPMENT IS USED, TO INCLUDE STEEL-TOED SAFETY SHOES, SAFETY GLASSES, HARD HATS AND GLOVES.

2. Assembly

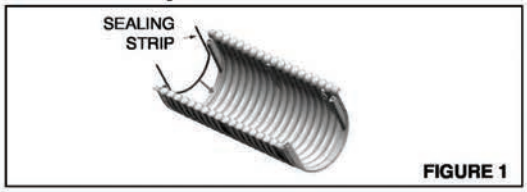


FIGURE 1

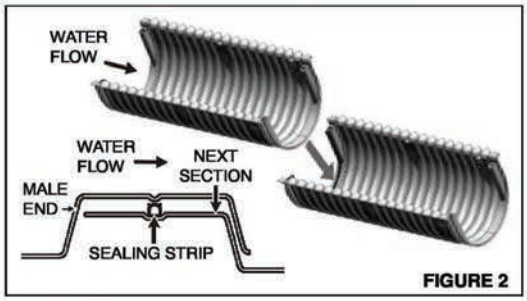


FIGURE 2

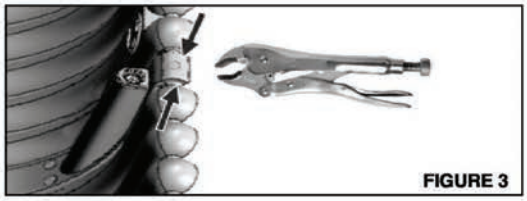


FIGURE 3

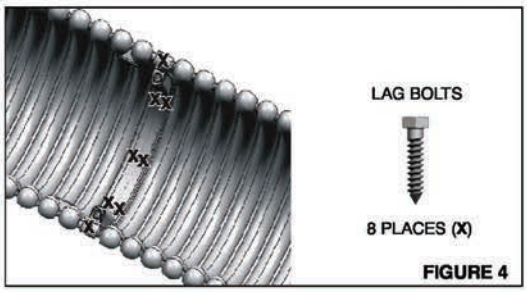


FIGURE 4

STEP 1
Place SmartDitch® sections end-to-end along the water diversion area. Ensure that the water diversion area is free of tripping hazards and is level for connecting the ditch sections.

STEP 2 (FIGURE #1)
Install sealing strip inside the channel groove (female end).

NOTE: 58" (1473 mm) Sealing strip for 36" (914mm) ditch.
39" (991 mm) Sealing strip for 24" (610 mm) ditch.

STEP 3 (FIGURE #2)
Nest the sections by placing the male end with the "No Swimming" logo over the stacking column of the section without the "No Swimming" logo.

STEP 4
Once parts are nested, place one Vise Grip on each side of nested area and clamp to secure for installation of screws.

STEP 5
Install lag bolts through both nested sections at the dimples visible on the top side of the male section. (8 screws per connection.)

NOTE: Visually inspect backside of connected sections to ensure that bolts have pushed through and secured overlapped sections.

5.4 INSTALLATION / ASSEMBLY INSTRUCTIONS

SADDLE FOR ABOVE GROUND INSTALLATION

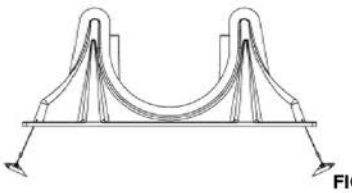


FIGURE 5

STEP 6
Place connected sections onto the SmartDitch® saddles. Saddles should be placed at the joint area.

STEP 7 (FIGURE #5)
Drill 1/2" (13mm) holes through each side of the SmartDitch® saddle.

STEP 8 (FIGURE #5)
Drive cable anchor into ground at desired location close to the previously drilled hole.

Pull up on cable to engage anchor horizontally. The installer should feel the anchor rotate and then no more motion will be present. This ensures the anchor head is properly set.

STEP 9
Thread loose end of cable anchor up through 1/2" (13mm) holes drilled in the SmartDitch® saddle.

STEP 10
Slide the washer over the cable and on to saddle base. Thread the cable through the cable lock. Slide the cable lock down snuggly against the washer on the saddle base.

STEP 11
Use pliers to grip cable lock body. Firmly tighten the cable lock by engaging the set screw. Make sure the SmartDitch® saddle is secured and motion is limited. Trim excess cable.

STEP 12
Repeat process to all SmartDitch® saddles. Cut/trim excess cable leaving 2" (51 mm) to 4" (102 mm) above the cable lock.

5.0 APPENDIX

5.5 EDGE PROTECTION GUIDELINES

SMARTDITCH
FINALLY, SMARTER SOLUTIONS IN WATER MANAGEMENT.®

30 MIL HDPE EDGE PROTECTION
INSTALLATION INSTRUCTIONS

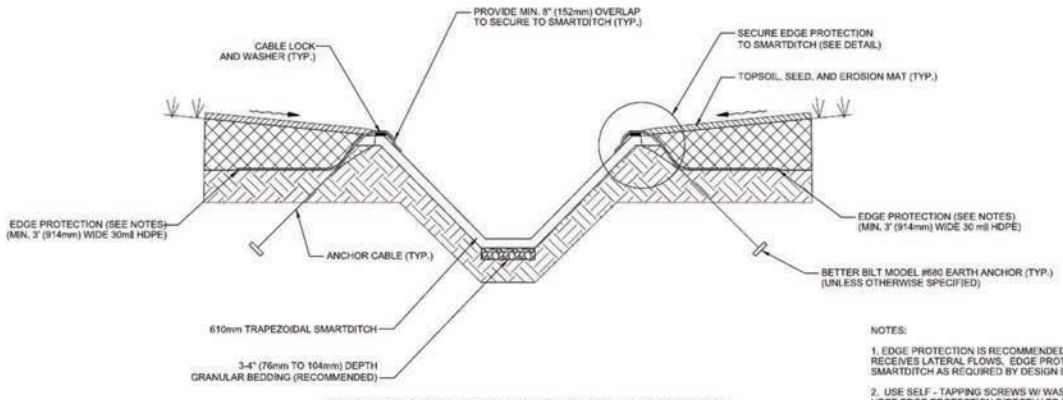
Tools Required:

1. Leather work gloves
2. Battery operated hand-held drill
3. 7/16" (11mm) hex head socket with adaptor for the drill.

READ ALL INSTRUCTIONS THOROUGHLY BEFORE STARTING. ALWAYS PERFORM WORK SAFELY. ENSURE THAT PROPER SAFETY EQUIPMENT IS USED.

STEP 1

During SmartDitch® or MegaDitch™ installation, excavate the outer edge of the trench to provide room for the edge protection as indicated in Figure 1. Install the SmartDitch or MegaDitch in accordance with their installation instructions.



610mm TRAPEZOIDAL SMARTDITCH TYPICAL SECTION DETAIL
SCALE: NONE

STEP 2

Place the 30 mil HDPE edge protection on the SmartDitch or MegaDitch with a 6" (152mm) overlap on the side wall as indicated in Figure 1 and lay the edge protection on top of the excavated area outside of the SmartDitch or MegaDitch.

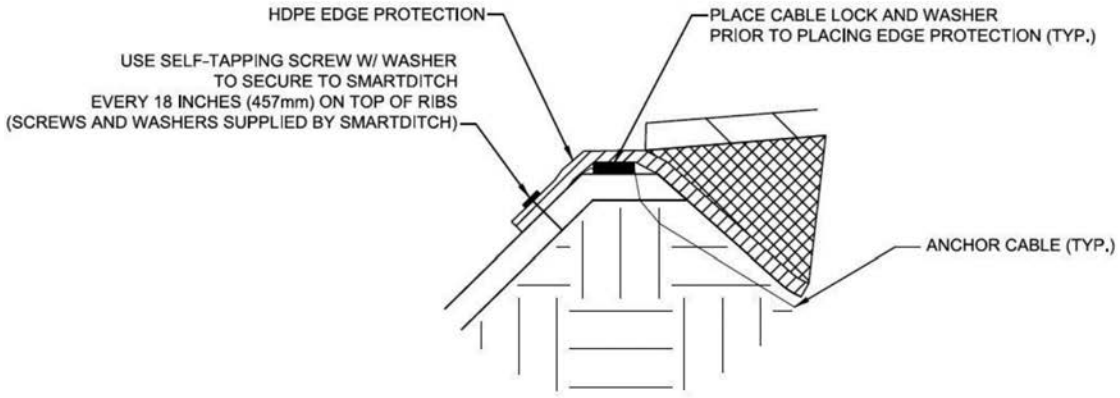
5.5 EDGE PROTECTION GUIDELINES

STEP 3

Install a self-tapping screw and washer approximately every 18 (457mm) inches on top of the SmartDitch or MegaDitch ribs as indicated in Figure 2.

One self-tapping screw and washer should be installed at the following locations:

- 12" (305mm) SmartDitch – every 6 ribs
- 24" (610mm) SmartDitch – every 5 ribs
- MegaDitch – every 3 ribs)



EDGE PROTECTION
SCALE: NONE

STEP 4

Backfill over the edge protection and install topsoil, seed and erosion mat as indicated in Figure 1.

For questions or assistance: 1-866576-2783 / www.smartditch.com

5.0 APPENDIX

5.6 WARRANTY INFORMATION

(A) This Limited Warranty applies solely to the SmartDitch® HDPE channels and fittings, MegaDitch® HDPE panels and HDPE accessories available from **PendaForm** and sold to the original purchaser (the "Purchaser"). The HDPE channels, panels and accessories are collectively referred to as the "Products."

(B) **PendaForm** warrants the Products to the Purchaser against defects in materials and workmanship for one (1) year from the date of purchase. This warranty excludes Products that have not been installed strictly in accordance with **PendaForm** written installation instructions at the time of installation. **THIS WARRANTY EXCLUDES PRODUCTS THAT HAVE NOT BEEN INSTALLED, INSPECTED AND/OR MAINTAINED STRICTLY IN ACCORDANCE WITH PENDAFORM WRITTEN INSTALLATION AND MAINTENANCE INSTRUCTIONS AT THE TIME OF INSTALLATION AND PERFORMANCE.**

Should a defect appear during the Limited Warranty period, the Purchaser shall provide **PendaForm** with written notice of the alleged defect at **PendaForm** corporate headquarters within ten (10) forty-five (45) days of the defect's discovery. The notice shall describe the alleged defect in reasonable detail.

PendaForm agrees to supply replacements for those Products determined by **PendaForm** to be defective and covered by this Limited Warranty. The supply of replacement products is the sole remedy of the Purchaser for breaches of this Limited Warranty. **PendaForm's** liability Limited Warranty specifically excludes liability for the cost of removal and/or installation of the Products.

(C) This Limited Warranty is exclusive. There are no other warranties with respect to the Products, including not implied warranties of merchantability or of fitness for a particular purpose. **PENDAFORM EXPRESSLY DISCLAIMS ANY IMPLIED WARRANTY OF MERCHANTABILITY OR OF FITNESS FOR A PARTICULAR PURPOSE.**

(D) No representative of **PendaForm** has the authority to change the terms of this Limited Warranty in any manner or extend the duration of this Limited Warranty. This Limited Warranty is not transferable and does not apply to any person other than to the Purchaser.

(E) Under no circumstances shall **PendaForm** be liable to the Purchaser or to any third party for claims arising from the shipment or installation of the Products, or the cost of other goods or services related to the purchase and installation of the Products.

For this Limited Warranty to apply, the Products must be installed in accordance with all site conditions and as required by any country, province, federal, state and local codes, ordinances, Regulations and all other applicable laws.

(F) **THE LIMITED WARRANTY DOES NOT EXTEND TO INCIDENTAL, CONSEQUENTIAL, SPECIAL OR INDIRECT DAMAGES, INCLUDING — BUT NOT LIMITED TO — THE FOLLOWING:**

- **LABOR AND MATERIALS;**
- **OVERHEAD COSTS;**
- **LOSS OF PRODUCTION AND PROFITS;**
- **ANY OTHER LOSS OR EXPENSE INCURRED BY THE PURCHASER OR ANY THIRD PARTY.**

IN ADDITION, PENDAFORM SHALL NOT BE LIABLE FOR PENALTIES OR LIQUIDATED DAMAGES.

SPECIFICALLY EXCLUDED FROM LIMITED WARRANTY COVERAGE ARE:

- **DAMAGE TO THE PRODUCTS ARISING FROM ORDINARY WEAR AND TEAR;**
- **ALTERATION, ACCIDENT, MISUSE, ABUSE, NEGLECT OR OTHER CONDITIONS WHICH ARE CONTRARY TO PENDAFORM'S WRITTEN SPECIFICATIONS OR INSTALLATION INSTRUCTIONS;**
- **FAILURE TO MAINTAIN APPROPRIATE ANCHORING STABILITY, AS SET FORTH IN THE INSTALLATION INSTRUCTIONS;**
- **THE PLACEMENT OF IMPROPER MATERIALS INTO THE PRODUCTS;**
- **FAILURE OF THE PRODUCTS DUE TO IMPROPER SITING OR IMPROPER SIZING;**
- **EVENTS BEYOND PENDAFORM'S CONTROL SUCH AS EARTHQUAKES, FALLING ROCKS, STORMS, FLOODING AND HIGH WINDS;**
- **ANY OTHER EVENT NOT CAUSED BY PENDAFORM.**

(G) This Limited Warranty represents **PendaForm's** sole liability to the Purchaser for claims arising from or related to the Products, whether the claim is based upon contract, tort or other legal theory.

This warranty gives you specific legal rights, and you may have other rights that vary from state to state. Information or assistance regarding warranty claims may be obtained by writing Consumer Service, **PendaForm**, P.O. Box 449, 2344 W. Wisconsin Street, Portage, WI 53901.

Although the utmost care has been taken to ensure the accuracy of the contents of this brochure, PendaForm and its subsidiaries do not accept liability for errors or omissions in this publication. Customers must satisfy themselves of the suitability of a given product supplied or manufactured by PendaForm or its subsidiaries before using the same.

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