FIBERGLASS COMPOSITE TROUGHS

Elmira, CA Flat Bottom Curved Troughs

Glass-Steel, Inc. manufactures a proprietary system of composite effluent troughs for water collection in the water/wastewater applications. Troughs are typically used in clarifiers (both circular and rectangular), grit collectors, sedimentation basins, thickeners, filter systems, etc. Glass-Steel, Inc.'s composite troughs offer features and benefits not available in pre-cast or cast in place concrete troughs, aluminum troughs, stainless steel troughs, galvanized or painted steel troughs, or conventional fiberglass troughs.

Glass-Steel, Inc. composite toughs utilize a glass reinforced fiberglass skin on the inner and outer surfaces with a polymer concrete core. Typically our trough walls are 1 -1/2" thick with 1/8" fiberglass skins although different thickness can be produced. Because the entire system is made with Isothalic polyester resin the composite is impermeable to water absorption, the sandwich type construction acts as a monolithic unit, and all components have the same coefficient of thermal expansion (we can also make vinylester, epoxy, or other resin systems).

Because of the mass of the composite troughs we do not need any spreader devices or exterior bracing of any kind. Our mass also creates a moment of inertia that allows us to clear span distances of over 14' on our shallowest & widest trough to over 40'0" on our narrowest & deepest trough without the need for intermediate supports or lateral stabilizers. This means that all of our troughs are easily walk able for maintenance purposes and they require less or no additional structural supports. In the instances as in rectangular clarifiers where troughs can be over 50' in length we do require an end support and at least one intermediate support.

Glass-Steel, Inc. composite troughs are competitive with all other conventional type troughs on a dollar to dollar per foot cost basis. They are less than half the cost of stainless, far less than aluminum, less than or equal to most conventional fiberglass troughs. Also the benefits of longer clear span capability, no internal spreaders, smooth uninterrupted inside & outside surfaces, easier installation, and less maintenance and you have an economically superior system to any other trough system available.■

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Glass·Steel® trough designs:

- **MEET OR EXCEED ALL AWWA F101-07 PERFORMANCE REQUIREMENTS**
- **SUPERIOR STRUCTURAL PROPERTIES VS ALL OTHER FRP TROUGHS (see table on next page and tables on page 13 to 18)**
- **LATERAL SUPPORTS ARE NEVER REQUIRED**
- **SPREADER BARS ARE NEVER REQUIRED**
- **DESIGNS AVAILABLE TO CLEAR SPAN 50 FT**
- **AVAILABLE IN MULTIPLE CROSS SECTION SHAPES**
- **LOWEST LIFETIME COST VS STEEL, ALUMINUM, STAINLESS**
- **LOWEST INSTALLED LABOR COST**
- **LOWEST MAINTENANCE COST, LONGEST INSTALLED LIFE**
- **STANDARD 5 YEAR WARRANTY, 10 YR AVAIL ON REQUEST.**
- **EACH GLASS·STEEL INC. TROUGH IS CUSTOMER SPECIFIED**
- **IN MOST INSTALLATIONS GLASS·STEEL® TROUGHS CAN BE USED AS SUPPORT FOR OTHER EQUIPMENT**
- **AFTER INSTALLATION MAINTENANCE PERSONELL CAN WALK IN A GLASS·STEEL® TROUGH W/O A TRIP HAZARD**
- **POLYMER CONCRETE CORE HAS SUPERIOR STRUCTURAL PROPERTIES AND PERFORMANCE vs. CONCRETE IN WATER AND WWTP ENVIRONS**
- **NSF61 DESIGNS AVAILABLE**

Reviewing the above and the table on the next page (and tables on pages 13 to 18) you can see that Glass·Steel® Trough designs have no significant competition. Yet competitors troughs are specified and sold every day. This is typically done by “bundling” by the local reps of clarifiers, filters, and other equipment to prevent the use of competitors products. The only way around this is to specify this design or equal.

The difficulty is finding an equal to this product…….

Table 1.
Comparison of competition in Troughs

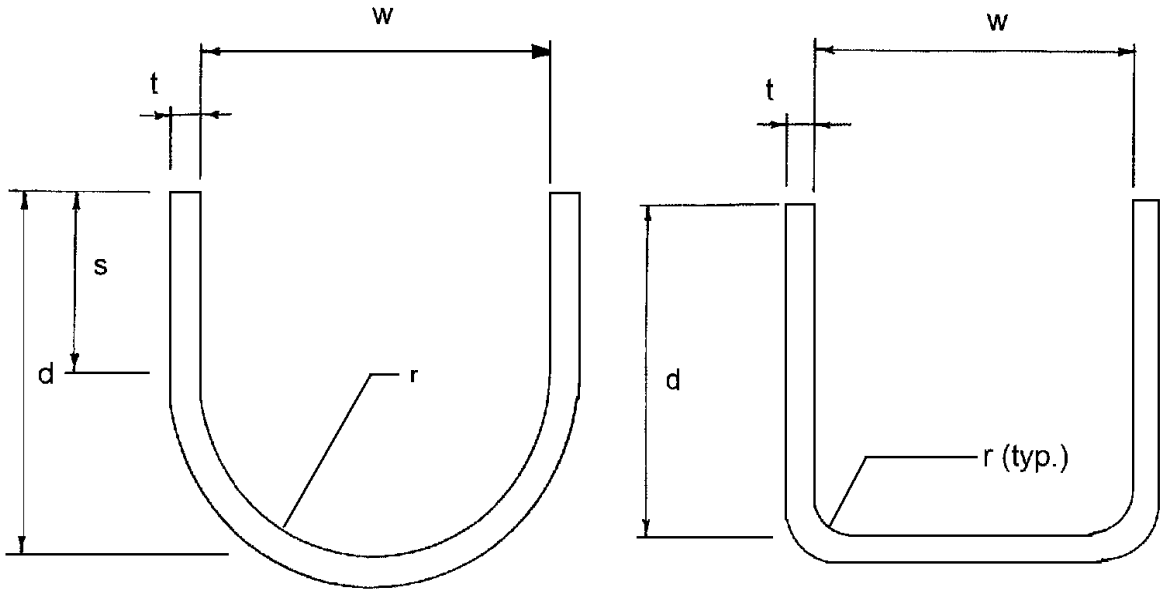
	SPREADER BARS REQ'D?	LATERAL SUPPORTS REQ'D?	STRUCTURAL SUPPORTS* REQUIRED ?	SIDE WALL DEFLECTION < 3/16 INCH ?	BOTTOM DEFLECTION < 3/16 INCH ?	HANG OTHER EQUIP?	MAX. SPAN** W/O SUPPORTS FOR 12x12, 24x24, 36x36
Brand W	Yes	Yes	Yes	Not without spreader bars	Only for deep-narrow cross-sects	No	No published values
Brand N	Yes	Yes	Yes	Not without spreader bars	Only for deep-narrow cross-sects	No	No published values
Brand M	Yes	Yes	Yes	Not without spreader bars	Only for deep-narrow cross-sects	No	No published values
Brands P, F	Yes	Yes	Yes	Not without spreader bars	Only for deep-narrow cross-sects	No	No published values
Glass·Steel Inc	NOT **EVER** REQ'D	NOT **EVER** REQ'D	RARELY, IF EVER REQUIRED	Yes up to 40" depth	12" Depth 36" wide 22ft span	Yes	27 ft 33 ft 36 ft

*Assumes 3/16 inch max deflection allowed. On spans over 10 to 15 ft, depending on cross section, competitors must support the trough at mid span or provide multiple supports, or use design "stiffeners" applied to the outside of the trough to meet this criteria. Glass-Steel® troughs do not. Competitors designs must be limited to certain narrow and deep cross sections to allow use of their design. Glass-Steel® troughs have no cross section design limitations like our competitors. Ask our competitors for their published span values that do not require additional stiffeners mounted to the product, what their maxium span is for flat bottom wide troughs, what unsupported spans they are capable of without structural supports, lateral supports, and without stiffeners? Can other equipment be supported from their troughs? Why do they need spreader bars? Honest answers will lead you to the conclusion: Glass-Steel® Troughs have no competition.

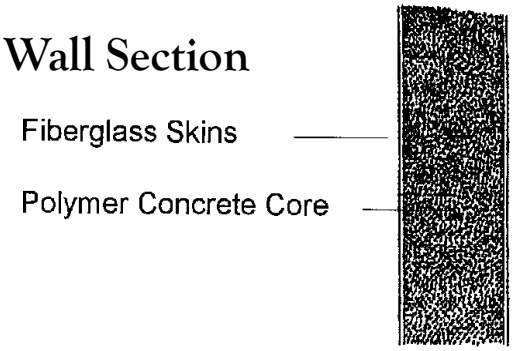
**Round bottom tough both ends fixed.

The following are drawings and load tables indication some standard details and attachment methods for some standard sizes and configurations of troughs. Troughs are furnished in round bottom or square bottom configurations and can be furnished as straight or curved sections. Glass-Steel, Inc. also furnished custom trough with tapered sides and or bottoms, etc. Our side mount troughs eliminate the expense of forming and pouring in place concrete extended wall troughs. Glass-Steel, Inc. also custom builds drop troughs and other accessories.■

Typical Trough Sections



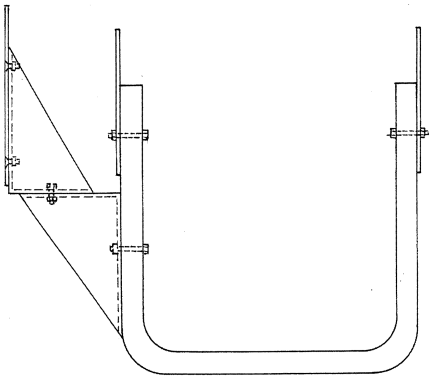
Typical Wall Section



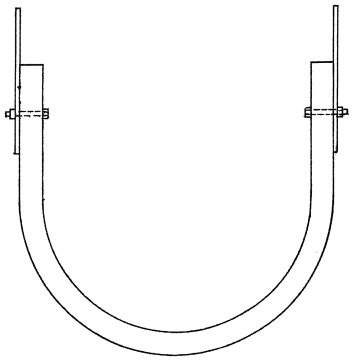
w = width
d = depth
r = radius
t = thickness
s = d-r

FIBERGLASS COMPOSITE TROUGH CONFIGURATIONS

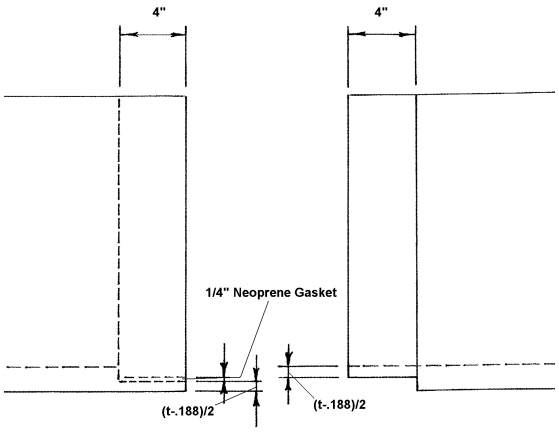
Typical Weir & Baffle Configurations for Clarifiers

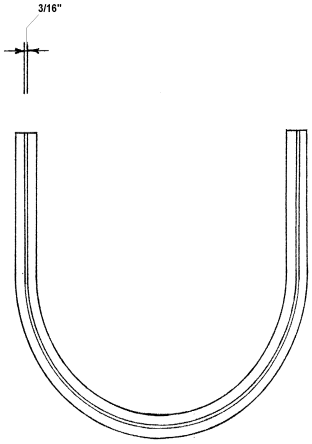


Typical Weir Configuration for Launderer Troughs

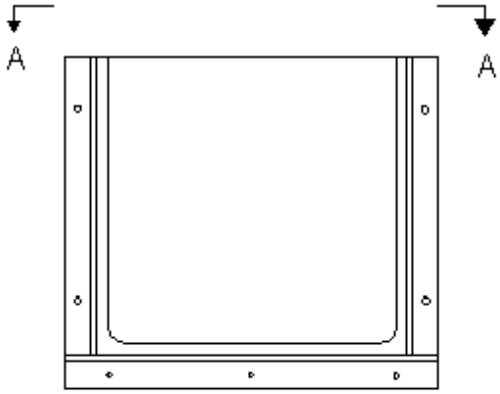


Typical Tongue & Groove Joint

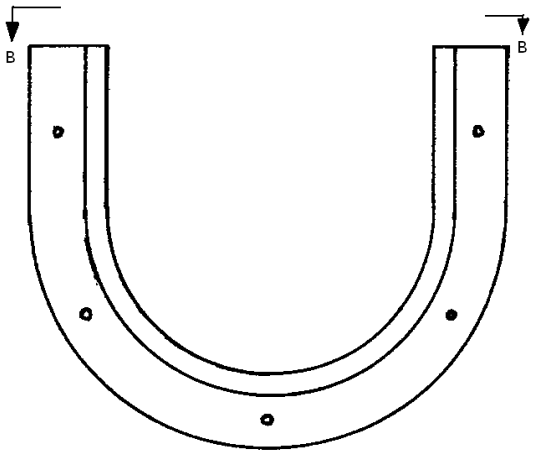




TYPICAL END WALL CONNECTIONS



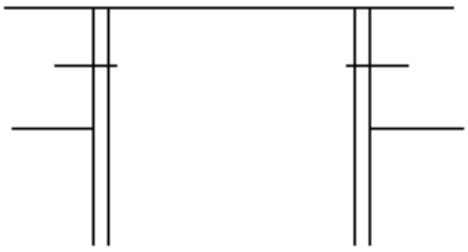
Separate Saddle Connection
Square Bottom Trough Shown



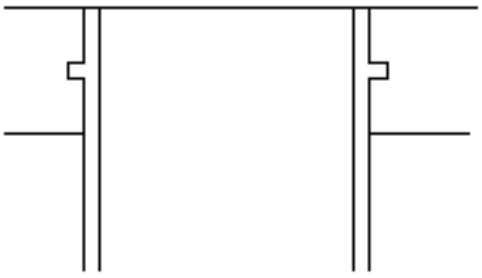
Integral End Wall Connection
Round Bottom Trough Shown
Square Bottom Trough Similar

Section A-A
With Blind End

Section B-B
Open End



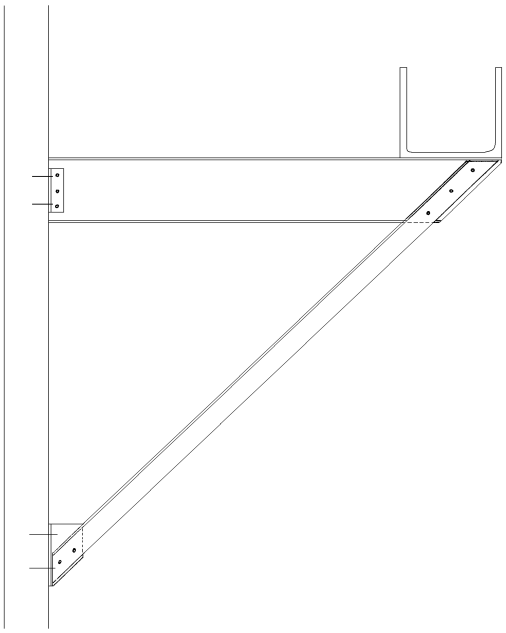
Through Wall Connection
Anchor Bolted



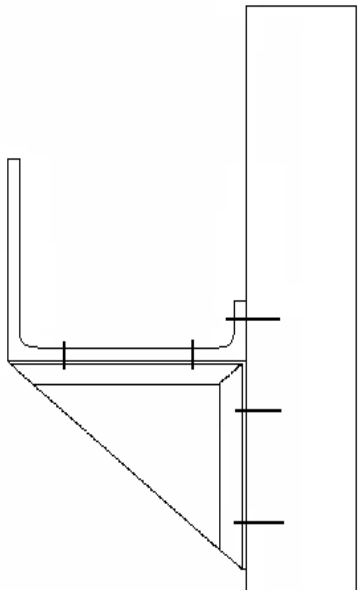
Through Wall Connection
Water Stop Integral Anchor

Note: All connections shown are typical of both round & square bottom troughs
Other special configurations can also be made

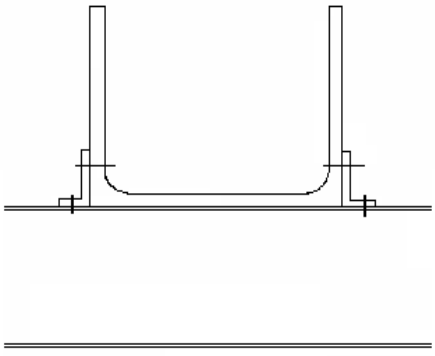
SUPPORTS FOR CIRCULAR TROUGHS & INTERMEDIATE SUPPORTS FOR LONG TROUGHS



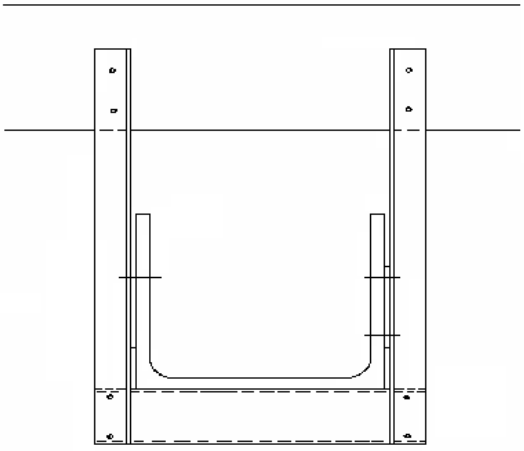
Cantilever Side Wall Support for Circular Clarifier Trough. Typical Support Consists of 18" FRP I-Beams and 6" x 6" x 1/2" Angle Knee Brace



Typical Support consists of 4" x 4" x 1/2" FRP Angle and 8" x 2-3/16" x 1/4" FRP Channel



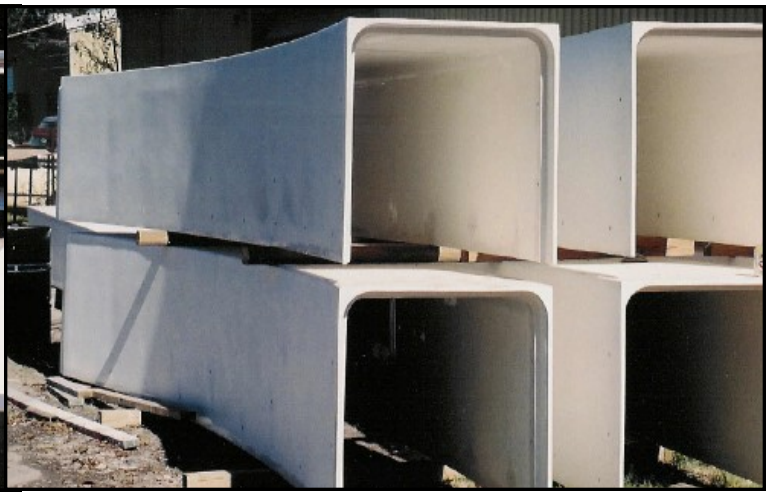
Angle Connection to Support Beam under Trough



Hanger Saddle Support for support from above Typical Support consists of 4" x 4" x 1/2" FRP Angle and 8" x 2-3/16" x 1/4" FRP Channel

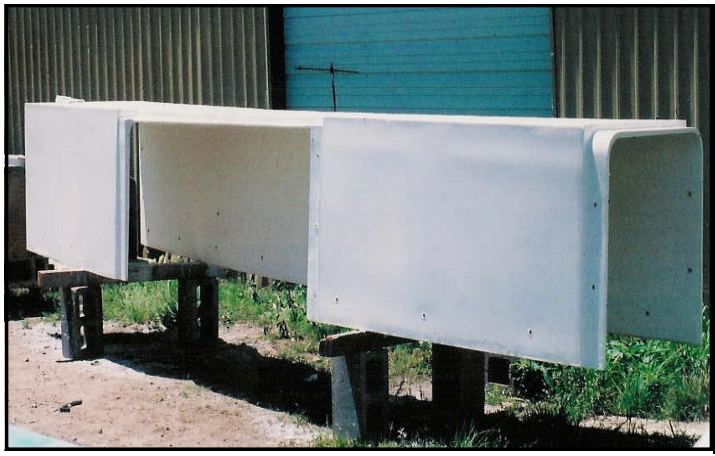
Note: All braces occur at trough splices.
All typical wall connections are considered fixed connections.
All intermediate connections at supports are considered not fixed except side mount trough, which is fully supported on one side.

Shop pictures of composite troughs for Elmira, CA. Shows tongue and groove connections, integral flanges, special configurations for circular and straight troughs.



Straight Trough
Top trough shows tongue end of tongue and Groove, bottom trough shows square end for saddle mount

Curved Trough
Troughs show groove end of Tongue & Groove



Curved Trough with block out for drop out trough. Shows tongue end of tongue and groove and integral recess for attachment of drop out trough.

Drop out Trough
Integral end mounts

BENSON, AZ WALL MOUNT TROUGHS.
SHOP AND FIELD INSTALLATION PICTURES.

Curved Wall mounted trough
Shows groove end of tongue and groove

Curved wall mounted trough
With hole for drop out box

Curved Wall mounted trough installed with
Weirs & Baffles

Curved Wall mounted trough with drop
out box

FLAT BOTTOM TROUGHS FOR ROCKLIN, CA & CHALK BLUFF, NV

Rocklin, CA troughs supported on steel beams. 12”wide x 18”deep trough spanning 24’0” Ends not fixed

Rocklin, CA troughs fixed one end supported by steel beam on other end.

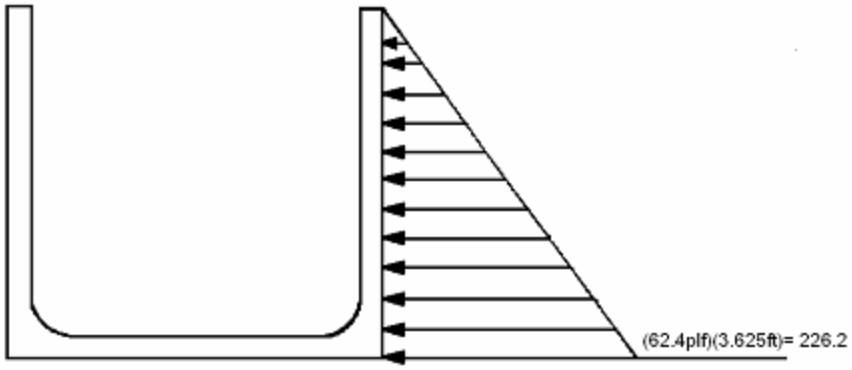
Chalk Bluff, NV trough with blind end and wall saddle mount.

Chalk Bluff, NV troughs anchor bolted to effluent end.

PHYSICAL PROPERTIES*

Tensile Strength	8,700psi min ASTM D638
Flexural Strength	18,000psi min ASTM D790
Flexural Modulus	1.0 x 10^6psi min ASTM D790
Compressive Strength	11,000psi min ASTM D695
Average Coefficient of Thermal Expansion	10.5 x 10^{-6} ASTM D696
Water Absorption % 24 hours	0.10% ASTM D570

Height of 1-1/2" wall troughs is limited to 42" inside depth per the following formula. For deeper troughs we increase the wall thickness to accommodate the depth. This also increases the physical properties of the trough.



Vertically Cantilever Beam-Fixed one end

$$I = \frac{bd^3}{12} = \frac{43.5(1.5)^3}{12} = 12.234$$

$$W = \frac{226.2 \times 3.625}{2} = 409.988$$

$$\Delta MAX = \frac{WL^3}{15EI} = \frac{409.988(43.5)^3}{15(1.0 \times 10^6)12.234} = \frac{3.375 \times 10^7}{1.835 \times 10^8} = .184 < .1875 \text{ OK}$$

The following tables indicate the maximum lengths various sizes of troughs can span without additional supports when fully loaded. Most troughs can carry additional weight such as piping, or equipment suspended from the troughs in addition to the dead weight of the trough plus the weight of water filled to the top of trough. The following calculation is an example of such a condition.

Assume 2'wide x 2'deep trough ends fixed spanning 24'0" with 1,000# additional load.
W_{water} = 62.4 x 2 x 2 = 249.6plf L = 24'0" = 288"
W_{trough} = 85.938
W_{extra} = 1,000# concentrated = 2 x 1,000/24 = 83.333plf
W_{total} = 249.6 + 85.938 + 83.333 = 418.871

$$\text{Deflection Max} = \frac{WL^4}{384EI} = \frac{24(418.871)(288)^3}{384(1.0 \times 10^6)7677.223} = \frac{2.401 \times 10^{11}}{2.948 \times 10^{12}} = .081 < .1875 \text{ OK}$$

*See next page for other details of material.

PHYSICAL PROPERTIES* FOR LAMINATE ONLY

Glass-Steel offers the following laminate properties as available on request:

Tensile Strength	87,000psi min	per ASTM D638
Flexural Strength	59,000psi min	per ASTM D790
Flexural Modulus	4.7 x 10^6psi min	per ASTM D790
Barcol Hardness	40	per ASTM D 2853
Notched Izod	20 ft-lbs/in	per ASTM D256
Water Absorption % 24 hours	0.10%	per ASTM D570

The above values use very high content woven stitched mats and produce the highest engineering values.

The standard we use for our laminate skins uses chopped strand FRP with a maximum allowed values per ASME/ASTM standards are:

Tensile Strength	using 30% Glass Fiber	8,700 psi min.	per ASTM D638
Flexural Strength	using 35% Glass Fiber	18,000psi min	per ASTM D790
Flexural Modulus	using 30% Glass Fiber	1.0 x 10^6psi min	per ASTM D790
Barcol Hardness		40	per ASTM D 2853
Notched Izod		20 ft-lbs/in	per ASTM D256
Water Absorption % 24 hours		0.10%	per ASTM D570

The above data table was created to eliminate the myths published by manufacturers claiming values that far exceed those shown above. Based on data published by ASTM and ASME the values shown above are the maximums allowed for the statement of “minimum” using the glass fiber content shown.

Glass-Steel, Inc. can also offer other values for FRP skins. Be sure to call us today and let us help you design a product that suits your application. Find our brochures on our website shown below.

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Flat Bottom Troughs Both Ends Fixed

Max span values shown are to maintain < 3/16 inch max deflection

Width of Trough

Depth		12"		15"		18"		21"		24"		27"		30"		36"	
			Max Span		Max Span		Max Span		Max Span		Max Span		Max Span		Max Span		Max Span
12"	I_{YY}	1067.08		1140.11		1203.37		1258.90		1307.94		1351.75		1390.88		1458.43	
	I_{XX}	2068.89	25'-4"	3186.018	24'-9"	4586.64	24'-3"	6291.01	23'-9"	8319.39	23'-4"	10692.01	22'-11"	13432.14	22'-7"	20077.89	22'-0"
	WT/FT*	45		48		52		55		58.5		62		65.5		72.5	
15"	I_{YY}	1868.70		1997.36		2110.84		2211.75		2302.14		2383.58		2457.35		2585.91	
	I_{XX}	2480.64	27'-10"	3800.27	27'-1"	5443.89	26'-7"	7431.77	26'-1"	9784.14	25'-8"	12521.27	25'-3"	15663.39	24'-10"	23243.64	24'-2"
	WT/FT*	52		55		58.5		62		65.5		62		72.		79	
18"	I_{YY}	2972.01		3174.21		3355.12		3518.11		3665.60		3779.80		3922.36		4138.30	
	I_{XX}	2896.40	30'-0"	4414.52	29'-4"	6301.15	28'-8"	8572.52	28'-2"	11248.90	27'-8"	14350.52	27'-3"	17897.65	26'-10"	26409.40	26'-2"
	WT/FT*	58.5		62		65.5		69		72		76		79		86	
21"	I_{YY}	4417.78		4712.37		4979.0		5221.40		5442.84		5646.27		5832.87		6165.23	
	I_{XX}	3304.15	32'-0"	5028.78	31'-3"	7158.40	30'-7"	9713.28	30'-0"	12713.05	29'-6"	16179.78	29'-1"	20366.16	28'-8"	29575.15	27'-11"
	WT/FT*	65.5		69		72		76		79		81		86		93	
24"	I_{YY}	6246.98		6653.24		7024.12		7364.28		7677.22		7966.16		8233.80		8713.83	
	I_{XX}	3715.91	33'-10"	5643.03	33'-1"	8115.66	32'-4"	10854.03	31'-9"	14178.41	31'-3"	18009.03	30'-9"	22366.16	30'-2"	32740.91	29'-7"
	WT/FT*	72		76		79		82.5		86		90		93		100	
27"	I_{YY}	8500.66		9037.83		9532.11		9988.17		10411.07		10803.50		11168.94		11829.32	
	I_{XX}	4127.66	35'-7"	6257.29	34'-9"	8872.91	34'-0"	11994.79	33'-4"	15643.16	32'10"	19838.29	32'-4"	24600.41	31'-9"	35906.66	31'-1"
	WT/FT*	79		82.5		85		90		93		96.5		100		107	
30"	I_{YY}	11220.07		11911.10		12548.04		13135.51		13686.27		14200.35		14681.28		15555.90	
	I_{XX}	4539.42	37'-3"	6871.54	36'-4"	9730.17	35'-6"	13,135.54	34'-10"	17107.92	34'-3"	21667.54	33'-9"	26834.49	33'-2"	39072.23	32'-6"
	WT/FT*	86		89.5		93		96.5		100		103.5		106.5		113.5	
33"	I_{YY}	14444.5		15,301.85		16100.87		16846.66		17544.36		18198.54		18813,14		19937.07	
	I_{XX}	4951.17	38'-10"	7,485.80	37'-10"	10587.47	37'-0"	14276.3	36'-3"	18572.67	35'-8"	23496.8	35'-2"	29068.92	34'-6"	42238.17	33'-9"
	WT/FT*	93		96.5		100		103.5		107		110		113.5		120.5	
36"	I_{YY}	18215.20		19262.81		20243.51		21162.94		22026.72		22839.68		23606.24		25015.35	
	I_{XX}	5362.92	40'-4"	8100.05	39'-3"	11444.67	38'-5"	13135.54	37'-8"	20037.42	37'-0"	25321.05	36'-5"	31303.17	35'-10"	45403.92	35'-1"
	WT/FT*	100		103.5		107		110		113.5		117		121		127.5	

*WT/FT– weight per lineal foot in pounds (lbs)

Rev Jan 10 2014

Flat Bottom Troughs with one end fixed

Maximum span values shown are to maintain max 3/16 inch deflection

Depth		Width Of Trough															
		12"		15"		18"		21"		24"		27"		30"		36"	
12"	I_{YY}	1067.08	Max Span	1140.11	Max Span	1203.37	Max Span	1258.90	Max Span	1307.94	Max Span	1351.75	Max Span	1390.88	Max Span	1458.44	Max Span
	I_{XX}	2068.89	21'1"	3186.01	20'7"	4586.64	20'2"	6291.01	19'10"	8319.39	19'5"	10692.01	19'1"	13432.14	18'10"	20077.89	18'4"
	WT/FT*	45		48.5		52		55		58.5		62		65.5		72.5	
15"	I_{YY}	1868.70		1997.36		2110.84		2211.75		2302.14		2383.58		2457.35		2585.92	
	I_{XX}	2480.64	23'2"	3800.27	22'7"	5443.90	22'2"	7431.77	21'9"	9784.14	21'4"	12521.27	21'0"	15663.39	20'8"	23243.64	20'2"
	WT/FT*	51.5		55		58.5		62		65.5		62		72.5		79	
18"	I_{YY}	2972.01		3174.21		3355.12		3518.11		3665.60		3779.80		3922.36		4138.30	
	I_{XX}	2896.40	25'0"	4414.53	24'5"	6301.15	23'11"	8572.52	23'5"	11248.90	23'1"	14350.52	22'8"	17897.65	22'4"	26409.40	21'10"
	WT/FT*	58.5		62		65.5		69		72.5		76		79		86	
21"	I_{YY}	4417.78		4712.37		4979.0		5221.40		5442.84		5646.27		5832.87		6165.23	
	I_{XX}	3304.16	26'8"	5028.78	26'0"	7158.40	25'6"	9713.28	25'0"	12713.05	24'7"	16179.78	24'3"	20366.16	23'10"	29575.15	23'2"
	WT/FT*	65.5		69		72.5		76		79		81.0		86		93	
24"	I_{YY}	6246.98		6653.24		7024.12		7364.28		7677.22		7966.16		8233.80		8713.83	
	I_{XX}	3715.91	28'3"	5643.03	27'6"	8115.66	26'11"	10854.03	26'5"	14178.41	26'0"	18009.03	25'7"	22366.16	25'2"	32740.91	24'7"
	WT/FT*	72.5		76		79		82.5		86		89.5		93		100	
27"	I_{YY}	8500.67		9037.83		9532.11		9988.17		10411.07		10803.50		11168.94		11829.32	
	I_{XX}	4127.67	29'1"	6257.29	28'11"	8872.91	28'4"	11994.79	27'9"	15643.16	27'4"	19838.29	26'11"	24600.41	26'5"	35906.66	25'10"
	WT/FT*	79		82.5		86		89.5		93		96.5		100		107	
30"	I_{YY}	11220.07		11911.10		12548.04		13135.51		13686.27		14200.35		14681.28		15555.90	
	I_{XX}	4539.42	31'0"	6871.54	30'3"	9730.17	29'7"	13135,54	29'1"	17107.92	28'7"	21667.54	28'1"	26834.49	27'8"	39072.23	27'0"
	WT/FT*	86		89.5		93		96.5		100		103.5		107		113.5	
33"	I_{YY}	14444.5		15301.85		16100.87		16846.66		17544.36		18198.54		18813,14		19937.07	
	I_{XX}	4951.17	32'4"	7,485.80	31'6"	10587.47	30'10"	14276.3	30'3"	18572.67	29'9"	23496.8	29'3"	29068.92	28'9"	42238.17	28'2"
	WT/FT*	93		96.5		100		103.5		107		110		113.5		120.5	
36"	I_{YY}	18215.21		19262.81		20243.51		21162.94		22026.72		22839.68		23606.24		25015.35	
	I_{XX}	5362.93	33'7"	8100.05	32'8"	11444.67	32'0"	13135.54	31'3"	20037.42	30'10"	25321.05	30'4"	31303.17	29'10"	45403.92	29'2"
	WT/FT*	100		103.5		107		110		113.5		117		120.5		127.5	

*WT/FT = weight per lineal ft in lbs per ft

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Flat Bottom Trough with ends not fixed

Maximum span for deflection < 3/16 inch

	Width of Trough															
Depth	**12"**		**15"**		**18"**		**21"**		**24"**		**27"**		**30"**		**36"**	
	I_{YY}	1067.08	Max Span	1140.11	Max Span	1203.37	Max Span	1258.90	Max Span	1307.94	Max Span	1351.75	Max Span	1390.885	Max Span	1458.43	Max Span
12”	I_{XX}	2068.89	**16'11"**	3186.01	**16'6"**	4586.64	**16'2"**	6291.01	**15'10"**	8319.39	**15'7"**	10692.01	**15'4"**	13432.14	**15'1"**	20077.89	**14'8"**
	WT/FT*	45		48.5		52		55		58.5		62		65.5		72.5	
	I_{YY}	1868.70		1997.36		2110.84		2211.75		2302.14		2383.58		2457.35		2585.91	
15”	I_{XX}	2480.64	**18'7"**	3800.27	**18'2"**	5443.9	**17'9"**	7431.77	**17'5"**	9784.14	**17'2"**	12521.27	**16'10"**	15663.4	**16'7"**	23243.64	**16'2"**
	WT/FT*	52		55		58.5		62		65.5		62		72.5		79	
	I_{YY}	2972.01		3174.21		3355.12		3518.11		3665.60		3779.80		3922.36		4138.30	
18”	I_{XX}	2896.40	**20'1"**	4414.52	**19'7"**	6301.15	**19'2"**	8572.52	**18'10"**	11248.90	**18'6"**	14350.52	**18'2"**	17897.65	**17'11"**	26409.40	**17'6"**
	WT/FT*	58.5		61.87		65.5		69		72.5		76		79		86	
	I_{YY}	4417.78		4712.37		4979.0		5221.40		5442.84		5646.27		5832.87		6165.23	
21”	I_{XX}	3304.15	**21'5"**	5028.78	**20'11"**	7158.40	**20'5"**	9713.28	**20'1"**	12713.05	**19'9"**	16179.78	**19'5"**	20366.16	**19'2"**	29575.15	**18'8"**
	WT/FT*	65.5		69		72.5		76		79		81		86		93	
	I_{YY}	6246.98		6653.24		7024.12		7364.28		7677.22		7966.16		8233.80		8713.8	
24”	I_{XX}	3715.91	**22'8"**	5643.03	**22'1"**	8115.66	**21’7"**	10854.03	**21'3"**	14178.41	**20'10"**	18009.03	**20'7"**	22366.16	**20'2"**	32740.91	**19'9"**
	WT/FT*	72.5		76		79		82.5		86		89.5		93		100	
	I_{YY}	8500.66		9037.83		9532.11		9988.17		10411.07		10803.50		11168.9		11829.32	
27”	I_{XX}	4127.66	**23'10"**	6257.29	**23'3"**	8872.91	**22'9"**	11994.79	**22'3"**	15643.16	**21'11"**	19838.29	**21'7"**	24600.4	**21'2"**	35906.66	**20'9"**
	WT/FT*	79		82.5		86		89.5		93		96.5		100		107	
	I_{YY}	11220.07		11911.10		12548.04		13135.5		13686.27		14200.35		14681.28		15555.90	
30”	I_{XX}	4539.42	**24'11"**	6871.54	**24'3"**	9730.17	**23'9"**	13,135,5	**23'4"**	17107.92	**22'11"**	21667.54	**22'7"**	26834.49	**22'2"**	39072.23	**21'8"**
	WT/FT*	86		89.5		93		96.5		100		103.5		107		113.5	
	I_{YY}	14444.5		15,301.8		16100.87		16846.66		17544.36		18198.5		18813,14		19937.07	
33”	I_{XX}	4951.17	**25'11"**	7,485.8	**25'3"**	10587.47	**24'9"**	14276.3	**24'3"**	18572.67	**23'10"**	23496.8	**23'6"**	29068.92	**23'1"**	42238.17	**22'7"**
	WT/FT*	93		96.5		100		103.5		107		110		113.5		120.5	
	I_{YY}	18215.20		19262.81		20243.51		21162.94		22026.72		22839.68		23606.24		25015.35	
36”	I_{XX}	5362.92	**26'11"**	8100.05	**26'-3”**	11444.67	**25'8"**	13135.54	**25'2"**	20037.42	24'-9"	25321.05	**24'4"**	31303.17	**23'11"**	45403.92	**23'5"**
	WT/FT*	100		103.5		107		110.		113.5		117		120.5		127.5	

*WT/FT - Weight per lineal foot in pounds (lbs) per foot

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Round Bottom Trough with Both Ends fixed

Max span to for deflection < 3/16 inch

Depth		Width of Trough															
		12"		15"		18"		21"		24"		27"		30"		36"	
			Max Span		Max Span		Max Span		Max Span		Max Span		Max Span		Max Span		Max Span
12"	I_{YY}	1277.0															
	I_{XX}	1559.09	27'-5"														
	WT/FT*	38.05															
15"	I_{YY}	1778.8		2256.12													
	I_{XX}	1968.8	28'-3"	2869.61	28'-11"												
	WT/FT*	44.25		47													
18"	I_{YY}	2589.7		3058.9		3743.10											
	I_{XX}	2380.60	29'-8"	3449.83	29'-10"	4768.56	30'-5"										
	WT/FT*	52		54		56											
21"	I_{YY}	3704.19		4165.24		4835.50		5772.97									
	I_{XX}	2792.36	31'-3"	4098.12	31'-0"	5625.80	31'-3"	6065.31	31'-9"								
	WT/FT*	59		61		63		65									
24"	I_{YY}	5162.69		5630.35		6293.85		7205.17		8429.98							
	I_{XX}	3204.11	32'-10"	4678.34	32'-4"	6483.20	32'-3"	7206.06	32'-6"	10759.54	33'-0"						
	WT/FT*	66		67.5		69.5		71.5		73.5							
27"	I_{YY}	7006.14		7488.6		8149.56		9050.26		10247.8		11798.0					
	I_{XX}	3615.87	34'-6"	5326.63	33'-9"	7340.31	33'-5"	8346.82	33'-4"	12224.3	33'-7"	15068.52	34'1"				
	WT/FT*	72.5		74.5		76.5		78.5		80.5		82.5					
30"	I_{YY}	9275.42		9784.14		10455.04		11350.74		12529.24		14047.3		15962.82			
	I_{XX}	4027.62	36'-0"	5940.88	35'-2"	8197.57	34'-7"	9487.57	34'-4"	13689.05	34'-5"	16897.8	34'-7"	20397.78	35'1"		
	WT/FT*	79.5		81.5		83.5		85.5		87.5		89		91			
33"	I_{YY}	24011.2		12,556.9		13208.08		14148.45		15376.7		16810.68		18689.58			
	I_{XX}	4439.38	37'-6"	6555.14	36'-7"	9054.82	35'-10"	10628.33	35'-5"	15153.8	35'-3"	18727.03	35'-4"	22632.0	35'7"		
	WT/FT*	86.5		88.5		90		92		94		96		98			
36"	I_{YY}	15254.04		15846.		16569.8		17484.74		18652.26		20130.8		21981.04		27017.0	
	I_{XX}	4851.13	39'-0"	7169.39	37'-11"	9912.08	37'-1"	11769.08	36'-7"	16618.56	36'-3"	20556.29	36'-2"	24866.24	36'3"	34550.1	36'9"
	WT/FT*	93		95		97		99		101		103		105		115	
39"	I_{YY}											24050.0		25880.02		30837.14	
	I_{XX}											22385.5	37'-0"	27100.55	36'-11"	37716.72	37'-3"
	WT/FT*											108		112		116	
42"	I_{YY}													30428.82		35322.42	
	I_{XX}													29334.80	29'-9"	40882.48	37'-10"
	WT/FT*													119		122.5	

*WT/FT - Weight per lineal foot in pounds (lbs/ft)

Round Bottom Trough One End Fixed

Max Span for deflection < 3/16 inch

Depth		12"		15"		18"		21"		24"		27"		30"		36"	
								Width of Trough									
12"	I_{YY}	1277.042	Max Span		Max Span		Max Span		Max Span		Max Span		Max Span		Max Span		Max Span
	I_{XX}	1559.098	22'-10"														
	WT/FT*	38															
15"	I_{YY}	1778.79		2256.119													
	I_{XX}	1968.8	23'-7"	2869.613	24'-1"												
	WT/FT*	44		47													
18"	I_{YY}	2589.68		3058.89		3743.10											
	I_{XX}	2380.60	24'-9"	3449.83	24'-10"	4768.56	25'-4"										
	WT/FT*	52		54		56											
21"	I_{YY}	3704.19		4165.24		4835.50		5772.97									
	I_{XX}	2792.36	26'-0"	4098.12	25'-10"	5625.80	26'-0"	6065.31	26'-6"								
	WT/FT*	59		61		63		65									
24"	I_{YY}	5162.69		5630.35		6293.85		7205.17		8429.98							
	I_{XX}	3204.11	27'-4"	4678.34	26'-11"	6483.20	26'-10"	7206.06	27'-0"	10759.54	27'-5"						
	WT/FT*	66		67.5		69.5		71.5		73.5							
27"	I_{YY}	7006.14		7488.6		8149.56		9050.26		10247.8		11798					
	I_{XX}	3615.8	28'-8"	5326.63	28'-1"	7340.31	27'-10"	8346.82	27'-9"	12224.30	28'-0"	15068.52	28'-4"				
	WT/FT*	72.5		74.5		76.5		78.5		80.5		82.5					
30"	I_{YY}	9275.42		9784.14		10455.4		11350.74		12529.24		14047.27		15962.82			
	I_{XX}	4027.62	30'-0"	5940.88	29'-3"	8197.57	28'1-0"	9487.57	28'-7"	13689.05	28'-8"	16897.78	28'-10"	20397.78	29'-2"		
	WT/FT*	79.5		81.5		83.5		85.5		87.5		89		91			
33"	I_{YY}	24011.1		12,556.9		13208.8		14148.45		15376.69		16810.68		18689.58			
	I_{XX}	4439.3	31'-3"	6555.14	30'-5"	9054.82	29'-10"	10628.33	29'-6"	15153.81	29'-5"	18727.03	29'-5"	22632.03	29'-7"		
	WT/FT*	86.5		88.5		90.5		92		94		96		98			
36"	I_{YY}	15254.04		15846.96		16569.9		17484.75		18652.26		20130.80		21981.04		27017.05	
	I_{XX}	4851.13	32'-6"	7169.39	31'-7"	9912.08	30'-11"	11769.08	30'-5"	16618.56	30'-2"	20556.29	30'-1"	24866.29	30'-2"	34550.1	30'-7"
	WT/FT*	93		95		97		99		101		103		105		115	
39"	I_{YY}											24050.0		25880.02		30837.14	
	I_{XX}											22385.55	30'-10"	27100.54	30'-9"	37716.72	31'-0"
	WT/FT*											110		112		116	
42"	I_{YY}													30428.82		35322.42	
	I_{XX}													29334.80	31'-5"	40882.48	31'-6"
	WT/FT*													119		122.5	

*WT/FT - weight per lineal ft in pounds (lbs).

Round Bottom Trough Ends not fixed

Maximum Span for deflection < 3/16 inch

Width of Trough

Depth		12"		15"		18"		21"		24"		27"		30"		36"	
12"	I_{YY}	1277.04	Max Span		Max Span		Max Span		Max Span		Max Span		Max Span		Max Span		Max Span
	I_{XX}	1559.09	18'-4"														
	WT/FT*	38															
15"	I_{YY}	1778.79		2256.12													
	I_{XX}	1968.85	18'-11"	2869.61	19'-4"												
	WT/FT*	44.5		47													
18"	I_{YY}	2589.68		3058.90		3743.10											
	I_{XX}	2380.60	19'-10"	3449.83	19'-11"	4768.56	20'-4"										
	WT/FT*	52		54		56											
21"	I_{YY}	3704.19		4165.24		4835.50		5772.97									
	I_{XX}	2792.36	20'-11"	4098.12	20'-9"	5625.80	20'-10"	6065.31	21'-3"								
	WT/FT*	59		61		62		65									
24"	I_{YY}	5162.69		5630.35		6293.85		7205.18		8429.98							
	I_{XX}	3204.11	22'-0"	4678.34	21'-8"	6483.20	21'-7"	7206.06	21'-8"	10759.55	22'-0"						
	WT/FT*	66		67.5		69		71.5		73.5							
27"	I_{YY}	7006.14		7488.6		8149.56		9050.26		10247.8		11797.0					
	I_{XX}	3615.87	23'-0"	5326.63	22'-7"	7340.31	22'-4"	8346.82	22'-4"	12224.30	22'-5"	15068.52	22'-9"				
	WT/FT*	72.5		74.5		76		78.5		80.5		82					
30"	I_{YY}	9275.42		9784.14		10455.04		11350.74		12529.25		14047.26		15962.82			
	I_{XX}	4027.62	24'-1"	5940.88	23'-7"	8197.57	23'-2"	9487.57	23'-0"	13689.06	23'-0"	16897.78	23'-2"	20397.78	23'-5"		
	WT/FT*	79.5		81.5		83		85		87		89		91			
33"	I_{YY}	24011.2		12,557.0		13208.08		14148.45		15376.70		16810.69		18689.59			
	I_{XX}	4439.38	25'-1"	6555.14	24'-5"	9054.82	24'-0"	10628.33	23'-8"	15153.81	23'-7"	18727.03	23'-7"	22632.04	23'-9"		
	WT/FT*	86.5		88.5		90		92		94		96		98			
36"	I_{YY}	15254.04		15846.96		16569.80		17484.74		18652.26		20130.80		21981.04		27017.05	
	I_{XX}	4851.13	26'-1"	7169.39	25'-4"	9912.08	24'-10"	11769.08	24'-5"	16618.56	24'-3"	20556.29	24'-2"	24866.3	24'-2"	34550.1	24'-7"
	WT/FT*	93.5		95.5		97		99		101		103		105		115	
39"	I_{YY}											24050.0		25880.02		30837.1	
	I_{XX}											22385.54	24'-9"	27100.54	24'-8"	37716.7	24'-11"
	WT/FT*											108		112		116	
42"	I_{YY}													30428.82		35322.42	
	I_{XX}													29334.8	25'-3"	40882.5	25'-3"
	WT/FT*													119		122.5	

*WT/FT - weight per lineal foot in pounds (lbs).

TROUGH FLOW RATES FOR FLAT BOTTOM TROUGHS

Height/Width	12”	15”	18”	21”	24”	30”	36”	Ha
10”	467	584	700	817	934	1167	1400	8”
12”	652	814	977	1140	1303	1629	1855	10”
14”	857	1071	1286	1500	1714	2143	2571	12”
16”	1080	1351	1621	1891	2161	2701	3241	14”
18”	1319	1649	1978	2308	2638	3297	3957	16”
20”	1574	1968	2362	2755	3149	3936	4723	18”
22”	1845	2306	2767	3227	3689	4612	5534	20”
24”	2127	2658	3190	3722	4254	5317	6380	22”
26”	2424	3030	3636	4242	4848	6060	7272	24”
28”	2734	3417	4101	4812	5468	6834	8201	26”
30”	3054	3817	4581	5344	6108	7635	9162	28”
32”	3388	4234	5081	5928	6775	8469	10163	30”
34”	3733	4666	5599	6532	7465	9332	11198	32”
36”	4086	5108	6130	7151	8173	19216	13359	34”
38”	4453	5566	6680	7793	8906	11133	13359	36”
40”	4829	6037	7244	8451	9659	12073	14488	38”
42”	5215	6518	7822	9126	10430	13037	15644	40”
44”	5612	7014	8417	9820	11223	14029	16935	42”

Formula for: $GPM = 857\ WHa^{3/2}$
W = width inside in feet
Ha = water height inside in feet
Height = Ha + 2”

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TROUGH FLOW RATES IN GPM* FOR ROUND BOTTOM TROUGHS

Height/Width	12”	15”	18”	21”	24”	30”	36”	Ha
12”	467	584	700	817	934	1167	1400	8”
14”	652	814	977	1140	1303	1629	1855	10”
16”	857	1071	1286	1500	1714	2143	2571	12”
18”	1080	1351	1621	1891	2161	2701	3241	14”
20”	1319	1649	1978	2308	2638	3297	3957	16”
22”	1574	1968	2362	2755	3149	3936	4723	18”
24”	1845	2306	2767	3227	3689	4612	5534	20”
26”	2127	2658	3190	3722	4254	5317	6380	22”
28”	2424	3030	3636	4242	4848	6060	7272	24”
30”	2734	3417	4101	4812	5468	6834	8201	26”
32”	3054	3817	4581	5344	6108	7635	9162	28”
34”	3388	4234	5081	5928	6775	8469	10163	30”
36”	3733	4666	5599	6532	7465	9332	11198	32”
38”	4086	5108	6130	7151	8173	19216	13359	34”
40”	4453	5566	6680	7793	8906	11133	13359	36”
42”	4829	6037	7244	8451	9659	12073	14488	38”
44”	5215	6518	7822	9126	10430	13037	15644	40”
46”	5612	7014	8417	9820	11223	14029	16935	42”

Formula for: $GPM = 857\ WHa^{3/2}$
W = width inside in feet
Ha = water height inside in feet
Height = Ha + 4

* Gallons per minute

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