PRESSURE BUBBLE SELF-BALANCING

FOR TERRACED SEPTIC LEACH FIELDS

(May 25, 2021)

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Western Canada Onsite Wastewater Management Association of BC.

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- Test A 1¼" transfer pipe to lower lateral
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- See www.premierplastics.com for videos

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'Good Solid Tanks'

PRESSURE BUBBLE SELF-BALANCING FOR TERRACED SEPTIC LEACH FIELDS

The object of this technique is to deliver the same flow rate to all laterals in the terraced distribution without the need for balancing valves. In a conventional system the absence of balancing valves will allow more vertical head and flow rate to develop in the transfer pipes to laterals at lower elevations. The result is system imbalance.

Principle of Operation:

Consider two identical vertical cylinders, one is filled with water, the other with air. The pressure head at the bottom of the water cylinder will be the pressure at the top plus the added pressure from the weight of the water column in the cylinder.

The pressure at the bottom of the air cylinder will be exactly the same as the pressure at the top because the air has no weight to add to the pressure at the bottom.

Now, consider a small flow of water entering the top of the air cylinder. If the flow is such that it will just pour down the inside wall of the cylinder and flow out the bottom (without forming any fully flooded slugs), the pressure in the cylinder at the bottom will be the same as at the top. The trapped air in the cylinder will form a pressure bubble and prevent head build up in the cylinder as the flow descends.

Similarly, water flowing down an open channel at atmospheric pressure arrives at the other end still at atmospheric pressure.

The pressure bubble principle operates the same way except the ‘open channel’ is at a pressure higher than atmospheric pressure. The pressure is induced by the effluent flowing into a fully flooded transport pipe from a dosing tank at a higher elevation to the distribution manifold. The pressure at the manifold is commonly referred to as to the residual head.

The trapped bubble in the transfer pipes to laterals at lower level prevents the transfer pipe from flooding and building up static head. The pressure bubble effect is created by selecting a pipe diameter several times larger than the diameter of the laterals. This larger diameter transfer pipe allows the effluent to flow down the slope in the bottom of the pipe to the next lateral at the same residual head as the manifold.

Practical Considerations:

With the pressure bubble technique, the squirt height from the laterals further down the slope will be theoretically the same as the squirt height from the uppermost lateral thus requiring no balancing valves. In current practice, quarter turn ball valves or gate valves are installed on each lateral for balancing, rebalancing and maintenance.

Using pressure bubble natural balancing, quarter turn ball valves can be used for shut-off only as no rebalancing will be necessary when the valves are reopened.
Theoretically means the length of the pressure bubble must extend from the exit at the manifold down to the connection to the respective lateral. If there is a reduced air volume in the bubble, a short fully flooded section of the transfer pipe will appear at the lower end, “adding back” static head in the transfer pipe.

Causes of reduced air volume (bubble) in the transfer pipe to a lower lateral:

As with any flood/drain system (Flout or pump) the initial flow into the transport pipe at startup will be at a maximum for the first few seconds. The flow rate will reduce as the pipe fills and resistance to flow increases. The flow will stabilize when a pre-estimated equilibrium point between friction head and flow rate has been reached.

Causes of reduced air volume are as follows:

a) The incoming surge of water in a pressure bubble system could initially overwhelm the top end of the transfer pipe and cause excess air to be discharged out at the bottom, thus reducing the length of the trapped air volume.
b) The initial higher effluent flow volume will drop back to a steady state flow volume which will displace less air along the length of the transfer pipe causing the lower end of the closed bubble to shrink upwards. The effect of the initial surge can be reduced by installing an air cushion pipe at the end of the manifold to dampen the shock. Also, the connection from the manifold to the transfer pipe can be reduced to one size smaller than the diameter of the lateral (1¼” to 1”) to restrict the initial flow rate until the back pressure from the orifices regulates the flow. At the lower end of the transfer pipe the connection to the lateral can also be reduced to a size smaller than the diameter of the lateral (1¼” to 1”) to quickly “plug off” the loss of air from the transfer pipe at the

moment the initial discharge reaches the bottom. The reduced pipe size at each end of the transfer pipe will also add a small resistance to effluent flow which will partly offset any static head added back at the lower end of the transfer pipe.

c) The air in the transfer pipe, being initially at atmospheric pressure will become compressed to the pressure of the residual head in the manifold which will also reduce the volume of trapped air. The higher the residual head the more the compression of the air bubble. This compression or loss of volume can be easily determined using Boyle's Law. (Temperature effects are negligible.)

$$The\ compressed\ volume\ ratio = \frac{34\text{ft(Atmospheric Pressure)}}{34\text{ft} + \text{Residual Head (ft)}}$$

Example: (4ft residual head) $=$ 0.9 = 90%

$=$ 10% shrinkage in air volume

To compensate for the startup loss of air volume in the closed bubble, a 2-3 ft. section of transfer pipe at the connection to the lower lateral can be installed at a near horizontal slope to allow air shrinkage to occur in this horizontal section of pipe that would otherwise reduce the length of the bubble in the sloped section of the transfer pipe.

Test Apparatus: (see diagram)

A test apparatus was set up to observe performance and determine residual pressure profiles of each discharge cycle.

The apparatus consisted of:

- Flout dosing tank delivering a 20 gal. discharge.
- 2" dia. transport pipe sloping down 17 ft. from the dosing tank outlet to a 2" dia. manifold at a vertical fall of 68".
- 3" dia. air cushion pipe extending 36" from end of the manifold for the pressure bubble test.
- Two Horizontal 1¼" dia. laterals with 20 -1/8" dia. orifices. (Upper and Lower)
- 1", 1¼" and 3" dia. 15' long transfer pipe options from the manifold sloped down to the lower lateral with a vertical fall of 52".

Observations and Conclusions:

The following comparison tests were performed with two laterals. See attached flow profiles.

Test A Standard system with 1¼" dia. transfer pipe to lower lateral.

Test B Standard system with 1" dia. transfer pipe to lower lateral.

Test C Pressure Bubble system with 3" dia. transfer pipe to lower lateral.

RESIDUAL HEAD AT MID-DOSE

	TEST A	TEST B	TEST C
TRANSFER PIPE DIA. TO LOWER LATERAL	1¼"	1"	3"
UPPER LATERAL RESIDUAL HEAD	66"	64"	68"
LOWER LATERAL RESIDUAL HEAD	103"	90"	70"
INCREASE IN RESIDUAL HEAD AT LOWER LATERAL	56%	41%	3%

TEST A and B demonstrate (in the absence of valve control) the induced head effect of descending fully flooded transfer pipes to laterals at a lower elevation. The added restriction of a 1" dia. transfer line to the lower lateral shows only a minor reduction of residual head. Trying a further reduction in pipe diameter is not recommended.

TEST C Pressure bubble profile indicates approx. 3% higher flow rate to the lower lateral and also indicates a delay of about 2 seconds in the start-up of the lower lateral which would offset the slightly higher flow rate at peak flow. Note the closeness of the drain out profiles.

The desired air volume of the air cushion pipe is difficult to quantify. A larger volume will have more damping effect than a smaller volume with less of a surge of water at start-up entering the transfer pipe. For Test C, the 3" dia. x 36" long air cushion pipe appeared to be adequate in achieving a smooth entry startup of effluent into the 3" transfer pipe. The air cushion pipe could be horizontal or vertical but should be high enough to prevent air being flushed out. An air cushion pipe of any size would be preferred to no air cushion pipe.
The following diagram illustrates the piping concept.

The test results demonstrate that the concept of PRESSURE BUBBLE natural hydraulic balancing is a viable alternative (and superior in the long term) to the current method of manual balancing of terraced septic fields.

As a point of interest, the pressure bubble effect in some Flout dosing systems can be responsible for low discharge rates at the orifices. Proper venting of the transport pipe from the dosing tank will expel the trapped air and allow fully flooded flow to induce the required residual head at the manifold.

Your comments are welcomed.

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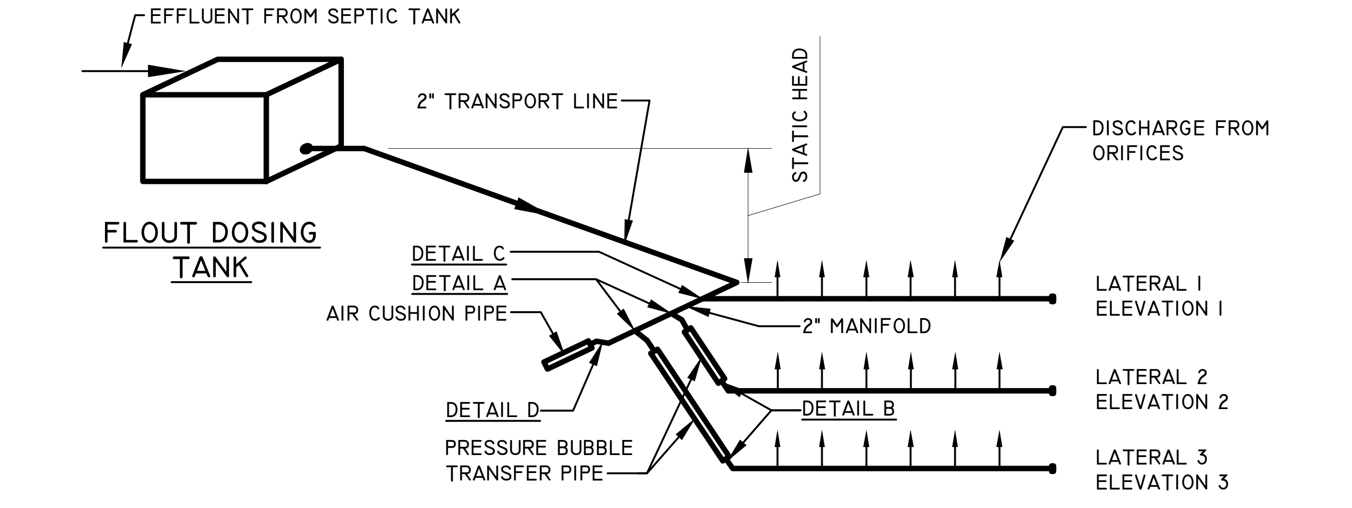
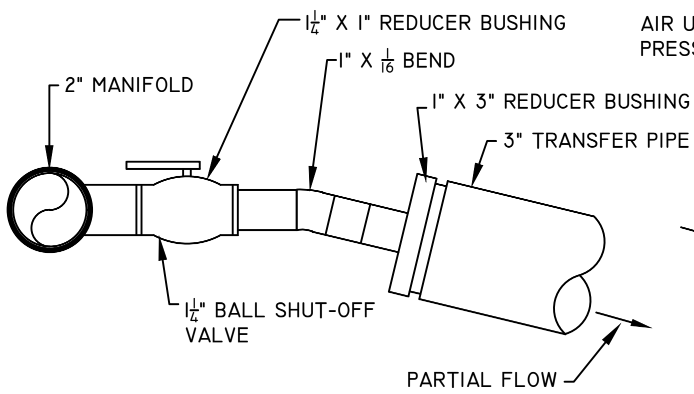
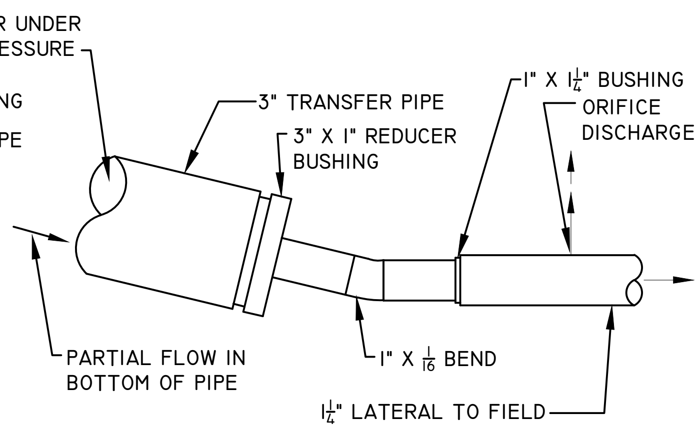
PRESSURE BUBBLE SELF-BALANCING SCHEMATIC





DETAIL A



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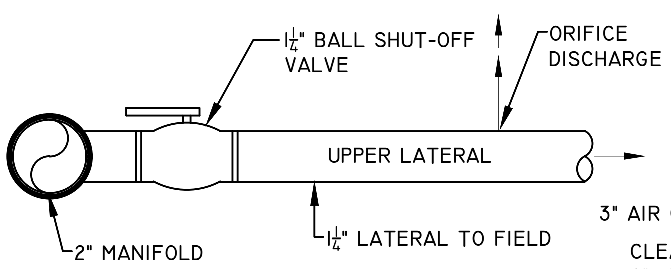

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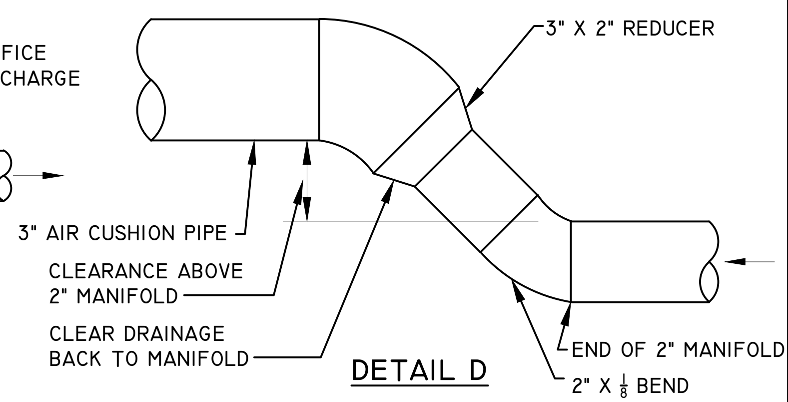

DETAIL D

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PRESSURE BUBBLE SELF-BALANCING FOR TERRACED SEPTIC FIELDS

(REFER TO DISCUSSION PAPER)

DATE:	FEB 22 2021
SCALE:	NTS
DRAWN:	JZ
SHEET. No.	1
REV.	

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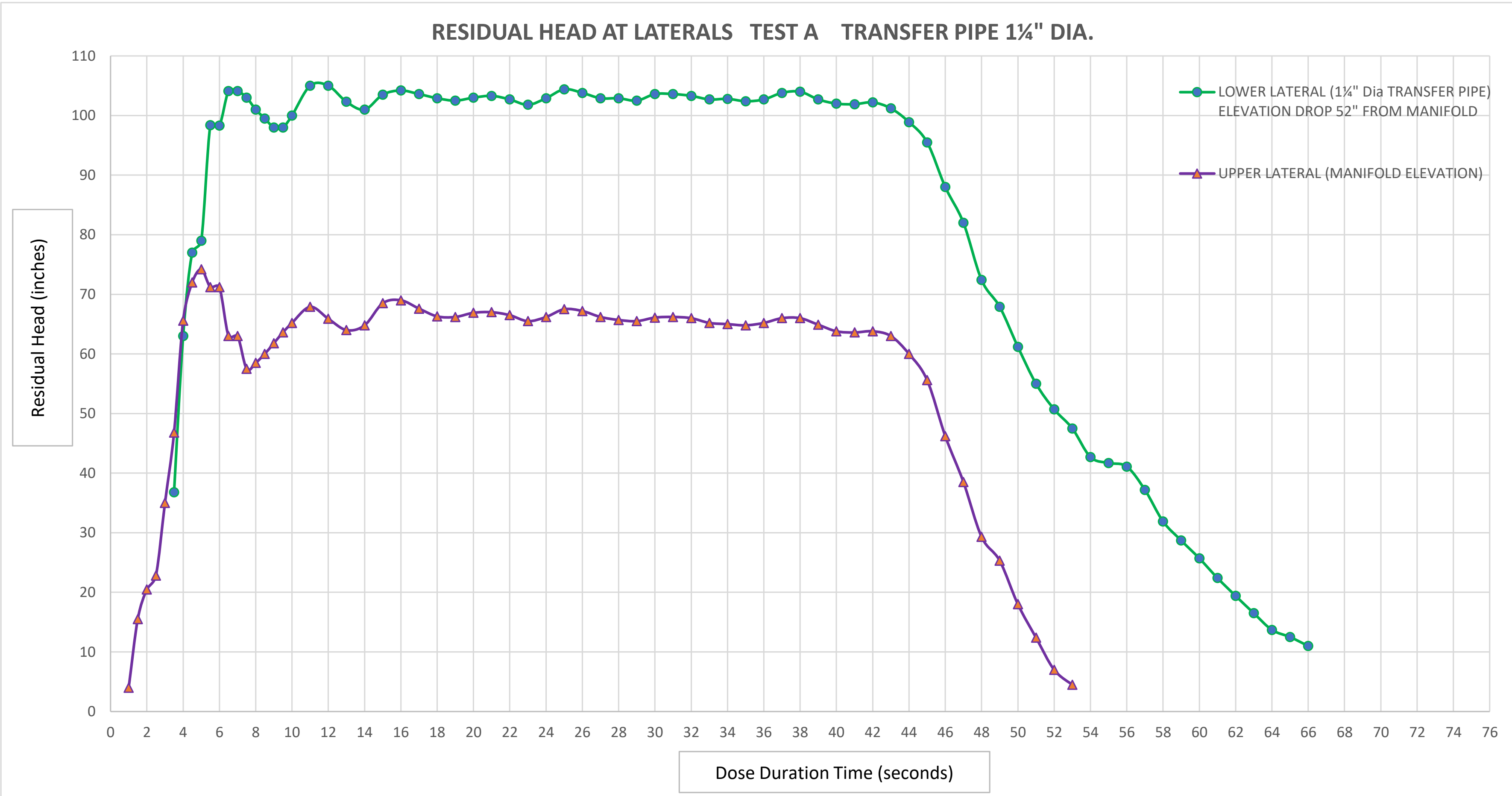

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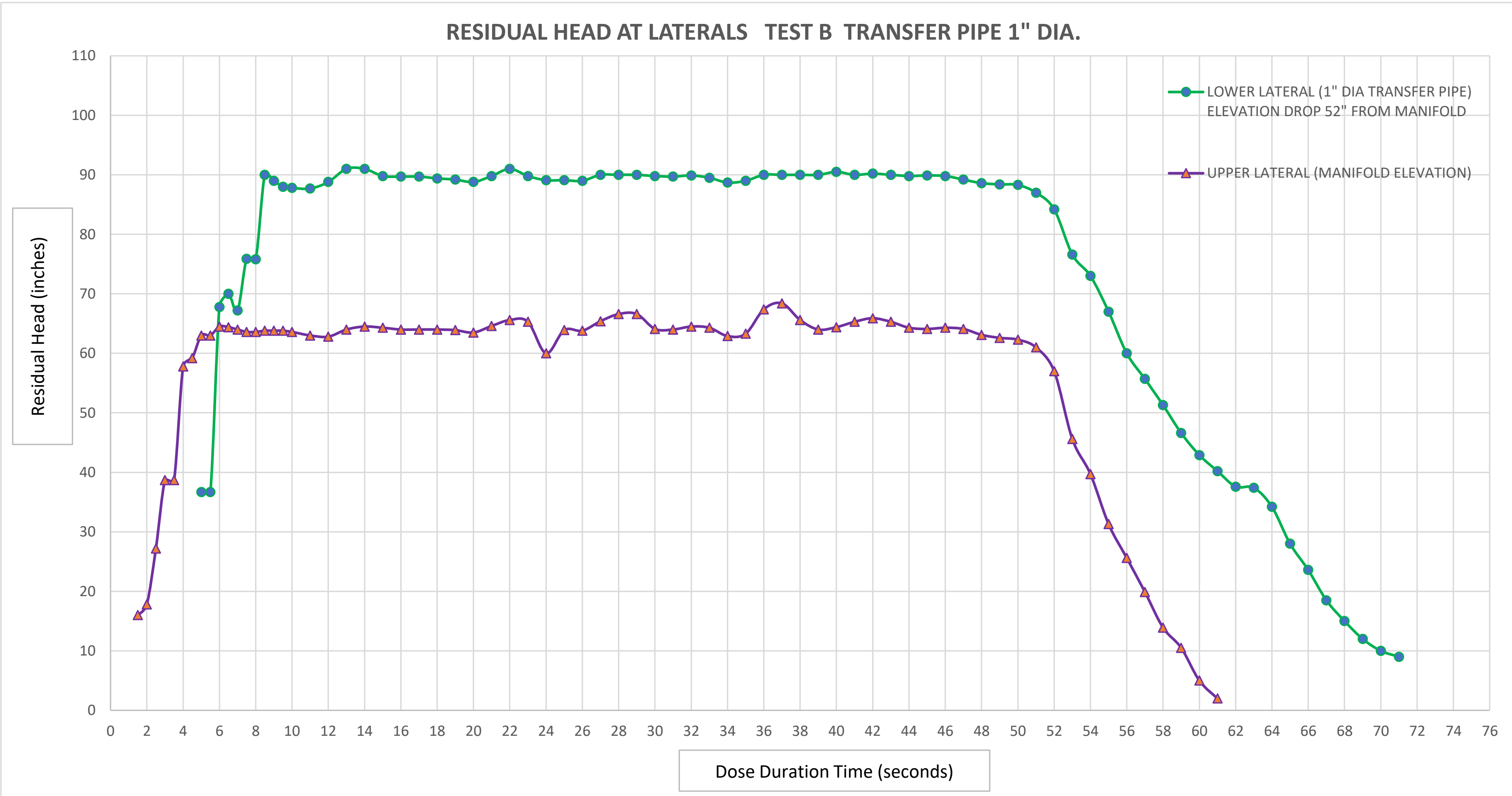
April 29, 2021

PRESSURE BUBBLE SELF-BALANCING FOR TERRACED SEPTIC LEACH FIELDS



PREMIER PLASTICS INC.
April 29, 2021

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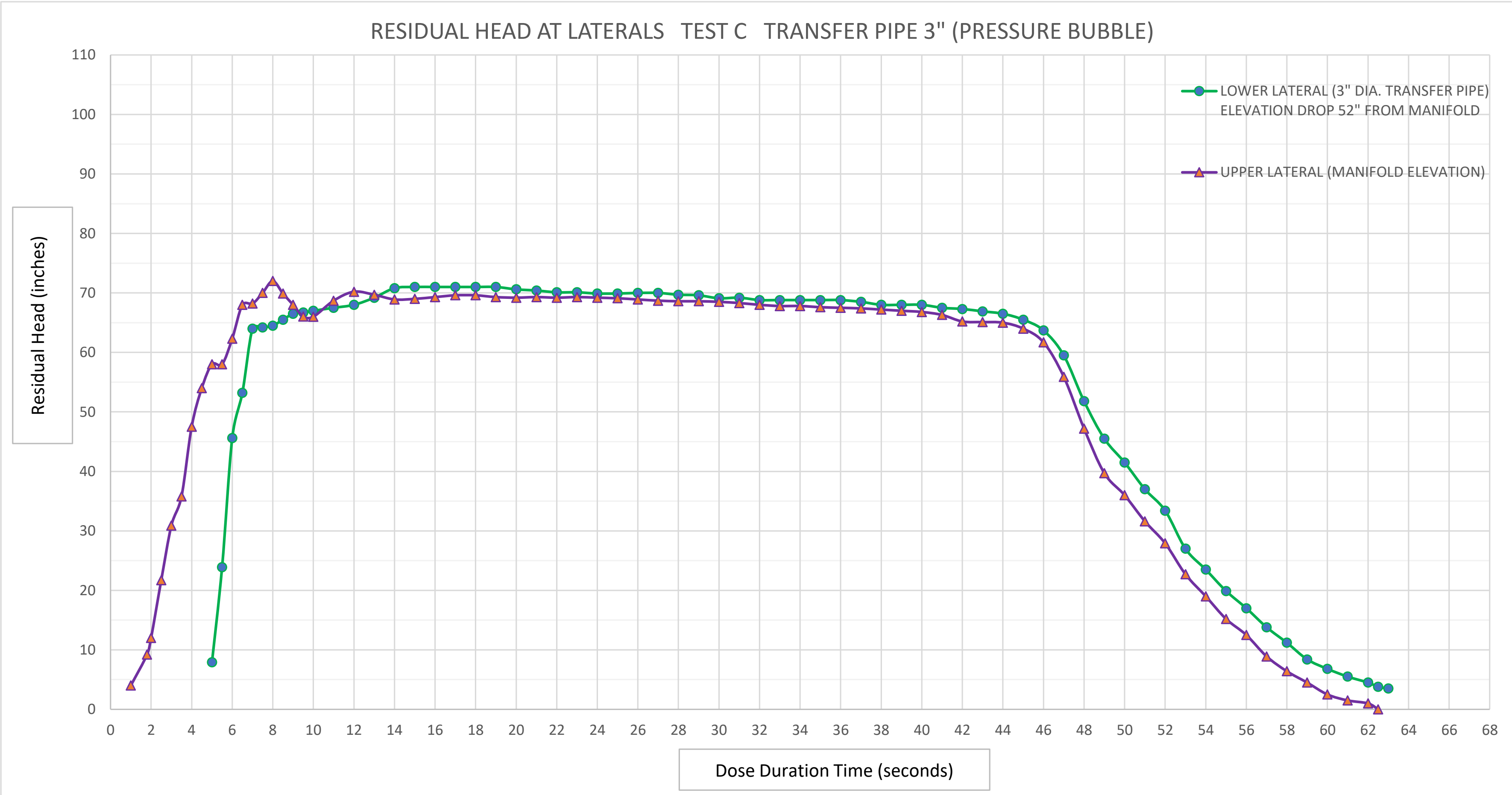

Note: No readings were taken between 7 and 13 seconds at the lower lateral owing to a short burst of aerated water entering the manometer tube. (Estimate only)

PREMIER PLASTICS INC.
FEB 20, 2021