Developing Tile Drain P Filters

Vermont Agricultural Water Quality Partnership, Scientific Advisory Committee

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Tile drainage primer

Tile drainage changes the hydrologic behavior of a field, enhancing infiltration and ground water transmission while reducing surface runoff.

Tile drainage offers many benefits, both agronomic and environmental.

In fields otherwise too wet to farm efficiently, tile drainage enables:

- Increased crop yields
- Timely equipment access
- Timely application of conservation measures
- Reduced soil erosion and compaction
- Reduced surface runoff

Downside:

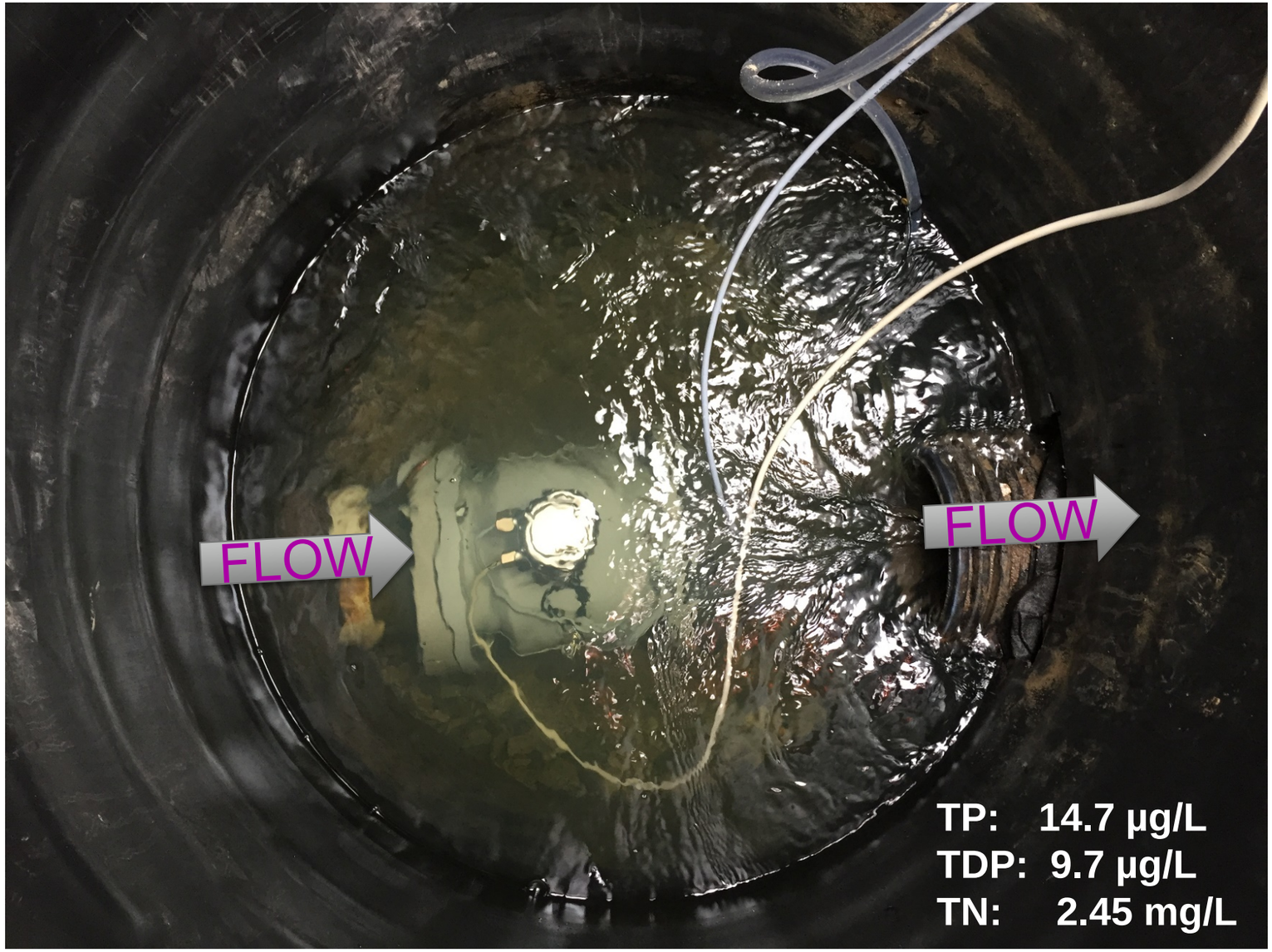
- Tile drainage provides a direct conduit from fields to receiving waters.
- Tile drainage can contribute significant amounts of P and N to surface waters

Tile drainage primer

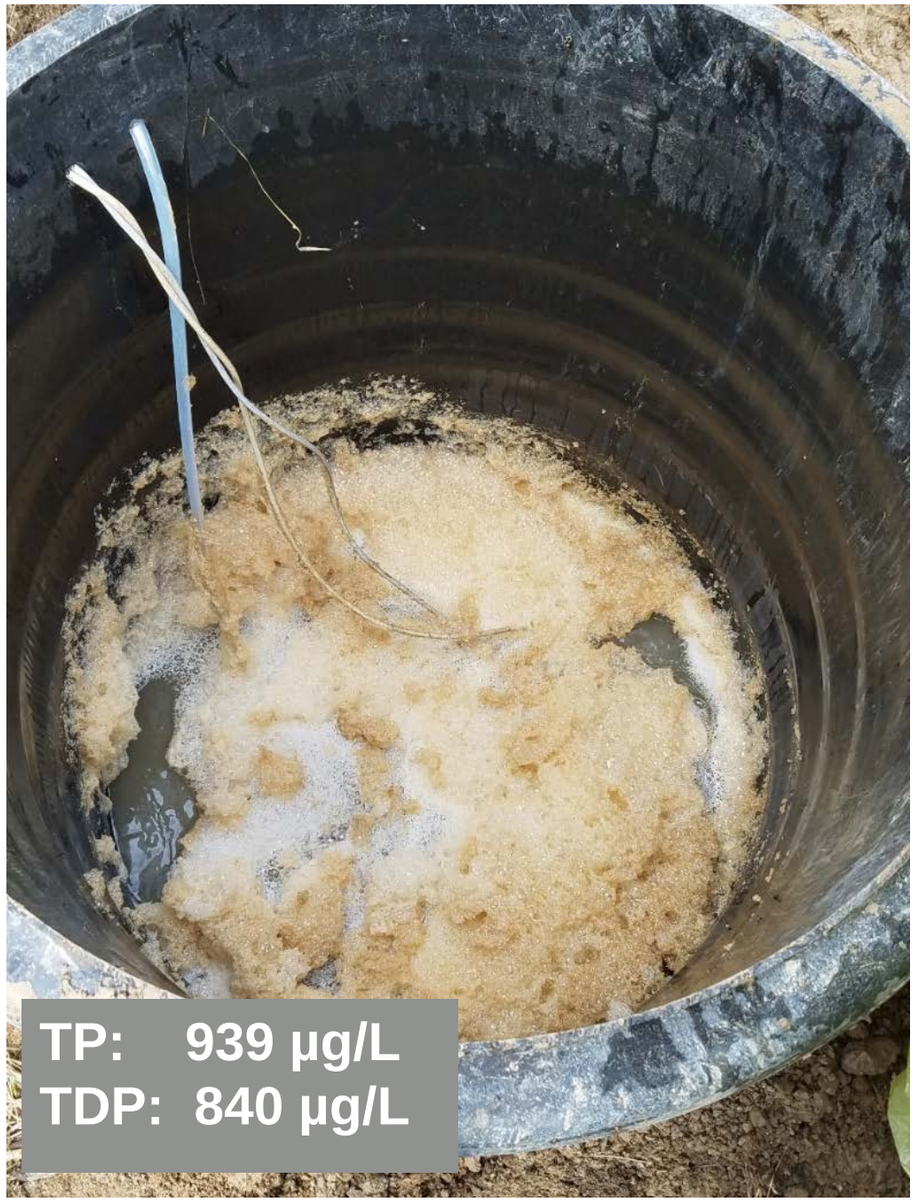
Research accelerated when links were made between the “re-eutrophication” of western Lake Erie and no-till / tile drained agriculture

JBT11 monitoring station

Electromagnetic flowmeter at JBT11



ACT4 manhole, 12/3/18



ACT3 tile outlet, 10/8/19

Annual mean P concentrations in tile discharge[1]

	[TP] (µg/L)	[TDP] (µg/L)
Range	45 – 1,166	23 – 762
Median	185	90
Mean	**260**	**141**

1. Calculated by site as total annual P load / total discharge volume

TP concentrations in JBW tile drainage comparable to ranges observed in NY, OH, WI, Quebec, and Ontario

Median Jewett Br. [TP] = 390 µg/L
St. Albans Bay target: [TP] = 17 µg/L

Annual areal P loads in tile discharge

	Areal TP load (kg/ha/yr)	Areal TDP load (kg/ha/yr)
Range	0.12 – 1.12	0.083 – 0.56
Median	0.54	0.20
Mean	**0.56**	**0.27**
95% C.I.	0.37 – 0.74	0.17 – 0.38

TP loads in JBW tile drainage comparable to loads observed in tile drainage elsewhere:

Quebec (LCB) = 0.61 kg/ha/yr
Ohio = 0.28 – 0.92 kg/ha/yr

BMPs for P in Tile Drainage

- Eliminate surface inlets
- Change depth/spacing of drainage lines
- Reduce rates of manure/nutrient applications
- Adjust timing of manure/nutrient applications
- Reduction in preferential flow paths (e.g., shallow tillage)
- Drainage water management/conservation drainage
- **Drainage water treatment with P sorbing media**

Vermont NRCS's Conservation Practice Standard:

Phosphorus Removal System (Code 782)

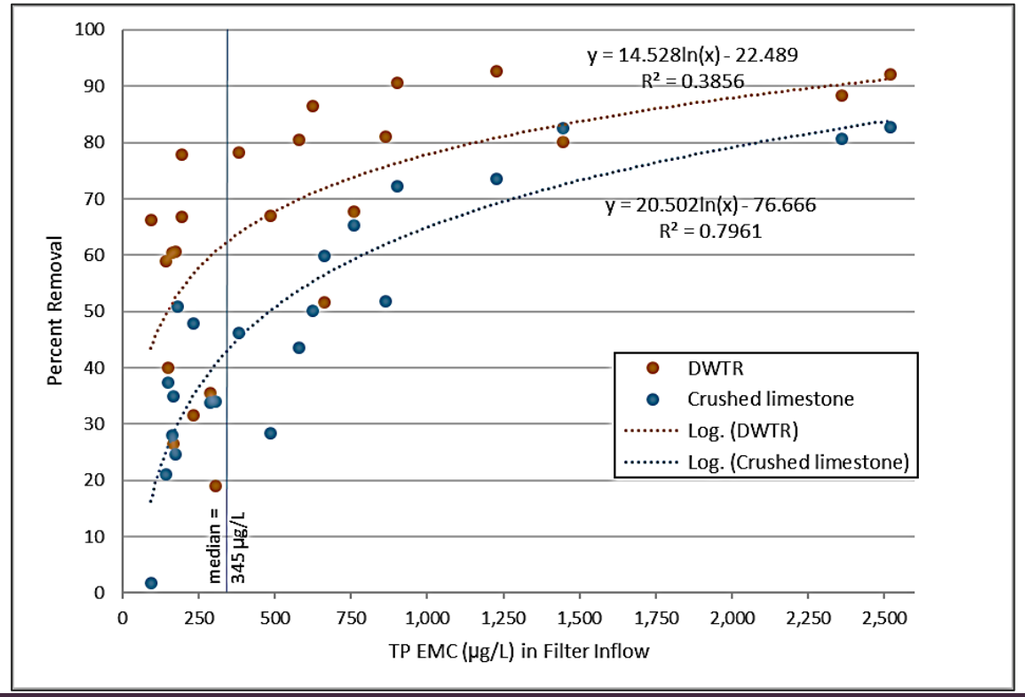
(Under Evaluation)

- Overly general technical requirements need work.
- However, this practice standard establishes the basis for implementing and funding these P removal systems through EQIP.

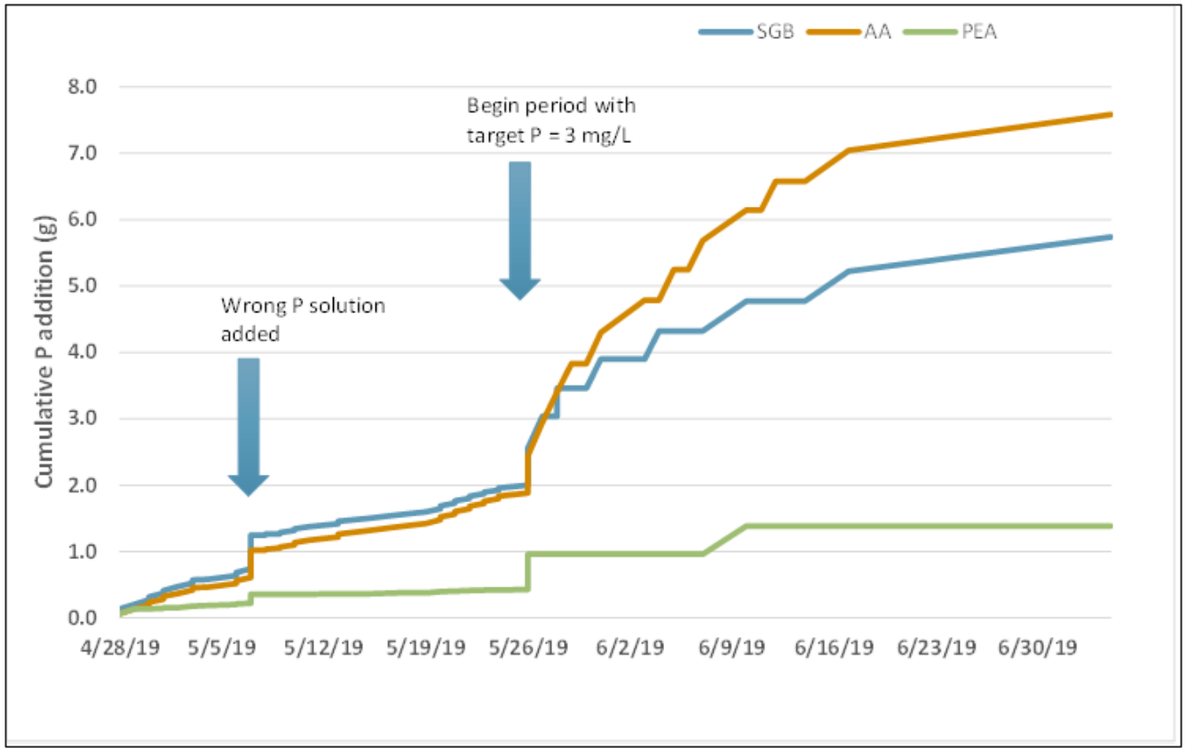
Questions we are asking in designing P filters:

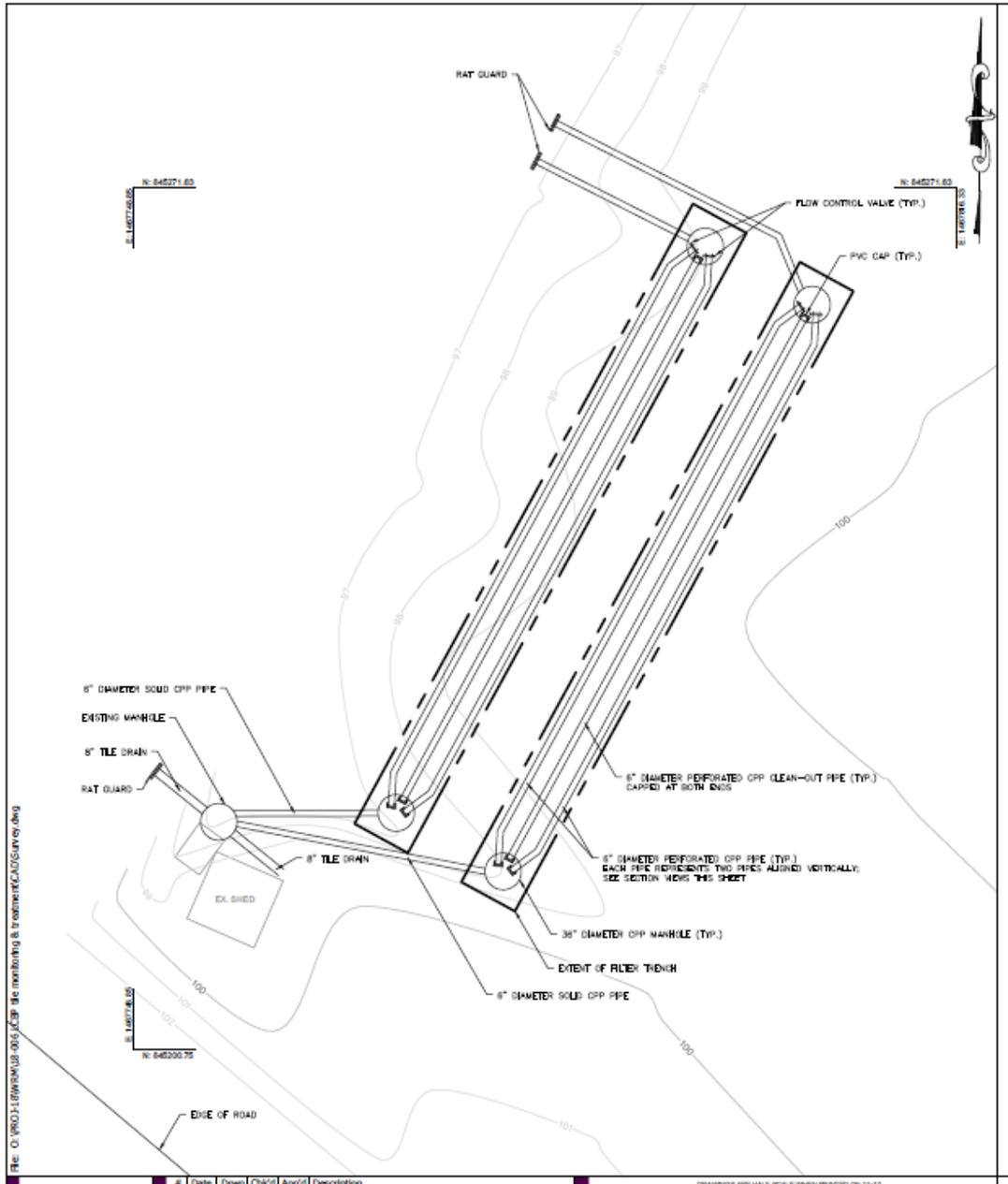
- Mass of P to be removed
- Influent P concentrations—How low can we go? Is it worth it?
- Longevity
- Cost effectiveness
- Eventual disposition of the media (replacement, removal, or leave in place)

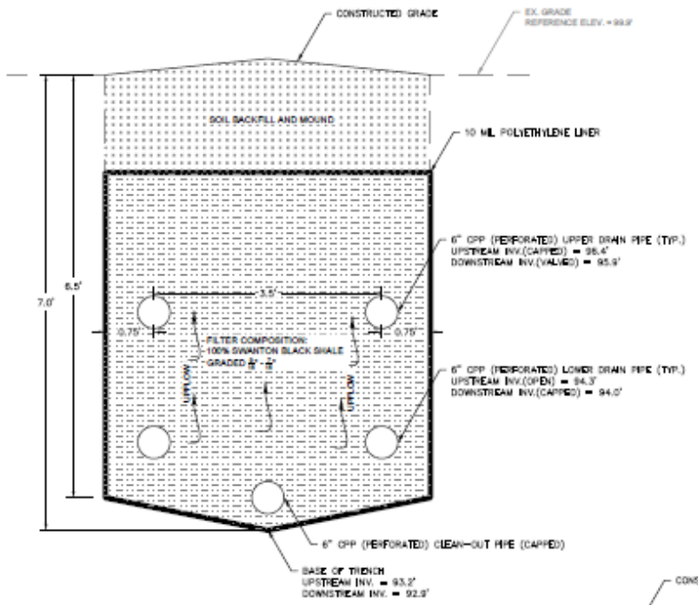
Stone's first attempt, on a farm in Franklin, VT



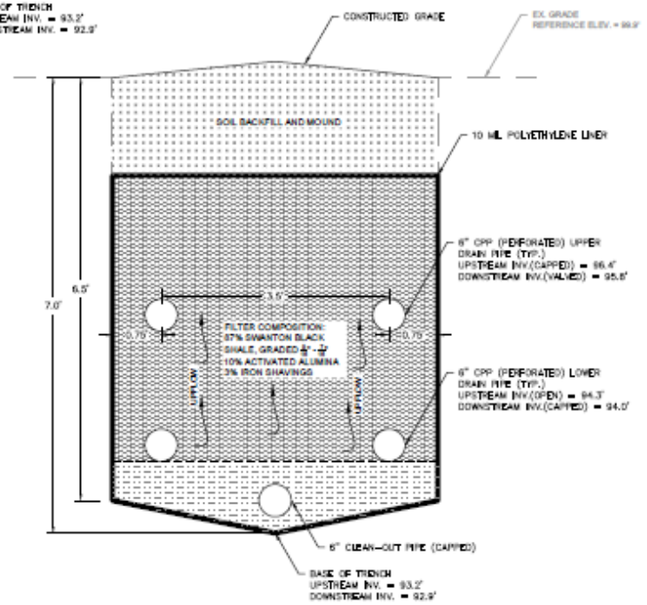
Our second attempt began in the garage







FILTER A



FILTER B

File: O:\PROJ-18\WRW\18-006\LCBP tile monitoring & treatment\CAD\Survey.dwg

DRAWING DETAILS
Drawn On: 07/14/2021
Drawn By: MLS
Checked On: 07/15/2021
Checked By: DCB
Project No.: 18-006

REVISIONS

#	Date	Drwn	Chk'd	App'd	Description

DRAWING SCALE
DRAWINGS ARE HALF SCALE WHEN PRINTED ON 11x17
1 inch = 5 feet
(1 : 60)

LCBP TILE MONITORING & TREATMENT
ST. ALBANS P FILTER
AS-BUILT PLAN
ST. ALBANS VERMONT

SHEET NO. 1

Adding stone in filter trench

Spreading and raking in activated alumina and iron

Comparison of P filters at site JBT05

P loading (2017-2018): mean TP = 168 ug/L, TP load =14 kg/yr, 77% dissolved

Design:

- Upflow media filter
- 50 ft long x 5 ft wide x 2.1 ft depth of P reactive media
- Residence time of water in filter should be almost an hour
- No power or moving parts; just hydraulics and large quantities of filter media

	Filter A	Filter B
Media	60 tons of ½-inch Swanton black shale	55 tons of ½-inch Swanton black shale (90% by vol.), 2700 lb. of activated alumina (8% by vol.), and 2000 lb. elemental iron (2% by vol.)
Total cost	$4,000	$10,000

View down filter outlet manhole

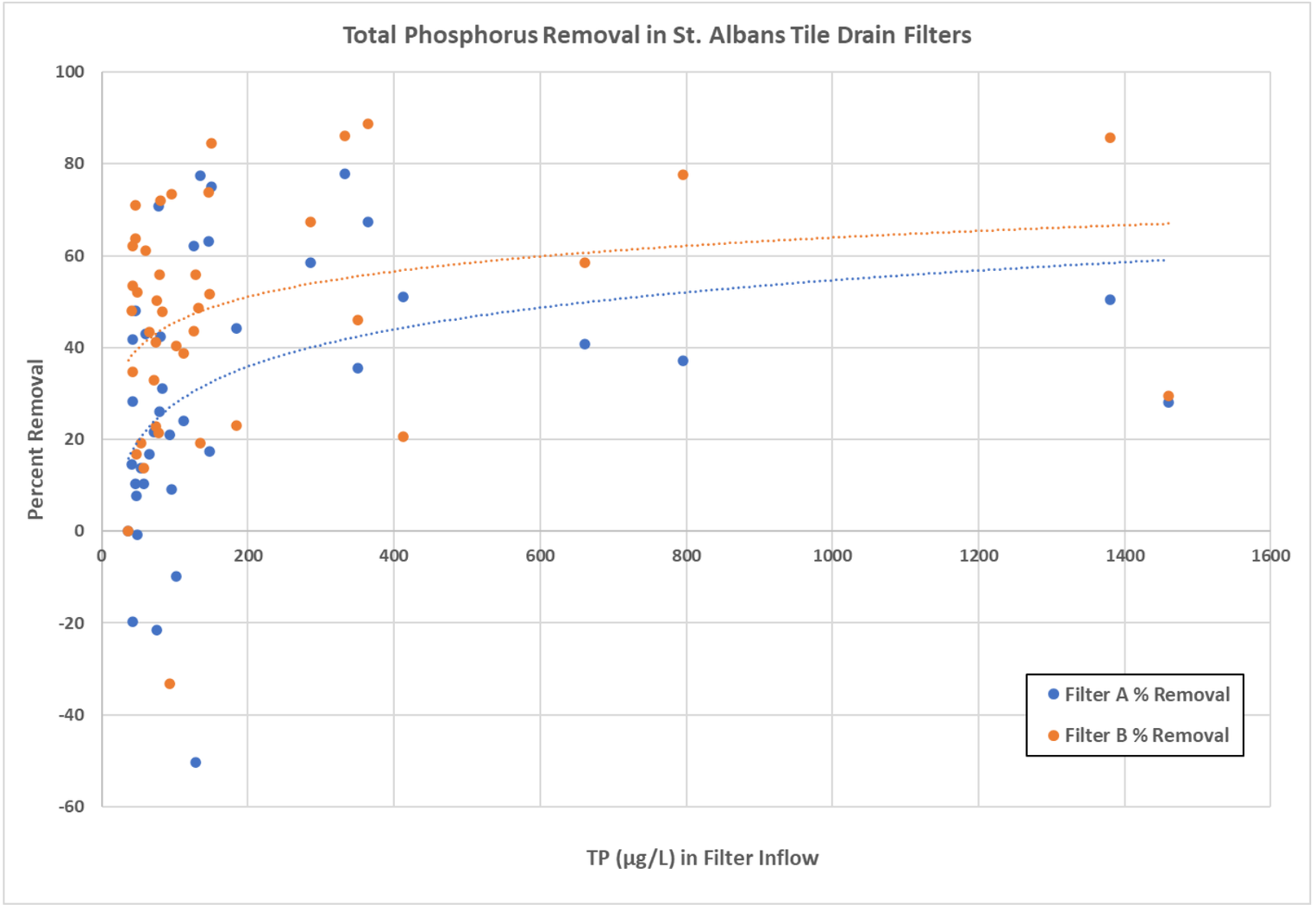
Customized autosampler installation in filter outlet manhole

St. Albans P filter performance (full report coming soon)

Substantial P removal from both filters:

Filter A (Swanton black only):
31% TP and 25% TDP Removal

Filter B (Swanton black + AA + iron):
48% TP and 45% TDP Removal



Dorset Park stormwater pond P filters in South Burlington

Dorset Park stormwater pond P filters

Filter media

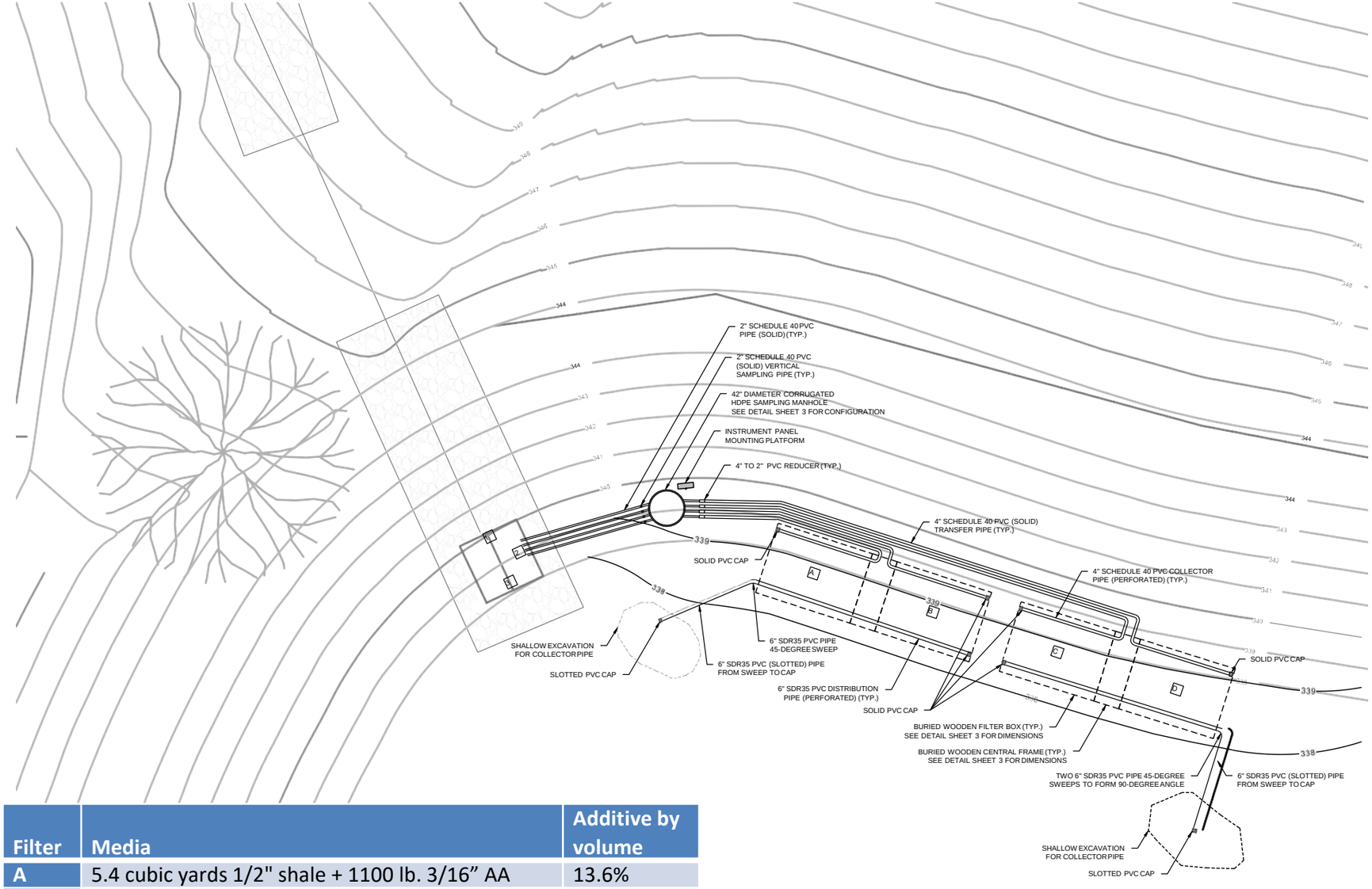
½” Swanton black shale

drinking water treatment residuals

iron shavings

activated alumina

Filter media



NOTES:

- DRAWING ON SHEET 2 IS ROTATED 90 DEGREES COUNTER-CLOCKWISE FROM DRAWING ON SHEET 1
- ALTHOUGH SHOWN WITH SOLID LINES, ALL PIPES ARE BURIED UNLESS OTHERWISE NOTED..
- 1 LABELS ARE RISER STRUCTURE FACE LABELS CORRESPONDING TO DETAILS ON SHEET 3.
- A LABELS ARE FILTER BOX LABELS CORRESPONDING TO FILTER MEDIA TABLE ON THIS SHEET

Filter	Media	Additive by volume
A	5.4 cubic yards 1/2" shale + 1100 lb. 3/16” AA	13.6%
B	6.0 cubic yards 1/2" shale	NA
C	5.4 cubic yards 1/2" shale + 88 gal. DWTR	7.5%
D	5.4 cubic yards 1/2" shale + 1800 lb. CC-1107 iron	7.6%

AS-BUILT DRAWINGS

DRAWING CREDITS

DRAWN ON: 03/14/2022
DRAWN BY: MLS
CHECKED ON: 03/15/2022
CHECKED BY: DB
PROJECT NO: 19-020

REVISIONS

#	DATE	DRWN	CHK'D	APP'D	DESCRIPTION

DRAWING SCALE

5 0 5 10 20 ft
1 0 3 5 m
1 inch = 5 feet
(1 : 60)

STONE ENVIRONMENTAL
535 Stone Cutters Way / Montpelier / VT / 05602 / USA
802.229.4541 / info@stone-env.com / www.stone-env.com

DORSET PARK STORMWATER POND P FILTER

FILTER LAYOUT

SOUTH BURLINGTON VERMONT

SHEET NO. 2

Data from the pond study are trickling in

Early findings:

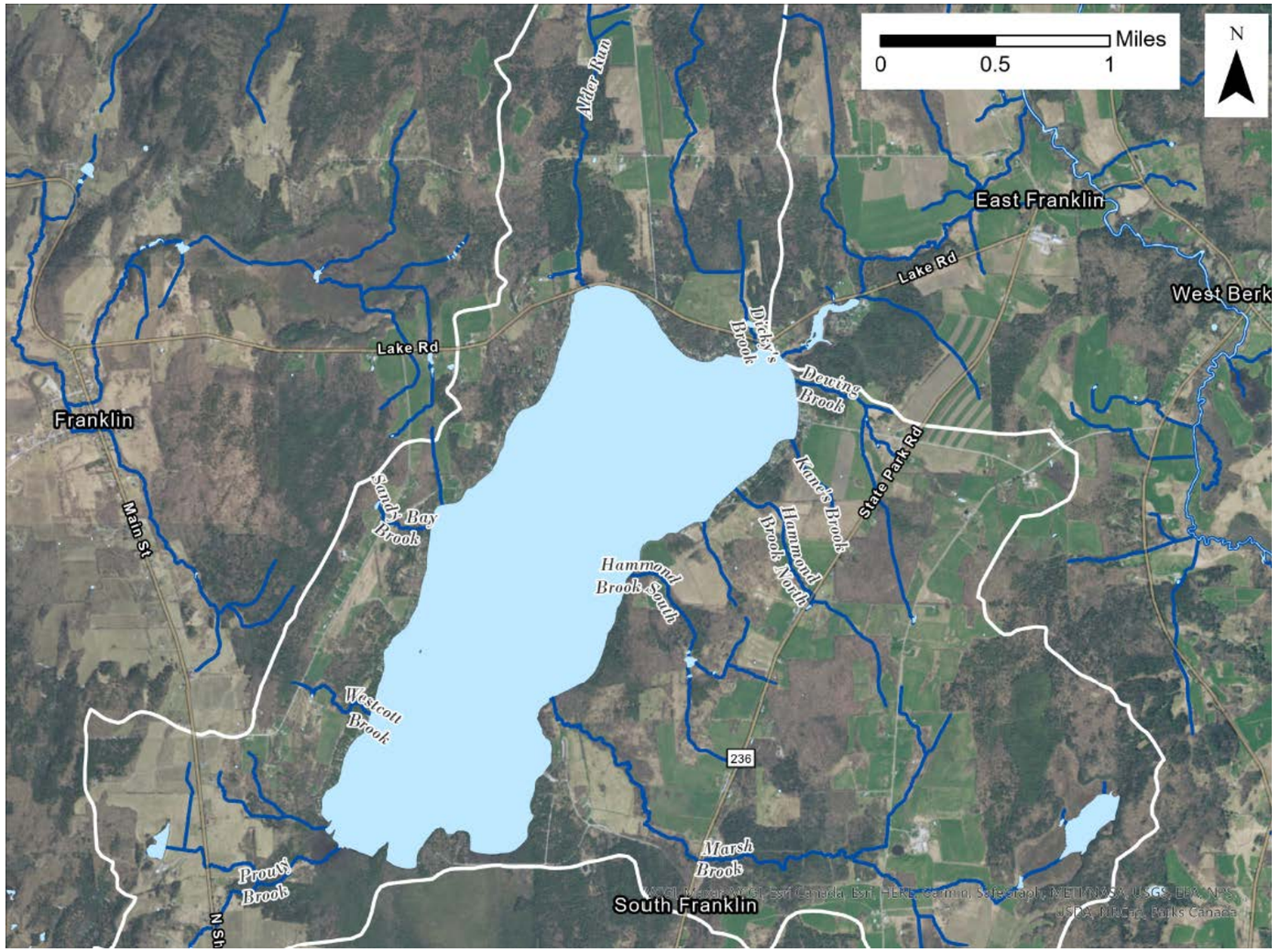
1. Encouraged by substantial filter flow rates, up to 18 gpm (68 L/min) to date, though may need to reduce flow rates to achieve adequate residence time for treatment.
2. Poor P removal seen in all filters at low influent P concentrations (<=40 µg/L)
3. Significant P removal (~40%) in all filters during a high flow period with high inflow P concentrations (100 µg/L)
4. Filter D (iron shavings) thus far achieving the lowest P concentrations

Lake Carmi tile drain P filters (construction planned for August)

Objectives:

- To reduce P loading from tile drains to Lake Carmi
- To refine the P filter design to improve performance, improve constructability, and reduce cost
- To demonstrate use of tile drain P filters to farmers

Filter	Swanton black shale	Activate alumina	Iron shavings
Filter 1	80%	17%	3%
Filter 2	80%	14%	6%
Filter 3	90%	7%	3%
Filter 4	90%	4%	6%



Some lessons learned to date

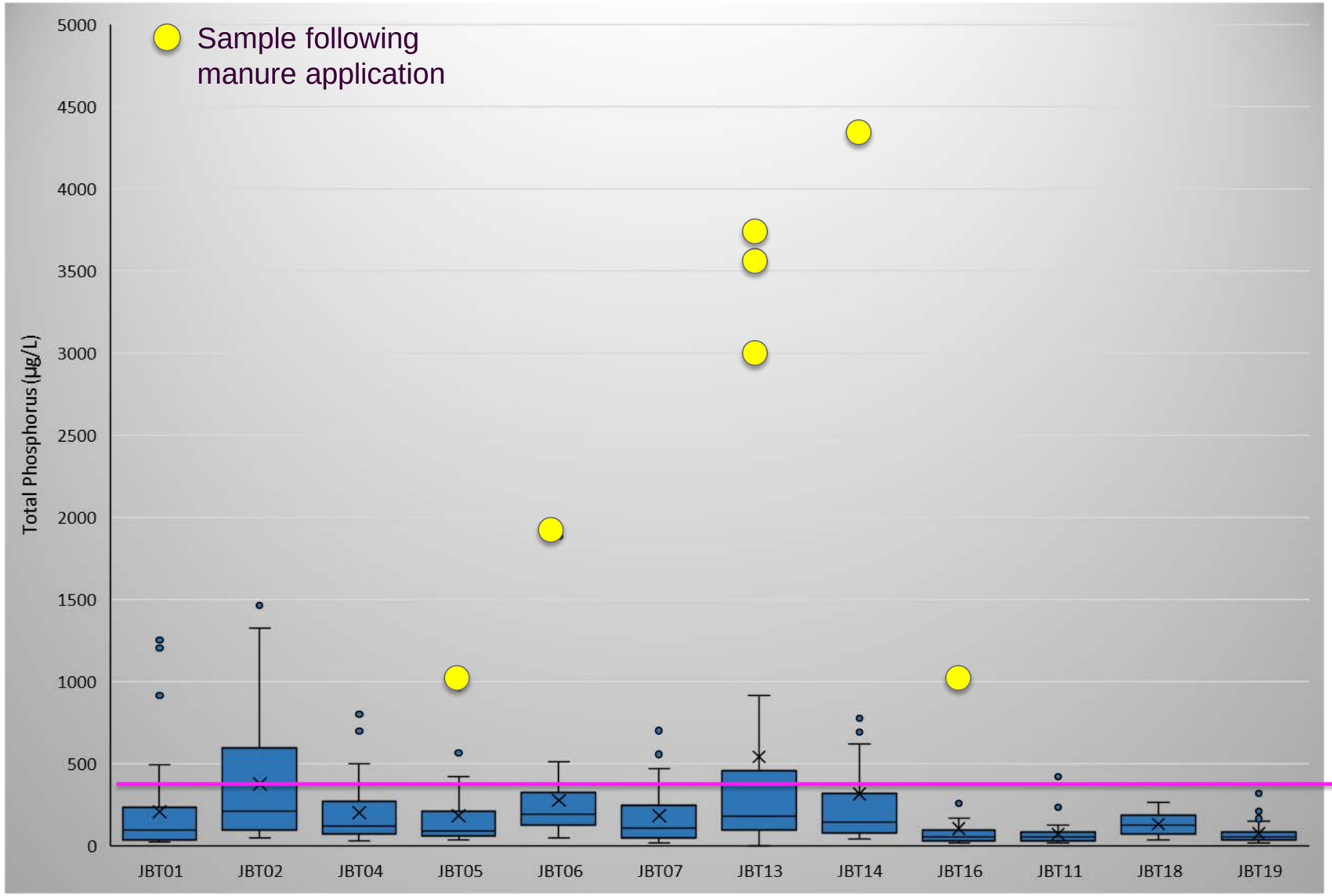
- Avoid poorly constructed tile drains (especially with holes)
- Upflow/lateral flow design is better than downflow
- Selected media must have high hydraulic conductivity
- Use perforated, rigid pipe (SDR35) for distribution and collection
- While it should be possible to design filters for most sites, avoid drains with submerged outlets if possible
- Local crushed black shale amended with zero valent iron is looking good

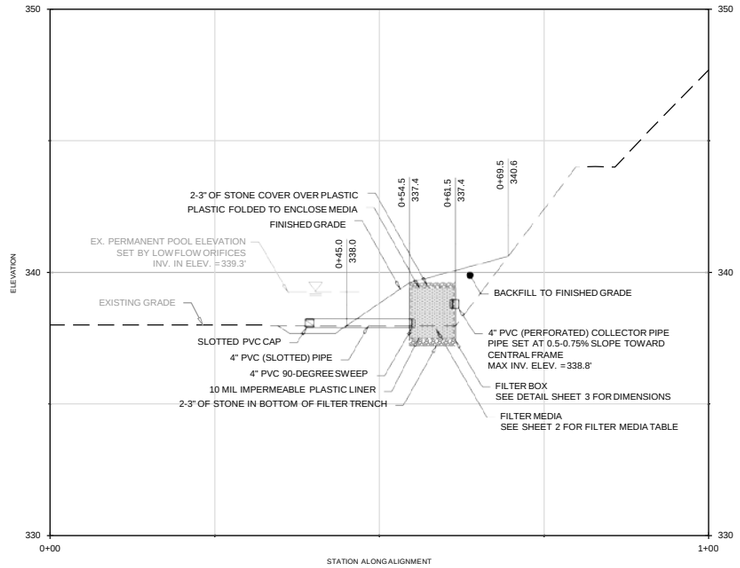
Thank you.

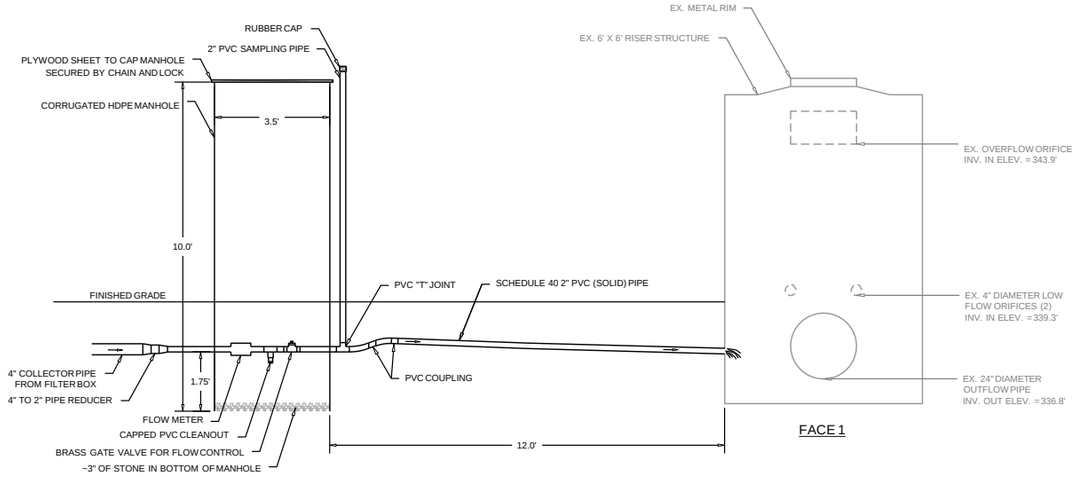
Contact: dbraun@stone-env.com

Jewett Brook Watershed tile drains—TP concentrations

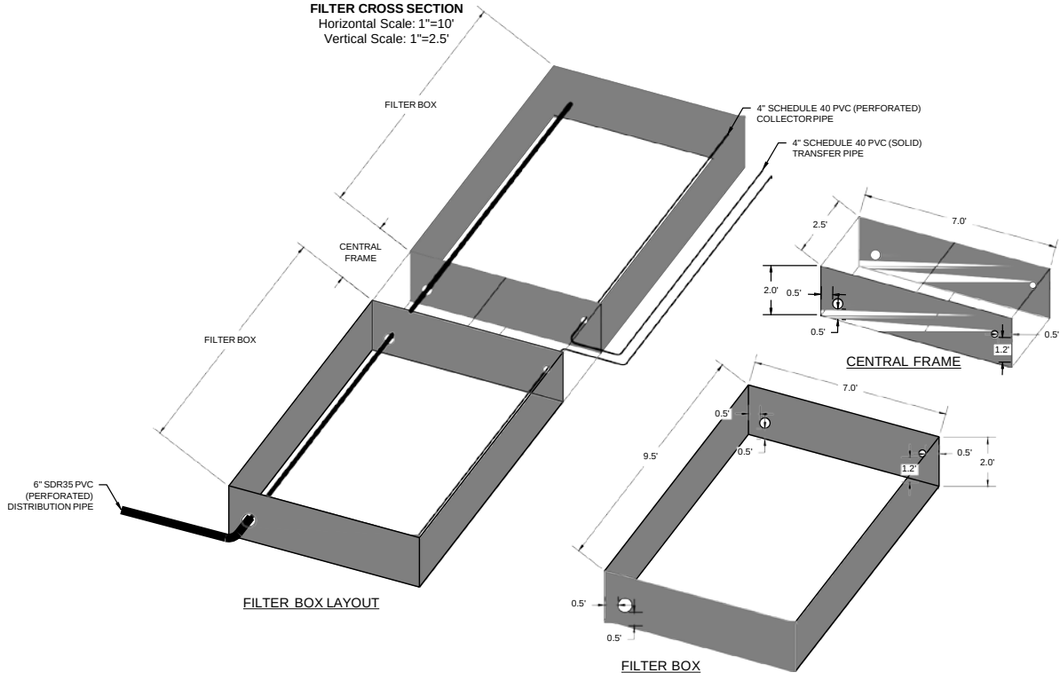
★ High outlier at JBT13 on May 16, 2017: TP=35,295 µg/L

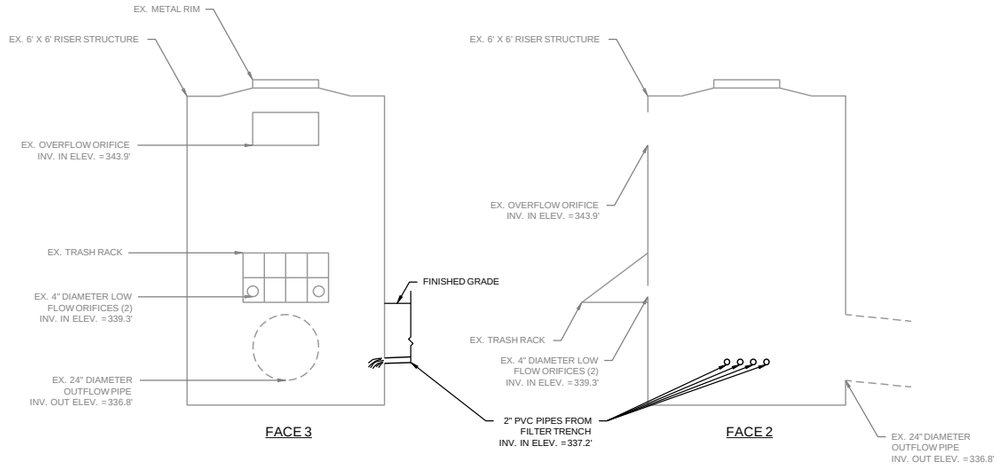






FILTER CROSS SECTION
Horizontal Scale: 1"=10'
Vertical Scale: 1"=2.5'





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DORSET PARK STORMWATER POND P FILTER

FILTER SECTION AND RISER DETAILS

SOUTH BURLINGTON VERMONT

SHEET NO. 3