Floating Treatment Wetlands for Stormwater & Wastewater Treatment

CATHERINE WIECHMANN

WATERSHED CONSULTING LLC.

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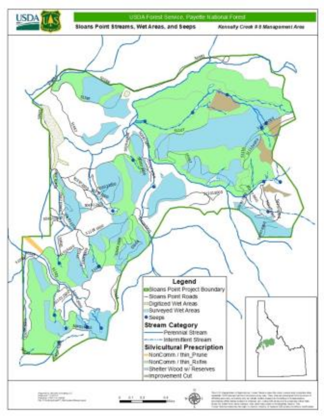
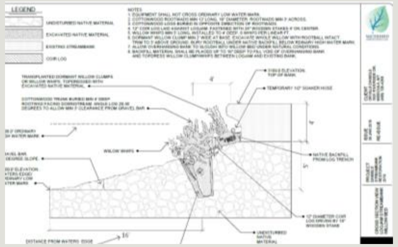
We are a natural resource consulting firm in Missoula, MT that provides comprehensive ecological assessment and restoration services in the Northern Plains and Rocky Mountains. We offer a range of services in:

- ***Ecological Assessment & Design***
- ***Restoration Design & Implementation***
- ***Wetland Assessment & Permitting/Delineation***
- ***Alternative Wastewater/Stormwater Treatments***
- ***Monitoring and Data Collection***
- ***Forestry Services***
- ***Mapping & Aerial Imagery***





What is a floating treatment wetland?

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Manmade island ecosystems that mimic natural wetlands to create a “Concentrated Wetland Effect”

Reference Floating Wetlands

Evans Creek Natural Area, Redmond WA

Floating mats in bog in Montana

Floating peat mats in NH

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Biohaven Matrix is manufactured with 100% recycled polyethylene terephthalate (PET) sourced from plastic drinking bottles.

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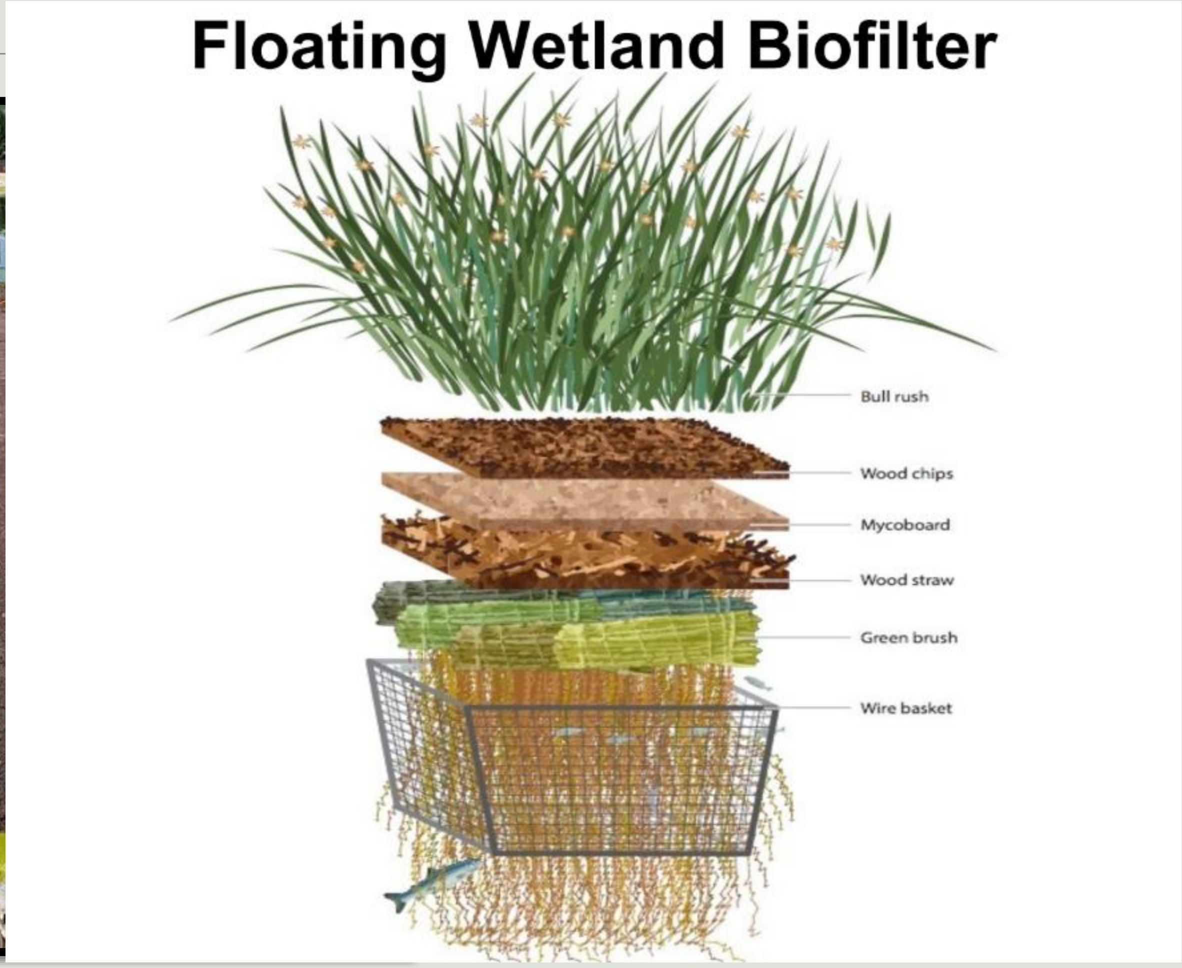

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Manmade island ecosystems that mimic natural wetlands to create a “Concentrated Wetland Effect”

Biohaven Matrix is manufactured with 100% recycled polyethylene terephthalate (PET) sourced from plastic drinking bottles.

Matrix contains planting hole to plant wetland plants.

What is a floating treatment wetland?

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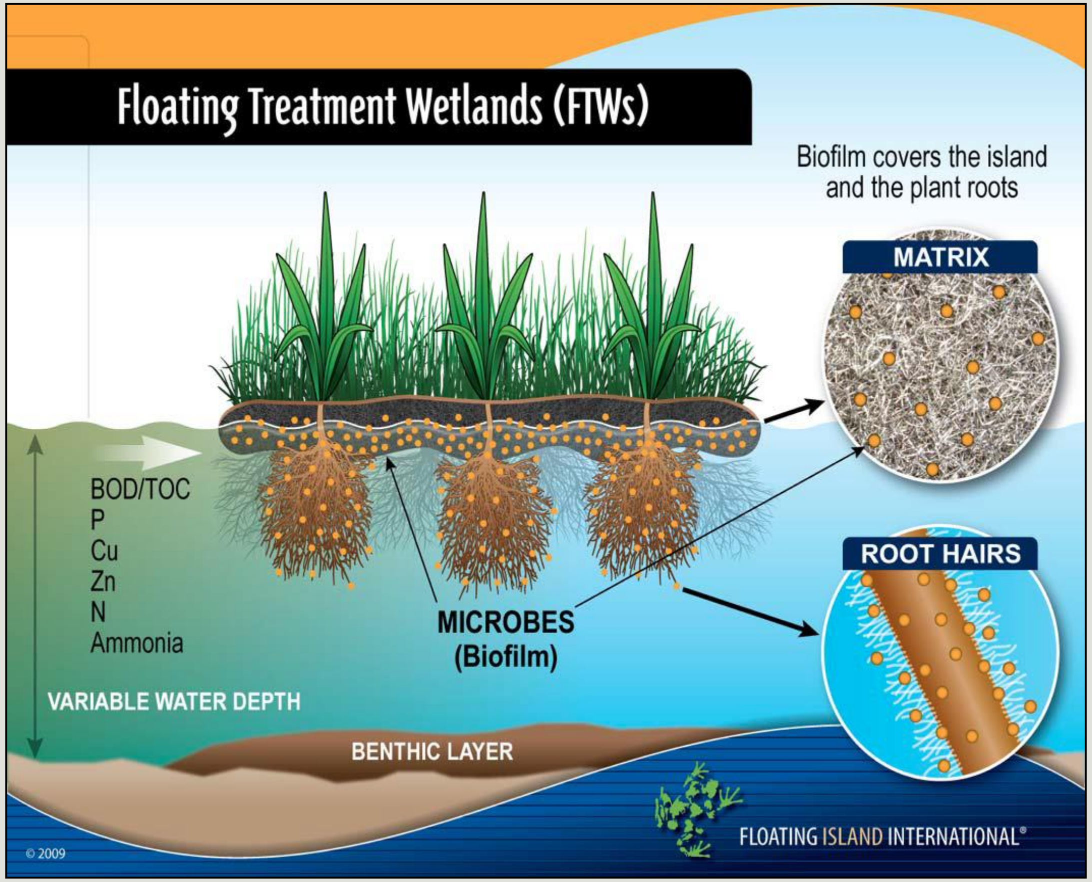
Biohaven Matrix is manufactured with 100% recycled polyethylene terephthalate (PET) sourced from plastic drinking bottles.

Anchoring/Tethering system

Matrix contains planting hole to plant wetland plants.

How do they work?

FTW matrix and plant roots provide extensive surface area ideal for underwater microbial communities (**biofilm**) that rapidly process contaminants.



How do they work?

FTW matrix and plant roots provide extensive surface area ideal for underwater microbial communities (**biofilm**) that rapidly process contaminants.

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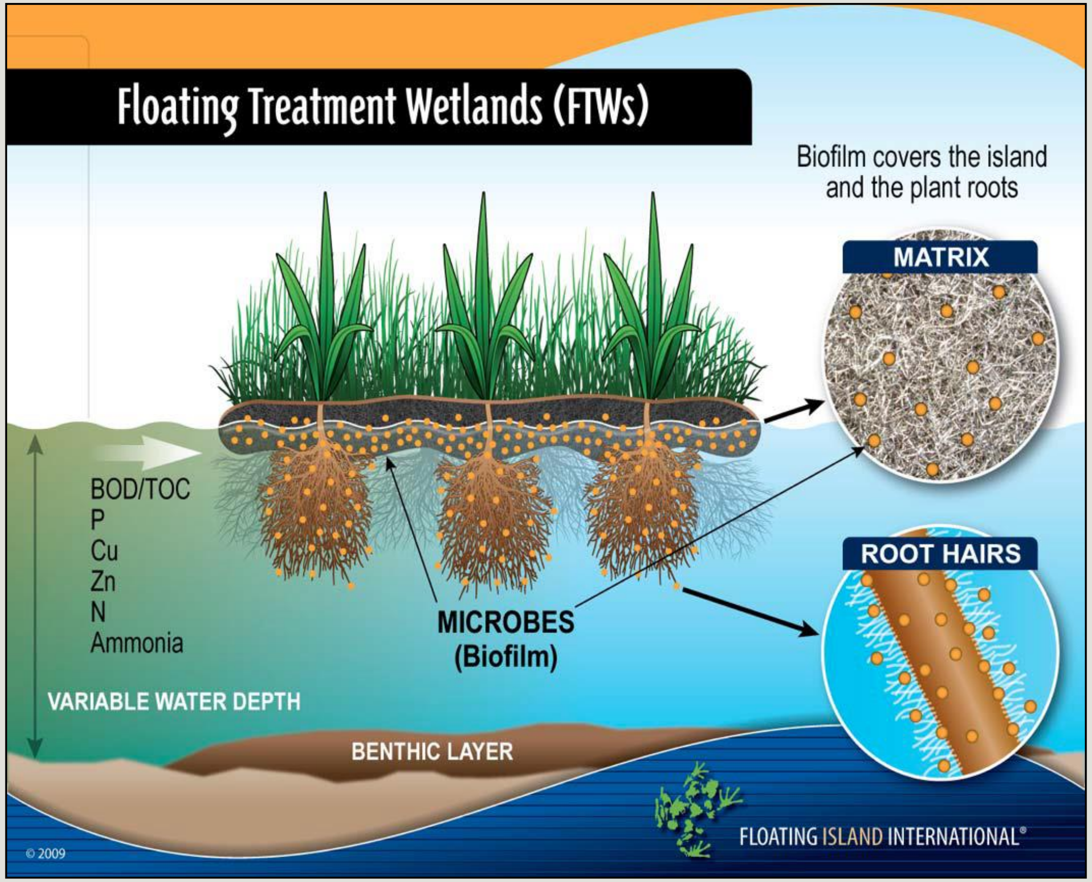
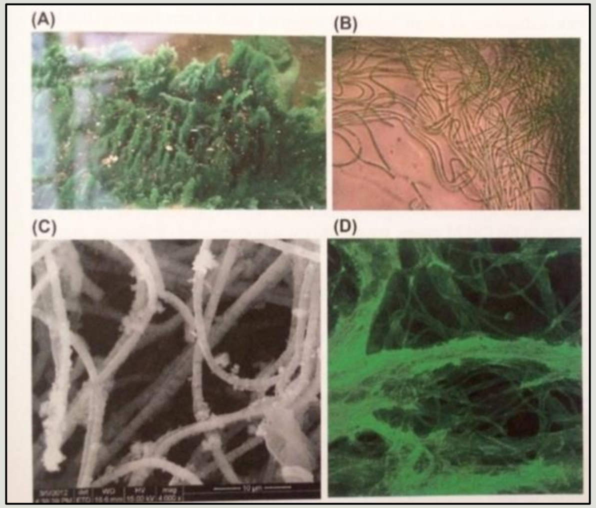
FTW matrix and plant roots provide extensive surface area ideal for underwater microbial communities (**biofilm**) that rapidly process contaminants.

Primary mechanisms for nutrient removal:

- **microbial conversion and uptake**
- plant assimilation
- *absorption into organic and inorganic substrate materials*; and
- ***volatilization.***



Biochemical and physical processes occur to absorb contaminants where they are then introduced into the food web.



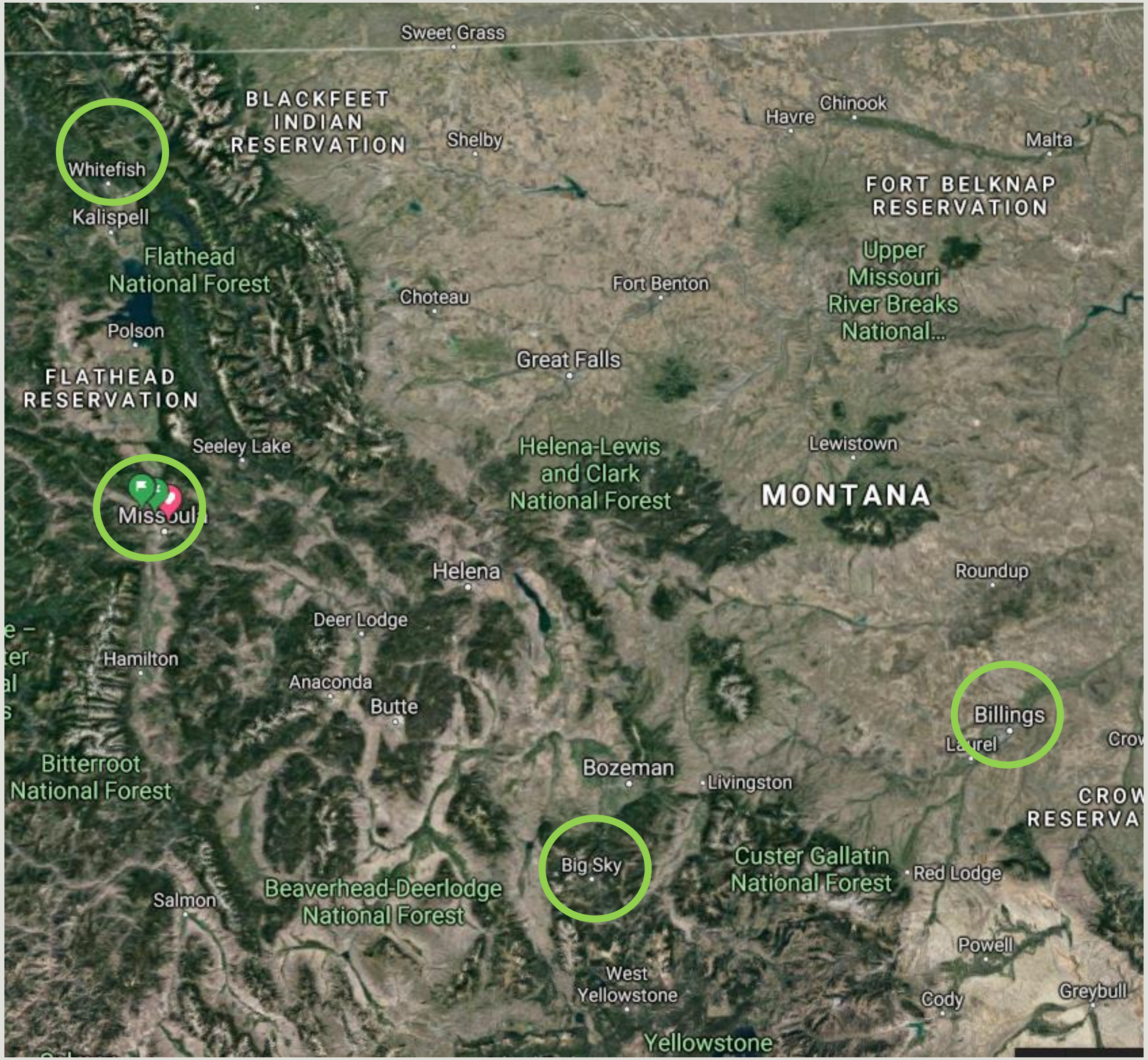
Wu. Yonghong. Periphyton: Functions and Application in Environmental Remediation.(2017) Amsterdam, Netherlands.

What is the role of Floating Treatment Wetlands (FTWs)?

FTWs represent a relatively low cost and sustainable engineered best management practice (BMP) for reducing pollution in stormwater and wastewater.

Primary uses of FTWs are water quality enhancement for stormwater, wastewater and lakes; fishery improvement; wave mitigation; and creation of waterfowl and riparian-edge wildlife habitat.

Our projects…



Wastewater Lagoon in Big Sky, MT

Partners: Lone Mtn Land Company

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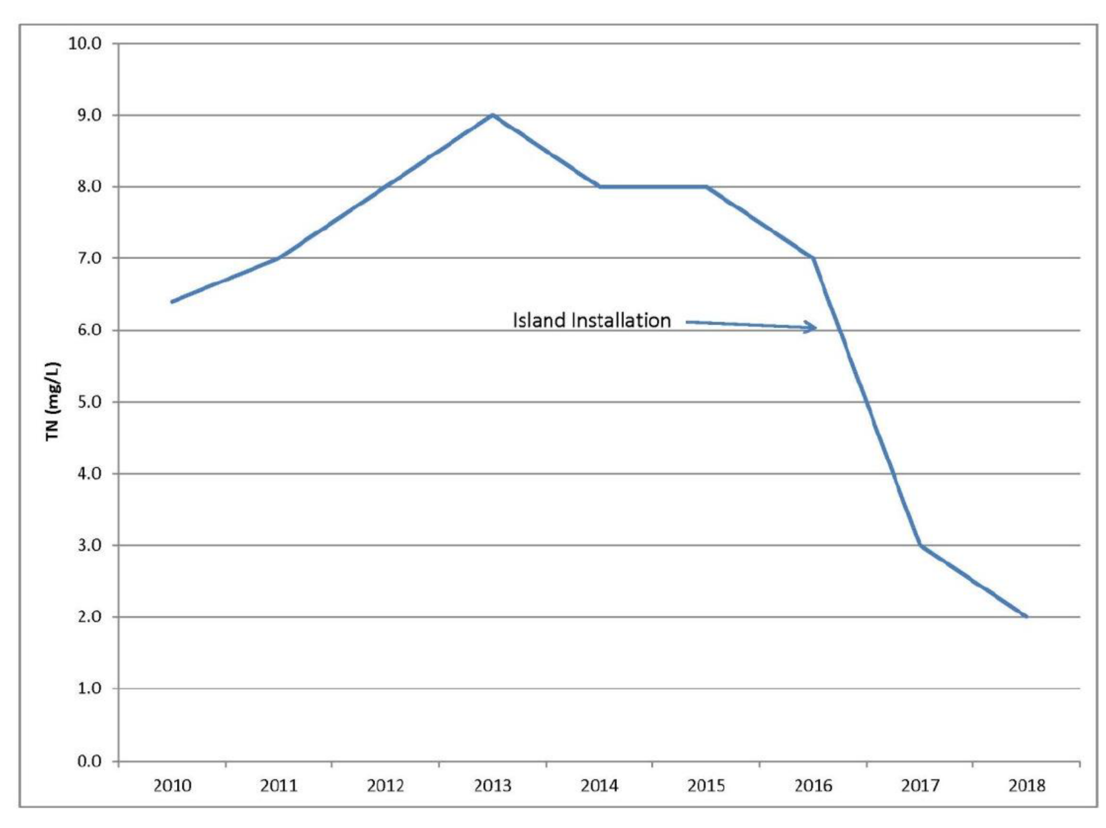
Wastewater Lagoon in Big Sky, MT

What have we learned?



Total Nitrogen levels are decreasing, likely due to increased removal of ammonia and nitrate.

Islands overwinter well!

Partners: Lone Mtn Land Company

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City of Joliet, MT Wastewater Treatment Plant

Partners: Floating Island International, MT Dept. of Environmental Quality, City of Joliet

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City of Whitefish Stormwater Pond

Stormwater pollutants:
TSS, TP, TN, Cu, Pb, Zn

Partners: City of Whitefish

City of Missoula- Pattee Creek Stormwater Pond

Partners: Watershed Education Network, City of Missoula, Missoula Stormwater Utility, Sentinel High School watershed education network

Lesson 3: Water Quality and Wetlands
Time: 60 minutes
Location: Classroom

Goals:
I. Learn about chemical and physical aspects of water quality
II. Consider environmental variables that affect water quality

Students will: 1. After playing a game and watching a powerpoint, describe the role of the nutrients phosphorus and nitrogen in aquatic systems. 2. With information from a game and a powerpoint, predict what will happen to algae when salt, coffee grounds, and detergent is added to the water. 3. Using information from a powerpoint, describe several ways to measure water quality, including conductivity, turbidity, and dissolved oxygen.	In class formative assessments: 1. Students will write a correct prediction of what will happen in each demonstration jar and explain why. Summative Assessment test: Q 2, 3, and 4—nutrients

Materials
- *Butcher paper posters*
- *Colored paper labeled organic matter, soil, algae, stonefly larvae, cattails*
- *Powerpoint*
- *Article*
- *Four Jars*
- *Pond water*
- *Used coffee grounds*
- *Detergent*
- *Salt*

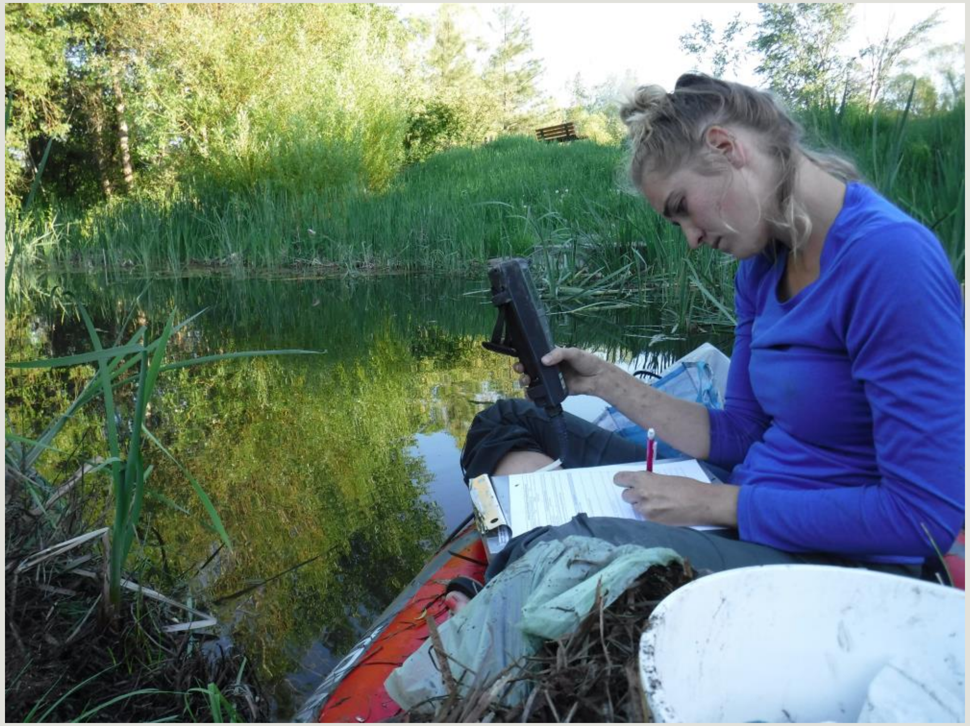
Doyle, Sylvia, 2018, University of Montana Master's Portfolio. Missoula, MT.

Tompkins, Lucy. 2018. Hall Passages: Sentinel Students Learn Nature Knows Best. *The Missoulian*. Missoula, MT.
Photographer: Chelsea Culp

High School Curriculum Surrounding Stormwater & Wetlands

Future

- Standardize monitoring and data collection.
- Increase partnerships with local schools, government agencies and private businesses.
- Creatively secure funding.
- Continue to learn about the application of this technology in various contexts.



Acknowledgements

Partners

Watershed Education Network

City of Missoula- Missoula Stormwater Utility

City of Whitefish

Sentinel High School

Montana Department of Environmental Quality

Colleagues

Watershed Consulting: Patrick Hurley, Christine Brissette, Lauren Sullivan, Marnie Criley, Mark Vander-Meer

Watershed Education Network: Deb Fassnacht, Rebecca Paquette, Sylvia Doyle

Floating Island International: Bruce Kania, Anne Kanie, Alicia Pettys, Mark Reinsel

Questions?

Hybrid poplar stand after 8 years growth.

Table 2
Dataset for ammonium-nitrogen, total nitrogen and total phosphorus removal rates.

Reference	Plant sp.	Vegetation cover	Depth (m)	HLR (m/d)	HRT (d)	NH_4-N			Total nitrogen			Total phosphorus		
						In (mg/L)	Out (mg/L)	Removal (%)	In (mg/L)	Out (mg/L)	Removal (%)	In (mg/L)	Out (mg/L)	Removal (%)
[22]	*Canna* sp.	1.00	1.20	0.12	5.00	2.75	0.00	100.00	8.71	4.32	50.40	[a]	[a]	[a]
	Blank	0.00	1.20	0.12	5.00	2.80	1.35	51.79	8.71	6.56	24.68	[a]	[a]	[a]
[16]	*Carex* sp.	0.50	1.20	0.164	11.00	16.10	10.80	32.92	21.8	13.1	39.91	2.16	1.77	18.06
	Blank	0.00	1.20	0.164	11.00	16.10	16.50	−2.48	21.8	19.5	10.55	2.16	1.90	12.04
[50]	*Ipomonea aquatica*	1.00	1.10	0.063	16.00	[a]	[a]	[a]	20.00	4.90	75.50	[a]	[a]	[a]
	Blank	0.00	1.10	0.063	16.00	[a]	[a]	[a]	20.00	8.90	55.50	[a]	[a]	[a]
	Ipomonea aquatica	1.00	1.10	0.125	8.00	[a]	[a]	[a]	31.96	19.52	38.92	[a]	[a]	[a]
	Blank	0.00	1.10	0.125	8.00	[a]	[a]	[a]	31.96	11.62	63.64	[a]	[a]	[a]
	Ipomonea aquatica	1.00	1.10	0.250	4.00	[a]	[a]	[a]	29.40	27.00	8.16	[a]	[a]	[a]
	Blank	0.00	1.10	0.250	4.00	[a]	[a]	[a]	29.40	22.80	22.45	[a]	[a]	[a]
	Ipomonea aquatica	1.00	1.10	0.375	2.70	[a]	[a]	[a]	29.40	26.70	9.18	[a]	[a]	[a]
	Blank	0.00	1.10	0.375	2.70	[a]	[a]	[a]	29.40	25.90	11.90	[a]	[a]	[a]
	Ipomonea aquatica	1.00	1.10	0.500	2.00	[a]	[a]	[a]	31.96	26.60	16.78	[a]	[a]	[a]
	Blank	0.00	1.10	0.500	2.00	[a]	[a]	[a]	31.96	25.90	18.96	[a]	[a]	[a]
	Ipomonea aquatica	1.00	1.10	0.625	1.60	[a]	[a]	[a]	20.00	19.20	4.00	[a]	[a]	[a]
	Blank	0.00	1.10	0.625	1.60	[a]	[a]	[a]	20.00	19.20	4.00	[a]	[a]	[a]
[25]	*Vetiveria zizanoides* (L.)	0.55	0.50	0.104	7.00	30.14	15.00	50.23	38.40	19.40	49.48	5.20	4.10	21.15
	Vetiveria zizanoides (L.)	0.55	0.50	0.104	7.00	32.70	14.70	55.05	46.92	19.90	57.59	6.26	4.30	31.31
	Vetiveria zizanoides (L.)	0.55	0.50	0.145	5.00	30.14	18.50	38.62	38.40	23.50	38.80	5.20	4.50	13.46
	Vetiveria zizanoides (L.)	0.55	0.50	0.145	5.00	32.69	19.40	40.66	46.92	23.00	50.98	6.26	5.20	16.93
	Vetiveria zizanoides (L.)	0.55	0.50	0.242	3.00	30.14	23.60	21.70	38.40	30.00	21.88	5.20	4.40	15.38
	Vetiveria zizanoides (L.)	0.55	0.50	0.242	3.00	32.69	25.70	21.38	46.92	28.10	40.11	6.26	4.80	23.32
[39]	*Canna* sp.	1.00	0.20	0.06	1.00	110.70	72.10	34.87	[a]	[a]	[a]	[a]	[a]	[a]
	Cyperus sp.	1.00	0.20	0.06	1.00	110.70	83.50	24.57	[a]	[a]	[a]	[a]	[a]	[a]
	Canna sp.	1.00	0.20	0.03	2.00	110.70	64.50	41.73	[a]	[a]	[a]	[a]	[a]	[a]
	Cyperus sp.	1.00	0.20	0.03	2.00	110.70	74.30	32.88	[a]	[a]	[a]	[a]	[a]	[a]
[47]	*Fragmites* sp.	1.00	0.30	0.005	5.00	62.10	1.31	97.89	[a]	[a]	[a]	3.50	0.88	74.86
	Blank	0.00	0.30	0.005	5.00	62.10	3.00	95.17	[a]	[a]	[a]	3.50	2.07	40.86
[49]	*Cyperus* sp.	1.00	0.43	0.242	5.00	28.90	7.10	75.43	58.50	16.10	72.48	[a]	[a]	[a]
	Miscanthidium violaceum	1.00	0.43	0.242	5.00	28.90	11.10	61.59	58.50	17.90	69.40	[a]	[a]	[a]
	Blank	0.00	0.43	0.242	5.00	28.90	20.80	28.03	58.50	43.50	25.64	[a]	[a]	[a]
[48]	*Cyperus* sp.	1.00	0.35	0.115	2.70	19.10	7.60	60.21	31.00	10.30	66.77	23.80	9.10	61.76
	Miscanthidium violaceum	1.00	0.35	0.115	2.70	19.10	10.10	47.12	31.00	13.40	56.77	23.80	14.10	40.76
	Blank	0.00	0.35	0.115	2.70	19.10	10.70	43.98	31.00	14.90	51.94	23.80	13.30	44.12
[30]	*Oenanthe javanica*	0.56	0.48	0.014	15.00	8.37	0.46	94.56	18.32	1.59	91.32	0.80	0.34	58.00
[28]	*Oenanthe javanica*	1.00	0.38	0.0035	35.00	9.33	0.31	96.68	12.58	1.16	90.78	0.68	0.16	76.47
	Blank	0.00	0.38	0.0035	35.00	9.33	2.79	70.10	12.58	4.35	65.42	0.68	0.45	33.82
[13]	*Ipomonea aquatica*	0.14	1.80	0.16	7.00	2.16	1.13	47.69	5.15	1.96	61.94	0.97	0.36	62.90
	Ipomonea aquatica	0.14	1.80	0.22	5.00	2.16	1.30	39.82	5.15	2.29	55.53	0.97	0.43	55.67
	Ipomonea aquatica	0.14	1.80	0.37	3.00	2.16	1.50	30.56	5.15	2.80	45.63	0.97	0.51	47.42
[37]	*Oenanthe javanica*	1.00	0.75	0.200	3.00	[a]	[a]	[a]	3.76	2.59	31.12	1.25	1.17	6.40
	Oenanthe javanica	1.00	0.75	0.300	2.00	[a]	[a]	[a]	4.57	2.95	35.45	1.35	1.16	14.07
	Oenanthe javanica	1.00	0.75	0.600	1.00	[a]	[a]	[a]	7.94	2.86	63.98	1.54	1.34	13.00
[10]	*Cyperus* sp.	1.00	0.32	0.030	7.00	73.05	27.15	62.84	90.20	38.90	56.87	34.85	16.00	54.09
	Colocasia Esculenta	1.00	0.32	0.030	7.00	70.01	37.55	46.37	89.30	56.75	36.45	34.1	20.00	41.35
	Blank	0.00	0.32	0.030	7.00	69.30	60.90	12.12	88.85	83.60	5.91	31.5	31.05	1.43
[15]	*Canna sp* & *Juncus* sp.	0.95	0.51	0.190	3.00	[a]	[a]	[a]	0.85	0.14	83.53	0.08	0.02	75.00
	Canna sp & *Juncus* sp.	0.95	0.51	0.190	3.00	[a]	[a]	[a]	1.88	0.79	58.00	0.22	0.12	45.45
[19]	*Lolium multiflorum*	1.00	0.40	0.009	35.00	[a]	[a]	[a]	17.00	3.16	81.41	1.84	0.19	89.51
	Blank	0.00	0.40	0.009	35.00	[a]	[a]	[a]	17.40	5.36	69.20	2.16	0.62	71.30

[a] No data.

Table 1
Summary of CFWs studies for treatment of various water/wastewater types, presenting author, scale of experiment, type of water/wastewater, plant species, average nutrient removal efficiency, and location.

Study	Scale	Water/WW type	Plant species used	Average removal rates (%)	Location
[9]	Batch	Synthetic wastewater	*Lolium perenne* L. *Daytona*	COD: 85; TN: 45.3–57.9; NH_4: 86.5–92.7	China
[10]	Microcosm	Primary treated sewage	*Cyperus papyrus* *Colocasia esculenta*	TN: 90.4; NH_4: 89.3; TP: 84.5 TN: 67.8; NH_4: 68.8; TP: 63.8	Uganda
[11]	In situ application	River water	*Equisetum* sp., *Ipomoea aquatic Forsk*	COD: 79.3; NH_4: 83.6; TP: 87.5	China
[12]	In situ application	Aquaculture effluent and river water	*Chrysopogon zizanioides, Typha latifolia, Sparganium erectum*	COD: 66; BOD_5: 52; TP: 65	Italy
[13]	Mesocosm	Lake water	*Ipomonea aquatica*	TN: 66.4–76.5; NH_4 : 58.7–68.9; TP: 45.7–61.7	China
[14]	Microcosm	River water	*Festuca arundinacea*	TN: 90.1; NH_4: 86.3; TP: 72.1	China
[15]	Mesocosm	Lake water enriched with nutrient solution	*Canna flaccid, Juncus effuses*	TN: 58–83.5; TP: 45.5–75	South Carolina, USA
[16]	Mesocosm	Raw domestic wastewater	*Carex*>95%	COD: 52.9; TN: 42.3; NH_4: 34.9; TP: 22.1	Belgium
[17]	Mesocosm	Refinery wastewater	*Lolium perenne Caddieshack* *Lolium perenne Topone* *Lolium perenne* L. *Geophila herbacea O Kumtze*	COD: 62.2; TN: 62.2; TP: 63.1 COD: 66; TN: 69.5; TP: 72.3 COD: 62.6; TN: 64.1; TP: 68.5 COD: 52.2; TN: 59.1; TP: 55.7	China
[18]	Mesocosm	Nutrient solution	*Iris pseudacorus* *Typha angustifolia*	TN: 98; TP: 92 TN: 57; TP: 23	Netherlands
[19]	Mesocosm	Swine wastewater	*Lolium multiflorum Lam 'Dryan'* *Lolium multiflorum Lam 'Waseyutaka"* *Lolium multiflorum Lam 'Tachimasari'*	COD: 83.4; TN: 84; TP: 90.4 COD: 80.7; TN: 80.3; TP: 89.9 COD: 85.4; TN: 79.6; TP: 88.3	China
[20]	Mesocosm	Anaerobically digested flushed dairy manure wastewater	*Eichhornia crassipes*	TN: 84.5–91.7; NH_4 ; 99.6; TP: 82–98.5	Florida, USA
[21]	Mesocosm	Domestic wastewater	*Typha angustifolia* *Canna iridiflora*	BOD_5 : 48.5–76.1; NH_4: 50–86.4 BOD_5 : 63.5–85; NH_4: 58.4–81.6	Shri Lanka
[22]	Mesocosm	River water	*Canna* sp.	TN: 50.4; NH_4: 100	China
[23]	Mesocosm	Meat processing wastewater	*Glyceria maxima*	TN: 46–49	New Zealand
[24]	Mesocosm	Nutrient solution	*Canna* sp., *Calamus* sp.	TN: 76.94; NH_4: 93.50 (removal rates for batch experiment and rice straw substratum)	China
[25]	Mesocosm	Domestic wastewater	*Vetiveria zizanoides* (L.) *Nash*	BOD_5 : 62.02–91.89; TN: 21.9–57.6; NH_4: 21.4–55; TP: 13.5–31.3	Thailand
[26]	Mesocosm	Fertilizer	*Thailand angustifoliate cultivar* *Jiangxi big leafage cultivar* *Panteng native cultivar*	NH_4: 86–99 NH_4: 83–88 NH_4: 81–90	China
[27]	Mesocosm	Lake water	*Ipomonea aquatica*	TN: 30.7; TP: 38.2	China
[28]	Mesocosm	River water	*Oenanthe javanica*	TN: 90.8; NH_4: 96.7; TP: 76.5	China
[29]	Mesocosm	Eutrophic pool water	*Lolium perenne var Top One* *Lollium perenne var. Respect*	COD: 66.8; TN: 55.6; NH_4: 62.8; TP: 87.1 TN: 40.1	China
[30]	Mesocosm	River water	*Oenanthe javanica*	TN: 91.3; NH_4: 94.6; TP: 58	China
[31]	Mesocosm	Stormwater	*Juncus effusus* and *Pontederia cordata*	TN: 15.7; TP: 47.7	Florida, USA
[32]	Microcosm	Eutrophic pool water	*Oenanthe javanica D.C* and *Nasturtium officinale*	BOD_5 : 83	China
[33]	Microcosm	Nutrient solution	*Canna generalis* *Scirpus validus* *Alternanthera philoxeroides* *Thalia geniculata* *Cyperus alternifolius*	COD: 58.2; BOD_5: 33.2; TN: 76.3; NH_4: 83.8; TP: 81.4 COD: 56.2; BOD_5: 32; TN: 90.5; NH_4: 75.8; TP: 80.8 COD: 69.7; BOD_5: 39.7; TN: 86; NH_4: 82.3; TP: 85.7 COD: 54.1; BOD_5: 30.8; TN: 54.5; NH_4: 84.3; TP: 78.9 COD: 40.5; BOD_5: 23.1; TN: 72.7; NH_4: 89.5; TP: 82.3	China
[34]	Microcosm	Synthetic river water	*Typha orientalis, Phragmites australis, Scirpus validus, Iris*	TN: 64; NH_4: 90.3; TP: 61	China