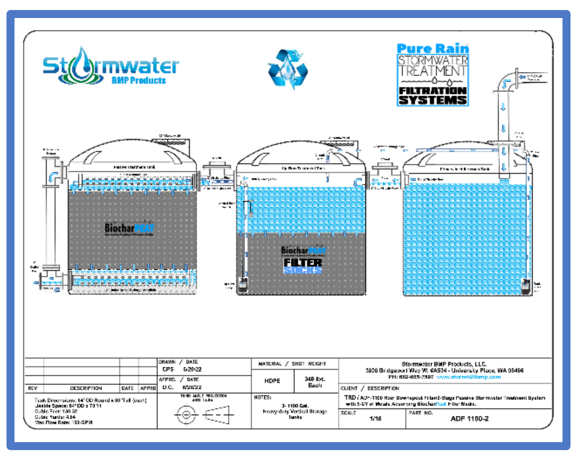
Stormwater BMP Products

Pure Rain™ STORMWATER TREATMENT FILTRATION SYSTEMS

Industrial Stormwater Treatment



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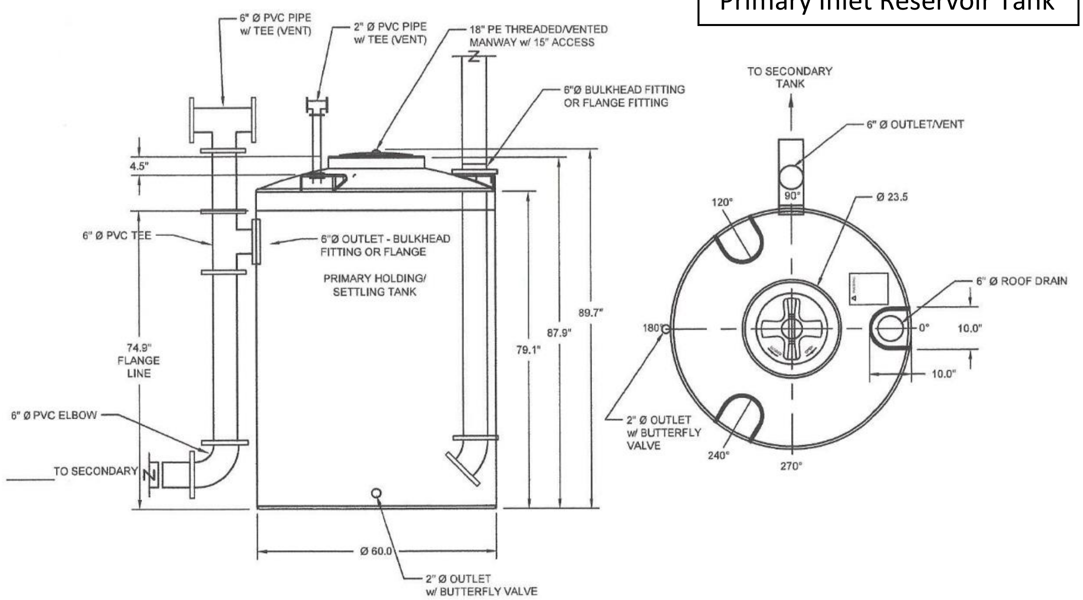
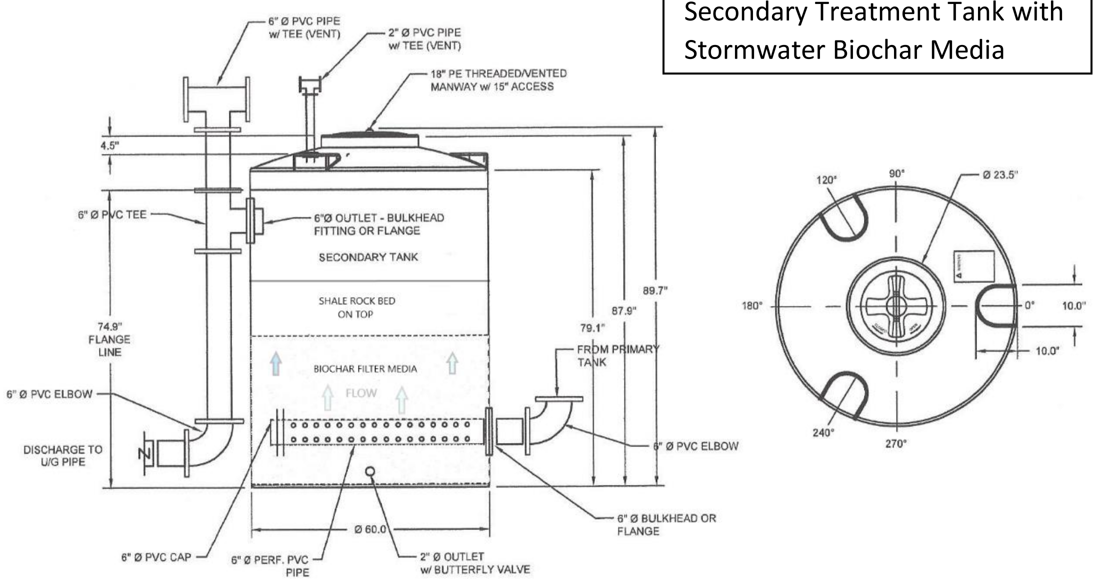
Primary Inlet Reservoir Tank



Secondary Treatment Tank with Stormwater Biochar Media

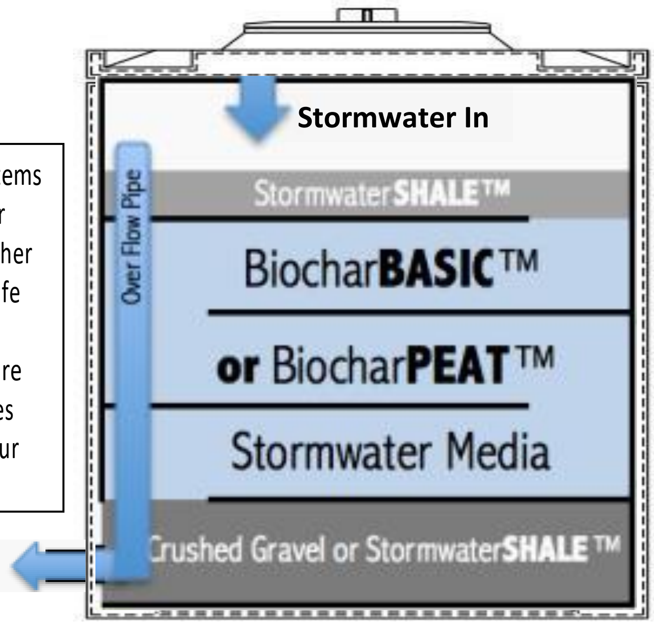


Stormwater Treatment

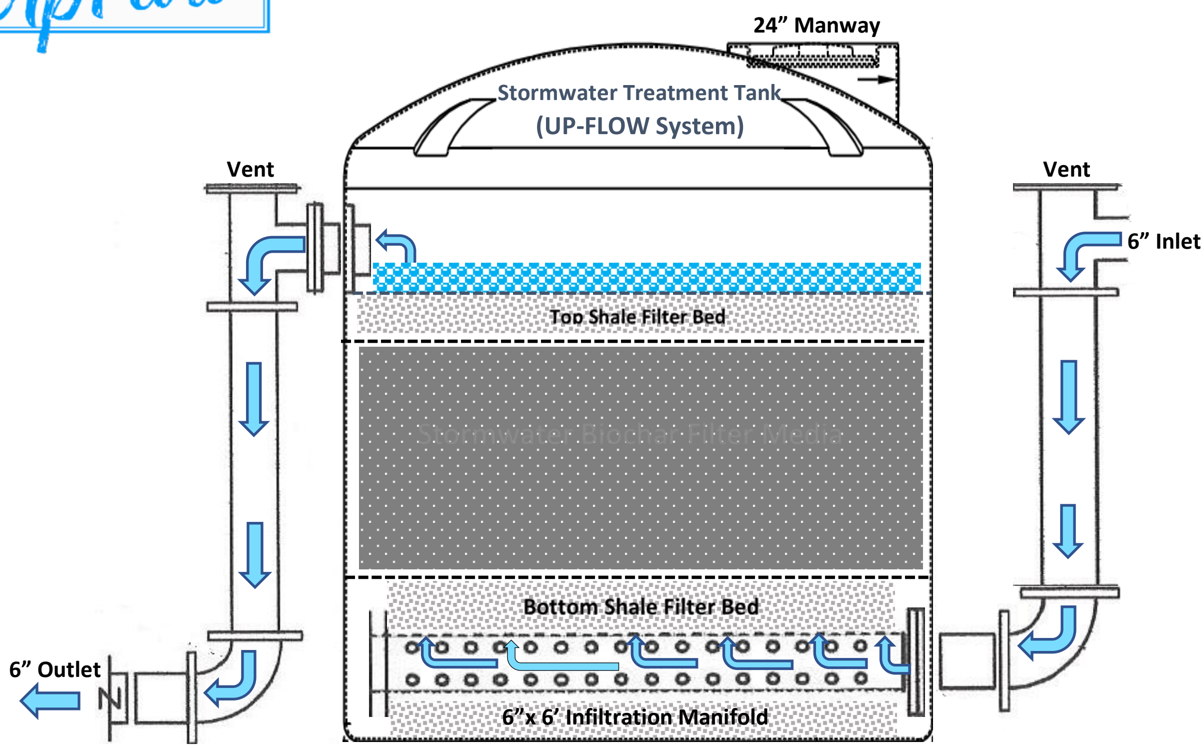
System Configurations

FLOW TYPE: *Passive*

Pure Rain™ PASSIVE Stormwater Treatment Systems with **Biochar**BASIC™ or **Biochar**PEAT™ Filter Medias to capture these unwanted metals and other pollutants and is designed to be a low cost, long life Filter media.
Stormwater Treatment Systems standard sizes are 275-gal., 330-gal. or 405-gal. totes, but other sizes and configurations are available depending on your on your treatment needs.



FLOW TYPE: *UpFlow*



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FIELD ANALYSIS Treatment Systems

Average Test Results

Pure Rain STORMWATER TREATMENT FILTRATION SYSTEMS	with BiocharBASIC Stormwater Treatment Filtration Media	One Year **Before** Treatment Installation		One Year **After** Treatment Installation		% Reduced
Marine Industrial	Copper	101.24	µg/L	10.63	µg/L	89.05%
	Zinc	152.74	µg/L	8.95	µg/L	94.07%
Glass Mfg. Facility	Copper	27.9	µg/L	7.35	µg/L	73.66%
	Zinc	125	µg/L	7.4	µg/L	94.08%
Treatment Tank-01	Lead	18.4	mg/L	0.207	ug/L	99.02%
Glass Mfg. Facility	Copper	62.475	µg/L	8.15	µg/L	86.95%
	Zinc	521	µg/L	61.5	µg/L	88.20%
Treatment Tank-02	Lead	437.5	µg/L	9	µg/L	97.94%

The Three Treatment Systems listed above had no more than 2 cy. of **BiocharBASIC™ for each Unit.

Marine Industrial Treatment Tank Farm – Seattle, WA

Design Conductivity Rate

BIOCHAR FILTRATION RATE (275-GAL TOTE) 108 in/hr

Tote Width (ft) = 3.3 Tote Length (ft) = 4.0 Media Conductivity (in/min) = 1.8 Filtration Rate (gpm) = 15.0

FIELD ANALYSIS
Treatment Systems

Date of Test	Pollutant Tested	**PRE** Treatment	Unit of Measure	**POST** Treatment	Unit of Measure	% Change	Amount of Media	24 hr. Rain Event at Test
3/22/18	Copper	**21.4**	µg/L	**ND**	µg/L	100%	1 CY	0.3"
3/22/18	Iron	**96.9**	µg/L	**ND**	µg/L	100%	1 CY	0.3"
3/22/18	Zinc	**29.5**	µg/L	**ND**	µg/L	100%	1 CY	0.3"
3/8/18	Copper	**2260**	µg/L	**311**	µg/L	86%	1 CY	0.4"
3/8/18	Iron	**16100**	µg/L	**3280**	µg/L	80%	1 CY	0.4"
3/8/18	Lead	**2.88**	µg/L	**2.16**	µg/L	25%	1 CY	0.4"
3/8/18	Zinc	**314**	µg/L	**236.0**	µg/L	25%	1 CY	0.4"
3/22/18	Copper	**13400**	µg/L	**14.5**	µg/L	99.9%	1 CY	0.3"
3/22/18	Iron	**152000**	µg/L	**251**	µg/L	99.8%	1 CY	0.3"
3/22/18	Lead	**18.4**	µg/L	**0.207**	µg/L	99%	1 CY	0.3"
3/22/18	Zinc	**2120**	µg/L	**9.9**	µg/L	99.5%	1 CY	0.3"

Transpor tation Company / Roadway & RR Runoff / Passive Box

Pure Rain™ Filtration System | Flow Type Passive

After More Than 80,000 Gallons through 2/3 Cubic Yards of Biochar**PEAT**™

- **Copper** 28.3% Pre: 12 µg/L Post: 8.6 µg/L
- **Zinc** 85.9% Pre: 370 µg/L Post: 52 µg/L
- **Turbidity** 50% Pre: .02 NTU Post: .01 NTU
- **#2 Diesel** 48.4% Pre: 3.1 mg/L Post: 1.6 mg/L
- **Motor Oil** 50% Pre: 4.4 mg/L Post: 2.2 mg/L

Stormwater**BIOCHAR**.com

STORMWATER **TREATMENT**

Stormwater**BIOCHAR**.com

MEDIAS:

Biochar**BASIC**
Stormwater Treatment Filtration Media

Biochar**PEAT**
Stormwater Treatment Filtration Media

SYSTEMS:

Pure Rain STORMWATER TREATMENT FILTRATION SYSTEMS

STORMWATER TREATMENT CATCH BASIN Inserts

Pure Rain STORMWATER TREATMENT FILTER SOCKS

Stormwater BMP Products

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THE RIGHT **BIOCHAR**,
THE RIGHT **BLEND**, DIALED IN

| **AMERICAN** MADE

BiocharBASIC™ and **BiocharPEAT™** Stormwater Filter Medias are an affordable, natural organic carbon neutral Bio-Char media that is a relatively new treatment technology used in the removal of most pollutants found in storm water discharges. Bio-Char filter media is made from a specialized (Biological Carbon) organic media that filters stormwater naturally.

Utilizing Carbon Lock™ Technology, this university tested technology uses Biochar as its basis for locking heavy metals onto the filter media. Small and soluble heavy metals are attracted to the polarity of Biochar and attach to surface areas through both absorption and adsorption.

The Bio-Char media serves as an ionic exchange medium to enhance the treatment process and effectively removes:

- Sediments/Debris
- Total Suspended Solids (TSS)
- Turbidity (Cloudy Water)
- Chemicals (Phosphorus, Nitrogen, Etc.)
- Heavy-Metals (Zinc, Copper, Lead)
- Oil & Gas (Petrochemicals)

Stormwater Biochar Filter Media has undergone extensive Field & University testing and has shown a 95% reduction of total Aluminum and Zinc, and up to a 99% reduction of Cadmium, Chromium, Total Copper, Lead and Iron.

The **Stormwater Biochar Filter Media** has been used in many applications such as catch basin filters, roof downspout filters, treatment trains, tanks, bed filters, contour ditch booms, filter socks/pillows and filter booms used in channels, ditches and bio-swales.

Stormwater Biochar Filter Media is universally applicable to all manufacturer's systems and is highly adaptable to custom configurations and design installations.

ADF-50 Downspout Filters with
BiocharPEAT™ Filter Media

ADF-150 Downspout Filters with
BiocharPEAT™ Filter Media

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BiocharPEAT™

Stormwater Treatment Filtration Media

Stormwater Roof Runoff Filter Lifetime for Benchmark[1]

Media	Dissolved **Zinc** (influent = ~1,000 ug/L)				Dissolved **Copper** (influent = ~120 ug/L)			
	Filter Volumes	Gallons/ft[3]	Changeout Time (years)[2] 5,000 ft²	10,000 ft²	Filter Volumes	Gallons/ft[3]	Changeout Time (years)[2] 5,000 ft²	10,000 ft²
BiocharPEAT™	1,500	11,221	**1.8 Yrs**	**0.9 Yrs**	>10,000	>75,000	**12 Yrs**	**6 Yrs**
100% Biochar	207	1,548	**0.2 Yrs**	**0.1 Yrs**	2,550	19,075	**3.1 Yrs**	**1.5 Yrs**

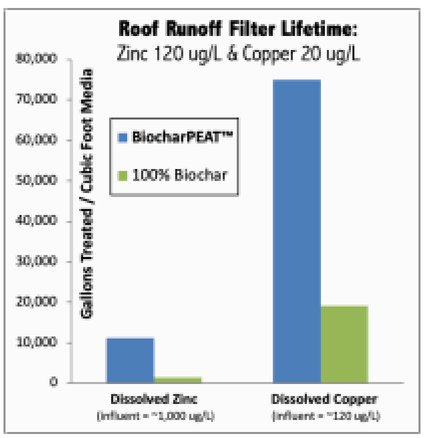
[1] Estimates for Zinc and Copper Oregon 1200-Z **benchmarks of 120 ug/L and 20 ug/L** respectively, and influent levels listed above

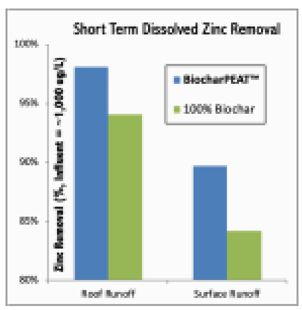
[2] Changeout time assumes 36" annual rainfall with 100% runoff and a 1.5 safety factor. Actual Stormwater Utilized in All Testing.

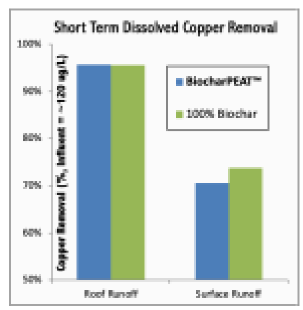
Stormwater Roof Runoff Filter Lifetime for >50% Removal

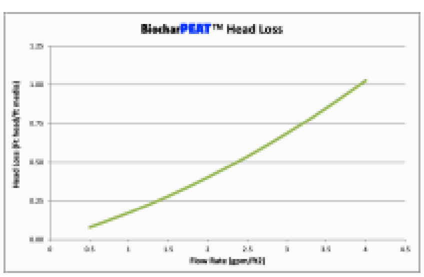
BiocharPEAT™	2,770	20,721	**3.3 Yrs**	**1.7 Yrs**	>10,000	>75,000	**>12 Yrs**	**>6 Yrs**
100% Biochar	405	3,030	**0.5 Yrs**	**0.2 Yrs**	3,480	26,032	**.2 Yrs**	**2.1 Yrs**

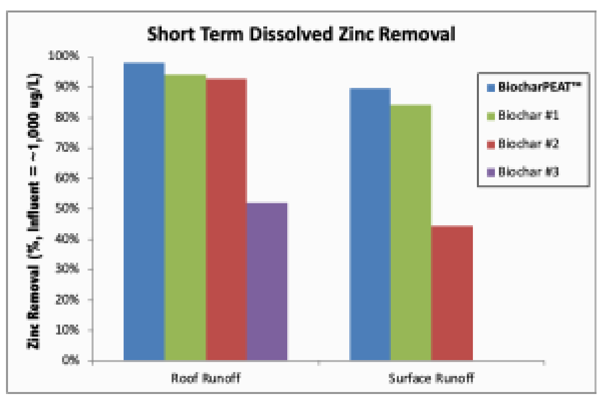
*Changeout time assumes 36" annual rainfall with 100% runoff and a 1.5 safety factor.. Actual Stormwater Utilized in All Testing.











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Biochar for Stormwater Filtration:

Product Optimization & Commercialization

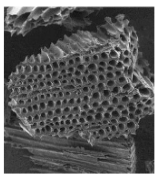
Myles Gray MS, Markus Kleber PhD, Oregon State University

1. Problem

- Stormwater management is a growing concern nationwide, with lower discharge limits for many common pollutants including copper and zinc
- Current technologies for removing dissolved copper and zinc are either prohibitively expensive or are not effective enough to meet discharge benchmarks
- Low-cost, effective alternative treatment is needed

2. Biochar as Solution

- Biochar is a carbon-negative charcoal-like material that is a byproduct of renewable bioenergy production
- Biochar has unique properties including incredible surface area as high as 300 m^2/g that endows the material with strong sorption capabilities
- Research shows that biochar can remove multiple contaminants from water:
  - Heavy metals: Pb, Zn, Cu, Cd,
  - Organics: PAHs, PCBs, VOCs, etc.
  - Nutrients



SEM image of Douglas-fir Biochar

3. Sunmark: Initial Installations

- Beginning in 2010, Sunmark in conjunction with BioLogical Carbon, LLC have developed and installed Earthlite™ biochar-based stormwater treatment media and RainClear™ filtration devices
- Results from these installations have shown encouraging, but variable results for removal of heavy metals

RainClear™ filtration device

Heavy metals removal rates for RainClear™ filtration devices using Earthlite™ media

Removal Rate	Copper	Zinc	Lead
Mean (%)	90%	51%	95%
Maximum (%)	99%	95%	99%
Minimum (%)	48%	25%	79%

4. OregonBEST Optimization Project

- To improve performance and consistency of biochar-based stormwater filtration media, OregonBEST™ has provided funding to Oregon State University to complete a rigorous product development and optimization project in conjunction with Sunmark and BioLogical Carbon
- Given the current challenges in stormwater treatment, this project will focus primarily on copper and zinc removal
- **Project goals** include optimization of biochar-based stormwater **filtration media**, design and optimization of suitable **filtration devices**, rigorous **pilot testing**, and **outreach and commercialization**
- Project goals will be achieved in 4 phases:

Phase 1: Biochar characterization

- Characterize copper and zinc removal of available biochars to select the most effective for further testing
- Investigate other biochar properties relevant for filtration and will seek to create a rapid screening protocol for new biochars

Phase 2: Secondary component characterization

- Characterize copper and zinc removal of secondary (non-biochar) filter media components and select those components that are most effective
- Secondary components will include both mineral and organic components, some of which are currently used in the Earthlite™ filtration media

Phase 3: Complete filtration media characterization

- Create and test multiple complete media filtration mixtures using most effective components from Phases 1 & 2
- Select most effective complete filtration mixture
- Complete rigorous testing of selected media mixture to determine flow rate properties, filter lifetime, spent filter toxicity, and contaminant removal rates for numerous contaminants including heavy metals, TSS, hydrocarbons, and BODs

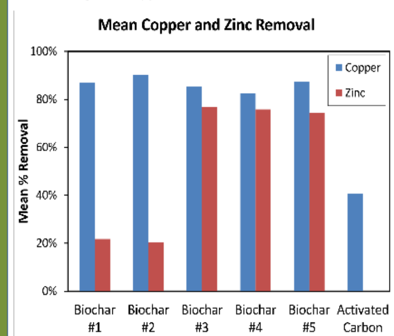
Phase 4: Filtration device pilot testing

- Design and construct suitable filtration devices including downspout totes, above-ground totes, filter bags, etc.
- Install and rigorously monitor pilot installations

5. Phase 1 Results

Copper and Zinc Removal

- Five biochars and activated carbon were assessed for zinc and copper removal using batch trials of synthetic stormwater with concentrations from 0.05 to 2 mg/L
- All biochars exhibit excellent copper removal capacity, with more variable zinc removal
- All biochars were more effective than activated carbon at removing both copper and zinc



Particle Size Distribution

- Particle size distributions indicate that all biochars would need to be rinsed or sieved prior to use in high-flow filtration applications
- Some biochars are composed primarily of fine particles and may not be suitable for filtration

6. Conclusions and Project Schedule

- All tested biochars show high capacity to remove copper, with variable zinc removal
- Phase 2 characterization has begun with initial results showing that some secondary components may provide synergistic effects when combined with biochars
- The project schedule calls for media characterization to be completed the end of 2014 with pilot projects installed during the 2014-15 rainy season
- Optimized filtration media and filtration devices will be available from Sunmark Environmental, LLC, Portland, OR www.earth-lite.com or (503) 241-7333