



Ground Penetrating Carbon, Inc.

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Memorandum

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This memorandum describes the most recent results of the third of three rounds of tests on two GPC Filters operating at a wastewater treatment system at Mill Pond Village in Yarmouth, MA, a sixty unit residential subdivision. The testing results have shown a substantial reduction of many common constituents of emerging concern from treated wastewater passing through the GPC Filters. The two previous testing events (8/26/2014 & 10/9/2014) provided similar results.

Wastewater from the homes is collected by sewers and drains to the south end of the subdivision where a pump station delivers raw wastewater to the RUCK wastewater treatment system at the north end of the site. Raw wastewater passes through a series of settling tanks prior to periodic dosing to RUCK filters (stratified, modified, vented sand filters) which provide secondary treatment. The RUCK effluent then flows to a series of denitrification tanks where MicroC, an innocuous organic carbon, is added. The denitrified wastewater is mixed with a GPC carbon at an appropriate ratio prior to dosing to the GPC Filters. The GPC Filters were installed to reduce the concentration of Total Suspended Solids prior to disinfection by ultraviolet light. The final effluent is discharged to the ground.

The goal of these tests was to evaluate the capability of the GPC Filter to remove certain pharmaceuticals and personal care products (“PPCPs”). PPCPs are also known as Constituents of Emerging Concern. The samples of influent and effluent waters from the active GPC Filter were analyzed by Eurofins Eaton Analyticals (“Eurofins”), a Massachusetts DEP certified laboratory. Eurofins performed an analysis called a Broad Spectrum Sweep, for 97 different chemical analytes present in PPCPs. The collection of grab samples was performed by a Massachusetts Certified Wastewater Operator and followed the testing protocols recommended by Eurofins. The GPC Filter influent was collected from the denitrification tank prior to the GPC Filter pump. The effluent was collected from the ultraviolet light (“UV”) trough located after the GPC Filter, but the UV lights were turned off before sampling so the UV did not contribute any removal factor for the sampled compounds.

The following twenty-five chemical compounds were detected in the influent. Detection limits were based on the Minimum Reporting Level (“MRL”) listed by Eurofins:

GPC Filter Influent

<u>Analyte</u>	<u>Concentration Value (ng/l)</u>	<u>MRL (ng/l)</u>
4-nonylphenol - semi quantitative	280	100
4-tert-Octylphenol	100	50
Acesulfame-K	21000	200
Albuterol	86	5
Amoxicillin (semi-quantitative)	20000	200
Atenolol	120	5
BPA	52	10
Butalbital	24	5
Cotinine	31	10
DEET	960	100
Diltiazem	11	5
Gemifibrozil	330	5
Ibuprofen	190	10
Iohexal	220	10
Iopromide	43	5
Lidocaine	200	5
Naproxen	23	10



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<u>Analyte</u>	<u>Concentration Value (ng/l)</u>	<u>MRL (ng/l)</u>
Sucralose	26000	1000
Sulfamethoxazole	260	5
TCEP	120	10
TCP	670	100
TDCPP	380	100
Triclocarban	28	5
Triclosan	11	10
Trimethoprim	52	5

The following ten chemical compounds were detected in the effluent. Detection limits were based on Minimum Reporting Level ("MRL") listed by Eurofins:

GPC Filter Effluent

<u>Analyte</u>	<u>Concentration Value (ng/l)</u>	<u>MRL (ng/l)</u>
Acesulfame-K	54	20
Atenolol	8.8	5
Benroflumthiazide	6.5	5
Butalbital	15	5
DEET	14	10
Lidocaine	130	5
Sucralose	21000	1000
TCEP	93	10
TCP	100	100
TDCPP	240	100

The following pharmaceutical compound was not detected in the influent, but was detected in the effluent:

Analyte

Benroflumthiazide

REMOVAL RATES

The removal rates for the chemical compounds are estimated below. Sixteen chemical compounds found in the influent were not detected in the final effluent and are marked with an asterisk. Since the concentrations are measured in parts per trillion, the removal rates will vary when considering the Minimum Reporting Level. The low removal rate was calculated by dividing the lowest delta between the influent and effluent concentrations by the influent concentration plus the MRL. The high removal rates were calculated by dividing the highest delta between the influent and effluent concentrations by the influent concentration minus the MRL. The removal rate can only be described as estimated. The calculation assumes that the concentration of the analyte dosed to the GPC Filter was the same at the time of application as at the time of the sampling. It is not known precisely how long it takes for the applied water to drain through the GPC Filter. The approximate removal rates are listed below:

<u>Analyte</u>	<u>Approximate Removal rates</u>
4-nonylphenol - semi quantitative	29% to >99%*
4-tert-Octylphenol	<1% to >99%*
Acesulfame-K	>99%
Albuterol	88% to >99%*



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<u>Analyte</u>	<u>Approximate Removal rates</u>
Amoxicillin (semi-quantitative)	>99%*
Atenolol	88% to >97%
Bendroflumethiazide	increase
BPA	81% to >99%*
Butalbital	Increase to 66%
Cotinine	35% to >99%*
DEET	97% to 99%
Diltiazem	9% to >99%*
Gemfibrozil	97% to >99%*
Ibuprofen	89% to >99%*
Iohexal	91% to >99%*
Iopromide	77% to >99%*
Lidocaine	31% to 39%
Naproxen	13% to >99%*
Sucralose	12% to 26%
Sulfamethoxazole	96% to >99%*
TCEP	6% to 36%
TCP	65% to >99%
TDCPP	increase to 71%
Triclocarban	64% to >99%*
Triclosan	1% to >99%*
Trimethoprim	81% to >99%*

Of particular interest ought to be what class of chemicals were detected in the influent. Those chemicals are listed below as either derived from pharmaceuticals or household chemicals:

Pharmaceuticals

Albuterol (Anti Asthmatic)
Amoxicillin (semi-quantitative) (Antibiotic)
Atenolol (Beta Blocker)
Butalbital (Analgesic-NSAID)
Diltiazem (Anti-Seizure)
Gemfibrozil (Lipid Regulator)
Ibuprofen (Analgesic-NSAID)
Iohexal (X-ray Contrast Agent)
Iopromide (X-ray Contrast Agent)
Lidocaine (Analgesic)
Naproxen (Analgesic-NSAID)
Sulfamethoxazole (Sulfa Antibiotic)
Trimethoprim (Antibiotic)

Household Chemicals

4-nonylphenol - semi quantitative (surfactant)
4-tert-Octylphenol (surfactant)
Acesulfame-K (artificial sweetener)
BPA (plasticizer)
Cotinine (nicotine degradate)
DEET (insect repellent)
Sucralose (artificial sweetener)
TCEP (Flame Retardant)
TCP (fire retardant)
TDCPP (fire retardant)
Triclocarban (anti-bacterial)
Triclosan (anti-bacterial)



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Summary

Of the thirteen pharmaceuticals detected in the influent, the GPC Filter reduced ten pharmaceuticals to levels below detection. Of the remaining three pharmaceuticals, one was reduced substantially (over 90%), while the other two were reduced by varying amounts. One pharmaceutical was found in the effluent and not in the influent.

Of the twelve household chemicals detected in the influent, the GPC Filter reduced six chemicals to levels below detection, two chemicals were reduced substantially, (over 95% removal), one chemical was reduced by 85% and three chemicals were reduced by varying amounts.

71 of the 97 compounds in the typical PPCP testing spectrum were not detected in either the influent or effluent waters. They included:

Endocrine Disruptors Positive Mode – SPE

1,7-Dimethylxanthine	DACT	Lopressor	Simazine
Acetaminophen	DEA	Meclofenamic Acid	Sulfachloropyridazine
Androstenedione	Dehydronifedipine	Meprobamate	Sulfadiazine
Atrazine	DIA ND	Metazachlor	Sulfadimethoxine
Azithromycin	Diazepam	Metolachlor	Sulfamerazine
Bezafibrate	Dilantin	Nifedipine	Sulfamethazine
Bromacil	Diuron	Norethisterone	Sulfamethizole
Caffeine	Erythromycin	OUST	Sulfathiazole
Carbadox	Flumequine	Oxolinic acid	Testosterone
Carbamazepine	Fluoxetine	Pentoxifylline	Theobromine
Carisoprodol	Isoproturon	Phenazone	Theophylline
Chloridazon	Ketoprofen	Primidone	Thiabendazole
Chlorotoluron	Ketorolac	Progesterone	Trimethoprim
Cimetidine	Lincomycin	Propazine	
Cyanazine	Linuron	Quinoline	

Endocrine Disruptors Negative Mode – SPE

2,4-D ND ng/L 5 1	Ethinyl Estradiol - 17 alpha
Bendroflumethiazide	Ethylparaben
Butylparaben Chloramphenicol	Isobutylparaben
Clofibric Acid	Methylparaben
Diclofenac	Propylparaben
Estradiol	Salicylic Acid
Estrone	Warfarin

Caution:

The Eurofins analysis reports concentrations in nanograms per liter (ng/L) or one part in one trillion (10⁻¹²). Some test samples were diluted during the testing process in order to accommodate the calibration range of the testing system, but both the influent and effluent values received the same dilution and the corresponding MRL was adjusted accordingly. This round of results represents the third PPCPs sampling event for the GPC Filters at this site.

The final effluent at this treatment system undergoes ultraviolet light disinfection before discharge to the ground. The final effluent will probably have less contaminants than the GPC Filter effluent since ultraviolet light has been demonstrated to remove or reduce certain PPCPs.