Experimental Evaluation of Compost Leachates

WA-RD 848.1

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September 2015

Washington State Department of Transportation
Office of Research & Library Services

WSDOT Research Report

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Report prepared for the
Washington State Department of Transportation
Lynn Peterson, Secretary

September 25, 2015

TECHNICAL REPORT STANDARD TITLE PAGE

1. REPORT NO.	2. GOVERNMENT ACCESSION NO.	3. RECIPIENTS CATALOG NO
WA-RD 848.1		
4. TITLE AND SUBTILLE Experimental Evaluation of Compost Leachates		5. REPORT DATE September 25, 2015
		6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) Markus Flury, Jessica Mullane, Maninder Chahal, Craig Cogger		8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS Department of Crop and Soil Sciences Washington State University Puyallup, WA 98371		10. WORK UNIT NO.
		11. CONTRACT OR GRANT NO. T1462-03
12. SPONSORING AGENCY NAME AND ADDRESS Washington State Department of Transportation Research Office PO Box 47372 Olympia WA 98504-7372		13. TYPE OF REPORT AND PERIOD COVERED
		14. SPONSORING AGENCY CODE
15. SUPPLEMENTARY NOTES This study was conducted in cooperation with the U.S. Department of Transportation, Federal Highway Administration.		

16. ABSTRACT

Compost is often used in raingardens, roadsides, and bioretention systems, not only because of its beneficial properties on soil quality, but also because compost improves water infiltration and retains stormwater contaminants. However, when compost is freshly applied, materials from compost can leach out when rain or stormwater seep through compost or compost-amended bioretention media. The goal of this research project was to experimentally evaluate and characterize leachates from compost. We quantified and characterized the leachate composition of compost following intermittent, simulated storm events. We used municipal compost of different ages and different source materials. Compost was filled into columns and then irrigated with deionized water and stormwater. Stormwater was spiked with copper to increase copper concentrations. Six-month, 24-hour rain storms were applied every two weeks for a total of up to 18 rain storms. Outflow was analyzed for pH, electrical conductivity (EC), particulate concentration, surface tension, dissolved organic carbon (DOC), nitrogen, phosphorus, and copper. Particulate and dissolved organic matter was further characterized for molecular structure by Nuclear Magnetic Resonance (NMR) and Fourier-Transformed Infrared (FTIR) Spectroscopy. Our results showed that concentrations of dissolved and particulate organic carbon and electrical conductivity in the leachate where high at the onset of each storm, but decreased as the storm progressed. However, each new storm released another peak of constituents. Leaching from mature compost was less a function of age and type, but more a function of number and frequency of storms and leaching history. Concentrations of nitrogen, phosphorus, and copper were high in the initial few storms, and then decreased. Only a small fraction (3%) of the copper present in the compost leached out, but nonetheless, the copper concentrations in the leachate remained above the regulatory waste discharge standards. NMR and FTIR analyses revealed that dissolved organic carbon consisted mainly of aliphatic and aromatic components typical of fulvic and humic acids. Our results show that municipal compost can serve as a sustained source of leaching of nutrients and metals, regardless of compost age and source. However, the copper concentrations observed in our experiment are likely not toxic due to the presence of elevated DOC, as DOC readily forms complexes with dissolved copper thereby reducing its toxicity to aquatic organisms. The DOC plays a dual role in terms of copper fate and transport: DOC can enhance leaching of copper by forming aqueous complexes, but at the same time, reduces toxicity of copper because copper-DOC complexes are less bioavailable.

17. KEY WORDS		18. DISTRIBUTION STATEMENT	
Compost, leaching, nitrate, phosphorus, copper			
19. SECURITY CLASSIF. (of this report)	20. SECURITY CLASSIF. (of this page)	21. NO. OF PAGES	22. PRICE
None	None		

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Note

The content of this report is part of the MS thesis of Jessica Mullane (WSU 2015) and the PhD dissertation of Maninder Chahal (WSU 2015). Parts of the material in this report have been published as a scientific paper [*Mullane et al.*, 2015], and other parts are being prepared for publication as a scientific paper.

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Executive Summary

Compost is often used in raingardens, roadsides, and bioretention systems, not only because of its beneficial properties on soil quality, but also because compost improves water infiltration and retains stormwater contaminants. However, when compost is freshly applied, materials from compost can leach out when rain or stormwater seep through compost or compost-amended bioretention media. The goal of this research project was to experimentally evaluate and characterize leachates from compost. We quantified and characterized the leachate composition of compost following intermittent, simulated storm events. We used municipal compost of different ages and different source materials. Compost was filled into columns and then irrigated with deionized water and stormwater. Stormwater was spiked with copper to increase copper concentrations. Six-month, 24-hour rain storms were applied every two weeks for a total of up to 18 rain storms. Outflow was analyzed for pH, electrical conductivity (EC), particulate concentration, surface tension, dissolved organic carbon (DOC), nitrogen, phosphorus, and copper. Particulate and dissolved organic matter was further characterized for molecular structure by Nuclear Magnetic Resonance (NMR) and Fourier-Transformed Infrared (FTIR) Spectroscopy. Our results showed that concentrations of dissolved and particulate organic carbon and electrical conductivity in the leachate where high at the onset of each storm, but decreased as the storm progressed. However, each new storm released another peak of constituents. Leaching from mature compost was less a function of age and type, but more a function of number and frequency of storms and leaching history. Concentrations of nitrogen, phosphorus, and copper were high in the initial few storms, and then decreased. Only a small fraction (3%) of the copper present in the compost leached out, but nonetheless, the copper concentrations in the leachate remained above the regulatory waste discharge standards. NMR and FTIR analyses revealed

that dissolved organic carbon consisted mainly of aliphatic and aromatic components typical of fulvic and humic acids. Our results show that municipal compost can serve as a sustained source of leaching of nutrients and metals, regardless of compost age and source. However, the copper concentrations observed in our experiment are likely not toxic due to the presence of elevated DOC, as DOC readily forms complexes with dissolved copper thereby reducing its toxicity to aquatic organisms. The DOC plays a dual role in terms of copper fate and transport: DOC can enhance leaching of copper by forming aqueous complexes, but at the same time, reduces toxicity of copper because copper-DOC complexes are less bioavailable.

1 Introduction

1.1 Background

Compost is used as amendment to improve soil fertility, soil structure, and soil water holding capacity. In general, compost helps to improve soil quality and is beneficial for establishing plant growth in re-vegetation sites. Compost is often used in raingardens and is a recommended amendment in other bioretention systems, not only because of its beneficial properties on soil quality, but also because compost improves water infiltration and can retain stormwater contaminants, namely heavy metals. However, when compost is freshly applied to bioretention systems, materials from compost can leach out when rain or stormwater seep through compost or compost-amended bioretention media.

[Note: The term "leachate" here refers to the material flowing out from mature compost applied as an amendment to soil or bioretention systems following exposure to rain or stormwater. This has to be distinguished from the leachate coming out from compost piles during the composting process itself.]

The initial leachate through freshly applied compost is often yellow-brown in color. This coloration of the leachate indicates that dissolved, and possibly also particulate, organic matter is leached from the compost. In one of the few studies where leachate from compost was studied as a function of outflow volume, Christensen and coworkers have reported that considerable amounts of nutrients, including nitrate, potassium, iron, as well as heavy metals were observed in compost leachate [*Christensen*, 1983; *Christensen*, 1984; *Christensen and Tjell*, 1984a]. In these studies it was also reported that there is an initial flush of nutrients and heavy metals, and that the concentrations in the leachate decrease over time.

Some of the nutrients and heavy metals are leached in association with organic matter. Compost leachate, at least initially, contains substantial amounts of dissolved and particulate organic matter [*Said-Pullicino et al.,* 2007]. It is this material that renders the leachate yellow-brown. The molecular characteristics of dissolved organic matter allow for chemical complexation of certain metals, particularly heavy metals [*Kaschl et al.,* 2002*; Bolea et al.,* 2006]. This complexation leads to enhanced solubility and decreased sorption of these metals, thereby facilitating the leaching.

Dissolved organic matter leaching from compost is, in general, similar to dissolved organic matter from soils, and its molecular structure is derived from degradation of macromolecular substances, like cellulose, lignin, and proteins. Dissolved organic matter often has ambiphilic characteristics, meaning the molecules have both hydrophilic and hydrophobic parts [*Kleber and Johnson,* 2010]. This characteristic allows the molecule to interact both with hydrophilic and hydrophobic constituents. An important consequence of this is that dissolved organic matter can bind hydrophobic contaminants, and thereby make these contaminants more mobile and enhance their apparent solubility. Hydrophobic contaminants, for instance polyaromatic hydrocarbons, can thereby become more mobile and potentially leach in association with dissolved organic matter.

Concerns about compost leachate arise when the leachate flows into sensitive environments, such as surface and groundwaters. Such conditions can occur when compost is used as an amendment to bioretention systems, where the outflow is conducted to surface waters, or when compost is applied as soil amendment along roadsides. To alleviate environmental hazards due to compost applications, we need to better understand what exactly leaches out from compost, what the quantities and concentrations of the leachate constituents are, and for how long after compost applications the leachates may be of concern.

1.2 Objectives

The overall goal of this research project was to experimentally evaluate and characterize leachates from compost. The specific objectives of this study were to:

1. Characterize the nature of compost leachate
2. Quantify loads and concentrations of selected constituents
3. Quantify the dynamics of the leaching process
4. Determine whether age can serve as indicator of leaching
5. Determine whether contaminants in the stormwater are retained or can be leached with compost leachate

2 Review of Previous Work

In a previous project, we have conducted a thorough literature review of compost leachate and its characteristics [*Chatterjee et al.*, 2013]. We summarized the biochemical processes occurring during composting, and the use and applications of compost in the environment. We then reviewed the chemical and physical characteristics of feedstock, compost, and compost leachate, and discussed environmental implications of the compost leachate.

The review showed that the compost source material, i.e., the feedstock, determines to a large degree the types of leachates. Compost leachate usually contains large amounts of dissolved organic matter. Together with the leaching of organic matter, there is evidence for leaching of various nutrients and contaminants present in the original feedstock. Contaminants can leach by direct dissolution out of the compost. Contaminants can also leach with the help of dissolved and particulate organic matter, both of which have a high sorption affinity for inorganic and organic constituents, and which can enhance contaminant leaching via the mechanism of colloid-facilitated transport. Organic matter, nutrient, and contaminant concentrations are highest in the initial leachate, and the concentrations decrease considerably with increasing amount of rain or runoff water leaching through the compost. More details can be found in *Chatterjee et al.* [2013].

Based on this previous project, we identified the need for comprehensive studies to experimentally quantify and characterize compost leachates as related to typical stormwater applications. Particularly, there is need to study leaching from compost during sequential storm events, with drying events between storms. We hypothesized that each new storm triggers a new flush of constituents leached from compost.

3 Research Approach/Procedures

3.1 Experimental Tests

The objectives of the project were addressed with a series of compost leaching experiments. We conducted two sets of leaching experiments:

1. Leaching experiments with two composts of different age

2. Leaching experiments with two composts of different type

3.2 Compost Material and Characterization

We obtained compost samples from local composting facilities in July 2013 and April 2014. For the experiments testing the effect of compost age, we obtained 6- and 24-month old compost from the Cedar Grove composting facility in Everett, WA. This compost was made from a feedstock consisting of 80% yard waste and 20% food waste (by volume). For the experiments testing the effect of compost type, we obtained compost from Royal Organic Products in Grant County, WA, and from Silver Springs Organics in Thurston County, WA. The compost from Royal Organic contained 96% yard waste and 4% food waste, the compost from Silver Springs contained 99% yard waste and 1% food waste.

The composts as received were air-dried and stored until use in five-gallon plastic buckets (covered with a 5-mm mesh to allow air circulation) in a greenhouse (16 to 20^{o}C). Triplicate samples of the composts were sent to Soiltest Farm Consultants, Inc (Moses Lake, WA) for characterization. Compost material was characterized for pH, electrical conductivity, various nutrients, heavy metals, and C/N ratio following the protocols of the Test Methods for the Examination of Composting and Compost (TMECC). Nutrient and metal contents are important chemical parameters of a compost, and electrical conductivity reflects the overall salt content. Electrical conductivity also is a measure of ionic strength, an important parameter that affects speciation of chemical in aqueous solution. A Solvita Compost Emissions Test [*Woods End Laboratories*, 2014] was performed on all composts to determine maturity. The Test Methods for the Examination of Composting and Compost (TMECC) have been established by the US Compost Council to provide a standardized characterization of compost properties. The methods have been modeled after the American Society for Testing and Materials (ASTM), and they provide a benchmark for compost analysis to enable comparison of analytical results. The methods help regulatory agencies to establish criteria for the safe use of compost. The Washington State Legislative Code WAC 173-350-220, for instance, specifies that compost facilities in Washington State must test their compost for a variety of metals and other parameters according to the Test Methods for the Examination of Composting and Compost (TMECC), and the WAC 173-350-220 lists criteria for these parameters.

The chemical structure of the composts prior to leaching was characterized with solid-state ^{13}C-NMR spectroscopy and ATR-FTIR (Attenuated Total Reflectance-FTIR). For NMR analysis, paramagnetic material in the compost samples was removed following a modified method of *Skjemstad et al.* [1994]. For ATR-FTIR analysis, compost samples were dried and ground. Sixty scans per sample were acquired using a Shimadzu IR-Prestige 21 analyzer (Columbia, MD) complemented with an ATR unit (PIKE Technologies, Madison, WI). The band assignments and interpretations of the spectra are based on literature reports: *Huang et al.* [2006], *Zmora-Nahum et al.* [2007], *Carballo et al.* [2008], *Smidt et al.* [2011], *Wang et al.* [2013], *Fels et al.* [2014], *Ouaqoudi et al.* [2014], *Higashikawa et al.* [2014], and *Provenzano et al.* [2014].

3.3 Experimental Setup

3.3.1 Experimental Setup with two Composts of Different Age

A total of six PVC columns (64 cm height, 10.2 cm diameter) were loosely packed with compost to a height of 25 cm. The compost used for these experiments was from Cedar Grove. The bottom of the columns was made of a perforated end-cap, consisting of a plate with 150 3-mm diameter holes. This end-cap held the compost in place, but did not restrict outflow. Three columns were packed with 6-month old compost, and three were packed with 24-month old compost. In these set of experiments, we only used compost as material inside the columns to test what the leachate will be from compost itself. When applied to the environment, compost is often mixed with soil and sand when, and in that case leachate from compost will interact with mineral particles from soil and sand. This will likely reduce the amount of material leached from compost; however, it is important to know what potentially can leach from compost itself. In the second set of experiments described below, we mixed compost with sand to create a typical mixture used in bioretention systems.

The columns were placed in wooden stands and set up in a greenhouse. A plastic funnel was used at the bottom to collect outflow into 1-L glass beakers. Each column was equipped with a custom-built sprinkler head, 5.7 cm in diameter, made of twelve 22-gauge syringe needles. The sprinkler heads were connected with Tygon tubing to Mariotte bottles made of 25-L Nalgene carboys. Deionized water, with a pH of around 6, was chosen as the irrigation solution as its low ionic strength represents a worst-case scenario for leaching. Figure 1 illustrates compost sampling and the experimental setup.

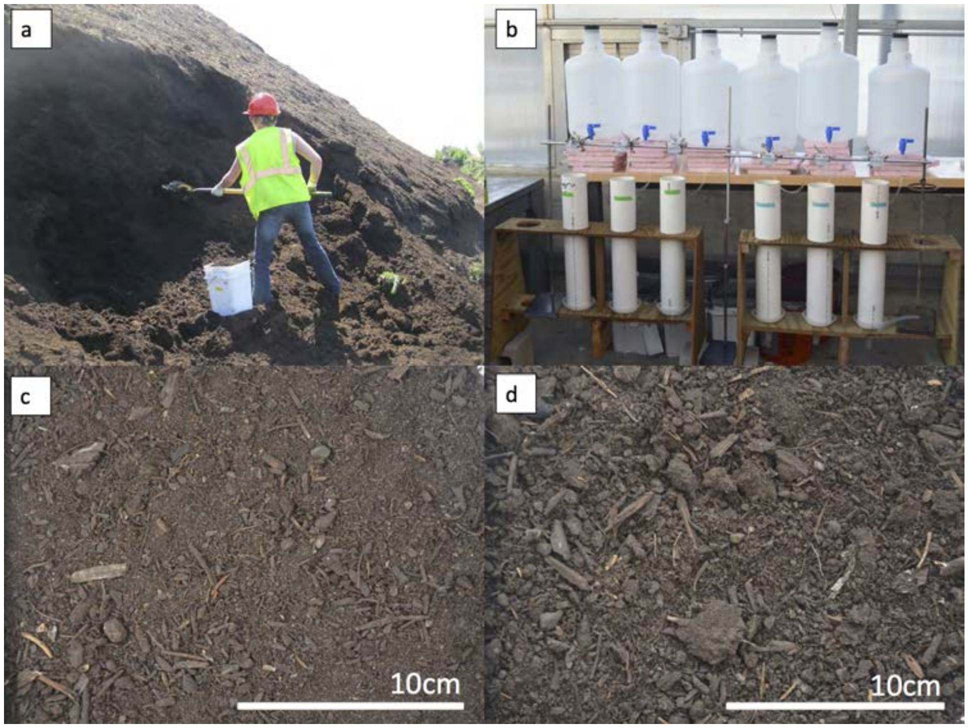

Figure 1: *Photos of experiment components. a: compost material collection; b: experimental column setup; c: close-up of 6-month compost; and d: close-up of 24-month compost.*

3.3.2 Experimental Setup with two Composts of Different Type

For these sets of experiments, compost (Royal Organic and Silver Spring) was mixed with sand at a 40:60 compost-sand volume ratio. This volume ratio of sand-to-compost is recommended for raingardens and bioretention soil media in Western Washington:

- Raingarden Handbook for Western Washington, available at: https://fortress.wa.gov/ecy/publications/documents/1310027.pdf
- Low Impact Development, Technical Guidance Manual for Puget Sound, available at: http://www.psp.wa.gov/LID_manual.php

The compost-sand mix was then filled into six columns (i.d. 5.1 cm and length 25 cm) in 5-cm increments to a total height of 15 cm. The composts, sand, and compost-sand mix are shown in Figure 2.

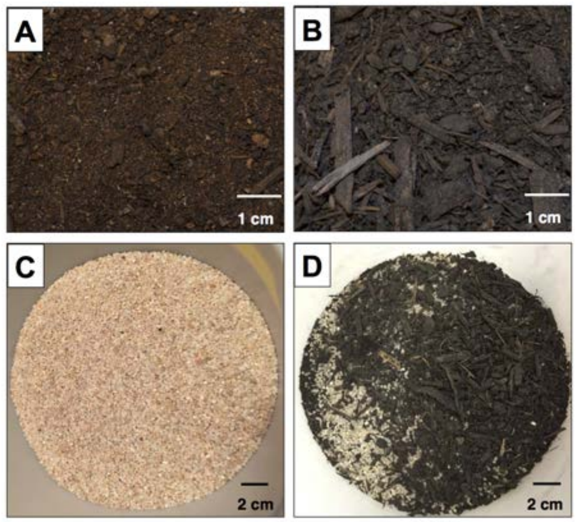

Figure 2: *Bioretention soil mix used in the experiment. (A) Silver Springs compost; (B) Royal Classics compost; (C) coarse sand; (D) bioretention mix after mixing compost with sand at a 40:60 volume ratio (Silver Springs compost).*

The remaining setup was the same as described in Section 3.3.1, except that we used a peristaltic pump to apply the irrigation, and that we used real stormwater collected at the WSU Puyallup Research and Extension Station as irrigation solution (Table 1).

Because the stormwater contained little copper, we spiked the stormwater with copper to reach copper concentrations of 17--70 μg/L to ‘‘pollute’’ the stormwater. Our target copper concentration in the stormwater was 50 μg/L, but when we measured the actual concentrations in the stormwater coming out of the sprinkler heads, the concentrations were initially always lower than 50 μg/L, so we increased the concentrations in later storms.

Table 1: *Chemical constituents of the stormwater used in the experiments.*

Constituent	Concentration/Value†
pH	6.8 ± 0.05
Electrical conductivity (dS m^{-1})	0.02 ± 0.003
Dissolved organic carbon (mg L^{-1})	2.9 ± 0.5
Total Kjeldahl N (mg L^{-1})	2.2 ± 1.3
Nitrate + Nitrite (mg L^{-1})	0.10 ± 0.02
Total phosphorus (mg L^{-1})	$< 0.01^{\ddagger}$
Ortho-phosphorus (mg L^{-1})	$< 0.01^{\ddagger}$
Total copper (mg L^{-1})	0.04 ± 0.02
Dissolved copper (mg L^{-1})	0.03 ± 0.01
Total calcium (mg L^{-1})	2238 ± 404
Total magnesium (mg L^{-1})	135 ± 30
Total zinc (mg L^{-1})*	179 ± 91

†Values represent mean ± standard deviation ($n = 14$)

‡Below detection limits of 0.01 mg/L

3.4 Column Leaching Experiments

The irrigation rate for our compost columns was designed to simulate storm events passing through a bioretention cell. For that purpose, we chose our irrigation rates based on a 6-month, 24-hour storm for the Seattle-Tacoma region of Washington State, which corresponds to a rainfall of 33.5 mm/day [*Washington State Department of Ecology*, 2012]. The drainage to bioretention cell surface area was taken as 10:1, and we considered that a fraction of 0.81 of the runoff is collected by the bioretention system. Such drainage parameters are typical for bioretention and raingarden designs in this region [*Hinman*, 2013]. The storms were applied within a 4-hour time period. Leachate was collected into 1-L beakers at the base of each column every hour during the storm event. A storm was simulated every two weeks, so that the compost column could drain and air-dry between storm events. In total, we simulated 18 individual, successive storms for the experiments with different compost ages, and 7 individual, successive storms for the experiments with different compost types.

3.5 Leachate Characterization

The pH of each leachate sample was measured immediately following collection. The samples were then transferred to a 1-L graduated cylinder to determine the volume, and stored in Nalgene bottles in the dark at 4^{o}C prior to analysis. Each sample was further analyzed for electrical conductivity, particulate matter, UV-vis absorbance, dissolved organic carbon, and surface tension. Electrical conductivity is measure of salts leached from the compost, and is a surrogate for easily leached chemicals. Electrical conductivity can serve as a conservative indicator of how fast material can leach. Particulate matter that is leaching from compost can carry contaminants (like metals or organic pollutants) and it is important to know how much particulate material leaches out in relation to the dissolved organic carbon fraction. We determined a calibration curve between UV-vis absorption and dissolved organic carbon. This calibration curve was then used to determine dissolved organic carbon from UV-vis absorption. Further, specific absorbance bands in the UV-vis spectra can be used to characterize the chemical nature of the dissolved organic carbon. Surface tension was measured because we expected that dissolved organic carbon will reduce the surface tension. In that case, dissolved organic carbon would accumulate at the air-water interface, and therefore leach more during infiltration and rainfall events when air-water interface are present and moving though the compost.

Particulate concentrations were measured using sequential vacuum filtration through 11, 1, and 0.45 μm pore filters (Whatman 1, Millipore Glass Fibre without binders, Millipore Mixed Cellulose Ester Membrane Filter, respectively; all filters from Fisher Scientific). Prior to filtration, all filters were dried at 105^{o}C for 24 hours, then cooled in a desiccator, and weighed using an analytical balance. After filtration, the filters were transferred back to the oven to dry for 24 hours at 105^{o}C, cooled in a desiccator, and measured gravimetrically. The particulate concentrations were then determined by dividing the mass difference by the volume of solution filtered.

We measured dissolved organic carbon (DOC) via spectrophotometric absorbance at a wavelength of 465 nm [*Zmora-Nahum et al.*, 2005]. A calibration curve was developed by plotting absorbance at 465 nm against the total organic carbon (TOC) for a series of 0.45 μm-filtered dilutions from the column leachate for each compost treatment. These calibration standards were analyzed for TOC using a TOC analyzer (TOC-V_{CSH}, Shimadzu, Tokyo, Japan). Surface tension of the filtered leachate samples was measured using the Wilhelmy plate method at 20^oC (Processor Tensiometer K100, Krüss, Hamburg, Germany). Nanopure water water was used to verify surface tension measurements.

Selected storms were analyzed for nitrogen, phosphorus, and copper. For each storm a total of six composite samples (one per column) were made. The composite samples were made on an outflow volume basis for each hourly outflow-increment. Grab samples were collected at the base of each column after each hour of the storm, and a 20% outflow volume aliquot from each of these replicate samples was pipetted into the associated acid-washed amber glass bottles. Samples were kept at 4^{o}C using ice for the duration of the experiment and during transport to the contracting laboratory. The samples and the necessary chain of custody documents were delivered to the laboratory immediately following the completion of the storm.

Analytical methods for the composite samples are summarized in Table 2. Analytical Resources, Inc. (ARI) in Tukwila, WA, and Spectra Laboratories in Tacoma, WA, were the contracting laboratories. ARI was used for the experiments with deionized water, Spectra was used for the experiments involving stormwater. ARI and Spectra are certified by the Washington State Department of Ecology. The samples were analyzed for total Kjeldahl nitrogen (EPA 351.2), nitrate and nitrite (EPA 353.2), total and ortho-phosphorus (EPA 365.2), and total and dissolved copper (EPA 200.8). In EPA 200.8, total and dissolved concentrations are differentiated by filtration through a 0.45 μm filter. The laboratory provided reports containing sample and quality control data as well as a summary of problems encountered during the analytical process. These reports are included in the appendix.

Table 2: *Analytical methods used for chemical analyses.*

Analyte	Method Number[a]	Holding Time[b]	Preservation[c]	Reporting Limit/ Resolution	Units
Total Kjeldahl nitrogen	EPA 351.2	28 days	Cool to 4^oC; H_2SO_4 to pH<2	1.0	mg/L
Nitrate + nitrite nitrogen	EPA 353.2	2 days	Cool to 4^oC; H_2SO_4 to pH<2	0.200	mg/L
Total phosphorus	EPA 365.2	28 days	Cool to 4^oC; H_2SO_4 to pH<2	0.080	mg/L
Ortho-phosphorus	EPA 365.2	2 days	Cool to 4^oC; filter through 0.45 μm	0.040	mg/L
Copper, total	EPA 200.8	6 months	Cool to 4^oC; HNO_3 to pH<2	0.5	μg/L
Copper, dissolved	EPA 200.8	6 months	Cool to 4^oC; filter through 0.45 μm; HNO_3 to pH<2	0.5	μg/L

[a] EPA method numbers are from US EPA (1971, 1993, and 1994).

[b] Holding time specified in EPA methods.

[c] Sample filtration and/or preservation will occur within 24 hours of sample collection.

Field and laboratory quality control procedures were employed for the nitrogen, phosphorus, and copper analyses. Field blanks were collected for the first four storm events. One field blank per storm was collected from the deionized water carboys into the acid-washed bottles used for samples. ARI and Spectra performed laboratory control spikes and method blank analyses for each analyte for each set of samples. ARI and Spectra staff reviewed the analytical results for errors and ensured that method and quality assurance procedures were followed. The laboratory review was included in the analytical report.

We analyzed selected leachate samples with liquid-state ^{1}H-NMR (Nuclear Magnetic Resonance) and ATR-FTIR (Attenuated Total Reflectance-Fourier Transform Infrared Spectroscopy). ^{1}H-NMR spectra were acquired with 0.1 N NaOD in D_2O at 399.764 MHz and 303 K (Varian 400 MR equipped with a Varian One-NMR multi-tunable probe) at the WSU NMR center. In addition to the compost leachate, a 100 mg/L humic acid standard (1S102H, International Humic Substances Society) was used for comparison. The NMR capillary contained 550 μl sample with an insert treated with trimethylsilyl propanoic acid (TMSP, 2 mg/mL). The spectra were acquired using a spinning speed of 6 kHz, a saturation frequency of -191.6 Hz, a relaxation delay of 2.5s, and a saturation delay of 2.2s. The spectra were analyzed using Varian VnmrJ 3.2A software, and peak assignments and interpretations are based on *Sparks* [1999] and *Genest et al.* [2014].

3.6 Chemical Speciation Modeling

Visual MINTEQ, version 3.1 [*Gustafsson*, 2010], was used to determine the speciation of copper and to quantify interactions of copper with DOC. We used measured and estimated ionic compositions of the outflow samples as inputs for the Visual MINTEQ modeling. Measured input parameters were pH, NO_3^-, PO_4^{3-}, dissolved Cu, DOC, and estimated parameters were major cations and anions (from measured concentrations in the stormwater inflow). The stormwater used for these MINTEQ simulations was the stormwater spiked with Cu to a total Cu concentration of 28 μg/L. The partial pressure of carbon dioxide was fixed at 2 x 0.0032 atm. We used the Stockholm Humic Model (SHM) [*Gustaffson*, 2001] to model the interaction of copper with DOC. This model employs the basic Stern Model as the interface model. We simulated the effects of DOC concentrations and pH on copper speciation and copper-DOC complexes. The pH (at constant DOC concentrations) was varied from pH 6 to 8, and DOC concentrations were varied (at constant pH) from 0.01 to 1500 mg/L. Model outputs were the activities (concentrations) of different copper species.

3.7 Statistical Analysis

Statistical analysis was performed using the three replicates from each treatment. Analysis of variance was carried out to determine significant differences in compost characteristics between the treatments both before and after leaching ($p < 0.05$) [*R Core Team*, 2013].

4 Findings/Discussion

4.1 Compost Characteristics

The results of the compost characterization are listed in Tables 3 and 4. Comparison between the before-leaching and after-leaching values revealed statistically significant differences in pH, EC, potassium, sodium, and boron. There was a noticeable reduction in EC, potassium, sodium, and boron following the leaching experiment. These reductions were consistent with our expectations, as monovalent alkali metals, potassium and sodium, are readily exchanged with protons during leaching. The results of the Solvita Compost Emissions Test revealed that the composts were mature. Each compost scored a 5 and a 6 on the ammonia and the carbon dioxide emissions indices, respectively. These two numbers correspond to the mature stage of the composting process [*Woods End Laboratories*, 2014].

Table 3: *Chemical characteristics of the 6- and 24-month old Cedar Grove compost at the beginning and the end of the leaching experiments.*

		Compost Age			
		6-Month Old Compost		24-Month Old Compost	
Parameter	Units	Initial	Final	Initial	Final
pH		$6.7\pm0^{a,A}$	6.6 ± 0.1^{B}	$6.4\pm0.1^{b,A}$	6.8 ± 0.1^{B}
Electrical Conductivity	dS/m	2.75 ± 0.26^{A}	0.26 ± 0.06^{B}	2.8 ± 0.73^{A}	0.26 ± 0.05^{B}
Organic Matter	g/kg	406±54	381±20	400±17	405±30
Organic Carbon (C)	g/kg	205±38	191±27	206±10	213±21
Total Nitrogen (N)	g/kg	14±2	13±1	15.6±0.3	15±1
Total Iron (Fe)	g/kg	16±1.7	15.6 ±1.1	17±1.1	18± 1.7
Total Phosphorus (P)	g/kg	2.9±0.6	2.5±0.3	2.7±0.1	2.7±0.4
Total Potassium (K)	g/kg	7.3 ± 0.9^{A}	1.4 ± 0.2^{B}	6.9 ± 0.1^{A}	1.5 ± 0.2^{B}
Total Calcium (Ca)	g/kg	20 ± 0^{a}	20±1.4	19 ± 0.6^{b}	20.1±2.6
Total Magnesium (Mg)	g/kg	5.8±0.8	5.2±0.1	5.8±0.3	6.1±0.3
Total Sodium (Na)	g/kg	$1.5\pm0.2^{a,A}$	0.3 ± 0.1^{B}	$0.9\pm0.6^{b,A}$	0.3 ± 0.6^{B}
Total Sulfur (S)	g/kg	1.8±0.2	1.7±0.1	2.1±0.6	2±0.3
Total Boron (B)	mg/kg	10.3 ± 2.7^{A}	5.2 ± 0.7^{B}	11.4 ± 0.6^{A}	4.2 ± 0.6^{B}
Total Zinc (Zn)	mg/kg	183±12	194 ±10	193±5	213 ±30
Total Manganese (Mn)	mg/kg	464±34	504±22	476±11	533±51
Total Copper (Cu)	mg/kg	45±4	64±21	50±2	122±65
C/N Ratio	–	14.3±0.7	14.3±0.5	13.1 ± 0.4^{A}	14.3 ± 0.3^{B}

Superscripts indicate a significant difference, while the absence of a superscript indicates no difference.

^{a,b} denotes significant difference between initial 6- and 24-month old compost.

^{A,B} denotes significant difference before and after the leaching experiments within the 6- and 24-month old compost.

Table 4: *Chemical composition of Royal Classics and Silver Springs composts used in the experiment.*

Parameter	Royal Classics	Silver Springs
pH	6.6[†] ± 0.1 (a)[‡]	8.4 ± 0.3 (b)
Electrical conductivity (dS/m)	4.9 ± 0.6	4.3 ± 0.3
Organic matter (g/kg)	368 ± 9	374 ± 9
C : N ratio	10 ± 0.0	12 ± 0.6
Total N (g/kg)	19 ± 1	16 ± 1
Ammonium N (mg/kg)	7 ± 2 (a)	2058 ± 57 (b)
Nitrate N (mg/kg)	1590 ± 356 (a)	28 ± 8 (b)
Phosphorus (g/kg)	2.9 ± 0.4	3.3 ± 0.3
Potassium (g/kg)	12 ± 1	11 ± 1
Calcium (g/kg)	15 ± 0	14 ± 2
Magnesium (g/kg)	4.9 ± 0.1	5.0 ± 0.4
Sulfate-S (mg/kg)	371 ± 98 (a)	170 ± 13 (b)
Iron (g/kg)	13.7 ± 0.4	13.6 ± 0.3
Chloride (mg/kg)	2250 ± 153 (a)	3176 ± 277 (b)
Manganese (mg/kg)	412 ± 21	401 ± 21
Zinc (mg/kg)	146 ± 29	146 ± 12
Copper (mg/kg)	42 ± 4	43 ± 3
Sodium (g/kg)	0.9 ± 0.0 (a)	0.7 ± 0.1 (b)

[†]Values represent mean ± standard deviation ($n = 3$)

[‡]Values followed by different letters in a row are significantly different at $p < 0.05$

4.2 ^{13}C-Nuclear Magnetic Resonance (NMR) and Fourier Transform Infrared Spectroscopy (FTIR)

Figure 3 shows the ^{13}C-NMR spectra of the Cedar Grove composts (the spectra for the Royal Organic and Silver Springs composts were similar to the Cedar Grove compost and are therefore not shown). The spectra for the 6- and 24- month composts showed the same peaks, which are typical of municipal compost [*Wilson et al.*, 1981; *Spaccini and Piccolo*, 2008]. The major peaks in our spectra occurred in the aliphatic (0-110 ppm) and the carboxyl regions (160-190 ppm). The most intense peak at 78.2 ppm is associated with the C2, C3, and C5 carbons of cellulose. The peaks at 159.6 and 177.4 ppm indicate carbons of phenolic and carboxylic functional groups, respectively [*Wilson et al.*, 1981; *Genest et al.*, 2014; *Gao et al.*, 2015]. The spectra reveal a predominance of ligno-cellulose and recalcitrant aliphatic compounds (29.6 and 35.2 ppm) [*Spaccini and Piccolo*, 2008; *Genest et al.*, 2014]. Overall, the NMR spectra indicate minimal difference in the molecular structure of the composts.

Figure 4 shows the FTIR spectra of the Cedar Grove composts (the spectra for the Royal Organic and Silver Springs composts were similar to the Cedar Grove compost and are therefore not shown). The spectra of the composts had absorbance bands in the same wavenumber regions. Main absorbance bands occurred at 3280, 2924, 2853, 1590, 1505, 1416, 1265, 1028, and 646 cm^{-1}. The most intense band in the 6- and 24-month compost occurred at 1024 and 1028 cm^{-1}, respectively. Absorbance at these wavenumbers is associated with C-O stretching of polysaccharides [*Carballo et al.*, 2008; *Smidt et al.*, 2011; *Wang et al.*, 2013; *Provenzano et al.*, 2014].

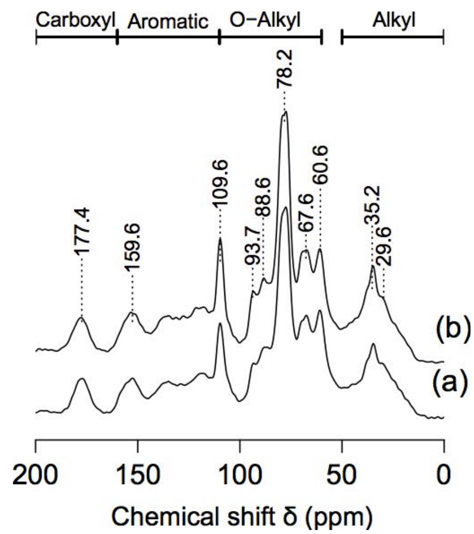

Figure 3: *^{13}C-NMR spectra from (a) 6-month and (b) 24-month old Cedar Grove compost. Structural groups were assigned according to* Spaccini and Piccolo *[*2008*]. Spectra are offset for clarity.*

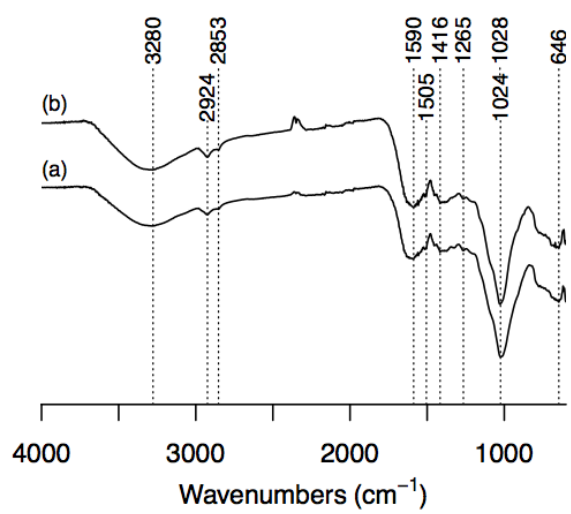

Figure 4: *FTIR transmittance spectra from (a) 6-month and (b) 24-month old Cedar Grove compost. Spectra are offset for clarity.*

The spectra show a shallow band around 3280 cm^{-1}, associated with O-H stretching of bonded and non-bonded hydroxyl groups [*Smidt et al.*, 2011*; Higashikawa et al.*, 2014*; Provenzano et al.*, 2014]. This band has also been associated with phenolic OH and with phenol, alcohol, and carboxyl groups [*Ouaqoudi et al.*, 2014]. The presence of phenol and carboxyl groups is further supported by the band at 1416 cm^{-1}, which is associated with the C-O stretching of carboxylic acids [*Smidt et al.*, 2011*; Wang et al.*, 2013*; Ouaqoudi et al.*, 2014].

The presence of aliphatic C-H stretching was indicated by weak bands at 2924 and 2853 cm^{-1} [*Huang et al.*, 2006*; Ouaqoudi et al.*, 2014*; Provenzano et al.*, 2014]. These wavenumbers correspond to the asymmetric and symmetric C-H stretching of methyl and methylene groups [*Smidt et al.*, 2011*; Fels et al.*, 2014]. The intensity of bands at 2924 and 2853 cm^{-1} have been shown to decrease during the composting process. In mature compost, these aliphatic methylene bands indicate the presence of recalcitrant biomolecules such as long chain fatty acids and waxes [*Smidt et al.*, 2011*; Ouaqoudi et al.*, 2014].

The presence of aromatic groups was indicated by absorbances at 1590, 1505, and 1265 cm^{-1}. The band at 1590 cm^{-1} is associated with C=C vibration of aromatic carbon [*Carballo et al.*, 2008*; Smidt et al.*, 2011], and the band at 1505 cm^{-1} indicates the C=C vibration of lignin and lignocellulosic materials [*Carballo et al.*, 2008*; Smidt et al.*, 2011*; Ouaqoudi et al.*, 2014]. The band at 1265 cm^{-1} has been attributed to aromatic carbon and C-O stretching [*Huang et al.*, 2006*; Provenzano et al.*, 2014].

The FTIR spectra support the structural information obtained from the ^{13}C-NMR spectra. The spectra indicate the presence of aliphatic, aromatic, and carboxylic functional groups, as well as lignin. The ^{13}C-NMR and FTIR spectra suggest that there was no significant difference between the molecular structure of the organic matter of the composts.

4.3 Dynamics of pH, Dissolved Organic Carbon, and Electrical Conductivity in Leachate

Figure 5 shows a comparison of the leachate dynamics between the two Cedar Grove composts (the leaching patterns for the Royal Organic and Silver Spring composts was similar to the Cedar Grove compost, and the data are therefore not shown). Overall, the pH of the leachate from both treatments increased during the first few storms, but leveled off as the leaching continued (Figure 5a). The initial pH of the leachate samples of both treatments was 6.5. In the subsequent samples until 600 mm cumulative flux, the pH increased, and then leveled off at a pH between 7.5 and 7.8.

The electrical conductivity of leachates from both treatments followed a decreasing trend as leaching progressed (Figure 5b). The initial electrical conductivities were higher in the 24-month treatment than in 6-month treatment. Electrical conductivities were elevated for the first two to three storms, corresponding to about 500 mm cumulative flux, and then dropped below 1 dS/m. Each storm was characterized by a distinct peak in electrical conductivity followed by a continuous decrease in electrical conductivity as the storm progressed.

The DOC concentrations peaked between 400 and 600 mg/L during the first two storms (Figure 5c). At the initiation of the third storm, the DOC concentrations increased to greater than 1000 mg/L. After the spike of the third storm, the DOC concentrations decreased with each successive storm. Each storm was characterized by a distinct peak in DOC followed by a continuous decrease in DOC as the storm progressed. The peaks of successive storms decreased continuously, similar to, but more gradual than what was observed for the electrical conductivity.

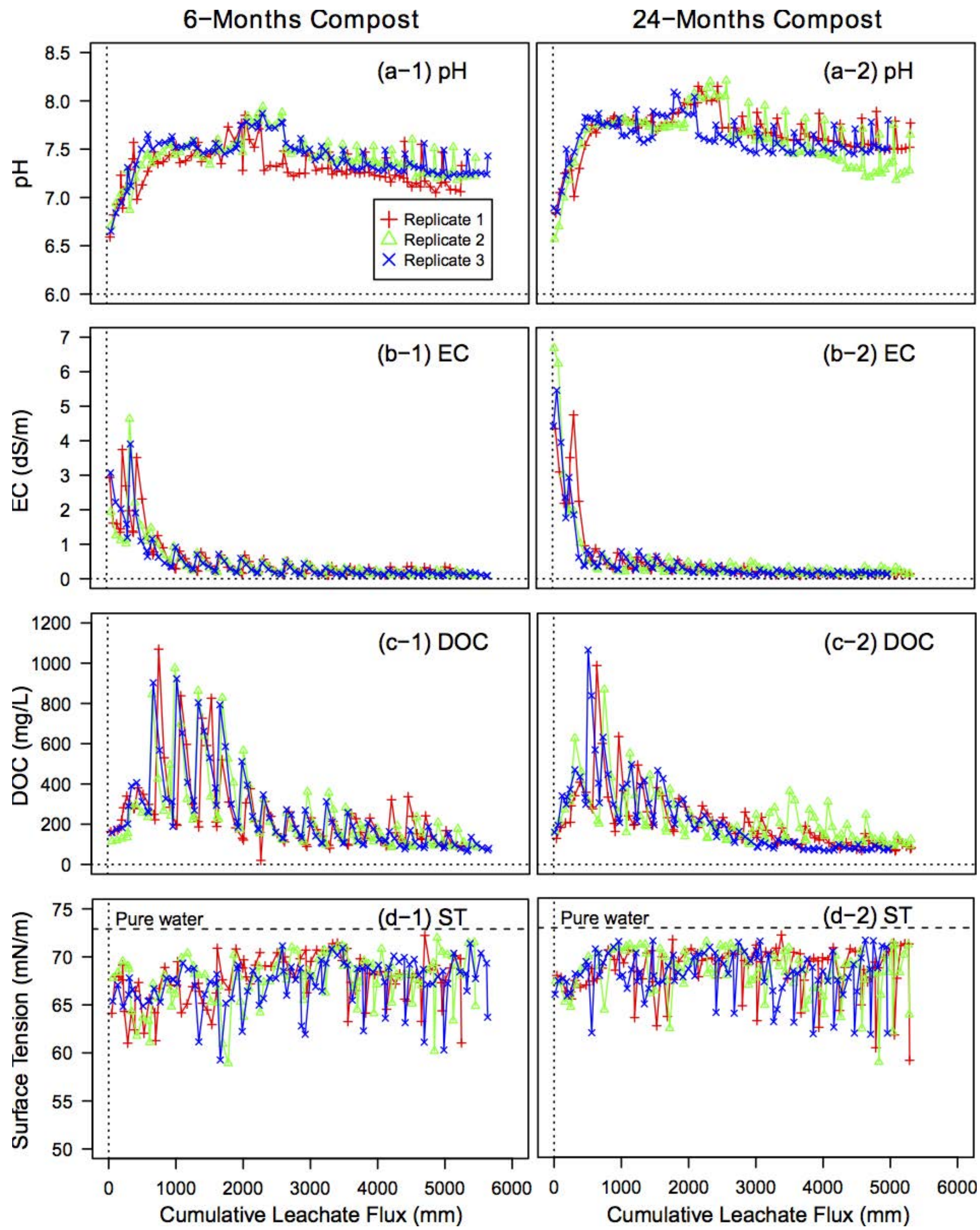

Figure 5: *Dynamics of leachate from 6-month (left column) and 24-month old Cedar Grove compost (right column). (a) pH, (b) electrical conductivity (EC), (c) dissolved organic carbon (DOC), (d) surface tension. Distinct peaks visible in EC and DOC coincide with the initiation of a new storm.*

Surface active compounds, i.e., DOM, decreased the surface tension of the leachate compared to that of the influent. We hypothesized that the dynamics of the surface tension would follow the same pattern as observed for the DOC. Over the course of the experiment, the surface tension of the leachate from both treatments varied between 60 and 72 mN/m (Figure 5d); however, there was no temporal trend. This indicates continued mobilization of surface active compounds, but no distinct temporal pattern, contrary to what was seen in case of EC and DOC. There was no correlation of surface tension within individual storms.

Similar to the pattern seen in the DOC dynamics, the particulate concentrations for each size fraction (11, 1, and 0.45 μm) reached a peak after the first few storms (Figure 6). After reaching this peak, the particulate concentration in both treatments decreased with each successive storm. As observed for both the electrical conductivity and DOC, each storm was characterized by a distinct peak in particulate concentration followed by a continuous decrease as the storm progressed. The peaks of successive storms decreased continuously.

The particulate concentrations for each size fraction were less in the 24-month old compost than in the 6-month old compost. The majority of particulates in both treatments were retained on the 1 μm filter, indicating that the particulates of 1 to 11 μm in diameter were the dominant fraction leached (on a mass basis).

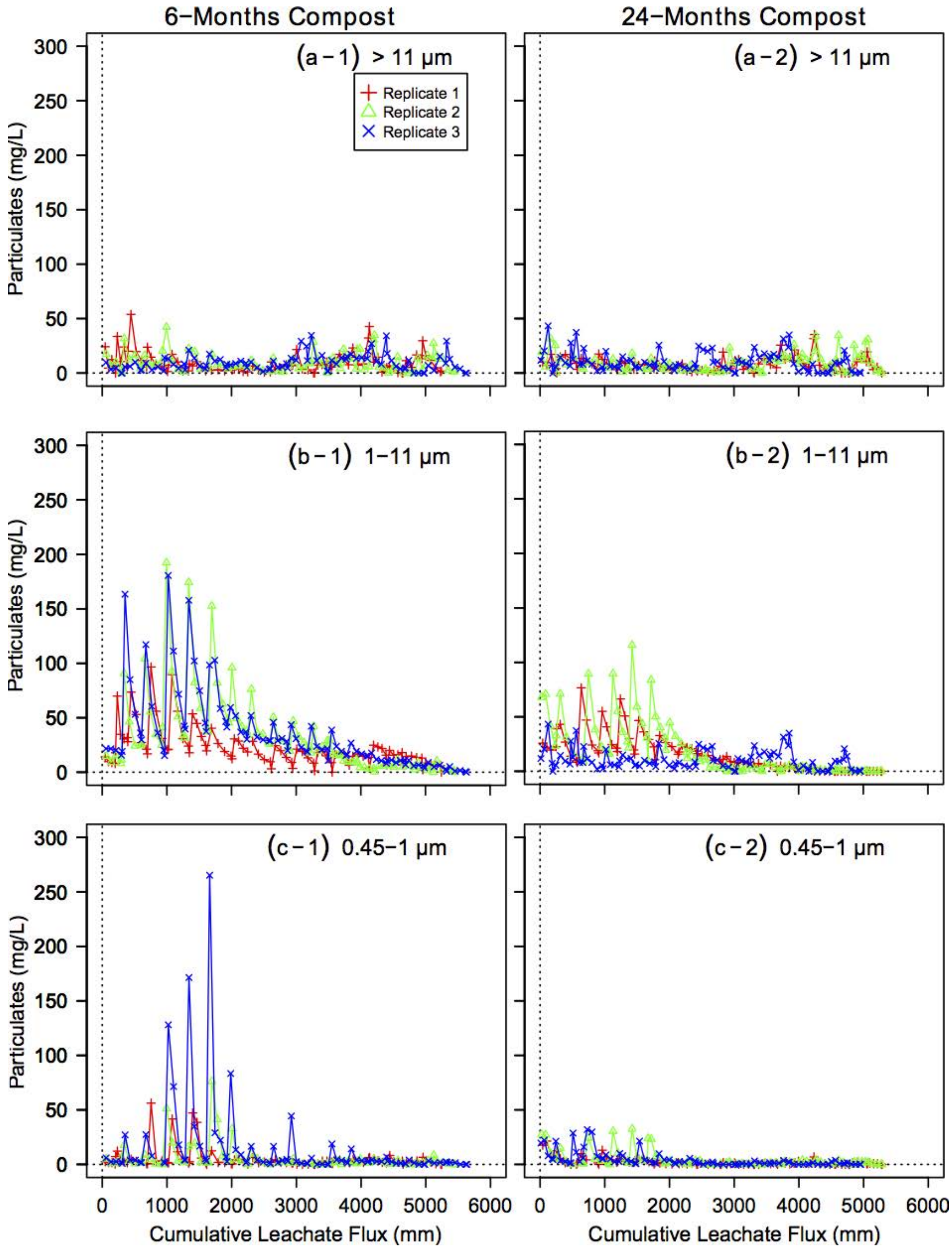

Figure 6: *Dynamics of particulate leaching from 6-month (left column) and 24-month (right column) old Cedar Grove compost. (a) particulate fraction* $> 11\ \mu m$*, (b) particulate fraction* $1 - 11\ \mu m$*, (c) particulate fraction* $0.45 - 1\ \mu m$*. Distinct peaks coincide with the initiation of a new storm.*

4.4 ^{1}H-Nuclear Magnetic Resonance (NMR) and Fourier Transform Infrared Spectroscopy (FTIR) of Leachate

Figure 7 shows the ^{1}H-NMR spectra of the humic acid standard and the compost leachate for each hour of the first storm for the Cedar Grove compost. The spectra from the composts correlated well with the humic acid standard; with all three spectra exhibiting the same resonance signals. The major peaks in our spectra occurred between 0.7 and 2.5 ppm. Signals in this region correspond with protons of aliphatic chains and protons adjacent to carbonyl groups such as those in fatty acids and esters [*Genest et al.*, 2014]. The most intense peak at 1.9 ppm is associated with methyl and methylene protons α to aromatic rings as well as protons α to carboxylic acid groups [*Sparks*, 1999].

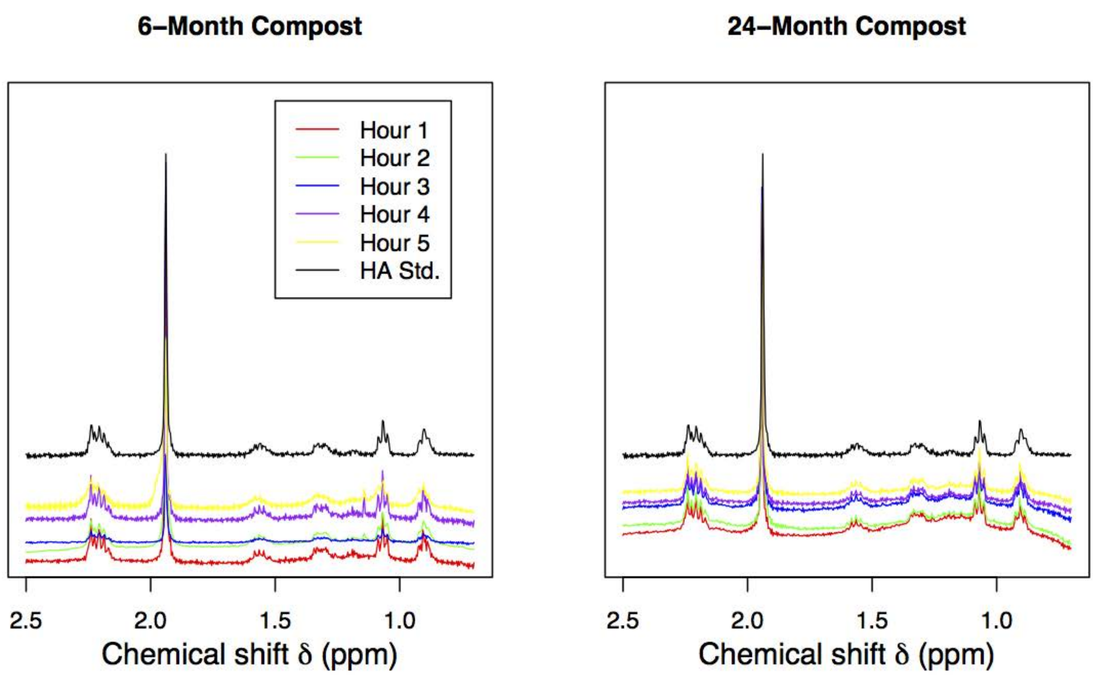

Figure 7: *^{1}H-NMR spectra from 6-months (left) and 24-months (right) old Cedar Grove compost for hourly intervals during the initial storm. Spectra are offset for clarity.*

The signals at 0.9 and 1.07 ppm are associated with the protons of terminal methyl groups and methylene chains, respectively. *Genest et al.* [2014] identified similar signals at 0.9 and 1.05 ppm as protons from terminal and chain methyl groups of aliphatic compounds composing plant cuticles and microbial lipids. The signals at 1.07 and 1.3 ppm indicate protons of methylene chains within two carbons of a ring or polar group, and the signal at 1.55 ppm represent protons specific to alicyclic carbon structures [*Sparks*, 1999]. In summary, the leachate ^{1}H-NMR spectra do not indicate a change in the functional group composition of the organic matter over the course of an individual storm.

The FTIR spectra of the leachates of different composts were similar (Figure 8). The main absorbance bands for both leachates occurred at 3300, 2360, 2330, 1635, 660, and 600 cm^{-1}. The broad FTIR peak at 3300 cm^{-1} is associated with O-H hydroxyl bonds of organics and water. Absorbance at this band was likely dominated by water. The leachates showed bands at 1635 cm^{-1}, which are typically associated with vibrational C=C bonds in aromatic structures as well as vibrational C=O bonds in amides, ketones, esters, and carboxylic acids [*Smidt and Meissl*, 2007; *Carballo et al.*, 2008; *Smidt et al.*, 2011; *Wang et al.*, 2013; *Ouaqoudi et al.*, 2014; *Higashikawa et al.*, 2014]. There were no differences over the course of a storm.

The leachate FTIR confirmed the presence and mobility of the organic and inorganic constituents identified in the compost. The results of the leachate FTIR analysis also complemented the ^{1}H-NMR spectra as both revealed signals corresponding to aromatic and carbonyl groups.

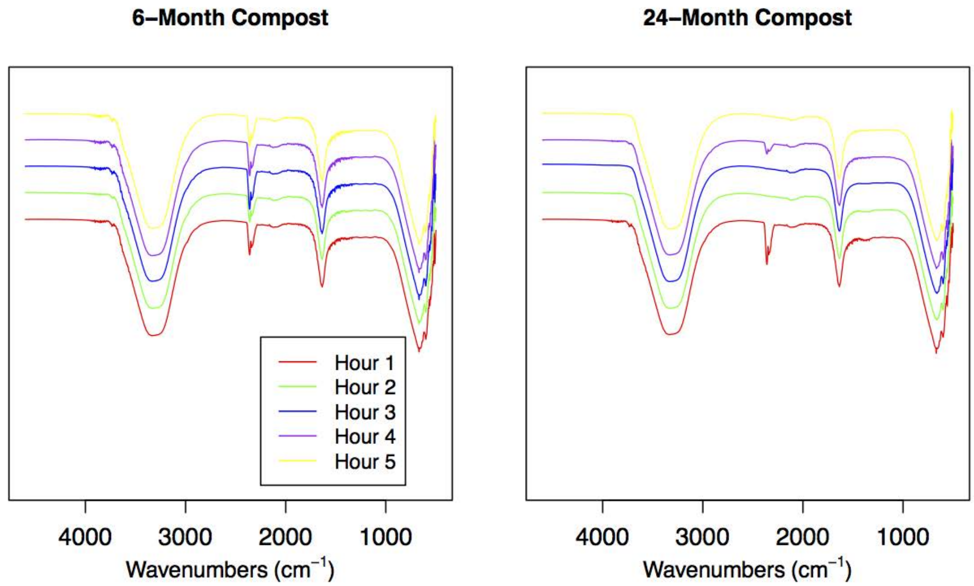

Figure 8: *FTIR transmittance spectra from 6-month and 24-month old Cedar Grove compost. Spectra are offset for clarity.*

4.5 Nitrogen, Phosphorus, and Copper Dynamics

Figures 9 (experiments with using deionized water as influent) and 10 (experiments using copper-spiked stormwater as the influent) show the average concentrations of nitrogen, phosphorus, and copper in the leachate samples. The data represent concentrations in composite samples for selected storms. Due to the gradual decline of concentrations, we did not analyze each storm, but skipped several storms in the later part of the experiment.

The majority of nitrate/nitrite was leached within the first three storms. The 24-month old Cedar Grove compost leached a significantly higher concentration of nitrate/nitrite than the 6-month old Cedar Grove compost (334 mg N/L vs. 72 mg N/L) during the first storm, and so did the Royal Organics compost. There was a pronounced decrease in nitrate/nitrite concentration between storm 1 and storm 2. Although the nitrate/nitrite concentration decreased considerably after four storms, there was a sustained leaching of nitrate/nitrite on the order of 1 to 10 mg N/L.

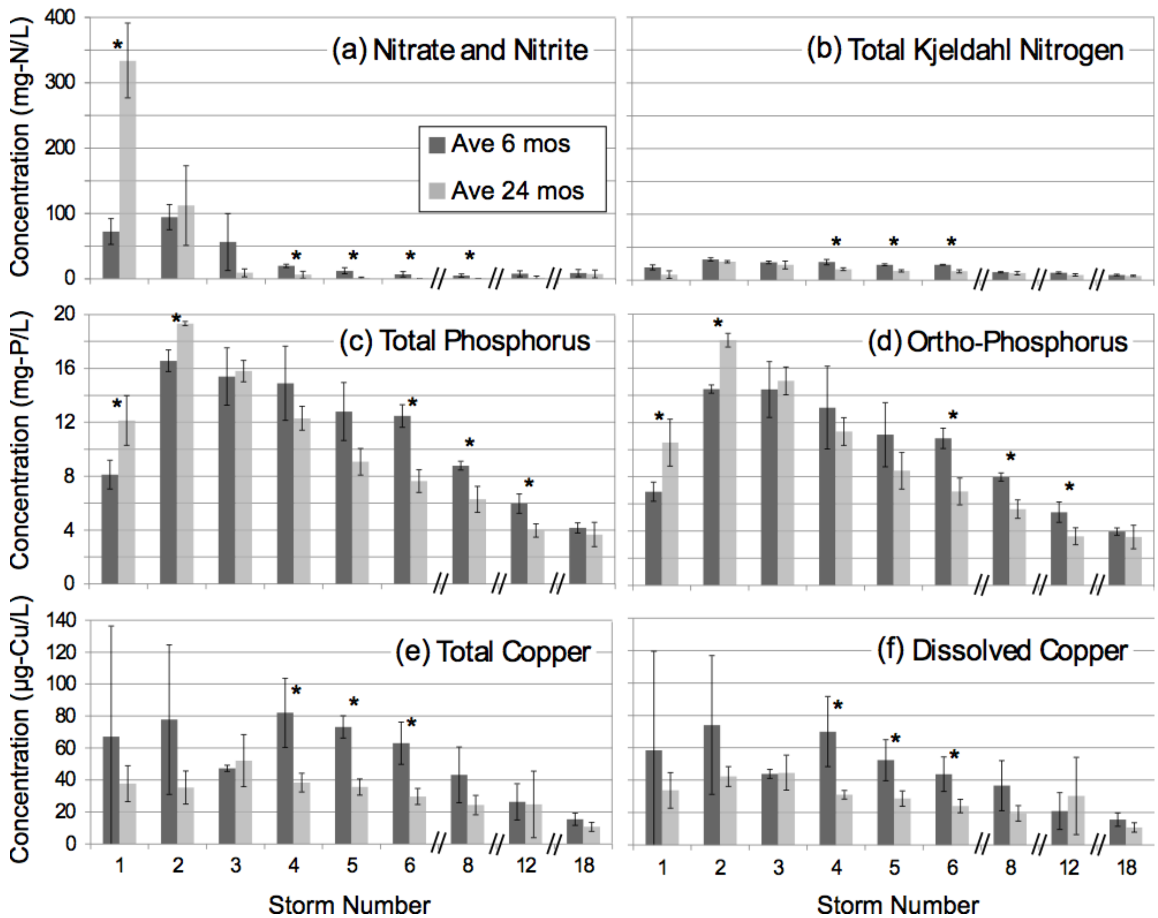

Figure 9: *Concentrations of nitrogen, phosphorus, and copper in the leachate from 6-month and 24-month old Cedar Grove compost for successive storms using deionized water as the influent. In the later part of the experiment, not all storms were analyzed, as indicated by the gaps in the storm number sequence. Significant differences between 6-month and 24-month old compost are denoted by an asterisk* ($p = 0.05$)*. Error bars represent ± one standard deviation.*

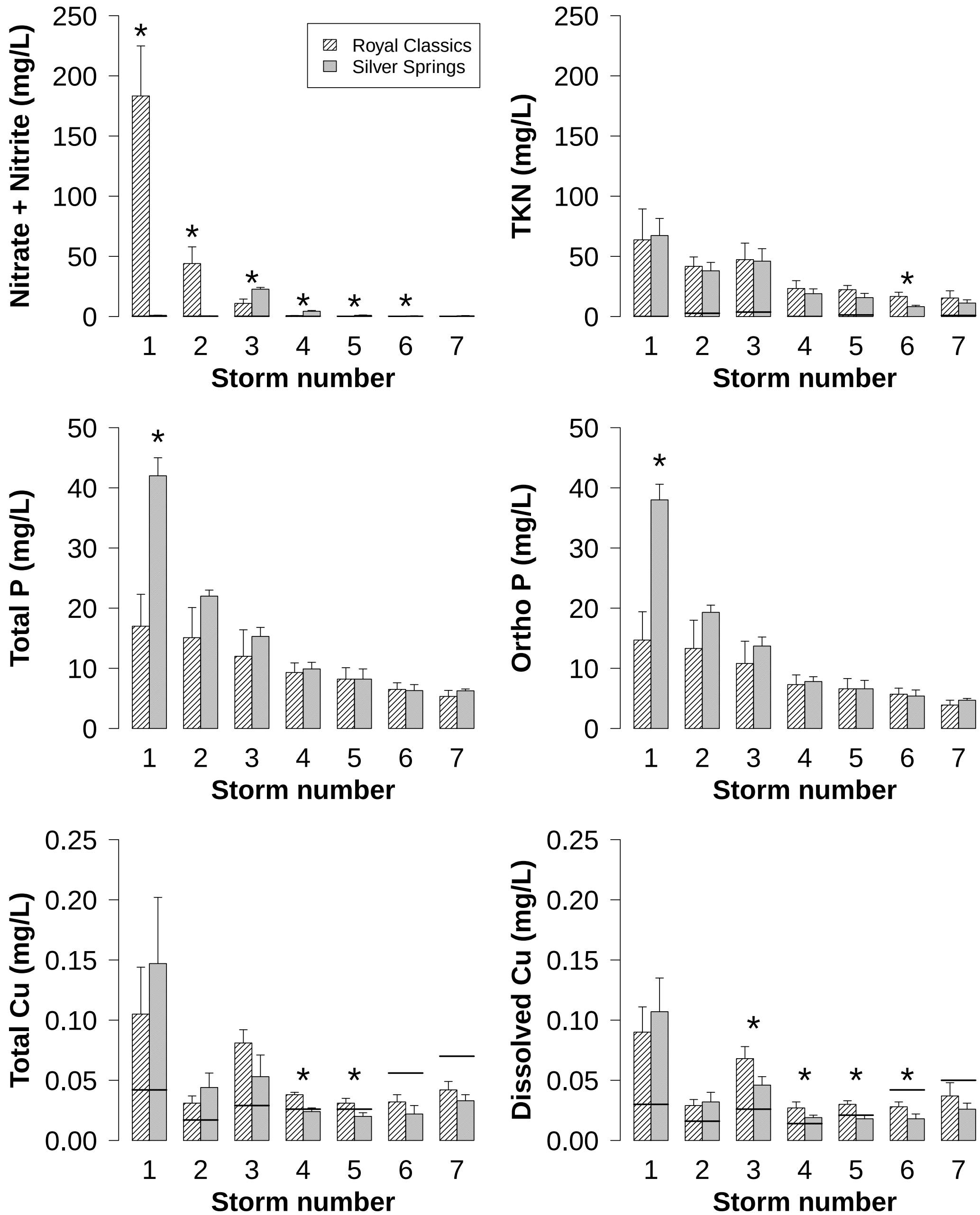

Figure 10: *Nutrient and trace metal concentrations in composite samples for successive storms from Royal Organic and Silver Springs composts using copper-spiked stormwater as the influent. Horizontal black lines indicate the nutrient and trace metal concentration in the influent stormwater.*

Total Kjeldahl nitrogen represents the organically-bound nitrogen and ammonia in the leachate. During each storm the 6-month old Cedar Grove compost leached a higher concentration of Kjeldahl nitrogen than the 24-month old compost (Figure 9b). In the later part of the experiment, significantly more nitrogen (both nitrate/nitrite and Kjeldahl nitrogen) was leached from the 6-month compost compared with the 24-month compost. This is consistent with more nitrogen-mineralization occurring in the younger compost during the course of the experiment.

Most of the phosphorus leached was in the form of ortho-phosphorus in both the deionized water and the stormwater experiments (Figures 9 and 10). Ortho-phosphorus is the inorganic, plant available form of phosphorus that is associated with excessive plant and algal growth. This is a concern for receiving waters as excess plant growth depletes the dissolved oxygen required for other aquatic life. During the first two storms, significantly more phosphorus leached from the 24-month compared to the 6-month old compost. After storm 2, there was a steady decrease in phosphorus concentrations; however, sustained leaching of phosphorus was observed at concentrations of 4 to 15 milligrams of phosphorus per liter.

The majority of copper leached was in the dissolved phase for both the deionized water and the stormwater experiments (Figures 9 and 10). The largest portion of copper leached within the first five to six storms. This was likely the labile fraction of copper leaching out.

For the deionized water experiments, where no copper was present in the inflow, copper was exported from the compost and leached out (Figure 9). The final leachate concentrations from the Cedar Grove composts exceeded the allowable discharge level of 14 μg Cu/L for Western Washington [*Washington State Department of Ecology,* 2014]. The observed total copper concentrations, however, were far below the National Recommended Water Quality Criteria (NRWQC) for human health (1,300 μg Cu/L), but exceeded the saltwater

NRWQC for aquatic life (4.8 and 3.1 μg Cu/L for acute and chronic exposure, respectively) [*USEPA*, 2014]. However, the copper concentrations observed in our experiment may not be toxic due to the presence of elevated DOC, as it is known that DOC readily forms complexes with dissolved copper [*McBride*, 1994], thereby reducing its toxicity to aquatic organisms [*Linbo et al.*, 2009; *USEPA*, 2014]. Chemical complexation is affected by pH, ionic strength, alkalinity, and ionic composition of the aqueous solution. The MINTEQ model does consider all these effects in combination (see results of the modeling below). To highlight the complexation, we plotted copper vs. DOC concentrations (Figure 11). This plot revealed a significant linear correlation between dissolved copper and DOC in the leachate from both composts ($p < 0.05$). It is likely that most of the dissolved copper was complexed with DOC. It also has to be considered that during compost applications to the environment, plants and soil fauna will interact with compost and its leachate, potentially changing the dynamics of DOC leaching and copper complexation.

For the experiments where copper was spiked to the stormwater, the data show an interesting trend (Figure 10). During the first few storms, a net export of copper was observed, but at the later storms, copper was retained in the bioretention systems. This is likely related to the elevated concentrations of DOC leaching in the first few storms. The first few storms generated the highest DOC concentrations, thereby having the greatest potential to complex and mobilize copper. It is also likely that the copper leached with the first few storms was the most labile form of copper, associated with readily leachable DOC. As this readily leachable DOC is removed from the compost during the first few storms, compost starts to act as a sink for copper. Copper in later storms will sorb to non-leachable organic matter in compost.

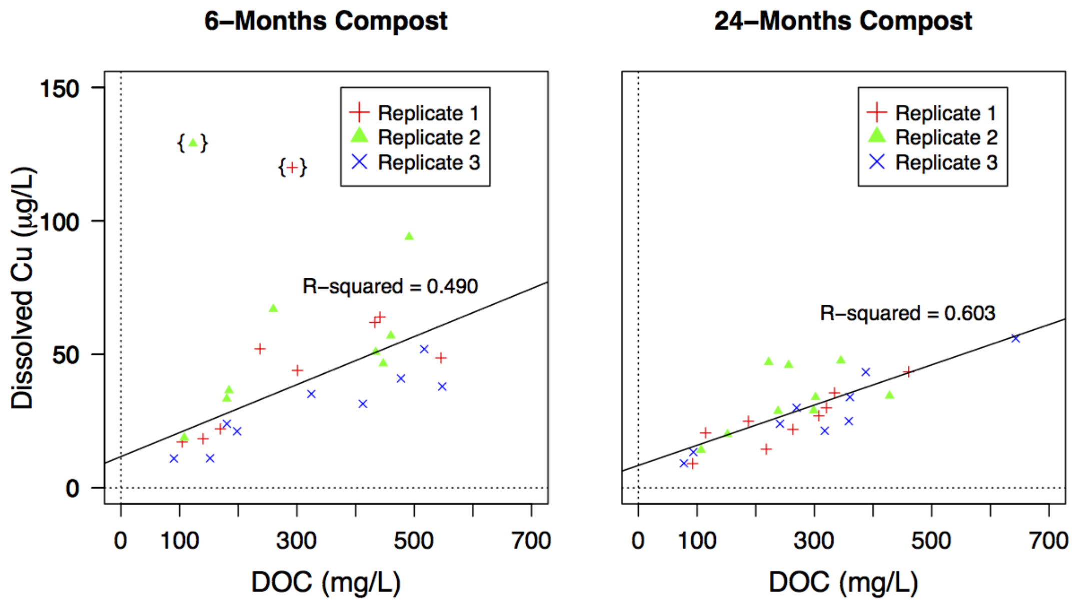

Figure 11: *Correlation of dissolved copper with DOC in 6-month and 24-month old Cedar Grove compost using deionized water as influent. The bracketed data are considered outliers and were excluded from the linear regression.*

In the case where stormwater containing copper was used for the irrigation, the data show an interesting trend (Figures 10). During the first few storms, a net export of copper was observed, but at the later storms, copper was retained in the bioretention systems. This is likely related to the elevated concentrations of DOC leaching in the first few storms.

4.6 Mass Balance of C, N, P, and Cu

Table 5 shows the percentage of carbon, nitrogen, phosphorus, and copper that leached from the Cedar Grove composts for the experiment using deionized water as influent. The 6-month compost leached a significantly greater percentage of both dissolved and particulate carbon than the 24-month compost. For both composts, the DOC leached was an order of magnitude greater than the particulate carbon. These results are consistent with the observed leaching of DOC (Figure 5c) and particulate concentrations (Figure 6). This also supports our hypothesis that the 24-month compost would be more stable and therefore contribute less to leaching.

Table 5: *Mass balance of C, N, P, and Cu from the 6- and 24-month old Cedar Grove compost for the experiments using deionized water as influent. Data represent percentages of material leached compared with initial content. The percentages listed for each compost represent an average and standard deviation of three replicates.*

	Compost Age	
	6-month old	24-month old
Parameter	% Leached	% Leached
Dissolved organic carbon	5.39 ± 0.05[a]	3.98 ± 0.37[b]
Particulate organic carbon	0.53 ± 0.12[a]	0.31 ± 0.04[b]
Total nitrogen	8.07 ± 0.19	7.63 ± 1.46
Total phosphorus	8.87 ± 0.44	7.37 ± 1.39
Total copper	2.82 ± 0.88[a]	1.21 ± 0.14[b]
Dissolved copper	2.36 ± 0.84	1.13 ± 0.25

[a,b] denotes significant difference between 6- and 24-month old compost.

There was no significant difference in the percentage of nitrogen and phosphorus leached from the two composts. This result agrees with the leachate concentrations of nitrogen and phosphorus (Figure 9), where no consistent differences were observed between the two composts. The 6-month compost leached a significantly greater percentage of total copper than the 24-month compost ($p = 0.035$). However, there was no significant difference in the leaching of dissolved copper ($p = 0.072$). About 90% of the leached copper was in the dissolved form. The 6-month compost leached just under 3% of the original total copper content, while the 24-month compost leached just above 1%. This low percentage of copper leached is supported by the findings of *Christensen and Tjell* [1984b], who noted that only 0.1 to 1.9% of original heavy metal content leached from their compost lysimeters. The mass balance of copper in our study shows that the majority of the original copper content remained in the compost. This, combined with the relatively stable leachate concentrations of copper in later storms (Figure 9e,f), shows that compost can be a source for continuous copper export. As mentioned earlier, the copper in the leachate is most likely complexed with DOC [*Kaschl et al.*, 2002; *Chen et al.*, 2010], which mitigates its toxicity to aquatic organisms.

Table 6 shows the percentage of carbon, nitrogen, phosphorus, and copper that leached from the Royal Classic and Silver Springs composts for the experiment using copper-spiked stormwater as influent. The amount of organic carbon leached was similar between the two compost and comparable to the data from the experiments with Cedar Grove compost. Royal Classic compost leached more total nitrogen but less phosphorus than Silver Springs. A higher percentage of copper leached from these experiments as compared to the experiments with the deionized water. We suspect that this is because most of the copper in the stormwater will form organic complexes with the DOC from compost and leach out of the columns.

Table 6: *Mass balance of C, N, P, and Cu in the two compost-amended bioretention systems (Royal Classics and Silver Springs). Percentage data shows the amounts of constituents leached as percentage of constituents in the compost and stormwater inflow.*

Constituent	— Amounts leached (%)† —	
	Royal Classics	Silver Springs
Organic carbon	6.2‡ ± 0.5	5.4 ± 0.1
Total nitrogen	14.4 ± 1.8 (a)	10.3 ± 0.8 (b)
Total phosphorus	14.8 ± 3.5 (a)	23.3 ± 0.7 (b)
Total copper	4.8 ± 0.5	5.3 ± 1.2
Dissolved copper	4.2 ± 0.4	4.1 ± 0.7

†Values followed by different letters in a row are significantly different at $p < 0.05$

‡Values represent mean ± standard deviation ($n = 3$)

4.7 Copper Speciation Modeling

Copper forms various organic and inorganic complexes. It is important to determine these different complexes, because not all forms of copper are toxic to aquatic life. The most toxic form of copper is the free copper or cupric ion (Cu^{2+}), followed by copper hydroxide complexes [*Magnuson et al.,* 1979]. Copper also forms dissolved complexes with organic substances (Cu-Fulvic acid-Cu) and inorganic ions ($CuCl^{+}$, $CuCO_3$ (aq)), and these complexes are not toxic [*Seligman and Zirino,* 1998].

We conducted chemical speciation modeling with MINTEQ to determine the forms of copper and copper-DOC complexes in the stormwater and leachate from our experiments. As input parameters for the MINTEQ modeling, we used the solution chemistry measured from our leachates from the experiments with the copper-spiked stormwater as influent.

In our bioretention leachate at pH 7, the major aqueous copper species were organic Cu species and the inorganic species Cu^{2+}, $CuOH^{+}$, $Cu(OH)_2$ (aq), $Cu_2(OH)_2^{2+}$, $CuCl^{+}$, $CuCO_3$ (aq), and $CuHCO_3^{+}$. The first four of the inorganic copper species are toxic to aquatic organisms, the latter three are non-toxic [*Magnuson et al.,* 1979]. In the presence of DOC (fulvic acid, FA), copper formed the following organic complexes: FA_2Cu (aq), $FACu^{+}$ (aq), FA_2CuOH with small amounts of FA-Cu+2G (aq). The FA_2Cu (aq) and FA_2CuOH are the organically complexed Cu-bidentate complexes, while $FACu^{+}$ (aq) is the organically complexed Cu-monodentate complex.

Figure 12A shows the effect of varying concentrations of DOC on copper speciation at pH 7. The dominant inorganic Cu species was Cu^{2+} and the dominant organic copper species was FA_2Cu (aq). Also shown in the figure are the total inorganic and total organic copper species. At low concentration of DOC (0.01 mg/L), copper was primarily found in inorganic form, with Cu^{2+} being the dominant copper species, with a distribution of 64%.

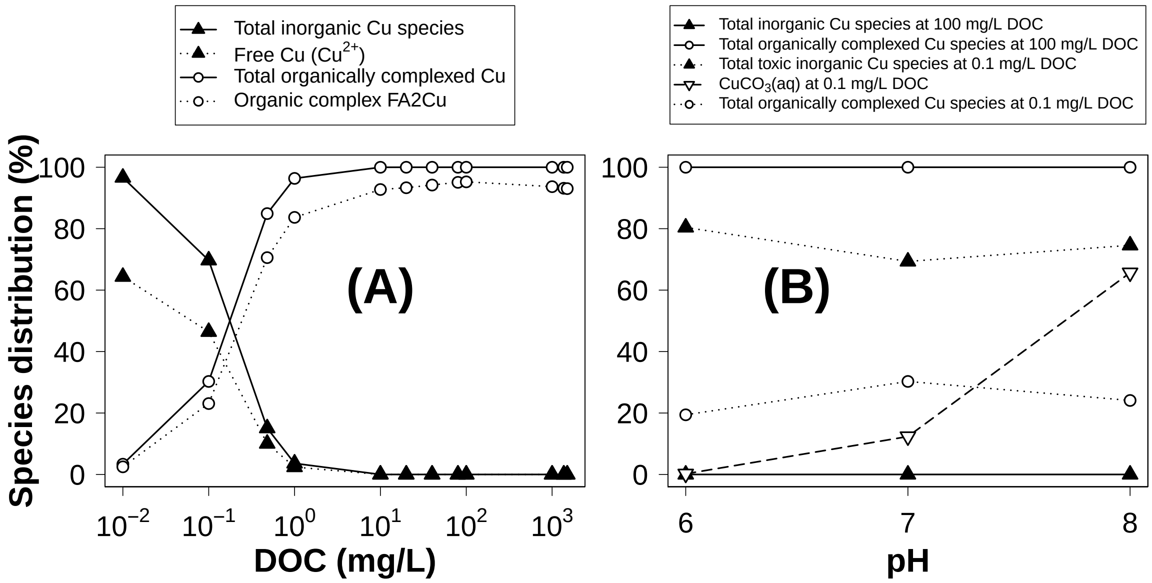

Figure 12: *Copper speciation modeling. (A) Species distribution of copper versus the amounts of DOC (mg/L) in solution at pH = 7, (B) Species distribution of total inorganic and total organically complexed copper at two DOC concentrations (0.1 and 100 mg/L) versus solution pH.*

As the concentration of DOC increases, the inorganic forms of copper decline in favor of organic complexes. When the concentration of DOC is greater than 1 mg/L, nearly all of the Cu is organically complexed, mainly as stable bidentate complex.

The stormwater in our experiments had a concentration of 0.48 mg/L DOC, which results in about 12% of copper in the toxic Cu^{2+} form, and about 85% of the copper in organic form (Figure 12A). The leachate, however, had concentrations of 32 to 1368 mg/L DOC, resulting in all the copper being organically complexed. This indicates that the DOC released from the compost in the bioretention system effectively complexed free aqueous copper, thereby rendering it non-toxic to aquatic organisms.

Figure 12B shows the effect of pH on copper speciation at constant concentrations of DOC of 0.1 and 100 mg/L. At high DOC concentrations (100 mg/L), all copper was organically complexed, regardless of pH (solid lines). At low DOC concentrations (0.1 mg/L), there is substantial presence of toxic inorganic copper species, concentrations of which decrease with increasing pH (80% at pH 6, 9% at pH 8). This decrease in toxic inorganic Cu forms with increasing pH was balanced by formation of $CuCO_3$ (aq). However, pH fluctuations had no effect on the concentrations of organic copper complexes. This indicates that when the DOC is high (100 mg/L), pH fluctuations do not affect the distribution of toxic Cu species. However, at low DOC (0.1 mg/L), an increase in pH decreases the Cu toxicity by formation of $CuCO_3$ (aq). Overall, high pH and high DOC concentrations are conducive for reduced Cu toxicity to aquatic organisms.

5 Conclusions

Our results suggest that, in general, leachate concentrations from mature compost decrease over the course of individual rainstorms as well as following successive storms. However, we observed that this overall decline was not smooth, as the initiation of each storm mobilized a new peak of constituent concentrations in the leachate. The pattern of decline also depends on the constituent, and can be rapid as in the case of EC and nitrate/nitrite, or slow and less pronounced as in the case of DOC, total Kjeldahl nitrogen, and copper. The elevated leachate concentrations from both composts at the beginning of the experiment and the beginning of each new rainstorm suggest that leaching from mature compost is less a function of age and type, but more a function of leaching history. Concentrations of DOC in initial storms readily reach several hundreds of milligrams DOC per liter. Even after several storms, DOC concentrations in the leachate remain in the order of several tenths of milligrams per liter. At such high DOC concentrations, copper is effectively complexed with DOC and organic copper complexes are formed.

6 Recommendations/Applications/Implementation

Compost contains significant amounts of organic carbon, nitrogen, phosphorus and copper. Both 6-month and 24 month old composts subjected to 6 month 24 hour simulated rain events leached organic carbon, nitrogen, phosphorus. Nitrogen leached in both organic and inorganic forms. Phosphorus found in the leachate was mostly in form of ortho-phoshorus, which is the form of phosphorus readily available to organisms and which contributes to eutrophication of aquatic ecosystems. Copper also leached from the compost in these simulated storm events. Our results indicate that the effluent from the first several storms pose the greatest threat to water quality as the mobile C, N, P and Cu all decrease with subsequent storms.

If the stormwater applied to columns is spiked with copper, our results show that additional copper will also be found in leachate after simulated storm events. Our research has shown that most of the copper in leachate is in the dissolved phase. In addition, the compost leachates were high in dissolved carbon. Our modeling of copper speciation showed that with high levels of DOC all of the dissolved copper is expected to form DOC-Cu complexes at pHs between 6 and 8. In this form the copper is not toxic to aquatic organisms. However, DOC-Cu complexes may break apart when the dissolved organic matter is consumed and metabolized by microbial action. Then the Cu would be released back in toxic form to the aqueous ecosystem. More research is needed to determine whether, how, and under what conditions DOC-Cu complexes will break apart. More research is also needed to determine how the quantity of compost and incorporation methods in real situations effects the movement of C, N, P and Cu.

Our results indicate that the effluent from the first several storms pose the greatest threat to water quality as the mobile C, N, P, and Cu all decrease with subsequent storms.

If there is a receiving waterbody that is impaired or has a TMDL restriction, the amount and placement of compost should be carefully evaluated to protect water quality.

Future research is recommended in a real-world context, using direct rainfall and stormwater runoff from a highway that has not been spiked with additional elements. It will be important to capture the effects of vegetation, soil biota, and varying depths of compost application and incorporation. In addition, future studies should include the analysis of zinc and organic pollutants.

7 References

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A Appendix A

This appendix contains reports of chemical analyses of the composts. The product key is as follows:

Product	Lab #	Description	Replicate
LC13-02-002a	C14-590	Cedar Grove Compost 6-months (before leaching)	1
LC13-02-002b	C14-591	Cedar Grove Compost 6-months (before leaching)	2
LC13-02-002c	C14-592	Cedar Grove Compost 6-months (before leaching)	3
LC13-02-0002-1	C14-596	Cedar Grove Compost 6-months (after leaching)	1
LC13-02-0002-2	C14-597	Cedar Grove Compost 6-months (after leaching)	2
LC13-02-0002-3	C14-598	Cedar Grove Compost 6-months (after leaching)	3
LC13-02-004a	C14-593	Cedar Grove Compost 24-months (before leaching)	1
13-02-004b	C14-594	Cedar Grove Compost 24-months (before leaching)	2
LC13-02-004c	C14-595	Cedar Grove Compost 24-months (before leaching)	3
LC13-02-0004-4	C14-599	Cedar Grove Compost 24-months (after leaching)	1
LC13-02-0004-5	C14-600	Cedar Grove Compost 24-months (after leaching)	2
LC13-02-0004-6	C14-601	Cedar Grove Compost 24-months (after leaching)	3
Compost 2_001	C14-648	Royal Classics Compost	1
Compost 2_003	C14-581	Royal Classics Compost	2
Compost 2_003	C14-582	Royal Classics Compost	3
Compost 1_001	C14-531	Silver Springs Compost	1
Compost 1_002	C14-532	Silver Springs Compost	2
Compost 1_003	C14-533	Silver Springs Compost	3

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Client: **WSU Puyallup**	Product: **LC13-02-002a**		Date Reported: 10/08/14
Attn: Jessica Mullane	Date Sampled:	09/25/14	Laboratory # C14-590
2606 W Pioneer	Date Received:	09/26/14	Reveiwed by Brent Thyssen, CPSSc
Puyallup, WA 98371			
916-316-3366			Amount: $ 52.50

Nutrients

	Method	As Rcvd.	Dry Wt.	Units	Low	Normal	High	Typical Range
Moisture	70 C	16		%	**************			15 to 40
Solids	70 C	84		%	*********************			60 to 85
pH	1:5	6.7	NA	SU	*************			5.5 to 8.5
E.C	1:5	2.45	2.92	mmhos/cm	**************			below 5.0
Organic Matter	TMECC 05.07A	39.3	46.8	%	*************			40 to 60
Ash	550 C	44.6	53.2	%	**********************			40 to 60
Total N	TMECC 04.02D	1.38	1.64	%	*************			1 to 5
Organic C	TMECC 04.01A	20.8	24.8	%	*************			18 to 45
Phosphorous	TMECC 04.12B/04.14A	0.20	0.24	%				
P_2O_5		0.46	0.55	%	*********			1 to 8
Potassium	TMECC 04.12B/04.14A	0.69	0.82	%				
K_2O		0.83	0.99	%	****			3 to 12
Calcium	TMECC 04.12B/04.14A	1.69	2.0	%	*************			0.5 to 10
Magnesium	TMECC 04.12B/04.14A	0.44	0.52	%	***********************			0.05 to 0.7
Sodium	TMECC 04.12B/04.14A	0.14	0.17	%	****************			0.05 to 0.7
Sulfur	TMECC 04.12B/04.14A	0.16	0.19	%	****************			0.1 to 1.0
Boron	TMECC 04.12B/04.14A	10.5	12.5	mg/kg	************			25 to 150
Zinc	TMECC 04.12B/04.14A	154	184	mg/kg	*************			100 to 600
Manganese	TMECC 04.12B/04.14A	364	434	mg/kg	********************			250 to 750
Copper	TMECC 04.12B/04.14A	37	44	mg/kg	***			100 to 500
Iron	TMECC 04.12B/04.14A	11963	14267	mg/kg	***********************			1000 to 25000
C/N ratio			15.1	ratio	********			18 to 24

Sample was received, handled and tested in accordance with TMECC procedures

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Client: **WSU Puyallup**	Product: **LC13-02-002b**	Date Reported: 10/08/14
Attn: Jessica Mullane	Date Sampled: 09/25/14	Laboratory # C14-591
2606 W Pioneer	Date Received: 09/26/14	Reveiwed by Brent Thyssen, CPSSc
Puyallup, WA 98371		
916-316-3366		Amount: $ 52.50

Nutrients

	Method	As Rcvd.	Dry Wt.	Units	Low	Normal	High	Typical Range
Moisture	70 C	11		%	*********			15 to 40
Solids	70 C	89		%	********************************			60 to 85
pH	1:5	6.7	NA	SU	*************			5.5 to 8.5
E.C	1:5	2.18	2.45	mmhos/cm	**************			below 5.0
Organic Matter	TMECC 05.07A	32.8	36.9	%	*******			40 to 60
Ash	550 C	56.1	63.1	%	********************************			40 to 60
Total N	TMECC 04.02D	1.13	1.27	%	*************			1 to 5
Organic C	TMECC 04.01A	15.5	17.5	%	**********			18 to 45
Phosphorous	TMECC 04.12B/04.14A	0.31	0.35	%				
P_2O_5		0.71	0.79	%	*********			1 to 8
Potassium	TMECC 04.12B/04.14A	0.57	0.64	%				
K_2O		0.69	0.77	%	****			3 to 12
Calcium	TMECC 04.12B/04.14A	1.74	2.0	%	*************			0.5 to 10
Magnesium	TMECC 04.12B/04.14A	0.60	0.67	%	***********************			0.05 to 0.7
Sodium	TMECC 04.12B/04.14A	0.12	0.13	%	****************			0.05 to 0.7
Sulfur	TMECC 04.12B/04.14A	0.13	0.15	%	****************			0.1 to 1.0
Boron	TMECC 04.12B/04.14A	6.5	7.3	mg/kg	****			25 to 150
Zinc	TMECC 04.12B/04.14A	152	171	mg/kg	*************			100 to 600
Manganese	TMECC 04.12B/04.14A	407	457	mg/kg	********************			250 to 750
Copper	TMECC 04.12B/04.14A	37	42	mg/kg	***			100 to 500
Iron	TMECC 04.12B/04.14A	15719	17671	mg/kg	***********************			1000 to 25000
C/N ratio			13.7	ratio	********			18 to 24

Sample was received, handled and tested in accordance with TMECC procedures

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Client: **WSU Puyallup**	Product: **LC13-02-002c**	Date Reported: 10/08/14
Attn: Jessica Mullane	Date Sampled: 09/25/14	Laboratory # C14-592
2606 W Pioneer	Date Received: 09/26/14	Reveiwed by Brent Thyssen, CPSSc
Puyallup, WA 98371		
916-316-3366		Amount: $ 52.50

Nutrients

	Method	As Rcvd.	Dry Wt.	Units	Low	Normal	High	Typical Range
Moisture	70 C	**15**		%	*********			15 to 40
Solids	70 C	**85**		%	*********************			60 to 85
pH	1:5	**6.7**	**NA**	SU	*************			5.5 to 8.5
E.C	1:5	**2.45**	**2.87**	mmhos/cm	**************			below 5.0
Organic Matter	TMECC 05.07A	**32.5**	**38.0**	%	*******			40 to 60
Ash	550 C	**53.0**	**62.0**	%	********************************			40 to 60
Total N	TMECC 04.02D	**1.18**	**1.38**	%	*************			1 to 5
Organic C	TMECC 04.01A	**16.5**	**19.3**	%	*************			18 to 45
Phosphorous	TMECC 04.12B/04.14A	**0.24**	**0.28**	%				
P_2O_5		**0.55**	**0.64**	%	*********			1 to 8
Potassium	TMECC 04.12B/04.14A	**0.63**	**0.74**	%				
K_2O		**0.76**	**0.89**	%	****			3 to 12
Calcium	TMECC 04.12B/04.14A	**1.73**	**2.0**	%	*************			0.5 to 10
Magnesium	TMECC 04.12B/04.14A	**0.48**	**0.56**	%	***********************			0.05 to 0.7
Sodium	TMECC 04.12B/04.14A	**0.13**	**0.15**	%	****************			0.05 to 0.7
Sulfur	TMECC 04.12B/04.14A	**0.16**	**0.19**	%	****************			0.1 to 1.0
Boron	TMECC 04.12B/04.14A	**9.5**	**11.1**	mg/kg	************			25 to 150
Zinc	TMECC 04.12B/04.14A	**167**	**195**	mg/kg	*************			100 to 600
Manganese	TMECC 04.12B/04.14A	**428**	**501**	mg/kg	********************			250 to 750
Copper	TMECC 04.12B/04.14A	**42**	**49**	mg/kg	***			100 to 500
Iron	TMECC 04.12B/04.14A	**13797**	**16145**	mg/kg	***********************			1000 to 25000
C/N ratio			**14.0**	ratio	********			18 to 24

Sample was received, handled and tested in accordance with TMECC procedures

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Client: **WSU Puyallup**	Product: **LC13-02-0002-1**		Date Reported: 10/08/14
Attn: Jessica Mullane	Date Sampled:	09/25/14	Laboratory # C14-596
2606 W Pioneer	Date Received:	09/26/14	Reveiwed by Brent Thyssen, CPSSc
Puyallup, WA 98371			
916-316-3366			Amount: $ 52.50

Nutrients

	Method	As Rcvd.	Dry Wt.	Units	Low	Normal	High	Typical Range
Moisture	70 C	**7**		%	***			15 to 40
Solids	70 C	**93**		%	********************************			60 to 85
pH	1:5	**6.5**	**NA**	SU	*************			5.5 to 8.5
E.C	1:5	**0.28**	**0.30**	mmhos/cm	******			below 5.0
Organic Matter	TMECC 05.07A	**35.5**	**38.4**	%	*******			40 to 60
Ash	550 C	**57.0**	**61.6**	%	********************************			40 to 60
Total N	TMECC 04.02D	**1.14**	**1.23**	%	*************			1 to 5
Organic C	TMECC 04.01A	**16.1**	**17.4**	%	**********			18 to 45
Phosphorous	TMECC 04.12B/04.14A	**0.26**	**0.28**	%				
P_2O_5		**0.60**	**0.65**	%	*********			1 to 8
Potassium	TMECC 04.12B/04.14A	**0.14**	**0.15**	%				
K_2O		**0.17**	**0.18**	%	****			3 to 12
Calcium	TMECC 04.12B/04.14A	**1.73**	**1.9**	%	*************			0.5 to 10
Magnesium	TMECC 04.12B/04.14A	**0.47**	**0.51**	%	***********************			0.05 to 0.7
Sodium	TMECC 04.12B/04.14A	**0.03**	**0.03**	%	****			0.05 to 0.7
Sulfur	TMECC 04.12B/04.14A	**0.15**	**0.17**	%	****************			0.1 to 1.0
Boron	TMECC 04.12B/04.14A	**4.2**	**4.5**	mg/kg	****			25 to 150
Zinc	TMECC 04.12B/04.14A	**172**	**186**	mg/kg	*************			100 to 600
Manganese	TMECC 04.12B/04.14A	**457**	**494**	mg/kg	********************			250 to 750
Copper	TMECC 04.12B/04.14A	**47**	**51**	mg/kg	*******			100 to 500
Iron	TMECC 04.12B/04.14A	**13463**	**14549**	mg/kg	***********************			1000 to 25000
C/N ratio			**14.1**	ratio	********			18 to 24

Sample was received, handled and tested in accordance with TMECC procedures

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Client: **WSU Puyallup**	Product: **LC13-02-0002-2**		Date Reported: 10/08/14
Attn: Jessica Mullane	Date Sampled:	09/25/14	Laboratory # C14-597
2606 W Pioneer	Date Received:	09/26/14	Reveiwed by Brent Thyssen, CPSSc
Puyallup, WA 98371			
916-316-3366			Amount: $ 52.50

Nutrients

	Method	As Rcvd.	Dry Wt.	Units	Low	Normal	High	Typical Range
Moisture	70 C	**7**		%	***			15 to 40
Solids	70 C	**93**		%	***********************************			60 to 85
pH	1:5	**6.6**	**NA**	SU	**************			5.5 to 8.5
E.C	1:5	**6.23**	**6.71**	mmhos/cm	**			below 5.0
Organic Matter	TMECC 05.07A	**37.1**	**39.9**	%	**************			40 to 60
Ash	550 C	**55.8**	**60.1**	%	************************			40 to 60
Total N	TMECC 04.02D	**1.39**	**1.50**	%	**************			1 to 5
Organic C	TMECC 04.01A	**20.6**	**22.2**	%	**************			18 to 45
Phosphorous	TMECC 04.12B/04.14A	**0.22**	**0.24**	%				
P_2O_5		**0.51**	**0.55**	%	*********			1 to 8
Potassium	TMECC 04.12B/04.14A	**0.13**	**0.14**	%				
K_2O		**0.16**	**0.17**	%	****			3 to 12
Calcium	TMECC 04.12B/04.14A	**1.91**	**2.1**	%	**************			0.5 to 10
Magnesium	TMECC 04.12B/04.14A	**0.49**	**0.53**	%	*************************			0.05 to 0.7
Sodium	TMECC 04.12B/04.14A	**0.04**	**0.04**	%	****			0.05 to 0.7
Sulfur	TMECC 04.12B/04.14A	**0.17**	**0.18**	%	*****************			0.1 to 1.0
Boron	TMECC 04.12B/04.14A	**5.4**	**5.8**	mg/kg	****			25 to 150
Zinc	TMECC 04.12B/04.14A	**190**	**205**	mg/kg	**************			100 to 600
Manganese	TMECC 04.12B/04.14A	**491**	**529**	mg/kg	**********************			250 to 750
Copper	TMECC 04.12B/04.14A	**49**	**53**	mg/kg	*******			100 to 500
Iron	TMECC 04.12B/04.14A	**15579**	**16783**	mg/kg	*************************			1000 to 25000
C/N ratio			**14.8**	ratio	********			18 to 24

Sample was received, handled and tested in accordance with TMECC procedures

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Client:	**WSU Puyallup**	Product:	**LC13-02-0002-3**	Date Reported:	10/08/14
	Attn: Jessica Mullane	Date Sampled:	09/25/14	Laboratory #	C14-598
	2606 W Pioneer	Date Received:	09/26/14	Reveiwed by	Brent Thyssen, CPSSc
	Puyallup, WA 98371				
	916-316-3366			Amount:	$ 52.50

Nutrients

	Method	As Rcvd.	Dry Wt.	Units	Low	Normal	High	Typical Range
Moisture	70 C	**7**		%	***			15 to 40
Solids	70 C	**93**		%	********************************			60 to 85
pH	1:5	**6.6**	**NA**	SU	*************			5.5 to 8.5
E.C	1:5	**0.2**	**0.21**	mmhos/cm	******			below 5.0
Organic Matter	TMECC 05.07A	**33.6**	**36.0**	%	*******			40 to 60
Ash	550 C	**59.6**	**64.0**	%	********************************			40 to 60
Total N	TMECC 04.02D	**1.19**	**1.28**	%	*************			1 to 5
Organic C	TMECC 04.01A	**16.6**	**17.8**	%	**********			18 to 45
Phosphorous	TMECC 04.12B/04.14A	**0.21**	**0.23**	%				
P_2O_5		**0.48**	**0.52**	%	*********			1 to 8
Potassium	TMECC 04.12B/04.14A	**0.11**	**0.12**	%				
K_2O		**0.13**	**0.14**	%	****			3 to 12
Calcium	TMECC 04.12B/04.14A	**16.94**	**18.17**	%	*****************************			0.5 to 10
Magnesium	TMECC 04.12B/04.14A	**0.48**	**0.52**	%	***********************			0.05 to 0.7
Sodium	TMECC 04.12B/04.14A	**0.03**	**0.03**	%	****			0.05 to 0.7
Sulfur	TMECC 04.12B/04.14A	**0.15**	**0.16**	%	****************			0.1 to 1.0
Boron	TMECC 04.12B/04.14A	**5.0**	**5.4**	mg/kg	****			25 to 150
Zinc	TMECC 04.12B/04.14A	**178**	**191**	mg/kg	*************			100 to 600
Manganese	TMECC 04.12B/04.14A	**455**	**488**	mg/kg	********************			250 to 750
Copper	TMECC 04.12B/04.14A	**82**	**88**	mg/kg	*******			100 to 500
Iron	TMECC 04.12B/04.14A	**14334**	**15377**	mg/kg	***********************			1000 to 25000
C/N ratio			**13.9**	ratio	********			18 to 24

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Client: **WSU Puyallup**	Product: **LC13-02-004a**		Date Reported: 10/08/14
Attn: Jessica Mullane	Date Sampled:	09/25/14	Laboratory # C14-593
2606 W Pioneer	Date Received:	09/26/14	Reveiwed by Brent Thyssen, CPSSc
Puyallup, WA 98371			
916-316-3366			Amount: $ 52.50

Nutrients

	Method	As Rcvd.	Dry Wt.	Units	Low	Normal	High	Typical Range
Moisture	70 C	**17**		%	***************			15 to 40
Solids	70 C	**83**		%	**********************			60 to 85
pH	1:5	**6.4**	**NA**	SU	**************			5.5 to 8.5
E.C	1:5	**2.77**	**3.34**	mmhos/cm	***************			below 5.0
Organic Matter	TMECC 05.07A	**34.1**	**41.1**	%	**************			40 to 60
Ash	550 C	**48.8**	**58.9**	%	***********************			40 to 60
Total N	TMECC 04.02D	**1.31**	**1.58**	%	**************			1 to 5
Organic C	TMECC 04.01A	**17.2**	**20.8**	%	**************			18 to 45
Phosphorous	TMECC 04.12B/04.14A	**0.22**	**0.26**	%				
P_2O_5		**0.50**	**0.60**	%	*********			1 to 8
Potassium	TMECC 04.12B/04.14A	**0.58**	**0.70**	%				
K_2O		**0.70**	**0.84**	%	****			3 to 12
Calcium	TMECC 04.12B/04.14A	**1.56**	**1.9**	%	**************			0.5 to 10
Magnesium	TMECC 04.12B/04.14A	**0.45**	**0.54**	%	************************			0.05 to 0.7
Sodium	TMECC 04.12B/04.14A	**0.08**	**0.10**	%	*************			0.05 to 0.7
Sulfur	TMECC 04.12B/04.14A	**0.17**	**0.21**	%	*****************			0.1 to 1.0
Boron	TMECC 04.12B/04.14A	**9.1**	**11.0**	mg/kg	*************			25 to 150
Zinc	TMECC 04.12B/04.14A	**157**	**189**	mg/kg	**************			100 to 600
Manganese	TMECC 04.12B/04.14A	**386**	**466**	mg/kg	*********************			250 to 750
Copper	TMECC 04.12B/04.14A	**42**	**50**	mg/kg	*******			100 to 500
Iron	TMECC 04.12B/04.14A	**13541**	**16346**	mg/kg	************************			1000 to 25000
C/N ratio			**13.2**	ratio	********			18 to 24

Sample was received, handled and tested in accordance with TMECC procedures

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Client: **WSU Puyallup**	Product: **LC13-02-004b**	Date Reported: 10/08/14
Attn: Jessica Mullane	Date Sampled: 09/25/14	Laboratory # C14-594
2606 W Pioneer	Date Received: 09/26/14	Reveiwed by Brent Thyssen, CPSSc
Puyallup, WA 98371		
916-316-3366		Amount: $ 52.50

Nutrients

	Method	As Rcvd.	Dry Wt.	Units	Low	Normal	High	Typical Range
Moisture	70 C	**12**		%	*********			15 to 40
Solids	70 C	**88**		%	********************************			60 to 85
pH	1:5	**6.3**	**NA**	SU	*************			5.5 to 8.5
E.C	1:5	**2.87**	**3.27**	mmhos/cm	**************			below 5.0
Organic Matter	TMECC 05.07A	**33.4**	**38.0**	%	*******			40 to 60
Ash	550 C	**54.4**	**62.0**	%	********************************			40 to 60
Total N	TMECC 04.02D	**1.34**	**1.53**	%	*************			1 to 5
Organic C	TMECC 04.01A	**17.1**	**19.5**	%	*************			18 to 45
Phosphorous	TMECC 04.12B/04.14A	**0.24**	**0.28**	%				
P_2O_5		**0.56**	**0.64**	%	*********			1 to 8
Potassium	TMECC 04.12B/04.14A	**0.60**	**0.68**	%				
K_2O		**0.71**	**0.81**	%	****			3 to 12
Calcium	TMECC 04.12B/04.14A	**1.61**	**1.8**	%	*************			0.5 to 10
Magnesium	TMECC 04.12B/04.14A	**0.53**	**0.60**	%	***********************			0.05 to 0.7
Sodium	TMECC 04.12B/04.14A	**0.08**	**0.09**	%	************			0.05 to 0.7
Sulfur	TMECC 04.12B/04.14A	**0.19**	**0.22**	%	****************			0.1 to 1.0
Boron	TMECC 04.12B/04.14A	**9.7**	**11.1**	mg/kg	************			25 to 150
Zinc	TMECC 04.12B/04.14A	**175**	**199**	mg/kg	*************			100 to 600
Manganese	TMECC 04.12B/04.14A	**428**	**488**	mg/kg	********************			250 to 750
Copper	TMECC 04.12B/04.14A	**45**	**52**	mg/kg	*******			100 to 500
Iron	TMECC 04.12B/04.14A	**16140**	**18389**	mg/kg	***************************************			1000 to 25000
C/N ratio			**12.7**	ratio	********			18 to 24

Sample was received, handled and tested in accordance with TMECC procedures

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Client: **WSU Puyallup**	Product: **LC13-02-004c**		Date Reported: 10/08/14
Attn: Jessica Mullane	Date Sampled:	09/25/14	Laboratory # C14-595
2606 W Pioneer	Date Received:	09/26/14	Reveiwed by Brent Thyssen, CPSSc
Puyallup, WA 98371			
916-316-3366			Amount: $ 52.50

Nutrients

	Method	As Rcvd.	Dry Wt.	Units	Low	Normal	High	Typical Range
Moisture	70 C	**13**		%	*********			15 to 40
Solids	70 C	**87**		%	********************************			60 to 85
pH	1:5	**6.5**	**NA**	SU	*************			5.5 to 8.5
E.C	1:5	**1.78**	**2.04**	mmhos/cm	******			below 5.0
Organic Matter	TMECC 05.07A	**35.7**	**40.9**	%	*************			40 to 60
Ash	550 C	**51.6**	**59.1**	%	**********************			40 to 60
Total N	TMECC 04.02D	**1.39**	**1.59**	%	*************			1 to 5
Organic C	TMECC 04.01A	**18.8**	**21.5**	%	*************			18 to 45
Phosphorous	TMECC 04.12B/04.14A	**0.24**	**0.27**	%				
P_2O_5		**0.54**	**0.62**	%	*********			1 to 8
Potassium	TMECC 04.12B/04.14A	**0.60**	**0.69**	%				
K_2O		**0.72**	**0.82**	%	****			3 to 12
Calcium	TMECC 04.12B/04.14A	**1.69**	**1.9**	%	*************			0.5 to 10
Magnesium	TMECC 04.12B/04.14A	**0.52**	**0.59**	%	***********************			0.05 to 0.7
Sodium	TMECC 04.12B/04.14A	**0.08**	**0.09**	%	************			0.05 to 0.7
Sulfur	TMECC 04.12B/04.14A	**0.18**	**0.21**	%	****************			0.1 to 1.0
Boron	TMECC 04.12B/04.14A	**10.5**	**12.0**	mg/kg	************			25 to 150
Zinc	TMECC 04.12B/04.14A	**167**	**191**	mg/kg	*************			100 to 600
Manganese	TMECC 04.12B/04.14A	**414**	**474**	mg/kg	********************			250 to 750
Copper	TMECC 04.12B/04.14A	**43**	**49**	mg/kg	***			100 to 500
Iron	TMECC 04.12B/04.14A	**14436**	**16546**	mg/kg	***********************			1000 to 25000
C/N ratio			**13.5**	ratio	********			18 to 24

Sample was received, handled and tested in accordance with TMECC procedures

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Client: **WSU Puyallup**	Product: **LC13-02-0004-4**		Date Reported: 10/08/14
Attn: Jessica Mullane	Date Sampled:	09/25/14	Laboratory # C14-599
2606 W Pioneer	Date Received:	09/26/14	Reveiwed by Brent Thyssen, CPSSc
Puyallup, WA 98371			
916-316-3366			Amount: $ 52.50

Nutrients

	Method	As Rcvd.	Dry Wt.	Units	Low	Normal	High	Typical Range
Moisture	70 C	8		%	***			15 to 40
Solids	70 C	92		%	********************************			60 to 85
pH	1:5	6.9	NA	SU	*************			5.5 to 8.5
E.C	1:5	0.18	0.20	mmhos/cm	******			below 5.0
Organic Matter	TMECC 05.07A	39.9	43.4	%	*************			40 to 60
Ash	550 C	52.0	56.6	%	**********************			40 to 60
Total N	TMECC 04.02D	1.40	1.52	%	*************			1 to 5
Organic C	TMECC 04.01A	20.5	22.3	%	*************			18 to 45
Phosphorous	TMECC 04.12B/04.14A	0.22	0.24	%				
P_2O_5		0.51	0.56	%	*********			1 to 8
Potassium	TMECC 04.12B/04.14A	0.12	0.13	%				
K_2O		0.15	0.16	%	****			3 to 12
Calcium	TMECC 04.12B/04.14A	17.57	19.14	%	*****************************			0.5 to 10
Magnesium	TMECC 04.12B/04.14A	0.54	0.59	%	***********************			0.05 to 0.7
Sodium	TMECC 04.12B/04.14A	0.03	0.03	%	****			0.05 to 0.7
Sulfur	TMECC 04.12B/04.14A	0.18	0.20	%	****************			0.1 to 1.0
Boron	TMECC 04.12B/04.14A	3.4	3.7	mg/kg	****			25 to 150
Zinc	TMECC 04.12B/04.14A	181	197	mg/kg	*************			100 to 600
Manganese	TMECC 04.12B/04.14A	457	498	mg/kg	********************			250 to 750
Copper	TMECC 04.12B/04.14A	47	52	mg/kg	*******			100 to 500
Iron	TMECC 04.12B/04.14A	15180	16528	mg/kg	***********************			1000 to 25000
C/N ratio			14.7	ratio	********			18 to 24

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Client:	**WSU Puyallup**	Product:	**LC13-02-0004-5**	Date Reported:	10/08/14
	Attn: Jessica Mullane	Date Sampled:	09/25/14	Laboratory #	C14-600
	2606 W Pioneer	Date Received:	09/26/14	Reveiwed by	Brent Thyssen, CPSSc
	Puyallup, WA 98371				
	916-316-3366			Amount:	$ 52.50

Nutrients

	Method	As Rcvd.	Dry Wt.	Units	Low	Normal	High	Typical Range
Moisture	70 C	**7**		%	***			15 to 40
Solids	70 C	**93**		%	*********************************			60 to 85
pH	1:5	**6.7**	**NA**	SU	*************			5.5 to 8.5
E.C	1:5	**0.27**	**0.29**	mmhos/cm	******			below 5.0
Organic Matter	TMECC 05.07A	**34.9**	**37.5**	%	*******			40 to 60
Ash	550 C	**58.0**	**62.5**	%	*********************************			40 to 60
Total N	TMECC 04.02D	**1.24**	**1.33**	%	*************			1 to 5
Organic C	TMECC 04.01A	**17.6**	**18.9**	%	*************			18 to 45
Phosphorous	TMECC 04.12B/04.14A	**0.30**	**0.32**	%				
P_2O_5		**0.68**	**0.73**	%	*********			1 to 8
Potassium	TMECC 04.12B/04.14A	**0.15**	**0.16**	%				
K_2O		**0.18**	**0.20**	%	****			3 to 12
Calcium	TMECC 04.12B/04.14A	**2.03**	**2.19**	%	*************			0.5 to 10
Magnesium	TMECC 04.12B/04.14A	**0.57**	**0.61**	%	***********************			0.05 to 0.7
Sodium	TMECC 04.12B/04.14A	**0.04**	**0.04**	%	************			0.05 to 0.7
Sulfur	TMECC 04.12B/04.14A	**0.22**	**0.24**	%	****************			0.1 to 1.0
Boron	TMECC 04.12B/04.14A	**4.6**	**4.9**	mg/kg	****			25 to 150
Zinc	TMECC 04.12B/04.14A	**230**	**247**	mg/kg	*************			100 to 600
Manganese	TMECC 04.12B/04.14A	**550**	**592**	mg/kg	********************			250 to 750
Copper	TMECC 04.12B/04.14A	**166**	**179**	mg/kg	**************			100 to 500
Iron	TMECC 04.12B/04.14A	**16476**	**17729**	mg/kg	***********************			1000 to 25000
C/N ratio			**14.2**	ratio	********			18 to 24

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Client: **WSU Puyallup**	Product: **LC13-02-0004-6**	Date Reported: 10/08/14
Attn: Jessica Mullane	Date Sampled: 09/25/14	Laboratory # C14-601
2606 W Pioneer	Date Received: 09/26/14	Reveiwed by Brent Thyssen, CPSSc
Puyallup, WA 98371		
916-316-3366		Amount: $ 52.50

Nutrients

	Method	As Rcvd.	Dry Wt.	Units	Low	Normal	High	Typical Range
Moisture	70 C	**7**		%	***			15 to 40
Solids	70 C	**93**		%	*********************************			60 to 85
pH	1:5	**6.9**	**NA**	SU	*************			5.5 to 8.5
E.C	1:5	**0.27**	**0.29**	mmhos/cm	******			below 5.0
Organic Matter	TMECC 05.07A	**37.5**	**40.6**	%	*************			40 to 60
Ash	550 C	**55.0**	**59.4**	%	**********************			40 to 60
Total N	TMECC 04.02D	**1.48**	**1.60**	%	*************			1 to 5
Organic C	TMECC 04.01A	**20.9**	**22.6**	%	*************			18 to 45
Phosphorous	TMECC 04.12B/04.14A	**0.23**	**0.25**	%				
P_2O_5		**0.53**	**0.57**	%	*********			1 to 8
Potassium	TMECC 04.12B/04.14A	**0.14**	**0.15**	%				
K_2O		**0.17**	**0.18**	%	****			3 to 12
Calcium	TMECC 04.12B/04.14A	**1.69**	**1.82**	%	*************			0.5 to 10
Magnesium	TMECC 04.12B/04.14A	**0.59**	**0.64**	%	***********************			0.05 to 0.7
Sodium	TMECC 04.12B/04.14A	**0.03**	**0.03**	%	****			0.05 to 0.7
Sulfur	TMECC 04.12B/04.14A	**0.17**	**0.18**	%	****************			0.1 to 1.0
Boron	TMECC 04.12B/04.14A	**3.6**	**3.9**	mg/kg	****			25 to 150
Zinc	TMECC 04.12B/04.14A	**180**	**195**	mg/kg	*************			100 to 600
Manganese	TMECC 04.12B/04.14A	**471**	**509**	mg/kg	********************			250 to 750
Copper	TMECC 04.12B/04.14A	**125**	**135**	mg/kg	**************			100 to 500
Iron	TMECC 04.12B/04.14A	**18466**	**19954**	mg/kg	***************************************			1000 to 25000
C/N ratio			**14.1**	ratio	********			18 to 24

Sample was received, handled and tested in accordance with TMECC procedures

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Client: **WSU**	Product: **Compost 2_001**	Date Reported:	11/10/14
Attn: Maninder Chahal	Date Sampled: 09/12/14	Laboratory #	C14-648
2606 W Pioneer Ave	Date Received: 10/24/14	Reveiwed by	Brent Thyssen, CPSSc
Puyaallup, WA 98371			
253-445-4592		Amount:	$ 147.00

Nutrients

	Method	As Rcvd.	Dry Wt.	Units	Low	Normal	High	Typical Range
Moisture	70 C	**26.3**		%	****************			15 to 40
Solids	70 C	**73.7**		%	*****************			60 to 85
pH	1:5	**6.5**	**NA**	SU	*************			5.5 to 8.5
E.C	1:5	**4**	**5.43**	mmhos/cm	********************			below 5.0
Total N	TMECC 04.02D	**1.45**	**1.97**	%	*************			1 to 5
Organic C	TMECC 04.01A	**14.2**	**19.3**	%	*************			18 to 45
Organic Matter	TMECC 05.07A	**27.6**	**37.5**	%	*******			40 to 60
Ash	550 C	**46.1**	**62.5**	%	********************************			40 to 60
Ammonium -N	TMECC 05.02C	**4**	**5**	mg/kg	***			90 to 450
Nitrate-N	TMECC 04.02B	**1345.0**	**1825.8**	mg/kg				50 to 250
Chloride	TMECC 04.12D	**1782**	**2419**	mg/kg	************			500 to 5000
Sulfate-S	TMECC 04.12D	**340**	**462**	mg/kg				
$CaCO_3$	TMECC 04.08A	**37**	**50**	lbs/T	*****************			20 to 80
Phosphorus	TMECC 04.12B/04.14A	**0.23**	**0.32**	%				
P_2O_5		**0.54**	**0.73**	%	*********			1 to 8
Potassium	TMECC 04.12B/04.14A	**0.91**	**1.24**	%				
K_2O		**1.09**	**1.48**	%	****			3 to 12
Calcium	TMECC 04.12B/04.14A	**1.10**	**1.5**	%	*************			0.5 to 10
Magnesium	TMECC 04.12B/04.14A	**0.36**	**0.49**	%	***********************			0.05 to 0.7
Sodium	TMECC 04.12B/04.14A	**0.06**	**0.09**	%	************			0.05 to 0.7
Sulfur	TMECC 04.12B/04.14A	**0.16**	**0.21**	%	****************			0.1 to 1.0
Boron	TMECC 04.12B/04.14A	**11.3**	**15.4**	mg/kg	************			25 to 150
Zinc	TMECC 04.12B/04.14A	**85**	**115**	mg/kg	*************			100 to 600
Manganese	TMECC 04.12B/04.14A	**312**	**423**	mg/kg	********************			250 to 750
Copper	TMECC 04.12B/04.14A	**28**	**38**	mg/kg	***			100 to 500
Iron	TMECC 04.12B/04.14A	**9797**	**13300**	mg/kg	***********************			1000 to 25000
C/N ratio			**10**	ratio	****			18 to 24
C/P Ratio			**61**	ratio	******			80 to 140
Ag Index			**11**	ratio	*******************************			3 to 10

Respiration & Stability

	Method		Units	Low	Normal	High	Normal
CO2 Evolution	TMECC 05.08	**0.3**	mg CO_2-C/g OM/day	**			1 to 7
	TMECC 05.08	**0.2**	mg CO_2-C/g TS/day	****			0.5 to 5
	TMECC 05.08	**0.12**	mg NH_3-N /kg /day	***			10 to 100

Stability Rating **Stable**

Sample was received, handled and tested in accordance with TMECC procedures

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Office: (509)765-1622 - Fax:(509)765-0314 - (800)764-1622

Client:	WSU	Product: Compost 2_001	Date Reported: 11/10/14
	2606 W Pioneer Ave	Date Sampled: 09/12/14	Laboratory # C14-648
	Puyaallup, WA 98371	Date Received: 10/24/14	Reveiwed by Brent Thyssen, CPSSc
	253-445-4592		

Cucumber Bioassay

	Method		Units	Low	Normal	Normal
Emergence	TMECC 05.05A	**97**	%	********************************		80 to 100
Vigor	TMECC 05.05A	**95**	%	********************************		85 to 100
Plant Description		**Mature**				

Pathogens

	Method		Date Tested units	1/0/1900	Low	Normal	High	Normal
Fecal Coliforms	TMECC 07.01B	**Not Tested**	MPN/g					Less than 1000
Salmonella	TMECC 07.01c	**Not Tested**	MPN/4g					Less than 3

ND = None Detected

WAC 173-350-220

	Method	Dry Wt.	Units	Low	Normal	High	WAC Limit
Arsenic	TMECC 04.12B/04.14A	**8.8**	mg/kg	********			20
Cadmium	TMECC 04.12B/04.14A	**0.3**	mg/kg	****			10
Chromium	TMECC 04.12B/04.14A	**19.9**	mg/kg				-
Cobalt	TMECC 04.12B/04.14A	**6.2**	mg/kg				-
Copper	TMECC 04.12B/04.14A	**38.4**	mg/kg	****			750
Lead	TMECC 04.12B/04.14A	**39.5**	mg/kg	****			150
Mercury	TMECC 04.12B/04.14A	**0.06**	mg/kg	****			8
Molybdenum	TMECC 04.12B/04.14A	**2.1**	mg/kg	**************			9
Nickel	TMECC 04.12B/04.14A	**17.1**	mg/kg	****			210
Selenium	TMECC 04.12B/04.14A	**0.5**	mg/kg	****			18
Zinc	TMECC 04.12B/04.14A	**115**	mg/kg	****			1400
		Pass					

Particle Size Distribution TMECC 2.02 B & C

inches	mm	% Passing	Inerts	% by wt.
3	**76.2**	**100**		
2	**50**	**100**	Total Plastic	**0.00**
1	**25**	**100**	Film Plastic	**0.00**
3/4	**19.1**	**100**	Glass	**0.00**
5/8	**16**	**100**	Metal	**0.00**
1/2"	**12.5**	**100**	Sharps	**0.00**
3/8"	**9.5**	**100**		
1/4"	**6.3**	**100**		

Sample was received, handled and tested in accordance with TMECC procedures

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Client:	**WSU**	Product:	**Compost 2_003**
	Attn: Maninder Chahal	Date Sampled:	09/11/14
	2606 W Pioneer Ave	Date Received:	09/17/14
	Puyaallup, WA 98371		
	253-445-4592		

Date Reported:	10/09/14
Laboratory #	C14-581
Reveiwed by	Brent Thyssen, CPSSc
Amount:	$ 147.00

Nutrients

	Method	As Rcvd.	Dry Wt.	Units	Low	Normal	High	Typical Range
Moisture	70 C	**22.5**		%	**************			15 to 40
Solids	70 C	**77.5**		%	*********************			60 to 85
pH	1:5	**6.6**	**NA**	SU	*************			5.5 to 8.5
E.C	1:5	**3.29**	**4.24**	mmhos/cm	********************			below 5.0
Total N	TMECC 04.02D	**1.34**	**1.73**	%	*************			1 to 5
Organic C	TMECC 04.01A	**14.0**	**18.0**	%	*************			18 to 45
Organic Matter	TMECC 05.07A	**27.7**	**35.8**	%	*******			40 to 60
Ash	550 C	**49.8**	**64.2**	%	********************************			40 to 60
Ammonium -N	TMECC 05.02C	**6.5**	**8.4**	mg/kg	***			90 to 450
Nitrate-N	TMECC 04.02B	**915.0**	**1180.2**	mg/kg				50 to 250
Chloride	TMECC 04.12D	**1645**	**2122**	mg/kg	************			500 to 5000
Sulfate-S	TMECC 04.12D	**208**	**268**	mg/kg				
$CaCO_3$	TMECC 04.08A	**20**	**26**	lbs/T	************			20 to 80
Phosphorus	TMECC 04.12B/04.14A	**0.24**	**0.31**	%				
P_2O_5		**0.56**	**0.72**	%	*********			1 to 8
Potassium	TMECC 04.12B/04.14A	**0.92**	**1.18**	%				
K_2O		**1.10**	**1.42**	%	****			3 to 12
Calcium	TMECC 04.12B/04.14A	**1.17**	**1.5**	%	*************			0.5 to 10
Magnesium	TMECC 04.12B/04.14A	**0.38**	**0.49**	%	***********************			0.05 to 0.7
Sodium	TMECC 04.12B/04.14A	**0.07**	**0.09**	%	************			0.05 to 0.7
Sulfur	TMECC 04.12B/04.14A	**0.14**	**0.19**	%	****************			0.1 to 1.0
Boron	TMECC 04.12B/04.14A	**12.1**	**15.6**	mg/kg	************			25 to 150
Zinc	TMECC 04.12B/04.14A	**119**	**153**	mg/kg	*************			100 to 600
Manganese	TMECC 04.12B/04.14A	**300**	**387**	mg/kg	************			250 to 750
Copper	TMECC 04.12B/04.14A	**33**	**43**	mg/kg	***			100 to 500
Iron	TMECC 04.12B/04.14A	**10877**	**14030**	mg/kg	***********************			1000 to 25000
C/N ratio			**10**	ratio	********			18 to 24
C/P Ratio			**57**	ratio	******			80 to 140
Ag Index			**11**	ratio	*******************************			3 to 10

Respiration & Stability

	Method		Units	Low	Normal	High	Normal
CO2 Evolution	TMECC 05.08	**0.5**	mg CO_2-C/g OM/day	**			1 to 7
	TMECC 05.08	**0.2**	mg CO_2-C/g TS/day	****			0.5 to 5
	TMECC 05.08	**0.10**	mg NH_3-N /kg /day	***			10 to 100

Stability Rating **Stable**

Sample was received, handled and tested in accordance with TMECC procedures

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Client:	**WSU**	Product: **Compost 2_003**		Date Reported: 10/09/14
	2606 W Pioneer Ave	Date Sampled:	09/11/14	Laboratory # C14-581
	Puyaallup, WA 98371	Date Received:	09/17/14	Reveiwed by Brent Thyssen, CPSSc
	253-445-4592			

Cucumber Bioassay

	Method		Units	Low	Normal	Normal
Emergence	TMECC 05.05A	**100**	%	***********************************		80 to 100
Vigor	TMECC 05.05A	**99**	%	********************************		85 to 100
Plant Description		**Mature**				

Pathogens

	Method		units	Low	Normal	High	Normal
			Date Tested 1/0/1900				
Fecal Coliforms	TMECC 07.01B	**Not Tested**	MPN/g				Less than 1000
Salmonella	TMECC 07.01c	**Not Tested**	MPN/4g				Less than 3

ND = None Detected

WAC 173-350-220

	Method	Dry Wt.	Units	Low	Normal	High	WAC Limit
Arsenic	TMECC 04.12B/04.14A	**7.5**	mg/kg	********			20
Cadmium	TMECC 04.12B/04.14A	**0.2**	mg/kg	****			10
Chromium	TMECC 04.12B/04.14A	**26.6**	mg/kg				-
Cobalt	TMECC 04.12B/04.14A	**6.1**	mg/kg				-
Copper	TMECC 04.12B/04.14A	**43.1**	mg/kg	****			750
Lead	TMECC 04.12B/04.14A	**38.8**	mg/kg	****			150
Mercury	TMECC 04.12B/04.14A	**0.04**	mg/kg	****			8
Molybdenum	TMECC 04.12B/04.14A	**3.3**	mg/kg	**************			9
Nickel	TMECC 04.12B/04.14A	**18.9**	mg/kg	****			210
Selenium	TMECC 04.12B/04.14A	**0.5**	mg/kg	****			18
Zinc	TMECC 04.12B/04.14A	**153**	mg/kg	****			1400
		Pass					

Particle Size Distribution TMECC 2.02 B & C

inches	mm	% Passing	Inerts	% by wt.
3	**76.2**	**100**		
2	**50**	**100**	Total Plastic	**0.00**
1	**25**	**100**	Film Plastic	**0.00**
3/4	**19.1**	**100**	Glass	**0.00**
5/8	**16**	**100**	Metal	**0.00**
1/2"	**12.5**	**100**	Sharps	**0.00**
3/8"	**9.5**	**100**		
1/4"	**6.3**	**100**		

Sample was received, handled and tested in accordance with TMECC procedures

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Client: **WSU**	Product: **Compost 2_003**	Date Reported:	10/09/14
Attn: Maninder Chahal	Date Sampled: 09/11/14	Laboratory #	C14-582
2606 W Pioneer Ave	Date Received: 09/17/14	Reveiwed by	Brent Thyssen, CPSSc
Puyaallup, WA 98371			
253-445-4592		Amount:	$ 147.00

Nutrients

	Method	As Rcvd.	Dry Wt.	Units	Low	Normal	High	Typical Range
Moisture	70 C	**26.0**		%	****************			15 to 40
Solids	70 C	**74.0**		%	*****************			60 to 85
pH	1:5	**6.6**	**NA**	SU	*************			5.5 to 8.5
E.C	1:5	**3.64**	**4.92**	mmhos/cm	********************			below 5.0
Total N	TMECC 04.02D	**1.42**	**1.92**	%	*************			1 to 5
Organic C	TMECC 04.01A	**14.0**	**18.9**	%	*************			18 to 45
Organic Matter	TMECC 05.07A	**27.4**	**37.0**	%	*******			40 to 60
Ash	550 C	**46.6**	**63.0**	%	********************************			40 to 60
Ammonium -N	TMECC 05.02C	**5**	**7**	mg/kg	***			90 to 450
Nitrate-N	TMECC 04.02B	**1305.0**	**1763.0**	mg/kg				50 to 250
Chloride	TMECC 04.12D	**1636**	**2210**	mg/kg	************			500 to 5000
Sulfate-S	TMECC 04.12D	**284**	**384**	mg/kg				
$CaCO_3$	TMECC 04.08A	**41**	**56**	lbs/T	*****************			20 to 80
Phosphorus	TMECC 04.12B/04.14A	**0.18**	**0.24**	%				
P_2O_5		**0.41**	**0.55**	%	*********			1 to 8
Potassium	TMECC 04.12B/04.14A	**0.97**	**1.32**	%				
K_2O		**1.17**	**1.58**	%	****			3 to 12
Calcium	TMECC 04.12B/04.14A	**1.13**	**1.5**	%	*************			0.5 to 10
Magnesium	TMECC 04.12B/04.14A	**0.37**	**0.50**	%	***********************			0.05 to 0.7
Sodium	TMECC 04.12B/04.14A	**0.07**	**0.09**	%	************			0.05 to 0.7
Sulfur	TMECC 04.12B/04.14A	**0.16**	**0.22**	%	****************			0.1 to 1.0
Boron	TMECC 04.12B/04.14A	**12.0**	**16.2**	mg/kg	************			25 to 150
Zinc	TMECC 04.12B/04.14A	**127**	**171**	mg/kg	*************			100 to 600
Manganese	TMECC 04.12B/04.14A	**315**	**425**	mg/kg	********************			250 to 750
Copper	TMECC 04.12B/04.14A	**33**	**45**	mg/kg	***			100 to 500
Iron	TMECC 04.12B/04.14A	**10208**	**13790**	mg/kg	***********************			1000 to 25000
C/N ratio			**10**	ratio	****			18 to 24
C/P Ratio			**78**	ratio	******			80 to 140
Ag Index			**11**	ratio	*******************************			3 to 10

Respiration & Stability

	Method		Units	Low	Normal	High	Normal
CO2 Evolution	TMECC 05.08	**0.4**	mg CO_2-C/g OM/day	**			1 to 7
	TMECC 05.08	**0.2**	mg CO_2-C/g TS/day	****			0.5 to 5
	TMECC 05.08	**0.06**	mg NH_3-N /kg /day	***			10 to 100

Stability Rating **Stable**

Sample was received, handled and tested in accordance with TMECC procedures

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Office: (509)765-1622 - Fax:(509)765-0314 - (800)764-1622

Client:	**WSU**	Product: **Compost 2_003**	Date Reported: 10/09/14
	2606 W Pioneer Ave	Date Sampled: 09/11/14	Laboratory # C14-582
	Puyaallup, WA 98371	Date Received: 09/17/14	Reveiwed by Brent Thyssen, CPSSc
	253-445-4592		

Cucumber Bioassay

	Method		Units	Low	Normal	Normal
Emergence	TMECC 05.05A	**100**	%	***********************************		80 to 100
Vigor	TMECC 05.05A	**92**	%	********************************		85 to 100
Plant Description		**Mature**				

Pathogens

	Method		Date Tested 1/0/1900 units	Low	Normal	High	Normal
Fecal Coliforms	TMECC 07.01B	**Not Tested**	MPN/g				Less than 1000
Salmonella	TMECC 07.01c	**Not Tested**	MPN/4g				Less than 3

ND = None Detected

WAC 173-350-220

	Method	Dry Wt.	Units	Low	Normal	High	WAC Limit
Arsenic	TMECC 04.12B/04.14A	**9.7**	mg/kg	********			20
Cadmium	TMECC 04.12B/04.14A	**0.3**	mg/kg	****			10
Chromium	TMECC 04.12B/04.14A	**21.6**	mg/kg				-
Cobalt	TMECC 04.12B/04.14A	**6.4**	mg/kg				-
Copper	TMECC 04.12B/04.14A	**44.7**	mg/kg	****			750
Lead	TMECC 04.12B/04.14A	**41.2**	mg/kg	****			150
Mercury	TMECC 04.12B/04.14A	**0.05**	mg/kg	****			8
Molybdenum	TMECC 04.12B/04.14A	**3.1**	mg/kg	**************			9
Nickel	TMECC 04.12B/04.14A	**17.7**	mg/kg	****			210
Selenium	TMECC 04.12B/04.14A	**0.5**	mg/kg	****			18
Zinc	TMECC 04.12B/04.14A	**171**	mg/kg	****			1400
		Pass					

Particle Size Distribution TMECC 2.02 B & C

inches	mm	% Passing	Inerts	% by wt.
3	**76.2**	**100**		
2	**50**	**100**	Total Plastic	**0.00**
1	**25**	**100**	Film Plastic	**0.00**
3/4	**19.1**	**100**	Glass	**0.00**
5/8	**16**	**100**	Metal	**0.00**
1/2"	**12.5**	**100**	Sharps	**0.00**
3/8"	**9.5**	**100**		
1/4"	**6.3**	**100**		

Sample was received, handled and tested in accordance with TMECC procedures

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Client: **WSU**	Product: **Compost 1_001**	Date Reported: 09/16/14	
Attn: Maninder Chahal	Date Sampled: 08/18/14	Laboratory # C14-531	
2606 W Pioneer Ave	Date Received: 08/27/14	Reveiwed by Brent Thyssen, CPSSc	
Puyaallup, WA 98371			
253-445-4592		Amount: $ 147.00	

Nutrients

	Method	As Rcvd.	Dry Wt.	Units	Low	Normal	High	Typical Range
Moisture	70 C	**43.0**		%	****************************			15 to 40
Solids	70 C	**57.0**		%	************			60 to 85
pH	1:5	**8.4**	**NA**	SU	*******************			5.5 to 8.5
E.C	1:5	**2.4**	**4.21**	mmhos/cm	***************			below 5.0
Total N	TMECC 04.02D	**0.96**	**1.68**	%	**************			1 to 5
Organic C	TMECC 04.01A	**11.1**	**19.4**	%	**************			18 to 45
Organic Matter	TMECC 05.07A	**21.3**	**37.3**	%	********			40 to 60
Ash	550 C	**35.8**	**62.7**	%	***********************************			40 to 60
Ammonium -N	TMECC 05.02C	**1155**	**2025**	mg/kg	**********************************			90 to 450
Nitrate-N	TMECC 04.02B	**18.5**	**32.4**	mg/kg	********			50 to 250
Chloride	TMECC 04.12D	**1941**	**3403**	mg/kg	*************************			500 to 5000
Sulfate-S	TMECC 04.12D	**100**	**175**	mg/kg				
$CaCO_3$	TMECC 04.08A	**38**	**66**	lbs/T	*************************			20 to 80
Phosphorus	TMECC 04.12B/04.14A	**0.18**	**0.32**	%				
P_2O_5		**0.42**	**0.73**	%	**********			1 to 8
Potassium	TMECC 04.12B/04.14A	**0.67**	**1.18**	%				
K_2O		**0.81**	**1.41**	%	****			3 to 12
Calcium	TMECC 04.12B/04.14A	**0.78**	**1.4**	%	**************			0.5 to 10
Magnesium	TMECC 04.12B/04.14A	**0.28**	**0.49**	%	*************************			0.05 to 0.7
Sodium	TMECC 04.12B/04.14A	**0.04**	**0.08**	%	*************			0.05 to 0.7
Sulfur	TMECC 04.12B/04.14A	**0.11**	**0.20**	%	*****************			0.1 to 1.0
Boron	TMECC 04.12B/04.14A	**8.0**	**14.1**	mg/kg	*************			25 to 150
Zinc	TMECC 04.12B/04.14A	**88**	**155**	mg/kg	**************			100 to 600
Manganese	TMECC 04.12B/04.14A	**230**	**403**	mg/kg	**********************			250 to 750
Copper	TMECC 04.12B/04.14A	**23**	**41**	mg/kg	***			100 to 500
Iron	TMECC 04.12B/04.14A	**7718**	**13530**	mg/kg	*************************			1000 to 25000
C/N ratio			**12**	ratio	*********			18 to 24
C/P Ratio			**61**	ratio	******			80 to 140
Ag Index			**8**	ratio	*************************			3 to 10

Respiration & Stability

	Method		Units	Low	Normal	High	Normal
CO2 Evolution	TMECC 05.08	**2.2**	mg CO_2-C/g OM/day	*************			1 to 7
	TMECC 05.08	**1.4**	mg CO_2-C/g TS/day	**************			0.5 to 5
	TMECC 05.08	**46.1**	mg NH_3-N /kg /day	*************************			10 to 100
Stability Rating		**Stable**					

Sample was received, handled and tested in accordance with TMECC procedures

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Client:	**WSU**	Product:	**Compost 1_001**	Date Reported:	09/16/14
	2606 W Pioneer Ave	Date Sampled:	08/18/14	Laboratory #	C14-531
	Puyaallup, WA 98371	Date Received:	08/27/14	Reveiwed by	Brent Thyssen, CPSSc
	253-445-4592				

Cucumber Bioassay

	Method		Units	Low	Normal	Normal
Emergence	TMECC 05.05A	**100**	%	***********************************		80 to 100
Vigor	TMECC 05.05A	**100**	%	*************************************		85 to 100
Plant Description		**Mature**				

Pathogens

	Method		Date Tested / units	1/0/1900	Low	Normal	High		Normal
Fecal Coliforms	TMECC 07.01B	**Not Tested**	MPN/g						Less than 1000
Salmonella	TMECC 07.01c	**Not Tested**	MPN/4g						Less than 3

ND = None Detected

WAC 173-350-220

	Method	Dry Wt.	Units	Low	Normal	High	WAC Limit
Arsenic	TMECC 04.12B/04.14A	**8.4**	mg/kg	********			20
Cadmium	TMECC 04.12B/04.14A	**0.3**	mg/kg	****			10
Chromium	TMECC 04.12B/04.14A	**21.0**	mg/kg				-
Cobalt	TMECC 04.12B/04.14A	**6.4**	mg/kg				-
Copper	TMECC 04.12B/04.14A	**40.7**	mg/kg	****			750
Lead	TMECC 04.12B/04.14A	**35.1**	mg/kg	****			150
Mercury	TMECC 04.12B/04.14A	**0.05**	mg/kg	****			8
Molybdenum	TMECC 04.12B/04.14A	**1.9**	mg/kg	**********			9
Nickel	TMECC 04.12B/04.14A	**20.6**	mg/kg	****			210
Selenium	TMECC 04.12B/04.14A	**0.5**	mg/kg	****			18
Zinc	TMECC 04.12B/04.14A	**155**	mg/kg	****			1400
		Pass					

Particle Size Distribution TMECC 2.02 B & C

inches	mm	% Passing	Inerts	% by wt.
3	**76.2**	**100**		
2	**50**	**100**	Total Plastic	**0.00**
1	**25**	**100**	Film Plastic	**0.00**
3/4	**19.1**	**100**	Glass	**0.00**
5/8	**16**	**100**	Metal	**0.00**
1/2"	**12.5**	**100**	Sharps	**0.00**
3/8"	**9.5**	**100**		
1/4"	**6.3**	**95**		

Sample was received, handled and tested in accordance with TMECC procedures

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2925 Driggs Dr., Moses Lake, Wa 98837 - www.soiltestlab.com
Office: (509)765-1622 - Fax:(509)765-0314 - (800)764-1622

Client:	**WSU**	Product: **Compost 1_002**	Date Reported:	09/16/14
	Attn: Maninder Chahal	Date Sampled: 08/18/14	Laboratory #	C14-532
	2606 W Pioneer Ave	Date Received: 08/27/14	Reveiwed by	Brent Thyssen, CPSSc
	Puyaallup, WA 98371			
	253-445-4592		Amount:	$ 147.00

Nutrients

	Method	As Rcvd.	Dry Wt.	Units	Low	Normal	High	Typical Range
Moisture	70 C	**45.5**		%	**************************			15 to 40
Solids	70 C	**54.5**		%	***********			60 to 85
pH	1:5	**8.7**	**NA**	SU	*****************************			5.5 to 8.5
E.C	1:5	**2.22**	**4.07**	mmhos/cm	**************			below 5.0
Total N	TMECC 04.02D	**0.87**	**1.60**	%	*************			1 to 5
Organic C	TMECC 04.01A	**10.4**	**19.0**	%	*************			18 to 45
Organic Matter	TMECC 05.07A	**20.9**	**38.3**	%	*******			40 to 60
Ash	550 C	**33.6**	**61.7**	%	********************************			40 to 60
Ammonium -N	TMECC 05.02C	**1320**	**2420**	mg/kg	*******************************			90 to 450
Nitrate-N	TMECC 04.02B	**8.0**	**14.7**	mg/kg	***			50 to 250
Chloride	TMECC 04.12D	**1777**	**3258**	mg/kg	***********************			500 to 5000
Sulfate-S	TMECC 04.12D	**98**	**180**	mg/kg				
$CaCO_3$	TMECC 04.08A	**47**	**86**	lbs/T	*****************************			20 to 80
Phosphorus	TMECC 04.12B/04.14A	**0.17**	**0.31**	%				
P_2O_5		**0.39**	**0.71**	%	*********			1 to 8
Potassium	TMECC 04.12B/04.14A	**0.59**	**1.08**	%				
K_2O		**0.71**	**1.30**	%	****			3 to 12
Calcium	TMECC 04.12B/04.14A	**0.82**	**1.5**	%	*************			0.5 to 10
Magnesium	TMECC 04.12B/04.14A	**0.25**	**0.46**	%	**********************			0.05 to 0.7
Sodium	TMECC 04.12B/04.14A	**0.04**	**0.07**	%	************			0.05 to 0.7
Sulfur	TMECC 04.12B/04.14A	**0.10**	**0.18**	%	****************			0.1 to 1.0
Boron	TMECC 04.12B/04.14A	**7.5**	**13.7**	mg/kg	************			25 to 150
Zinc	TMECC 04.12B/04.14A	**82**	**150**	mg/kg	*************			100 to 600
Manganese	TMECC 04.12B/04.14A	**229**	**420**	mg/kg	********************			250 to 750
Copper	TMECC 04.12B/04.14A	**25**	**46**	mg/kg	***			100 to 500
Iron	TMECC 04.12B/04.14A	**7592**	**13920**	mg/kg	**********************			1000 to 25000
C/N ratio			**12**	ratio	********			18 to 24
C/P Ratio			**61**	ratio	******			80 to 140
Ag Index			**8**	ratio	**********************			3 to 10

Respiration & Stability

	Method		Units	Low	Normal	High	Normal
CO2 Evolution	TMECC 05.08	**2.0**	mg CO_2-C/g OM/day	************			1 to 7
	TMECC 05.08	**1.4**	mg CO_2-C/g TS/day	*************			0.5 to 5
	TMECC 05.08	**47.1**	mg NH_3-N /kg /day	***********************			10 to 100
Stability Rating		**Stable**					

Sample was received, handled and tested in accordance with TMECC procedures

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Office: (509)765-1622 - Fax:(509)765-0314 - (800)764-1622

Client:	**WSU**	Product:	**Compost 1_002**	Date Reported:	09/16/14
	2606 W Pioneer Ave	Date Sampled:	08/18/14	Laboratory #	C14-532
	Puyaallup, WA 98371	Date Received:	08/27/14	Reveiwed by	Brent Thyssen, CPSSc
	253-445-4592				

Cucumber Bioassay

	Method		Units	Low	Normal	Normal
Emergence	TMECC 05.05A	**100**	%	***********************************		80 to 100
Vigor	TMECC 05.05A	**100**	%	*************************************		85 to 100
Plant Description		**Mature**				

Pathogens

	Method		Date Tested units	1/0/1900	Low	Normal	High		Normal
Fecal Coliforms	TMECC 07.01B	**Not Tested**	MPN/g						Less than 1000
Salmonella	TMECC 07.01c	**Not Tested**	MPN/4g						Less than 3

ND = None Detected

WAC 173-350-220

	Method	Dry Wt.	Units	Low	Normal	High	WAC Limit
Arsenic	TMECC 04.12B/04.14A	**9.8**	mg/kg	********			20
Cadmium	TMECC 04.12B/04.14A	**0.3**	mg/kg	****			10
Chromium	TMECC 04.12B/04.14A	**22.8**	mg/kg				-
Cobalt	TMECC 04.12B/04.14A	**6.9**	mg/kg				-
Copper	TMECC 04.12B/04.14A	**45.8**	mg/kg	****			750
Lead	TMECC 04.12B/04.14A	**32.6**	mg/kg	****			150
Mercury	TMECC 04.12B/04.14A	**0.07**	mg/kg	****			8
Molybdenum	TMECC 04.12B/04.14A	**1.5**	mg/kg	**********			9
Nickel	TMECC 04.12B/04.14A	**18.8**	mg/kg	****			210
Selenium	TMECC 04.12B/04.14A	**0.5**	mg/kg	****			18
Zinc	TMECC 04.12B/04.14A	**150**	mg/kg	****			1400
		Pass					

Particle Size Distribution TMECC 2.02 B & C

inches	mm	% Passing	Inerts	% by wt.
3	**76.2**	**100**		
2	**50**	**100**	Total Plastic	**0.00**
1	**25**	**100**	Film Plastic	**0.00**
3/4	**19.1**	**100**	Glass	**0.00**
5/8	**16**	**100**	Metal	**0.00**
1/2"	**12.5**	**100**	Sharps	**0.00**
3/8"	**9.5**	**100**		
1/4"	**6.3**	**97**		

Sample was received, handled and tested in accordance with TMECC procedures

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Office: (509)765-1622 - Fax:(509)765-0314 - (800)764-1622

Client: **WSU**	Product: **Compost 1_003**	Date Reported: 09/16/14	
Attn: Maninder Chahal	Date Sampled: 08/18/14	Laboratory # C14-533	
2606 W Pioneer Ave	Date Received: 08/27/14	Reveiwed by Brent Thyssen, CPSSc	
Puyaallup, WA 98371			
253-445-4592		Amount: $ 147.00	

Nutrients

	Method	As Rcvd.	Dry Wt.	Units	Low	Normal	High	Typical Range
Moisture	70 C	**41.2**		%	**************************			15 to 40
Solids	70 C	**58.8**		%	***********			60 to 85
pH	1:5	**8.1**	**NA**	SU	*****************			5.5 to 8.5
E.C	1:5	**2.71**	**4.61**	mmhos/cm	**************			below 5.0
Total N	TMECC 04.02D	**0.87**	**1.48**	%	*************			1 to 5
Organic C	TMECC 04.01A	**9.7**	**16.5**	%	**********			18 to 45
Organic Matter	TMECC 05.07A	**21.5**	**36.6**	%	*******			40 to 60
Ash	550 C	**37.3**	**63.4**	%	********************************			40 to 60
Ammonium -N	TMECC 05.02C	**1250**	**2124**	mg/kg	*******************************			90 to 450
Nitrate-N	TMECC 04.02B	**11.0**	**18.7**	mg/kg	***			50 to 250
Chloride	TMECC 04.12D	**1687**	**2867**	mg/kg	***********************			500 to 5000
Sulfate-S	TMECC 04.12D	**92**	**156**	mg/kg				
$CaCO_3$	TMECC 04.08A	**51**	**86**	lbs/T	*****************************			20 to 80
Phosphorus	TMECC 04.12B/04.14A	**0.22**	**0.37**	%				
P_2O_5		**0.50**	**0.85**	%	*********			1 to 8
Potassium	TMECC 04.12B/04.14A	**0.61**	**1.04**	%				
K_2O		**0.74**	**1.25**	%	****			3 to 12
Calcium	TMECC 04.12B/04.14A	**0.71**	**1.2**	%	*************			0.5 to 10
Magnesium	TMECC 04.12B/04.14A	**0.32**	**0.54**	%	***********************			0.05 to 0.7
Sodium	TMECC 04.12B/04.14A	**0.04**	**0.07**	%	************			0.05 to 0.7
Sulfur	TMECC 04.12B/04.14A	**0.10**	**0.18**	%	****************			0.1 to 1.0
Boron	TMECC 04.12B/04.14A	**7.6**	**12.9**	mg/kg	************			25 to 150
Zinc	TMECC 04.12B/04.14A	**78**	**133**	mg/kg	*************			100 to 600
Manganese	TMECC 04.12B/04.14A	**223**	**379**	mg/kg	************			250 to 750
Copper	TMECC 04.12B/04.14A	**24**	**41**	mg/kg	***			100 to 500
Iron	TMECC 04.12B/04.14A	**7844**	**13330**	mg/kg	***********************			1000 to 25000
C/N ratio			**11**	ratio	********			18 to 24
C/P Ratio			**44**	ratio	******			80 to 140
Ag Index			**8**	ratio	***********************			3 to 10

Respiration & Stability

	Method		Units	Low	Normal	High	Normal
CO2 Evolution	TMECC 05.08	**2.2**	mg CO_2-C/g OM/day	************			1 to 7
	TMECC 05.08	**1.4**	mg CO_2-C/g TS/day	*************			0.5 to 5
	TMECC 05.08	**51.5**	mg NH_3-N /kg /day	***********************			10 to 100
Stability Rating		**Stable**					

Sample was received, handled and tested in accordance with TMECC procedures

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2925 Driggs Dr., Moses Lake, Wa 98837 - www.soiltestlab.com
Office: (509)765-1622 - Fax:(509)765-0314 - (800)764-1622

Client:	WSU	Product:	Compost 1_003	Date Reported:	09/16/14
	2606 W Pioneer Ave	Date Sampled:	08/18/14	Laboratory #	C14-533
	Puyaallup, WA 98371	Date Received:	08/27/14	Reveiwed by	Brent Thyssen, CPSSc
	253-445-4592				

Cucumber Bioassay

	Method		Units	Low	Normal	Normal
Emergence	TMECC 05.05A	97	%	********************************		80 to 100
Vigor	TMECC 05.05A	91	%	********************************		85 to 100
Plant Description		Mature				

Pathogens

	Method		Date Tested / units	1/0/1900	Low	Normal	High	Normal
Fecal Coliforms	TMECC 07.01B	Not Tested	MPN/g					Less than 1000
Salmonella	TMECC 07.01c	Not Tested	MPN/4g					Less than 3

ND = None Detected

WAC 173-350-220

	Method	Dry Wt.	Units	Low	Normal	High	WAC Limit
Arsenic	TMECC 04.12B/04.14A	8.2	mg/kg	********			20
Cadmium	TMECC 04.12B/04.14A	0.2	mg/kg	****			10
Chromium	TMECC 04.12B/04.14A	26.7	mg/kg				-
Cobalt	TMECC 04.12B/04.14A	7.3	mg/kg				-
Copper	TMECC 04.12B/04.14A	40.7	mg/kg	****			750
Lead	TMECC 04.12B/04.14A	30.7	mg/kg	****			150
Mercury	TMECC 04.12B/04.14A	0.04	mg/kg	****			8
Molybdenum	TMECC 04.12B/04.14A	2.1	mg/kg	**************			9
Nickel	TMECC 04.12B/04.14A	22.4	mg/kg	****			210
Selenium	TMECC 04.12B/04.14A	0.5	mg/kg	****			18
Zinc	TMECC 04.12B/04.14A	133	mg/kg	****			1400
		Pass					

Particle Size Distribution TMECC 2.02 B & C

inches	mm	% Passing	Inerts	% by wt.
3	76.2	100		
2	50	100	Total Plastic	0.00
1	25	100	Film Plastic	0.00
3/4	19.1	100	Glass	0.00
5/8	16	100	Metal	0.00
1/2"	12.5	100	Sharps	0.00
3/8"	9.5	100		
1/4"	6.3	95		

Sample was received, handled and tested in accordance with TMECC procedures

B Appendix B

Reports of chemical analyses from ARI and Spectra Laboratories.

SAMPLE RESULTS-CONVENTIONALS
YG11-Washington State University

ANALYTICAL RESOURCES INCORPORATED

Matrix: Water
Data Release Authorized:
Reported: 04/21/14

Project: WSU Puyallup LID Research Pr
Event: NA
Date Sampled: 04/10/14
Date Received: 04/10/14

Client ID: LC14-02-0053
ARI ID: 14-6709 YG11A

Analyte	Date Batch	Method	Units	RL	Sample
Nitrate + Nitrite	04/18/14 041814#1	EPA 353.2	mg-N/L	0.050	3.05
Total Phosphorus	04/10/14 041014#1	EPA 365.2	mg-P/L	0.080	6.79
Ortho-Phosphorus	04/11/14 041114#1	EPA 365.2	mg-P/L	0.080	6.26
Total Kjeldahl Nitrogen	04/15/14 041514#1	EPA 351.2	mg-N/L	2.0	9.8

RL Analytical reporting limit
U Undetected at reported detection limit

INORGANICS ANALYSIS DATA SHEET
DISSOLVED METALS
Page 1 of 1

ANALYTICAL RESOURCES INCORPORATED

Sample ID: LC14-02-0053
SAMPLE

Lab Sample ID: YG11G
LIMS ID: 14-6715
Matrix: Water
Data Release Authorized:
Reported: 04/21/14

QC Report No: YG11-Washington State University
Project: WSU Puyallup LID Research Program

Date Sampled: 04/10/14
Date Received: 04/10/14

Prep Meth	Prep Date	Analysis Method	Analysis Date	CAS Number	Analyte	DL	LOQ	µg/L	Q
200.8	04/11/14	200.8	04/15/14	**7440-50-8**	**Copper**	0.16	0.5	**18.4**	

U-Analyte undetected at given DL
J-Analyte detected between DL and LOQ
DL-Detection Limit

Results reported below the LOQ are for statistical purposes only and have not been evaluated by either an analyst or data reviewer.

FORM-I

ANALYTICAL RESOURCES INCORPORATED

INORGANICS ANALYSIS DATA SHEET
TOTAL METALS
Page 1 of 1

Sample ID: LC14-02-0053
SAMPLE

Lab Sample ID: YG11A
LIMS ID: 14-6709
Matrix: Water
Data Release Authorized
Reported: 04/21/14

QC Report No: YG11-Washington State University
Project: WSU Puyallup LID Research Program

Date Sampled: 04/10/14
Date Received: 04/10/14

Prep Meth	Prep Date	Analysis Method	Analysis Date	CAS Number	Analyte	DL	LOQ	µg/L	Q
200.8	04/11/14	200.8	04/15/14	**7440-50-8**	**Copper**	0.16	0.5	**19.7**	

U-Analyte undetected at given DL
J-Analyte detected between DL and LOQ
DL-Method Detection Limit

Results reported below the LOQ are for statistical purposes only and have not been evaluated by either an analyst or data reviewer.

SAMPLE RESULTS-CONVENTIONALS
YG11-Washington State University

ANALYTICAL RESOURCES INCORPORATED

Matrix: Water
Data Release Authorized:
Reported: 04/21/14

Project: WSU Puyallup LID Research Pr
Event: NA
Date Sampled: 04/10/14
Date Received: 04/10/14

Client ID: LC14-02-0054
ARI ID: 14-6710 YG11B

Analyte	Date Batch	Method	Units	RL	Sample
Nitrate + Nitrite	04/18/14 041814#1	EPA 353.2	mg-N/L	0.200	12.2
Total Phosphorus	04/10/14 041014#1	EPA 365.2	mg-P/L	0.080	5.53
Ortho-Phosphorus	04/11/14 041114#1	EPA 365.2	mg-P/L	0.080	5.00
Total Kjeldahl Nitrogen	04/15/14 041514#1	EPA 351.2	mg-N/L	2.0	12

RL Analytical reporting limit
U Undetected at reported detection limit

ANALYTICAL RESOURCES INCORPORATED

INORGANICS ANALYSIS DATA SHEET
DISSOLVED METALS
Page 1 of 1

Sample ID: LC14-02-0054
SAMPLE

Lab Sample ID: YG11H
LIMS ID: 14-6716
Matrix: Water
Data Release Authorized:
Reported: 04/21/14

QC Report No: YG11-Washington State University
Project: WSU Puyallup LID Research Program

Date Sampled: 04/10/14
Date Received: 04/10/14

Prep Meth	Prep Date	Analysis Method	Analysis Date	CAS Number	Analyte	DL	LOQ	µg/L	Q
200.8	04/11/14	200.8	04/15/14	**7440-50-8**	**Copper**	0.16	0.5	**33.4**	

U-Analyte undetected at given DL
J-Analyte detected between DL and LOQ
DL-Detection Limit

Results reported below the LOQ are for statistical purposes only and have not been evaluated by either an analyst or data reviewer.

FORM-I

ANALYTICAL RESOURCES INCORPORATED

INORGANICS ANALYSIS DATA SHEET
TOTAL METALS
Page 1 of 1

Sample ID: LC14-02-0054
SAMPLE

Lab Sample ID: YG11B
LIMS ID: 14-6710
Matrix: Water
Data Release Authorized:
Reported: 04/21/14

QC Report No: YG11-Washington State University
Project: WSU Puyallup LID Research Program

Date Sampled: 04/10/14
Date Received: 04/10/14

Prep Meth	Prep Date	Analysis Method	Analysis Date	CAS Number	Analyte	DL	LOQ	µg/L	Q
200.8	04/11/14	200.8	04/15/14	**7440-50-8**	**Copper**	0.16	0.5	**39.4**	

U-Analyte undetected at given DL
J-Analyte detected between DL and LOQ
DL-Method Detection Limit

Results reported below the LOQ are for statistical purposes only and have not been evaluated by either an analyst or data reviewer.

SAMPLE RESULTS-CONVENTIONALS
YG11-Washington State University

ANALYTICAL RESOURCES INCORPORATED

Matrix: Water
Data Release Authorized:
Reported: 04/21/14

Project: WSU Puyallup LID Research Pr
Event: NA
Date Sampled: 04/10/14
Date Received: 04/10/14

Client ID: LC14-02-0055
ARI ID: 14-6711 YG11C

Analyte	**Date Batch**	**Method**	**Units**	**RL**	**Sample**
Nitrate + Nitrite	04/18/14 041814#1	EPA 353.2	mg-N/L	0.100	7.29
Total Phosphorus	04/10/14 041014#1	EPA 365.2	mg-P/L	0.080	5.56
Ortho-Phosphorus	04/11/14 041114#1	EPA 365.2	mg-P/L	0.040	4.92
Total Kjeldahl Nitrogen	04/15/14 041514#1	EPA 351.2	mg-N/L	2.0	12

RL Analytical reporting limit
U Undetected at reported detection limit

ANALYTICAL RESOURCES INCORPORATED

INORGANICS ANALYSIS DATA SHEET
DISSOLVED METALS
Page 1 of 1

Sample ID: LC14-02-0055
SAMPLE

Lab Sample ID: YG11I
LIMS ID: 14-6717
Matrix: Water
Data Release Authorized:
Reported: 04/21/14

QC Report No: YG11-Washington State University
Project: WSU Puyallup LID Research Program

Date Sampled: 04/10/14
Date Received: 04/10/14

Prep Meth	Prep Date	Analysis Method	Analysis Date	CAS Number	Analyte	DL	LOQ	µg/L	Q
200.8	04/11/14	200.8	04/15/14	**7440-50-8**	**Copper**	0.16	0.5	**11.1**	

U-Analyte undetected at given DL
J-Analyte detected between DL and LOQ
DL-Detection Limit

Results reported below the LOQ are for statistical purposes only and have not been evaluated by either an analyst or data reviewer.

ANALYTICAL RESOURCES INCORPORATED

INORGANICS ANALYSIS DATA SHEET
TOTAL METALS

Sample ID: LC14-02-0055
SAMPLE

Lab Sample ID: YG11C
LIMS ID: 14-6711
Matrix: Water
Data Release Authorized:
Reported: 04/21/14

QC Report No: YG11-Washington State University
Project: WSU Puyallup LID Research Program

Date Sampled: 04/10/14
Date Received: 04/10/14

Prep Meth	Prep Date	Analysis Method	Analysis Date	CAS Number	Analyte	DL	LOQ	µg/L	Q
200.8	04/11/14	200.8	04/15/14	**7440-50-8**	**Copper**	0.16	0.5	**19.8**	

U-Analyte undetected at given DL
J-Analyte detected between DL and LOQ
DL-Method Detection Limit

Results reported below the LOQ are for statistical purposes only and have not been evaluated by either an analyst or data reviewer.

SAMPLE RESULTS-CONVENTIONALS
YG11-Washington State University

ANALYTICAL RESOURCES INCORPORATED

Matrix: Water
Data Release Authorized:
Reported: 04/21/14

Project: WSU Puyallup LID Research Pr
Event: NA
Date Sampled: 04/10/14
Date Received: 04/10/14

Client ID: LC14-02-0056
ARI ID: 14-6712 YG11D

Analyte	**Date Batch**	**Method**	**Units**	**RL**	**Sample**
Nitrate + Nitrite	04/18/14 041814#1	EPA 353.2	mg-N/L	0.010	0.133
Total Phosphorus	04/10/14 041014#1	EPA 365.2	mg-P/L	0.080	4.41
Ortho-Phosphorus	04/11/14 041114#1	EPA 365.2	mg-P/L	0.040	4.13
Total Kjeldahl Nitrogen	04/16/14 041614#1	EPA 351.2	mg-N/L	2.5	6.4

RL Analytical reporting limit
U Undetected at reported detection limit

ANALYTICAL RESOURCES INCORPORATED

INORGANICS ANALYSIS DATA SHEET
DISSOLVED METALS
Page 1 of 1

Sample ID: LC14-02-0056
SAMPLE

Lab Sample ID: YG11J
LIMS ID: 14-6718
Matrix: Water
Data Release Authorized:
Reported: 04/21/14

QC Report No: YG11-Washington State University
Project: WSU Puyallup LID Research Program

Date Sampled: 04/10/14
Date Received: 04/10/14

Prep Meth	Prep Date	Analysis Method	Analysis Date	CAS Number	Analyte	DL	LOQ	µg/L	Q
200.8	04/11/14	200.8	04/15/14	**7440-50-8**	**Copper**	0.16	0.5	**20.6**	

U-Analyte undetected at given DL
J-Analyte detected between DL and LOQ
DL-Detection Limit

Results reported below the LOQ are for statistical purposes only and have not been evaluated by either an analyst or data reviewer.

ANALYTICAL RESOURCES INCORPORATED

INORGANICS ANALYSIS DATA SHEET
TOTAL METALS

Sample ID: LC14-02-0056
SAMPLE

Lab Sample ID: YG11D
LIMS ID: 14-6712
Matrix: Water
Data Release Authorized:
Reported: 04/21/14

QC Report No: YG11-Washington State University
Project: WSU Puyallup LID Research Program

Date Sampled: 04/10/14
Date Received: 04/10/14

Prep Meth	Prep Date	Analysis Method	Analysis Date	CAS Number	Analyte	DL	LOQ	µg/L	Q
200.8	04/11/14	200.8	04/15/14	**7440-50-8**	**Copper**	0.16	0.5	**11.5**	

U-Analyte undetected at given DL
J-Analyte detected between DL and LOQ
DL-Method Detection Limit

Results reported below the LOQ are for statistical purposes only and have not been evaluated by either an analyst or data reviewer.

SAMPLE RESULTS-CONVENTIONALS
YG11-Washington State University

ANALYTICAL RESOURCES INCORPORATED

Matrix: Water
Data Release Authorized:
Reported: 04/21/14

Project: WSU Puyallup LID Research Pr
Event: NA
Date Sampled: 04/10/14
Date Received: 04/10/14

Client ID: LC14-02-0057
ARI ID: 14-6713 YG11E

Analyte	Date Batch	Method	Units	RL	Sample
Nitrate + Nitrite	04/18/14 041814#1	EPA 353.2	mg-N/L	0.010	0.404
Total Phosphorus	04/10/14 041014#1	EPA 365.2	mg-P/L	0.080	3.43
Ortho-Phosphorus	04/11/14 041114#1	EPA 365.2	mg-P/L	0.040	2.92
Total Kjeldahl Nitrogen	04/16/14 041614#1	EPA 351.2	mg-N/L	2.5	9.9

RL Analytical reporting limit
U Undetected at reported detection limit

ANALYTICAL RESOURCES INCORPORATED

INORGANICS ANALYSIS DATA SHEET
DISSOLVED METALS
Page 1 of 1

Sample ID: LC14-02-0057
SAMPLE

Lab Sample ID: YG11K
LIMS ID: 14-6719
Matrix: Water
Data Release Authorized:
Reported: 04/21/14

QC Report No: YG11-Washington State University
Project: WSU Puyallup LID Research Program

Date Sampled: 04/10/14
Date Received: 04/10/14

Prep Meth	Prep Date	Analysis Method	Analysis Date	CAS Number	Analyte	DL	LOQ	µg/L	Q
200.8	04/11/14	200.8	04/15/14	**7440-50-8**	**Copper**	0.16	0.5	**47.1**	

U-Analyte undetected at given DL
J-Analyte detected between DL and LOQ
DL-Detection Limit

Results reported below the LOQ are for statistical purposes only and have not been evaluated by either an analyst or data reviewer.

INORGANICS ANALYSIS DATA SHEET
TOTAL METALS
Page 1 of 1

ANALYTICAL RESOURCES INCORPORATED

Sample ID: LC14-02-0057
SAMPLE

Lab Sample ID: YG11E
LIMS ID: 14-6713
Matrix: Water
Data Release Authorized:
Reported: 04/21/14

QC Report No: YG11-Washington State University
Project: WSU Puyallup LID Research Program

Date Sampled: 04/10/14
Date Received: 04/10/14

Prep Meth	Prep Date	Analysis Method	Analysis Date	CAS Number	Analyte	DL	LOQ	µg/L	Q
200.8	04/11/14	200.8	04/15/14	**7440-50-8**	**Copper**	0.16	0.5	**48.7**	

U-Analyte undetected at given DL
J-Analyte detected between DL and LOQ
DL-Method Detection Limit

Results reported below the LOQ are for statistical purposes only and have not been evaluated by either an analyst or data reviewer.

SAMPLE RESULTS-CONVENTIONALS
YG11-Washington State University

ANALYTICAL RESOURCES INCORPORATED

Matrix: Water
Data Release Authorized:
Reported: 04/21/14

Project: WSU Puyallup LID Research Pr
Event: NA
Date Sampled: 04/10/14
Date Received: 04/10/14

Client ID: LC14-02-0058
ARI ID: 14-6714 YG11F

Analyte	**Date Batch**	**Method**	**Units**	**RL**	**Sample**
Nitrate + Nitrite	04/18/14 041814#1	EPA 353.2	mg-N/L	0.100	4.37
Total Phosphorus	04/10/14 041014#1	EPA 365.2	mg-P/L	0.080	4.07
Ortho-Phosphorus	04/11/14 041114#1	EPA 365.2	mg-P/L	0.040	3.80
Total Kjeldahl Nitrogen	04/15/14 041514#1	EPA 351.2	mg-N/L	2.0	7.4

RL Analytical reporting limit
U Undetected at reported detection limit

ANALYTICAL RESOURCES INCORPORATED

INORGANICS ANALYSIS DATA SHEET
DISSOLVED METALS

Sample ID: LC14-02-0058
SAMPLE

Lab Sample ID: YG11L
LIMS ID: 14-6720
Matrix: Water
Data Release Authorized:
Reported: 04/21/14

QC Report No: YG11-Washington State University
Project: WSU Puyallup LID Research Program

Date Sampled: 04/10/14
Date Received: 04/10/14

Prep Meth	Prep Date	Analysis Method	Analysis Date	CAS Number	Analyte	DL	LOQ	µg/L	Q
200.8	04/11/14	200.8	04/15/14	**7440-50-8**	**Copper**	0.16	0.5	**13.4**	

U-Analyte undetected at given DL
J-Analyte detected between DL and LOQ
DL-Detection Limit

Results reported below the LOQ are for statistical purposes only and have not been evaluated by either an analyst or data reviewer.

ANALYTICAL RESOURCES INCORPORATED

INORGANICS ANALYSIS DATA SHEET
TOTAL METALS

Sample ID: LC14-02-0058
SAMPLE

Lab Sample ID: YG11F
LIMS ID: 14-6714
Matrix: Water
Data Release Authorized:
Reported: 04/21/14

QC Report No: YG11-Washington State University
Project: WSU Puyallup LID Research Program

Date Sampled: 04/10/14
Date Received: 04/10/14

Prep Meth	Prep Date	Analysis Method	Analysis Date	CAS Number	Analyte	DL	LOQ	µg/L	Q
200.8	04/11/14	200.8	04/15/14	**7440-50-8**	**Copper**	0.16	0.5	**13.9**	

U-Analyte undetected at given DL
J-Analyte detected between DL and LOQ
DL-Method Detection Limit

Results reported below the LOQ are for statistical purposes only and have not been evaluated by either an analyst or data reviewer.

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02/05/2015

WSU Puyallup Research and Extension Center

2606 W Pioneer
Puyallup, WA 98371-4998

Client ID: Storm 1 Rep 1
Sample Matrix: Water
Date Sampled: 01/21/2015
Date Received: 01/21/2015
Spectra Project: 2015010563
Spectra Number: 1

Analyte	Result	Units	Method
Copper	0.056	mg/L	EPA 200.7
Dissolved Copper	0.040	mg/L	EPA 200.7
Nitrate/Nitrite	0.09	mg/L-N	Easy1-Reagent
TKN	<0.5	mg/L-N	SM 4500-N-C
Orthophosphate, as P	<0.01	mg/L	SM4500-P E
Total Phosphorus	<0.01	mg/L	SM4500-P E

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Steve Hibbs, Laboratory Manager
a6/scj

02/05/2015

WSU Puyallup Research and Extension Center

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Puyallup, WA 98371-4998

Client ID: Storm 1 Rep 2
Sample Matrix: Water
Date Sampled: 01/21/2015
Date Received: 01/21/2015
Spectra Project: 2015010563
Spectra Number: 2

Analyte	Result	Units	Method
Copper	0.028	mg/L	EPA 200.7
Dissolved Copper	0.020	mg/L	EPA 200.7
Nitrate/Nitrite	0.08	mg/L-N	Easy1-Reagent
TKN	<0.5	mg/L-N	SM 4500-N-C
Orthophosphate, as P	<0.01	mg/L	SM4500-P E
Total Phosphorus	<0.01	mg/L	SM4500-P E

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Client ID: Storm 1 Column 1
Sample Matrix: Water
Date Sampled: 01/21/2015
Date Received: 01/21/2015
Spectra Project: 2015010563
Spectra Number: 3

Analyte	Result	Units	Method
Copper	0.082	mg/L	EPA 200.7
Dissolved Copper	0.078	mg/L	EPA 200.7
Nitrate/Nitrite	150	mg/L-N	Easy1-Reagent
TKN	40	mg/L-N	SM 4500-N-C
Orthophosphate, as P	13	mg/L	SM4500-P E
Total Phosphorus	15	mg/L	SM4500-P E

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Client ID:	Storm 1 Column 2
Sample Matrix:	Water
Date Sampled:	01/21/2015
Date Received:	01/21/2015
Spectra Project:	2015010563
Spectra Number:	4

Analyte	Result	Units	Method
Copper	0.150	mg/L	EPA 200.7
Dissolved Copper	0.115	mg/L	EPA 200.7
Nitrate/Nitrite	230	mg/L-N	Easy1-Reagent
TKN	91	mg/L-N	SM 4500-N-C
Orthophosphate, as P	20	mg/L	SM4500-P E
Total Phosphorus	23	mg/L	SM4500-P E

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Client ID: Storm 1 Column 3
Sample Matrix: Water
Date Sampled: 01/21/2015
Date Received: 01/21/2015
Spectra Project: 2015010563
Spectra Number: 5

Analyte	Result	Units	Method
Copper	0.083	mg/L	EPA 200.7
Dissolved Copper	0.078	mg/L	EPA 200.7
Nitrate/Nitrite	170	mg/L-N	Easy1-Reagent
TKN	60	mg/L-N	SM 4500-N-C
Orthophosphate, as P	11	mg/L	SM4500-P E
Total Phosphorus	13	mg/L	SM4500-P E

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Client ID: Storm 1 Column 4
Sample Matrix: Water
Date Sampled: 01/21/2015
Date Received: 01/21/2015
Spectra Project: 2015010563
Spectra Number: 6

Analyte	Result	Units	Method
Copper	0.121	mg/L	EPA 200.7
Dissolved Copper	0.095	mg/L	EPA 200.7
Nitrate/Nitrite	1.0	mg/L-N	Easy1-Reagent
TKN	75	mg/L-N	SM 4500-N-C
Orthophosphate, as P	36	mg/L	SM4500-P E
Total Phosphorus	39	mg/L	SM4500-P E

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Client ID: Storm 1 Column 5
Sample Matrix: Water
Date Sampled: 01/21/2015
Date Received: 01/21/2015
Spectra Project: 2015010563
Spectra Number: 7

Analyte	Result	Units	Method
Copper	0.210	mg/L	EPA 200.7
Dissolved Copper	0.139	mg/L	EPA 200.7
Nitrate/Nitrite	1.1	mg/L-N	Easy1-Reagent
TKN	51	mg/L-N	SM 4500-N-C
Orthophosphate, as P	41	mg/L	SM4500-P E
Total Phosphorus	45	mg/L	SM4500-P E

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Client ID: Storm 1 Column 6
Sample Matrix: Water
Date Sampled: 01/21/2015
Date Received: 01/21/2015
Spectra Project: 2015010563
Spectra Number: 8

Analyte	Result	Units	Method
Copper	0.110	mg/L	EPA 200.7
Dissolved Copper	0.088	mg/L	EPA 200.7
Nitrate/Nitrite	1.0	mg/L-N	Easy1-Reagent
TKN	76	mg/L-N	SM 4500-N-C
Orthophosphate, as P	37	mg/L	SM4500-P E
Total Phosphorus	42	mg/L	SM4500-P E

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SPECIAL INSTRUCTIONS/COMMENTS: See the quote (attached)

Return Samples: Y N Page ____ of ____

CHAIN OF CUSTODY

SPECTRA PROJECT # 201501 0563

STANDARD [X] RUSH [ ]

CLIENT: Maninder WSU-Puy
ADDRESS: 2606 W Pioneer Ave, Puyallup WA 98371
ADDRESS CHANGE [ ]

PROJECT:

CONTACT: Maninder Chahal

SAMPLED BY: Maninder Chahal

PHONE: 253-445-4592 FAX:

e-MAIL: maninder.chahal@email.wsu.edu Prefer FAX [ ] or e-MAIL [X]

PURCHASE ORDER #

Analyses: HYDROCARBONS (NWTPH-HCID, BTEX, BTEX/NWTPH-G, NWTPH-G, NWTPH-Dx, 1664 SGT-HEM (TPH), 1664 HEM (FOG)); ORGANICS (8260/624 VOA, 8260 CHLOR SOLVENTS, 8270-625 SEMI VOA, 8270 PAH/PNA, 8082/608 PCB); METALS (TOTAL METALS RCRA 8, TOTAL METALS (SPECIFY), TCLP METALS RCRA 8, TCLP METALS (SPECIFY)); OTHER (PH 9040/9045, TX/TOX/EOX, TURBIDITY, FLASH POINT, BOD, SOLIDS (SPECIFY))

	SAMPLE ID	DATE SAMPLED	TIME SAMPLED	MATRIX	NUMBER OF CONTAINERS
1	Storm 1 Rep 1	1/21/15	3pm		1
2	Storm 1 Rep 2	1/21/15	3 pm		1
3	Storm 1 Column 1	1/21/15	3 pm		1
4	Storm 1 Column 2	1/21/15	3 pm		1
5	Storm 1 Column 3	1/21/15	3 pm		1
6	Storm 1 Column 4	1/21/15	3 pm		1
7	Storm 1 Column 5	1/21/15	3 pm		1
8	Storm 1 Column 6	1/21/15	3 pm		1
9					
10					

LAB USE ONLY
Shipped Via: US Mail UPS Fed Ex Courier Client
Shipping Container: Cooler Box Envelope None
Tracking # ____
Custody Seals: Y N Intact: Y N
Cooler Temp. ____ Sample Temp. ____

	SIGNATURE	PRINTED NAME	COMPANY	DATE	TIME
RELINQUISHED BY	MChahal	Maninder Chahal	WSU	1/21/15	4:43
RECEIVED BY	Karie Kindra	Karie Kindra	Spectra	1/21	4:44
RELINQUISHED BY					
RECEIVED BY					

Payment Terms: Net 30 days. Past due accounts subject to 1 1/2% per month interest. Customer agrees to pay all costs of collection including reasonable attorney's fees and all other costs of collection regardless of whether suit is filed in Pierce Co., WA venue. *Spectra Laboratories, LLC*

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02/19/2015

WSU Puyallup Research and Extension Center

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Puyallup, WA 98371-4998

Client ID: Storm 2 Rep 1
Sample Matrix: Water
Date Sampled: 02/04/2015
Date Received: 02/04/2015
Spectra Project: 2015020113
Spectra Number: 1

Analyte	Result	Units	Method
Copper	0.016	mg/L	EPA 200.7
Dissolved Copper	0.015	mg/L	EPA 200.7
Nitrate/Nitrite	0.10	mg/L-N	Easy1-Reagent
TKN	0.6	mg/L-N	SM 4500-N-C
Orthophosphate, as P	<0.01	mg/L	SM4500-P E
Total Phosphorus	<0.01	mg/L	SM4500-P E

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02/19/2015

WSU Puyallup Research and Extension Center

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Client ID:	Storm 2 Rep 2
Sample Matrix:	Water
Date Sampled:	02/04/2015
Date Received:	02/04/2015
Spectra Project:	2015020113
Spectra Number:	2

Analyte	Result	Units	Method
Copper	0.017	mg/L	EPA 200.7
Dissolved Copper	0.016	mg/L	EPA 200.7
Nitrate/Nitrite	0.10	mg/L-N	Easy1-Reagent
TKN	4.8	mg/L-N	SM 4500-N-C
Orthophosphate, as P	<0.01	mg/L	SM4500-P E
Total Phosphorus	<0.01	mg/L	SM4500-P E

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02/19/2015

WSU Puyallup Research and Extension Center

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Client ID: Column 1 Storm 2
Sample Matrix: Water
Date Sampled: 02/04/2015
Date Received: 02/04/2015
Spectra Project: 2015020113
Spectra Number: 3

Analyte	Result	Units	Method
Copper	0.028	mg/L	EPA 200.7
Dissolved Copper	0.026	mg/L	EPA 200.7
Nitrate/Nitrite	60	mg/L-N	Easy1-Reagent
TKN	48	mg/L-N	SM 4500-N-C
Orthophosphate, as P	16	mg/L	SM4500-P E
Total Phosphorus	18	mg/L	SM4500-P E

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02/19/2015

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Client ID: Column 2 Storm 2
Sample Matrix: Water
Date Sampled: 02/04/2015
Date Received: 02/04/2015
Spectra Project: 2015020113
Spectra Number: 4

Analyte	Result	Units	Method
Copper	0.037	mg/L	EPA 200.7
Dissolved Copper	0.035	mg/L	EPA 200.7
Nitrate/Nitrite	35	mg/L-N	Easy1-Reagent
TKN	44	mg/L-N	SM 4500-N-C
Orthophosphate, as P	16	mg/L	SM4500-P E
Total Phosphorus	18	mg/L	SM4500-P E

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02/19/2015

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Client ID:	Column 3 Storm 2
Sample Matrix:	Water
Date Sampled:	02/04/2015
Date Received:	02/04/2015
Spectra Project:	2015020113
Spectra Number:	5

Analyte	Result	Units	Method
Copper	0.027	mg/L	EPA 200.7
Dissolved Copper	0.026	mg/L	EPA 200.7
Nitrate/Nitrite	37	mg/L-N	Easy1-Reagent
TKN	33	mg/L-N	SM 4500-N-C
Orthophosphate, as P	7.9	mg/L	SM4500-P E
Total Phosphorus	9.4	mg/L	SM4500-P E

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02/19/2015

WSU Puyallup Research and Extension Center

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Client ID: Column 4 Storm 2
Sample Matrix: Water
Date Sampled: 02/04/2015
Date Received: 02/04/2015
Spectra Project: 2015020113
Spectra Number: 6

Analyte	Result	Units	Method
Copper	0.036	mg/L	EPA 200.7
Dissolved Copper	0.028	mg/L	EPA 200.7
Nitrate/Nitrite	0.63	mg/L-N	Easy1-Reagent
TKN	46	mg/L-N	SM 4500-N-C
Orthophosphate, as P	20	mg/L	SM4500-P E
Total Phosphorus	23	mg/L	SM4500-P E

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02/19/2015

WSU Puyallup Research and Extension Center

2606 W Pioneer
Puyallup, WA 98371-4998

Client ID: Column 5 Storm 2
Sample Matrix: Water
Date Sampled: 02/04/2015
Date Received: 02/04/2015
Spectra Project: 2015020113
Spectra Number: 7

Analyte	Result	Units	Method
Copper	0.058	mg/L	EPA 200.7
Dissolved Copper	0.041	mg/L	EPA 200.7
Nitrate/Nitrite	0.62	mg/L-N	Easy1-Reagent
TKN	35	mg/L-N	SM 4500-N-C
Orthophosphate, as P	18	mg/L	SM4500-P E
Total Phosphorus	21	mg/L	SM4500-P E

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02/19/2015

WSU Puyallup Research and Extension Center

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Puyallup, WA 98371-4998

Client ID:	Column 6 Storm 2
Sample Matrix:	Water
Date Sampled:	02/04/2015
Date Received:	02/04/2015
Spectra Project:	2015020113
Spectra Number:	8

Analyte	Result	Units	Method
Copper	0.039	mg/L	EPA 200.7
Dissolved Copper	0.026	mg/L	EPA 200.7
Nitrate/Nitrite	0.68	mg/L-N	Easy1-Reagent
TKN	33	mg/L-N	SM 4500-N-C
Orthophosphate, as P	20	mg/L	SM4500-P E
Total Phosphorus	22	mg/L	SM4500-P E

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Steve Hibbs, Laboratory Manager
a6/scj

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SPECIAL INSTRUCTIONS/COMMENTS:

See the quote (attached)

Return Samples: Y N Page ____ of ____

CHAIN OF CUSTODY

SPECTRA PROJECT # 2015020113

STANDARD [X] RUSH [ ]

CLIENT: WSU - Puy

ADDRESS: 2606 W Pioneer Ave, Puyallup, WA 98371

ADDRESS CHANGE [ ]

PROJECT:

CONTACT: Maninder Chahal

SAMPLED BY: Maninder Chahal

PHONE: 253-445-4592 FAX:

e-MAIL: maninder.chahal@email.wsu.edu Prefer FAX [ ] or e-MAIL [X]

PURCHASE ORDER #

HYDROCARBONS: NWTPH-HCID, BTEX, BTEX/NWTPH-G, NWTPH-G, NWTPH-Dx, 1664 SGT-HEM (TPH), 1664 HEM (FOG)

ORGANICS: 8260/624 VOA, 8260 CHLOR SOLVENTS, 8270-625 SEMI VOA, 8270 PAH/PNA, 8082/608 PCB

METALS: TOTAL METALS RCRA 8, TOTAL METALS (SPECIFY), TCLP METALS RCRA 8, TCLP METALS (SPECIFY)

OTHER: PH 9040/9045, TX/TOX/EOX, TURBIDITY, FLASH POINT, BOD, SOLIDS (SPECIFY)

	SAMPLE ID	DATE SAMPLED	TIME SAMPLED	MATRIX	NUMBER OF CONTAINERS
1	Storm2 Rep1	02/04/15	3 pm	Water	
2	Storm2 Rep2	02/04/15	3pm	Water	
3	Column1 Storm2	02/04/15	3 pm	Water	
4	Column2 storm2	02/04/15	3pm	water	
5	Column3 storm 2	02/04/15	3pm	Water	
6	Column 4 Storm 2	02/04/15	3pm	Water	
7	column 5 storm2	02/04/15	3 pm	Water	
8	Column 6 Storm 2	02/04/15	3pm	Water	
9					
10					

LAB USE ONLY

Shipped Via: US Mail UPS Fed Ex Courier Client

Shipping Container: Cooler Box Envelope None

Tracking # ____

Custody Seals: Y N Intact: Y N

Cooler Temp. ____ Sample Temp. ____

	SIGNATURE	PRINTED NAME	COMPANY	DATE	TIME
RELINQUISHED BY	M Chahal	Maninder Chahal	WSU	02/04/15	4:19 pm
RECEIVED BY	Karie Kindre	Karie Kindre	Spectra	2/4	4:20
RELINQUISHED BY					
RECEIVED BY					

Payment Terms: Net 30 days. Past due accounts subject to 1 1/2% per month interest. Customer agrees to pay all costs of collection including reasonable attorney's fees and all other costs of collection regardless of whether suit is filed in Pierce Co., WA venue. *Spectra Laboratories, LLC*

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03/03/2015

WSU Puyallup Research and Extension Center

2606 W Pioneer
Puyallup, WA 98371-4998

Sample Matrix: Water
Date Sampled: 02/18/2015
Date Received: 02/18/2015
Spectra Project: 2015020546

Client ID	Spectra #	Analyte	Result	Units	Method
Storm 3 Rep 1	1	Copper	0.029	mg/L	EPA 200.7
Storm 3 Rep 1	1	Dissolved Copper	0.025	mg/L	EPA 200.7
Storm 3 Rep 1	1	Nitrate/Nitrite	0.14	mg/L-N	Easy1-Reagent
Storm 3 Rep 1	1	TKN	1.0	mg/L-N	SM 4500-N-C
Storm 3 Rep 1	1	Orthophosphate, as P	<0.01	mg/L	SM4500-P E
Storm 3 Rep 1	1	Total Phosphorus	<0.01	mg/L	SM4500-P E
Storm 3 Rep 2	2	Copper	0.029	mg/L	EPA 200.7
Storm 3 Rep 2	2	Dissolved Copper	0.027	mg/L	EPA 200.7
Storm 3 Rep 2	2	Nitrate/Nitrite	0.14	mg/L-N	Easy1-Reagent
Storm 3 Rep 2	2	TKN	6.4	mg/L-N	SM 4500-N-C
Storm 3 Rep 2	2	Orthophosphate, as P	<0.01	mg/L	SM4500-P E
Storm 3 Rep 2	2	Total Phosphorus	<0.01	mg/L	SM4500-P E
Column 1 Storm 3	3	Copper	0.068	mg/L	EPA 200.7
Column 1 Storm 3	3	Dissolved Copper	0.057	mg/L	EPA 200.7
Column 1 Storm 3	3	Nitrate/Nitrite	8.1	mg/L-N	Easy1-Reagent
Column 1 Storm 3	3	TKN	45	mg/L-N	SM 4500-N-C
Column 1 Storm 3	3	Orthophosphate, as P	9.3	mg/L	SM4500-P E
Column 1 Storm 3	3	Total Phosphorus	10	mg/L	SM4500-P E
Column 2 Storm 3	4	Copper	0.087	mg/L	EPA 200.7
Column 2 Storm 3	4	Dissolved Copper	0.073	mg/L	EPA 200.7
Column 2 Storm 3	4	Nitrate/Nitrite	9.7	mg/L-N	Easy1-Reagent
Column 2 Storm 3	4	TKN	62	mg/L-N	SM 4500-N-C
Column 2 Storm 3	4	Orthophosphate, as P	15	mg/L	SM4500-P E

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03/03/2015

WSU Puyallup Research and Extension Center

2606 W Pioneer
Puyallup, WA 98371-4998

Sample Matrix: Water
Date Sampled: 02/18/2015
Date Received: 02/18/2015
Spectra Project: 2015020546

Client ID	Spectra #	Analyte	Result	Units	Method
Column 2 Storm 3	4	Total Phosphorus	17	mg/L	SM4500-P E
Column 3 Storm 3	5	Copper	0.087	mg/L	EPA 200.7
Column 3 Storm 3	5	Dissolved Copper	0.075	mg/L	EPA 200.7
Column 3 Storm 3	5	Nitrate/Nitrite	15	mg/L-N	Easy1-Reagent
Column 3 Storm 3	5	TKN	35	mg/L-N	SM 4500-N-C
Column 3 Storm 3	5	Orthophosphate, as P	8.1	mg/L	SM4500-P E
Column 3 Storm 3	5	Total Phosphorus	9.0	mg/L	SM4500-P E
Column 4 Storm 3	6	Copper	0.074	mg/L	EPA 200.7
Column 4 Storm 3	6	Dissolved Copper	0.053	mg/L	EPA 200.7
Column 4 Storm 3	6	Nitrate/Nitrite	21	mg/L-N	Easy1-Reagent
Column 4 Storm 3	6	TKN	51	mg/L-N	SM 4500-N-C
Column 4 Storm 3	6	Orthophosphate, as P	14	mg/L	SM4500-P E
Column 4 Storm 3	6	Total Phosphorus	15	mg/L	SM4500-P E
Column 5 Storm 3	7	Copper	0.045	mg/L	EPA 200.7
Column 5 Storm 3	7	Dissolved Copper	0.044	mg/L	EPA 200.7
Column 5 Storm 3	7	Nitrate/Nitrite	23	mg/L-N	Easy1-Reagent
Column 5 Storm 3	7	TKN	53	mg/L-N	SM 4500-N-C
Column 5 Storm 3	7	Orthophosphate, as P	12	mg/L	SM4500-P E
Column 5 Storm 3	7	Total Phosphorus	14	mg/L	SM4500-P E
Column 6 Storm 3	8	Copper	0.041	mg/L	EPA 200.7
Column 6 Storm 3	8	Dissolved Copper	0.040	mg/L	EPA 200.7
Column 6 Storm 3	8	Nitrate/Nitrite	24	mg/L-N	Easy1-Reagent
Column 6 Storm 3	8	TKN	34	mg/L-N	SM 4500-N-C

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03/03/2015

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2606 W Pioneer
Puyallup, WA 98371-4998

Sample Matrix: Water
Date Sampled: 02/18/2015
Date Received: 02/18/2015
Spectra Project: 2015020546

Client ID	Spectra #	Analyte	Result	Units	Method
Column 6 Storm 3	8	Orthophosphate, as P	15	mg/L	SM4500-P E
Column 6 Storm 3	8	Total Phosphorus	17	mg/L	SM4500-P E

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SPECIAL INSTRUCTIONS/COMMENTS: See the attached quote

CHAIN OF CUSTODY

SPECTRA PROJECT # 20150205HP

Return Samples: Y N   Page ____ of ____

STANDARD ☒ RUSH ☐

CLIENT: WSU-Puy   ADDRESS: 2606 W Pioneer Ave, Puyallup, WA 98371   ADDRESS CHANGE ☐

PROJECT:

CONTACT: Maninder Chahal

SAMPLED BY: Maninder Chahal

PHONE: 253-445-4592 FAX:

e-MAIL: maninder.chahal@email.wsu.edu   Prefer FAX ☐ or e-MAIL ☒

PURCHASE ORDER #

Analysis columns — NUMBER OF CONTAINERS; HYDROCARBONS: NWTPH-HCID, BTEX, BTEX/NWTPH-G, NWTPH-G, NWTPH-Dx, 1664 SGT-HEM (TPH), 1664 HEM (FOG); ORGANICS: 8260/624 VOA, 8260 CHLOR SOLVENTS, 8270-625 SEMI VOA, 8270 PAH/PNA, 8082/608 PCB; METALS: TOTAL METALS RCRA 8, TOTAL METALS (SPECIFY), TCLP METALS RCRA 8, TCLP METALS (SPECIFY); OTHER: PH 9040/9045, TX/TOX/EOX, TURBIDITY, FLASH POINT, BOD, SOLIDS (SPECIFY)

	SAMPLE ID	DATE SAMPLED	TIME SAMPLED	MATRIX
1	Storm 3 Rep 1	2/18/15	3 pm	Water
2	Storm 3 Rep 2	2/18/15	3 pm	Water
3	Column 1 storm 3	2/18/15	3 pm	Water
4	Column 2 storm 3	2/18/15	3 pm	Water
5	Column 3 storm 3	2/18/15	3 pm	Water
6	Column 4 storm 3	2/18/15	3 pm	Water
7	Column 5 storm 3	2/18/15	3 pm	Water
8	Column 6 storm 3	2/18/15	3 pm	Water
9				
10				

LAB USE ONLY

Shipped Via: US Mail UPS Fed Ex Courier Client

Shipping Container: Cooler Box Envelope None

Tracking # ____

Custody Seals: Y N   Intact: Y N

Cooler Temp. ____ Sample Temp. ____

	SIGNATURE	PRINTED NAME	COMPANY	DATE	TIME
RELINQUISHED BY	M Chahal	Maninder Chahal	WSU	2/18/15	5:09
RECEIVED BY	Marie Holt	MARIE HOLT	Spectra	2-18-15	5:09
RELINQUISHED BY					
RECEIVED BY					

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03/18/2015

WSU Puyallup Research and Extension Center

2606 W Pioneer
Puyallup, WA 98371-4998

Sample Matrix: Water
Date Sampled: 03/04/2015
Date Received: 03/04/2015
Spectra Project: 2015030111

Client ID	Spectra #	Analyte	Result	Units	Method
Storm 4 Rep 1	1	Copper	0.026	mg/L	EPA 200.7
Storm 4 Rep 1	1	Dissolved Copper	0.013	mg/L	EPA 200.7
Storm 4 Rep 1	1	Nitrate/Nitrite	0.08	mg/L-N	Easy1-Reagent
Storm 4 Rep 1	1	TKN	<0.5	mg/L-N	SM 4500-N-C
Storm 4 Rep 1	1	Orthophosphate, as P	<0.01	mg/L	SM4500-P E
Storm 4 Rep 1	1	Total Phosphorus	<0.01	mg/L	SM4500-P E
Storm 4 Rep 2	2	Copper	0.026	mg/L	EPA 200.7
Storm 4 Rep 2	2	Dissolved Copper	0.015	mg/L	EPA 200.7
Storm 4 Rep 2	2	Nitrate/Nitrite	0.08	mg/L-N	Easy1-Reagent
Storm 4 Rep 2	2	TKN	<0.5	mg/L-N	SM 4500-N-C
Storm 4 Rep 2	2	Orthophosphate, as P	<0.01	mg/L	SM4500-P E
Storm 4 Rep 2	2	Total Phosphorus	<0.01	mg/L	SM4500-P E
Storm 4 Column 1	3	Copper	0.036	mg/L	EPA 200.7
Storm 4 Column 1	3	Dissolved Copper	0.023	mg/L	EPA 200.7
Storm 4 Column 1	3	Nitrate/Nitrite	0.80	mg/L-N	Easy1-Reagent
Storm 4 Column 1	3	TKN	17	mg/L-N	SM 4500-N-C
Storm 4 Column 1	3	Orthophosphate, as P	6.9	mg/L	SM4500-P E
Storm 4 Column 1	3	Total Phosphorus	8.8	mg/L	SM4500-P E
Storm 4 Column 2	4	Copper	0.039	mg/L	EPA 200.7
Storm 4 Column 2	4	Dissolved Copper	0.032	mg/L	EPA 200.7
Storm 4 Column 2	4	Nitrate/Nitrite	0.76	mg/L-N	Easy1-Reagent
Storm 4 Column 2	4	TKN	30	mg/L-N	SM 4500-N-C
Storm 4 Column 2	4	Orthophosphate, as P	9.1	mg/L	SM4500-P E

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for

Steve Hibbs, Laboratory Manager

a7/scj

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03/18/2015

WSU Puyallup Research and Extension Center

2606 W Pioneer
Puyallup, WA 98371-4998

Sample Matrix: Water
Date Sampled: 03/04/2015
Date Received: 03/04/2015
Spectra Project: 2015030111

Client ID	Spectra #	Analyte	Result	Units	Method
Storm 4 Column 2	4	Total Phosphorus	11	mg/L	SM4500-P E
Storm 4 Column 3	5	Copper	0.040	mg/L	EPA 200.7
Storm 4 Column 3	5	Dissolved Copper	0.026	mg/L	EPA 200.7
Storm 4 Column 3	5	Nitrate/Nitrite	0.94	mg/L-N	Easy1-Reagent
Storm 4 Column 3	5	TKN	23	mg/L-N	SM 4500-N-C
Storm 4 Column 3	5	Orthophosphate, as P	6.0	mg/L	SM4500-P E
Storm 4 Column 3	5	Total Phosphorus	8.0	mg/L	SM4500-P E
Storm 4 Column 4	6	Copper	0.022	mg/L	EPA 200.7
Storm 4 Column 4	6	Dissolved Copper	0.017	mg/L	EPA 200.7
Storm 4 Column 4	6	Nitrate/Nitrite	3.8	mg/L-N	Easy1-Reagent
Storm 4 Column 4	6	TKN	19	mg/L-N	SM 4500-N-C
Storm 4 Column 4	6	Orthophosphate, as P	8.0	mg/L	SM4500-P E
Storm 4 Column 4	6	Total Phosphorus	10	mg/L	SM4500-P E
Storm 4 Column 5	7	Copper	0.028	mg/L	EPA 200.7
Storm 4 Column 5	7	Dissolved Copper	0.021	mg/L	EPA 200.7
Storm 4 Column 5	7	Nitrate/Nitrite	4.5	mg/L-N	Easy1-Reagent
Storm 4 Column 5	7	TKN	15	mg/L-N	SM 4500-N-C
Storm 4 Column 5	7	Orthophosphate, as P	6.9	mg/L	SM4500-P E
Storm 4 Column 5	7	Total Phosphorus	8.8	mg/L	SM4500-P E
Storm 4 Column 6	8	Copper	0.022	mg/L	EPA 200.7
Storm 4 Column 6	8	Dissolved Copper	0.018	mg/L	EPA 200.7
Storm 4 Column 6	8	Nitrate/Nitrite	5.0	mg/L-N	Easy1-Reagent
Storm 4 Column 6	8	TKN	23	mg/L-N	SM 4500-N-C

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for

Steve Hibbs, Laboratory Manager
a7/scj

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03/18/2015

WSU Puyallup Research and Extension Center

2606 W Pioneer
Puyallup, WA 98371-4998

Sample Matrix: Water
Date Sampled: 03/04/2015
Date Received: 03/04/2015
Spectra Project: 2015030111

Client ID	Spectra #	Analyte	Result	Units	Method
Storm 4 Column 6	8	Orthophosphate, as P	8.5	mg/L	SM4500-P E
Storm 4 Column 6	8	Total Phosphorus	11	mg/L	SM4500-P E

SPECTRA LABORATORIES

for

Steve Hibbs, Laboratory Manager

a7/scj

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SPECIAL INSTRUCTIONS/COMMENTS:

See the attached quote

Return Samples: Y N Page ______ of ______

CHAIN OF CUSTODY

SPECTRA PROJECT # 2015030111

STANDARD [X] RUSH [ ]

CLIENT: WSU-Puy

ADDRESS: 2606 W Pioneer Ave, Puyallup, WA 98371

ADDRESS CHANGE [ ]

PROJECT:

CONTACT: Maninder Chahal

SAMPLED BY: Maninder Chahal

PHONE: (253)(445-4592) FAX:

e-MAIL: maninder.chahal@email.wsu.edu

Prefer FAX [ ] or e-MAIL [X]

PURCHASE ORDER #

	SAMPLE ID	DATE SAMPLED	TIME SAMPLED	MATRIX	NUMBER OF CONTAINERS	HYDROCARBONS: NWTPH-HCID	BTEX	BTEX/NWTPH-G	NWTPH-G	NWTPH-Dx	1664 SGT-HEM (TPH)	1664 HEM (FOG)	ORGANICS: 8260/624 VOA	8260 CHLOR SOLVENTS	8270-625 SEMI VOA	8270 PAH/PNA	8082/608 PCB	METALS: TOTAL METALS RCRA 8	TOTAL METALS (SPECIFY)	TCLP METALS RCRA 8	TCLP METALS (SPECIFY)	OTHER: PH 9040/9045	TX/TOX/EOX	TURBIDITY	FLASH POINT	BOD	SOLIDS (SPECIFY)
1	Storm 4 rep1	3/14/15	3pm	water	1																						
2	Storm 4 rep 2	3/4/15	3 pm	water	1																						
3	Storm 4 column 1	3/4/15	3 pm	water	1																						
4	Storm 4 Column 2	3/4/15	3 pm	water	1																						
5	Storm 4 column 3	3/4/15	3 pm	water	1																						
6	Storm 4 column 4	3/4/15	3 pm	Water	1																						
7	Storm 4 Column 5	3/4/15	3 pm	water	1																						
8	Storm 4 Column 6	3/4/15	3 pm	Water	1																						
9																											
10																											

LAB USE ONLY

Shipped Via: US Mail UPS Fed Ex Courier Client

Shipping Container: Cooler Box Envelope None

Tracking # ______

Custody Seals: Y N Intact: Y N

Cooler Temp. _____ Sample Temp. _____

	SIGNATURE	PRINTED NAME	COMPANY	DATE	TIME
RELINQUISHED BY	M Chahal	Maninder Chahal	WSU	3/4/15	3:50 pm
RECEIVED BY	Marie Holt	MARIE HOLT	Spectra	3-4-15	3:50 pm
RELINQUISHED BY					
RECEIVED BY					

Payment Terms: Net 30 days. Past due accounts subject to 1 1/2% per month interest. Customer agrees to pay all costs of collection including reasonable attorney's fees and all other costs of collection regardless of whether suit is filed in Pierce Co., WA venue. *Spectra Laboratories, LLC*

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03/31/2015

WSU Puyallup Research and Extension Center

2606 W Pioneer
Puyallup, WA 98371-4998
Attn: Maninder Chahal

Client ID: Storm 5 Rep 1
Sample Matrix: Water
Date Sampled: 03/18/2015
Date Received: 03/18/2015
Spectra Project: 2015030505
Spectra Number: 1

Analyte	Result	Units	Method
Copper	0.026	mg/L	EPA 200.7
Dissolved Copper	0.022	mg/L	EPA 200.7
Nitrate/Nitrite	0.11	mg/L-N	Easy1-Reagent
TKN	0.9	mg/L-N	SM 4500-N-C
Orthophosphate, as P	<0.01	mg/L	SM4500-P E
Total Phosphorus	<0.01	mg/L	SM4500-P E

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WSU Puyallup Research and Extension Center

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Attn: Maninder Chahal

Client ID: Storm 5 Rep 2
Sample Matrix: Water
Date Sampled: 03/18/2015
Date Received: 03/18/2015
Spectra Project: 2015030505
Spectra Number: 2

Analyte	Result	Units	Method
Copper	0.025	mg/L	EPA 200.7
Dissolved Copper	0.020	mg/L	EPA 200.7
Nitrate/Nitrite	0.10	mg/L-N	Easy1-Reagent
TKN	1.3	mg/L-N	SM 4500-N-C
Orthophosphate, as P	<0.01	mg/L	SM4500-P E
Total Phosphorus	<0.01	mg/L	SM4500-P E

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Attn: Maninder Chahal

Client ID: Storm 5 Column 1
Sample Matrix: Water
Date Sampled: 03/18/2015
Date Received: 03/18/2015
Spectra Project: 2015030505
Spectra Number: 3

Analyte	Result	Units	Method
Copper	0.028	mg/L	EPA 200.7
Dissolved Copper	0.028	mg/L	EPA 200.7
Nitrate/Nitrite	0.17	mg/L-N	Easy1-Reagent
TKN	19	mg/L-N	SM 4500-N-C
Orthophosphate, as P	7.3	mg/L	SM4500-P E
Total Phosphorus	8.9	mg/L	SM4500-P E

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Puyallup, WA 98371-4998
Attn: Maninder Chahal

Client ID: Storm 5 Column 2
Sample Matrix: Water
Date Sampled: 03/18/2015
Date Received: 03/18/2015
Spectra Project: 2015030505
Spectra Number: 4

Analyte	Result	Units	Method
Copper	0.030	mg/L	EPA 200.7
Dissolved Copper	0.029	mg/L	EPA 200.7
Nitrate/Nitrite	0.13	mg/L-N	Easy1-Reagent
TKN	22	mg/L-N	SM 4500-N-C
Orthophosphate, as P	7.8	mg/L	SM4500-P E
Total Phosphorus	9.6	mg/L	SM4500-P E

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03/31/2015

WSU Puyallup Research and Extension Center

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Puyallup, WA 98371-4998
Attn: Maninder Chahal

Client ID: Storm 5 Column 3
Sample Matrix: Water
Date Sampled: 03/18/2015
Date Received: 03/18/2015
Spectra Project: 2015030505
Spectra Number: 5

Analyte	Result	Units	Method
Copper	0.036	mg/L	EPA 200.7
Dissolved Copper	0.033	mg/L	EPA 200.7
Nitrate/Nitrite	0.13	mg/L-N	Easy1-Reagent
TKN	26	mg/L-N	SM 4500-N-C
Orthophosphate, as P	4.7	mg/L	SM4500-P E
Total Phosphorus	6.1	mg/L	SM4500-P E

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03/31/2015

WSU Puyallup Research and Extension Center

2606 W Pioneer
Puyallup, WA 98371-4998
Attn: Maninder Chahal

Client ID: Storm 5 Column 4
Sample Matrix: Water
Date Sampled: 03/18/2015
Date Received: 03/18/2015
Spectra Project: 2015030505
Spectra Number: 6

Analyte	Result	Units	Method
Copper	0.019	mg/L	EPA 200.7
Dissolved Copper	0.017	mg/L	EPA 200.7
Nitrate/Nitrite	0.66	mg/L-N	Easy1-Reagent
TKN	19	mg/L-N	SM 4500-N-C
Orthophosphate, as P	7.3	mg/L	SM4500-P E
Total Phosphorus	9.0	mg/L	SM4500-P E

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Steve Hibbs, Laboratory Manager
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03/31/2015

WSU Puyallup Research and Extension Center

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Puyallup, WA 98371-4998
Attn: Maninder Chahal

Client ID: Storm 5 Column 5
Sample Matrix: Water
Date Sampled: 03/18/2015
Date Received: 03/18/2015
Spectra Project: 2015030505
Spectra Number: 7

Analyte	Result	Units	Method
Copper	0.023	mg/L	EPA 200.7
Dissolved Copper	0.021	mg/L	EPA 200.7
Nitrate/Nitrite	0.97	mg/L-N	Easy1-Reagent
TKN	12	mg/L-N	SM 4500-N-C
Orthophosphate, as P	5.0	mg/L	SM4500-P E
Total Phosphorus	6.3	mg/L	SM4500-P E

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Steve Hibbs, Laboratory Manager
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03/31/2015

WSU Puyallup Research and Extension Center

2606 W Pioneer
Puyallup, WA 98371-4998
Attn: Maninder Chahal

Client ID: Storm 5 Column 6
Sample Matrix: Water
Date Sampled: 03/18/2015
Date Received: 03/18/2015
Spectra Project: 2015030505
Spectra Number: 8

Analyte	Result	Units	Method
Copper	0.017	mg/L	EPA 200.7
Dissolved Copper	0.016	mg/L	EPA 200.7
Nitrate/Nitrite	1.3	mg/L-N	Easy1-Reagent
TKN	16	mg/L-N	SM 4500-N-C
Orthophosphate, as P	7.6	mg/L	SM4500-P E
Total Phosphorus	9.4	mg/L	SM4500-P E

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Steve Hibbs, Laboratory Manager
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03/31/2015

WSU Puyallup Research and Extension Center

2606 W Pioneer
Puyallup, WA 98371-4998
Attn: Maninder Chahal

Client ID:	Cu Stock Solution 1
Sample Matrix:	Water
Date Sampled:	03/18/2015
Date Received:	03/18/2015
Spectra Project:	2015030505
Spectra Number:	9

Analyte	Result	Units	Method
Copper	13.3	mg/L	EPA 200.7
Dissolved Copper	12.7	mg/L	EPA 200.7

SPECTRA LABORATORIES

Steve Hibbs, Laboratory Manager
a6/scj

SPECTRA Laboratories
2221 Ross Way • Tacoma, WA 98421 • (253) 272-4850 • Fax (253) 572-9838 • www.spectra-lab.com

03/31/2015

WSU Puyallup Research and Extension Center

2606 W Pioneer
Puyallup, WA 98371-4998
Attn: Maninder Chahal

Client ID: Cu Stock Solution 2
Sample Matrix: Water
Date Sampled: 03/18/2015
Date Received: 03/18/2015
Spectra Project: 2015030505
Spectra Number: 10

Analyte	Result	Units	Method
Copper	13.2	mg/L	EPA 200.7
Dissolved Copper	12.1	mg/L	EPA 200.7

SPECTRA LABORATORIES

Steve Hibbs, Laboratory Manager
a6/scj

SPECTRA Laboratories
2221 Ross Way, Tacoma, WA 98421
(253) 272-4850 Fax (253) 572-9838
www.spectra-lab.com info@spectra-lab.com

SPECIAL INSTRUCTIONS/COMMENTS:
SAMPles #1-#8
See the attached quote
SAMPles #9-#10
Total + Dissolved copper ONly

Return Samples: Y N Page ______ of ______

2015030505

CHAIN OF CUSTODY

SPECTRA PROJECT #

STANDARD [X] RUSH [ ]

CLIENT: WSU-Puy ADDRESS: 2606 W Pioneer Ave, Puyallup, WA 98371 ADDRESS CHANGE [ ]

PROJECT:

CONTACT: Maninder Chahal

SAMPLED BY: Maninder Chahal

PHONE: (253) 445-4592 FAX:

e-MAIL: maninder.chahal@email.wsu.edu Prefer FAX [ ] or e-MAIL [X]

PURCHASE ORDER #

						HYDROCARBONS								ORGANICS						METALS					OTHER											
	SAMPLE ID	DATE SAMPLED	TIME SAMPLED	MATRIX	NUMBER OF CONTAINERS	NWTPH-HCID	BTEX	BTEX/NWTPH-G	NWTPH-G	NWTPH-Dx	1664 SGT-HEM (TPH)	1664 HEM (FOG)		8260/624 VOA	8260 CHLOR SOLVENTS	8270-625 SEMI VOA	8270 PAH/PNA	8082/608 PCB		TOTAL METALS RCRA 8	TOTAL METALS (SPECIFY) Copper	TCLP METALS RCRA 8	TCLP METALS (SPECIFY)	Dissolved copper	PH 9040/9045	TX/TOX/EOX	TURBIDITY	FLASH POINT	BOD	SOLIDS (SPECIFY)						
1	Storm 5 rep 1	3/18/15	3 pm	water	1																															
2	Storm 5 rep 2	3/18/15	3 pm	water	1																															
3	Storm 5 Column 1	3/18/15	3 pm	water	1																															
4	Storm 5 Column 2	3/18/15	3 pm	water	1																															
5	Storm 5 Column 3	3/18/15	3 pm	water	1																															
6	Storm 5 column 4	3/18/15	3 pm	water	1																															
7	Storm 5 Column 5	3/18/15	3 pm	water	1																															
8	Storm 5 Column 6	3/18/15	3 pm	water	1																															
9	Cu Stock solution 1	3/18/15	3 pm	water	1																X		X													
10	Cu stock solution 2	3/18/15	3 pm	water	1																X		X													

LAB USE ONLY

Shipped Via:
US Mail UPS Fed Ex Courier Client

Shipping Container:
Cooler Box Envelope None

Tracking # ______

Custody Seals: Y N Intact: Y N

Cooler Temp. ______ Sample Temp. ______

	SIGNATURE	PRINTED NAME	COMPANY	DATE	TIME
RELINQUISHED BY	Chahal	Maninder Chahal	WSU	3/18/15	
RECEIVED BY	Karie Kinder	Karie Kinder	Spectra	3/18	4:30
RELINQUISHED BY					
RECEIVED BY					

Payment Terms: Net 30 days. Past due accounts subject to 1 1/2% per month interest. Customer agrees to pay all costs of collection including reasonable attorney's fees and all other costs of collection regardless of whether suit is filed in Pierce Co., WA venue. *Spectra Laboratories, LLC*

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04/09/2015

WSU Puyallup Research and Extension Center

2606 W Pioneer
Puyallup, WA 98371-4998

Client ID: Storm 6 Rep 1
Sample Matrix: Water
Date Sampled: 04/01/2015
Date Received: 04/01/2015
Spectra Project: 2015040027
Spectra Number: 1

Analyte	Result	Units	Method
Copper	0.060	mg/L	EPA 200.7
Dissolved Copper	0.044	mg/L	EPA 200.7
Nitrate/Nitrite	0.09	mg/L-N	Easy1-Reagent
TKN	<0.5	mg/L-N	SM 4500-N-C
Orthophosphate, as P	<0.01	mg/L	SM4500-P E
Total Phosphorus	<0.01	mg/L	SM4500-P E

SPECTRA LABORATORIES

Steve Hibbs, Laboratory Manager
a6/scj

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04/09/2015

WSU Puyallup Research and Extension Center

2606 W Pioneer
Puyallup, WA 98371-4998

Client ID: Storm 6 Rep 2
Sample Matrix: Water
Date Sampled: 04/01/2015
Date Received: 04/01/2015
Spectra Project: 2015040027
Spectra Number: 2

Analyte	Result	Units	Method
Copper	0.052	mg/L	EPA 200.7
Dissolved Copper	0.040	mg/L	EPA 200.7
Nitrate/Nitrite	0.09	mg/L-N	Easy1-Reagent
TKN	<0.5	mg/L-N	SM 4500-N-C
Orthophosphate, as P	<0.01	mg/L	SM4500-P E
Total Phosphorus	<0.01	mg/L	SM4500-P E

SPECTRA LABORATORIES

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04/09/2015

WSU Puyallup Research and Extension Center

2606 W Pioneer
Puyallup, WA 98371-4998

Client ID: Storm 6 Column 1
Sample Matrix: Water
Date Sampled: 04/01/2015
Date Received: 04/01/2015
Spectra Project: 2015040027
Spectra Number: 3

Analyte	Result	Units	Method
Copper	0.035	mg/L	EPA 200.7
Dissolved Copper	0.026	mg/L	EPA 200.7
Nitrate/Nitrite	0.17	mg/L-N	Easy1-Reagent
TKN	20	mg/L-N	SM 4500-N-C
Orthophosphate, as P	5.5	mg/L	SM4500-P E
Total Phosphorus	6.5	mg/L	SM4500-P E

SPECTRA LABORATORIES

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04/09/2015

WSU Puyallup Research and Extension Center

2606 W Pioneer
Puyallup, WA 98371-4998

Client ID:	Storm 6 Column 2
Sample Matrix:	Water
Date Sampled:	04/01/2015
Date Received:	04/01/2015
Spectra Project:	2015040027
Spectra Number:	4

Analyte	Result	Units	Method
Copper	0.026	mg/L	EPA 200.7
Dissolved Copper	0.026	mg/L	EPA 200.7
Nitrate/Nitrite	<0.10	mg/L-N	Easy1-Reagent
TKN	17	mg/L-N	SM 4500-N-C
Orthophosphate, as P	6.8	mg/L	SM4500-P E
Total Phosphorus	7.6	mg/L	SM4500-P E

SPECTRA LABORATORIES

Steve Hibbs, Laboratory Manager
a6/scj

04/09/2015

WSU Puyallup Research and Extension Center

2606 W Pioneer
Puyallup, WA 98371-4998

Client ID: Storm 6 Column 3
Sample Matrix: Water
Date Sampled: 04/01/2015
Date Received: 04/01/2015
Spectra Project: 2015040027
Spectra Number: 5

Analyte	Result	Units	Method
Copper	0.036	mg/L	EPA 200.7
Dissolved Copper	0.033	mg/L	EPA 200.7
Nitrate/Nitrite	0.14	mg/L-N	Easy1-Reagent
TKN	13	mg/L-N	SM 4500-N-C
Orthophosphate, as P	4.8	mg/L	SM4500-P E
Total Phosphorus	5.5	mg/L	SM4500-P E

SPECTRA LABORATORIES

Steve Hibbs, Laboratory Manager
a6/scj

04/09/2015

WSU Puyallup Research and Extension Center

2606 W Pioneer
Puyallup, WA 98371-4998

Client ID: Storm 6 Column 4
Sample Matrix: Water
Date Sampled: 04/01/2015
Date Received: 04/01/2015
Spectra Project: 2015040027
Spectra Number: 6

Analyte	Result	Units	Method
Copper	0.018	mg/L	EPA 200.7
Dissolved Copper	0.016	mg/L	EPA 200.7
Nitrate/Nitrite	0.33	mg/L-N	Easy1-Reagent
TKN	8.3	mg/L-N	SM 4500-N-C
Orthophosphate, as P	6.0	mg/L	SM4500-P E
Total Phosphorus	6.9	mg/L	SM4500-P E

SPECTRA LABORATORIES

Steve Hibbs, Laboratory Manager
a6/scj

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04/09/2015

WSU Puyallup Research and Extension Center

2606 W Pioneer
Puyallup, WA 98371-4998

Client ID: Storm 6 Column 5
Sample Matrix: Water
Date Sampled: 04/01/2015
Date Received: 04/01/2015
Spectra Project: 2015040027
Spectra Number: 7

Analyte	Result	Units	Method
Copper	0.030	mg/L	EPA 200.7
Dissolved Copper	0.022	mg/L	EPA 200.7
Nitrate/Nitrite	0.55	mg/L-N	Easy1-Reagent
TKN	7.0	mg/L-N	SM 4500-N-C
Orthophosphate, as P	4.3	mg/L	SM4500-P E
Total Phosphorus	5.1	mg/L	SM4500-P E

SPECTRA LABORATORIES

Steve Hibbs, Laboratory Manager
a6/scj

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04/09/2015

WSU Puyallup Research and Extension Center

2606 W Pioneer
Puyallup, WA 98371-4998

Client ID: Storm 6 Column 6
Sample Matrix: Water
Date Sampled: 04/01/2015
Date Received: 04/01/2015
Spectra Project: 2015040027
Spectra Number: 8

Analyte	Result	Units	Method
Copper	0.019	mg/L	EPA 200.7
Dissolved Copper	0.015	mg/L	EPA 200.7
Nitrate/Nitrite	0.50	mg/L-N	Easy1-Reagent
TKN	9.2	mg/L-N	SM 4500-N-C
Orthophosphate, as P	6.0	mg/L	SM4500-P E
Total Phosphorus	6.9	mg/L	SM4500-P E

SPECTRA LABORATORIES

Steve Hibbs, Laboratory Manager
a6/scj

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(253) 272-4850 Fax (253) 572-9838
www.spectra-lab.com info@spectra-lab.com

SPECIAL INSTRUCTIONS/COMMENTS:
See the attached quote

Return Samples: Y N Page ______ of ______

CHAIN OF CUSTODY

SPECTRA PROJECT # 2015040027

STANDARD [X] RUSH [ ]

CLIENT: WSU-Puy ADDRESS: 2606 W Pioneer Ave, Puyallup, WA 98371 ADDRESS CHANGE [ ]

PROJECT:

CONTACT: Maninder Chahal

SAMPLED BY: Maninder Chahal

PHONE: (253)445-4592 FAX:

e-MAIL: maninder.chahal@email.wsu.edu Prefer FAX [ ] or e-MAIL [X]

PURCHASE ORDER #

	SAMPLE ID	DATE SAMPLED	TIME SAMPLED	MATRIX	NUMBER OF CONTAINERS	NWTPH-HCID	BTEX	BTEX/NWTPH-G	NWTPH-G	NWTPH-Dx	1664 SGT-HEM (TPH)	1664 HEM (FOG)	8260/624 VOA	8260 CHLOR SOLVENTS	8270-625 SEMI VOA	8270 PAH/PNA	8082/608 PCB	TOTAL METALS RCRA 8	TOTAL METALS (SPECIFY)	TCLP METALS RCRA 8	TCLP METALS (SPECIFY)	PH 9040/9045	TX/TOX/EOX	TURBIDITY	FLASH POINT	BOD	SOLIDS (SPECIFY)
						HYDROCARBONS							ORGANICS					METALS				OTHER					
1	Storm 6 Rep 1	4/1/15	3pm	water	1																						
2	Storm 6 Rep 2	4/1/15	3pm	water	1																						
3	Storm 6 Column 1	4/1/15	3pm	water	1																						
4	Storm 6 Column 2	4/1/15	3pm	water	1																						
5	Storm 6 Column 3	4/1/15	3pm	water	1																						
6	Storm 6 Column 4	4/1/15	3pm	water	1																						
7	Storm 6 Column 5	4/1/15	3pm	water	1																						
8	Storm 6 Column 6	4/1/15	3pm	water	1																						
9																											
10																											

LAB USE ONLY
Shipped Via: US Mail UPS Fed Ex Courier Client
Shipping Container: Cooler Box Envelope None
Tracking # ______
Custody Seals: Y N Intact: Y N
Cooler Temp. ______ Sample Temp. ______

	SIGNATURE	PRINTED NAME	COMPANY	DATE	TIME
RELINQUISHED BY	Chahal	Maninder Chahal	WSU	1/4/15	4:40pm
RECEIVED BY	Marie Holt	MARIE HOLT	Spectra	4-1-15	4:40pm
RELINQUISHED BY					
RECEIVED BY					

Payment Terms: Net 30 days. Past due accounts subject to 1 1/2% per month interest. Customer agrees to pay all costs of collection including reasonable attorney's fees and all other costs of collection regardless of whether suit is filed in Pierce Co., WA venue. *Spectra Laboratories, LLC*

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04/29/2015

WSU Puyallup Research and Extension Center

2606 W Pioneer
Puyallup, WA 98371-4998

Client ID: Storm 7 Rep 1
Sample Matrix: Water
Date Sampled: 04/15/2015
Date Received: 04/15/2015
Spectra Project: 2015040381
Spectra Number: 1

Analyte	Result	Units	Method
Copper	0.070	mg/L	EPA 200.7
Dissolved Copper	0.048	mg/L	EPA 200.7
Nitrate/Nitrite	0.09	mg/L-N	Easy1-Reagent
TKN	0.9	mg/L-N	SM 4500-N-C
Orthophosphate, as P	<0.01	mg/L	SM4500-P E
Total Phosphorus	<0.01	mg/L	SM4500-P E

SPECTRA LABORATORIES

Steve Hibbs, Laboratory Manager
a6/scj

04/29/2015

WSU Puyallup Research and Extension Center

2606 W Pioneer
Puyallup, WA 98371-4998

Client ID: Storm 7 Rep 2
Sample Matrix: Water
Date Sampled: 04/15/2015
Date Received: 04/15/2015
Spectra Project: 2015040381
Spectra Number: 2

Analyte	Result	Units	Method
Copper	0.070	mg/L	EPA 200.7
Dissolved Copper	0.053	mg/L	EPA 200.7
Nitrate/Nitrite	0.10	mg/L-N	Easy1-Reagent
TKN	<0.5	mg/L-N	SM 4500-N-C
Orthophosphate, as P	<0.01	mg/L	SM4500-P E
Total Phosphorus	<0.01	mg/L	SM4500-P E

SPECTRA LABORATORIES

Steve Hibbs, Laboratory Manager
a6/scj

04/29/2015

WSU Puyallup Research and Extension Center

2606 W Pioneer
Puyallup, WA 98371-4998

Client ID: Storm 7 Column 1
Sample Matrix: Water
Date Sampled: 04/15/2015
Date Received: 04/15/2015
Spectra Project: 2015040381
Spectra Number: 3

Analyte	Result	Units	Method
Copper	0.040	mg/L	EPA 200.7
Dissolved Copper	0.033	mg/L	EPA 200.7
Nitrate/Nitrite	0.14	mg/L-N	Easy1-Reagent
TKN	9.1	mg/L-N	SM 4500-N-C
Orthophosphate, as P	3.1	mg/L	SM4500-P E
Total Phosphorus	4.3	mg/L	SM4500-P E

SPECTRA LABORATORIES

Steve Hibbs, Laboratory Manager
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04/29/2015

WSU Puyallup Research and Extension Center

2606 W Pioneer
Puyallup, WA 98371-4998

Client ID: Storm 7 Column 2
Sample Matrix: Water
Date Sampled: 04/15/2015
Date Received: 04/15/2015
Spectra Project: 2015040381
Spectra Number: 4

Analyte	Result	Units	Method
Copper	0.037	mg/L	EPA 200.7
Dissolved Copper	0.028	mg/L	EPA 200.7
Nitrate/Nitrite	<0.10	mg/L-N	Easy1-Reagent
TKN	16	mg/L-N	SM 4500-N-C
Orthophosphate, as P	4.7	mg/L	SM4500-P E
Total Phosphorus	6.3	mg/L	SM4500-P E

SPECTRA LABORATORIES

Steve Hibbs, Laboratory Manager
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04/29/2015

WSU Puyallup Research and Extension Center

2606 W Pioneer
Puyallup, WA 98371-4998

Client ID: Storm 7 Column 3
Sample Matrix: Water
Date Sampled: 04/15/2015
Date Received: 04/15/2015
Spectra Project: 2015040381
Spectra Number: 5

Analyte	Result	Units	Method
Copper	0.050	mg/L	EPA 200.7
Dissolved Copper	0.049	mg/L	EPA 200.7
Nitrate/Nitrite	0.15	mg/L-N	Easy1-Reagent
TKN	21	mg/L-N	SM 4500-N-C
Orthophosphate, as P	3.9	mg/L	SM4500-P E
Total Phosphorus	5.4	mg/L	SM4500-P E

SPECTRA LABORATORIES

Steve Hibbs, Laboratory Manager
a6/scj

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04/29/2015

WSU Puyallup Research and Extension Center

2606 W Pioneer
Puyallup, WA 98371-4998

Client ID: Storm 7 Column 4
Sample Matrix: Water
Date Sampled: 04/15/2015
Date Received: 04/15/2015
Spectra Project: 2015040381
Spectra Number: 6

Analyte	Result	Units	Method
Copper	0.038	mg/L	EPA 200.7
Dissolved Copper	0.030	mg/L	EPA 200.7
Nitrate/Nitrite	0.35	mg/L-N	Easy1-Reagent
TKN	8.6	mg/L-N	SM 4500-N-C
Orthophosphate, as P	4.4	mg/L	SM4500-P E
Total Phosphorus	6.0	mg/L	SM4500-P E

SPECTRA LABORATORIES

Steve Hibbs, Laboratory Manager
a6/scj

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04/29/2015

WSU Puyallup Research and Extension Center

2606 W Pioneer
Puyallup, WA 98371-4998

Client ID: Storm 7 Column 5
Sample Matrix: Water
Date Sampled: 04/15/2015
Date Received: 04/15/2015
Spectra Project: 2015040381
Spectra Number: 7

Analyte	Result	Units	Method
Copper	0.033	mg/L	EPA 200.7
Dissolved Copper	0.026	mg/L	EPA 200.7
Nitrate/Nitrite	0.81	mg/L-N	Easy1-Reagent
TKN	14	mg/L-N	SM 4500-N-C
Orthophosphate, as P	4.7	mg/L	SM4500-P E
Total Phosphorus	6.3	mg/L	SM4500-P E

SPECTRA LABORATORIES

Steve Hibbs, Laboratory Manager
a6/scj

SPECTRA Laboratories

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04/29/2015

WSU Puyallup Research and Extension Center

2606 W Pioneer
Puyallup, WA 98371-4998

Client ID:	Storm 7 Column 6
Sample Matrix:	Water
Date Sampled:	04/15/2015
Date Received:	04/15/2015
Spectra Project:	2015040381
Spectra Number:	8

Analyte	Result	Units	Method
Copper	0.029	mg/L	EPA 200.7
Dissolved Copper	0.021	mg/L	EPA 200.7
Nitrate/Nitrite	0.59	mg/L-N	Easy1-Reagent
TKN	11	mg/L-N	SM 4500-N-C
Orthophosphate, as P	5.0	mg/L	SM4500-P E
Total Phosphorus	6.5	mg/L	SM4500-P E

SPECTRA LABORATORIES

Steve Hibbs, Laboratory Manager
a6/scj

SPECTRA Laboratories
2221 Ross Way, Tacoma, WA 98421
(253) 272-4850 Fax (253) 572-9838
www.spectra-lab.com info@spectra-lab.com

SPECIAL INSTRUCTIONS/COMMENTS:
See the attached quote ✓

Return Samples: Y N Page ____ of ____

CHAIN OF CUSTODY

SPECTRA PROJECT # 201504038

STANDARD [X] RUSH [ ]

CLIENT: WSU-Puy

ADDRESS:

ADDRESS CHANGE [ ]

PROJECT:

CONTACT: Maninder Chahal

SAMPLED BY: Maninder Chahal

PHONE: (253)445-4592 FAX:

e-MAIL: maninder.chahal@email.wsu.edu Prefer FAX [ ] or e-MAIL [X]

PURCHASE ORDER #

Analyses columns — HYDROCARBONS: NWTPH-HCID, BTEX, BTEX/NWTPH-G, NWTPH-G, NWTPH-Dx, 1664 SGT-HEM (TPH), 1664 HEM (FOG); ORGANICS: 8260/624 VOA, 8260 CHLOR SOLVENTS, 8270-625 SEMI VOA, 8270 PAH/PNA, 8082/608 PCB; METALS: TOTAL METALS RCRA 8, TOTAL METALS (SPECIFY), TCLP METALS RCRA 8, TCLP METALS (SPECIFY); OTHER: PH 9040/9045, TX/TOX/EOX, TURBIDITY, FLASH POINT, BOD, SOLIDS (SPECIFY)

	SAMPLE ID	DATE SAMPLED	TIME SAMPLED	MATRIX	NUMBER OF CONTAINERS
1	Storm7 Rep1	4/15/15	3pm	water	1
2	Storm 7 Rep2	4/15/15	3pm	water	1
3	Storm7 Column1	4/15/15	3pm	water	1
4	Storm7 Column2	4/15/15	3pm	water	1
5	Storm7 Column3	4/15/15	3 pm	water	1
6	Storm7 column4	4/15/15	3 pm	water	1
7	Storm7 Column5	4/15/15	3 pm	water	1
8	Storm7 Column6	4/15/15	3pm	water	1
9					
10					

LAB USE ONLY
Shipped Via: US Mail UPS Fed Ex Courier Client
Shipping Container: Cooler Box Envelope None
Tracking # ______
Custody Seals: Y N Intact: Y N
Cooler Temp. _____ Sample Temp. _____

	SIGNATURE	PRINTED NAME	COMPANY	DATE	TIME
RELINQUISHED BY	M Chahal	Maninder Chahal	WSU	4/15/15	4:50
RECEIVED BY	Karie Kirdw	Karie Kirdw	Spectra	4/15	4:50
RELINQUISHED BY					
RECEIVED BY					

Payment Terms: Net 30 days. Past due accounts subject to 1 1/2% per month interest. Customer agrees to pay all costs of collection including reasonable attorney's fees and all other costs of collection regardless of whether suit is filed in Pierce Co., WA venue. *Spectra Laboratories, LLC*