SAMPLING AND ANALYSIS PLAN
Project Title: Biosolids Land Application – PFAS Transport and Risk Evaluation
Response to: Colorado Department of Public Health and the Environment
SB 20-218 Perfluoroalkyl and Polyfluoroalkyl Substances
Cash Fund Grant Program, RFA #41164B
March 14, 2025

Project Overview

This sampling and analysis plan describes work proposed to be conducted at fields owned by South Platte Renew (SPR), co-funded by Colorado Department of Public Health and the Environment (CDPHE) grant and SPR. The goal of the work is to expand understanding of PFAS presence, composition, and mobility potential in agricultural soils with historical land-application of biosolids. PFAS in biosolids are an emerging and widespread concern across Colorado and the U.S. Select states, including Michigan, Wisconsin, Maine, and Minnesota, have proposed or implemented policy regulating the land application of biosolids containing PFAS. At the federal level, EPA has recently released a draft risk assessment for PFAS.

The data collection proposed herein expands a longstanding partnership between South Platte Renew (SPR) and Colorado State University (CSU). Biosolids produced by SPR have been land applied at SPR-owned agricultural fields east of Denver (see Figure 1) for over 40 years. Associated with this biosolids land application, CSU has collected detailed data sets involving interactions between soil quality, moisture, and crop yield that have produced several publications and advanced general knowledge of biosolids impacts on agricultural soils. The historical CSU/SPR data collection has focused on a field referred to as the CSU Test Plot. The proposed work expands that existing data set to evaluate presence and transport potential of per- and polyfluoroalkyl substances (PFAS) associated with land-applied biosolids.

This project is intended to support CDPHE and SPR in addressing the EPA PFAS risk assessment and/or future Colorado biosolids policy related to PFAS. The overarching goals of this project are to assess the nature and extent of PFAS in biosolid-amended soils and to assess potential exposure risks in Colorado's agricultural fields.

Based on these project goals, the project team has developed the following general research questions to guide subsequent activities:

1. How widespread and variable are PFAS concentrations across agricultural fields where biosolids have been land applied?
2. What are the concentrations and composition of PFAS (target list and non-target PFAS) present in environmental media where biosolids have been land applied?
3. What are the drivers/limiters of PFAS mobility in the environment at biosolids land application sites?
4. Is groundwater quality threatened by PFAS at biosolids land application sites?
5. Can we use models to inform current and/or future risk associated w/ biosolids land application at Colorado sites?

Proposed Scope of Work

The project team has prepared this scope of work on the assumption that basic questions will be addressed over 1 year of data collection, and additional funding may be pursued for subsequent years, as warranted to address more detailed/specific research questions. The scope of activities, described below, is designed to address the research questions at a high level, providing actionable insights into the presence, mobility, and potential risk of PFAS in environmental media at SPR-owned biosolids land application sites while setting the stage for focused data collection and modeling efforts in subsequent years.

In support of the overall project objectives, the 2025-2026 activities will include a broad evaluation of PFAS occurrence and preliminary evaluation of PFAS mobility/retention processes at the CSU Test Plot. This evaluation will include field sample collection supplemented with laboratory testing and desktop evaluation of existing data; each of these are described below.

Field sampling

- For the first project year, field activities for the PFAS project will include sampling of surface soil (up to 2 inches), shallow soil (up to 6 feet bgs), and porewater. To the extent possible, soil sampling methods and locations will be conducted in conjunction with sampling activities conducted under the existing CSU/SPR Biosolids Land Application Research Program (C/S-BLARP).
- Surface soils (0 to 2 inches bgs) will be collected from approximately 20 locations associated with the CSU Test Plot (also referred to as the Byers plot). Three fields will be selected for sampling, generally aligning with C/S-BLARP sampling. At least six surface soil samples will be collected from each of these fields; samples will be collected from the north and south subfields (one treated with biosolids, the other with nitrogen fertilizer) at locations at the western end, center, and eastern end of each selected subfield (the western sample location will align with C/S-BLARP sampling. Additional samples will be collected from the sediments associated with the creekbed (typically dry) located northeast of the Byers plot.
- Field mobility of PFAS will be evaluated through pore-water sampling via soil-suction lysimeters. Pore-water data will complement the soil data and support risk assessment through more quantitative evaluation of PFAS partitioning between soil and pore water, and associated mobility/retention in shallow soils.
- A trowel will be used for collection of surface samples (up to 2 inches bgs) and a truck-mounted Giddings hydraulic soil sampler will be used to collect deeper samples. PFAS-compatible equipment and methods will be used throughout sampling activities.
- If possible, soil suction lysimeters will be installed at 2 depths (approximately 8 and 40 inches). Lysimeters will be constructed of stainless steel. Soil moisture sensors will be deployed at both depths at one of the locations. We assume that the lysimeters will be sampled two times in the project year, under variable precipitation conditions (dry and after heavy rain).
- The team understands that biosolids have been sampled on a bi-monthly basis. If available, samples of the source biosolids/sludge will be collected and analyzed with the soil samples for non-targeted PFAS analysis.

Laboratory analysis and testing

- Soil samples will be analyzed for target-list PFAS, including 40 compounds, via analytical methods based on EPA 1633.

- Select portions of samples will be refrigerated and stored for potential non-targeted analysis (NTA) via liquid chromatography (LC) quadrupole time-of-flight (QToF); NTA will only be conducted after consultation with SPR after target PFAS analysis is complete.
- Select portions of samples will be refrigerated and stored for potential leachability testing via EPA Leaching Environmental Assessment Framework (LEAF) methodology; LEAF desorption testing will only be conducted after consultation with SPR after target PFAS analysis is complete.

Desktop evaluation of existing data

- CSU has conducted extensive testing and research at the Test Plot. The project team will work with CSU personnel involved in non-PFAS data collection (Steve Blecker and others) to compile information that supports understanding of PFAS transport and transformation. Relevant data will be provided and assessed in the project report (see below).
- Existing data on groundwater and geology will be evaluated during the project period, to support evaluation of risk. Preliminary review of USGS groundwater data in the area suggests highly variable depth-to-groundwater conditions exist, with depths ranging from approximately 10 to over 100 ft bgs[1].

Schedule and Budget

The above activities will be conducted over 12 months from 2025 to 2026. Initial sampling and suction-lysimeter installation is anticipated for summer 2025. The budget for the proposed work is $150,000 including $50,000 from SPR and $100,000 from CDPHE grant funding. This will include site sample collection, analysis, laboratory testing, and office-based work as described herein. The approximate division of services for CSU and Brown and Caldwell is shown in Table 1.

Project Team

The project will be conducted by an integrated team from CSU and Brown and Caldwell.

CSU's project team includes Dr. Mitchell Olson and Dr. Andrea Rhoades, who serve as co-directors for CSU's Center for Contaminant Hydrology (CCH) within the department of Civil and Environmental Engineering. Dr. Olson will serve as Principal Investigator for CSU and will lead CSU's portion of project implementation. Dr. Rhoades will provide technical expertise in PFAS analysis and will assist in directing student activities. Drs. Olson and Rhoades will be supported by a graduate student (MS or PhD) as well as undergraduate research assistants, who will conduct hands-on sampling and analytical work for this project.

Brown and Caldwell's team is comprised of a multidisciplinary group of practitioners selected to support various aspects of the project. Devon Gibson, Associate Environmental Engineer, will serve at the Project Manager for BC. Sarah Reeves, Director of Technical Services, will provide insight into local, regional, and national policy developments regarding biosolids and PFAS. Steve Young, Principal Hydrogeologist, will provide subject matter expertise pertaining to PFAS fate and transport modeling and risk assessment. Andrew Safulko, Principal Environmental Engineer, will provide

[1] https://cida.usgs.gov/ngwmn/provider/USGS/site/393902103554001/

subject matter expertise related to PFAS. Dr. Allegra da Silva, Director of Research and Innovation, will provide general project oversight and support alignment with associated research efforts.

Reporting

Project reporting will be conducted in accordance with CDPHE's program requirements for SB 20-218.

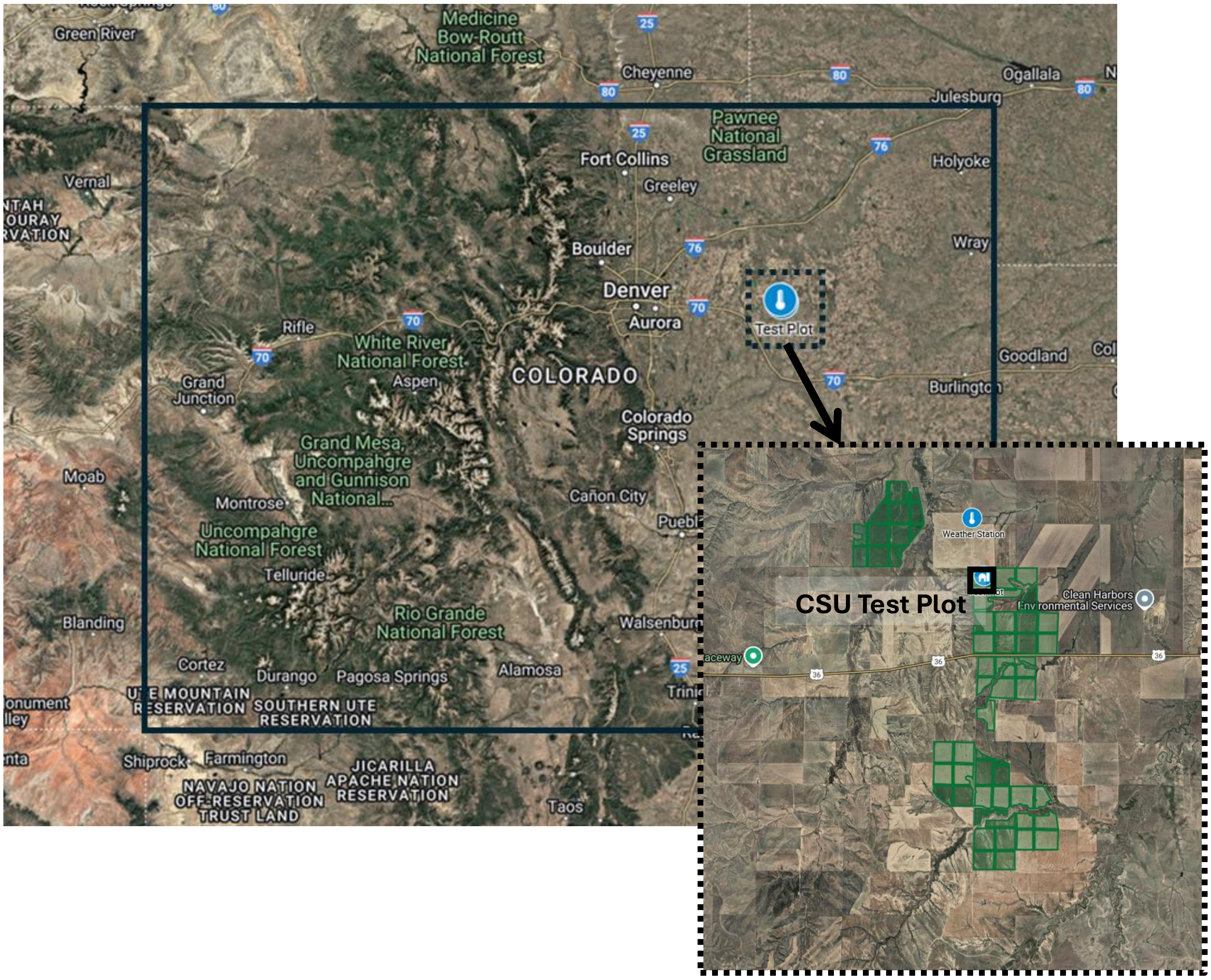

Figure 1. Location of CSU Test Plot.

TABLE 1. SPR PFAS Biosolids Study Scope Breakdown			
		Role/Responsibility	
Task	Lead	Colorado State University (CSU)	Brown and Caldwell (BC)
Field Sampling	CSU	▪ Identify soil sample locations ▪ Coordinate and collect soil samples ▪ Identify soil suction lysimeter locations ▪ Install soil suction lysimeters ▪ Coordinate and collect soil suction lysimeter samples ▪ Coordinate and collect biosolids samples ▪ Document sample locations via GPS lat/long and provide sample/monitoring location IDs to BC	▪ Review and comment on proposed soil sample and soil suction lysimeter sample locations ▪ Develop GIS layer/figure displaying soil, soil suction lysimeter, and crop sample locations
Laboratory Analysis and Testing	CSU	▪ Complete targeted PFAS analysis for soil, soil suction lysimeter, biosolid, and crop samples ▪ As necessary, complete NTA for analysis for soil, soil suction lysimeter, biosolid, and crop samples ▪ As necessary, conduct LEAF protocol and associated targeted and/or NTA PFAS analysis on soil leachate samples ▪ Provide validated PFAS analytical results for all analyses in Microsoft Excel format ▪ Document and provide various analytical methodologies, SOPs, etc.	▪ Review PFAS analytical results ▪ Prepare GIS layers/figures summarizing targeted PFAS analytical results in soil, soil suction lysimeter, and crop samples

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Desktop Evaluation of Existing Data	CSU	▪ Coordinate, review, and organize existing relevant non-PFAS data obtained from SPR plots ▪ Coordinate, review, and organize relevant and reasonably ascertainable information related to site, local, or regional geology and hydrogeology	▪ Review data summaries prepared by CSU ▪ Develop GIS layers/figures of relevant data provided by CSU ▪ Support data search and evaluation for local geology/hydrogeology
Reporting	CSU	▪ Develop draft/final 2025 summary report including detailed description of sampling methods, analytical methods, desktop data review summary, results, preliminary risk evaluation, conclusions, and recommendations for the following year. ▪	▪ Review and comment on draft 2025 summary report. ▪ Support site-specific risk assessment and identification of data gaps ▪ Develop additional GIS layers/figures, as necessary, to support 2025 summary report