National Park Service/USGS Water Quality Partnership

Evaluation of suspended sediment sources, concentrations, and loads in relation to streamflow and season in White Clay Creek, a National Wild and Scenic River

Project Category: Synoptic
Funding Request: $150,000 total (75,000 per year for 2 years)
NPS Park Unit or Network: White Clay Creek National Wild and Scenic River
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Introduction and Problem Statement

The White Clay Creek in southern Pennsylvania and northern Delaware (fig. 1) was named a National Wild and Scenic River in 2000, a designation that affords federal protection and oversight by the National Park Service (NPS) to 199 stream miles (Scenic, 31.4 miles; Recreational, 167.6 miles) (National Park Service, 2017). The White Clay Creek drains 107 square miles of mixed land uses, including forested, agricultural, and urban (residential, institutional, and other) and is a resource for recreational and drinking-water supply uses, in addition to having ecological value (such as providing habitat for the federally-listed endangered Bog Turtle). The various land uses have resulted in stream water-quality impairments identified by the two state agencies, Pennsylvania Department of Environmental Protection (PADEP) and Delaware Department of Natural Resources and Environmental Control (DNREC) to include pathogens (bacteria), sediment/siltation, total suspended solids, nutrients, and organic enrichment/low dissolved oxygen in Pennsylvania and bacteria, nutrients, and zinc in Delaware (fig. 2). As a result of these impairments, Pennsylvania and Delaware have developed total maximum daily loads (TMDLs) for some of the pollutants of concern as required by the Federal Clean Water Act of 1972, including TMDLs for bacteria and sediment (high-flow) and nutrients (high- and low-flow) in 2006 (EPA, 2006a, b).

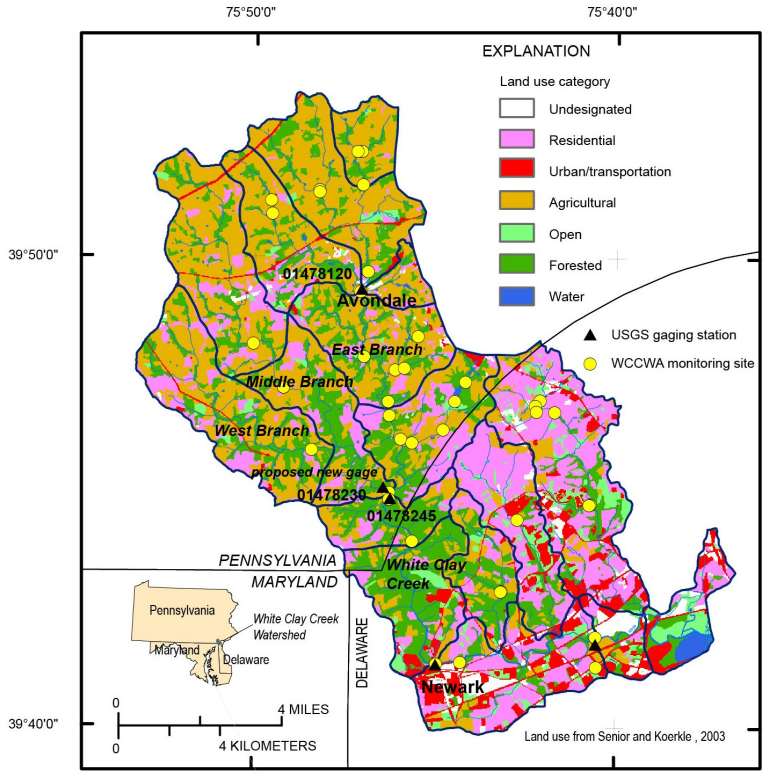

Figure 1. Land use, gaging stations, and bacteria monitoring sites in the White Clay Creek, a National Wild and Scenic River, Pennsylvania and Delaware. Scenic-designated reaches are in forested areas of the watershed that straddle state lines and bog-turtle habitat is in open wetlands near stream channel, often near forested areas. (WCWA, White Clay Watershed Association)

The White Clay Creek National Wild and Scenic River is managed by the White Clay Watershed Association (WCWA) in partnership with the NPS, state and local governments, and other organizations. Improvement in water quality is a shared goal of these partnerships. Ongoing studies to provide information about or assess some of the impairments include near real-time turbidity and associated estimates of suspended sediment concentrations and loads and fecal coliform bacteria concentrations determined from regression relations with discrete samples at one U.S. Geological Survey (USGS) stream gaging location (01478245) on the main stem of White Clay Creek (USGS in cooperation with Chester County); bacteria monitoring and source tracking from grab samples collected throughout the watershed (WCCWA in coordination with local partners), and citizen volunteer monitoring at several locations (including continuous instream monitoring of turbidity, temperature, and stream depth in three tributaries to White Clay Creek) in coordination with WCWA (fig. 1). Estimates of sediment yields from current USGS monitoring (Leif Olson, USGS, written commun., 2018) and past monitoring/modeling efforts (Senior and Koerkle, 2003) indicate that sediment yields at some locations in White Clay Creek Watershed are relatively elevated compared to other monitored or modeled areas in Chester County, Pennsylvania. Available data also indicate that bacteria are associated with elevated turbidity and suspended sediment and tend to be most elevated during the summer and high flows (Senior, 2017; Shane Morgan, WCWA, written commun., 2018).

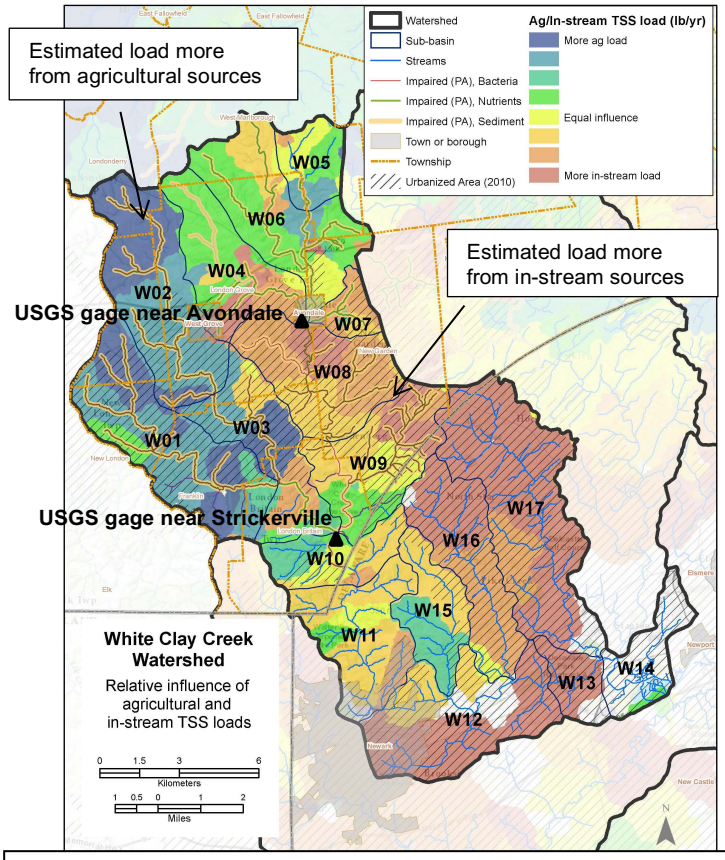

Figure 2. Impaired stream reaches (colored tan for sediment impairment) and USGS gages in Pennsylvania, and estimated sources for total suspended sediment loads determined using Stream Reach Assessment Tool in the White Clay Creek Watershed (The Academy of Natural Sciences, 2017). Shaded areas indicate likely sediment sources ranging from more agricultural, in blue, to more in-stream, in red. (Modified from University of Delaware Water Resources Center, 2016, written commun., 2016)

Possible source areas for sediment impairments within White Clay Creek include eroding soils and stream banks, some of which are likely legacy sediments deposited behind historic (18th and 19th century) mill dams along the stream channel as described by Walker and Merritts (2008). Source areas (land surface or stream channel) for sediment impairment of reaches within the White Clay Creek Watershed have been tentatively identified by use of a model (Stream Reach Assessment Tool or SRAT) that was developed by Delaware River Watershed Initiative partners (The Academy of Natural Sciences, 2017) and estimates total suspended solids (TSS) using land use and other characteristics. The SRAT model indicates that agricultural sources of sediment are likely to predominate in the Middle and West Branches of White Clay Creek whereas a mixture of stream channel or agricultural sources of sediment are likely in reaches of the East Branch of White Clay Creek (fig. 2) (University of Delaware Water Resources Center, written commun. 2016). However, the SRAT model for the White Clay Creek Watershed was not calibrated using data collected within this watershed.

Confidence in the tentative identification of source areas for sediment within the White Clay Creek, and thus in decisions to take management actions to address sediment problems, would be improved with additional information about sediment sources, such as sediment fingerprinting (Gellis and others, 2016) in the watershed.

Agricultural lands, including a substantial number of mushroom farms in Pennsylvania, make up one third of all land uses in the watershed, and therefore are expected to have a large influence on water quality, especially in sediment-impaired reaches. Mushroom Farm Environmental Management Plans that address spent substrate (composted manure) are required by PADEP, yet little is known on how much of the substrate actually washes into the creek. The production, storage, and disposal of mushroom compost and common practices associated with growing mushrooms contribute significant nonpoint source pollutant loading to waterways when not managed carefully, and as mushroom growers switch to phase 2 composting, intensified production will result in an estimated 30 percent increase in spent compost volume just with existing houses (Mike Zuk, Chester County Conservation District, written commun., 2018). Increased volume of spent compost combined with little to no change in the amount of land area available for passive composting, creates a greater threat to water quality in the White Clay Creek in the near future. Thus, there is an urgent need to develop a better understanding of the extent of environmental issues associated with spent substrate so that WCWA, NPS, and partners can better communicate and manage those impacts.

The water, natural resources, and ecosystems in the White Clay Creek watershed contribute an estimated economic value of $55 million to $500 million annually to the Delaware and Pennsylvania economies (Miller, Cruz-Ortiz, 2013; Narvaez and others, 2016). About 130,000 people rely on the White Clay Creek as their drinking water source (Miller, Cruz-Ortiz, 2013), and drinking water purveyors in Delaware embrace source water protection as the most sustainable approach to improving water quality. An estimated 60,000 recreationists visit the White Clay Creek National Wild and Scenic River annually to hike, hunt, fish, bike, swim and view wildlife. High sediment loads smother macro-invertebrate habitat which fish and birds rely on as a prime food source, thus not only affecting healthy aquatic habitat and resiliency, but also negatively impacting recreational opportunities (fishing) in the White Clay Creek. Furthermore, because bacteria is known to be associated with sediment, and bacteria counts in the White Clay Creek regularly exceed federal and state standards, there is a human health component of concern for those engaging in primary and secondary contact with the Creek. Threats to recreational uses, and clean water supply, not only threaten local economies, but also the NPS mission to preserve resources in land that they manage.

Additional information about the suspended sediment (sources and loads) in relation to season and streamflow conditions on the two main branches above the existing main-stem gaging station in Pennsylvania is needed to help determine relative contributions from these parts of the watershed and thus help identify areas to target land-management practices to reduce stream sediment impairments, and also would complement and extend the other ongoing monitoring for suspended sediment, turbidity, and bacteria in the watershed. Current continuous monitoring for streamflow, turbidity and estimated suspended sediment concentrations under a range of hydrologic conditions is limited to one gaging station the main stem (01478245 White Clay Creek near Strickersville, PA; fig. 1). Without information about sediment sources and

suspended sediment concentrations and loads, strategies and actions to reduce sediment impairments within the watershed may be misguided and consequently ineffective.

Proposed Activity

Sediment Loads and Concentrations

Determine sediment concentrations and loads in the two main branches of the White Clay Creek (1, combined West/Middle Branch and 2, East Branch) to quantify relative magnitude of sediment contributions from these parts of the watershed above the existing USGS gaging station on the main stem, 01478245 White Clay Creek near Strickersville, PA (figs. 1 and 2). In the first year, a new gaging station would be installed just above the confluence of West/Middle Branches with the East Branch White Clay Creek and operated for two years to collect continuous data on streamflow and turbidity, with additional automated collection of suspended sediment samples, concurrent with ongoing similar data collection at the main-stem gaging station. The location of the new gaging station for the combined West/Middle Branches (01478230 Middle Branch White Clay Creek; fig. 1) is the site of a wire-weight gage operated by USGS 1989-2006 (and thus where a streamflow rating may be still applicable) and other data collection efforts, including long-term USGS annual stream quality and biological monitoring and current bacteria sampling by WCWA and partners. If technically feasible, continuous turbidity and automated collection of suspended sediment samples also would be added to the existing gaging station 01478120 on the East Branch White Clay Creek near Avondale (fig. 1). Regression relations will be developed between turbidity and suspended sediment concentrations in discrete samples collected during two years to determine instantaneous sediment concentrations and daily and annual sediment concentrations and loads at the new (USGS station 0148230) and existing (USGS station 01478245) gaging stations under a range of hydrologic conditions as has been done by USGS at the existing station 2015-present and at other sites in Chester County, Pennsylvania (Sloto and Olson, 2011). Differences between the sediments loads at the new West/Middle Branch (25.5 mi^2 drainage area) and existing main-stem (59.2 mi^2 drainage area) gaging stations will allow determination of contributions from the two main branches of the White Clay Creek during the study period, with difference representing contributions from the East Branch (draining about 33.7 mi^2). Data from the station 01478120 near Avondale (11.2 mi^2 drainage area) would be used to quantify sediment contributions from upper and lower areas within the East Branch White Clay Creek.

Sediment source identification

Additional characterization of sediment source areas (land surface, stream bank, or stream channel) is proposed through sediment fingerprinting as described by Gellis and others (2015). Differences in geology, soils, and land uses among the Branches of White Clay Creek are likely, but not known, to have chemical differences sufficient for the purposes of distinguishing sediment source areas. Sediment samples will be collected by USGS personnel in partnership with the WCWA from soils in various land uses, from eroding stream banks, and from selected locations in the stream channel in the West, Middle, and East Branches of White Clay Creek in Pennsylvania and analyzed for a suite of constituents including trace elements, carbon and carbon isotopes (to help identify mushroom soils), and other possible tracers to be determined after review of available data to develop characterization of source areas. Suspended sediment samples collected at automated samplers at the two (or three if possible) gaging stations will also be analyzed for this suite of constituents. Statistical analyses of these data to develop sediment fingerprints will be done using a tool developed by Gorman and others (2017).

Expected Outcome

Quantification of sediment concentrations and loads in the two main branches of the White Clay Creek (combined West/Middle Branch and East Branch) will provide information to determine relative magnitude of sediment contributions from these parts of the watershed above the existing USGS gaging site on main stem and, thus, aid in targeting management efforts in the various branches of the Creek to improve water quality. Identification of sediment sources through sediment fingerprinting will provide information to identify surface or stream banks as sources and thus also further aid in targeting management efforts in the watershed. Better land management practices will help mitigate threats to the natural resources and local economies. Perhaps equally important, the information gathered from this study will allow for improved data-driven communication between watershed managers, NPS and partners, farmers, elected officials, regulators, and the public on water quality issues and best management practices specific to the issues affecting the White Clay, and ideally broaden public awareness, acceptance, and adoption of best management practices to protect both the environment and the citizens who rely on those ecosystem services. Results of the sediment loads and fingerprinting study will be summarized in a USGS report, and also provided to the public, NPS, and watershed partners through at least one presentation. Near-real time continuous turbidity and streamflow data collected at the USGS gaging stations and associated calculated sediment loads will be available online. All data collected by the USGS will be entered into the USGS National Water Information System (NWIS) databases and be publically available.

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