Red **C**lay **C**reek **A**ction **P**lan
(RCCAP)

Report by Group 6:
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Mission statement:

RRCAP's mission is to identify various pollutants affecting the Red Clay Creek Watershed in both DE and PA and provide recommendations for reducing these pollutants by at least 30% by 2040 in order to maintain a safe, healthy watershed with suitable drinking water for its 50,000+ inhabitants.

Background:

The Red Clay Creek Watershed is a small but important watershed, spanning approximately 54 sq. miles across Chester County, Pennsylvania and New Castle County, Delaware (Figure 1). Due to its size, the RCCW is mainly governed at a local level (county or below) though, of course, broader federal and state policies do apply such as with TMDLs. In total, there are about 102 miles of streams, with 61 miles consisting of headwater streams. As of 2015, land use is fairly evenly divided among three categories; agriculture at 39%, forest/wetland at 33%, and urban/suburban development at 27%. Per 2001 data, the percentage of agriculture has continuously increased over the last two decades (Figure 2) (Brandywine Red Clay Alliance, 2022).

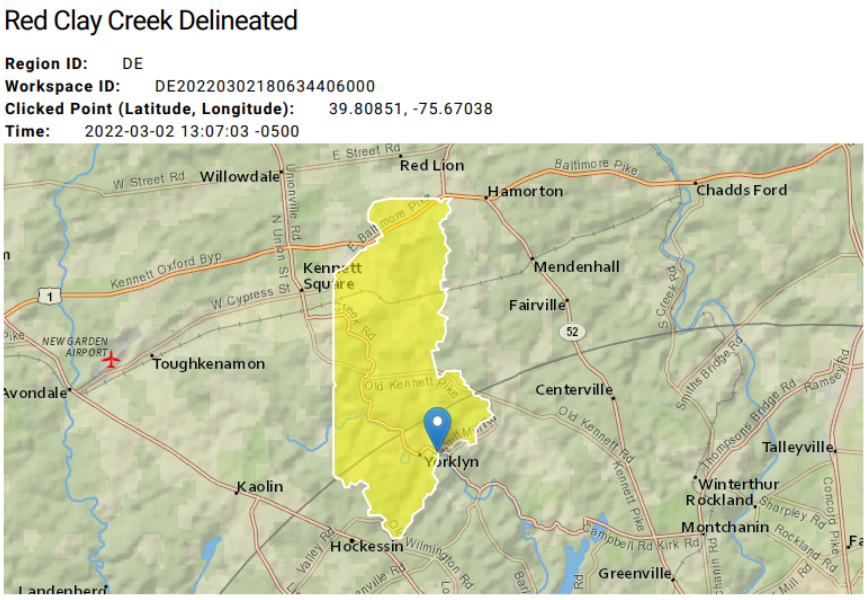

Figure 1. Delineation of the Red Clay Creek Watershed by the StreamStats software.

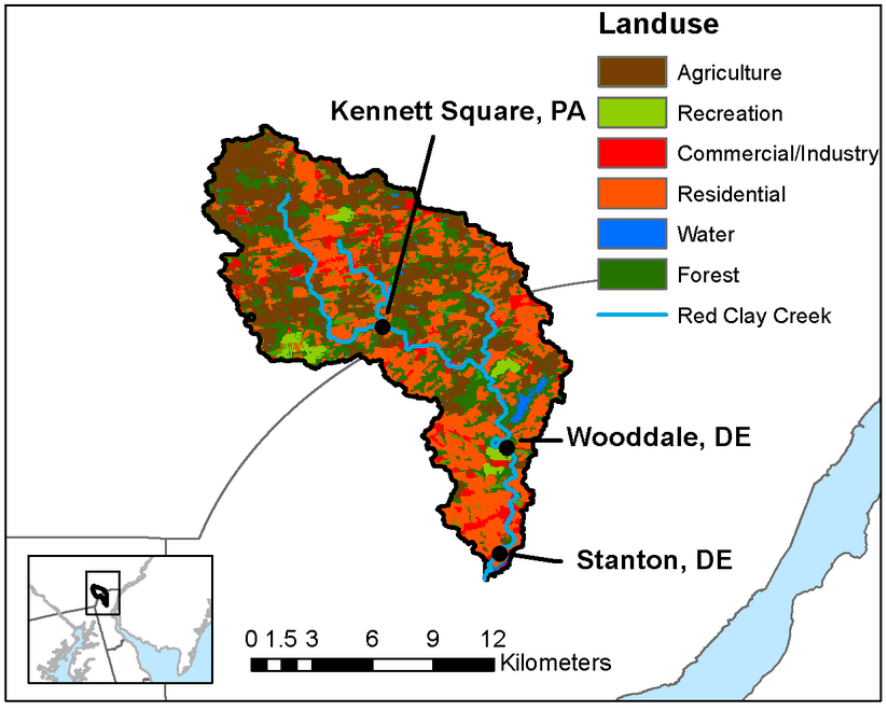

Figure 2. Land use in the Red Clay Creek Watershed from the USGS 2001 survey. Adapted from Baum 2012.

According to a 2013 report, this watershed contributes between $9.8 to $19.7 billion to the economies in both Pennsylvania and Delaware (Cruz-Ortiz 2013). This impressive amount is sourced from the economic value of the watershed resources and habitats, the value of goods and services provided by these ecosystems, and employment related to these resources and habitats. In total, the Red Clay Creek Watershed both directly and indirectly supports over 11,000 jobs and over $30.4 million in annual wages. Additionally, its 43 million gallons per day water flow provides an essential source of drinking water for nearly 50 thousand residents (and rising).

The Red Clay Creek Watershed is one of four watersheds in the 565 sq. mile Christina River Basin, which in turn is part of the much larger (13,000 sq. mile) Delaware River Basin. As such, the Red Clay Creek directly flows into the Christina River, eventually reaching the Delaware River and finally, the Atlantic Ocean. Thus, any harmful pollutants deposited into the Red Clay Creek Watershed would subsequently affect the entire Delaware River Basin, emphasizing the importance of ensuring a healthy watershed.

History:

The earliest known name of what is currently referred to as the Red Clay Creek is Hwiskakimensi Sippus (Lenape name meaning “young tree stream”), described as a creek headed in Pennsylvania which flows southeast to White Clay Creek per Lidestrom’s Map (1654-1655) (Water Resources Center 2021). The Red Clay Creek has also been referred to as Rodlers Creek.

The Red Clay Creek Watershed has an extensive industrial history, being the home of many different mill sites, including those producing vulcanized fiber, flour, wool, iron, and more. Per both its natural resources and role in history, some of the land inside the RCCW is protected. For example, Auburn Valley State Park (formally Auburn Heights Preserve), founded in 2018, contains much of the land previously owned by National Vulcanized Fiber. NVF's mill sites along the Red Clay Creek significantly contaminated the water with zinc chloride (commonly used in the paper-making process) as well as other industrial pollutants. As of 2009, the TMDL for zinc in the Red Clay Creek was designated to be 55.93 pounds each day (State of Delaware 2009). Additionally, the Wilmington and Western Railroad once serviced this area, transporting goods to and from these mill sites and the port of Wilmington. The area has since moved from industry to agriculture with a significant increase in mushroom farming due to its proximity to Kennett Square, the self-stated mushroom capital of the world.

Despite its small size, the RCCW has attracted attention from local conservation groups, including the Brandywine Red Clay Alliance. This environmental education organization promotes both restoration and conservation of both the Brandywine and Red Clay watersheds (Brandywine Red Clay Alliance 2022). In addition to Auburn Valley State Park, the Delaware Nature Society also encourages community engagement with the RCCW.

Table 1: Problems statement

Problem	**Description**	**Cause**
Problem 1: Industrial Pollutants	A long and careless industrial history has left the RCCW with long-standing industrial contaminant issues, notably a large amount of zinc chloride	Historically, many industrial by-products were incorrectly disposed of and typically have a long half-life, leading to prolonged pollution
Problem 2: Fertilizer Runoff/Eutrophication	The gradual transition from industry to agriculture has increased the amount of fertilizer runoff entering streams in the RCCW	Significant levels of agricultural activity or fertilizer use leads to more nitrogen and phosphorus in waterways, oftentimes resulting in eutrophication

Problem 3: Impervious cover/Stormwater runoff/Flooding	A rapidly growing population in the RCCW has increased the amount of impervious cover	As the amount of impervious cover in a watershed grows, stream water flow is impeded, water quality decreases, and flooding increases

Problem 1: Industrial Contaminants

The Red Clay Creek has historically faced some significant issues related to industrial contaminants. The industrial processes at the various historical mill sites, including those owned by National Vulcanized Fiber (NVF), created high levels of harmful pollutants like zinc chloride, lead, PCBs, dioxins, and chlorinated pesticides (Baker et al. 2017). Though not particularly harmful to humans, zinc chloride is detrimental to the ecosystem, adversely affecting many organisms including macroinvertebrates. Though the initial effects on the environment were very harmful, cleanup efforts have been very successful; in 2008, DNREC began the process of pumping up groundwater and removing contaminants, removing more than 75,000 pounds of zinc chloride from the groundwater, along with an additional 277,000 pounds of contaminated soil. Efforts to remove the other aforementioned contaminants are not as well-documented. These other contaminants pose health risks for both humans and animals alike, threatening the drinking water quality for both the residents in the RCCW and in the Delaware River Basin as a whole. Further data collection is necessary to determine the magnitude of contamination at present. However, it can generally be assumed that this issue has not been completely resolved, requiring further action to ensure full watershed recovery.

Goal 1:

Our first goal is to ensure that lingering industrial pollutants including zinc chloride are successfully removed from the Red Clay Creek Watershed while limiting effects on the surrounding environment. We aim to meet the TMDLs set by both the Commonwealth of Pennsylvania and the State of Delaware and/or provide recommendations for revisions where necessary given updated water quality parameters.

Problem 2: Fertilizer Runoff/Eutrophication

More modern pollutants such as fertilizer runoffs have caused the Red Clay Creek Watershed to decline in quality. Agriculture (especially mushroom farms) is prominent in surrounding lands, leading to excessive amounts of nitrogen and phosphorus. Per the State of Delaware, the target level for nitrogen levels falls between 1.0-3.0 mg/L; in a 2007 State of the Watershed report by the Delaware Nature Society, only 20-29% of collection sites in 2007 fell below 3.0 mg/L (Delaware Nature Society 2017). Though outdated, an upwards trend in agricultural activity

raises concerns about current nitrogen and phosphorus levels. These excess nutrients can lead to eutrophication and a subsequent decrease in DO and generally poorer water quality. This same 2007 report indicated concern for pre-dawn DO levels that could potentially prove deadly to aquatic organisms. Monitoring of present watershed conditions is necessary to identify sources of pollution and mitigate damage to the surrounding ecosystem.

Goal 2:

Our second goal is to locate sources of significant fertilizing run-off by conducting fieldwork to determine levels of nitrogen and phosphorus in streams within the Red Clay Creek Watershed. We will then create guidelines to ensure that this nutrient load is reduced, which may include educating farmers and encouraging them to alter/improve fertilization tactics, working to reduce fertilizers used on lawns in the area, and more.

Problem 3: Impervious cover/Stormwater runoff/Flooding

Per its population of 50,000 and growing, the lands both in and surrounding the Red Clay Creek Watershed have been or likely will be developed in the future, causing there to be a large amount of impervious cover. Impervious cover is any type of artificial surface that cannot adequately absorb water such as asphalt, concrete, and even compacted soil. By preventing the collection of rainfall as groundwater, these structures impede stream flow by decreasing the amount of water they receive. Stormwater runoff increases dramatically with the presence of impervious cover, unequally distributing polluted water into nearby streams and rivers. Flooding is specifically prevalent in flatter regions; much of the RCCW falls into this category per its location on a coastal plain (Figure 3). As such, impervious cover upsets the balance of a healthy watershed. If the amount of impervious cover in a watershed exceeds 10%, the overall health of the region will experience a decline. As of 2015, impervious cover in the Red Clay Creek Watershed was about 13%; this number is likely higher now (estimated to be 14% by 2020). If the cover reaches 60% or greater, the water quality will be significantly compromised to the extent where the damage may not be easily reversible.

Goal 3:

Our last goal is to reduce the amount of impervious cover and mitigate stormwater runoff in the RCCW. We will create recommendations that encourage alternatives to impervious cover for both existing and future structures and improve existing stormwater drainage systems.

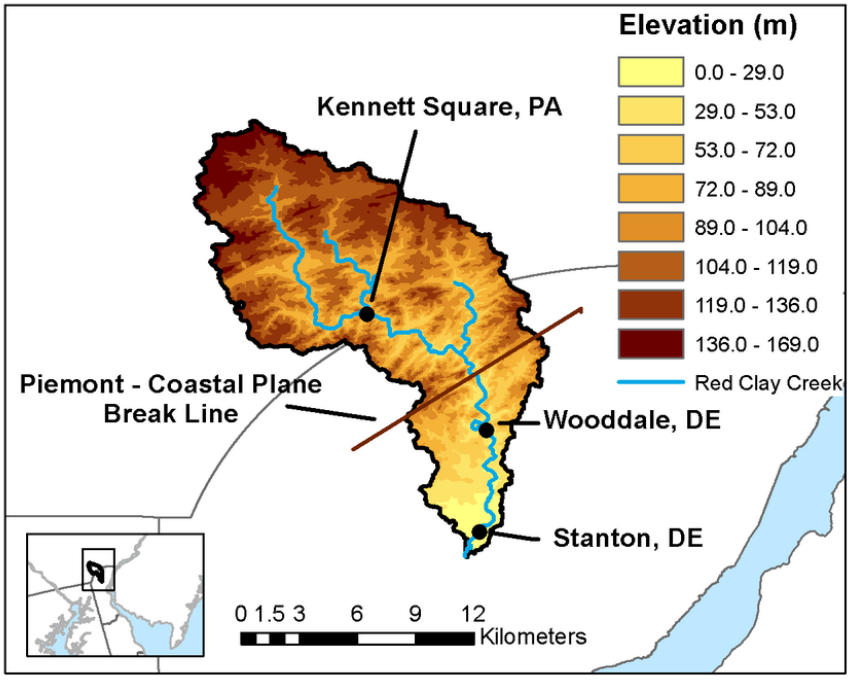

Figure 3. Elevation of the watershed above mean sea level in the Red Clay Creek Watershed. Adapted from Baum 2012.

Recommendations:

Problem #1:

For the issue of industrial contaminants, we first and foremost recommend more data collection in both the Red Clay Creek and other streams contained in the RCCW. We found that most of the data we referenced was severely outdated--some by 17+ years. As such, we also recommend a reviewal and possible revision of the set TMDLs for the various pollutants prior to any further action. The removal of zinc chloride by DNREC has been regarded as largely successful, but little has been recorded in references to the other contaminants. We recommend monitoring of water conditions to ensure further action is necessary.

Problem #2

For the issue of the increased nutrient load, we again recommend more data collection and stream monitoring. Further research will help to identify both point and nonpoint sources of pollution, which we can then develop individualized management plans for. Under the assumption that nutrient loading is occurring and is damaging to the ecosystem, we generally recommend bolstering protection of stream corridors through riparian buffers and stream

fencing. We also encourage mushroom farmers to file a Mushroom Farm Environmental Management Plan that will empower farmers to manage groundwater pollution. Implementing further voluntary and mandatory educational programs/certifications such as PA's Nutrient Management Plan will also help farmers make informed decisions about their agricultural practices (Chester County Water Resources et al. 2002). We further recommend that better manure management practices be put in place to prevent further contamination.

Problem #3

As aforementioned, further data collection is necessary to move ahead with planning management strategies. Generally, however, we recommend renovation of stormwater drainage systems to possibly include infiltration and water quality treatment. We also advise that these drainage systems be cleaned out periodically to eliminate the worst of the debris and prevent clogs. We further recommend establishment of riparian buffers, stream corridors, and stream fencing. We advise that impervious cover be eliminated wherever possible, and pervious alternatives used, including but not limited to mulch, gravel, and pervious concrete.

Conclusion:

The Red Clay Creek Watershed is a small but impactful subwatershed, with a growing population of 50,000 people and direct influence over the much larger Delaware River Basin. Our recommendations for management of the RCCW are limited without current data to reference. Most data referenced is at least several years out of date; further collection is necessary to provide a more comprehensive management plan. Although we believe our mission to reduce all three categories of pollution by 30% by 2040 is feasible, this goal may be adjusted given updated data. Management may be difficult across state borders. Collaborating with local environmental groups such as the Brandywine Red Clay Alliance may be the most efficient way of gathering data and communicating findings. Our recommendations are limited by the lack of data but still may prove useful to inform future management decisions.

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