Action for Red Clay Creek (ARCC)

A Comprehensive Watershed Management Plan

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Mission Statement

The goals of the Action for Red Clay Creek plan (ARCC) are: to attain the acceptable levels of TMDLs, to improve water quality such that each water body is removed from the EPA 303d list of impaired streams, and to reduce flooding in the Red Clay Creek watershed by the year 2030.

Background

Red Clay Creek is a 54 square mile watershed that is part of the Christina River Basin (Figure 1), which is a subbasin of the Delaware River Basin. It is split between southern Chester County (PA) and northern New Castle County (DE) and is a large source of drinking water for these areas via streams and wells. The Red Clay Creek watershed is also home to the Hoopes Reservoir, which can store up to 2,000 million gallons of drinking water [1]. The total population for the watershed is over 47,000 and has been increasing historically. Land use is split almost evenly between agriculture, urban/suburban, and wetland with approximately 17% as impervious cover [1]. Red Clay also contains cold water fish habitats and sites of historic structures, districts, and landmarks [2].

Figure 1: Christina Basin

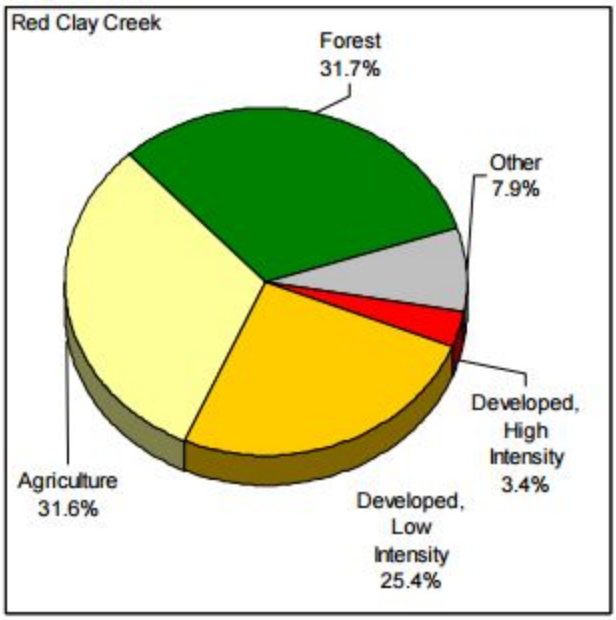

Figure 2. 2001 Land use in the Delaware portion of the Red Clay Creek watershed [1]

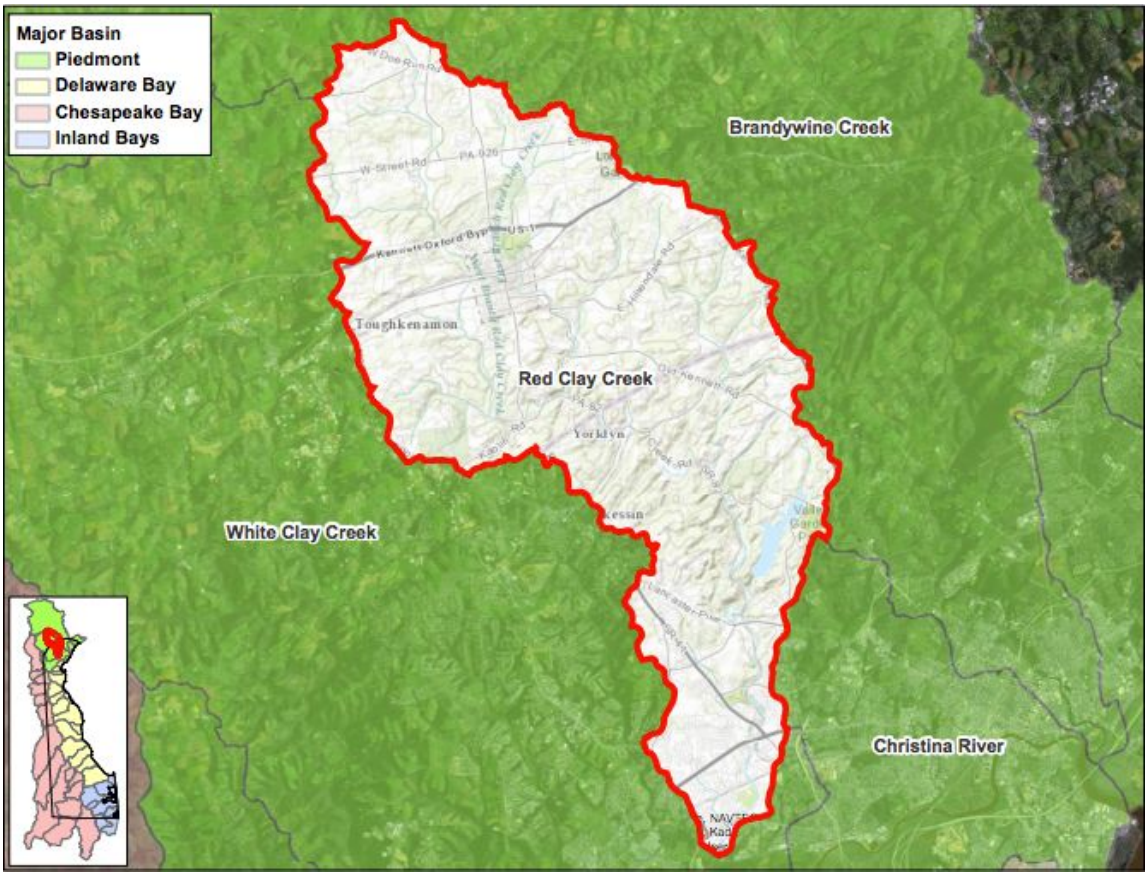

Figure 3: Red Clay Creek Watershed Location and Delineation

History

In 1992, the Delaware portion of the Red Clay Creek consisted primarily of forest, followed by low intensity development and agricultural land [1]. In 2001, agricultural land use increased by approximately 68% and forested land decreased by approximately 40% (Figure 2). Much of this agricultural land is used for mushroom farming. There was also a 14% increase in low intensity, developed land (Figure 2). Agriculture is a likely source of nutrient runoff when farmers over-fertilize their fields. Forests are effective buffers and can aid in reducing runoff. The increase in agricultural land and simultaneous decrease in forested land suggests a potential reason for the high nutrient loading in the Red Clay Creek.

From 1990 to 2000, the percent of impervious cover in the Red Clay Creek watershed increased 1% every 5 years [1]. Urbanization of the watershed can contribute to more runoff, flooding, and contaminant transport to local waterways. From 1970 to 2000, the population increased by approximately 8,800 people [1]. This trend is consistent with the historical increase in impervious cover. In 2004, a flood in northern Delaware made 149 of 159 homes in the community of Glenville uninhabitable [1]. Historical data suggests that flooding must be considered when creating management strategies for the Red Clay Creek watershed.

Problems

91% of Red Clay's total stream miles are listed as impaired on the EPA 303d list. ARCC identifies three major problems faced in the Red Clay Creek watershed and develops goals to fix these needs:

Table 1: Description and Causes of Problems

Problem	**Description**	**Causes**
1. Contaminants	PCBs, dioxins, and chlorinated pesticides exceed recommended levels. These contaminants are toxic to wildlife, humans, and general water quality.	Point source pollution. Stormwater runoff from industrial land. Agricultural lands using chlorinated pesticides.
2. Nutrients	Total phosphorus concentrations are higher than the EPA standard. Increasing nitrogen levels are contributing to a decline in water quality. Zinc concentrations exceed recommended levels.	Fertilizer running off from agricultural lands (mostly including pastures and mushroom farms), silviculture, and lawns.
3. Stormwater Runoff and Flooding	As rates of development continuously increase, the amount of flooding and stream destruction are also increasing.	Rapid urbanization increases impermeable surfaces. The soil cannot handle runoff from agricultural lands, roads, paved areas, etc.

Problem 1: Presence of Contaminants

The presence of contaminants within the Red Clay Creek has resulted in fish consumption advisories. Specifically polychlorinated benzenes (PCBs), dioxin, and chlorinated pesticides. These contaminants as well as other metals are toxic to humans and wildlife. More specifically, these contaminants bioaccumulate in the fatty tissues of animals. The PCB concentration is Red Clay Creek watershed was estimated to be 0.011µg/l, which exceeds the water quality criterion of 0.00004 by 99.9%.

Problem 2: Excess Nutrient Loading

The dissolved oxygen concentration in the Red Clay Creek has been consistently decreasing over the past 15 to 26 years. This trend indicates nutrient loading is impacting the surface water quality, as nutrient buildups ultimately suffocate oxygen and lead to eutrophication. The total phosphorus concentration was found to exceed the EPA limit of 0.1 mg/L more than 90% of the time along the of the Red Clay Creek [8]. Nitrogen to Phosphorus ratios along the creek indicate that Phosphorus is likely the limiting nutrient. In addition to Nitrogen and Phosphorus, Zinc concentrations frequently exceed EPA water quality criteria. Zinc levels exceed the chronic and acute state water quality levels 85% of the time in the Red Clay Creek [8]. Historical data suggests a slight decline in total phosphorus and zinc and an increase in nitrate-nitrogen over time. However, updated data must be collected and analyzed to determine if these trends have continued over the last 20 years.

Table 2: Nutrient Concentrations and Trends

Nutrient of Concern	Concentration	Historical Trend
Zinc	Exceeds chronic and acute state water quality levels 85% of the time	Decreasing
Phosphorus	Exceeds EPA water quality levels 90% of the time	Decreasing
Nitrogen	Does not exceed standards	Increasing

Problem 3:Stormwater Runoff and Flooding

The rapid development within the Christina River Basin has resulted in an increased percentage of impervious area. Approximately 17% of the river basin is classified as impervious, which debilitates the ability of soils and vegetation to absorb runoff. Increasing impervious cover has increased the amount of runoff and resulted in 93 miles of the stream in this watershed not meeting its designated water use.

Goals

Goal 1: Reduce Presence of Contaminants
First, identifying sources and reducing the input of contaminants to meet fishable water quality standards is necessary. To do this, we must locate both point and nonpoint sources of pollution by performing field tests and GIS analyses. Local, state, and federal regulations will be needed to reduce the input of contaminants from these sources. Taking the proper steps to reduce the presence of multiple contaminants will make it safer for the public to use the Red Clay Creek as a recreational fishing location.

Goal 2: Reduce Nutrient Loading
The second goal is to decrease the concentrations of Nitrogen, Phosphorus, and Zinc in the Red Clay Creek by targeting sources of high nutrient runoff and determining reduction strategies. These strategies will likely include better management of stormwater runoff and educating the public on the negative impacts of nutrient loading and eutrophication. Educating the local community could potentially encourage the reduction of lawn fertilization, which contributes to nutrient loading in nearby waterways. Furthermore, all farmers and ranchers with high nutrient runoff should participate in best management solutions.

Goal 3: Reduce Stormwater Runoff and Flooding
To decrease the amount of stormwater runoff and resulting flooding and encourage better municipal stormwater management and planning, we hope to balance the expansion of impervious surfaces with sufficient stormwater management practices. These will encourage recharge of rainwater into the soil and groundwater rather than runoff and eventual flooding. It is also important to educate the public on ways that they can promote stormwater infiltration on their own private properties.

Existing Organizations

Brandywine Red Clay Alliance
Founded recently in 2015, this is a local organization that helps educate students about the environment and organize hands-on volunteer programs. Their education and service programs, such as the Environmental Stream Teams as part of the Red Streams Blue Program, help to curb pollution in the Red Clay watershed and improve water quality. More information can be found at http://www.brandywineredclay.org/.

Christina Basin Clean Water Partnership (CBCWP)
The goals of the CBCWP align with our own: to attain fishable, swimmable, and potable statuses for the Red Clay Creek. It also focuses on the three other watersheds within the Christina River Basin. Valued at $270 million per year, the Christina Basin receives financial help from innovative watershed financing such as fees, surcharges, and funding all through the CBCWP. The CBCWP also has watershed governance initiatives that provide stakeholder progress reports, increase education and outreach, create restoration plans, and join relevant municipalities across Delaware and Pennsylvania. Partners span from the local to the national level, so there are multitudes of opportunities. More information can be found at http://www.wra.udel.edu/public-service/watershedmanagement/christinabasinpartnership/.

Delaware River Basin Commission
Signed into existence in 1961 by President Kennedy, the Delaware River Basin Commission joins Delaware, Pennsylvania, New York, and New Jersey to conserve and improve the watersheds within the Delaware River Basin. This includes the Red Clay Creek Watershed, which ultimately flows into the Delaware River. The Delaware River Basin Commission has programs spanning all areas of concern, including water supply, pollution control, flood protection, watershed management, regulations, and intergovernmental relations. More information can be found at http://www.state.nj.us/drbc/.

United States Environmental Protection Agency (EPA)
While it is a national agency, the EPA is crucial in aiding local watersheds and improving water quality by establishing TMDLs and other water regulations, obtaining data, and providing many grants. By following the EPA guidelines and regulations and applying for grants, the Red Clay Creek can improve stormwater management, nutrient loads, habitat, pollutant levels, etc. More information can be found at www.epa.gov.

Existing Regulations/Ordinances

Cristina Basin TMDL Implementation Partnership (CTIP) Plan
The Christina Basin TMDL Implementation Partnership initially formed in 2010 after municipalities recognized that working together to meet the TMDL, NPDES, and MS4 requirements would will allow for decreased costs and greater water quality improvements. These requirements affected the entire watershed, so working together as a watershed community rather than individual municipalities is more efficient [3]. The CTIP Plan was created by the group of 32 municipalities now part of CTIP in order to lay out a strategic plan to implement these requirements and necessary changes to the watershed. The CTIP plan fills the

gaps in the current stormwater management policies and identifies watershed stakeholders and their roles. The final plan includes implementation components for municipal activities, agricultural activities, and watershed conservation stakeholder activities [3].

Total Maximum Daily Load (TMDL)

Under the Clean Water Act it is required that a total maximum daily load (TMDL) be developed for any water body which has been identified as impaired based on its inability to meet the water quality standards. The TMDL determines the allowable amount of loading of a pollutant from point and nonpoint sources, including a margin of safety, in order to meet water quality standards [4]. TMDLs have been created for the Christina Basin, which the Red Clay Creek is part of, based on the data collected from the identified impaired streams by PADEP and DNREC. The TMDLs were specifically created for total nitrogen, total phosphorus, and sediment [4].

National Pollutant Discharge Elimination System (NPDES)

The National Pollutant Discharge Elimination System (NPDES) was created in 1972 by the Federal Pollution Control Act in order to control discharges from point sources into waters of the United States. The goal of the NPDES permits are to ensure that discharges do not affect human health or cause exceedances of the federal water quality standards [5]. The NPDES permits include discharge limits, monitoring, and reporting requirements.The discharge permits in the Red Clay Creek watershed are managed by the Environmental Protection Agency Region 3. Agriculture and stormwater discharges both require permits under this program, which are some of the major factors affecting water quality in the Red Clay Creek [5].

Stormwater Management Act (PA Act 167)

Pennsylvania passed the Stormwater Management Act (PA Act 167) in 1978 in response to inadequate management of accelerated stormwater runoff as a result of increasing development and impervious area within the watershed. This inadequate management resulted in numerous problems including increased flood flows, erosion, sedimentation, increased costs to control stormwater, and reduction of groundwater recharge. Act 167 requires that within 2 years each county create and adopt a comprehensive stormwater management program for each watershed within the county. The goal of the act was to preserve and restore the watershed from the problems associated with increased runoff [6]. In order to ensure the plan is effective, the act also calls for the plan to be reviewed and revised every 5 years. All watershed stormwater management plans are required to include certain elements, some of which include a survey of runoff and watershed characteristics, a review of existing and proposed stormwater collection systems, identification of flood plains, and designated areas to serve as stormwater collection and control facilities within the next 10 years [6].

Management Strategies

Contaminant Pollution

Riparian Buffers: Riparian buffers will provide a vegetative barrier to nutrient and contaminants in runoff coming from nearby industrial and agricultural land. These buffers also reduce the severity of floods, which will help to deal with the issue of flooding in this area as well. Currently, a riparian buffer exists along a 0.75 mile portion of the Red Clay Creek watershed. Trees were planted inside plastic tubes in this area to allow establish a forested buffer that would be protected from White-tailed Deer, Eastern Cottontails, and other animals. Increasing the usage of riparian buffers to cover a larger portion of the watershed would decrease the amount of contaminant and nutrient pollution entering the stream as well as decrease flooding in the area.

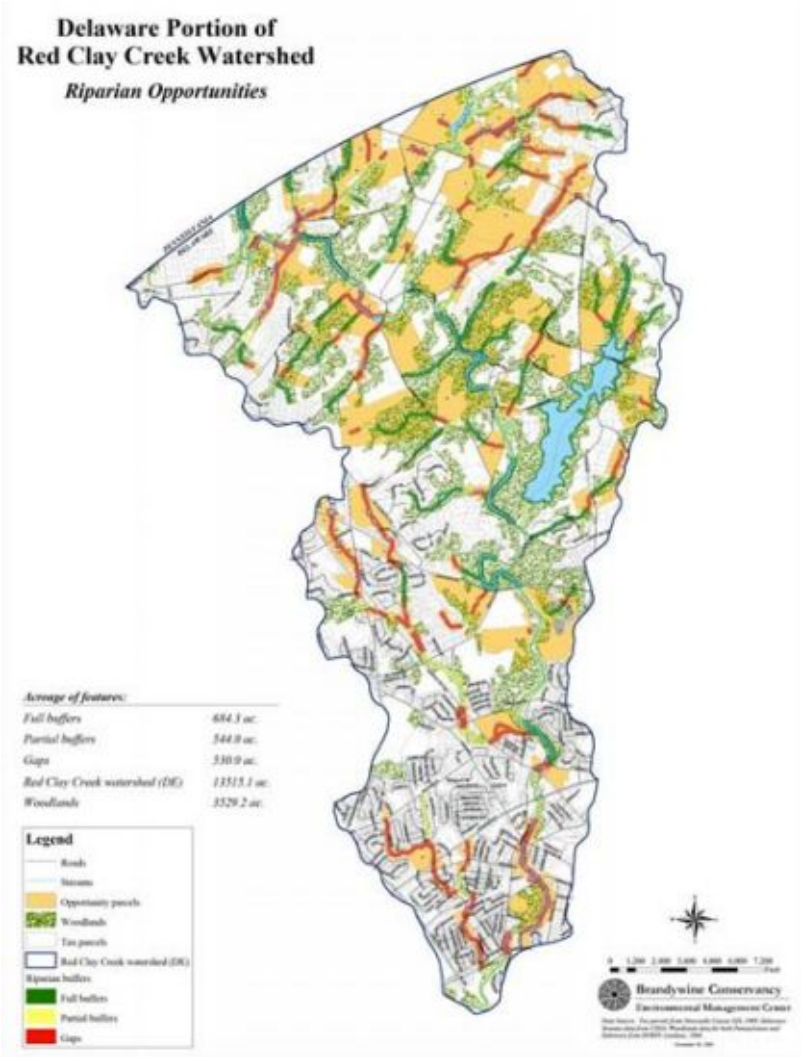

Figure 4: Riparian Buffer Opportunities in Red Clay Creek, Delaware [1]

Nutrient Pollution

Precision Farming: Precision farming is a process that only applies fertilizer to the plants that need it. This technology uses sensors to collect data on the health of the soil and crops in order to determine which individual crops require additional fertilizer. By limiting the application of fertilizers to only plants that require the additional nutrients, excess nutrient loading in runoff from agricultural lands will be decreased. Reducing the amount of fertilizer that farmers need to apply to their crops will also save farmers money, which may be a helpful incentive to convince them to adopt this new process.

Cover Crops: Cover crops are planted after the fall harvest and remain throughout the winter. These crops will absorb some of the excess nutrients from the soil as well as help stabilize the soil. This will result in decreased nutrients in runoff from the nearby agricultural lands. As with precision farming, it will be necessary to educate the farmers on this technique and convince them to participate. In New Castle County, a Cost-Share Program exists to help farmers pay for 30%-75% of the costs of implementing cover crops and other best management practices [7]. Chester County should be encouraged to follow suit.

Table 3: Winter Cover Crop Program in New Castle County, DE [7]

CROP	PLANTING DATE	SEEDING RATE (includes broadcast with disk or cultipack)	SEEDING RATE (aerial or broadcast with no incorporation) **
Annual Ryegrass	9/1 – 10/31	20 lbs/ac	26 lbs/ac
Cereal Rye	9/1 – 10/31	112 lbs/ac	146 lbs/ac
Wheat ***	9/1 – 10/31	120 lbs/ac	156 lbs/ac
Triticale	9/1 – 10/31	105 lbs/ac	137 lbs/ac
Spring Oats	9/1 – 10/15	95 lbs/ac	124 lbs/ac
Barley	9/1 – 10/31	120 lbs/ac	156 lbs/ac
Forage Radish ****	9/1 – 9/15	10 lbs/ac	13 lbs/ac
Forage Radish & Spring Oats ****	9/1 – 9/15	2 lbs/ac forage radish 52 lbs spring oats	3 lbs/ac forage radish 68 lbs spring oats
Crimson Clover & Cereal Rye	9/1 – 10/15	10 lbs/ac clover 40 lbs/ac rye	13 lbs/ac clover 52 lbs/ac rye
Hairy Vetch & Cereal Rye	9/1 – 10/15	18lbs/ac vetch 40 lbs/ac rye	24 lbs/ac vetch 52 lbs/ac rye

Stormwater Runoff and Flooding

Bioretention Areas: Bioretention areas are shallow depressions that allow runoff to pool, after which it is filtered through the soil and vegetation. They promote infiltration into the soil and as a result effectively reduce the amount of runoff that enters nearby waterways. This will help to reduce the amount of flooding in the Red Clay Creek watershed, as well as filter out some of the excess nutrients present in the runoff

Constructed Wetlands: Constructed wetlands mimic natural wetlands. The addition of constructed wetlands will increase the capture and filtration of stormwater runoff. Water will be captured and contained as either standing water on the surface of the wetland or saturated water just below the soil surface. Capturing and filtering this runoff will reduce overall runoff as well as reduce the nutrient loading.

Conclusions & Recommendations

The Action for Red Clay Creek (ARCC) outlines the plan for addressing the major issues currently facing the Red Clay Creek watershed. The major issues include the presence of contaminants in waterways, excess nutrient loading, and stormwater runoff and flooding. Each of these issues calls for innovative management strategies. Following the tentative schedule laid out in Table 5, the strategies outlined in the report will be further evaluated and implemented within the watershed by 2030.

The Christina Basin TMDL Partnership Plan, NPDES, TMDLs and Stormwater Management Act have established the basis for regulation of pollution and stormwater runoff within the watershed. However, it is suggested that additional enforcement and education is needed to make these regulations and plans more effective in the improvement of water quality within the Red Clay Watershed. These regulations will require efforts and cooperation from the municipalities, existing agencies, citizens, and other stakeholders within the watershed in order to accomplish the goals laid out in ARCC. The existing organizations and programs including the U.S. EPA, Delaware River Basin Commission, and Christina Basin Clean Water Partnership can serve as the leaders in implementing the suggested solutions.

In order to create programs and implement the solutions outlined in ARCC, we must find financing. We can start at the local level with the six municipalities of the Red Clay Creek, including five townships in PA and New Castle County, DE. Table 4 shows possible percentages for financial mandates in the form of fees, surcharges, or taxes for each municipality based on different variables. Another option is to ask each municipality for grants, a budget portion, or to simply create a watershed team. Other funding can be found through pre-existing organizations, especially the extensive EPA grant system that focuses on impaired streams. Finally, ARCC plans to advertise locally for additional donations and volunteers.

Table 4: Possible % Financial Contributions of Red Clay Creek Municipalities

Municipality	MS4 Separate Sewer	Sediment Allocation	Nitrogen Allocation	Phosphorus Allocation	Percent Urban	Percent Agriculture	Percent Urban + Agriculture
Pennsbury Twp	0.9%		1.3%	0.6%	1.4%	0.6%	1.0%
Kennett Square Boro	2.0%	4.0%	2.3%	1.2%	4.1%	1.3%	2.6%
New Garden Twp	10.5%	21.1%	12.4%	17.1%	5.4%	18.4%	12.2%
East Marlborough Twp	20.8%	41.8%	22.1%	8.2%	13.1%	34.7%	24.5%
Kennett Twp	26.0%	33.0%	31.9%	21.8%	22.4%	28.9%	25.8%
New Castle Co, Del.	39.8%		30.0%	50.0%	53.5%	16.2%	33.9%

Table 5: Tentative Schedule

Tentative Deadline	**Action(s) to be completed**
December 31st, 2017	Compile list of necessary sources, contacts, regulations, and standards Begin compiling data
December 31st, 2020	Identify, locate, and assess all point and nonpoint pollution sources and stormwater management systems Identify other areas of highest concern
December 31st, 2025	Have all programs in place to meet ultimate requirements Reverse increasing nitrogen trends Have at least half of streams removed from EPA 303d list of impaired streams Reduce flooding by 25%
December 31st, 2030	Attain proper concentrations for TMDLs Reduce flooding by 50% Have each water body removed from EPA 303d list of impaired streams

Works Cited

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