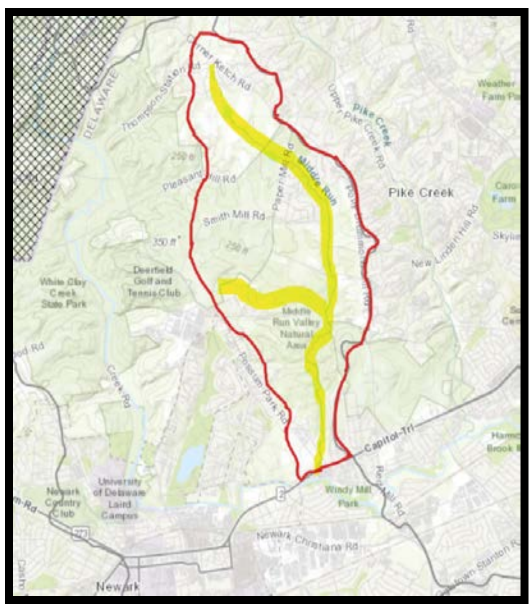
# Spring 2026

# UAPP 411: Regional Watershed  Management

# *Team 3: RISE UP* (Middle Run Watershed, DE)

*(Restoring Integrity in Stream Ecosystems – United Partnership)*




# Final Report

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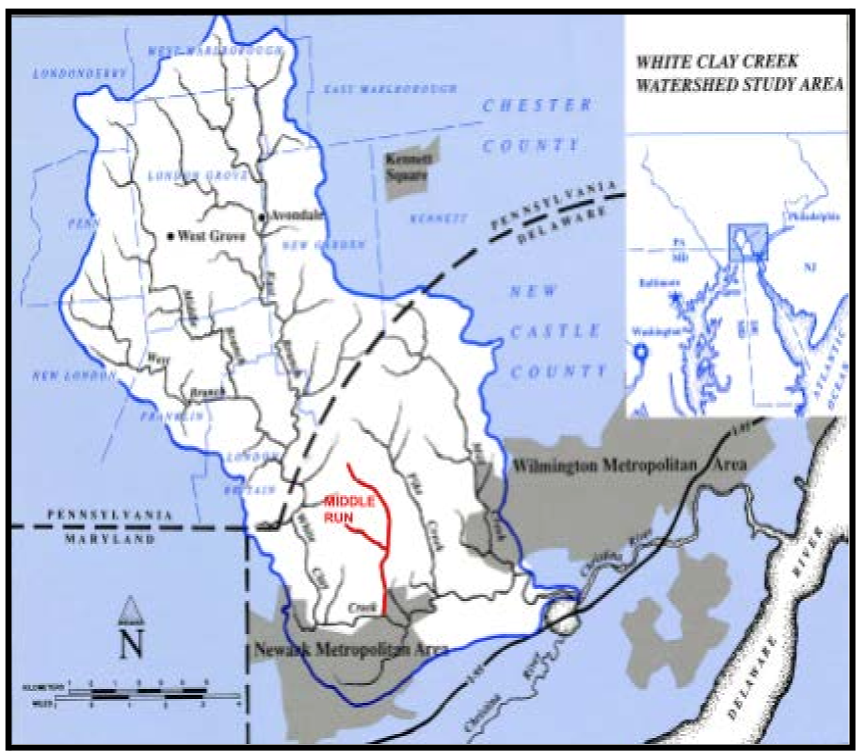
# Mission Statement

Project RISE UP aims to assess the watershed challenges in the Middle Run watershed and to develop strategies to mitigate them. Project RISE is dedicated to protecting and restoring the Middle Run watershed by reducing stormwater impacts, improving water quality, and enhancing ecological habitats for a more sustainable community and superior environmental health. RISE proposes the following changes to the Middle Run watershed management, hoping to decrease pollutant levels by 50% by the year 2030.

# Background – Middle Run Watershed (Delaware)

***Geographic Context:***

The Middle Run watershed is located in northern Delaware, primarily within and around the city of Newark. It is a sub-watershed of the larger White Clay Creek watershed, which ultimately drains into the Christina River and the Delaware Bay. Much of the watershed lies within protected lands such as the Middle Run Valley

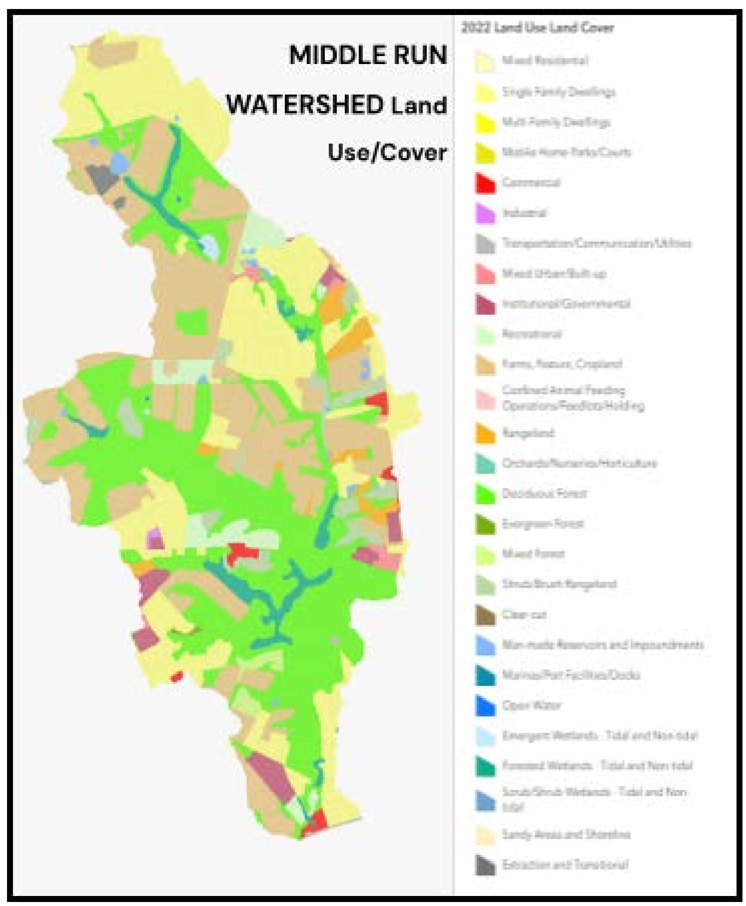



[Image Source](#)

Natural Area and White Clay Creek State Park, though surrounding suburban development, influence its hydrology. There is also a portion of the Pike Creek community within the Middle Run watershed. According to some estimates, the total number of Delaware residents within the watershed is about 4000.

***Physical Characteristics of Middle Run:***

The Middle Run watershed is characterized by rolling hills typical of the Piedmont region, with moderate slopes and a dendritic stream network. The main channel, Middle Run, is a tributary that feeds into White Clay Creek. Soils in the region are generally well-drained but susceptible to erosion when vegetation is removed. Riparian buffers (i.e., vegetated areas along streambanks) play a crucial role in stabilizing soils and filtering runoff. It has a total drainage area of approximately 3.92 square miles. The land-use composition of the watershed is as follows: 24% Residential, 25% Industrial/Agricultural, 33% Forrest, 3% Commercial, 15% Other (e.g., recreational, idle fields, etc.). See the Middle Run Watershed Land Use/Cover GIS Map of the various land uses within the watershed (*this figure was created using ArcGIS Online*).




***Water Quality and Composition:***

Both natural processes and human activity influence water quality in the Middle Run watershed. Common concerns include elevated levels of nutrients such as nitrogen and phosphorus, increased sediment loads, and contaminants from stormwater runoff. These pollutants can lead to reduced dissolved oxygen levels and degraded aquatic habitats. Monitoring efforts in the broader White Clay Creek watershed have identified stormwater as a primary contributor to water quality impairment.

***Biological Diversity:***

The watershed supports a diverse range of species, including fish, amphibians, birds, and macroinvertebrates. Aquatic organisms such as mayflies, stoneflies, and caddisflies serve as indicators of water quality. Forested areas provide habitat for mammals like deer and foxes, as well as numerous bird species. Healthy riparian zones are essential for maintaining biodiversity, as they offer food sources, shelter, and temperature regulation for aquatic ecosystems.

***Human Activities and Ecological Factors:***

Human activities significantly impact the Middle Run watershed. Suburban development around Newark has increased impervious surfaces such as roads, parking lots, and rooftops, thereby accelerating stormwater runoff and reducing groundwater infiltration. This leads to stream erosion, higher peak flows, and pollutant transport. Recreational use of parks and trails also contributes minor impacts, though these are generally managed. Ecological stressors include habitat fragmentation, invasive species, and climate-related changes in precipitation patterns. The Middle Run watershed has an average impervious cover of 4.85%; however, this figure is expected to increase with infrastructure/population growth.

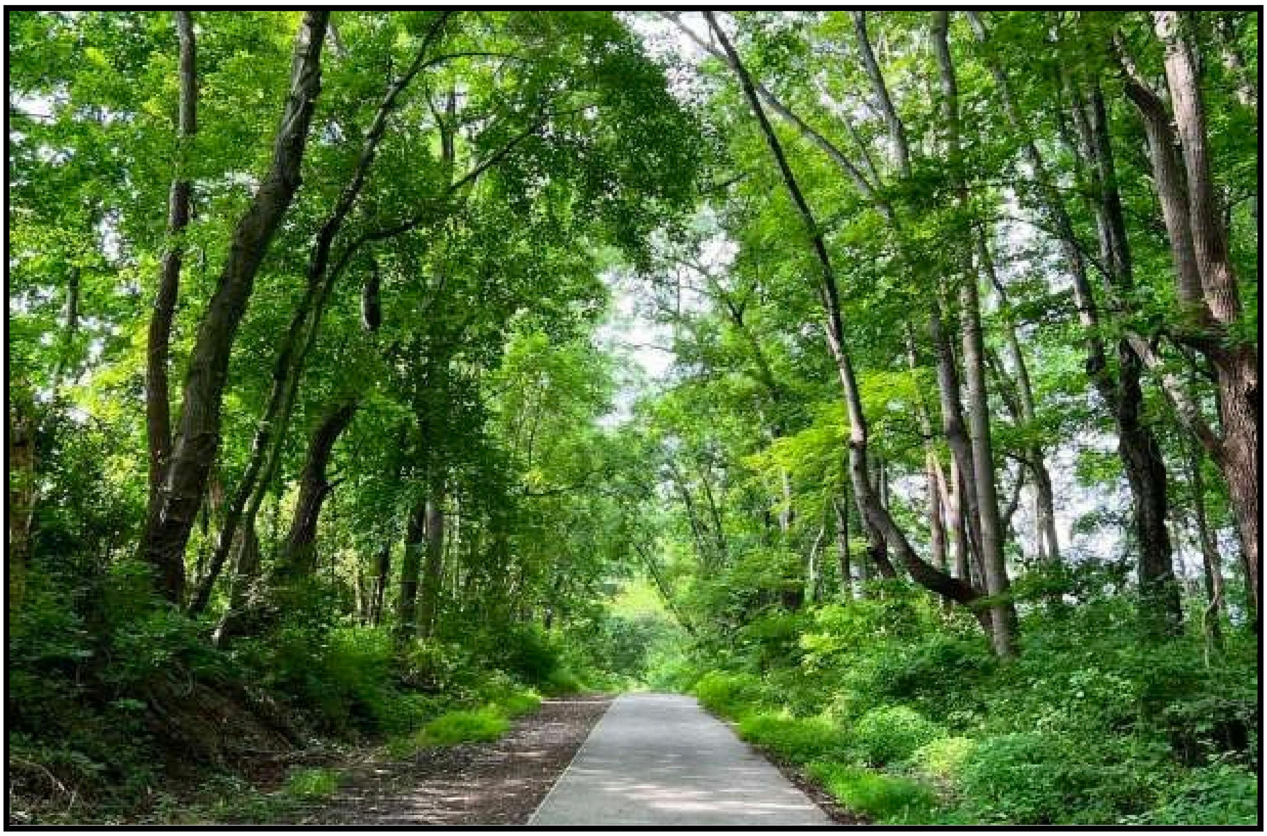
To address the economic value that the watershed generates in terms of the fishery and freshwater means of production, the fishery value rate of $32M/p/yr and freshwater rate of

$1000M/mg/yr were utilized to estimate the economic value of Middle Run. Since the Middle Run stream does not have a USGS stream gage, the data from an adjacent available stream is used (Pike Creek Near Newark, DE - USGS-01478950). This yields a flow of 5.14 MGD. As stated previously, the estimated population of the watershed is 4000. Now with both figures, the fishery and freshwater economic value was calculated as follows: $128,000 mil/yr and $1,876,100 mil/yr, respectively.

## Policies

Policies affecting the Middle Run watershed operate at all governance levels, and collectively provide a foundation for water quality protection while also limiting how aggressively improvements can be made. At the federal level, the Wild and Scenic Rivers Act protects the broader White Clay Creek system, including Middle Run, by preserving its ecological and free-flowing condition and requiring review of federally funded projects. At the state level, the Delaware Department of Natural Resources and Environmental Control enforces sediment and stormwater regulations that require erosion control and post-construction runoff management, while federal Clean Water Act programs, such as National Pollutant Discharge Elimination System (MS4 permits), require municipalities to monitor stormwater, reduce illicit discharges, and promote public education. Additionally, conservation efforts supported by programs like Delaware's Open Space initiatives and guidance from the White Clay Creek Watershed Management Plan help preserve natural land and coordinate regional protection strategies.

However, these policies also present limitations that may impede Project RISE UP's goal of reducing pollutants by 50% by 2030. Existing developments are often exempt from modern stormwater standards, leaving significant sources of runoff unaddressed. Furthermore, watershed management plans are largely non-binding and rely on voluntary cooperation, while local zoning policies continue to permit suburban expansion that increases impervious surfaces and stormwater volume. As a result, while current policies support long-term protection and provide a regulatory baseline, achieving substantial pollutant reductions will likely require stronger enforcement, retrofitting of existing infrastructure, and more stringent local land-use controls.



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# Problems

| Problem | Description | Causes |
| --- | --- | --- |
| P1: Increased Stormwater Runoff | The extent of urban and suburban development within Middle Run increases the amount of impervious surface. Consequently, stormwater runoff increases because impervious materials like concrete prevent adequate infiltration into the subterrain. According to various models, watersheds exceeding 10-15% impervious cover show noticeable negative impacts on biological stream health. | Expansion of impervious cover (e.g., roads, buildings, concrete)...<br><br>…Urbanization in Newark and limited infiltration.<br><br>Insufficient stormwater infrastructure. |
| P2: Nonpoint Source Pollution | As a result of dense development and increased impervious cover, the quality of stormwater runoff declines as more pollutants come in contact with water. In fact, a typical city block generates 5 times as much runoff as a woodland area of the same size. Related problems of NPS: eutrophication and reduced dissolved oxygen levels. | Agricultural / landscaping fertilizers and practices in residential and industrial land uses. |
| P3: Riparian Buffer Fragmentation | Due to the extent of development in the region, the effects of lawn encroachment and riparian fragmentation reduce the capacity of the natural filtration system for pollutants. Consequently, the ecological habitat is altered, leading to reduced biodiversity. | Increased amount of residential |

# Problem 1: Increased Stormwater Runoff

Although the 4.85% impervious cover is fairly low for the Middle Run watershed compared to adjacent watersheds (like Fairfield Run in Newark with 22%), this figure is expected to increase with the projected growth of infrastructure and population. As a result of increased impervious cover, the watershed will face escalating stormwater runoff, leading to higher flood risks, increased erosion, and diminished stream health. These impacts will strain the existing stormwater infrastructure and contribute to poorer water quality. According to 39 years of data from 280 U.S. streamgages, a 1% increase in impervious cover causes a 3.3% increase in annual flood magnitude on average (Blum et al., 2020). From this study, it can be asserted that just a minute change in impervious cover significantly contributes to stormwater runoff.

An example of where this is most pressing within the Middle Run watershed is the city of Newark, which is partially encapsulated by the watershed. The City of Newark, Delaware's Comprehensive Development Plan V, adopted in 2016, justifies infrastructure expansion by linking it directly to supporting future growth and redevelopment. In particular, the plan calls for upgrades to utilities and transportation, all aimed at fostering new development. This planned expansion is expected to increase impervious cover, which will in turn increase stormwater runoff and strain the watershed.

# Goal 1: Reduce Stormwater Impacts

To address rising stormwater impacts from increased impervious cover, the goal is to reduce effective impervious cover through green infrastructure solutions. Strategies such as rain gardens and permeable pavement aim to increase infiltration and groundwater recharge. By slowing runoff, these measures help reduce peak discharge, ensuring more resilient water quality and stream conditions within the Middle Run watershed. Stormwater runoff, potentiated by high impervious cover, releases contaminants into the nearby water bodies, such as bacteria, trash, heavy metals, and other pollutants, making them one of the most important sources of water pollution (EPA, 2008). Through the selective application of permeable pavement within the Middle Run watershed, particularly in frequently inundated regions, the promotion of groundwater infiltration will help curtail the stormwater runoff impacts.

According to a study by Rossi, M. L. et al., small changes in impervious surface cover are associated with higher chloride concentrations, and small changes in low-intensity development are associated with higher chloride concentrations. With the projected growth of infrastructure and population in the Middle Run watershed, this study suggests that the rise in impervious surface and development in the watershed could lead to higher pollutant concentrations (particularly chloride). This is intuitive under the principle of groundwater infiltration: less permeable surfaces result in increased stormwater runoff, which increases the water's propensity to pick up and carry pollutants into the eventual stream system.

# Problem 2: Nonpoint Source Pollution With Increased Runoff

Within the Middle Run watershed, increasing suburban development and expanding impervious cover have contributed to a noticeable decline in stormwater quality. As runoff travels across roads, rooftops, lawns, and parking lots, it accumulates a wide range of pollutants before entering nearby streams. Compared to natural landscapes, developed areas produce significantly more runoff—often up to five times that of a woodland area of the same size—greatly increasing the transport of contaminants. In Middle Run, this process leads to elevated levels of nutrients such as nitrogen and phosphorus, which promote eutrophication. As excess algae grow and subsequently decompose, dissolved oxygen levels in the water decrease, creating stressful conditions for aquatic life and degrading overall stream health.

A major consequence of this process in Middle Run is elevated nutrient loading, particularly nitrogen and phosphorus from fertilizers. These nutrients promote eutrophication, leading to excessive algal growth. As algae die and decompose, dissolved oxygen (DO) levels in the water decline, creating stressful or even hypoxic conditions for aquatic organisms. This degrades stream health, reduces biodiversity, and disrupts the natural ecological balance of the watershed.

These impacts are largely driven by common land-use practices throughout the watershed. Fertilizer application on residential lawns, parks, and nearby agricultural areas introduces excess nutrients that are easily mobilized during rainfall events. Landscaping practices that lack proper nutrient management or soil stabilization further exacerbate runoff issues, while impervious surfaces carry additional pollutants. At the same time, the loss and fragmentation of natural vegetation reduce the landscape's ability to filter these pollutants. Stormwater infrastructure often prioritizes rapid drainage, allowing untreated runoff to be conveyed directly into streams without sufficient opportunity for natural treatment.

## Goal 2: Restoration of Riparian Buffers

To address nonpoint source pollution in the Middle Run watershed, a primary goal is to reduce nutrient and pollutant loading into waterways. This can be achieved by limiting the amount of contaminants entering stormwater runoff through improved land-use practices and better management of residential, agricultural, and urban inputs. Reducing these inputs is critical to preventing eutrophication and protecting overall stream health.

Another key goal is to improve water quality and maintain healthy dissolved oxygen (DO) levels within the stream system. By minimizing nutrient inputs and slowing the movement of runoff, the watershed can better support balanced aquatic ecosystems. Maintaining adequate DO levels is essential for sustaining fish populations and other aquatic life, as well as preserving overall ecological integrity.

Finally, promoting best management practices (BMPs) is essential for long-term watershed protection. In particular, restoring and maintaining riparian buffers along Middle Run will help trap sediments, absorb excess nutrients, and slow runoff before it reaches the stream. These measures not only improve water quality but also stabilize streambanks, enhance habitat, and contribute to a more resilient watershed system.

## Problem 3: Riparian Buffer Fragmentation

Riparian buffer fragmentation has emerged as a significant stressor due to sustained residential development and associated land use practices. Stream-adjacent areas that were historically forested have increasingly been converted to maintained turf grass, resulting in discontinuous or absent vegetated buffers. This transition reduces the watershed's capacity to intercept nonpoint source pollutants, allowing elevated loads of nutrients to enter tributaries that ultimately feed into White Clay Creek. The loss of deep-rooted native vegetation also weakens bank stability, contributing to increased erosion and channel degradation.

Beyond water quality impacts, fragmentation disrupts longitudinal and lateral habitat connectivity within the riparian corridor. Isolated vegetated patches are less effective in supporting diverse terrestrial and aquatic species, leading to simplified ecological communities and reduced resilience to environmental stressors. Edge effects from adjacent residential land uses (such as increased invasive species encroachment and human disturbance) further degrade habitat quality. Collectively, these conditions diminish the ecological integrity of the riparian system and compromise its role as a critical interface between upland development and stream health.

# Goal 3: Reduce Nonpoint Source Pollution Through Community Engagement

To address these challenges, the goal is to reduce nonpoint source pollution in the Middle Run watershed through targeted community engagement and restoration of functional riparian buffers. Building on longstanding conservation efforts in the broader White Clay Creek watershed—including extensive reforestation initiatives that have resulted in the planting of over 50,000 trees since 1991—this goal emphasizes enhancing the natural filtration capacity of stream corridors. Restoring continuous, native vegetative buffers will improve pollutant uptake, promote infiltration, and reduce direct runoff into waterways, while simultaneously stabilizing streambanks and mitigating sediment transport.

Equally important is the role of community participation in sustaining these improvements. Outreach and incentive-based programs can encourage homeowners to adopt riparian-friendly landscaping practices, such as reducing lawn extent near streams and planting native species. By fostering local stewardship and increasing awareness of watershed processes, these efforts aim to reconnect fragmented buffer zones, enhance habitat continuity, and support greater biodiversity. Over time, this integrated approach will strengthen both the ecological function and social investment necessary to maintain water quality and habitat health in the watershed.

# Recommendations

The predominance of residential and industrial uses over forest within the existing land uses (i.e., 49% vs 33%) warrants concern for the watershed and supports the following actions for future restoration: reduce stormwater impacts, restore riparian buffers, and reduce nonpoint source pollution. However, upon initial inspection of the physical characteristics of the site, the average impervious cover of 4.85% shows good signs for the Middle Run watershed. Furthermore, the projected population growth and the region's infrastructure demands support the expectation that future stormwater impacts will increase. If sustainable watershed practices/solutions are applied consistently and appropriately, the watershed remains resilient to the addressed expected problems.

Stormwater impacts can be reduced through the use of green infrastructure such as rain gardens and permeable pavement, which can increase infiltration and groundwater recharge. Considering the increased infrastructure development in the area, specifically suburban, the amount of impervious pavement would be likely to increase. But by using permeable pavement instead, the amount of stormwater runoff will be decreased, leading to fewer pollutants and contaminants in the watershed.

# Conclusions

Project Rise Up views the Middle Run watershed as a good model for other nearby watersheds. The watershed faces problems that would be more significant if the watershed didn't have a strong forest presence that subdued the impact of the earlier problems. These problems stem from issues such as increasing impervious cover, landscaping fertilizers, and insufficient stormwater infrastructure. Following the group's recommendations will create an even stronger environment for the watershed to achieve an optimal score and help the group achieve its goal of reducing pollutant levels by 50% by the year 2030. Achieving the stated goal will require more than isolated interventions; however, it will depend on coordinated implementation across local governments, regulatory agencies, and the community. Ultimately, the watershed is currently doing well, but has the potential to thrive through proactive management and sustained commitment.

# Sources

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