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Resilient Ridgewood

A sustainability roadmap for the Village of Ridgewood, New Jersey by Columbia University

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Source: New York Times

EXECUTIVE SUMMARY

The effects of climate change, from floods and heat waves to severe storms and droughts, are felt the world over. Although global warming occurs universally, its effects on the local level are varied based on location. The responses to the issue of a worsening climate are intrinsically local and need to take into account the varying issues and resources available in each community.

The Village of Ridgewood has experienced 3 major flooding events since September 2023, costing hundreds of thousands of dollars to the municipality and residents alike (Kazmark, K., Ridgewood Village Manager, Personal Communication, 2024). Ridgewood is also, despite several decarbonization initiatives, currently not on track to meet 1.5 degree C targets (Sustainable Jersey). Given the Village's susceptibility to flooding and the municipality's desire to both reach and exceed state decarbonization targets, the Columbia School of International and Public Affairs Team was requested by the Village advisory committee, Green Ridgewood, to prepare the following report. This report outlines key sustainability problems, identifies solutions, evaluates the costs and benefits of each solution, and offers recommendations to furnish a sustainability roadmap for Ridgewood.

This report finds that Ridgewood's high level of urban development, steep topography, high water table, increasing precipitation levels, and relatively narrow river flows, flood mitigation and adaptation require a bevy of solutions (FEMA; NCEI; Refkin, Personal Communication, 2024). Although the Columbia team considered various surface basins as a way of capturing and filtering excess riparian flood water, given the low availability of open land in Ridgewood, the team recommends constructing modular underground detention basins at strategic locations along the river banks which can then be incorporated into Ridgewood's stormwater management planning. Additionally, private rain barrels, bioswales, and permeable pavement (in areas where the water table height does not preclude installation) can be useful infrastructure to help manage exacerbated levels of precipitation as well as engage the public on the issue of flooding. As we look beyond the immediacy of preventing Ridgewood's homes and sporting facilities from flooding through increasing stormwater storage, this report also considers the potential efficacy of riverine diversion in changing water flow, the use of weirs/barrages to moderate water flow, and the revitalization of wetlands along the river banks to increase natural storage capacity.

Through a combination of these measures, Ridgewood can abate its flood risk and allay the concerns of its residents who have experienced "significant financial strain, required time off from work, and…a detrimental impact on [their] mental health" (Ridgewood Residents, Personal Interview, 2024).

Additionally, this report finds that, despite Ridgewood's emissions being lower than the US average per capita, the Village's high car and home ownership mean that decarbonization initiatives in the municipality still fall short of New Jersey's net-zero targets (State of New Jersey, 2023). Ridgewood's emissions are also exacerbated by the almost 20% of current electricity supply provided through coal power (PSE&G, 2024). In order to meet New Jersey's net-zero emissions target by 2050, and building on the recommendations in the adopted Master Plan related to green buildings and sustainability, Ridgewood will have to reduce its total emissions by at least 42% by 2030, which would amount to a total reduction of around 50,000 MT CO_2e within the next 6 years (Sustainable Jersey). This emissions reduction will not be achieved through any one decarbonization initiative, and therefore the team proposes a phased emissions reduction, taking into account the varying difficulty of initiative implementation. Firstly, Ridgewood should negotiate with PSE&G, the main utility supplier for the village, to develop a new Power Purchasing Agreement (PPA), as it was previously agreed, that provides a greater percentage of the Village's energy through renewable sources and minimizes the prevalence of coal in the provided energy mix. Further, to abate vehicular emissions, Ridgewood should consider the use of its municipal parking lot to provide commuters with a park and ride system, continue the electrification of its municipal fleet, and make it easy for Ridgewood residents to electrify their own cars. In the long term, it will also be beneficial for Ridgewood to bolster its existing solar infrastructure and create its own community microgrid either on a municipal or third party basis. Through community engagement and easier transportation and energy choices, Ridgewood is well positioned to advance and set goals on net-zero in New Jersey.

Lastly, in order to implement flooding and decarbonization initiatives over a sustained period of time, the Columbia team recommends the formalization of Green Ridgewood, the Village's sustainability advisory board, into an organization with the capacity to coordinate long term on the budgeting for projects. Furnished with a dedicated sustainability budget and subject to well-defined project planning and key performance indicators, Ridgewood can follow its sustainability roadmap and ensure that its residents continue to reap the benefits of their beautiful township.

INTRODUCTION

The Village of Ridgewood is a municipality in Bergen County, New Jersey, serving just over 26,202 people (Data Commons, 2022). It covers an area of 5.8 square miles, of which approximately 96% is developed land (Figure 1.0) (Ibid.). The village government operates under a weak mayor system, supported by a council of five elected officials and specialized committees for town improvement. One such committee is Green Ridgewood, the official environmental advisory committee appointed by the Ridgewood Village Council. This committee identifies potential environmental issues, conducts research, and subsequently recommends solutions. It also includes a subcommittee, the Green Team, which concentrates on meeting the Sustainable Jersey certification requirements and educating village residents on green initiatives (Village of Ridgewood, 2023).

Currently, Ridgewood faces the recurring challenge of flooding, a concern that impacts the community at large. The village has developed a Master Plan aimed at not only addressing the immediate concerns posed by flooding but also guiding Ridgewood towards a resilient and sustainable future. This Master Plan serves as a strategic document for Ridgewood's growth, covering various elements such as land use, economic development, historic preservation, recycling, and green building and sustainability. The plan is underpinned by a commitment to sustainable development principles that harmonizes growth with ecological balance, in order to enhance the quality of life for all residents.

A key component of the Master Plan is its focus on green buildings and sustainability, which outlines strategies to encourage the efficient use of natural resources, promote renewable energy systems, and support sustainable community initiatives. In response to the pressing and recurring challenge of flooding, the plan supports integrating green infrastructure into stormwater management efforts to reduce flood risks and enhance water quality. This includes, but is not limited to, integrating green streets and enhancing on-site stormwater retention.

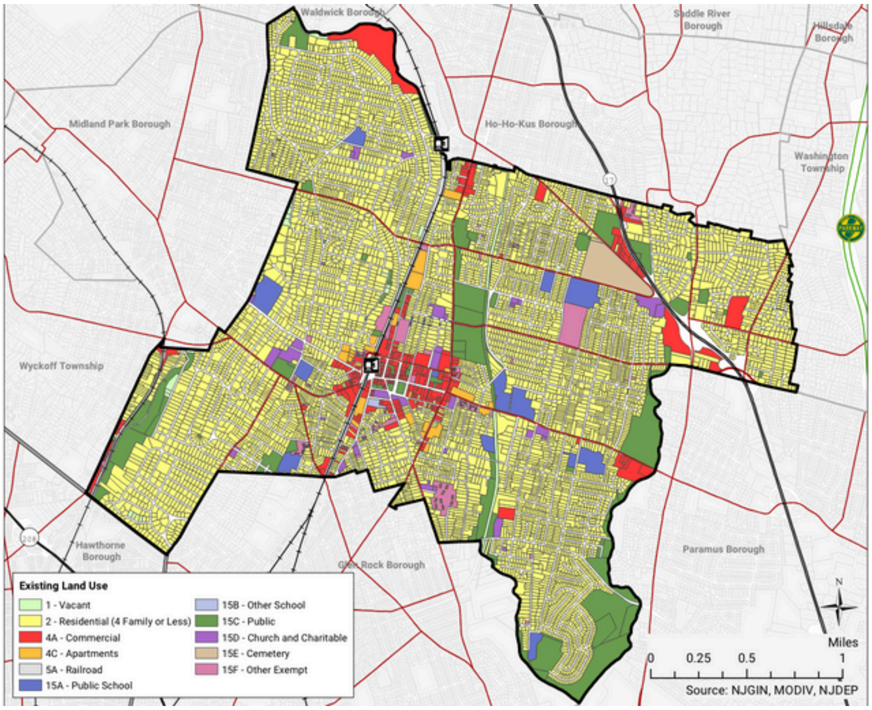


Figure 1.0 Land use map of Ridgewood, NJ.

The plan also aims to align Ridgewood's efforts with New Jersey's 2019 State Energy Master Plan goal of achieving 100% clean energy by 2050—a timeline that Governor Murphy's 2023 Executive Order No. 315 has expedited to 2035, specifically for clean electricity generation sources (Energy Master Plan; State of New Jersey, 2023). To support this accelerated goal, Ridgewood's Master Plan additionally proposes decarbonization strategies, such as promoting electric vehicles (EVs), advancing renewable energy like community solar, and enhancing building efficiency.

To this effect, our team—composed of Environmental Science and Policy (ESP) graduate students from Columbia University's School of International and Public Affairs—was requested to develop a detailed sustainability roadmap for the Village of Ridgewood. Under the guidance of our Faculty Advisor, Kathleen Callahan, and in collaboration with key stakeholders, including David Refkin, Chair of Green Ridgewood, and Alina Mordkovich, ESP alumna and active member of the Green Team, we researched the options for Ridgewood and developed a detailed and comprehensive roadmap addressing three critical areas: flood mitigation, decarbonization strategies, including waste management, and viable funding options for our suggested program. This evaluation took place from January to mid-April and is intended to support future sustainability initiatives in Ridgewood over the next several years.

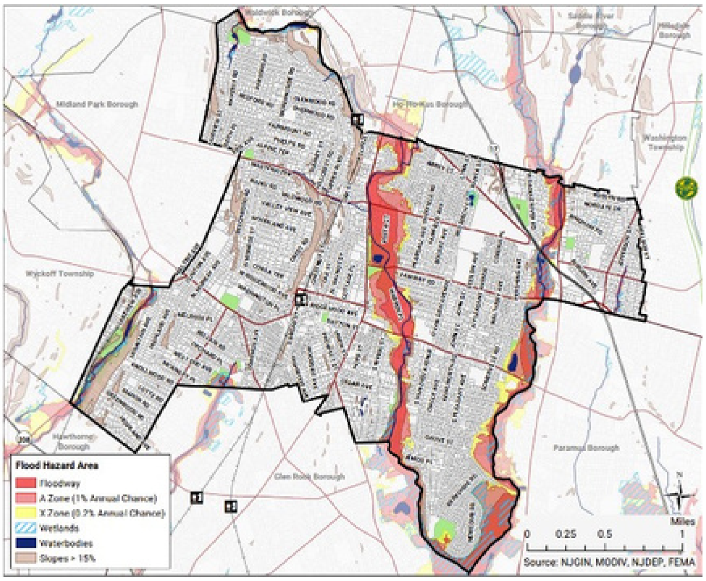


Figure 1.1 Flood hazard map of Ridgewood showing the Ho-Ho-Kus Brook and Saddle River. (NJDEP)

FLOODING

OVERVIEW

Ridgewood faces notable challenges related to flooding, particularly from the nearby Ho-Ho-Kus Brook and Saddle River, which merge to the south of the Village. The town's vulnerability to these water bodies is a key consideration in our flood resilience efforts.

The Village of Ridgewood is marked by extensive built infrastructure, at 96% development (Figure 1.1). This high level of development contributes to a large amount of impermeable surfaces, such as roads and buildings, which prevent natural water absorption. The Ho-Ho-Kus Brook basin, which bisects the town, has a small watershed so experiences sudden and severe floods. The Saddle River basin, by contrast, has a larger watershed, which results in more predictable flooding, albeit with longer drainage times. These two bodies of water are the main sources of flooding in Ridgewood.

Flood zones around the Ho-Ho-Kus Brook primarily include homes and sports fields, making these areas susceptible to damage during flooding events. The Saddle River has a more devastating history of flooding, but its overflows are less common (on average, once a year) and the surrounding parkland on its eastern banks somewhat mitigate spillover. If you combine these factors with the approximate 165 feet elevation to the west and an approximate 100 feet elevation to the east of the Brook, spillovers have nowhere to drain or percolate (Figure 1.2). Understanding these key characteristics sets the stage for developing targeted flood resilience strategies tailored to Ridgewood's specific vulnerabilities.

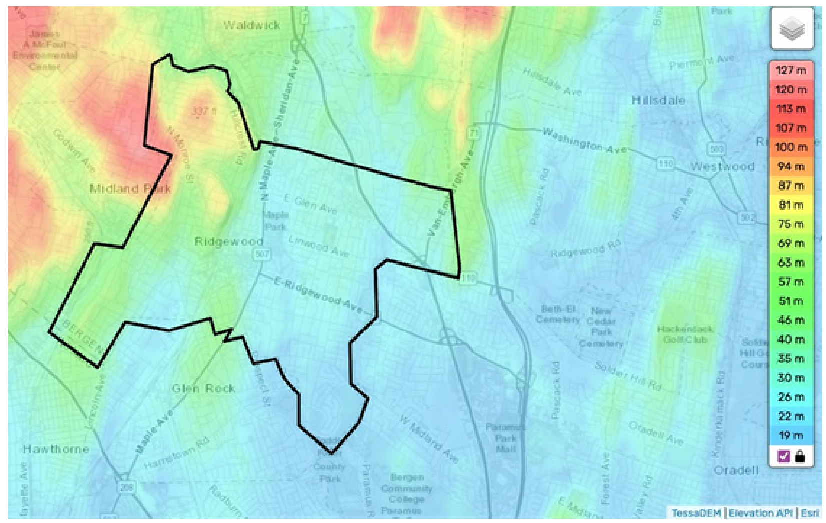
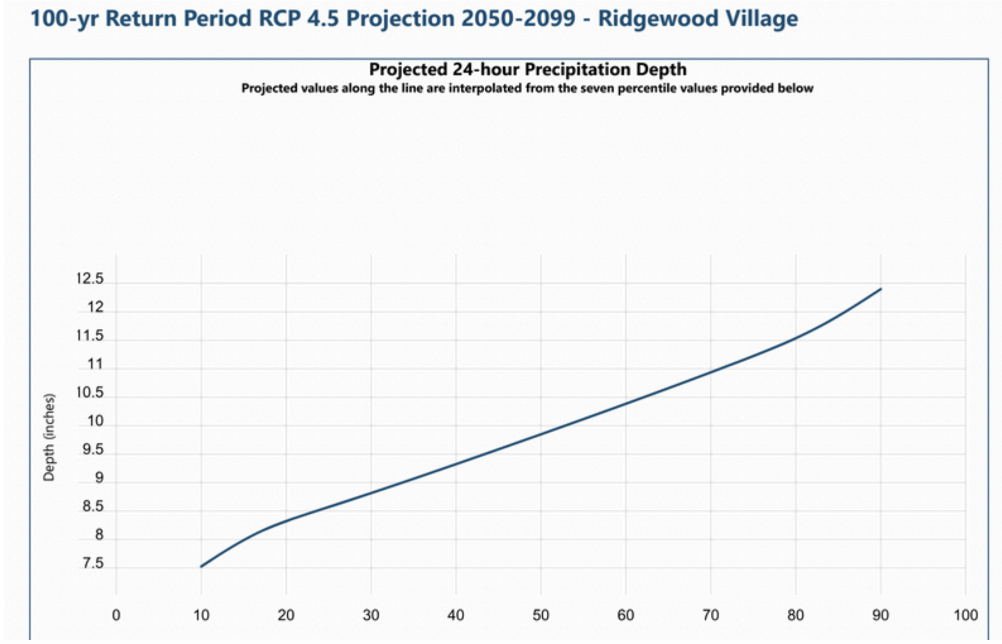


Figure 1.2 Flood hazard map of Ridgewood showing the Ho-Ho-Kus Brook and Saddle River. (NJDEP)

It is also imperative to consider future climatic trends that could exacerbate these challenges. Notably, Ridgewood's average precipitation is expected to increase substantially. Figure 1.3 llustrates the projected precipitation depth for Ridgewood's 100-year storm events, increasing from 8 inches in 2020 to just over 12 inches between 2050 and 2099. This anticipated increase underscores the urgency of reevaluating Ridgewood's stormwater management system, which, having been constructed in the early 20th century, was not designed to manage such significant influxes of precipitation. As it currently stands, 21% of Ridgewood's properties are at risk of flooding (Flood Factor, 2020). This number is representative of over 700 homes and families in the community.



	Projected Depth (inches)							NOAA Atlas 14 Values (Inches, data through Dec. 2000)		
Duration	10th	17th	25th	Median	75th	83rd	90th	LowCI	Mean	HighCI
24 hrs	7.53	8.21	8.55	9.83	11.2	11.72	12.4	7.63	8.55	9.31

Figure 1.3 Projected 24-hour precipitation depth over time (years) for a 100-year return period in Ridgewood, NJ (NJ DEP, 2024).

Given these projections, transitioning into proactive measures becomes not only necessary but also economically prudent for Ridgewood. The town's investment in flood prevention will not only avert economic losses for the residents, mitigate likely declines in home values within the flood zone, and enhance their quality of life, but will also result in future cost savings. Recent research supports the notion that investments in flood prevention and nature-based solutions not only pay for themselves but also offer substantial economic, social, and environmental returns. A study by the National Institute of Building Sciences found that every $1 invested in disaster mitigation, including flood mitigation, saves society $6 (Pew Trusts, 2018). A separate study, published in Nature, found that every dollar invested in floodplain protection today returns at least $5 in savings from avoided flood damages in the future (Keys, 2019). Similarly, an analysis by the World Resources Institute emphasized that flooding has caused over $1 trillion in losses globally since 1980. Investments in flood protection infrastructure are not only vital for safeguarding lives and property but also offer a strong return on investment.

FLOODING IS NOT JUST A NUMBER

What often gets lost in the cascade of data and statistics is the voices of those behind the numbers, those who have lost and who are forced to rebuild, those who are hurt and who are frustrated. To deepen our understanding of how Ridgewood’s increasingly devastating floods are impacting its residents, we conducted interviews with several Ridgewood residents, focusing particularly on two individuals’ experiences living along the Saddle River.

Resident 1, a father, has been a part of the Ridgewood Village community for nearly a decade. But in just the past 12 months, he has experienced “three events that would have resulted in [his] garage being flooded” had he not taken note after Hurricane Ida to replace his basement windows with solid glass brick.

When Ida swept through in 2021, though, his "garage and basement flooded. The basement was covered with 4 feet of water." He "lost the furnace, washer, dryer, couches, beds, desks, chairs, clothes, books, bookcases, lawnmower, water softener/purifier as well as several electronics (cameras, computers, monitors), cabinets, and counters." On top of that, it was over 9 months before repairs were completed and his daughter, who has asthma, struggled with all of the dust in the air during the basement rebuild.

Then there were the insurance problems. After Ida, the insurance company "took more than a month to come by, which slowed down the whole process of rebuilding the basement." His house had flood insurance, but no insurance for its contents so the total calculated loss, out of pocket, was around $80,000. The Federal Emergency Management Agency (FEMA) contributed a check of only around $6,000.

Source: NPR, Hurricane Ida

Resident 2 has called the town her home for approximately 30 years. Between just September 2023 and January 2024, she "had to empty [her] home into a moving truck three times…due to major rain events." As a result of these three flooding events, she lost "cars, garage doors, home doors, windows, boiler, AC unit, water heater, washer dryer, electrical panels, outlets, and various personal items such as a lawnmower, snow blower, and furniture." She noted that each of these events, in addition to Hurricanes Floyd, Irene, and Ida, "imposed significant financial strain, required time off from work, and had a detrimental impact on [her] mental health."

Resident 2 was also not free of the same insurance problems plaguing Resident 1. She suffered around $50,000 in total damages from Hurricanes Floyd (1999) and Irene (2011), yet "despite having a $1,000 deductible, State Farm claimed [her] damages weren't substantial enough." She stated that "flood insurance falls short of covering all the necessary replacement/repairs required with each flood event."

Ridgewood's safe community and renowned school system typically encourage long-term residents. But given the uptick in frequency and severity of flooding, this sentiment may not last. Resident 1 admitted that "at least once a month my family will discuss if/when we will sell our house", and Resident 2 expressed that "if [she] could sell the home to Blue Acres for its actual sale value…[she] would consider it." It is clear that the increased severity of storms and the Village's proclivity for flooding are beginning to exert a toll on those who have called Ridgewood home for many years.

Source: Village of Ridgewood

CASE STUDIES

The City of Dover, New Hampshire, implemented various Best Management Practices (BMP) in the Berry Brook watershed to combat pollution and flooding due to urbanization. The study developed and utilized four Personal Computer Stormwater Management models to analyze the impact of Green Stormwater Infrastructure (GSI) implementation, changes in impervious cover, and climate change on urban watershed hydrology. Findings indicated a median decrease in extreme peak flow by 7%, an increase in the time to peak flow, and significant reductions in runoff depth and total storm flow volume due to BMP implementation. The study demonstrates that GSI can effectively reduce flooding caused by extreme precipitation events, though not eliminate it, and emphasizes the greater impact of increasing impervious cover over climate change-induced rainfall intensity on urban flooding (Hastings, 2021).

Source: City of Dubuque

In Dubuque, Iowa, a project that cost over $200 million is expected to prevent $582 million in future damage (Pew Trusts, 2019). In response to repeated flooding since 1999, Dubuque implemented a flood mitigation project within the Bee Branch Watershed, focusing on infrastructure improvements and natural watercourse restoration. Over 50% of Dubuque residents either work or live in the watershed. From 2004 to 2009, commercial property values increased by 39% citywide in Dubuque, but they fell by 6% in the flood prone areas.

The project, especially the green alleys, will result in a significant reduction of runoffs of soils, fertilizers and road surface chemicals from the waterways. This project included the construction of detention basins, floodgates replacement, sewer system upgrades, and creek restoration. The result was a significant reduction in flood risk, with the project expected to prevent $582 million in future damage, showcasing how urban flood mitigation can protect communities and provide economic benefits through strategic infrastructure and environmental restoration (City of Dubuque). This approach led to significant improvements in flood management through the restoration of wetlands, construction of detention basins, stabilization of riverbanks, and the creation of vegetated buffers. The success of this program is attributed to its comprehensive strategy that not only mitigated flood impacts but also enhanced water quality and supported agricultural and urban areas, demonstrating an effective model for watershed-based flood management (Pew Trusts, 2019).

FLOOD RISK MODELS

Flood risk models are critical for Ridgewood to prepare for and mitigate the effects of flooding. Several companies use hydrological and regional climate modeling techniques to deliver an accurate analysis of a region's flood risk and the upper limits of flood events––their details can be found in the Appendix. Without a precise understanding of how streamflow along the Ho-Ho-Kus Brook and Saddle River varies on its path through the Village, proper infrastructure and response measures cannot be implemented. These models are also incredibly valuable for their ability to visualize long-term trends and forecast potential scenarios that Ridgewood can prepare for. While challenges exist in converting climate model outputs into hydrodynamic outputs for flood hazard assessment, advancements in modeling techniques show promise in accurately predicting future flood dynamics and informing adaptation strategies (Callaghan, 2022).

SURFACE BASINS

The first of our proposed options for flood mitigation concerns surface basins. There are three general surface basin designs in use: dry detention basins, wet retention ponds, and infiltration basins. Each has its merits and drawbacks, but it is Ridgewood's high percentage of land development that is the principal factor here, leading us to suggest an infiltration basin as the best design option of the three.

Dry detention basins can be extraordinarily effective at holding water during peak runoff, however, they need sites of at least 10 acres in order to be effective (EPA_1, 2021). There are no feasible 10 acre sites in the Village that could host a detention basin without transforming the space entirely into a basin. Taken in conjunction with the fact that dry detention basins are not designed to improve water quality, and often detract from property values (as they sit empty until used during a flood event) (Nilsson), these basins are not a feasible design option for Ridgewood.

Wet retention ponds are designed to retain water regardless of flooding events (Ibid.) They collect the water during flooding events and are typically designed to improve water quality over time. Because these ponds are usually lined with vegetation and remain filled, they can provide new aquatic habitats and outlets for recreation. Wet retention basins, however, encounter the same problem as dry detention basins—they need large areas of land. There is simply not enough undeveloped land in Ridgewood nor a large enough single plot to incorporate a wet retention pond.

The concept of an infiltration basin centers on allowing stormwater to permeate into the ground, offering a potential method for recharging Ridgewood's aquifer, which has been identified as a challenge for the Village (Calibi, R., Personal Interview, 2024). The effectiveness of such a basin as a groundwater recharge solution largely depends on its location, especially since Ridgewood's aquifer is largely confined. If the basin is placed next to the Brook or Saddle River, then it can contribute to baseflow and improve recharge capability.

Nonetheless, the viability of infiltration basins in Ridgewood requires careful consideration due to the community's shallow water table, particularly in flood-prone areas where these basins would likely be situated (Rutishauser, C., Chief Engineer, Personal Interview, 2024). Assessing the specific water table levels at potential sites is essential, as the distribution in water table height across Ridgewood's landscape varies. According to New Jersey Department of Environmental Protection (NJDEP) regulations, there should ideally be at least 4 feet of separation between the bottom of the basin and the seasonal high water table, although in areas close to the Brook or the Saddle River, a minimum of 2 feet of clearance may be permissible (EPA_2, 2021). It is also important to note that infiltration basins cannot be constructed at sites with surrounding slopes of 15% or greater, per NJDEP regulations (NJDEP, 2021).

Given that Ridgewood is now required by NJDEP to treat stormwater to 80% removal of Total Suspended Solids (TSS), the natural infiltration process could be a viable treatment solution because it utilizes the soil's inherent filtering properties (NJAC, 2023). Nevertheless, it is crucial to avoid contaminated soils, so the siting of any infiltration basins will need to be far from any sources of potential contamination.

The Environmental Protection Agency (EPA) also recommends percolation rates between 0.5 to 3 inches per hour to ensure proper filtering of solids and other contaminants. The soil composition also should not exceed more than 20% clay content and 40% silt/clay (EPA_2 2021).

To further ensure the effectiveness and longevity of any infiltration basins, lining them with bioswales, grasses, or vegetated filter strips is recommended for both pretreatment and clog-prevention control (Ibid.) These linings are particularly applicable for Ridgewood, given that its recent flooding events have left behind large silt deposits. Any excess silt that bypasses the linings into the basins will need to be cleaned afterward to ensure proper drainage for future events. Furthermore, these basins are particularly effective in parcels of 5 acres or less, which is a better geographic match for Ridgewood given its constraints on land availability.

Infiltration basins typically cost around $55,000-85,000 per acre (King, 2011). Given the amount of public land available, it is likely that the average infiltration basin in Ridgewood would be 1.5 to 2 acres in area. The depth of the basin depends upon water table height, but according to NJDEP calculations, a basin treating for Water Quality Design Storm (storm event that produces less than or equal to 90% stormwater runoff volume of all storms on an annual basis) would need to be at least ~2,517 cubic feet (NJDEP, 2021). Typical maintenance needs for infiltration basins are outlined in the table below, but specific tasks depend on the site in question:

Activity	Schedule
▪ Replace pea gravel or topsoil (when clogged)	As needed
▪ Ensure inlets are clear of debris, including sediment and oil/grease ▪ Stabilize the surrounding area ▪ Mow grass and remove grass clippings of filter strip areas, if applicable ▪ Repair undercut and eroded areas at inflow/outflow structures	Monthly
▪ Inspect pretreatment devices and diversion structures for debris accumulation and structural integrity; take corrective action as needed	Semiannually
▪ Aerate the pretreatment basin bottom or de-thatch it, if applicable	Annually
▪ Scrape the pretreatment bottom to remove accumulated sediment and re-seed ground cover, if applicable	Every 5 years
▪ Perform total rehabilitation of the basin and restore design storage capacity Excavate the basin bottom to expose clean soil	Upon failure

Source: MPCA, 2016

Table 1.1 Typical Maintenance activities for infilitration basins

Figure 1.4 Potential location of an infiltration basin around the Maple Park Herb Garden (Google Maps)

Regarding potential sites within Ridgewood for an infiltration basin, some of the area lining Meadowbrook Ave surrounding the Maple Park Herb Garden may be a feasible spot for an infiltration basin (Figure 1.4). If properly sited, an infiltration basin could prevent floodwaters from spilling onto the athletic field at Maple Park. However, proper maintenance of the basin and aesthetic design would need to be taken into consideration to ensure public support for park alteration. Ridgewood Wild Duck Pond may be a great upstream location for an infiltration basin that, post-flood event, could serve as a pleasing temporary second pond, depending on aesthetic design. If there is land available at Oak Manor and Cameron Apartments, a small infiltration basin could work well to reduce downhill stormwater flow to the Brook. However, it must be borne in mind that the apartment complex is next to train tracks which could introduce contaminants unable to be treated by percolation in an infiltration basin; more detailed studies would be needed. Another siting option further uphill is the George Washington Middle School, however as the school is relatively downstream from most flood events, the reduction of downhill stormwater flows may not ultimately prove effective. The Board of Education would also need to approve the measure.

PRIVATE RAIN BARRELS

Private rain barrels are a straightforward method for collecting and storing rainwater from a building's roof and downspouts for future use. Residential rain barrels typically range from 55 to 100 gallons, and they are essentially large containers that connect to a building's gutter system, capturing water that flows off the roof. Residents can also install a rain diverter to filter the collected rainwater. The primary function of a rain barrel is to store this water, which can then be utilized for various purposes such as watering gardens, washing cars, or other outdoor uses. The amount of water that can be collected depends on the rainfall amount and the size of the roof. One inch of rainfall over one square foot yields approximately 0.6 gallons of collected rainwater (The Home Depot$_1$).

During heavy rainfalls, the runoff from impervious surfaces, such as roofs and paved surfaces, can overwhelm stormwater systems, leading to floods. By capturing a portion of this water, rain barrels effectively reduce the immediate strain on these systems, thereby mitigating the risk of flooding. By encouraging households to collect and use rainwater, rain barrels reduce reliance on municipal water supplies, and inspire community awareness and participation in conservation and in mitigating flood events.

IMPLEMENTING RAIN BARRELS IN RIDGEWOOD

The average lifespan of a rain barrel is 20 years (The Home Depot$_2$). Regarding maintenance, rain barrels usually require seasonal checks on the overflow pipe and the roof gutters to remove debris (Montgomery County, 2013). Table 1.2 lists some of the advantages and disadvantages regarding rain barrels:

Source: HGTV, 2024

PROS	CONS
INEXPENSIVE AND EASY TO INSTALL AND MAINTAIN	LIMITED CAPACITY AND MAY QUICKLY OVERFLOW DURING HEAVY RAINFALL, WHICH MEANS THEY CAN ONLY MITIGATE FLOODING TO A CERTAIN EXTENT.
CAN REDUCE ENERGY CONSUMPTION, AS TREATING AND DISTRIBUTING MUNICIPAL WATER IS ENERGY-INTENSIVE	THEY REQUIRE REGULAR MAINTENANCE BY CLEARING DOWNSPOUT CLOGS AND ENSURING BARREL IS EMPTIED REGULARLY

Table 1.2 Pros and cons of integrating rain barrels

The optimal range of barrel sizes for rainwater collection in Ridgewood is informed by an analysis of the precipitation data provided by The National Centers for Environmental Information (NCEI) for Bergen County. The following analysis examines the rainfall trends in Ridgewood, particularly focusing on identifying the periods with the highest frequency and intensity of rainfall in the area (Table 1.3). By analyzing these patterns, and considering residential preferences, a range of rain barrel sizes from smaller 55-gallon drums to 6000-gallon cisterns is proposed to effectively manage and utilize the average precipitation, thus ensuring efficient rainwater collection.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
30yr? Normal	3.37	2.81	4.07	3.98	3.87	4.47	4.46	4.48	4.29	4.40	3.64	4.23	48.06
POR? Mean	3.43	3.15	3.92	3.96	4.05	3.96	4.53	4.53	4.08	3.85	3.73	3.85	47.04
Median	3.20	2.82	3.68	3.71	3.99	3.52	4.21	4.21	3.49	3.59	3.60	3.83	46.55
Min	0.58	0.78	0.81	1.07	0.54	0.25	0.82	0.86	0.32	0.31	0.51	0.35	31.05
Max	10.28	7.11	9.31	11.05	10.91	11.26	12.15	17.40	11.73	15.25	10.08	9.09	72.63
Count	130	130	129	129	129	129	129	129	129	129	129	129	129

Table 1.3 Bergen County Monthly Precipitation over one year (in.) (NCEI).

In Bergen County, the peak rainy season occurs from June to August, averaging ~4.5 inches of rainfall, making these months optimal for rainwater collection estimation. August, in particular, stands out with the highest recorded precipitation, reaching 17.4 inches.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
2015	4.27	1.74	3.69	2.39	1.71	6.11	2.88	1.90	3.47	3.82	1.96	4.62	38.56
2016	3.23	4.02	1.12	2.36	3.61	2.56	6.01	2.53	1.95	3.47	4.56	3.00	38.42
2017	3.51	1.94	4.19	4.17	5.92	3.26	5.04	3.80	2.03	4.75	1.24	1.51	41.36
2018	2.49	5.13	4.15	5.35	3.66	3.01	6.42	8.15	6.77	3.71	8.17	6.40	63.41
2019	4.32	3.22	3.59	4.20	7.30	5.30	6.73	3.66	0.75	7.26	2.18	5.57	54.08
2020	2.15	2.38	3.41	4.51	2.19	2.16	6.08	4.73	3.70	5.14	4.35	4.06	44.86
2021	2.02	3.95	2.89	2.35	5.01	3.07	8.44	7.68	9.17	6.27	1.22	1.27	53.34
2022	3.27	3.08	2.37	5.73	5.45	3.66	2.82	1.76	3.47	5.68	3.22	5.76	46.27
2023	4.50	1.30	2.78	6.21	1.81	3.37	6.29	5.50	9.46	4.27	3.10	7.51	56.10
2024	6.15	1.43	M	M	M	M	M	M	M	M	M	M	M

Table 1.4 Bergen County Monthly Precipitation over a 30 year period (in.) (NCEI).

To estimate the average rooftop size for private households in Ridgewood, a representative home was selected on Google Maps for analysis (Figure 1.5). The measurements taken on this average-sized home indicate a rooftop size of 25 feet by 55 feet, which equals an area of 1,375 square feet.

Rain barrels cost approximately $100 for a basic 55-gallon plastic model. Larger models, such as a 275-gallon water storage tank, typically cost around $600. For larger buildings, such as municipal ones, cisterns can hold up to 6,000 gallons, potentially costing up to $17,000, although smaller capacities are available at costs ranging from $0.50 to $4 per gallon.

These options cater to varying water storage needs and budgets (Figure 1.6).

Using the average estimated rooftop size for a household in Ridgewood, a 55-gallon rain barrel would capture approximately 1.43% to 1.55% of the rainfall from a 1375 sq ft roof during the rainiest month of August. Upgrading to a 100-gallon barrel would increase this to around 2.6% of the rainfall. Given these figures, a 55 to 60-gallon rain barrel offers a balance of financial and size feasibility for households. However, the specific choice of rainwater collection system should be tailored to the individual building's characteristics and available budget.

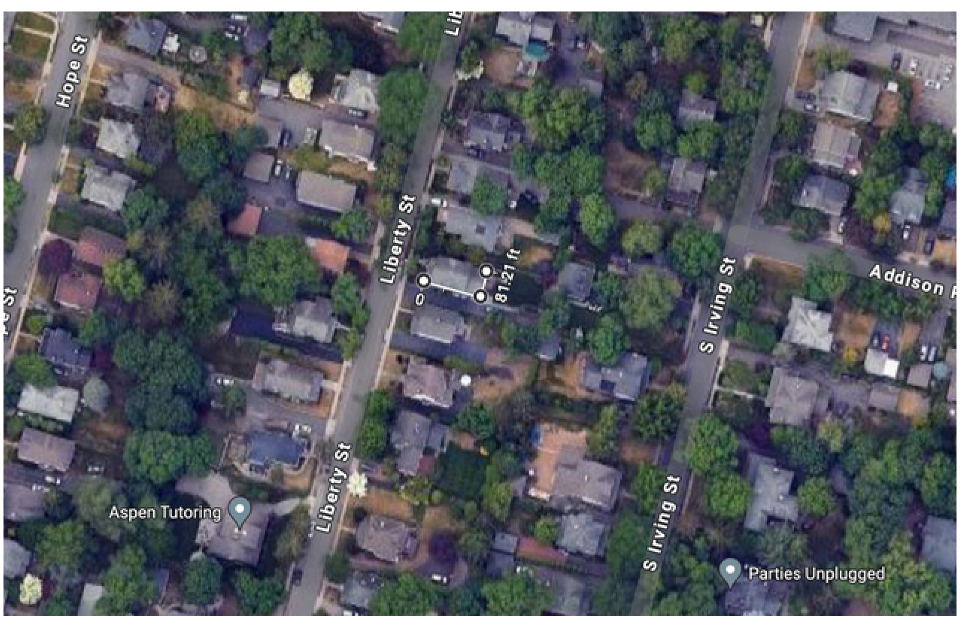


Figure 1.5 Average rooftop size in Ridgewood, NJ (Google Maps).

Rain Barrels

Storage Tank

Cistern

Figure 1.6 Rain storage options for residential rain capture (Monterey Bay Friendly Landscaping)

COST-BENEFIT ANALYSIS

In a 4.5-inches-precipitation scenario (i.e. precipitation in August):
Volume of rainwater reaching the rooftop = Roof area x Rainfall = 198,000 in2 x 4.5 in = 891,000 in3 = 3,857 gallons

So if the rain barrel fills every month, then a 55 ~ 60 gallon rain barrel can reduce 1.43% to 1.55% (55/3857 = 0.0142) of rainfall on a 25 foot x 55 foot roof. A 100 gallon rain barrel can reduce 2.6% (100/3857 = 0.0259) rainfall.

The public works department of San Diego County reports that one square foot of roof can capture 0.6 gallons of rainwater, which matches the capacity cited by Home Depot (Claudio, 2008). An example of an average rooftop in Ridgewood is about 1375 square feet (25 ft x 55ft). This means the average roof in the Village can capture 825 gallons of water. If each homeowner has one extensive 100-gallon rain barrel system (about $500), they can capture about 12% of the rooftop rainfall load (Rain Harvest).

Concerning the effectiveness of rain barrels writ large, the Saddle River flood zone area is about 19,358,760 square feet or 444.41 acres (FEMA). Assuming 4 feet of depth for floods, the flood zone can incorporate floods with a total volume of 77,435,043.84 cubic feet of water, or 579,254,353.92 gallons. Further assuming around 6000 homes in Ridgewood, if every home had a 100-gallon rain barrel, the total capture would be about .10% of the total flood volume. However, how all of this translates into direct flood-saving costs per resident is unclear.

Installing a private rain barrel system involves a thorough understanding of the financial commitment required. Table 1.5 presents a detailed cost analysis for setting up a rain barrel installation in a household that does and does not have existing gutters.

PRIVATE RAIN BARREL SYSTEM

The following is a detailed cost analysis for setting up a rain barrel installation in a household that does not have existing gutters

Category	Cost Range	Average
Required equipment		
Rooftop collection system (assuming no gutters)	$ 1,000 - $ 5,000	$ 3,000
Rain barrels	$ 70 - $ 840	$ 100 (55 gallon)
Conveyance system	$ 100 - $ 1,500	$ 800
Installation		
Rain barrel installation cost	$ 70 - $ 250	$ 160
Gutter installation cost		$ 1,030
Total (no gutters)		**$ 5,090**
Total (with gutters)		**$ 2,090**
Maintenance		
Water filtration system		$ 250 (per year)
A one-time gutter cleaning		$ 160
Optional		
Filtration syste for indoor	$ 75 - $ 200	$ 1,037.50
Irrigation syste	$ 4,000 - $ 7,000	$ 5,500

Table 1.5 Cost analysis for private rain barrel installation (with and without prior guttering).

PERMEABILITY SOLUTIONS

Another option to mitigate the impacts of flooding includes solutions to increase soil permeability in the Village. This general category of flood mitigation, which encompasses several potential strategies, could be explored to enhance infiltration and manage stormwater effectively. By considering these solutions, and potentially implementing them in future development projects or retrofitting existing areas, the Village of Ridgewood can work towards improving permeability, managing stormwater effectively, and enhancing overall environmental sustainability within the community.

Bioswales

Bioswales, characterized by shallow, vegetated drainage ditches, serve as a key component in stormwater management. Engineered with gentle slopes, vegetation, and specialized soil, bioswales are strategically placed alongside impervious surfaces like roads and parking lots. They function to capture, detain, and filter stormwater runoff, effectively reducing runoff speed and volume. Bioswales contribute not only to runoff reduction but also to water quality improvement, as the vegetation within them filters out pollutants, all while providing an aesthetically pleasing landscaping element.

Pervious Surfaces

Pervious surfaces, including permeable concrete, asphalt, and pavers, are materials designed to allow water to pass through, preventing surface runoff and facilitating groundwater recharge. Widely applicable to driveways, parking lots, sidewalks, and even some roadways, pervious surfaces offer benefits such as reduced runoff, groundwater replenishment, and effective removal of pollutants, contributing to sustainable urban development.

Green Infrastructure

Green infrastructure represents an innovative approach to managing stormwater and enhancing environmental sustainability. It incorporates various natural elements such as green roofs, permeable pavements, rain gardens, and vegetated swales. These features contribute not only to stormwater management by absorbing and slowing down runoff but also to biodiversity and aesthetics, as they provide habitat for wildlife and enhance the visual appeal of urban landscapes.

By incorporating green infrastructure into urban planning and development projects, Ridgewood can mitigate flooding risks, enhance groundwater recharge, and create more sustainable and resilient communities.

In the context of Ridgewood's flood mitigation, the adoption of green infrastructure elements and pervious surfaces both holds promise and presents challenges. Green infrastructure, including bioswales and green roofs, can bring about substantial benefits. It effectively manages stormwater, curbing surface runoff and reducing the risk of flooding during heavy rainfall. These elements also contribute to biodiversity conservation, enhance the aesthetic appeal of urban areas, and improve overall water quality by filtering pollutants. However, the initial costs associated with their installation can be a hurdle, and ongoing maintenance is crucial for sustained effectiveness.

Furthermore, permeable surfaces, such as permeable pavements, offer advantages like runoff reduction, pollution control, and versatility in application across driveways, parking lots, and sidewalks. While they can be durable and resistant to wear, their potential clogging over time requires regular maintenance. The initial costs are another consideration as, depending on the material used, projects can cost anywhere from $20,000-$35,000 per 1,000 square feet (Rutgers Water Resources Program). However, the long-term benefits in flood prevention and improved water quality may outweigh these challenges. It is important to note that, given Ridgewood's seasonally high water table, proper planning and adaptation to local conditions are imperative for the successful integration of these solutions, requiring community awareness and engagement.

REPLACING ARTIFICIAL TURF WITH NATURAL GRASS AND BORDERING WETLANDS

ARTIFICAL TURF

Another option Ridgewood can consider to alleviate the effects of flooding is replacing artificial turf with natural grass and bordering wetlands. Urban flooding arises from various factors, particularly the prevalence of impervious surfaces that hinder water's natural absorption into the ground. Given that non-porous surfaces escalate erosion, create rapid water flow, and lead to a greater accumulation of sediments in adjacent streams, it is critical to consider porous nature-based solutions.

Replacing the artificial turf of plots like Stevens Field and Ridgewood High School's field with permeable natural grass functions as a viable tool for flood-risk management. Additionally, planting native wetland grasses around the edges of the fields, especially along the riverfront sides, would help mitigate flooding and silt deposit events.

Natural grasslands can absorb rainwater much more effectively than conventional lawns, especially those with compacted soil or turf grass that is not native to the area. The difference is stark––conventional lawns can only absorb around 2 inches of water per hour compared to 14 inches per hour for natural grasslands (Penn State, 2020). This reduces surface runoff and allows more water to percolate into the ground. During heavy rainfall, these areas can temporarily store floodwater, acting as a natural buffer that slows down the flow of water and reduces peak flood levels. Moreover, by reintroducing native grasses and plants, these areas can help restore the natural hydrology of the landscape, improving the overall capacity of the environment to manage water flow and storage.

Moreover, compared to natural grass, turf fields cannot store carbon dioxide, counterproductive to the Village's goal of reducing municipal emissions. Turf fields can also contribute to warmer temperatures on the field because of the reduced ability to reflect solar radiation. For example, in NYC, on a day when the temperature was 78 degrees Fahrenheit, the artificial turf field reached a temperature of 140 degrees Fahrenheit. Contact with surfaces above 120 degrees Fahrenheit causes skin injuries (Claudio, 2008). Additionally, crumb rubber made from recycled tires is a common infill material for artificial turf fields and is associated with harmful chemicals, including carcinogens, endocrine disruptors, and neurotoxicants (Murphy, 2022). Chemical exposure through physical contact and inhalation of polyaromatic hydrocarbons and volatile organic compounds can negatively impact children's health (TURI, 2020).

WETLANDS

Wetlands are also pivotal for flood defense, with the capacity to hold up to 1.5 million gallons of floodwater per acre, as noted by the US EPA (US EPA, 2018). Beyond flood control, wetlands purify water pollutants and reduce the urban heat island effect, a prevalent concern in Ridgewood given its high percentage of impervious surface.

If Ridgewood decided to pursue a large-scale wetlands restoration program along its riverbanks, this program could support a diverse array of fish and wildlife, including roughly half of all species in the US listed as threatened or endangered (Ibid.). Specific siting of wetlands restoration projects would need to consider available land or land reuse projects, hydrologic modeling, and soil makeup. Generally speaking, though, restoration projects in as many feasible areas as possible would be advantageous.

The initial setup and restoration costs can be high, although these are often offset by long-term savings in flood management and environmental benefits. The economic benefits of converting sporting turf into wetlands and grasslands also include reduced need for expensive gray infrastructure, like detention basins or dams, and potential increases in property values due to improved landscape aesthetics and reduced flood risk (Monteiro, 2017).

CHALLENGES WITH NATURAL GRASS AND WETLANDS TRANSITION

High costs associated with artificial turf maintenance and replacement, inaccessability following flood events, and crumb rubber pollution of water bodies and associated health effects all underscore the need to transition away from artificial turf fields. However, there are certainly challenges associated with such a transition which cannot be ignored (Table 1.6).

Case Study

A research endeavor led by Tulane University, and published in Environmental Research Letters, delved into the role of wetlands in managing floodwaters. By examining the Brazos River basin in Texas, the team discovered that the integration of numerous smaller wetlands within a landscape can significantly bolster the flood mitigation effectiveness of larger water reservoirs. The findings suggest that a network of dispersed wetlands offers considerable advantages in terms of flood reduction and the provision of extra water storage capacity. Notably, the strategic arrangement of wetland areas proved to be as efficient in flood management as traditional dam structures. In an in-depth investigation using the Brazos River basin in Texas for their study, the researchers simulated over 140 wetland scenarios and assessed their performance relative to that of existing dams.

The outcome revealed that a network of small, strategically placed wetlands yields a noteworthy overall decrease in flood levels and provides additional water retention capabilities. The key insights from the study highlight the superior collective benefit of multiple smaller wetlands over a singular, large wetland area. This finding is important for Ridgewood who does not really have the space to set aside for a large-scale, singular restoration area. Additionally, the research pointed out that the benefits of adding wetlands to the flood management strategy begin to diminish after a certain number, indicating variability in individual wetland performance. Among the most significant findings was that the 18 most effective wetlands identified could increase the flood storage capacity of the area by 10% compared to the capacity of the largest existing reservoir, underscoring the supplementary role wetlands can play in flood management. Furthermore, an analysis comparing the impact of wetlands to dams on a per-unit basis confirmed that well-structured wetland systems can rival the flood control effectiveness of dams.

PROS	CONS
ENHANCES LOCAL ECOSYSTEMS	INITIAL CONVERSION PROCESS CAN BE COSTLY AND TIME-CONSUMING, WITH A PERIOD OF ADJUSTMENT BEFORE THE GRASSLANDS BECOME FULLY FUNCTIONAL.
GENERALLY MORE COST-EFFECTIVE TO MAINTAIN THAN TRADITIONAL SPORTS FIELDS BECAUSE THEY RECOVER NATURALLY FROM FLOODS	DIFFICULT TO MAINTAIN THE AESTHETICS IF IN CONSTANT USE
REDUCES THE RISK OF INJURIES, AND LONG-TERM HEALTH EFFECTS ASSOCIATED WITH ARTIFICIAL TURF MATERIALS	LIKE ARTIFICIAL TURF, THERE IS A PERIOD OF TIME AFTER FLOODING EVENTS WHERE FIELD IS UNUSABLE (THOUGH IT WILL NOT BE DAMAGED LIKE ARTIFICIAL TURF WILL BE)

Table 1.6 Pros and cons of transitioning from artificial turf to natural grass.

The transition back to natural turf and wetland restoration is not trivial, primarily due to the significant downtime required for athletic facilities. Fields would need to be out of service for one to two years to allow for the removal of artificial turf, soil preparation, planting, and establishment of natural grass. This operational gap poses a considerable challenge, especially given the limited availability of alternative fields.

With 13 fields under the Board of Education's management, many of which are small or undeveloped, the options for maintaining sports and recreational activities during the transition are constrained. If Stevens Field or the high school's field are unusable for a period of time during the transition, alternatives within Ridgewood will be limited.

As such, there is a need to explore alternative locations: the town should look into the temporary use of spaces not currently designated for sports. This might involve partnerships with neighboring communities, private entities, or reevaluating the use of currently undeveloped land and land slated for future transition.

COST BENEFIT ANALYSIS

According to a comparative analysis between artificial and natural turf done by the San Francisco Recreation and Park Department, installing a 90,000 square foot natural turf soccer field with new irrigation will cost about $300,000, which breaks down to about $3.30 per square foot (Morrison, 2005). The annual maintenance cost is about $42,000. An 80,000 square foot synthetic field with a sub-surface drainage system costs about $10 per square foot for a total of $800,000 (Morrison, 2005). The annual maintenance cost for artificial turf is about $6,000. Table 1.7 shows a summary of cost comparisons for this analysis.

The Ridgewood Board of Education reported that replacing a top layer of the current artificial turf football field is about $580,000. Using this information and the cost estimates from the San Francisco Recreation and Parks Department, we can calculate the net present value (NPV) for 8 years at a 2% discount rate. The NPV for natural grass for a 10-year period is about $3,270,818 versus a deficit of $651,379 for artificial turf, indicating that the natural grass installation cost may be a better financial assessment for the Village (Table 1.9)

Table 1.7 Summary of field material installation and maintenance costs from the San Francisco Recreation and Park Department analysis.

Type of Turf	Installation Costs	Annual Maintenance Costs
Normal	$ 260,000	$ 42,000
Synthetic	$ 800,000	$ 6,000
Diffrerence	$ 540,000 more initially for synthetic turf	$ 36,000 (more annually for natural turf)

An analysis of 80,000 square feet of field types found that the base installation costs for natural grass and turf fields are about $160,000 (including excavation, preparation, and engineering). Material costs for sod necessary for natural grass are $2.75 per square foot for natural grass and $4.50 per square foot for FieldTurf, about $220,000 vs. $360,000, respectively. The maintenance costs are about $52,500 for natural grass and $5,000 per year for FieldTurf field. Over 10 years, the average life cycle of a soccer field costs a total of $905,000 for a natural grass field and $570,000 for a synthetic turf field (Woodland Schools)(See Table 1.8). A 10 year cost comparison of a FieldTurf synthetic field versus natural grass can be found in Table 1.9. It should be noted that what follows is strictly a financial summary of material costs, excluding any health costs associated with artificial turf usage.

Table 1.8 Long term cost comparisons for natural grass and Fieldturf fields for Ridgewood, NJ.

CATEGORIES	NATURAL GRASS FIELD	*FIELDTURF* FIELD (SYNTHETIC FIELD)
BASE COST	$160,000	$160,000
MATERIAL COST	SOD $2.75 PER SQ FT X 80,000 SQ FT = $220,000	*FIELDTURF* ($4.50 PER SQ FT) X 80,000 SQ FT = $360,0000
MAINTENANCE (HERBICIDES, PESTICIDE, RESODDING, WATER, MOWING)	$52,5000 X 10 YEARS = $525,0000	$5,000 X 10 YEARS = $50,000
TOTAL PER 10 YEARS	$160,000+ $220,000 + $525,000 = $905,000	$160,000+$360,000+$50,0000= $570,000

Table 1.9 Summary of field material installation and maintenance costs from the San Francisco Recreation and Park Department analysis

Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Artificial turf	$ (260,000)	$ (42,000)	$ (42,000)	$ (42,000)	$ (42,000)	$ (42,000)	$ (42,000)	$ (42,000)	$ (42,000)	$ (42,000)	$ (42,000)
Natural grass	$ (800,000)	$ (6,000)	$ (6,000)	$ (6,000)	$ (6,000)	$ (6,000)	$ (6,000)	$ (6,000)	$ (6,000)	$ (6,000)	$ (6,000)
Cost Savings natural grass	$ 0	$ 580,000	$ 580,000	$ 580,000	$ 580,000	$ 580,000	$ 580,000	$ 580,000	$ 580,000	$ 580,000	$ 580,000
Cash Outflow for flooding turf field	$ 0	$ (580,000)	$ (580,000)	$ (580,000)	$ (580,000)	$ (580,000)	$ (580,000)	$ (580,000)	$ (580,000)	$ (580,000)	$ (580,000)
NPV (Natural grass)	**$ 3,270,818**										
NPV (Artificial turf)	**$ (651,371)**										

UNDERGROUND DETENTION SYSTEMS

Our team also considered underground detention systems as a feasible flood mitigation strategy. Underground detention systems operate by collecting and storing excess stormwater underground during heavy rainfall events, allowing it to slowly infiltrate into the ground or be released at a controlled rate to prevent flooding. They are typically modular constructions precast according to local specifications and assembled sectionally onsite. The stormwater can be stored in vaults, stone storage, pipe storage, and plastic grid storage and are typically designed for a 100-year flood event capacity (Power Engineers; PWD). Underground stormwater retention systems are used where infiltration is not considered feasible and space constraints prevent the use of surface infiltration.

For water to enter the basin, several sump entrances need to be set up on impermeable ground surfaces. When the water in the sump reaches its maximum carrying capacity, a pipe will allow the excess water to flow into the underground storage system. After flooding events, an outflow pipe––connected to the MS4 stormwater system during initial construction––can be used to discharge stormwater into the river. Alternatively, Ridgewood can initiate a pumping service to manually withdraw the water from the basin following a storm.

Inflow entrances often require pretreatment components to capture trash, sediment, and/or other contaminants in stormwater runoff (Figure 1.7). In addition, an observation well above the underground storage allows for the monitoring of conditions inside the system. Observation wells allow operators to check underground stormwater levels and the overall system status for maintenance and to ensure normal operation of the system (PWD).

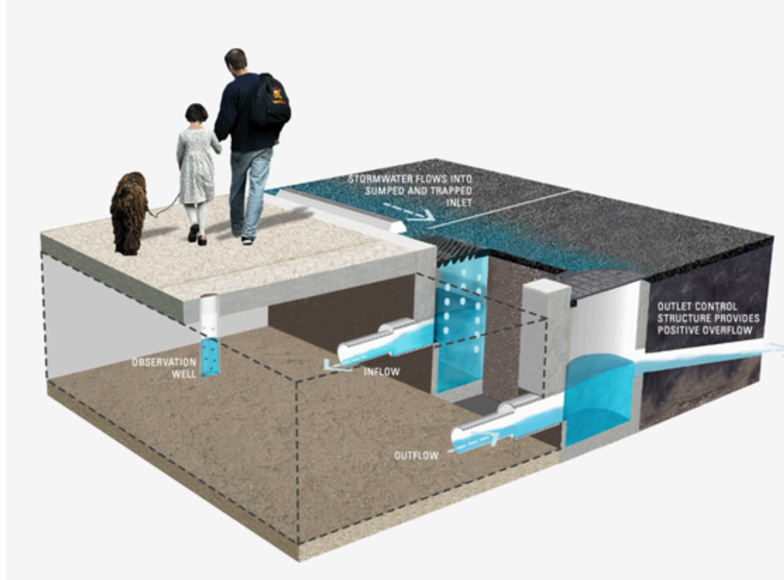


Figure 1.7 Subsurface Detention System Inflow and Outflow (PWD)

ADVANTAGES AND LIMITATIONS

The main advantage of underground retention stormwater systems is that they can manage stormwater runoff without taking up surface space and can be placed beneath lawns, recreational areas, parking lots, buildings, or other impervious areas with flexible design options. Also, because they generally employ a modular construction, the total storage capacity can be easily adjusted and can fit into almost any space/layout. These advantages can be well adapted to Ridgewood's current high surface occupancy rate, low soil water infiltration rate, and high underground water table conditions.

The main limitation of this method is that it may require some method of water filtration to meet the requirements of water inflow detention, otherwise, the debris in the water will block the water outflow. In addition, it is more costly and difficult to install and maintain underground storage systems, which require regular inspections and maintenance. Moreover, this method does not improve aesthetics or provide ancillary environmental benefits associated with vegetation, such as creating ecological benefits or natural habitats (PWD).

CATEGORIES OF UNDERGROUND STORAGE SYSTEMS

Underground storage systems are typically categorized into the following four types, as shown in the Table 1.10 and Figure 1.8:

Table 1.10 Types of underground retention systems

Type of Basin	Description
Underground Storage Vaults	Buried concrete, fiberglass, or polyethylene chambers.
Underground Stone Storage	Consists of buried stone beds wrapped in geotextiles that temporarily store and release stormwater. Stone storage beds provide the least amount of storage volume per unit area among the subsurface detention types. Removing sediment from underground stone storage is difficult, which necessitates effective pretreatment.
Underground Pipe and Chamber Storage	Consists of perforated plastic or metal pipes, or pipe-like linear chambers, that are placed in a stone bed to provide more storage per unit volume and temporarily store and release stormwater.
Underground Plastic Grid Storage	Consists of buried plastic structures that can be stacked and interconnected to form various shapes and sizes. Grid systems can provide as much as 95% void space for stormwater storage (PWD).

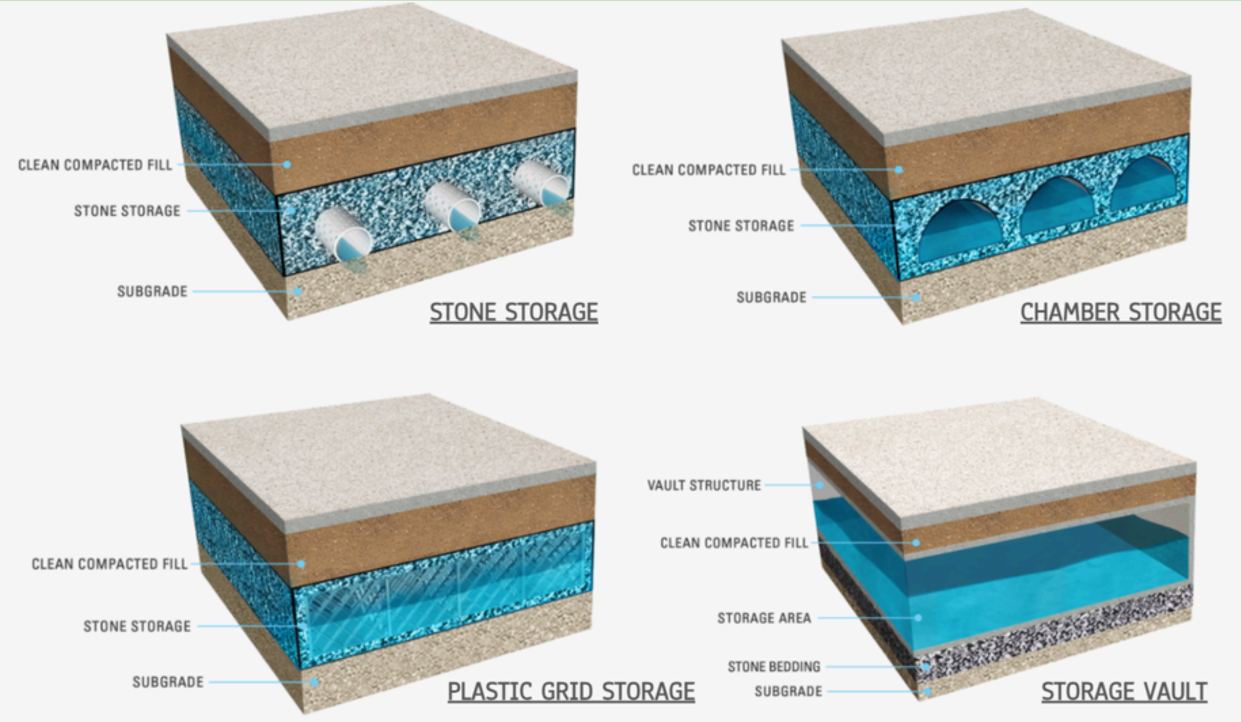


Figure 1.8 Categories of underground detention basins (PWD)

Figure 1.9: The plastic chamber storage detention basin system used in the Eastridge High School, NY (LaBella)

CASE STUDIES

UNDERGROUND DETENTION SYSTEM USED UNDER SPORTS FIELD

To combat water ponding on the grounds due to spring snowmelt and rainfall, Eastridge High School in Rochester, NY installed an underground water storage chamber beneath its artificial turf. This system conserves valuable land resources while complying with New York State Department of Environmental Conservation (NYSDEC) regulations for stormwater quantity and quality (LaBella, 2017). Similarly, in the Snättringe area near Stockholm, Sweden, an underground water storage system with a capacity of 1,600 cubic meters was used in response to the risk of flooding in low-lying areas during heavy rainfall events (Milford). Both cases use polypropylene chamber methods as the underground rainwater storage system.

UNDERGROUND DETENTION SYSTEM USED UNDER PARKING LOTS

The Skyline Trinity project, located in Dallas, Texas, uses water storage units installed beneath a parking lot. The system utilizes reinforced, high-strength precast concrete, which both meets the load requirements of the parking lot and accommodates sufficient local flood storage. For the Ridgewood parking lot project, a similar system could be adopted.

While considering the use of high-strength precast concrete materials to ensure system load requirements, modular design can be used to avoid possible pipe laying and other settings underground in the parking lot.

Both sporting fields and parking lots require efficient underground stormwater management systems, yet the specific design and functionality of these systems should reflect the unique functional and environmental demands of each application. Factors such as load-bearing capacity, environmental benefits, and available underground space vary significantly between these applications. Collaborating with engineering and environmental professionals can customize these systems to effectively meet these needs, ensuring long-term sustainability and compliance.

SITING OF SUBSURFACE SYSTEMS

The underground stormwater detention system would ideally be sited beneath the Ridgewood High School field, Stevens Field, or the Village Hall parking lot as these sites are both large enough to accommodate a subsurface basin and suffer some of the most deleterious flooding effects. However, the reality of implementing an underground stormwater detention basin in Ridgewood would involve careful planning, design, and coordination with relevant stakeholders. It would also require detailed engineering studies, environmental assessments, and regulatory approvals to ensure compliance with local regulations and standards. Additionally, community engagement and public awareness campaigns would be crucial to garner support for the project and address any concerns from residents.

Overall, while there are challenges associated with implementing such a system, the benefits in terms of flood risk reduction, water quality improvement, and groundwater recharge could make it a valuable investment for enhancing stormwater management in Ridgewood.

NON-LINEAR WEIRS

The first of our riparian options concerns nonlinear weirs. Weirs operate like dams in that they control the discharge of water at a particular location while influencing upstream and downstream water levels and current velocities. However, they do not store water, instead ensuring a continuous and steady discharge according to the river's streamflow. On average, weirs cost around $30 per cubic meter to construct (Toorn, 2010).

From a design standpoint, nonlinear weirs are more effective at mitigating upstream flooding than linear ones because they have a higher discharge coefficient. Since discharge capacity is proportional to crest length, the higher surface area of nonlinear weirs compared to their linear counterparts means they discharge water more efficiently. A primary concern with linear weirs is that they raise upstream water levels, but nonlinear weirs minimize that upstream head. They are so effective at discharge management that they are often used for spillways at dams. However, sediment transportation and deposition can be an issue with weirs.

Typically, most of the sediment will collect upstream of the weir, impacting the diversity of habitats. Downstream, reduced sediment collection often results in erosion of the riverbanks, which, depending on the severity of the storm, can result in downstream flooding. In general, Figure 1.10 shows the upstream and downstream impacts from weirs that need to be considered:

As addressed earlier, upstream water level is better mitigated by a nonlinear weir as compared to a linear one, but the specific height of upstream water levels is determined by the weir height. Weirs also tend to alter the diversity and productivity of stream ecosystems, not least because upstream current velocities slow significantly after construction (Mueller, 2011).

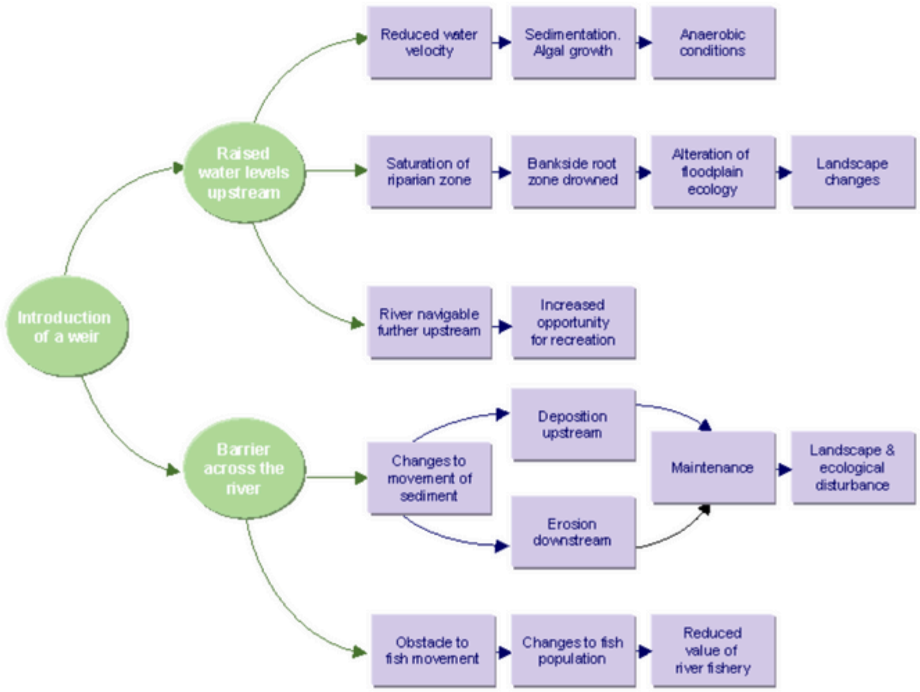


Figure 1.10 Examples of Environmental Impacts Resulting From the Introduction of Weir Adapted Mueller, 2011.

Other environmental impacts to consider include (Rickard, 2003):

- Water quality may suffer upstream
- Upstream conditions will favor flora and fauna which thrive in ponded conditions and with fine sediment
- Weir may obstruct fish movement depending on its height and design
- Velocity of flow downstream is typically varied and turbulent
- Sedimentation downstream tends to create spawning grounds for salmonids
- Tugging currents downstream create habitat for invertebrates
- If there are riparian flood zones downstream (like wetlands), they may suffer

There are also several legal and logistical matters that will need to be considered before constructing or adjusting the design of a weir: an Environmental Impact Statement (EIS), as mandated by the National Environmental Protection Act (NEPA), will most likely be required; written approval by downstream townships who may be adversely affected by higher discharges from the nonlinear weir will also be needed; a detailed hydrological study of the two water bodies, especially at their confluence will be necessary; and a NJDEP permit will likely be needed. All of these considerations will cost money and take time to gather.

There is currently a decommissioned linear weir at the confluence of the Ho-Ho-Kus Brook and Saddle River, originally constructed to provide water for a now-defunct utility. If all upstream and downstream impacts are appropriately considered, a nonlinear weir at this spot might prove productive. However, the confluence is some way downstream from the sites of major flooding events, and given the relatively small width of the water bodies, it is likely that a weir that far downstream will not exert much influence on flood events. More data is needed to determine possible sites for a nonlinear weir further upstream.

REDIRECTION OF THE BROOK

Redirecting the Ho-Ho-Kus Brook and/or Saddle River is probably the most complex and costly of the options for flood mitigation. However, such projects may largely solve Ridgewood's flooding problem.

In general, there are significant advantages to redirection of rivers for flood mitigation:

- Flood Risk: Redirection can significantly reduce the flood risk in vulnerable areas by channeling water away from residential zones and critical infrastructure. They are generally more effective and sustainable than levees (Sara-Llobet, 2022).
- Opportunity for Urban Renewal: Redesigning the Brook's course can be integrated with urban development plans, offering a chance to revitalize areas and improve public spaces along the new watercourse (Sara-Llobet, 2022).
- Regulatory Compliance: The project can be designed to meet NJDEP's stringent regulatory oversight by ensuring minimal impact on the local water table and ecosystem.
- Ecological Benefits: The project can be great for regional ecology if it is used to reconnect floodplains.

However, there are several noticeable disadvantages to river redirection (Flatley, 2018):

- High Costs and Complexity: The process of redirecting a watercourse is complex, requiring significant investment in planning, engineering, and construction. The financial burden can be substantial. Managing the split in flow, managing debris/sediment accumulation, and accelerated erosion due to variable flow are all factors to consider.
- Environmental Impact: Altering the Brook's path can disrupt local ecosystems, affecting flora and fauna dependent on the original watercourse. There may also be unintended consequences on downstream water quality and sedimentation patterns.
- Home Rule: Redirecting a water body usually involves collaboration among neighboring townships and counties. Bergen County has traditionally avoided becoming embroiled in town-specific projects, but the County will need to play an active role in a redirection project as it is liable to affect a notable percentage of their constituents. Additionally, the leadership that Bergen County is able to offer might inspire neighboring communities to work more closely with Ridgewood on the project.

REDIRECTION IN RIDGEWOOD

The Ho-Ho-Kus Brook averages around 60 cubic feet per second (cf/s) in the wet season and can top out at over 1000 cf/s during flood events. This presents an enormous strain on embankments and sediments, as evidenced by the large quantity of silt deposited after some flood events. As such, any redirection of the Brook or Saddle River will need to account for accelerated erosion and structure the diverting channel accordingly.

Following a site visit evaluating the possibility of redirecting part of the Ho-Ho-Kus Brook to 16 Acres Park in Ho-Ho-Kus Borough, the research team determined that such a redirection is unfeasible given the logistical and political challenges. 16 Acres Park, however, maybe a good spot for the partial redirection of the Saddle River.

Redirection of the Ho-Ho-Kus Brook in Ridgewood is a promising option, but given the amount of impervious surface in the town, and the fact that diversion needs to happen as far upstream within municipal limits as possible (assuming Ridgewood is not collaborating with other townships), diversion outlets are limited. There are, however, two possible locations. Irene Habernickel Family Park on the northernmost border of Ridgewood lines the Brook and provides around 5 acres of land in which a diversion could be situated. In fact, there seems to be an outlet already in place which has created a small pond in the park. For this to work, however, the entire park (which currently contains a baseball field, a playground, and a small parking lot) would have to be closed and restored to a natural wetland. Secondarily, just to the east is the Upper Ridgewood Tennis Club. This area seems to be surrounded by forest and natural wetlands. If the forested space to the south of the Tennis Club and bordering the storage facilities were earmarked as an outlet for Ho-Ho-Kus Brook redirection, then it would be around 10 acres of storage––equivalent to 10-15 million gallons of floodwater storage during peak flood events (EPA, 2003). Extra care would need to be taken to ensure the outlet does not run up against homes or businesses on the west side of the forest.

Source: The New York Times, 2019

GATE-ACTIVATED REDIRECTION

A crucial component of the redirection would be its potential to be gate-activated. This is already being done on the Mississippi River, albeit on a bigger scale:

In an effort to redirect sediment toward areas of the Mississippi River delta that are threatened by sea level rise, the Army Corps of Engineers is planning a diversion of the River that will create 27 square miles of marshland by 2050 (Figure 1.11) (Schleifstein, 2021). Crucially, the River is not running freely into this diversion, but is instead channeling only 7.5% of its capacity. A gated structure at the mouth of the channel will open when the River's flow reaches 450,000 cf/s, and 25,000 cf/s of water will then surge through the channel, carrying sediment with it. This amount is scaled up to 75,000 cf/s when the River's flow reaches 1 million cf/s.

The Mississippi River is orders of magnitude larger than any water body in Ridgewood. This example, however, is important because it demonstrates what is possible. A gate-activated redirection could be designed to operate when the Ho-Ho-Kus Brook reaches, for example, 300 cf/s (simulating a minor flood event). Downstream ecology and recreation would be preserved during normal flow rates.

For diversion projects, the NJDEP will have to be involved as one of the first permit issuers. Depending on the classification of the Ho-Ho-Kus Brook and Saddle River (whether they are A, B, C, or D water bodies), additional studies and permits may be required. If the Army Corps of Engineers is involved with the project, an EIS pursuant to NEPA will be required, a process which is likely to take at least a year given the necessary public comment period and time for revision. Coordination with downstream municipalities may also be required too.

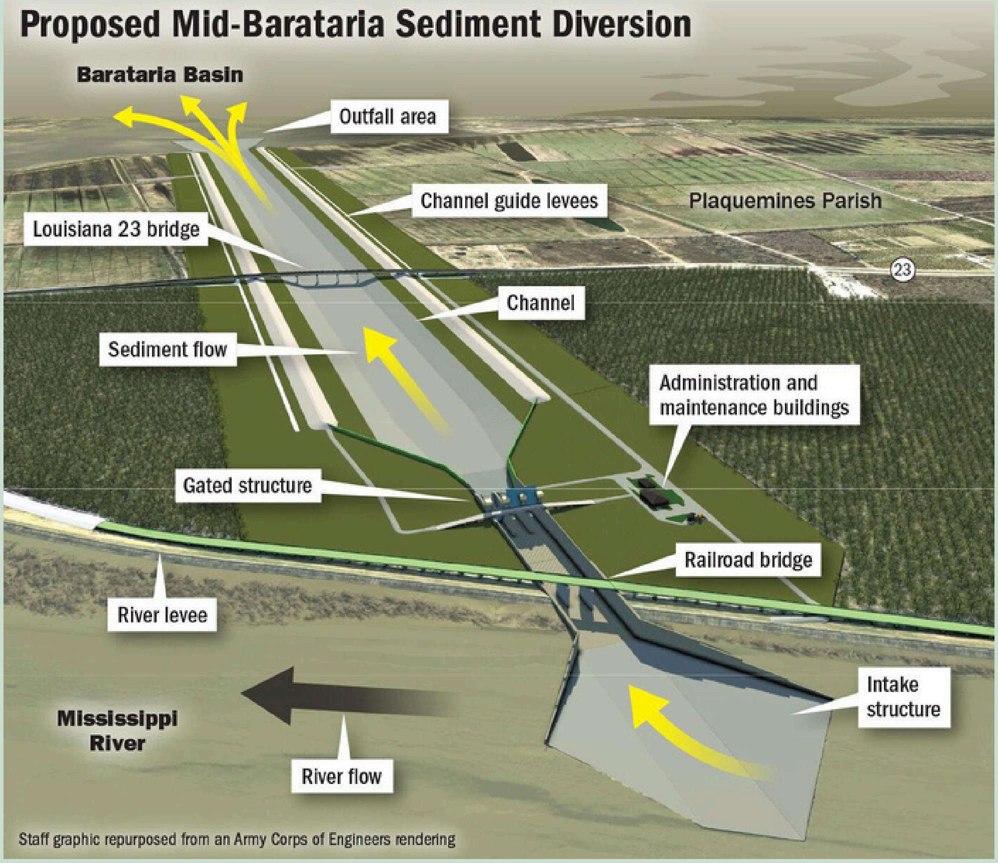


Figure 1.11 Rendering of the river diversion planned along the Mississippi River by the Army Corps of Engineers (Schleifstein, 2021).

BARRAGES

The last riparian solution we proposed concerns barrages. A barrage, functioning as a barrier across a river that controls water flow and levels, can be a significant part of flood management strategies. Unlike dams, barrages do not store water but manage flow to mitigate flooding risks. Barrages can regulate the amount of water flowing through a river, reducing the risk of sudden flooding downstream. Adjustable gates allow for the flexibility to respond to varying water levels, offering protection against both minor and major flood events.

There are some notable advantages associated with barrages:

- **Flood Control and Water Management:** Barrages can regulate water flow, storing excess water during heavy rainfall and releasing it gradually. This method has been effective in regions like Sacramento, California, where a series of barrages and levees protect the city from the Sacramento River's floods.

- **Multipurpose Use:** Beyond flood control, barrages can support irrigation, improve navigation, and even generate hydroelectric power, offering multiple benefits to the community.

- **Multipurpose Water Management:** Beyond flood control, integrating rain barrels and subsurface retention basins near barrages can capture and reuse stormwater, reducing reliance on the local water table and mitigating downstream impacts.

- **Community Engagement and Incentives:** Offering incentives for rain gardens and rain barrels encourages community participation in flood mitigation efforts, fostering a collective sense of responsibility towards water management.

However, there are also some notable disadvantages:

- **Financial and Political Feasibility:** Implementing advanced stormwater management solutions in conjunction with barrages may face financial and political hurdles, especially when considering the need for extensive permitting and potential impacts on downstream communities.

- **Operational and Maintenance Demands:** The complexity of managing a barrage system alongside sustainable water management features requires ongoing maintenance, monitoring, and community cooperation. The operational burden may include managing the water quality and ensuring the functionality of rain gardens and rain barrels, particularly in residential areas.

- **Potential Environmental and Social Impact:** There can be impacts on local wildlife habitats, changes in land use, and the need for community adaptation to new water management infrastructures.

Source: Gracon LLC

Research highlights the multifaceted nature of flood risk management, emphasizing that successful approaches must address the interconnectedness of infrastructure, economic systems, and human factors (Jonkman, 2012). The challenge lies in developing strategies that remain effective under uncertain future conditions, accommodating the dynamic nature of flood risks exacerbated by climate change and urbanization.

In assessing the potential for barrages as a flood management solution for Ridgewood, it is crucial to incorporate robust and academically validated findings alongside practical considerations of local geography, hydrology, and urban development. The effectiveness of flood risk management strategies, including barrages, relies on a nuanced understanding of these factors. However, while barrages offer control over water flow, their effectiveness also heavily depends on accurate flood forecasting and the ability to quickly adjust water levels. Sometimes barrages only require a few hours to adjust water flow, but this time ultimately depends on factors like the design of the barrage, the volume of water to be managed, and the situation's urgency.


Source: Wikipedia

Given Ridgewood's specific challenges—namely the high degree of urban development, the outdated stormwater management infrastructure, and the unique characteristics of the Ho-Ho-Kus Brook and Saddle River—a tailored approach is necessary. This strategy should not only consider the implementation of barrages but also evaluate their integration with wider flood management practices, including the restoration of natural water absorption capacities and the adoption of innovative stormwater management technologies.

Drawing on these insights, a barrage for Ridgewood would involve a dual approach:

To implement barrages, the town needs to evaluate the feasibility of barrages for immediate water flow control, especially in critical areas prone to rapid flooding. This requires detailed hydrological studies to ensure the design accommodates the updated 100-year return period for precipitation, including increased precipitation intensity. While the initial costs of constructing a barrage in Ridgewood might be high, the long-term benefits, including reduced flood damage and improved water management, could justify the investment. However, it is crucial to consider the environmental impacts and ensure that any intervention aligns with sustainable development goals. Implementing barrages should be part of a holistic approach to flood management, incorporating both structural and non-structural measures to enhance the town's resilience to flooding.

DECARBONIZATION

EMISSIONS OVERVIEW

In 2020, Ridgewood's total Scope 1 and 2 emissions were approximately 216,381 metric tons of carbon dioxide equivalent (MT CO2e), with an emissions intensity (i.e. the emissions per capita) of approximately 8.3 MT CO2 e across Ridgewood's 26,202 current residents (Sustainable JerseyA). While this is well below the national average of about 15 MT CO2e, it is still significantly higher than the per capita emissions required to limit global warming to 1.5 degrees Celsius (Statista, 2023). Figure 2.1 breaks down Ridgewood's 2020 emissions profile by scope. As seen, Scope 1 emissions, which include the emissions associated with the on-site use of natural gas and other fuels for heating purposes, as well as vehicular fuels, make up the majority of Ridgewood's overall emissions (nearly 84%). The data used in this analysis is from a comprehensive Greenhouse Gas Accounting study conducted by Sustainable Jersey, a certification program that recognizes municipalities and schools for achieving high standards of sustainability. The study measured community-wide emissions in 2015 and 2020 for towns across the state.*

It is important to note that the only data currently available is community-level data on Ridgewood's (and other New Jersey towns') emissions and energy initiatives gathered by the Sustainable Jersey team. This data does not make a distinction between municipal and community-wide operations, and thus does not have the level of granularity required to effectively calculate municipal emissions.

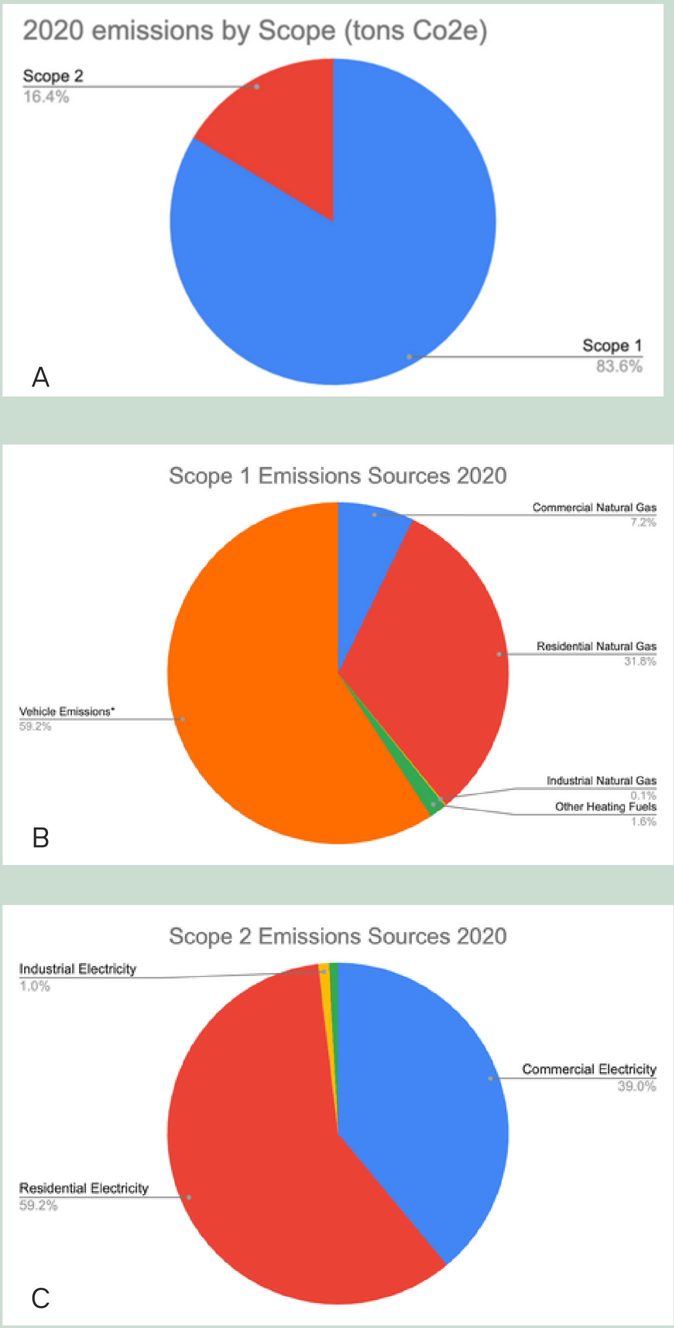


Figure 2.1: Scope 1 and 2 emissions profiles in 2020.

*Between 2015 and 2020, both the absolute emissions and the emissions intensity fell slightly, by about 8,000 and 0.55 metric tons CO2e respectively. However, as 2020 was an anomalous year due to COVID-19, this reduction in emissions can be ignored. While 2020 is not the ideal base year, it is the best data available for use.

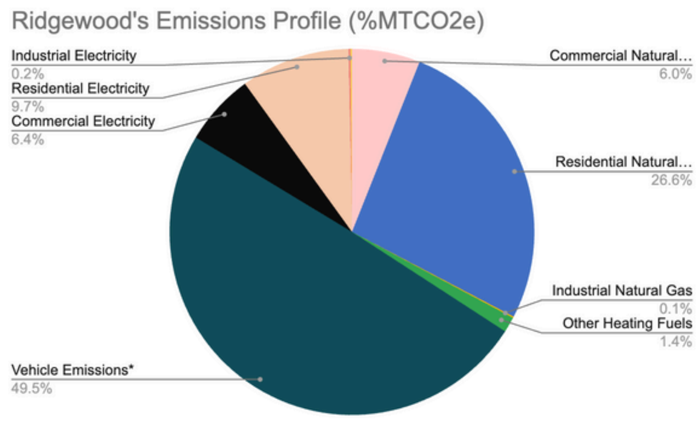


Figure 2.2 A complete breakdown of Ridgewood's total emissions by source in 2020.

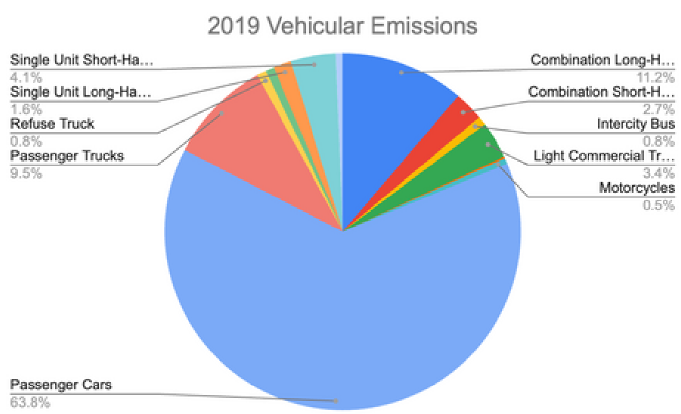


Figure 2.3 Breakdown of the contributing sources of vehicular emissions in Ridgewood. As seen in the figure, passenger cars make up a majority of the emissions, followed by combination long-haul trucks.

Ridgewood Solar Panels over a school parking lot

As seen in Figure 2.1 (B) the primary source of emissions in the Scope 1 category comes from gasoline-powered vehicles. Of these, passenger vehicles made up the bulk of the emissions (Figure 2.3). Although Ridgewood has increased its percentage of electric vehicles (EVs) from 0.15% to 1.84% from 2015 to 2020, the emissions from passenger vehicles, and in overall vehicular emissions, increased from 2017 to 2019 (Figure 2.3). Additionally, short haul and long haul trucking in both single unit and combination vehicles expanded greatly from 2017 to 2019, allowing for these emissions sources to play a larger role in overall emissions in Ridgewood. Anecdotally, Ridgewood has likely increased its overall registration of EVs since 2019 by a significant margin, however the total EV capacity is impossible to measure without access to current vehicle registration information (Refkin, D., Personal Communication, 2024).

Of the Scope 2 emissions, which refers to the emissions associated with purchased electricity, residential electricity use makes up the largest portion (nearly 60%), as seen in Figure 2.1 (A). Residential electricity use also accounts for over a quarter of the total emissions across both categories (as depicted in Figure 2.2).

AN ESTIMATION OF RIDGEWOOD'S EMISSIONS IN 2024

Using the difference between Ridgewood's 2015 and 2020 data to approximate the town's emissions trajectory, a rough estimate of Ridgewood's current emissions in 2024 can be expected to be around 216,900 MT CO2e using simple linear regression. Without interventions on a municipal scale to reduce the town's cumulative emissions, this figure can be expected to increase by over 1,100 metric tons, the equivalent of driving 4.8 million miles (CO2 Converter).

To align with New Jersey's Energy Master Plan (i.e. to meet the global 1.5 degree Celsius warming scenario), Ridgewood will need to achieve 100% emissions reduction, or net-zero, by 2050 (Figure 2.4 and 2.5). This would require Ridgewood to reduce its total emissions by at least 42% by 2030, which would amount to around 50,000 MTCO2e.

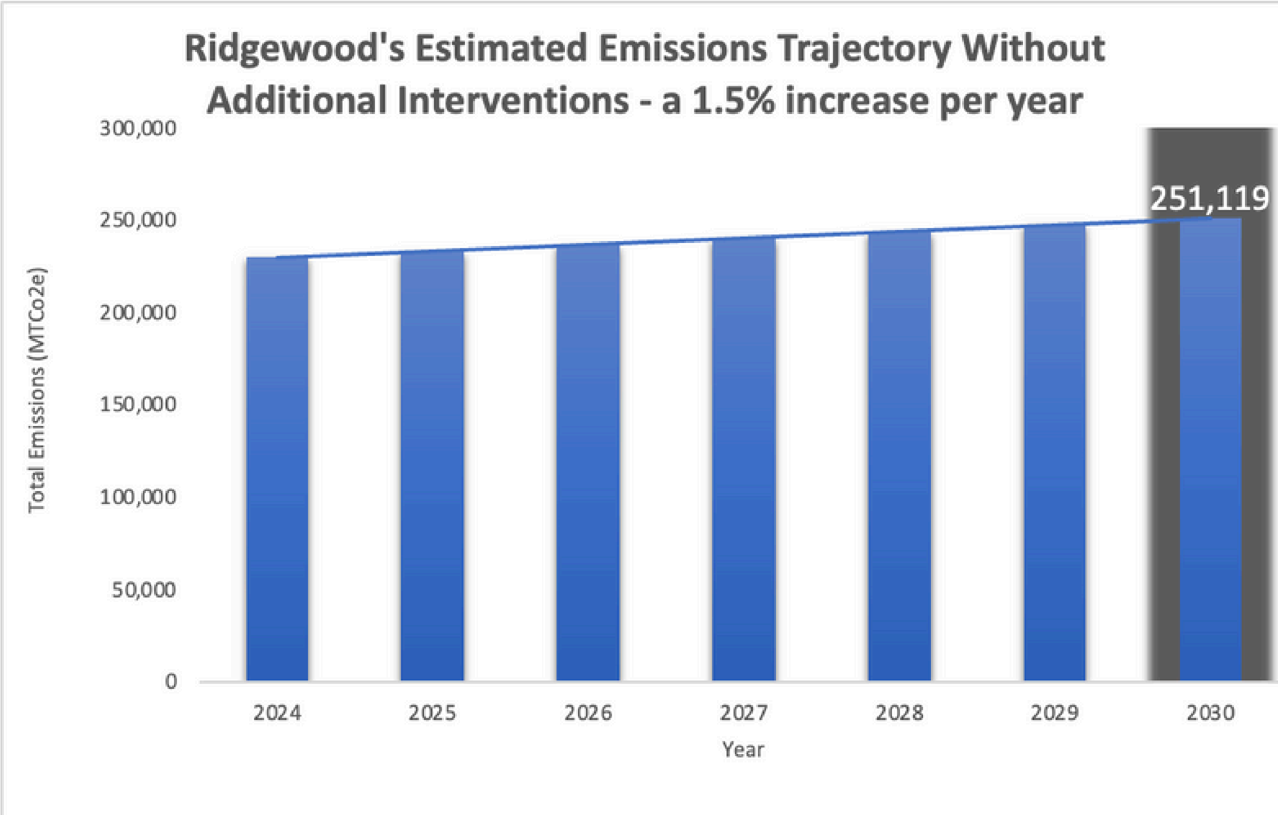


Figure 2.4 Current trajectory of Ridgewood's emissions without any interventions. Described in further detail in the Appendix.

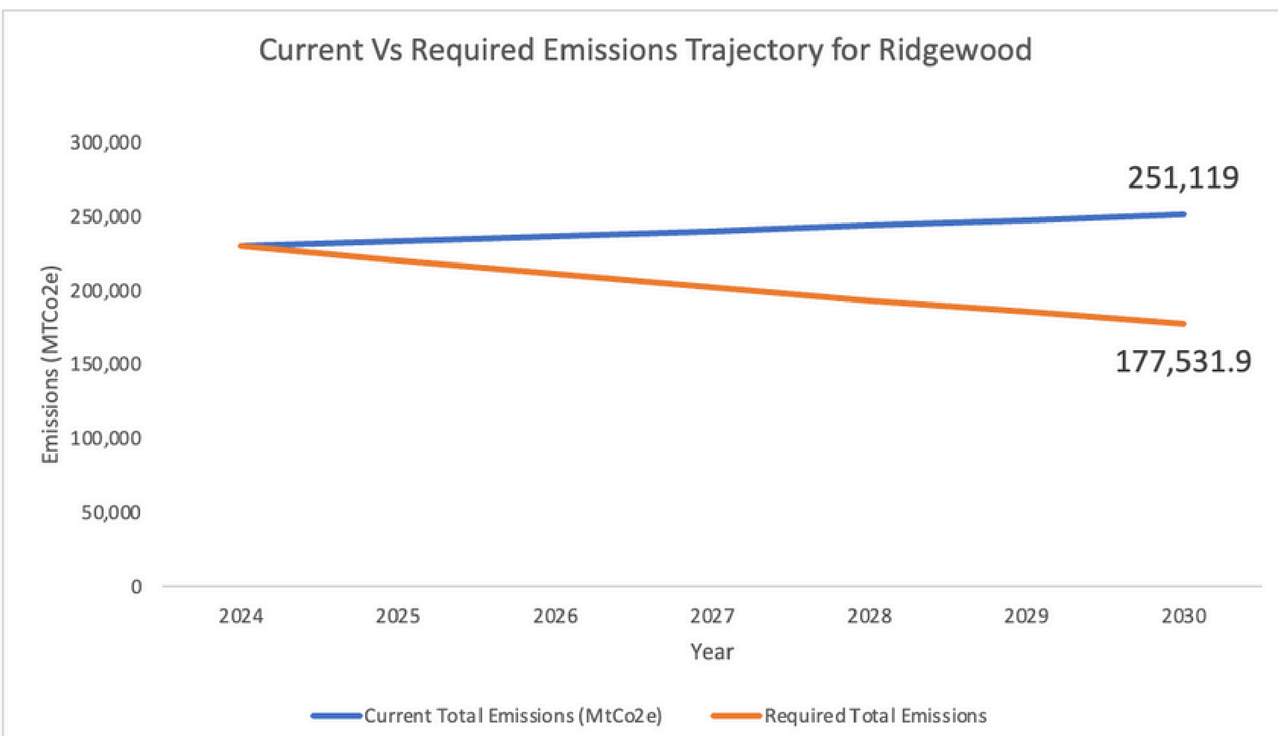


Figure 2.5 Current Vs Required Emissions Trajectory

A SUMMARY OF THE CURRENT DECARBONIZATION INITIATIVES IN RIDGEWOOD

Ridgewood currently has several initiatives in place to decarbonize its infrastructure. One initiative focuses on the adoption and expansion of solar energy systems to enhance the town's renewable energy capacity. As of 2020, the generating capacity of solar installations in Ridgewood is at least 2,083.6 kilowatts (kW), although actual solar capacity is likely higher (Judge, J., Ridgewood Fire Department Chief, Personal Communication, 2024). This capacity comes from 143 approved solar installations, of which 4 are commercial, 15 are classified as other, and the remainder are residential. These installations also include municipal on-site solar systems at 201 East Glen Avenue, Village Hall, the Water Pollution Control Facility at 561 Prospect Street, Glen Rock, and the Ridgewood Emergency Medical Services building at 33 Douglas Place, as well as at 8 schools in the Ridgewood School District (Village of Ridgewood, 2022).

From June 2020 - June 2022, Ridgewood also entered into a two-year contract, similar to a Power Purchase Agreement (PPA), to ensure its power supply from PSE&G included a higher percentage of renewable energy sources in its energy mix. This arrangement mandated the inclusion of 5% more energy from renewable sources than what New Jersey's Renewable Portfolio Standards typically require (Chilton, R., 2021). However, the current energy supply received by Ridgewood from PSE&G is composed of only ~6% renewable energy, which is overshadowed by the over 17% of energy supplied coming from coal, as pictured in Figure 2.6 (PSE&G, 2023).

To address energy supply, Ridgewood can explore more assertive strategies such as negotiating a more impactful PPA that stipulates not just increased renewable content, but also a specific reduction in coal usage.

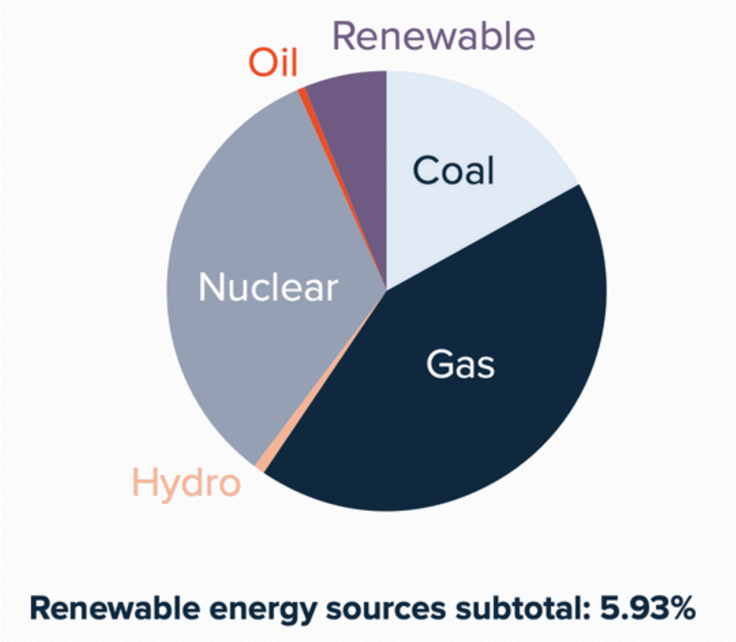


Figure 2.6 2023 PSE&G Electricity Supply Mix for Ridgewood, NJ (PSE&G, 2023).

Further, there is a significant opportunity for Ridgewood to lead or join a coalition of Bergen County municipalities to collectively pressure PSE&G to reform their energy sourcing more drastically. By presenting a united front, the collective bargaining power of these municipalities could effect meaningful changes in PSE&G's energy policy, potentially setting a precedent for other regions.

Furthermore, the town has installed 4 EV charging stations in its new parking garage, and implemented several initiatives to improve air quality. These initiatives include, but are not limited to, establishing smoke-free and tobacco-free public spaces, developing a Community Forestry Plan, and adopting a tree protection ordinance (Village of Ridgewood, 2023).

Businesses and residents in Ridgewood have also taken steps towards decarbonization. Valley Health has committed to reducing 50% of its Scope 1 and 2 emissions by 2030, and as of 2020, almost 2% of the approximate 16,000 personal vehicles in Ridgewood were electric vehicles (Sustainable JerseyA; Williamson, L., 2022).

As a result of some of these initiatives, Ridgewood earned a bronze certification from Sustainable Jersey in 2023, indicating that the town has not only committed to sustainability but has also achieved meaningful progress in its initial sustainability efforts.

SUSTAINABLE JERSEY

Sustainable Jersey is a collaborative initiative involving municipalities, schools, and districts aiming to promote sustainability across New Jersey. Working alongside state agencies, nonprofits, academia, and industry, it identifies and encourages best practices for sustainable community development, rewarding those that meet specific criteria with a certification (Sustainable JerseyB).

Sustainable Jersey offers two levels of certification: bronze and silver. The difference between these two certifications is that the silver certification requires municipalities to earn at least 200 more points, implement one more priority action item, and complete two more actions than are required for the bronze certification.

Sustainable Jersey also offers 'Gold Star' ratings for three categories: energy, health, and water. Achieving a Gold Star Standard in energy requires municipalities to demonstrate a reduction in greenhouse gas (GHG) emissions from municipal operations by an average annual rate of 3.6% over 3 years, as well as secure approval for 6 community energy action items, requiring 2 actions from each of the following categories: energy efficiency, renewable energy, and transportation (Sustainable Jersey, 2023). Presently, no community in New Jersey holds a Gold Star Standard in energy.

Given the limited data on electricity, gas, and heating fuel usage at the municipal level, along with the requirement for information from third-party stakeholders on current municipal vehicle fleet characteristics, municipal waste generation, and significant municipal purchases, it seems unlikely that Ridgewood will achieve its goal of Gold Star certification in the near term. If Ridgewood can compile its municipal emissions sources as defined above, it may be the case that municipal operations have reduced their emissions over the last three years, however without targeted initiatives to reduce municipal emissions, such reductions would be by happenstance. Ridgewood would additionally need to secure approval for 6 community actions as defined above.

FEASIBILITY OF POTENTIAL INITIATIVES

Some potential initiatives that can help reduce Ridgewood's electricity consumption and vehicular emissions include, but are not limited to, establishing green PPAs, park and rides, carpooling, a community microgrid, and bike lanes/jitneys, as well as transitioning to EVs, enhancing building efficiency, and improving waste management (Figure 2.7).

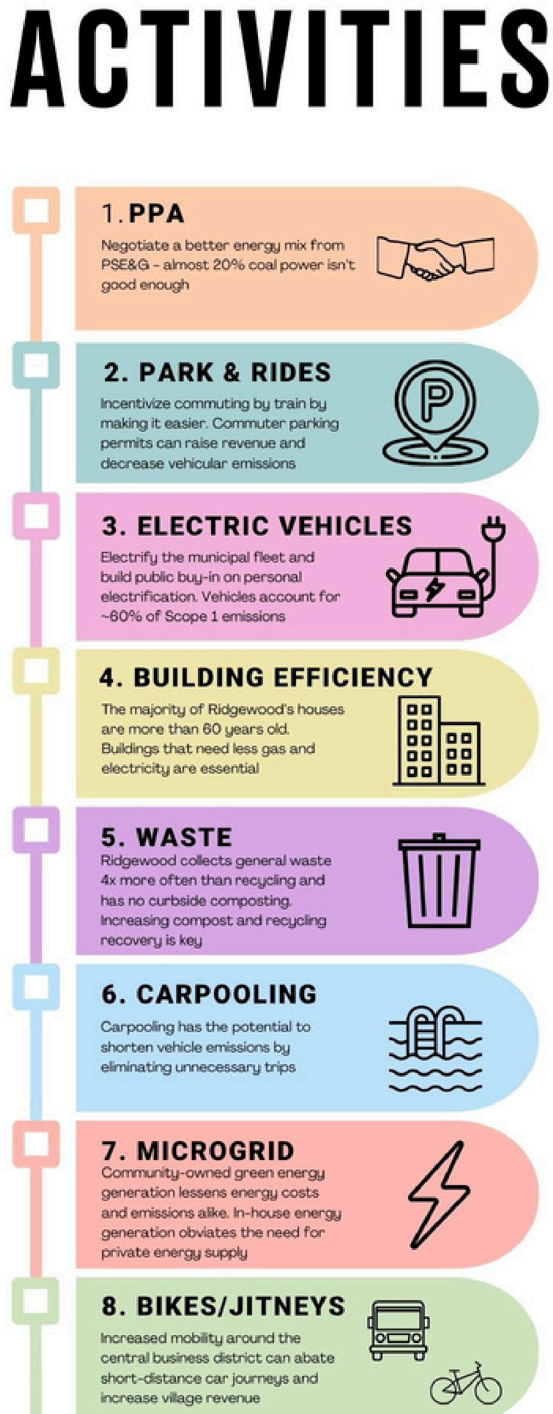


Figure 2.7 List of potential decarbonization initiatives for Ridgewood

This range of potential decarbonization programs were considered as part of the decarbonization portfolio for Ridgewood in order to meet the necessary emission reduction targets as specified by the New Jersey Master Plan. Table 2.1 summarizes the approximate cost of each program under consideration, each program's capacity to reduce GHG emissions, the overall cost effectiveness of each program, and the long term limit on GHG reduction pathways. Further details on the assumptions underlying all assessed programs are listed in the Appendix.

While this analysis primarily focuses on the direct financial costs, it is also important to acknowledge the broader societal impacts of carbon emissions. The social cost of carbon, estimated by the Biden Administration at $51 per ton of carbon, quantifies the economic damages associated with a metric ton of carbon dioxide emissions (Davenport, 2023). In future efforts, integrating the social cost of carbon could provide a more comprehensive understanding of the true economic and environmental impacts of our decarbonization strategies.

Table 2.2: Summary of the proposed initiatives' timeline, feasibility, and long-term efficacy

Activity	Estimated Total Emissions Reduction (MTCo2e/year)	Estimated Cost Effectiveness ($/MTCo2e)
Interventions for Vehicular Emissions		
Bicycle Shares	86, assuming a 100 bicycle fleet	$6,163
Carpooling	5,179	$4
Park & Ride	1700	NA
Municipal Fleet Electrification	1288	$547, assuming a vehicle life of 11 years
Walk to School Campaign	1.8	$556
Interventions for Energy Use		
Municipal Solar Electrification	1460	$176 assuming the panels last for 25 years
Green Power Purchase Agreements	40,000+	$109
Building Energy Efficiency Grants & Ordinances	66,480	NA
Other Initiatives		
Ordinances for electric leaf blowers	168	no cost to town, costs borne by residents
Recycling Mandates	42,556	$47

Given the above efficacy of each decarbonization program, a rudimentary analysis of total required funding, implementation timelines, community engagement, relative reduction capacity, and long term program sustainability is listed in Table 2.2:

Table 2.2: Summary of the proposed initiatives' timeline, feasibility, and long-term efficacy

Activity	Capital Intensive (>$50,000)	Implementation Timeline	Community Engagement Needed?	Achievable Impact in Ridgewood	Sustainable in the Long Run?
Interventions for Vehicular Emissions					
Bicycle Shares	Yes	Medium-term (2-5 years)	Yes	Low (<100 MTCo2e)	Depends
Carpooling	No	Short-term (0-2 years)	Yes	High (>1000 MTCO2e)	Depends
Park & Ride	No	Short Term	Yes	High	Yes
Municipal Fleet Electrification	Yes	Medium-term	No	High	Yes
Walk to School Campaign	No	Short Term	Yes	Low	Depends

Table 2.3: Summary of the proposed initiatives' timeline, feasibility, and long-term efficacy

Activity	Capital Intensive (>$50,000)	Implementation Timeline	Community Engagement Needed?	Achievable Impact in Ridgewood	Sustainable in the Long Run?
Interventions for Energy Use					
Municipal Solar Electrfication	Yes	Long-Term (+ 5 years)	Yes	High (>1000 MTCO2e)	Yes
Green Power Purchase Agreements	No	Short-term (0-2 years)	Yes	High	Depends
Building Energy Efficiency Grants & Ordinances	No	Medium-term (2-5 years)	Yes	High	Yes

Activity	Capital Intensive (>$50,000)	Implementation Timeline	Community Engagement Needed?	Achievable Impact in Ridgewood	Sustainable in the Long Run?
Other Initiatives					
Ordinances for electric leaf blowers	No	Short-term (0-2 years)	Yes	Medium (100-1000 MTCO2e)	Yes
Recycling Mandates	Yes	Medium-term (2-5 years)	Yes	High	Yes/Depends

HOW TO USE THE DATA: MAPPING EMISSIONS PATHWAYS

The data on the previous pages can be used to map potential emissions pathways to achieve the year-on-year reduction targets illustrated previously. Table 2.4 below displays potential emissions pathways for the 2025 - 2027 period using various combinations of these initiatives.

Table 2.4 Estimated emissions reduction targets from 2025 - 2027 across recommended initiatives.

2025		2026		2027	
Activity	**Additional Emissions Reduction (MT CO2e**	**Activity**	**Additional Emissions Reduction (MT CO2e**	**Activity**	**Additional Emissions Reduction (MT CO2e**
50% Green electricity sourcing for commercial businesses (PPA)	7326	100% Green electricity sourcing for commercial businesses	7326	30% Green electricity sourcing for residences	6870
Electric leaf blower ordinance	168	Electrify 2 municipal cars	9.2	Electrify 3 municipal cars	13.8
Park and Ride	1700	100% Green electricity sourcing for industry	1477	30 kW Municipal Solar	20.1
Solar panels for streetlights	310	Walk to School campaign	1.8	Ordinance for 10% reduction in commercial natural gas use	1451.1
Total Achievable	**9504**	**Total Achievable**	**8814**	**Total Achievable**	**8355**
Required to meet target	**9265.3**	**Required to meet target**	**8644**	**Required to meet target**	**8346.1**

It is important for Ridgewood to be able to quantify both the projected and the observed impacts of their decarbonization initiatives to be able to measure the success of these initiatives.

CASE STUDIES

COOPERATIVE SOLAR GRAND VALLEY, CO

In 2011, a rural electric cooperative formed in Grand Valley Colorado set up a 17 kW self-financed solar microgrid for the local community at a total project cost of $77,500 (EESI). Residents of the town can purchase electricity from the microgrid at a cost of $4 per credit on their bill. The cooperative chose an on-bill financing mechanism for the project because residents were reluctant to pay up-front. It could be an interesting initiative for the Ridgewood municipality to attempt to do something similar at a hyperlocal scale, that is, support neighborhoods within Ridgewood to set up their own cooperative microgrids for groups of households to promote residential solar adoption. This is a particularly useful idea for the promotion of residential solar adoption because many of the houses in Ridgewood have shingles made of ceramic or other materials that are less suitable for solar. While it is certainly possible to install rooftop solar systems on tiled/shingled roofs, they are significantly riskier as the panels are unbalanced, and can get knocked down by strong winds or snow. Installing a rooftop solar photovoltaic (PV) system may require retiling one's rooftop with more suitable materials. With a cooperative project where a system installed on one house feeds several houses in the area, costs associated with retiling could be negated or shared by the community (reducing the burden on a single household).

Source: Webb

OFFSITE COMMUNITY SOLAR IN HOBOKEN, NJ

The city of Hoboken has just launched a 'community solar energy program' this year, which allows residents who cannot install their own rooftop solar projects to buy energy from the municipality at a lower cost than that offered by PSE&G (Community Solar, 2024). This is an offsite project, with the solar plant located in Elizabeth, NJ due to a lack of space in Hoboken. The city of Hoboken has entered into a 15-year partnership with Hartz Solar, who has built and will maintain a 3.9 MW rooftop solar plant on a warehouse roof in Elizabeth, NJ. Residents have to apply to be eligible to receive energy from the city through this program. The project is funded by Hartz Solar, who receives the use-payments, and thus neither the city nor its taxpayers bear any of the project costs. While Hoboken has about double the population size of Ridgewood, which makes it more attractive for commercial solar vendors, a commercially-funded solar project may be a viable option for Ridgewood as well, particularly for the Valley Hospital rooftop space. It may also be possible to coordinate with local municipalities to option a larger, commercially-funded solar project.

MUNICIPALLY OWNED FLOATING SOLAR COHOES, NY

Cohoes, a small town in upstate New York with a population of less than 18,000 people, has proposed a 3.2 MW floating solar project, at a cost of about $5.6 million (Cohoes, NY). Though a much smaller town than Ridgewood, Cohoes intends to fund this project themselves and have the system be municipally-owned and operated. This allows Cohoes to reap the financial benefits of the project and have it be an additional source of revenue for the municipality. While a floating solar project would not be feasible for Ridgewood given its problems with flooding, Cohoes's proposed project does offer an interesting perspective of the potential benefits of developing a municipally-owned community solar project to serve Ridgewood and its neighboring towns. Cohoes intends to obtain grant money to develop its floating solar project.

A BACK-OF-THE ENVELOPE ESTIMATE OF THE SOLAR INSTALLATION POTENTIAL AT VALLEY HOSPITAL:

Suitable Area (using Google Maps, Figure 2.8):
Building 1 : Total = 281 + 281 m2 on each side of the south side + 210 m2 on west side + 700 m2 on the east side (unsure if this is flat empty roof space)

Building 2:
565 m2 (top) north side + 410 m2 (top) south side + 184 m2 (down) south

Total potential area: 1472 + 1159 = 2631 m2

As a thumb rule, a 1 kW system takes up about 10 m2 (Kumar, 2023). However, in reality the area required depends on the brand and type of panels used. Monocrystalline panels are usually much smaller, and companies like REC tend to have slimmer panels than the average, as an example. Therefore, we could potentially install about 263 kW on the hospital rooftop.

Assuming a cost of about $2.9 per watt, the total project cost for such a system size would be around **$762,700** (excluding inverters and storage systems). With a 30% Investment Tax Credit (ITC), the total cost would be around $533,890. The system would generate approximately **184,100 kWh** a year (assuming 2 kWh generated per day per kW for 350 days a year) and abate **40.5 MT CO2e** a year.

Disclaimer: This figure is an estimate only. An on-ground site survey will need to be conducted to determine the actual system size possible to install. The flooring type, existing wiring, relevant equipment, and other similar factors will all have to be taken into consideration.

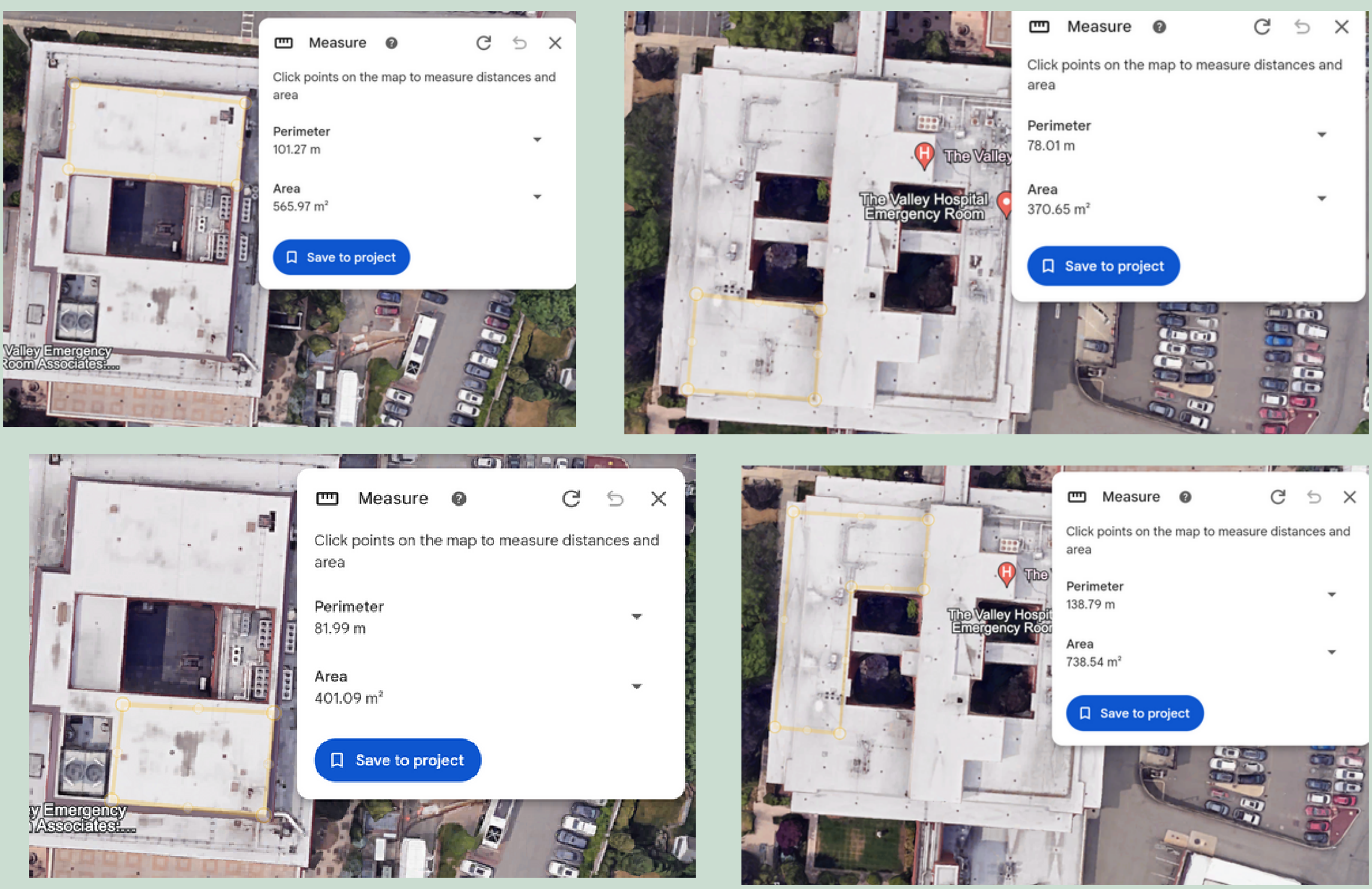


Figure 2.8 Screenshots taken from Google Maps to measure solar capacity at Valley Hospital. [left] building 1 and [right] building 2.

CASE STUDIES

JERSEY CITY, NJ

In 2020, Mayor Fulop issued an Executive Order requiring that 10% of all new municipal fleet vehicles in Jersey City be fully electric within the same year, with a target for the city's municipal fleet to be fully electric by 2030 (The City of Jersey City, 2023). As of April 2023, the city has added 37 EVs, namely Nissan LEAFs, to its municipal fleet and built 27 charging stations, bringing the city total to 49 chargers (Ibid.) These electrification initiatives were achieved through NJDEP grants and the New Jersey Board of Public Utilities (NJBPU)'s Charge Up New Jersey Program, which is an EV incentive initiative. Last year, the city was further awarded $1 million from a NJDEP grant to install 20 new dual-port charging stations, increasing the city's total portfolio to 89 EV chargers. Jersey City is also the first on the east coast to add electric garbage trucks to its municipal fleet, which was done using a $2 million NJDEP grant (Ibid.). Furthermore, the city is also establishing a citywide EV infrastructure through a public/private partnership with Via. This partnership has resulted in 5.3 million pounds of carbon dioxide emissions avoided since 2020 due to shared rides and EVs in Via's fleet (Israel, 2024).

WINTER PARK, FL

Winter Park is similar in population size to Ridgewood, and the city purchased five Nissan LEAFs in 2020 for its municipal fleet (Electrification Coalition, 2020). The city leveraged the Climate Mayors EV Purchasing Collaborative, a leasing program for public entities not subject to tax burden, to access federal tax credits, and the city found the cost reduction (~$7K) meaningful enough to pursue the opportunity (Ibid.) Additionally, the city invested in new charging stations on city-owned property, utilizing both public and private charging infrastructure, to support this fleet (Ibid.) For example, if all of the public charging stations are full, then the general public may use the private charging stations, which are predominantly used for the city's fleet. Implementing this mixed-use charging infrastructure serves as a dual investment, benefiting both the city's operational needs and the community at large.

Source: City of Jersey City

AN OVERALL MEASUREMENT FRAMEWORK

An important part of developing a decarbonization strategy is having a clearly-defined system to measure success. An effective measurement framework needs both quantifiable metrics of success and a system of evaluation that is both comprehensive and time-bound. Additionally, a good measurement framework for community-level decarbonization initiatives needs to involve a clearly defined mechanism for stakeholder engagement and feedback, as well as a community-wide entity who will support the evaluation process (Neveroff, 2023).

Community-wide data can be collected in aggregate from PSE&G (electricity and gas data) as well as the NJ Transit Corporation (for ridership data). It may also be possible to gather community-wide vehicular mileage by vehicle type through a partnership with the New Jersey Department of Transportation (NJDOT) or the New Jersey Department of Motor Vehicles (NJDMV). Additionally, waste management data can be gathered in aggregate to supplement municipal operations GHG calculations. Such measurements can then be multiplied by the appropriate conversion rates as follows:

Overall Vehicular Emissions =

$$\Sigma \left(\frac{miles\ traveled\ per\ car (miles)}{car\ efficiency\ (miles/gallon)} * 8.887\ kg\ CO2e/gallon\right)\ (US\ EPA,\ 2015)$$

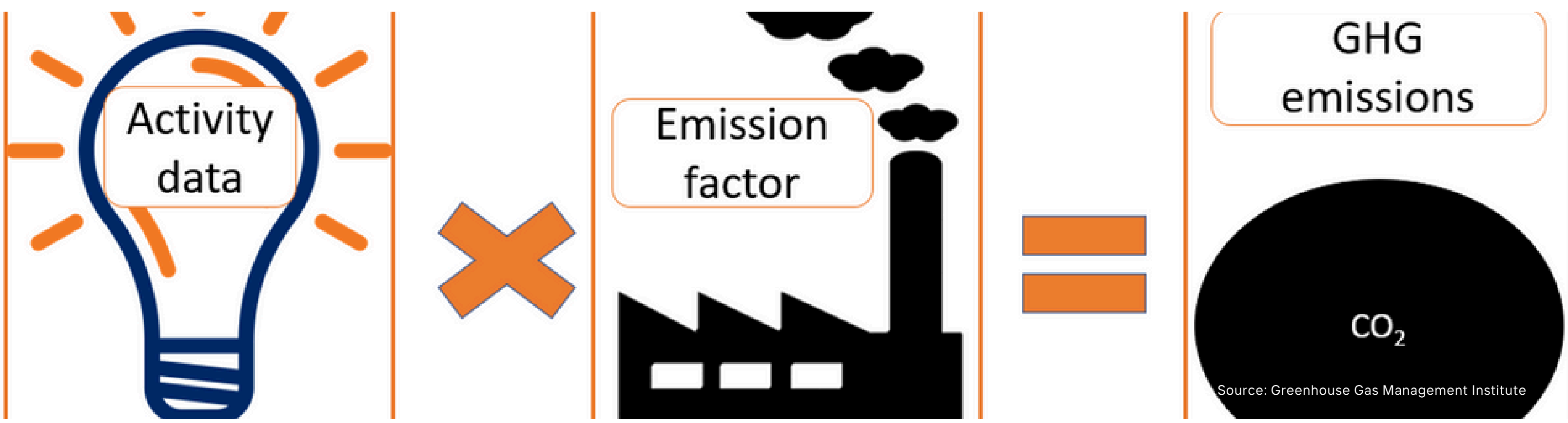
$$\text{Municipal Vehicular Emissions} = (gallons\ of\ fuel\ * 8.887\ kg\ CO2e/gallon)$$

Overall Heating Emissions =

$$(total\ supplied\ natural\ gas\ (Therm)\ * 5.48\ kg\ CO2e/Therm)\ (US\ EPA,\ 2015)$$

$$\text{Scope 2 Emissions} = (total\ supplied\ electricity\ (kWh)\ * 0.34\ kg\ CO2e/kWh)^{2}$$

Where it is not possible to obtain quantifiable data on the success of the initiatives, both within municipal operations and for residents, from relevant partner organizations, surveys can be used to bridge the data gap.



*This electricity is slightly higher than the NJ average (0.22 kg CO2e/kWh) and was obtained from the PSE&G energy mix as of 2023. The PSE&G energy mix can usually be found on the PSE&G website as it is required to be disclosed, and the carbon emissions factor in (pounds Co2 per MWh) is also disclosed. The emissions factor can also be calculated using the PSEG's annual energy mix percentages. In the 2023 PSE&G energy mix report, the reported mix was 17% coal, 34% natural gas, and 0.26% oil (the remaining are nuclear, hydroelectricity, & renewables like wind and solar, which have much lower emissions). The emissions factor (ef) for burning coal is 1.04 kg Co2 per kWh, the ef of natural gas is around 0.4 kg Co2e per kWh, and the ef of oil is around 1.07 kg Co2 per kWh. Using these factors we get an emissions factor of about 0.32 kg Co2e/kWh which is comparable to the disclosed Co2 value of 766.35 pounds per MWh or about 0.34 kg per kWh.

CITIZEN SURVEYS

Citizen surveys are an invaluable tool for measuring the success of community-level decarbonization efforts because they not only allow for the collection of precise data but also provide a space for the community to engage with, and share their feedback on, the initiatives undertaken. We propose conducting an annual citizen survey of Ridgewood's decarbonization efforts, both to better understand changes in electricity and gas consumption patterns, and to give residents a chance to share their opinions of some of the proposed initiatives. The citizen surveys would provide a means for the residents of Ridgewood to share their preferences and concerns to ensure that the decarbonization strategies implemented by the Village Council align with community values. In addition to the surveys, the committee overseeing the evaluation process could also consider conducting focus group discussions with residents and local businesses to understand the impact of the decarbonization initiatives on a more personal and detailed level. These discussions can offer deeper insights into how such changes affect daily life and business operations, identifying specific areas of success and opportunities for improvement.

SURVEY AIM AND DESIGN

The survey design would need to incorporate a mixed methods approach, blending quantitative data with qualitative insights for a comprehensive understanding of decarbonization in Ridgewood. The survey could be conducted either online or in-person (or both, catering to diverse preferences and accessibility needs). We recommend conducting the survey using an online platform, such as Google Forms, Qualtrics, or SurveyMonkey, due to the ease with which survey responses can be aggregated into an Excel spreadsheet. The survey questions should be applicable to both residents (1 response per household) and commercial businesses.

The key data points we want to obtain from the survey include:

1. Metrics of electricity, natural gas, and fuel consumption at the commercial and household level.
2. Community feedback on the effectiveness and reception of decarbonization initiatives, including but not limited to, ordinances on PPAs, leaf blowers, and recycling, in addition to initiatives such as park and ride, walk to school, carpooling, and community solar projects.

This data can be obtained through some version of the following questions:*

1. How many kilowatt-hours (kWh) of energy did you use in the last year per your cumulative electricity bill? (PSE&G, 2023).
2. What was your total natural gas supplied for this year? (PSE&G).
3. Do you have a green power purchase agreement for your home or business? Yes or No.
4. (short answer) Do you intend to renew your green power purchase agreement in the coming year? Why or why not?
5. Do you have a rooftop solar system? If yes, what is the size (in kilowatts) of this system?
6. Do you intend on installing a rooftop solar system in the near future?
7. What was your average monthly building gas consumption?
8. Do you have an EV?
9. Do you intend to purchase an EV in the near future (next two years)?
10. If you do not have an EV, what was your average monthly fuel consumption? Please answer in either gallons or price.
11. a. Did you participate in any of the following initiatives this year:
    a. Walk to school campaign
    b. Carpooling
    c. Park & Ride
    d. Do you think these initiatives were effective? Please rate each on a scale of 1-5.

*Further refinement can be done to separate the questions by respondent type (residents vs. businesses).

SURVEY TIMELINE

We recommend conducting an initial benchmarking survey before any decarbonization initiatives have been implemented. The survey can then be conducted annually after the implementation of the year 1 ordinances and initiatives (PPAs, carpooling, park & ride, and the walk to school campaign).

FACILITATING SUCCESS

While the survey would be voluntary, potential methods to increase survey participation could include monetary incentives (which could potentially increase response rates by nearly 20%), such as gift cards or restaurant discounts, as well as parking privileges or other such non-monetary incentives (CheckMarket, 2022).

EVALUATING THE DATA

Ideally, electricity and gas consumption data should be aggregated in a collective Excel spreadsheet, which is why an online survey platform is recommended, as it can be maintained over time and used to compare annual survey data to the benchmark data.

CALCULATING EMISSIONS

The aggregated electricity consumption data for households and businesses without a green PPA can be multiplied by the PSE&G emissions factor (0.34 kg CO_2e per kWh) to obtain an estimate for the GHG emissions (and an emissions factor of approximately 8.89 kg CO_2e per gallon for vehicle gasoline consumption) (US EIA).

If calculating emissions proves too rigorous a process, then observing changes in the raw data would also be suitable to track the effectiveness of the initiatives over time, although they would not be able to inform any estimates of the total emissions reduction achieved through these initiatives.

TRACKING MUNICIPAL SCOPE 1 AND 2 EMISSIONS

While community-wide emissions calculations may be too large a task, there must still be a framework in place to measure the Scope 1 and 2 emissions for Ridgewood's municipal operations in order to achieve the Sustainable Jersey Gold Star Energy requirements.

A simple and straightforward framework for tracking municipal emissions involves submitting both types of bills to the municipal accountant: 1) all energy bills (electricity and gas) from municipal buildings, and 2) all fuel bills for municipal vehicles.

To facilitate this process, a simple emissions calculator can be utilized. This tool would apply the conversion estimates and emissions factor estimates previously detailed. The resulting emissions calculations are intended to evaluate the impact of initiatives such as the municipal fleet electrification program and the proposed municipal microgrid initiative, as well as any building efficiency programs or other similar initiatives.

EXTERNAL AUDITING

In addition to evaluating municipal emissions internally, we also recommend conducting annual external energy audits for Ridgewood's municipal operations through the Local Government Energy Audit (LGEA) program. Offered by New Jersey's Clean Energy Program, this program provides local government entities in New Jersey with a cost-free opportunity to evaluate their energy usage (NJ OCEE). Participation in the LGEA program simply requires Ridgewood to provide its municipal utility bills for both energy and water usage.

WASTE MANAGEMENT

Currently, Ridgewood residents receive general trash collection twice a week and recycling collection every other week. General refuse is collected manually by waste management employees from back gardens, while recycling is collected curbside and separated into recycling types (metals, plastics, cardboard, etc.) by residents (Perron, P., Personal Interview, 2024). In 2021, Ridgewood launched a pilot program for compost collection through which 100 households received a town-issued 5-gallon food scraps bucket which they could then bring into the recycling center for large-scale composting (Samuels, 2021). Although some town officials would like to expand this pilot program via the creation of satellite food scrap collection points beyond the recycling center, there are presently no plans for the implementation of curbside compost collection.

Beyond municipal waste collection, some residents may additionally engage in home composting, however such private actions are limited in scope by public ordinances preventing compost piles due to rodent issues. Such regulation allows private actors interested in home composting to use only contained composting mechanisms (i.e. via compost bins). To date, Ridgewood has also not considered any pay-as-you-throw models for waste collection as it provides all services solely out of allocations of municipal revenue streams (Perron, P., Personal Interview, 2024). Some barriers to door-to-door municipal compost collection include the additional cost to the municipality, which is in part to do with the labor intensive nature of general refuse collection occurring manually from back garden collection points. According to Deputy Mayor Pam Perron, another issue with switching from labor intensive manual collection to curbside collection is the style of waste trucks in use within the municipality, which lack side-arms for easy waste depositing from the curb. Additionally, residents currently purchase their own waste receptacles which poses an issue for standardized waste collection.

Given the current status of waste collection, it may be useful for Ridgewood Village to consider the purchase/renting of side-arm waste trucks, which can be bought for as high as $300,000 and rented for considerably less if Ridgewood opts for a pilot waste collection program (Big Truck Rental, 2020). Such a purchase could likely be included within Ridgewood's capital budget and would likely free up budgetary dollars via the decreased need for waste collection employees as well as a reduction in workman's compensation insurance. Switching to curbside general refuse collection may additionally alleviate some of the risk of back garden waste collection given that waste management professionals will no longer have to enter private property for collection. Although there may be residential pushback as a service that was provided becomes less convenient, the potential savings in personnel can free up funds to expand compost collection to include residential pickups for the entirety of Ridgewood, which will offer new services to the Village.

Source: Patch

Regarding the current level of waste collection, it may additionally be of benefit to Ridgewood to consider altering its collection frequency. The current model of a fourfold higher general refuse collection means that residents are pushed towards more frequent general refuse generation rather than accommodate recyclable materials.

Additionally, the pilot program for compost collection requires both a high degree of engagement on the part of residents who have to take the time to drop off their waste to a consolidated collection point and a high degree of resource use owing to the large number of car trips required to drop off relatively small amounts of food scraps. Nationally, approximately 28% of general refuse placed into landfills could be composted (ERI).

Through curtailing general refuse collection frequency to once a week, bolstering recycling to once a week, and adding in curbside composting programs all aided by more efficient refuse collection, Ridgewood can increase its recovery efficiency of both recyclable goods and compostable products. Composting initiatives can be further augmented by the recognition of seasonal highs in the collection of yard trimmings and the encouragement of backyard composting (NJDEP). There may also be some opportunity to benefit from funding for educational grant programs through the New Jersey Composting Council (NJCC). As of 2021, Ridgewood spends over $750,000 on household trash disposal. By increasing the recovery rate of more cheaply disposed of composting ($65/ton in comparison to general refuse's $80/ton) and recycling, which has a material value, Ridgewood can alleviate issues of methane emissions from uncollected compost, improve material recycling rates, and modernize its waste management policies (Stoltz, 2021).

Source: Patch, James Kleiman

Source: Patch, James Kleiman

FUNDING FRAMEWORK

OVERVIEW

Communities face increasingly complex environmental challenges that demand effective, long-term solutions and proactive approaches. This is evident for Ridgewood, where flooding and decarbonization programs require long-term sustainability project management, which can be accomplished through a formalized environmental commission managing both operations and funding.

There are numerous examples highlighting the transformative impact of formalizing environmental commissions and elevating their role and capacity to manage initiatives within communities. For instance, the Princeton Environmental Commission initiated the Princeton Community Renewable Energy Program (PCRE). Under this program, all residents receive an electricity supply with more than double the renewable energy content of the supply provided by PSE&G, at a slightly lower cost. To achieve similar success, Ridgewood may need to undergo a strategic shift in its operating model. This entails allocating its budget and resources to better align with its environmental challenges and opportunities.

LEGALLY ESTABLISHED AND FUNDED ENVIRONMENTAL COMMISSION

As explained above, Green Ridgewood currently operates as an advisory company. Over the years, they have developed a respectable voice in the Village and ensured that environmental considerations are accounted for where possible. But they do not possess any legally binding authority over Village sustainability measures, and function solely within an advisory capacity. This presents a problem because unfavorable election cycles could lead to the committee's advisory capacity diminishing.

Therefore, we recommend Ridgewood establish a legally recognized environmental commission––the Ridgewood Environmental Commission. To ensure that the environmental committee functions properly for all stakeholders, the town may be required to provide them with an operating budget, which will vary with permanent staffing, project budgets, and consulting dollars (ANJEC, 2022). Such a committee should have a seat at the table for Village planning and have the capacity to manage long-term sustainability projects.

The overarching role of the Ridgewood Environmental Commission could draw lessons from the Princeton Environmental Commission. Princeton's commission was established to advocate for the protection, development, and use of natural resources, including water resources, composting, and recycling. Their commission also advises and educates local government, businesses, and residents on environmental issues, laws, and programs by drafting and amending ordinances, responding to the public regarding local environmental concerns, and reviewing and commenting on building and development applications (Municipality of Princeton).

Such a commission ensures environmental needs are considered whenever any decision is made by the Village Council or Planning Board. To that end, the Commission should have a permanent seat on the Planning Board as an acknowledgement of the Commission's authority, given the Planning Board is responsible for land use decisions and regulations.

The Commision could also hire environmental experts on its own authority, using its own budget. Hiring experts to fill resource gaps is crucial to ensure the Commission can tackle complex environmental issues with confidence and without full-time staffing expenses.

Whether it is conducting environmental assessments, developing management plans, or providing technical assistance, consultants will play a crucial role in guiding the Commission's decision-making process and implementing effective solutions.

In the vein of Princeton's Environmental Commission, the Ridgewood Environmental Commission can also allocate funds dedicated to environmental educational programs. These programs serve to inform and engage the community on environmental issues, fostering a greater understanding of the importance of conservation efforts. Whether it is hosting workshops on reducing household energy consumption, organizing educational seminars on renewable energy, or developing outreach materials on recycling and composting, these initiatives are essential for raising awareness and inspiring action among Ridgewood residents.

Beyond the day-to-day operations, the Ridgewood Environmental Commission can also allocate funds for special projects aimed at addressing specific environmental challenges or opportunities within the community. These projects often require additional resources and expertise beyond what is covered by the standard operating budget. One important special project is the preparation of an environmental resource database.

This comprehensive repository should provide data on natural resources within the community, including land use, stormwater management, flooding, carbon emissions, and more. Armed with this information, the Commission can make informed decisions about land management, conservation priorities, and development projects, ensuring the long-term health and sustainability of Ridgewood's environment.

POTENTIAL FUNDING SOURCES FOR PROJECTS

The Village of Ridgewood has access to various funding opportunities that can help it achieve its development and sustainability goals (Table 3.1). For example, the FEMA Hazard Mitigation Grant Program is crucial for reducing disaster risks. At the same time, the Community Development Block Grant (CDBG) program provides funding for community services and neighborhood revitalization. Additionally, research efforts can be supported by The Rockefeller Foundation Research Stipends, and environmental conservation projects can find backing through the World Wildlife Fund (WWF) Community Grants. Critical water infrastructure projects can be supported by the Water Infrastructure Finance and Innovation Act, and platforms like Kickstarter can enable community-driven crowdfunding. These funding sources allow Ridgewood to improve its disaster resilience, infrastructure, environmental stewardship, and community engagement, creating a more sustainable and vibrant village.

Source: Ridgewood New Jersey Master Plan

Table 3.1 Potential Sources of Funding for Ridgewood's Environmental Projects

Program Name	Deadline	Funding Amount	More Information
FEMA's Hazard Mitigation Grant Program (HMGP)	Varies by event; e.g., Aug 29, 2023 (Hurricane Ian), Oct 20, 2023 (Hurricane Nicole)	Varies; dependent on specific disaster declarations and state allocations	https://www.fema.gov/grants/mitigation/hazard-mitigation
Community Development Block Grant (CDBG)	Varies by locality and program; refer to local HUD offices or website	Not provided; depends on program allocations	https://www.hud.gov/program_offices/comm_planning/communitydevelopment/programs
The Rockefeller Foundation Research Stipends	November 3, 2023	Up to $5,000 for individual researchers	https://rockarch.org/collections/research-stipends/
World Wildlife Fund (WWF) Community Grants	Not provided; refer to WWF for the most current information	Not provided; refer to WWF for the most current information	Refer to WWF's official website
Water Infrastructure Finance and Innovation Act (WIFIA) Program	Announced annually	Not provided; refer to EPA for the most current information	https://www.epa.gov/wifia
Kickstarter Community Projects	Varies by project; refer to Kickstarter for the most current information	Not applicable; crowdfunding platform	https://www.kickstarter.com/
Google Community Grants	Not provided; refer to Google for the most current information	Not provided; refer to Google for the most current information	Refer to Google's official website
World Bank Grants for Infrastructure Projects	Not provided; refer to the World Bank for the most current information	Not provided; refer to the World Bank for the most current information	Refer to the World Bank's official website
Municipal Green Bonds	Depends on bond issuance schedule	Not specified; varies by municipal offerings	Information typically available through municipal financial departments
Community Energy Plan Grant	February 23rd (Year not provided; check for updates annually)	Not specified; check annually for new allocations	Refer to the Community Energy Plan Grant's official website
Greywater Capture System Grants	22nd round of Grant Applications (specific date not provided)	Not specified; check with The Funders Network or Urban Sustainability Directives Network for details	Refer to The Funders Network or Urban Sustainability Directives Network for more information
Residential Stormwater Credits	Ongoing with the utility billing cycle	Savings for residents with rain barrels and rain gardens/cisterns	Refer to Ann Arbor city or Washtenaw County websites for more information
FEMA Flood Mitigation Assistance Grant Programs	FY 2024 grant cycle (specific date not provided)	$1.8 billion for 2023; $800 million specifically for Flood Mitigation Assistance	https://www.fema.gov/grants
New Jersey Redevelopment Authority Bond	Not specified; bonds are typically associated with capital project timelines	$750 million authorized for funding capital projects in higher education	Refer to the New Jersey Redevelopment Authority or the New Jersey Educational Facilities Authority for more information

RECOMMENDATIONS

FLOODING

Ridgewood has experienced three major flooding events since September 2023 which, taken together with the impacts of Hurricanes Floyd, Sandy, and Ida, amount to hundreds of thousands of dollars in damages. What the team has presented above represents a compendium of possible solutions Ridgewood can explore. There are certainly more options available than those presented in this report, but this report does not strive to present an exhaustive list––instead, options have been presented which are 1) feasible for the Village and 2) representative of the coordination needed among riparian and land-based solutions and among green and gray infrastructure. There is no one solution to the flooding problem––a combination of solutions must be deployed in conjunction. If Ridgewood is unwilling or unable to reduce its impervious surface coverage and restore floodplains along the Brook and Saddle River, then it must invest in a combination of green and gray infrastructure that addresses the Village's vulnerability to flooding.

Of the eight solutions presented, the team recommends three be deployed in earnest: rain barrels for residential use, subsurface detention basins, and redirection of the Ho-Ho-Kus Brook and Saddle River. It should first be noted that, though we are recommending these three solutions, as many of the eight options as possible should be investigated and deployed to the extent Ridgewood is able.

Rain barrels in isolation are relatively ineffective. But if deployed at scale throughout the Village, either as part of a 100%-adoption mandate or as an incentive which generates 80-90% compliance, they will reduce the volume of water precipitation adds to floods. Our cost-benefit analysis focused on houses within Ridgewood's flood zones, but rain barrels might be even more effective for homes on the elevated west side of town. Much of the precipitation falling west of the railroad is flowing downhill into the MS4 stormwater system and feeding into the Brook, thereby contributing to rapid flood events. If a 100 gallon barrel for one home can capture its full capacity during a storm, then that represents thousands of gallons of stormwater not flowing downhill into the Brook. Rain barrels would also ensure sustained community engagement with flooding and partially address concerns with using potable water for irrigation, especially in the summer months, as the captured stormwater can easily be reused in that capacity.

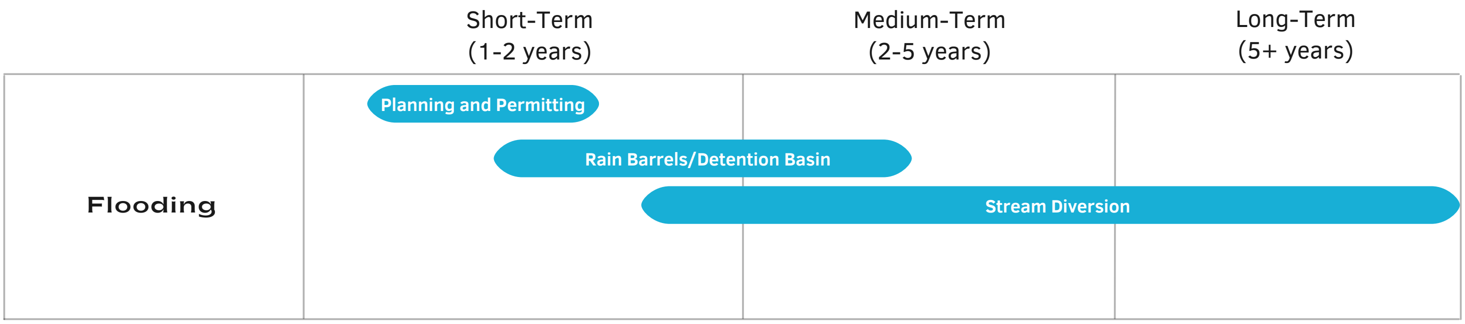
Subsurface detention basins are critical to address Ridgewood's flooding within a relatively short time frame. We selected the Village Hall parking lot, Stevens Field, and the High School field as potential sites for a subsurface basin because 1) they are all large enough to accommodate a basin, which is integral for the basin's efficacy, and 2) these plots are some of the most vulnerable in the Village to flood damage. If Ridgewood decides to design the basin for a 100-year storm event, then studies calculating the 100-year flood volume depth from Ho-Ho-Kus Brook will need to be conducted and considered in conjunction with 100-year precipitation models to determine the basin's capacity. It will also be incumbent upon the Village to decide whether they connect the basin to the stormwater system or whether the stormwater will simply sit in the basin until a service pumps out the water from aboveground. Additionally, as was noted above, it will be imperative for Ridgewood to install pretreatment controls for the stormwater entering the basin so as to prevent clogging and contamination of water bodies. The Columbia team recommends installing more than one basin, as it is unlikely only one basin will be able to handle the Brook's flood volume. However, Ridgewood's exact needs are dependent upon the outcome of environmental and feasibility studies.

Redirecting Ho-Ho-Kus Brook and Saddle River are certainly long-term solutions which will take a minimum of five years. It is likely Ridgewood will need to partner with the Army Corps. of Engineers for this project given its scope and the resources needed to accomplish it. However, redirection of the water bodies, especially if they are gate-activated, is probably the single most effective thing Ridgewood can do to ameliorate major flood events. Redirections are complicated projects, though, which often involve multiple stakeholders and millions of dollars. A federal-municipal partnership with the Army Corps. might significantly reduce Ridgewood's cost burden, especially if they do much of the preparatory work in-house and not at the Army Corps.' expense (this allows the Army Corps. to spend more money on the project itself and reduces Ridgewood's obligation to match the Army Corps.' investment). Federal and state environmental impact studies and permits will be needed in addition to cooperation with downstream townships directly affected by the Brook's and River's streamflows. Despite the complex nature of the project, the Columbia team recommends this option and believes it will yield benefits for decades to come should the Village pursue it.

Though the team has highlighted three of the eight options for Ridgewood to pursue, it is recommended that Ridgewood simultaneously develop a comprehensive urban flood management plan that incorporates green infrastructure, wetland restoration, and community-based flood resilience measures. These efforts should aim to mitigate the impacts of impermeable surfaces, enhance natural water storage and drainage, and reduce long-term flood risks.

The proposed timeline for this report's recommendations is subject to change per the specifications and requirements of the project once approved:

Sustainability Roadmap



FURTHER RECOMMENDATIONS

Ridgewood participates in the FEMA Community Rating System which assigns a value (1-10, with 1 being the highest, 10 being the lowest) to communities that initiate their own mitigation efforts beyond those that are required at the federal or state level (FEMA 2023). Such efforts can include collection of data, mapping, outreach projects, flood protection assistance, etc. Each value acts as a tier which assigns a progressive 5% discount to homeowners' flood insurance premiums. At tier 10, there is a 0% discount, but at tier 1, there is a 45% discount. Ridgewood currently sits at a 6 which means its mitigation efforts, data collection, and various other flood-related initiatives are below average. If Ridgewood improves upon its mitigation efforts and community initiatives per this report's recommendations, the Village should be able to achieve a higher tier and secure additional flood insurance discounts for its residents.

When considering which flood mitigation measures to adopt and how to do so, data is needed. In the course of compiling this report, there was a dearth of data which prevented the team from proceeding further with their calculations. Unknown variables such as total costs of flood damage for municipal buildings and average flood volume along various parts of the Brook and River complicated the team's recommendations. Moreover, the FEMA data was also incomplete in areas, further inhibiting precise calculations. Going forward, it is imperative that Ridgewood measure and collate all flood-related data in a single repository so as to ensure ease of access. The siting and preparatory work involved in mitigation measures will only be delayed if this data is not available.

Additionally, in the course of the team's research, there was much departmental redirection on flood and stormwater-related topics. Ridgewood Water seems to be the only entity with a hydrologist on staff, but per Ridgewood Water's focus area, all staff are only concerned with potable water contamination and aquifer maintenance. After being redirected to the Village's engineering department––who handles flooding in the Village––most data inquiries were redirected to the incomplete FEMA depositories. It is recommended that Ridgewood either appoint a dedicated flooding team, composed of engineers and hydrologists, or hire a full-time hydrologist and environmental planner to be situated within the engineering department to examine waterways and runoff. These measures will ensure that proper data is being collected at the municipal level and that everybody is united in knowing what the problem is and what needs to be done to rectify it.

Ridgewood cannot solve the problem of flooding on its own. Most of this report's options and recommendations do not require the input of other townships outside of their approval should the solution be riparian in nature. But the options presented here are only strengthened if Ridgewood advocates for other communities in Bergen County to mitigate precipitation-induced flooding where they can. Ridgewood's floodplains extend beyond its borders. If, for example, Ho-Ho-Kus Borough can install its own detention basins to prevent precipitation from flowing into the Brook, then Ridgewood's downstream neighborhoods will only benefit from this measure. Direct collaboration with neighboring municipalities will be crucial to Ridgewood's ability to weather the storms that are only increasing in frequency and severity with each passing year.

The following table provides further details regarding the timelines, efficacy, and Key Performance Indicators (KPIs) of the proposed flooding mitigation initiatives:

Table 4.1: Summary of the proposed Riparian initiatives' timeline, efficacy, and associated KPIs

Activity	Capital Intensive (>$50,000)	Implementation Timeline	Community Engagement Needed?	Achievable Impact in Ridgewood	Associated Key Performance Indicators
Riparian Interventions					
Nonlinear Weir	Yes	Medium-term (2-5 years)	Yes	Unknown (more data is needed)	Upstream/downstream flood events and corresponding depth of floodwaters; ecosystem health; sediment discharge/ accumulation; water quality; streamflow upstream and downstream of weir; home prices in flood zones
Barrage	Yes	Long-term (5+ years)	Yes	High	Upstream/downstream flood events and corresponding depth of floodwaters; ecosystem health; streamflow discharge; home prices in flood zones
Redirection of Water Bodies	Yes	Long-term (5+ years)	Yes	High	Upstream/downstream flood events and corresponding depth of floodwaters; erosion in channel diversion; percentage of water diverted; ecosystem health; home prices in flood zones

Table 4.2: Summary of the proposed Land initiatives' timeline, efficacy, and associated KPIs

Activity	Capital Intensive (>$50,000)	Implementation Timeline	Community Engagement Needed?	Achievable Impact in Ridgewood	Associated Key Performance Indicators
Land Interventions					
Green Infrastructure	Yes	Medium-term (2-5 years for all appointed sites)	No	Low to Medium locally (depends on seasonal water table fluctuations and extent of project)	Accumulated floodwaters; infiltration capacity; stormwater runoff reduction; ecosystem health; biodiversity impacts; soil health
Private Rain Barrels	Not on an individual level	Short-term (0-2 years)	Yes	Low	Local reduction of stormwater runoff; reuse capacity; adoption percentage
Subsurface Detention Basins	Yes, depending on capacity	Medium-term (2-5 years)	Yes	High locally (depending on capacity of basins)	Local reduction of floodwaters; water quality; discharge capacity (if applicable)
Surface Infiltration Basins	Yes, depending on capacity	Medium-term (2-5 years)	Yes	Medium locally	Local reduction of floodwaters; water quality; infiltration rate; aquifer replenishment
Natural Grass and Wetlands Restoration	Yes	Medium to long-term (depends on scale of restoration)	Yes	Medium to high (depending on restoration scale)	Reduction of floodwaters; silt deposit reduction; ecosystem health; biodiversity

DECARBONIZATION RECOMMENDATIONS

The Ridgewood team recommends a consolidated approach to measuring and reducing Scope 1 and Scope 2 emissions over the next 7 years, during which time key areas of high emissions can be addressed to meet the minimum reduction standards (Figure 4.1). Given that Ridgewood's two key sources of emissions are associated with gasoline-powered vehicles and purchased electricity, it is imperative for the town to focus on transitioning its municipal fleet to EVs and negotiating PPAs with PSE&G in the short and medium terms. However, it is important to note that following the establishment of Ridgewood's 2020 - 2022 PPA contract, the town encountered challenges, particularly in aligning its objectives with those of PSE&G. In response, the town legislated an ordinance to facilitate alternative energy sourcing through a third-party provider. However, market constraints have hindered the implementation of this alternative energy program (Calbi, R., Personal Interview, 2024). If Ridgewood completely electrifies its municipal fleet and negotiates PPA contracts with PSE&G to require electricity from a greater mix of renewable energy, then the town can reduce at least 41,288 MTCO2e/year. Considering that Ridgewood will need to reduce approximately 50,000 MTCO2e to align with New Jersey's Energy Master Plan target of net-zero by 2050, more initiatives will need to be implemented to guarantee this goal.

One such initiative that Ridgewood should prioritize is setting up a community microgrid in the long term. This will allow the town to gain a level of energy democracy that does not entirely rely on the PSE&G grid, and it will enhance resilience against power outages by facilitating a localized energy generation and distribution system. Moreover, this microgrid can be powered by renewable energy, like solar, which can be sourced from panels installed on residential and municipal buildings. It could even enable residents with solar panels to sell excess power back to the grid, which can further incentivize the adoption of renewable energy at the individual level. Additionally, this can enhance the community's overall sustainability by providing the Village with more opportunities to support affordable housing initiatives.

As far as achieving a Gold Star rating in energy within the next 3 years from Sustainable Jersey, Ridgewood will need to begin tracking its municipal emissions. Although a community emissions calculator is not explicitly mentioned as a requirement for achieving Gold Star recognition, some ability to demonstrate reductions in municipal emissions is needed to fulfill the criteria. This will require submitting municipal energy and vehicle fuel bills to the municipal accountant, which can start as soon as possible. Since no municipality in New Jersey has received a Gold Star energy rating yet, Ridgewood has the opportunity to lead by example and inspire other communities to become more sustainable and energy efficient.

Figure 4.1 Proposed decarbonization timeline

In order to evaluate the success of these initiatives, Ridgewood should conduct citizen surveys. These surveys serve as crucial tools for gathering feedback on energy consumption patterns and the community's reception to sustainability efforts. Incorporating a mix of quantitative and qualitative questions will allow for the collection of comprehensive data on electricity, natural gas, and fuel usage, while also gauging opinions on initiatives, like the PPAs and community grid. Conducting such surveys will also ensure that Ridgewood's sustainability measures are closely aligned with the values and expectations of its residents.

To further evaluate the success of these initiatives, Ridgewood should use a simple emissions calculator, which utilizes specified conversion and emissions factor estimates to assess the impact of its sustainability efforts. This tool will enable the town to make data-driven decisions in future sustainability planning by quantifying the reductions in GHG emissions from each initiative. It will also allow the town to modify its strategies accordingly for greater efficiency and effectiveness.

Lastly, for a more comprehensive assessment of Ridgewood's efforts towards sustainability, the town should undergo external energy audits offered through the LGEA program. Such audits will reveal further energy-saving opportunities and emissions reduction potentials, offering a more comprehensive overview of Ridgewood's environmental progress. By combining the emissions calculator with the insights from the LGEA program, Ridgewood will have the necessary data to refine and enhance its sustainability initiatives.

RECOMMENDED BUDGETARY APPROPRIATIONS FOR SUSTAINABILITY

To make the proposed recommendations a reality, the Village of Ridgewood should consider various internal and external funding opportunities. On March 23, 2023, the Village Council introduced an operating budget of $57.7M. Allocations included $2M for the street paving program, $172,000 for buildings and street improvements, and $1M for infrastructure enhancements. Additionally, $1.45M was earmarked for new EVs and $3.14M for public safety and Water Pollution Control Facility equipment. At this time, Ridgewood also aimed to update its fleet, with police vehicles also under consideration for replacement (DeLuca, 2023). An ambiguous category labeled “Other” was allocated $43,000, totaling a proposed capital budget of $7.8M (Mailander et al., 2023).

In 2022, Ridgewood’s budget primarily relied on property taxes, which generated $38.49M, and which was then supplemented by $4.67M from miscellaneous revenues (Village of Ridgewood, 2023). Despite setting aside $387,115 for emergency Master Plan appropriations in 2023, there seemed to be a gap in specific sustainability funding efforts, as outlined in the Plan. Currently, Ridgewood lacks a specified sustainability budget, however, it can allocate funds within its capital budget, as for environmental initiatives like tree planting across the town.

To enhance its environmental and sustainability projects budget, Ridgewood may benefit from looking into the fiscal strategies of environmental and sustainability focused strategies in other New Jersey municipalities and beyond. Despite having about 5,000 more residents than Ridgewood, Princeton allocated approximately 21.7% of its $68.24M budget to sustainability-related categories in 2022 (PrincetonBudget, 2022). According to the 2023 Princeton Master Plan, based on the community survey responses, the Master Plan categorized environmental concerns into the following aspects: stormwater management, utility, community facilities, conservation, open space, and recreation.

Similarly, Ann Arbor, Michigan, a city with a population much larger than Ridgewood, dedicates significant resources towards achieving carbon neutrality, including a $1.3M investment from its General Fund for sustainability measures (Ann Arbor Budget, 2023). These measures were created round six main strategies, including switching the electrical grid of the city to 100% renewable energy, transferring appliances and vehicles from gasoline and other forms to electric sources of energy, improving energy efficiency, reducing vehicle miles traveled, reforming recycling and handling of solid waste, and enhancing the resilience of people and places. The city has also established an Office of Sustainability and Innovations City Administrator and Council who oversees the engagement events to administer the city's overarching carbon neutrality plan.

Likewise, Hoboken, New Jersey, with a population doubling the the size of Ridgewood, is a coastal city acutely focused on combating storm surges and flooding. To address these challenges, the city has established a Department of Climate Action and Innovation, responsible for coordinating efforts across various sectors including sustainability and resilience, capital planning, engineering, and water utility.

In its 2023 General Budget of $136 million, Hoboken allocated significant funds towards environmental and infrastructure resilience: $1.92 million for parks and recreation, $6.4 million towards landfill and solid waste management, $2.62 million for various unclassified projects, and more than $3 million dedicated to public works. Collectively, these allocations represent approximately 10.3% of Hoboken's total budget for the year (Hoboken Budget, 2023).

In contrast, Ridgewood's Master Plan, while comprehensive in its scope, covering both environmental sustainability and broader community needs, currently allocates a minuscule 1.29% of its 2023 capital budget ($984,115) to sustainability projects. As demonstrated above, similar municipalities dedicate far more of their budget to sustainability. This suggests an opportunity for Ridgewood to reconsider its priorities and financial commitment towards environmental sustainability. By aiming to allocate at least 10% of its $7.8 million total capital investment to sustainability, specifically targeting projects that focus on decarbonization and enhancing flood resilience, the Village can establish a solid foundation for a sustainable future. Identifying and prioritizing 4-5 key projects would not only affirm the town's dedication to safeguarding its environment and community but also align its efforts with the proactive and impactful approaches observed in its peer cities.

To amplify Ridgewood's potential to enact meaningful environmental initiatives, alternative funding avenues such as state and federal grants could play a crucial role. These external funding sources can bolster the Village's budget for the array of interventions outlined in this report. Moreover, the innovative use of stormwater utilities, as successfully implemented by Ann Arbor, Michigan, offers a compelling model for Ridgewood to consider.

These utilities, funded by user fees based on impervious surface area, provide a sustainable revenue stream for stormwater management projects, underscoring the importance of community-based funding mechanisms in supporting extensive sustainability efforts.

For instance, Ann Arbor's stormwater utility, initiated with an $880,000 rebate, now facilitates a substantial $6.8 million allocation towards the city's sustainability projects (Ann Arbor Budget, 2023). Embracing such alternative funding mechanisms where possible, in conjunction with city funds, resident cooperation, and grants, could provide Ridgewood with the necessary resources to fulfill its envisioned sustainability goals, thereby enhancing the village's environmental resilience and quality of life for its residents.

Source: NorthJersey.com

CONCLUSION

Ridgewood has already made great strides in implementing its sustainability initiatives. With the backdrop of Green Ridgewood, the broad ranging goals cited in the Master Plan, and the Village Council's focus on improving Ridgewood's approach to a worsening climate, the Village is well positioned to equal and surpass peer municipalities. Whether it's expanding wetlands along the banks of the Ho-Ho-Kus Brook and Saddle River, increasing riparian storage capacity via modular underground detention basins, or focusing on upstream riverine flood prevention, Ridgewood can ensure that its townspeople in flood zones no longer suffer massive loss, climate anxiety, and property devaluation. And as Ridgewood negotiates more sustainable energy supplies, expands vehicle electrification, and increases its energy democratization through local green energy generation, the lofty targets set in New Jersey's net zero emission planning are within reach. Although more detailed data is required to further tailor programmatic approaches to flood mitigation and decarbonization, Ridgewood has the organizational capacity to consolidate all available resources to furnish a forward-facing sustainability program. The Columbia team hopes that this report can inform a formalization of environmental administration and aid in ensuring Ridgewood continues to push the boundaries of sustainable development.


Source: Larry Horowitz

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Source: Larry Horowitz

APPENDIX

Flood Risk Models

FEMA Community Rating System

Table 1. How Much Discount Property Owners in Your Community Can Get

CRS Class	*CRS Discount*	*Credit Points Required*
1	45%	4,500+
2	40%	4,000–4,499
3	35%	3,500–3,999
4	30%	3,000–3,499
5	25%	2,500–2,999
6	20%	2,000–2,499
7	15%	1,500–1,999
8	10%	1,000–1,499
9	5%	500–999
10	0%	0–499

Series 300	*Public Information*	*Maximum Points**	*Average Points**
	This series credits programs that advise people about the flood hazard, flood insurance, and ways to reduce flood damage. The activities also provide data insurance agents need for accurate flood insurance rating.		
310	**Elevation Certificates** ▪ Have written procedures for managing floodplain-related certificates for new construction in the floodplain. (At a minimum, a community must maintain certificates for buildings built after the date of its CRS application.) ▪ Maintain a rate of 90% accuracy of all certificates.	116	36
320	**Map Information Service** ▪ Provide Flood Insurance Rate Map information to those who inquire, and publicize this service.	90	78
330	**Outreach Projects** ▪ Distribute outreach projects with messages about flood hazards, flood insurance, flood protection measures, and/or the natural and beneficial functions of floodplains.	350	87
340	**Hazard Disclosure** ▪ Real estate agents advise potential purchasers of flood-prone property about the flood hazard. ▪ Regulations require notice of the hazard.	80	15
350	**Flood Protection Information** ▪ The public library and/or community's website maintains references on flood insurance and flood protection.	125	48
360	**Flood Protection Assistance** ▪ Give inquiring property owners technical advice on protecting their buildings from flooding, and publicize this service.	110	59
370	**Flood Insurance Promotion**	220	40

Series 400	***Mapping & Regulations***	*Maximum Points**	*Average Points**
	This series credits programs that limit floodplain development or provide increased protection to new and existing development.		
410	Floodplain Mapping ▪ Develop new flood elevations, floodway delineations, wave heights, or other regulatory flood hazard data for an area not mapped in detail by the flood insurance study. ▪ Have a more restrictive mapping standard.	850	78
420	Open Space Preservation ▪ Guarantee that currently open public or private floodplain parcels will be kept free from development. ▪ Incentivize keeping the floodplain open with zoning restrictions, lot size requirements, or other regulations.	2,870	471
430	Higher Regulatory Standards ▪ Limit new buildings and/or fill in the floodplain. ▪ Require freeboard. ▪ Require soil tests or engineered foundations. ▪ Require compensatory storage. ▪ Require coastal construction standards in AE Zones. ▪ Have regulations tailored to protect critical facilities or areas subject to special flood hazards such as alluvial fans, ice jams, subsidence, coastal erosion.	2,462	272
440	Flood Data Maintenance ▪ Keep flood and property data on computer records. ▪ Use better base maps. ▪ Maintain elevation reference marks.	222	127
450	Stormwater Management ▪ Regulate new development throughout the water- shed to ensure that post-development runoff is no greater than pre-	755	110

Series 500	*Flood Damage Reduction*	Maximum Points*	Average Points*
	This series credits programs that reduce the flood risk to existing development.		
510	**Floodplain Management Planning** ▪ Using a standard planning process, prepare, adopt, implement, and update ○ a comprehensive flood hazard mitigation plan, and/or ○ a plan to protect natural functions within the community's floodplain, and/or ○ a plan for managing substantial flood damage to properties in the community, and/or ○ a plan to conserve and/or recover threatened and endangered species in the floodplain. ▪ Prepare an analysis of the repetitive flood loss areas within the community. *Note: Category C repetitive loss communities must receive credit for either the floodplain management plan or the repetitive loss area analysis, above.*	762	197
520	**Acquisition & Relocation** ▪ Acquire and/or relocate floodprone buildings so that they are out of the floodplain, and the floodplain remains open	2,250	176
530	**Flood Protection** ▪ Protect existing floodplain development by floodproofing, elevation, or minor flood control projects.	1,600	64
540	**Drainage System Maintenance** ▪ Have a program for and conduct annual inspections of all channels and detention basins; remove debris as needed	470	203

Series 600	***Flood Preparedness***	*Maximum Points**	*Average Points**
	This series credits emergency services and flood warning and response programs that save lives and protect property		
610	**Flood Warning and Response** ▪ Provide early flood warnings to the public, and have a detailed flood response plan keyed to flood crest predictions. ▪ Incorporate substantial damage assessments into flood response operations.	365	266
620	**Levees** ▪ Annually inspect and maintain existing levees; have a system for recognizing the threat of levee failure and/or overtopping, disseminating warnings, and providing emergency response; and coordinate with operators of critical facilities.	235	111
630	**Dams** ▪ Have a high-hazard-potential dam that could affect the community; have a system for recognizing the threat of dam failure, disseminating warnings, planning and practicing emergency responses; and coordinating with operators of critical facilities.	160	38
	Series 600 Total	760	415
	Total for All Series	**14,092**	**2,505**

ESTIMATIONS OF THE CURRENT EMISSIONS TRAJECTORY

Figure X shows the current emissions trajectory from 2024 to 2030. Figure Y shows the desired emissions trajectory from 2024 to 2030. Due to a lack of available data, these trajectories were estimated based on Sustainable Jersey's 2015 and 2020 data.

	2024	2025	2026	2027	2028	2029	2030
Scope 1	181,484	181,614	181,744	181,874	182,003	182,133	182,263
Scope 2	35,416	35441.5	35467.0	35492.5	35518.1	35543.7	35569.2

Figure X: Current estimated emissions trajectory in Ridgewood based on 2015 and 2020 data.*

	2024	2025	2026	2027	2028	2029	2030
Scope 1	181,484	173861.9	166559.7	159564.2	152862.5	146442.2	140291.7
Scope 2	35,416	33928.5	32503.5	31138.4	29830.6	28577.7	27377.4

Figure X: Desired emissions trajectory for Ridgewood to meet net zero targets by 2050

*The percentage change in Scope 1 data between 2015 and 2020 has been used to model both Scope 1 and 2 projections to account for the impact of COVID-19 on the 2020 electricity data.

Table 1: Quantitative Decarbonization Program Analysis

Activity	Approx. Cost per unit	Estimated Emissions Reduction per unit	Overall effectiveness ($ per metric ton CO2e reduced)	Total MTCO2e reduction possible to achieve
Bicycle Shares	$3600/bicycle (Capital cost) + $1700 (Annual operating cost). (Midgely, P. 2010)Revenue from membership/spo nsor-ship & advertising can abate these costs	0.86 metric tons/bicycle/yea r (D'Almeida, L, 2021)	If bicycles are provided for free, $6162.79/mT CO2e can be reducedIf there are user fees (taking Barcelona as a model at $35/year) and we assume ~1000 registrations for 100 bicycles, then $5755.81/mT CO2e. Sponsors hip/partners can drive down the cost.	86mT/year, assuming a 100 bicycle fleet (Most journeys will likely occur within the downtown area)
Carpooling	$0, although carpooling apps or other ways of increasing take-up will incur some upfront investment (~$20'000) (Let's Nurture)	22% reduction in CO2e relative to daily commute to the same place (Bruck, B.P., 2017)	30% of car driving comes from commuting, so we assume 23539.512 mT CO2e from personal vehicles and trucks (US DOE, 2022). A 22% reduction, with a $20'000 investment in an app, allows for $3.86/mT CO2e	5178.7mT CO2eLikely the total capacity is less as clear information on commuting in Ridgewood is hard to find

Activity	Approx. Cost per unit	Estimated Emissions Reduction per unit	Overall effectiveness ($ per metric ton CO2e reduced)	Total MTCO2e reduction possible to achieve
Park and Ride	$0 - price commuter parking permits (weekly/monthly /annual) at such a rate as to not lose hourly rental for spots. Alternatively this could make money	0.3lb CO2e/passenger mile (CBO, 2022)	N/A	Assuming 36.2% CO2e reduction per commute (CBO, 2022) and that 30% of car journeys are commutes and 20% of those commutes switch to train journeys, ~1700mT CO2e
Solar electrification of public Buildings	$1757 per kw/hourI would say about 100 of the public buildings in the list seem like actual building within Ridgewood where we might be able to install solar, assuming an arbitrary amount of 10Kw installed per building we could do up to about 1MW overall	41 grams per CO2 equivalent emissions per kilowatt hour of electricity generated (Wigness, 2023)0.46 metric tons per MWhAssuming a 1 MW total installation would generate about 4 MWH per day or 1460 MWH over 365 days	40.0000463 dollars per ton= assuming $2.95 per watt it'd be 2.95 million for a total of 1 MW installed - say the panels last 25 years, that'd be 2.95 million/ (671.6*20) about $175.6 approx.	84870 grams per kw hour0.46*1460 = 671.6 tons approximately.

Activity	Approx. Cost per unit	Estimated Emissions Reduction per unit	Overall effectiveness ($ per metric ton CO2e reduced)	Total MTCO2e reduction possible to achieve
Power Purchasing Agreements (PPAs)	Around $50 per MWH (Utility Dive)	416.89 Kg CO2e per MWH = 0.416 metric tons of CO2e per MWH (US EPA, 2015)	50/0.416= $120.19 approx.	PPA for full electricity usage of Ridgewood is possible i.e. 156086.952 MWH approx.
Recycling	Depends on whether Ridgewood invests in new side-arm trash collection trucks, which can cost as much as $300,000 each	Depends on the material: Plastic: 1.02kg CO2 per kg Paper: 0.46kg CO2 per kgGlass: 0.31kg CO2 per kgMetal: 5.86kg CO2 per kgTextiles: 3.37kg CO2 per kg. (RecycleWits, 2023) Assuming an average composition of 1 kg of waste of equal parts of all these, amounting to about 2.2 kg CO2e per kg	Assuming the purchase of 2 sidearm trucks at 300k per truck and a cost of $65 per ton of waste recovered - with 744 kgs or 0.82 US tons of waste per person per year it'd be 0.82*65*26000 + 600,000/42,556 which is about $46.5 approx.	Uncertain/ depends on how much waste is generated by household in Ridgewood Assu ming the national average of approx. 744 kg per person per yearTotal emissions reduced = 744*2.2*0.001 = 1.63 tons per year per person. For about 26k people this would be 42,556 tons

Activity	Approx. Cost per unit	Estimated Emissions Reduction per unit	Overall effectiveness ($ per metric ton CO2e reduced)	Total MTCO2e reduction possible to achieve
Municipal Vehicle Fleet Electrification	60-70k per EV approx.(Yahoo Finance, 2023)$27,690 for a new Model 3	Estimates say about 30-45% reduction in emissions achieved from using EVs relative to conventional cars - avg. tailpipe emissions per vehicle/mile is about 0.4 kg CO2e - (Gao, 2023; Harrison, 2019; US EPA, 2021)	Assuming tailpipe emissions, there is an estimated average of 4.6 metric tons emitted per year by a passenger car (EPA)	Not in the short term- perhaps 2-3 vehicles to start with would be possibleAssuming the average vehicle driving distance of around 13,500 miles per year (though this would be more or less for fleet vehicles depending on the vehicle) - this is around
Building Efficiency Grants	Commercial, industrial, and local government (NJ OCEA; NJ OCEB; NJ OCEC; NJ OCED):Existing buildings program: Incentives up to $4MNew construction energy efficiency: Incentives can range from $0.08-$0.40 per square foot, can vary based on project completion, or can be up to $100,000	Upgrades to heating and cooling in existing buildings can reduce a total of 61% of building emissions (Greenbiz; ACEEE).New constructions could cut their emissions by 70% with efficient design and the use of cleaner electricity. (Energy Star; Better Buildings Initiative)	Savings for commercial, industrial, and local government: $0.60/ sq ft on operations and maintenance expenses annually$0.50/sq ft on janitorial expenses annually$0.53/sq ft on utility expenses annuallyFor residential, see Figure 1.For distributed energy resources, combined heat and power sources can save more than $28M over the 20-year lifetime of the project.	Given 2020 values of natural gas and electricity emissions and 61% emissions reductions in buildings due to upgrades → ~66480 MTCO2e

Activity	Approx. Cost per unit	Estimated Emissions Reduction per unit	Overall effectiveness ($ per metric ton CO2e reduced)	Total MTCO2e reduction possible to achieve
Walk to School Campaign for Students	Up to $5000 for marketing and personnel compensation (Safe Routes: WebFX)	400 grams of CO2e per mile (US EPA, 2016)	Cost per Metric Ton CO2e Reduced= Total cost of initiative/CO2e reduction per car→ Assuming campaign costs $1000 and 16-18% of Ridgewood population is school-aged children, then the estimated # of people going to school is ~4500. Therefore $1000/(0.0004*4500) metric tons = $556	0.0004 MTCO2e * 4500 school-aged children = approximately 1.8 MT CO2e reduced

Activity	Approx. Cost per unit	Estimated Emissions Reduction per unit	Overall effectiveness ($ per metric ton CO2e reduced)	Total MTCO2e reduction possible to achieve
Ordinances on electric leaf blowers	Average cost of battery-powered leaf blowers: $150 (Selzer, 2022)Average cost of corded-electric blowers: $60 (Ibid.)	1 hour of using a leaf blower is equivalent to driving 1,100 miles in an average gasoline car (Dutzik, 2023). This equates to 0.29 MTCO2e per leaf blower (Carbonfootprint.com).There are 8417 households in Ridgewood as of 2020, so assuming each household uses their lawn mowers for 19 hours per year*, that would equate to 46,377.67 MTCO2e in total (8417*19*0.29).*Peak Season (Fall): Assume usage once per week over approximately 10 weeks: 10*1*1=10 hours Off-Peak Use: For the rest of the year, assume occasional use such as after storms or for general yard cleanup. Let's say once a month for the remaining 9 months: 9*1*1 = 9 hours10+9=19 hours of use annually	One gasoline-powered lawn mower spews 0.29 MTCO2e annually. For residents: Assuming each household replaces their lawn mowers, then the total cost is between $505,020 and $1,262,550 (8417*$60 and 8417*$150). This translates to $10.89 and $27.22 per MTCO2e reduced annually, respectively ($505,020/46377.67 and $1,262,550 /46377.67).For the Village: Assuming there are 20 municipal gasoline-powered leaf blowers that need to be replaced with battery-powered ones, this would cost $3000 (20*$150). This would equate to $27.22 per MTCO2e reduced annually.	For residents: Assuming each household requires 1 lawn mower and uses it for 19 hours per year, 8417*0.29*19 MTCO2e = 46377.67 MTCO2e reduced annuallyFor the Village: Assuming 20 leaf blowers, 20 leaf*0.29*19 MTCO2e each=110.2 MTCO2e reduced annually

Table 2: Qualitative description

Activity	Funding/capital investment needed	Can it be done immediately / timeline	Level of community engagement needed (top down/ unilateral or bottom up),	Level of Reduction Achieved	Is it sustainable over time?
Bike Shares	For 100 bikes, and their annual operation, Ridgewood would need to invest ~ $530’000	Yes, although it will take some time to develop redistribution frameworks/ build depots/adve rtise and obtain sponsorship etc.	~4% of the community engaged in registration. Requires public buy-in	Low-Medium	Yes
Carpoolin g	~$20’000 for an app	Yes	Yes - bottom-up	High with enough buy-in	Yes
Park and Ride	$0	Yes	Top-down for parking permits and bottom-up for the switch in transport mode	High	Yes
Solar electrifica tion of public Buildings	3636990	Yes	Unilateral	High	Yes

Activity	Funding/capital investment needed	Can it be done immediately / timeline	Level of community engagement needed (top down/ unilateral or bottom up),	Level of Reduction Achieved	Is it sustainable over time?
PPAs	Depends - payments may be required for a municipal PPA but the costs won't need to be borne by the council- can issue an ordinance for all residents and commercial businesses to have PPAs	Yes	Top-down (ordinance)	high	Yes as long as the grid has the infrastructure to offer the service
Municipal Vehicle Fleet electrification	High - assuming about 280 municipal vehicles and an assumed cost of changing at around 60k per vehicle	No	This is for municipal fleet only - community may only support through taxes and/or donations	Depends on the grid electricity and reductions observed over a longer term not a shorter term	Yes - a one time investment would yield long term reductions results
Solar electrification of public Buildings	3636990	Yes	Unilateral	High	Yes

Activity	Funding/capital investment needed	Can it be done immediately / timeline	Level of community engagement needed (top down/ unilateral or bottom up),	Level of Reduction Achieved	Is it sustainable over time?
Recycling Mandate s	Low since the recycling vans and center already exist. Details on the potential to modernize the waste management fleet found in the waste management section.- 2 new trucks at 300k each	Yes, with an ordinance	High- residents need to be comfortable with being made to recycle/ need to be engaged	Depends on the composition of the material and the amount of waste generated	Yes, since the facilities already exist it would be easy to sustain a recycling requirement if the residents are willing and able to cooperate with one

Activity	Funding/capital investment needed	Can it be done immediately / timeline	Level of community engagement needed (top down/ unilateral or bottom up),	Level of Reduction Achieved	Is it sustainable over time?
Building Efficiency Grants	Varies depending on the size of the grant. New Jersey Clean Energy Program (NJCEP) provides incentives for commercial, industrial, and local government, as well as for residential. Commercial, industrial, and local government: Existing Buildings Energy Efficiency, New Construction Energy Efficiency, Distributed Energy Resources, and Other Specialized Programs (e.g. schools and small businesses, community energy plans)Residential: Residential New Construction**Note: There are no grants for existing residential units	Commercial, industrial, and local government: Application process can begin immediately, but implementation will take several months to years.Residential: Application process can begin immediately, but construction and post-construction evaluations will take several months to over a year.	Combination: Policies and strategies developed at the top level should be informed by feedback from the community level; the success of the program will hinge on active participation and buy-in from the community.	Generally high, but depends on the type of building and improvements made to it, and reductions observed over a longer term not a shorter term.	Yes as long as buildings are maintained

Activity	Funding/capital investment needed	Can it be done immediately / timeline	Level of community engagement needed (top down/ unilateral or bottom up),	Level of Reduction Achieved	Is it sustainable over time?
Walk to School Campaign for Students	Minimal to none. Where costs might be needed:Publicizing the eventCelebration (if goal is achieved)	NJ DOT recommends 4-5 months of planning:Month 1: Form a teamMonth 2: Hash out event detailsMonth 3: PublicizeMonth 4: Host eventMonth 5: Celebrate	Bottom-up	Low-Medium assuming the campaign is 1 week	Yes, and it could become a more frequent occurrence throughout the school year.
Ordinance on electric leaf blowers	$0	Yes but should be phased in over time.	Combination: top-down regulatory frameworks with bottom-up community involvement; Involvement of local businesses, environmental groups, and community leaders to aid in effective implementation	High	Yes