Student A
Student B
Student C
Student D
Ms. Rice
English 9 Honors
March 1st, 2021

Solving Stormwater Pollution in Redmond

Background

Student A: I've been very interested in the environment and conservation since I was really young, but a project that I did in fifth grade really got me dedicated to helping the environment in any way possible. When I was first introduced to the idea of rain gardens, green roofs, permeable asphalt, and other forms of low-impact development, I was really intrigued. I liked the idea of how something so simple and sustainable can be so effective in reducing pollution in runoff and double as a way to beautify the area that doesn't require too much human intervention. The amount of rain we get here in Redmond makes it an ideal place to plant rain gardens, which in turn helps our ecosystem.

Student B: Throughout my life, many of the people around me have talked about the issue of pollution. Excess runoff creates another way to cause pollution in our world. People are constantly seeking ways to eradicate pollution, and rain gardens are a great start to the process of stopping this horrendous cycle. The toxic chemicals from cars and other vehicles flood into the water bodies of Redmond. Since many people from my family use cars, I can understand the impact it has on our environment and how unsafe it is. Through the use of rain gardens, we can help stop this issue.

Student C: As I've gotten older and more aware of climate issues due to pollution, I've been able to make wiser choices and develop a passion for combating climate issues. I also feel

responsible for finding solutions because humans are the leading factor for pollution problems and I personally contribute to it. Water pollution affects our whole community, including wildlife. As our population increases, there is also an increase in water pollution due to cars and toxic chemicals. Fortunately, rain gardens are the perfect long-term solution to combat these concerns.

Student D: I have always been interested in the development of new solutions to environmental issues, including water pollution. Ever since I was little, I sought for unique and impactful ways on how I could take part in preserving the natural world. In Washington State especially, water is a key component to our environment- without proper strategies to combat water pollution, ecosystems with species native to our state will be destroyed. Having lived in Redmond for nearly a decade, I want to ensure a bright future for our city by using low-impact, natural, and effective techniques like rain gardens to reduce wastewater runoff and ultimately, water pollution.

Need Statement

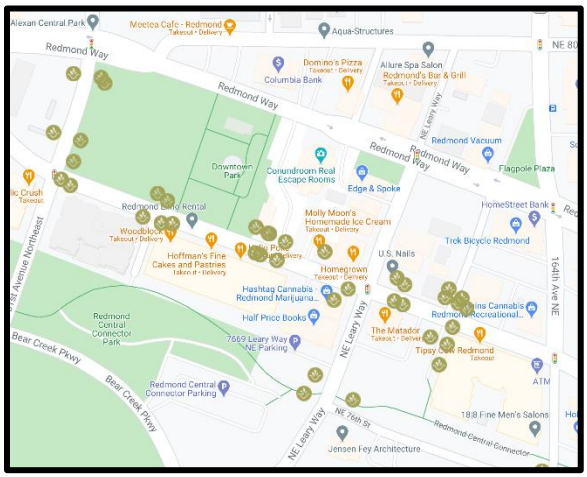
The city of Redmond lacks a sufficient amount of rain gardens to effectively filter pollution from rainwater.

Defining the Need: Background

In Redmond, there have already been rain garden projects in the past. Although none were large scale, the few that were built have proved their usefulness in the city. For instance, an article in the *Redmond Neighborhood Blog* from October 13th, 2010 titled “City Partners to Build a ‘Rain Garden’ at NE 40th & 172nd Ave” by John Reinke details how a group of Stewardship Partners staff and volunteers constructed a rain garden by planting “a variety of sedges, shrubs

and other plants … A few days later, an opening was made … to permit rainwater runoff to flow into the garden to fill it up. Another opening was created downhill from the intersection, so that any excess rainwater could run back out and into the stormwater runoff system" (Reinke). The rain garden built in this project consisted of native plants, helping the local ecosystem while preventing rainwater pollution in the busy intersection. This successful undertaking of planting a rain garden in a critical area suggests that further usage of this natural and low-maintenance technique should be utilized by the city. In the *Redmond, Washington* page entitled "Low-Impact Development (LID)", the city details their previous plans for incorporating low-impact development in Redmond, including rain gardens: "[For example], the City's 2006 Regional Facilities Plan describes the City's plan to incorporate low impact development as part of an overall approach to managing stormwater" ("LID"). The plan lists multiple locations that Redmond will plant rain gardens in, such as Grass Lawn Park, 161st Ave NE, and 185th Ave NE. However, this plan is extremely outdated and requires a restructured version to ensure new factors are considered as well, such as the increasing need for rain gardens.

Figure 1



There are approximately 64 rain garden projects planned by the 12,000 Rain Gardens in Puget Sound campaign in Redmond as of March 2018. The majority are scattered around Cleveland Street (Figure 1). Research conducted by Sound Impacts also exhibits that past projects in the city have already managed over 500,000 gallons of runoff. These statistics further highlight the effectiveness of rain gardens in the city

when being planted in high-traffic areas that pose great threats to nearby water bodies due to how susceptible they are to wastewater runoff.

The *Redmond, Washington* report published January 7th, 2021 entitled "Existing Conditions Natural Environment" mentions the current solutions in play for managing stormwater: "The City's National Pollutant Discharge Elimination System (NPDES) permit requires numerous actions to reduce the amount of polluted stormwater runoff flowing into our lake, river, groundwater, and streams (in compliance with the Clean Water Act)" ("Existing Conditions Natural Environment"). Although the NPDES permit does aid in the reduction of water pollution, it only applies to select facilities in the entirety of the United States. Additionally, the license still allows these sources to discharge a certain amount of pollution, emphasizing that the problem of runoff would not be solved with solely NPDES permits.

Defining the Need: Consequences

Water pollution poses three main consequences: first, the majority of wastewater is dumped back into water bodies, decreasing the overall water quality and increasing pollution. Second, wastewater carries several pathogens that are harmful to human health. Finally, water pollution is harmful to ecosystems and the organisms in them in various ways, such as reducing oxygen levels and preventing reproduction. This can cause drastic consequences, both in the short-term and long-term.

Water, which is aptly nicknamed a "universal solvent", is very susceptible to contamination because of how easily pollutants can dissolve in it. Melissa Denchak's article entitled "Water Pollution: Everything You Need to Know", published by the *Natural Resources Defense Council* on May 18th, 2018 notes how the majority of this polluted water finds its way

into larger water bodies, decreasing the overall water quality: “Some 80 percent of the world’s wastewater is dumped – largely untreated – back into the environment, polluting rivers, lakes, and oceans” (Denchak). Moreover, as the 2019 *American Rivers* article titled “How Stormwater Affects Your Rivers” details, the polluted water includes sewage, which “pollutes … waters with pathogens, excess nutrients, heavy metals, and other toxins” (“How Stormwater Affects”). Water is not an infinite resource, and access to clean water is extremely important. The general problem of decreased water quality harms two main groups in Redmond: humans and aquatic life. When the vast majority of wastewater reenters water bodies, it taints humans’ drinking water and the many aquatic ecosystems that are home to thousands of native species of Washington State. This contamination can lead to more serious consequences, such as increasing risks of multiple health issues and driving many species’ status to endangered or even extinct.

An article published on May 18th, 2019 in the *Natural Resources Defense Council* by Melissa Denchak, titled “Water Pollution: Everything You Need to Know” states that water pollution due to runoff is extremely detrimental to human health, and is more common than most people think: “While most Americans have access to safe drinking water, potentially harmful contaminants – from arsenic to copper to lead – have been found in the tap water of every single state in the nation” (Denchak). If this problem were to worsen, there would be disastrous consequences in the Redmond community. Current water quality concerns are especially apparent in a recent study conducted by the Environmental Working Group (EWG), revealing that, in Redmond, there are already more than ten contaminants over legal guidelines that can potentially lead to multiple cancers and developmental issues. The Environmental Working Group (EWG) report entitled “10 Pollutants In Washington Tap Water Put Your Health At Risk: Study”, published on *Patch* on July 26th, 2017 by Neal McNamara, says that they found six

contaminants that were “above legal limits: arsenic, nitrate and nitrite, uranium, total trihalomethanes, nitrate, [and] haloacetic acids (HAA5)” (McNamara). Runoff poses a serious threat to the residents of Redmond due to the various pollutants it adds to drinking water. An even more concerning aspect of this issue is that these microscopic contaminants are often overlooked, because while the water in an individual’s glass might appear to be clean and healthy, in reality, the water quality can be extremely poor.

The long-term problems with water pollution extend further than unsafe drinking water. The article published on the *Natural Resources Defense Council* titled “Water Pollution: Everything You Need to Know” by Melissa Denchak published on May 18th, 2018 notes how aquatic ecosystems are harmed as well: “When water pollution causes an algal bloom in a lake or marine environment, the proliferation of newly introduced nutrients stimulates plant and algae growth, which in turn reduces oxygen levels in the water. This dearth of oxygen, known as eutrophication, suffocates plants and animals and can create ‘dead zones,’ where waters are essentially devoid of life” (Denchak). This eutrophication makes certain locations uninhabitable, which is extremely harmful to the wildlife that lived in those regions. Over time, continual pollution of water bodies could have drastic impacts on the wildlife there. The different human activities across the city that result in this pollution (mainly nonpoint source pollution, or runoff pollution) in the water can only be expected to increase as the population of Redmond increases, consequentially harming both the ecosystem and the society built around it. A report by the *Department of Ecology State of Washington* authored by Ralph Svrjcek titled “Sammamish River Temperature & Dissolved Oxygen TMDL” highlights that, in fact, the Sammamish River, which flows through Redmond, already undergoes eutrophication during the summer months: “Water quality in the Sammamish River is poor during summer months. Much of the river lacks shade

and large portions are heavily infested by the invasive weed Egeria densa, or Brazilian Elodea. Along with relatively low flows that occur during dry summer months, these factors contribute to the observed high water temperatures and low dissolved oxygen levels in the river" (Svrjcek). As water pollution increases, the overwhelming consequences are accentuated in the natural world. Eutrophication devastates Redmond's environment and overall surroundings. Aquatic life is a key component to the city's ecosystem, and the decreasing water quality due to runoff serves as a barrier to the developing organisms in Redmond's water bodies.

Defining the Need: Stakeholders

In Redmond, successfully planting an effective amount of rain gardens can only be done with the help of the government and residents. To begin with, Redmond's government needs to ensure that its residents have access to high-quality drinking water. This problem is growing increasingly important. In fact, "Water Pollution: Everything You Need to Know", an article by Melissa Denchak published on the *Natural Resources Defense Council* on May 18th, 2018, states that the amount of water humans have access to is finite, and the demand for water is predicted to go up: "Without action, the challenges will only increase by 2050, when global demand for freshwater is expected to be one-third greater than it is now" (Denchak).

Figure 2

Therefore, the government needs to take initiative and start multiple rain garden projects in the city as soon as possible before the consequences worsen. They can accomplish this in multiple ways. First, by planting rain gardens in public areas (mainly in the places prone to flooding shown in Figure 2, which includes the 100 Year Floodplain, or around critical aquifer recharge areas), they can help reduce the amount of water pollution in Redmond. They also play a big part in demonstrating the values of having rain gardens, which can impact many people in the city. By encouraging and educating people on the benefits of rain gardens, and through a combination of private and volunteer work, the amount of green infrastructure in Redmond can increase, thus helping the environment.

Rain garden projects should appeal to the Redmond government, as the city has already had many committees and projects regarding this problem and even frequently encourages residents to participate in them. For instance, Abby Acone's article titled "New project to tackle Puget Sound's growing polluted stormwater" and published on *Komo News* in February 2020 reveals that "the Washington State Legislature approved $500,000 to help with [the Aurora Bridge runoff] project" (Acone). If a mere fraction of this project's budget were to go to building rain gardens, it would significantly relieve the current water pollution problem.

Apart from the government, the residents of Redmond also play an important part in successfully planting a sufficient amount of rain gardens around the city. If some residents give up space around their houses to build rain gardens, the City of Redmond will not only be helping the environment, but they will also be maintaining a solid, clean water supply, something necessary for all residents. In addition, the City of Redmond has a map published on February 28th, 2005, of the frequently flooded areas in Redmond, such as the 100 Year Floodplain (Figure 2). Residents living within these areas, around rivers, or in any area that receives a lot of

precipitation, especially, should be encouraged to build rain gardens on their property. This will greatly help prevent runoff in those areas. John Reinke's article in the *Redmond Neighborhood Blog* titled "City Partners to Build a 'Rain Garden' at NE 40th & 172nd Ave" published on October 13th, 2010, mentions that it doesn't take long to build a rain garden, and after one has been fully established, they don't require much human intervention to grow: "The garden needs to be watered twice a week for the first two years during dry periods, while it is getting established. After that, … it's time for 'tough love' and the garden has to make it on its own" (Reinke). Planting rain gardens is a simple and time-efficient task for residents that can solve multiple existing problems and provide future benefits to Redmond. Ultimately, this is a city-wide plan, and this would only work if enough people put in the time and effort to make it succeed.

Defining the Need: Future Problems

As the population grows, the city needs to accommodate for the higher demand for housing and an increase in products containing toxic chemicals such as mercury and PCBs. When products such as building and roofing materials and even fabric softeners are used and disposed of, they soon enter Redmond's nearby rivers, streams, and lakes. Exposure to these toxic chemicals can cause major harm to the humans and animals that encounter them. The article titled "Sammamish River Temperature & Dissolved Oxygen TMDL" by Ralph Svrjcek from the *Department of Ecology State of Washington* says, "Exposure to these toxic chemicals can cause harm to human health and the animals exposed to them in the environment. Infants and children are especially at risk … they can linger in the environment for decades and be found in the fatty tissue of people and animals long after their use has been stopped or products banned" (Svrjcek). These chemicals disrupt bodily chemistry and can cause developmental issues in

children and infants, liver damage, and neurological damage. By planting more rain gardens, this problem can be eradicated.

Furthermore, water pollution can also have long-term effects on Redmond's vegetation. Heavy metals used for buildings are released into the environment and soak into the soil. Plants absorb these toxic chemicals, which can lead to damage to the cell membrane in the future as well as metabolic dysfunction. An article on *IntechOpen* entitled "Water Pollution: Effects, Prevention, and Climatic Impact" published on March 21st, 2018, by Adejumoke Inyinbor, et al. says that these chemicals are also known to affect the "enzyme involved in chlorophyll production, thus reducing photosynthetic rate as well as affect plant reproduction via decrease in pollen and seed viability" (Inyinbor et al.). This can affect the food chain, the production of clean air, and the habitats of many native species. Unfortunately, these problems are already starting to emerge: the Washington Department of Fish & Wildlife (WDFW) Priority Habitats and Species reports that several species are threatened or endangered due to pollution in runoff, including various aquatic life in the Sammamish River (Figure 3). These animals are crucial to the development and maintenance of not only Redmond's ecosystem, but also nearby environments. Without them, food chains and natural routines would be disrupted. The critical endangerment or extinction of multiple species can even drive other animals to extinction as

Species	Federal Status	Critical Habitat	State Status	Occurrence Type
Coastal-Puget Sound Bull Trout *Salvelinus confluentus*	Threatened	Yes	species of concern	no recent documentation
Puget Sound Chinook Salmon *Oncorhynchus tshawytscha*	Threatened	Yes	species of concern	breeding / occurrence
Puget Sound Steelhead *Oncorhynchus mykiss*	Threatened	Proposed	none	Infrequent occurrence
Puget Sound / Strait of Georgia Coho Salmon *Oncorhynchus kisutch*	Candidate		none	rearing / occurrence
Kokanee (non-migrating sockeye) *Oncorhynchus nerka*	Proposed		priority	occurrence / migration
Sockeye salmon *Oncorhynchus nerka*	Not Warranted		priority	occurrence / migration
Resident Coastal Cutthroat *Oncorhynchus clarki*			priority	occurrence / migration
Rainbow trout *Oncorhynchus mykiss*			priority	occurrence / migration
Bald Eagle *Haliaeetus leucocephalus*			sensitive species	occasional presence
Pileated Woodpecker *Dryocopus pileatus*			species of concern	possible occurrence
Great blue heron (Species of Local Importance) *Ardea herodias*				probable occurrence
Purple martin *Progne subis*			candidate	general vicinity Lake Sammamish

Figure 3

well. If this continues in the future, it could easily get out of hand. In order to prevent this, Redmond needs to act now and incorporate rain gardens into the city.

Proposed Solution

Redmond should increase the number of community rain gardens in public areas as well as encourage homeowners to build rain gardens on their property by providing the necessary materials.

Explanation of Solution

An increase in the number of rain gardens would provide several benefits for the Redmond community. Some of the problems Redmond faces include the pollution of water through runoff, which in turn is harmful to both the ecosystem and humans, and the soaking of polluted water through the ground and into aquifers. The *National Ground Water Association* article "All about Rain Gardens" written in 2021 contains studies that show that rain gardens would greatly help reduce the amount of water pollution in Redmond: "Rain gardens are effective in removing up to 90% of nutrients and chemicals and up to 80% of sediments from the rainwater runoff. Compared to a conventional lawn, rain gardens allow for 30% more water to soak into the ground" ("About Rain Gardens"). By planting rain gardens in areas prone to flooding or where there is a lot of runoff, the amount of water pollution in Redmond will reduce by a lot. In addition, rain gardens have been built in several cities, and have proven their effectiveness in both beautifying the surrounding area and reducing runoff pollution. The *U.S. Department of the Interior* report "Effects of Rain Gardens on the Quality of Water in the Minneapolis–St. Paul Metropolitan Area of Minnesota, 2002-04" details that in the Minneapolis-Saint Paul metropolitan area of Minnesota, several rain gardens were built, and they were

effective in reducing the runoff pollution and filtering particles out of the water: "… The resulting data indicate that properly designed rain gardens enhance infiltration and can reduce concentrations of dissolved ions relative to background conditions …" ("Minnesota Rain Gardens" 7). The same *U.S. Department of the Interior* report "Effects of Rain Gardens on the Quality of Water in the Minneapolis–St. Paul Metropolitan Area of Minnesota, 2002-04" also notes that "overflow had reduced concentrations of suspended solids and most nutrient species associated with particulate material, as compared to inflow. Many of these materials settle to the bottom of the rain garden and some nutrients may be assimilated by the plant community" ("Minnesota Rain Gardens" 28). Any polluted water flowing into the rain garden system is mostly filtered upon leaving, and the rest is soaked into the plants in the garden. Through this process, pollution is removed from runoff.

With levels of contaminants in waters significantly decreased thanks to rain gardens, the number of physical health risks in Redmond will also decrease. As previously mentioned, rain gardens manage polluted runoff and stop them from advancing further into healthy water bodies. In the *Sightline Institute* research report published in January 2013 entitled "Are Rain Gardens Mini Toxic Cleanup Sites?", author Lisa Stiffler reveals that rain gardens are effective combatants against harmful organelles that lead to infections and disease: "Bacteria and viruses…can cause disease in humans in stormwater; [however,] … soil of rain gardens can destroy the pathogens" (Stiffler). As contaminant levels continue rising in Redmond's drinking waters, it's vital to increase the installment of rain gardens, especially in areas with heavy runoff, to ensure that the population does not face the long-term health consequences these pollutants can bring. The city should be able to provide safe and clean water for homes, and this can only be effectively accomplished with the addition of rain gardens.

Rain gardens also help preserve the wildlife of Redmond, protecting both land and aquatic environments around the city. According to the *Defenders Magazine* article "Saving Wildlife on a Rainy Day" published in 2018, a rain garden greatly helps the natural world because it "mimics water filtration and the gradual release of a natural forest ecosystem" ("Saving Wildlife on Rainy Day"). Additionally, in the *Lemon Bay Conservancy* entitled "Rain Gardens- Good for Water Quality and Wildlife" published on September 10th, 2019, author Bill Dunson says, "Such groundwater can thus be purged of many pollutants [by rain gardens] before reaching adjacent aquatic habitats" (Dunson). As previously stated, rain gardens greatly reduce contaminants in runoff before they reach water bodies in the area. Current environmental concerns regarding water pollution, such as eutrophication in the Sammamish River, can be relieved with the incorporation of rain gardens in Redmond. Furthermore, the *Defenders Magazine* article entitled "Saving Wildlife on a Rainy Day" published in 2018 notes that not only can rain gardens solve existing runoff problems, they also provide new homes for many animals as well as other municipal benefits: "[A rain garden] provides habitat for birds and other animals, reduces flooding in homes and streets, prevents erosion and increases property values" ("Saving Wildlife on Rainy Day"). This highlights the fact that rain gardens are crucial to maintaining biodiverse ecosystems in Redmond and even offer potential economical and housing benefits. They greatly reduce flooding and erosion risks for homeowners, making Redmond a safer city for its residents overall.

Ultimately, by encouraging people to build rain gardens on their property and building more in public areas, busy intersections, and areas with heavy flooding (Figure 2), the City of Redmond will make large steps towards solving problems due to polluted runoff. Teaching people about the positive impacts of rain gardens on a community as well as providing materials

or benefits to those that want to plant rain gardens on their property could help increase the number of rain gardens in Redmond, thus satisfying the need.

Suggestions for Further Research

Redmond should direct a survey for the community to get an estimate on how many people are willing and excited about this solution. This could help the city know how many residents (specifically landowners) would be able and willing to build rain gardens and how likely they are to build a rain garden if given an incentive. This could be done by mailing a survey or creating an online survey on the Redmond government's website. The results would be very helpful to know because the more the community gets involved, the more work can be done. Redmond should also further research the financial aspect of this solution. It would be vital to know what materials are needed and how much they will cost. Redmond could partner with a local landscaping company to help minimize the cost of the materials, making it easier to distribute out to the community. It is also important to research native plants and which are best suited for rain gardens.

Possible Counterarguments and Critiques

One alternate solution to rain gardens is infiltration trenches. According to the *State of Michigan* article "Infiltration Trench" published on December 1st, 1992, an infiltration trench is "a long, narrow, shallow excavation located over porous soils and back-filled with stone to form a subsurface reservoir to hold stormwater and allow it to infiltrate the soil" ("Infiltration Trench"). The *State of Michigan* article "Infiltration Trench" published on December 1st, 1992 also notes that they are more versatile compared to rain gardens; they can be used on "urban, urbanizing, transportation, and agricultural" ("Infiltration Trench") land, whereas rain gardens

require a location with an ideal blend of soil and growing conditions. Moreover, infiltration trenches are suitable for areas with limited space, such as spots next to driveways and between houses due to their size and shape.

Infiltration trenches are also highly effective at removing pollutants. The figure below, with data collected by the Massachusetts Department of Environmental Policies in 1999, highlights that infiltration trenches can remove a vast majority of multiple variants of contaminants in runoff before it reaches water bodies (Figure 4).

Figure 4

Pollutant	Percentage Removed
Total Suspended Solids (TSS)	80% with pretreatment
Total Nitrogen	40% to 70%
Total Phosphorus	40% to 70%
Metals (copper, lead, zinc, cadmium)	85% to 90%
Pathogens (coliform, e coli)	Up to 90%

In Redmond, infiltration trenches have been in use for longer compared to rain gardens. It would be a more realistic solution over rain gardens because the government has had experience installing them and understands how to properly take action. In fact, the *Redmond, Washington* article entitled “Groundwater Protection Incentive Program” notes that Redmond has used infiltration systems for nearly 18 years: “Stormwater infiltration systems[/trenches,] have been regulated by the City of Redmond since 2003 to meet State and Federal requirements associated with the Safe Drinking Water Act” (“Groundwater Protection Program”). This emphasizes that throughout the city’s history, Redmond has continuously strived to enhance water quality using alternative methods that are proven to be just, if not more, beneficial and convenient than rain gardens. Additionally, because the City has had prior laws regarding infiltration trench installments, finance and support would not be a major concern because first, the government

already has an idea of how much of the city budget will be pushed towards further installments, and second, residents have adjusted to living with these systems during past projects.

Rebuttal

Although infiltration trenches may seem like a viable alternate to rain gardens, rain gardens have several advantages over infiltration trenches. To begin with, rain gardens can also be built in a variety of different areas; however, by concentrating them in places with high traffic, there will be a greater amount of runoff collected compared to infiltration trenches. Moreover, in the *Buffalo-Niagara Gardening* article titled "Rain Gardens Are Low Maintenance, Help the Environment" published on August 31st, 2010, author Connie Oswald Stofko states that rain gardens don't require much care: "Native plants are hardy and can basically take care of themselves, so a rain garden is low maintenance" (Stofko). On the other hand, infiltration trenches require frequent maintenance. According to the *Susdrain* article "Component: Infiltration Trenches", if they are not treated properly, they "can start creating pollution instead of making it decrease" ("Component: Infiltration Trenches"). High maintenance and failure rates lead to an unclear future for combating stormwater pollution in Redmond if infiltration trenches were to act as a replacement for rain gardens.

In addition, infiltration trenches can lead to unforeseen financial strains due to their unpredictable behavior and success rate. For instance, the *Susdrain* article

Figure 5

Infiltration Trench System	Materials and Installation Cost ($/ft^3) (2010)[2]	Design Cost ($/ft^3) (2010)	Materials and Installation Cost ($/ft^3) (2017)[3]	Design Cost ($/ft^3) (2017)
Rural	8	2.8	9.84	3.44
Mixed	16	5.6	19.68	6.88
Urban	24	8.4	29.52	10.32

"Component: Infiltration Trenches" highlights that they are known to clog often: "High clogging potential without effective pre-treatment [are] not [suitable] for sites with fine particled soils (clay/slits) in upstream catchment" ("Component: Infiltration Trenches"). Additionally, even without these possible future costs, infiltration trenches cost significantly more than rain gardens. Statistics from the University of New Hampshire Stormwater Center collected in August of 2017 highlight the continuous increasing costs of infiltration trenches (Figure 5).

Taking the costs from mixed systems alone, the materials and installation cost as well as design cost rose by 23% over the seven years. With this trend, it can be expected that Redmond will need to put forth more and more money to maintain infiltration trenches. Furthermore, these costs are per cubic feet. The *State of Michigan* document titled "Infiltration Trench" published on December 1st, 1992, notes that infiltration trenches are often "used on small sites up to five acres in size" ("Infiltration Trench"), equating to approximately 217,800 cubic feet. Even if Redmond does know the predicted budget of infiltration trench installments, it will be a much more cost-efficient option to plant rain gardens instead, which only range from 100 to 300 square feet and are extremely low maintenance. In the long run, rain gardens are the most realistic, budget friendly, and effective solution to decreasing water pollution in Redmond.

Conclusion

Redmond should plant rain gardens throughout the city and encourage residents to do the same in their homes. The problem of stormwater pollution has great consequences now, and these will only grow as the population in Redmond grows. With the vast predicted increase in demand for clean drinking water by 2050, Redmond must work to ensure a steady supply of unpolluted water for everyone. Rain gardens are an easy-to-use, cost-friendly, natural, and

sustainable way of achieving this. They have been proven to be effective against water contaminants by absorbing and filtering nearly all polluted runoff. Planting them around Redmond, especially in areas where water is most absorbed in the ground, areas with the most flooding, and areas with the most runoff, can guarantee the necessary reserve of clean water that is suitable for human consumption. In addition, planting rain gardens will help prevent polluted stormwater from entering rivers, lakes, and other water bodies. The aquatic ecosystems currently thriving in Redmond's waters are threatened by pollution. Water pollution can lead to severe consequences in the ecosystem, the worst of which include the creation of "dead zones", areas devoid of life. A habitat once thriving with aquatic organisms can be emptied through eutrophication, all as a result of runoff pollution. Already, several species in the Sammamish River are threatened, and their conditions can only be worsened through the slow contamination of their habitat. By planting rain gardens and stemming stormwater pollution, the balance of the many aquatic ecosystems in Redmond can be preserved. By implementing this solution and planting rain gardens in Redmond, the city will make large steps towards completely solving the problem of contaminants in stormwater runoff, thereby ensuring the safety of both their wildlife and their residents.

Works Cited

Acone, Abby. "New Project to Tackle Puget Sound's Growing Polluted Storm Water." *Komo News*, 19 Feb. 2020, komonews.com/news/local/new-project-to-tackle-puget-sounds-growing-polluted-stormwater. Accessed 19 Feb. 2020.

"All about Rain Gardens." *The Groundwater Foundation*, National Ground Water Association, 2021, www.groundwater.org/action/home/raingardens.html. Accessed 8 Feb. 2021.

"Component: Infiltration Trenches." *Susdrain*, www.susdrain.org/delivering-suds/using-suds/suds-components/infiltration/infiltration_trench.html. Accessed 2 Mar. 2021.

Denchak, Melissa. "Water Pollution: Everything You Need to Know." *Natural Resources Defense Council*, 18 May 2018, www.nrdc.org/stories/water-pollution-everything-you-need-know. Accessed 2 Feb. 2021.

Dunson, Bill. "Rain Gardens- Good for Water Quality and Wildlife." *Lemon Bay Conservancy*, 10 Sept. 2019, lemonbayconservancy.org/rain-gardens-good-for-water-quality-and-wildlife/. Accessed 3 Mar. 2021.

"Effects of Rain Gardens on the Quality of Water in the Minneapolis–St. Paul Metropolitan Area of Minnesota, 2002-04." U.S. Department of the Interior. *USGS: Science for a Changing World*, USGS, pubs.usgs.gov/sir/2005/5189/ PDF/SIR2005_5189.pdf. Accessed 9 Feb. 2021. Raw data.

Existing Conditions Natural Environment. 7 Jan. 2021. *Redmond, Washington*, redmond.gov. Accessed 5 Feb. 2021.

"Frequently Flooded Areas." *Redmond, Washington*, 28 Feb. 2005, www.redmond.gov/DocumentCenter/View/75/Frequently-Flooded-Areas-PDF. Accessed 3 Mar. 2021. Map.

"Groundwater Protection Incentive Program." *Redmond, Washington*, www.redmond.gov/835/Stormwater-Infiltration. Accessed 27 Feb. 2021.

"How Stormwater Affects Your Rivers." *American Rivers*, 2019, www.americanrivers.org/threats-solutions/clean-water/stormwater-runoff/. Accessed 2 Feb. 2021.

"Infiltration Trench." *Michigan.gov*, State of Michigan, 1 Dec. 1992, www.michigan.gov/documents/deq/deq-wb-nps-it_250882_7.pdf. Accessed 27 Feb. 2021.

Infiltration Trench Factsheet. Durham, University of New Hampshire Stormwater Center, Aug. 2017. *University of New Hampshire*, unh.edu. Accessed 26 Feb. 2021

"Infiltration Trenches." *Massachusetts Clean Water Toolkit*, Massachusetts Department of Environmental Protection, 1999, megamanual.geosyntec.com/npsmanual/infiltrationtrenches.aspx. Accessed 27 Feb. 2021.

Inyinbor, Adejumoke, et al. "Water Pollution: Effects, Prevention, and Climatic Impact." *IntechOpen*, 21 Mar. 2018, www.intechopen.com/books/water-challenges-of-an-urbanizing-world/water-pollution-effects-prevention-and-climatic-impact. Accessed 2 Mar. 2021.

Lee, Katharine, M.S., and Ken Nogiere, M.S. *Critical Areas Report*. Hopelink. Redmond, redmond.gov. Accessed 8 Feb. 2021.

"LOW-IMPACT DEVELOPMENT (LID)." *Redmond, Washington*, www.redmond.gov/408/Low-Impact-Development. Accessed 2 Feb. 2021.

McNamara, Neal. "10 Pollutants in Washington Tap Water Put Your Health at Risk: Study." *Patch*, 26 July 2017, patch.com/washington/redmond/10-pollutants-washington-tap-water-put-your-health-risk-study. Accessed 24 Feb. 2021.

Reinke, John. "City Partners to Build a 'Rain Garden' at NE 40th and 172nd Ave." *Redmond Neighborhood Blog*, Blogger, 13 Oct. 2010, redmondcity.blogspot.com/2010/10/city partners-to-build-rain-garden-at.html. Accessed 6 Feb. 2021.

"Saving Wildlife on a Rainy Day." *Defenders of Wildlife*, Defenders Magazine, 2018, defenders.org/magazine/spring-2018/living-lightly. Accessed 25 Feb. 2021.

Sound Impacts. Stewardship Partners, 2021, www.soundimpacts.org/en/projects/list/type/rain-garden. Accessed 5 Feb. 2021.

Stiffler, Lisa. *Are Rain Gardens Mini Toxic Cleanup Sites?* Sightline Institute, 22 Jan. 2013, depts.washington.edu/esrm311/Winter2014/Documents/Are%20Rain%20Gardens%20Mini%20Toxic%20Cleanup%20Sites_Stiffler_2013.pdf. Accessed 25 Feb. 2021.

Stofko, Connie Oswald. "Rain Gardens Are Low Maintenance, Help the Environment." *Buffalo-Niagara Gardening*, 31 Aug. 2010, buffalo-niagaragardening.com/2010/08/31/rain-gardens-are-low-maintenance-help-the-environment/. Accessed 3 Mar. 2021.

Svrjcek, Ralph. "Sammamish River Temperature & Dissolved Oxygen TMDL." *Department of Ecology: State of Washington*, Washington State Department of Ecology,

ecology.wa.gov/Water-Shorelines/Water-quality/Water-improvement/Total-Maximum-Daily-Load-process/Directory-of-improvement-projects/Sammamish-River-TMDL. Accessed 24 Feb. 2021.