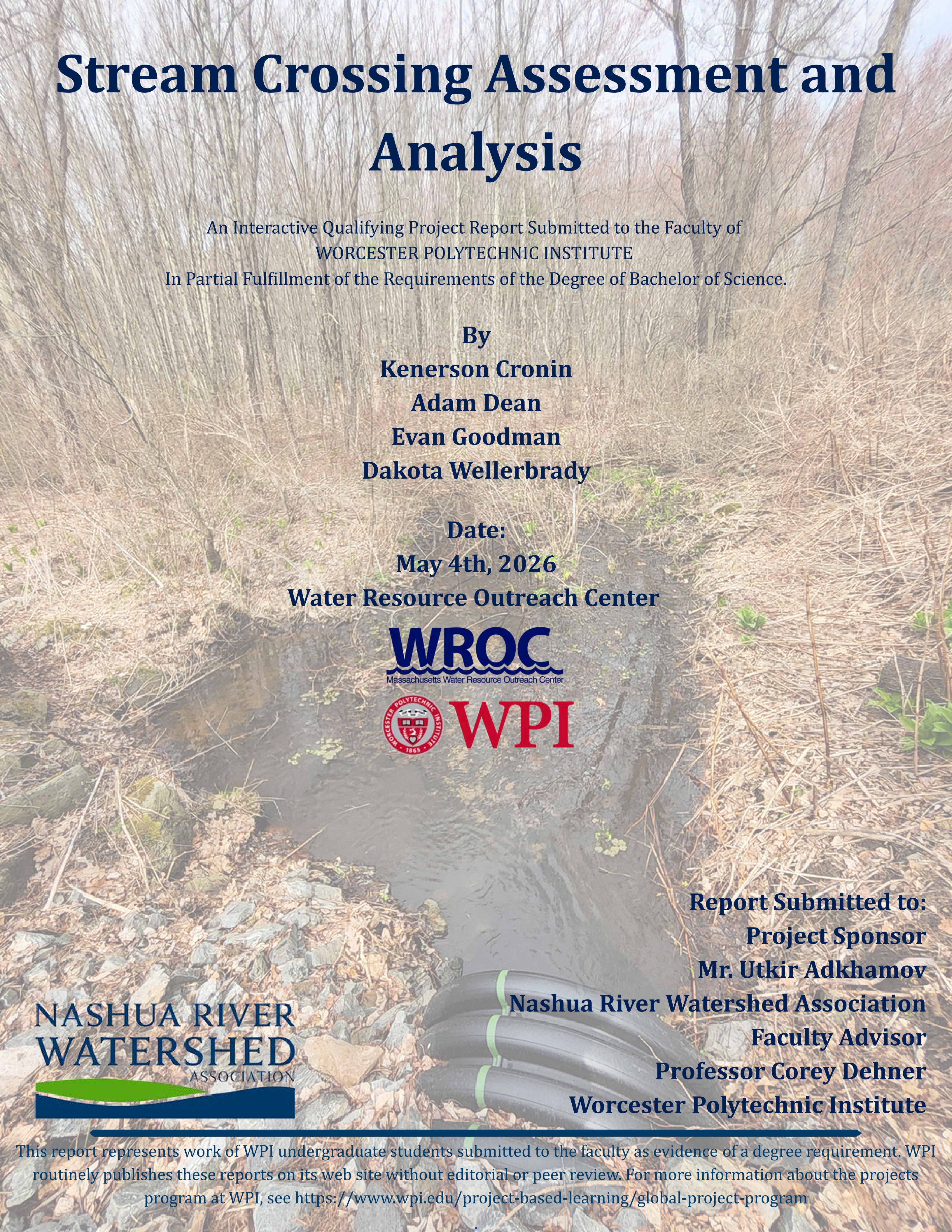

Stream Crossing Assessment and Analysis

An Interactive Qualifying Project Report Submitted to the Faculty of
WORCESTER POLYTECHNIC INSTITUTE
In Partial Fulfillment of the Requirements of the Degree of Bachelor of Science.

By
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Date:
May 4th, 2026
Water Resource Outreach Center

WROC
Massachusetts Water Resource Outreach Center

WPI

NASHUA RIVER WATERSHED ASSOCIATION

Report Submitted to:
Project Sponsor
Mr. Utkir Adkhamov
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Meet the Team

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Abstract

Massachusetts has 31,224 mapped culverts, of which, 6,769 (21.6%) have been assessed, and on average only 200 (3%) are repaired annually. Our goal was to explore whether socioeconomic factors impact the quality and condition of culverts. We worked with the Nashua River Watershed Association and researched eight towns in the watershed. From nine interviews, analyzing fiscal records, and participant observation we found that residents are unaware of the importance of culverts, towns have limited budgets, and state funding options are hard to get and time consuming. In order to increase public understanding of how important culverts are, we developed a four minute educational video for widespread distribution.

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Massachusetts Water Resource Outreach Center

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Background Information

The United States has seen notable increases in rainfall totals and flash flooding from 1959 to 2026, and outdated infrastructure has been struggling to keep up (Abegaz et al., 2026; Jaroszweski et al., 2010). This has affected not only human lives but also ecosystems nationwide. Specifically, in New England temperatures have risen, rainfall has increased, and extreme weather events have made flooding more common (Janowiak et al., 2018). Stream crossings are one type of infrastructure that has seen significant issues due to increased precipitation. Local organizations such as the Nashua River Watershed Association (NRWA) and regional networks such as North Atlantic Aquatic Connectivity Collaborative (NAACC) are working to mitigate issues relating to stream crossings. In this project we worked with the NRWA to explore culvert conditions and see if failing culverts disproportionately affect specific communities.

Project Goal

To explore trends regarding whether demographic factors impact the quality and condition of culverts or ability to apply for and get grants in the Nashua River Watershed, specifically Leominster, Groton, Townsend, Shirley, Sterling, Rutland, Lancaster, and Fitchburg. Additionally, increasing public understanding of how important culverts are.

Objective 1

To start, our first objective was to develop an initial understanding of culverts and the assessment process. This was done by completing some participant and direct observation by doing 20 culvert assessments and interviewing with Mr. Utkir Adkhamov from the NRWA. We also analyzed 1016 existing culvert assessment data using both QGIS and ArcGIS mapping software along with MongoDB for deeper data analysis using its querying capabilities.

Objective 2

Afterwards we moved on to our second objective where we determined the factors that impact culvert replacement. We found these factors by conducting more interviews both in person and online. We once again interviewed Utkir Adkhamov and other NRWA staff along with two Department of Public Works (DPW) employees, three conservation commission staff from our focus towns, and one Department of Environmental Restoration (DER) employee. We found from these interviews important points on how town funding affects culvert replacement like the grants these towns get, how the grant process works, and how town residents can affect budget allocation. We then finished up this objective by doing further content analysis by looking at data provided by our focus towns Department of Public Works (DPW) and conservation commissions .

Figure 1: Stream crossings team inside of 7 foot round metal culvert

Objective 3

We then took these factors that impact culvert replacement and moved on to our third objective where we decided to learn about how culverts are being prioritized. We did so by, once again, using the interview data we gathered from objective 2. We used this data to explore the best universal methods for culvert prioritization, i.e., how a town decides which culvert is most in need of repair usually based on condition, the surrounding areas, construction, and maintenance. We found this by using content analysis on the NAACC database, which is a database filled with culvert assessments across 13 different states.

Objective 4

We came up with conclusions and recommendations for the NRWA by using the data we had collected throughout our prior 3 objectives. We sent over the educational video we had also created to the towns we had been focusing on but also to the Massachusetts Rivers Alliance, and NRWA. We completed this final objective by compiling all the interview, observation, and content analysis we had done prior and analyzing it using a variety of tools like ArcGIS and MongoDB. ArcGIS allowed us to create detailed maps of our data allowing a visualization of them while MongoDB could find more detailed information like percentages of certain types of culverts by using its built in NoSQL document based databases allowing quick querying and easy output of content information.

Finding 1

Residents lack understanding of the importance of culverts, unless directly affected, and care more for the roadways that they use. Towns are financially responsible for projects like repairing roads, bridges, and most culverts. We found that town budgets are allocated based on the wants of its residents. These residents would rather have the town budget go towards roads than culverts. This results in culverts going unnoticed until they inevitably fail causing roads and even houses to become damaged.

Finding 2

Town funds coupled with the steep cost of replacement can restrict culverts from following stream crossing standards. Most towns try to follow them not only because they are supposed to but also because they cost less long term, they last longer, they are more effective at preventing flooding, and they are great for aquatic connectivity. Because funding is hard to secure they often can't get enough funding to build according to stream crossing standards.

Figure 2: 7 foot concrete box culvert in Pepperell MA

Finding 3

Next, we discovered that Massachusetts grants are competitive and lengthy making it harder for smaller towns to apply. Towns have to apply for grants to help them get financial assistance when replacing culverts. In the 2026 grant application cycle, Massachusetts released a new platform for grant applications called Eco One Stop which was meant to streamline the grant process, however 3/4 towns interviewed said it had the opposite effect. There were also some technical issues which led to the portal not saving information. The only town that had no issues with Eco One Stop, Leominster, had a dedicated grant administrator.

Finding 4

Massachusetts lacks culvert specific funding in its infrastructure programs with the Mass Ready Act potentially being able to rectify this. This goes back to our second finding in which residents of towns use roadways more often and want town funds to go towards those instead of culverts that are also just as important. CH90 funds given out by the state is based on road mileage and population but does not take into account the total number of stream crossings or the complexity of the roads. The proposed Mass Ready Act (an Environmental Bond Bill) could alleviate some of these funding issues. One big caveat to this bill is that its funds and work on culverts will be able to bypass local wetlands laws within these towns. This worried the 3/4 towns that we interviewed. But, it is also worth noting that they all did think the extra funding from the bill was a big positive. Although Massachusetts doesn't prioritize culvert replacement enough, the Mass Ready Act is a step in the right direction.

Recommendations

Throughout our research we identified two overarching issues facing the Nashua River Watershed, 1) there is a lack of understanding of the importance of culverts, and 2) small towns need additional funding assistance to adequately tackle failing culverts. Due to this lack of understanding we developed an informational video to help municipalities conduct public outreach. The video explains what culverts are, their importance, the good and the bad, how they can be maintained, created, and repaired, and how the viewer could potentially help. We also recommend that both the NRWA and MRA share and distribute the video with as many partner organizations and towns as possible. We believe this increased education and public outreach will translate into increased focus on culvert repairs.

Figure 3: Leominster MA road washout at stream crossing as a result of 2023 flooding (Wendy Wiiks 2023)

We recommend both the NRWA and MRA develop additional educational material for distribution as it will make it easier for towns to communicate with residents if they have access to already developed educational material. We also recommend monitoring lower income towns. This is due to the fact lower income towns often do not have the funds to apply for such grants and get the necessary engineering designs while they still have culverts that might need maintenance. We recommend that municipalities actively partner with watershed organizations, nonprofits, and universities to leverage external expertise in grant writing, technical analysis, and capacity building.

Figure 4: Five foot concrete pipe culvert with outlet drop and scour pool

Acknowledgements

Our project group would like to thank the many kind individuals who helped us along this project journey.

We would like to thank our advisor, Corey Dehner for assisting us throughout our research and project. We would also like to give a special thank you to our project sponsors, Dr. Jessica Veysey Powell and Mr. Utkir Adkhamov, for allowing us to work with them and for sharing their passion about culvert restoration, stream crossings, and the NRWA.

Additionally, we would like to thank all of our interviewees:

- *Leominster DPW, Assistant Director, Mark Piermarini*
- *Leominster Conservation Commission, Agent, Jesse Averka*
- *Shirley conservation commision, conservation agent, Michael Fleming*
- *Lancaster DPW, Administrative Assistant, Sam Belanger*
- *Central Mass Regional Stormwater Coalition, Co-Chair, Kerry Reed*
- *DS Prof, Proffesor at WPI, Stephan Sturm, ssturm@wpi.edu*
- *Mass River Alliance, Research Manager, Lydia Olson*
- *Wendy Wiiks, Grant Administrator for the town of Leominster*

Finally we would like to thank our librarian, Page Wilkins for her time helping us research and organize our references.

Dr. Jessica Veysey Powell
(Water Programs Director)

Utkir Adkhamov
(Senior Water Quality and Restoration Associate)

53
miles of outstandingly remarkable National Wild & Scenic Rivers

200
miles of riverside greenway protected

12,000+
water quality samples collected by volunteer monitors

50,000+
youth and adults engaged in River Classroom®

3,300
acres of forests protected thru Forest Legacy Program

76,000
acres designated as Areas of Critical Environmental Concern

Introduction

The United States has seen notable increases in rainfall totals and flash flooding from 1959 to 2026, and outdated infrastructure has been struggling to keep up (Abegaz et al., 2026; Jaroszweski et al., 2010) (See Figure 5). This has affected not only human lives but also ecosystems nationwide. Specifically, in New England temperatures have risen, rainfall has increased, and extreme weather events have made flooding more common (Janowiak et al., 2018). Stream crossings are one type of infrastructure that has seen significant issues due to increased precipitation. Local organizations such as the Nashua River Watershed Association (NRWA) and regional organizations such as North Atlantic Aquatic Connectivity Collaborative (NAACC) are working to mitigate issues relating to stream crossings. In this project we worked with the NRWA to explore culvert conditions and see if failing culverts disproportionately affect specific communities.

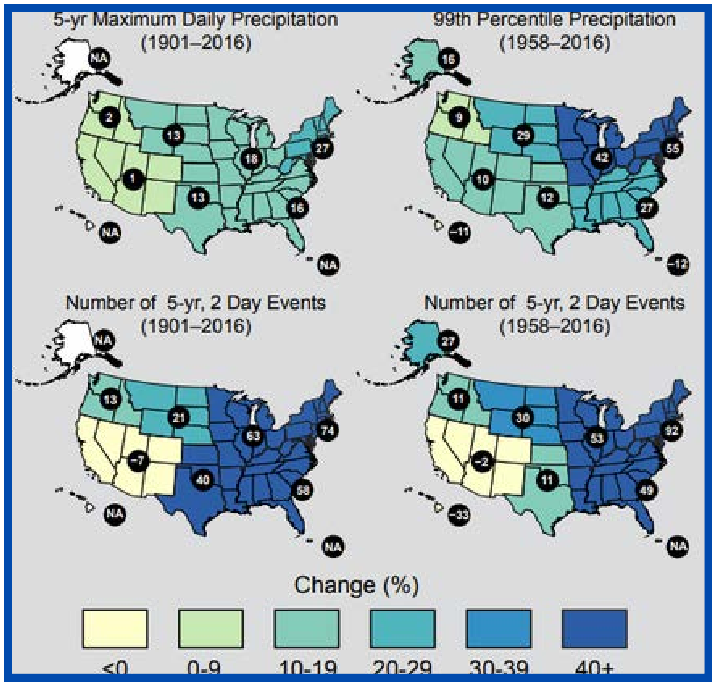


Figure 5: Percent Change in Rainfall in US (D. R. Easterling et al., 2017)

I. Climate Change in New England

Since 1901, mean annual temperature in New England has increased by 2.4 degrees Fahrenheit (Janowiak et al., 2018) with sea levels rising about 8 inches at the same time (Sweet et al., 2022). These changes in temperatures and sea levels can cause more extreme rainfall and weather events that can lead to exacerbated flooding (Tippett, 2018).

In New England, precipitation totals, the frequency of extreme weather events, and rainfall have been increasing since 1960 while snowfall has been at a downward trend. New England has also seen the largest increase in 99th percentile wet day precipitation in the continental US with a 55% increase in extreme weather events between 1958 and 2016. Additionally, temperatures are expected to rise an additional 3-8 °F, sea levels by 0.5m, and a four to five times increase in annual heavy precipitation by 2100 (Janowiak et al., 2018, D. Easterling et al., 2018).

II. Impacts of Climate Change in New England

Climate change can cause damage to infrastructure, aquatic life, and may also disproportionately impact lower income communities. For the purposes of this research, infrastructure refers to roads, bridges, and culverts with culverts being tunnel-like structures, typically made of concrete, steel, rock, stone, or plastic, that allows water to flow under roads, railroads, or embankments. They are a road stream crossing meant to decrease flood and erosion risk as well as managing the flow of water as well (Mukherjee et al., 2024). They come in many shapes and sizes including round pipes, arches, and boxes (See Figure 6).

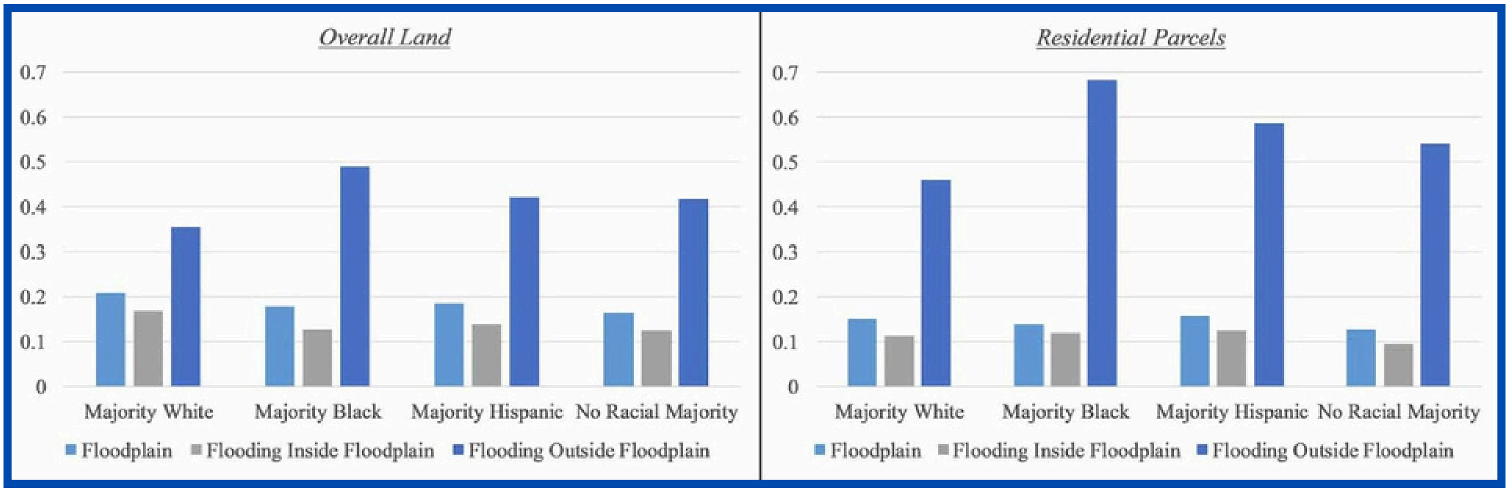
Figure 6: 7 foot round metal culvert. Stream Crossing group 2026.

The increased flooding that comes with climate change damages roads, bridges, and culverts, which can disrupt transportation, isolate communities, and impede emergency services (Sydor-Estable et al., 2025). Emergency infrastructure failures are extremely costly, with reactive repairs typically costing 30% to 40% more than proactive maintenance and large-scale highway culvert replacements often costing between $500,000 and $1,200,000 (MassDOT, 2025). Beyond direct construction, these failures trigger indirect economic losses through road closures that can cost regional economies millions of dollars per day in lost commerce and emergency service delays. New England has a history that shows that culvert failures in storms can isolate vulnerable communities (Mukherjee et al., 2024).

When culverts are in poorly designed, they can negatively impact aquatic ecosystems (Sydor-Estable et al., 2025). Stormwater runoff can mobilize sediment, nutrients, and pollutants, causing chemically unbalanced ecosystems, and leading to decreases in biodiversity (Kamanmalek & Alamdari, 2024). This proves why assessments are important for preserving habitats. Excess sediment can destroy habitat and decrease biodiversity (Jones & Hale, 2020).

Part of this problem is that there are very few management or assessment tools made available to use to assess these issues (Kamanmalek & Alamdari, 2024). Communities with limited political and financial resources are disproportionately affected by infrastructure failures and flooding, highlighting the intersection of environmental risk and social equity. This divide is exacerbated by the increasing effects of climate change (Jaroszweski et al., 2010; Zheng et al., 2025). High-quality and strategically placed infrastructure is frequently absent in marginalized communities. Because these communities often lack the systems necessary to mitigate runoff, heavy rainfall can lead to pollutant levels—including heavy metals and bacteria—that are 10 to 100 times higher than in modernized zones, increasing the risk of waterborne diseases (Kamanmalek & Alamdari, 2024). This infrastructure deficit directly correlates to a heightened public health burden, as seen in the $3.3 billion spent annually on treating waterborne illnesses that disproportionately affect low-income and minority populations (CDC, 2025; Kamanmalek & Alamdari, 2024).

Ethnic and racial minorities also face higher flood risk (See Graph 1) (Flores et al., 2025). Once an at-risk community experiences flooding, they are then faced with prolonged recovery times and major disruptions to everyday life, this includes transportation, water pollution, and emergency services. (Mukherjee et al., 2024). Socioeconomic backgrounds can affect if communities get funding for infrastructure and how often that infrastructure is assessed (Asadifakhr et al., 2025). Given the breadth of climate change impacts, communities need numerous mitigation tools in their toolbox.



Graph 1: Flood risk by Demographic (Smiley, 2020)

III. Mitigating Impacts of Climate Change

As climate change impacts increase, it is important for communities to be resilient. A resilient community has the ability to "absorb disturbance and reorganize" after a disaster (Janowiak et al., 2018). MassDOT even has its own standards for resiliency to be eligible for their grant program (MassDOT, 2026). Towns build resilience by upgrading roads and bridges so that the town can recover faster after a storm. Communities that use multiple methods to mitigate climate risks are often more successful in these efforts. For example, putting in "fish-friendly" open-bottom culverts while also protecting natural floodplains work better than only using one type of engineering (Mukherjee et al., 2024). Combined methods can help keep the water clean and prevent topsoil from washing away when huge 100-year storms hit. Trees and plants along riverbanks are another useful mitigation method since they soak up rain and keep dirt from getting in the water Abegaz et al. (2024). Land-use planning is important because, when done right, it prevents people from building in flood zones. Neighborhoods and natural sites are able to recover faster from flooding. The combination of natural and man-made strategies helps protect wildlife and keep the water clean as climate change makes storms worse.

Culverts and stream crossings connect ecosystems and are effective at keeping infrastructure in good condition for longer periods of time. When culverts are carefully designed to be as effective as possible, they can reduce flood risk, improve aquatic systems connectivity, and decrease erosion and sediment transportation (Huckins, 2015). Multiple studies have shown that to improve fish migration between bodies of water, decrease habitat fragmentation, and keep roads from being washed out during floods passable and correctly sized culverts are essential (Jones & Hale, 2020; Sydor-Estable et al., 2025). Also, culverts that use ecological design principles are shown to last longer helping reduce the cost of maintenance (Mukherjee et al., 2024). Properly designed and kept culverts can help avoid environmental damage and increase water connectivity while decreasing flood risk. New England has around 25,000 culverts and small bridges (MassDER, 2026). This sizable number means communities need a clear framework to maintain order and effectiveness.

State regulations issued by the Army Corps of Engineers and revised by MassDEP, require culverts to meet the “Stream Crossing Standards”. These standards include: the water carrying capacity of the stream; the ability for the stream bank to be used for wildlife breeding, refuge, and food for fisheries; and the ability to have important habitat functions (Ecological Restoration Stream Crossings Projects, 2014). The Division of Ecological Restoration (MassDER) supports communities in replacing undersized culverts and offers financial assistance through the Culvert Replacement Municipal Assistance Grant Program so long as the replacement meets these standards (Mass.Gov, n.d.). To assess these culverts post construction, the North Atlantic Aquatic Connectivity Collaborative has outlined assessment standards.

IV. Culvert Assessment and Prioritization

The NAACC has developed standard assessment protocols to keep data collection consistent across a 13 state region from Maine's to West Virginia's watersheds. NAACC assessments evaluate hydraulic capacity, structural condition, and aquatic connectivity at stream crossings. The data can also be used to understand flood risk, ecosystem impacts, and infrastructure vulnerability in surrounding areas. The data collected from these assessments can be used to prioritize culvert repairs and supports proper resource allocation (NAACC, 2019). Early detection of culvert failure is important in preventing failures of culverts and helps reduce costs of flooding both financially and socially (Abegaz et al., 2024). However, not all communities are able to conduct these assessments. Regular culvert assessments save money and resources by preventing costly culvert failures, while helping towns prioritize weaker culverts. Certain researchers have found that the NAACC's research into certain topics, like brook trout passage at road culverts in Pennsylvania, are lacking because they primarily focus on physical structural barriers while failing to account for biological and environmental variables, such as water temperature and flow velocity, which significantly impact the actual movement of brook trout through culverts and could be improved (Rogers et al., 2021). However, this doesn't take away from all of NAACC's important work. The NAACC is an ever developing and growing partnership hoping to improve stream connectivity and create means to protect the environment from adverse effects such as pollution and climate change. Yet they aren't the only ones to do so.

The NRWA is a leader in natural resource protection and environmental education for all 32 of their watershed communities located in north central Massachusetts and southern New Hampshire (See Figure 7).

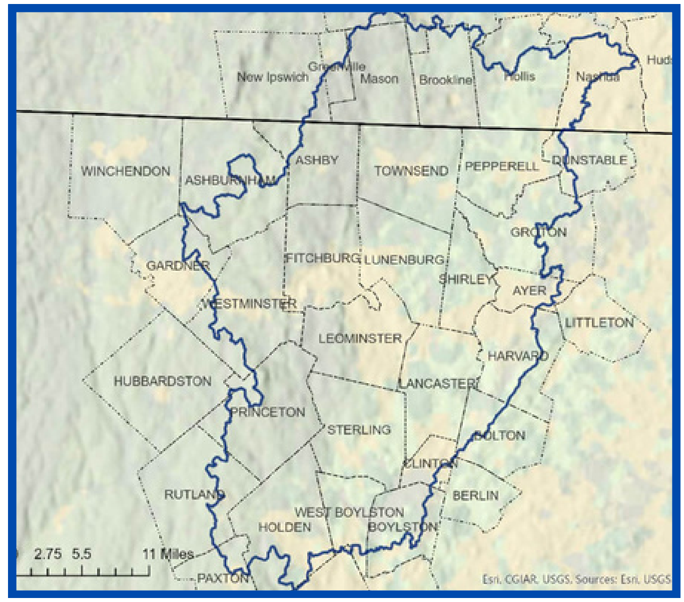
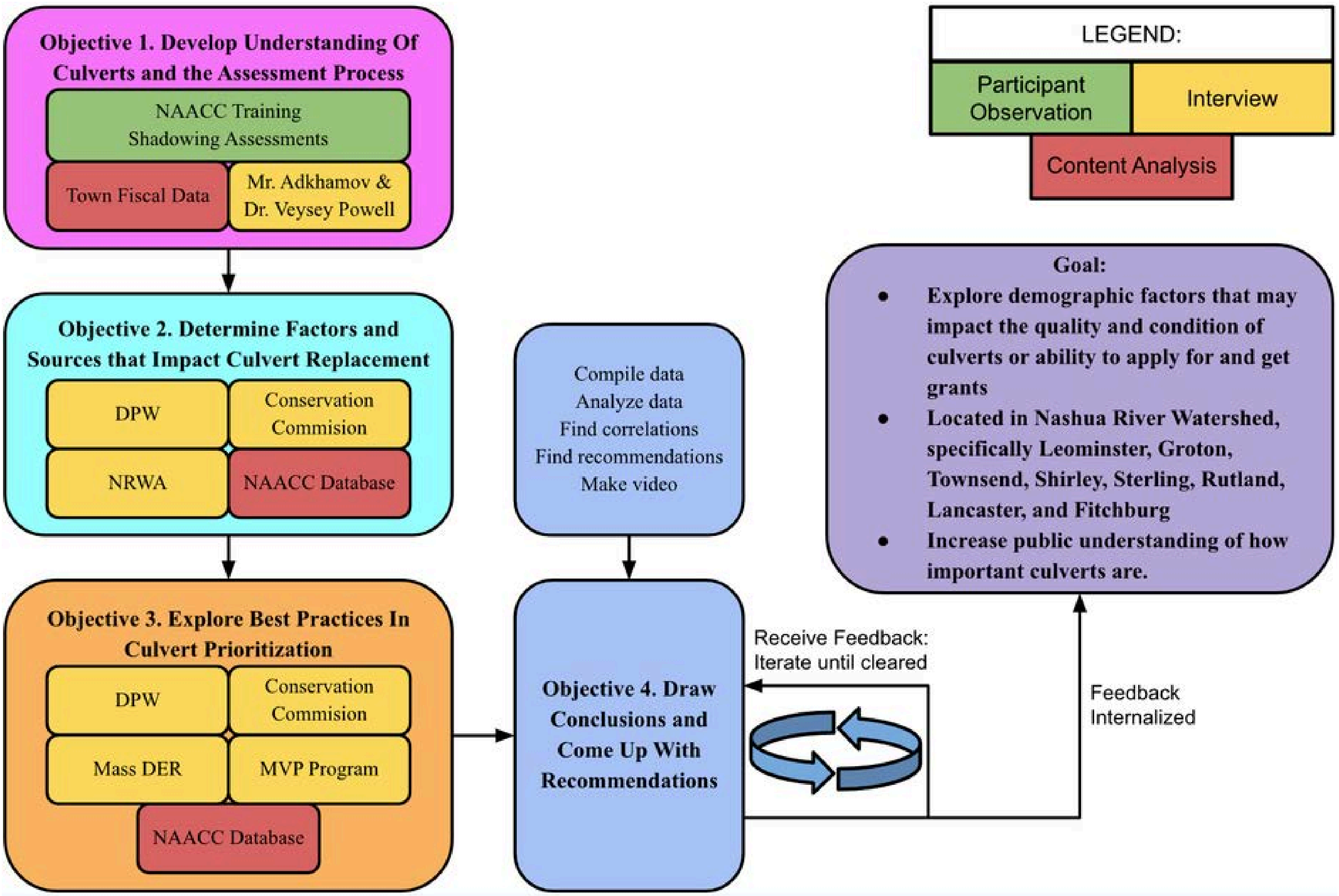


Figure 7: NRWA Towns What is a watershed?. Nashua River Watershed Association. (2024, October 10). https://www.nashuariverwatershed.org/what-is-watershed/

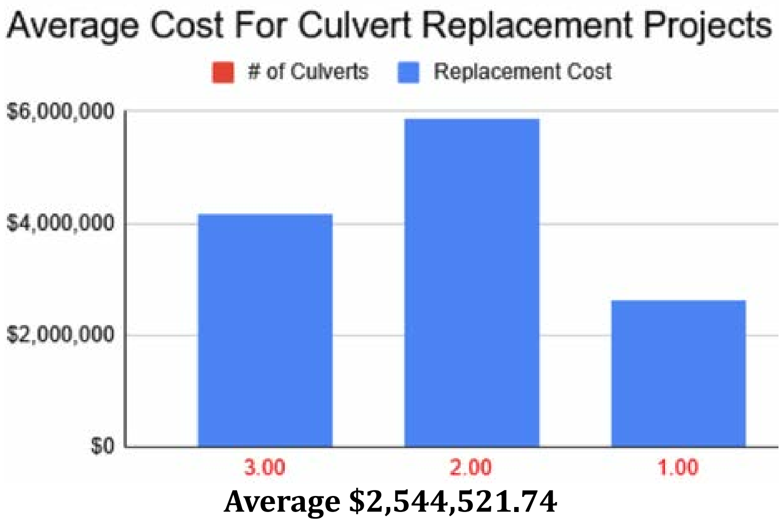
The NRWA was founded in 1969 through the belief that everyone can make a difference (NRWA, 2023). The organization's goal is to protect and advocate for water resources in the Nashua River Watershed. NRWA also protects land resources, stream crossings, addresses the impacts of climate change with nature-based solutions, uses hands-on science based education for adults and youth, and builds an equitable and enduring organization (NRWA, 2023). NRWA recognizes that climate resilience efforts, like maintaining, repairing and replacing culverts may be inequitable. Consequently, they partnered with WPI's Water Resource Outreach Center (WROC) to explore this topic. We worked In collaboration with the NRWA the goal of our project was to explore trends regarding whether socioeconomic factors impact the quality and condition of culverts in communities in the Nashua River Watershed communities. In addition to this, we have put together a public outreach video and supplemental materials to assist in their goals.

The goal of this project was to help the Nashua River Watershed Association (NRWA) look at stream crossing impacts and culvert assessments in Massachusetts, specifically in Lancaster, Leominster, Fitchburg, Rutland, Townsend, Shirley, Groton, and Sterling. We have outlined four objectives to help us complete this project goal. In these objectives we collect data, analyze it, and assess it for possible correlations. We discuss each objective in further depth along with their methods in the sub-sections below.

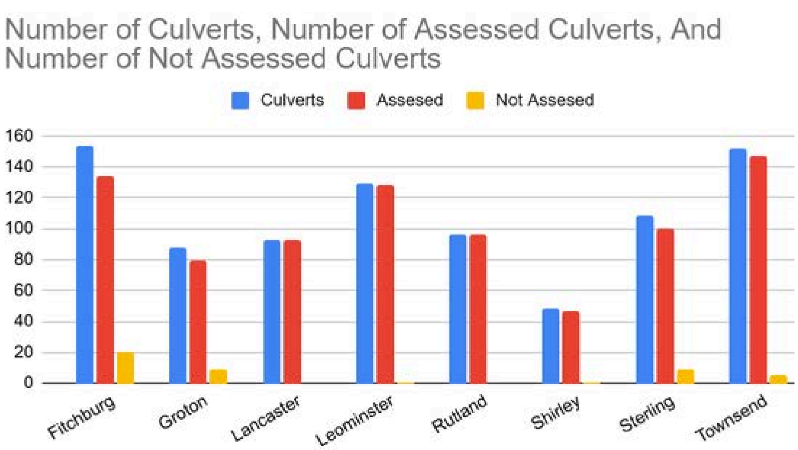
- Objective 1. Develop Understanding Of Culverts and the Assessment Process
- Objective 2. Determine Factors and Sources that Impact Culvert Replacement
- Objective 3. Explore Best Practices In Culvert Prioritization
- Objective 4. Draw Conclusions and Come Up With Recommendations



First to help us understand the culvert assessment process, we completed participant and direct observation of 20 culvert assessments, interviewed Mr. Utkir Adkhamov NRWA staff, and analyzed the content of at least 1,016 existing culvert assessment data using QGIS and ArcGIS mapping software and MongoDB for deeper data analysis. To begin, we underwent training from NRWA staff following the North Atlantic Connectivity Collaborative (NAACC) assessment training guide (NAACC, 2019). This included studying material and passing a test before observing or conducting assessments. This training was very important when we later decided to make educational videos which we sent out to towns as well as the NRWA and Massachusetts Rivers Alliance. Next, we shadowed NRWA staff and observed them conducting 20 assessments to complete our training. This process helped us to understand the real conditions and variability of culverts and how they are assessed. Throughout the assessments, we interviewed Utkir Adkhamov, Senior Water Quality and Restoration Associate with NRWA.Mr. Adkhamov has assessed over 1,000 culverts and is certified to train volunteers (see interview questions, Supp. Mats, Appendix B). He helped us understand some common conditions when looking at culvert disrepair. Next, we conducted content analysis of the data on already assessed culverts from the NAACC database in our focus towns and culvert roles in stream crossings. We examined data from eight Central Massachusetts towns: Lancaster, Leominster, Sterling, Fitchburg, Townsend, Shirley, Groton, and Rutland. We analyzed this data using both QGIS, an open-source Geographic Information System (GIS) application used for creating, editing, visualizing, and analyzing geospatial data, and a paid GIS software called ArcGIS. Both of these software allowed us to visualize and analyze the data. However, certain parts of the data required a deeper analysis. Therefore, we used MongoDB, a NoSQL document-oriented database, that allowed us to analyze large datasets of culvert information and reveal important correlations in the data. This allowed us to have a better understanding of the quality of the culverts in these areas and in what areas they are failing.



Graph 2: Average Cost for Culvert Replacement Projects vs number of culverts being replaced



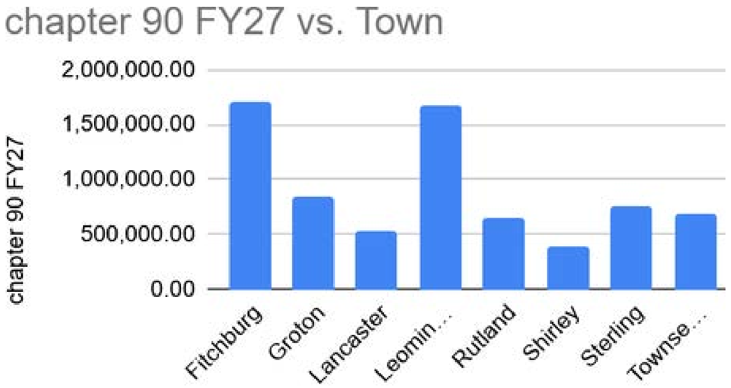
Graph 3: Number of Culverts, Assessed, and Not Assessed

Next, to determine whether and what factors impact culvert conditions, we conducted interviews in person, over zoom and microsoft teams, and in email conversations. To do this, we interviewed Utkir Adkhamov, and other NRWA staff again, two Department of Public Works (DPW) employees, three conservation commission staff from our focus towns, and one Department of Environmental Restoration (DER) employee. During these interviews, we focused on the grant process, how towns qualify for and receive funding, and perspectives on the stream crossing standards (See interview questions, Supp. Mats, App. X). These interviews helped us understand how towns go about securing funding and how they use that funding.

We then did a content analysis where we looked into data provided by the towns' Department of Public Works (DPW) and conservation commissions. This data came from town websites, state websites, and our interviews with town staff. These sources of data focused on the cost of culvert replacement and the grant process as well as affecting factors and sources. Prior student projects identified public perception of the importance of culvert conditions as a primary contributor to inadequate funding (Al Hakeem et al., 2023; Pagan et al., n.d.). We also conducted content analysis on the different conditions and materials of culverts while looking into the amount of town staff that are available to apply for grants. This data came primarily from the NAACC database when assessing culvert condition and material. We interviewed with some town staff, but also followed up with looking at staff directories on town websites. The feedback from interviewees combined with staff directories helped us understand how big town staff was and helped us understand who was available for grant applications. Because during these interviews the town staff brought up that residents not understanding the importance of culverts affects how much town funding goes to replacing culverts, we decided to also create an educational video to distribute to all the towns and the NRWA. These analyses helped us understand whether demographics or other town factors impact culvert conditions

.

Step by step process:
Assessments
Engineers (Permits & Planing)
Grants (Applications)
Receiving Grant Money
Engineers (Building the project)
Resident views (they prefer freshly paved roads over long term infastrucutre)



Graph 4: Towns' Chapter 90 Fiscal Year 2027

Table 1: Dillard Construction Group. (n.d.). Stormwater pipe options: CMP vs RCP vs HDPE vs HP PVC. LatestCost. (2025, October 24). Culvert cost guide: Price, budget, and typical ranges 2026. LatestCost – Real-Time Price Insights

Material	Typical Design Type	Structural Strength	Durability / Lifespan	Best Use Case	Relative Cost (Material)	Typical Cost Range
Reinforced Concrete (RCP / Box)	Rigid (pipe or box culvert)	Very high (handles heavy loads, highways)	50–100+ years	Highways, large drainage, high load areas	$$$ (most expensive)	~$40–$110 per ft (material only)
Corrugated Steel (CMP)	Flexible pipe (corrugated)	High (but less than concrete)	25–50 years (corrosion dependent)	Roads, moderate loads, rural crossings	$$	~$200–$500 per section
HDPE / Plastic	Flexible pipe	Moderate (depends on soil support)	50+ years (no corrosion)	Residential drainage, low–moderate	$ (cheapest)	~$150–$400 per section
Aluminum (Corrugated)	Flexible pipe	Moderate–high	30–50 years (corrosion resistant)	Coastal or corrosive environments	$$–$$$	Similar to steel but slightly higher
Structural Plate Steel / Arch	Flexible (large-span arch)	High (for large spans)	50+ years with coating	Large crossings, fish passage	$$$	Highly variable ($10k–$100k+)
Concrete Box Culvert	Rigid frame	Extremely high	75–100+ years	Bridges, large water flow	$$$$ (highest)	$7,000–$25,000+ installed

Reinforced concrete pipe (RCP) remains the superior material choice for culvert installations from a long-term performance standpoint. With a service life exceeding 50 years, RCP provides exceptional load-bearing capacity and hydraulic efficiency, with its smooth interior surface facilitating optimal water flow and reducing sediment accumulation. The installation process is more demanding — requiring heavy equipment and precise backfill compaction — but when properly installed, RCP requires minimal maintenance and delivers decades of reliable performance.

Corrugated metal pipe (CMP) and high-density polyethylene (HDPE) plastic represent the more commonly selected alternatives at the municipal level, driven primarily by their lower material costs and simpler installation requirements. Both materials are lightweight, easy to transport, and can be placed and backfilled with less specialized equipment and labor than concrete — factors that make them particularly appealing to municipalities operating under constrained budgets. However, neither material delivers comparable long-term performance.

CMP is highly susceptible to corrosion, particularly in acidic or high-moisture environments, and structural failure can occur suddenly when surrounding soil is compromised, posing significant safety risks. HDPE, while corrosion-resistant, is prone to deformation under heavy traffic loads when installation and compaction standards are not rigorously met, and its 20–40 year service life falls well short of what concrete provides.

Despite the clear long-term advantages of RCP, municipalities continue to default to cheaper alternatives due to the lower upfront cost and reduced installation complexity. The ease of placing and backfilling metal or plastic pipe makes them an operationally convenient choice for smaller road crews. The consequence, however, is infrastructure that requires replacement two to three times over the same period a single concrete culvert would remain in service — ultimately costing significantly more in material, labor, and emergency repair expenses over time.

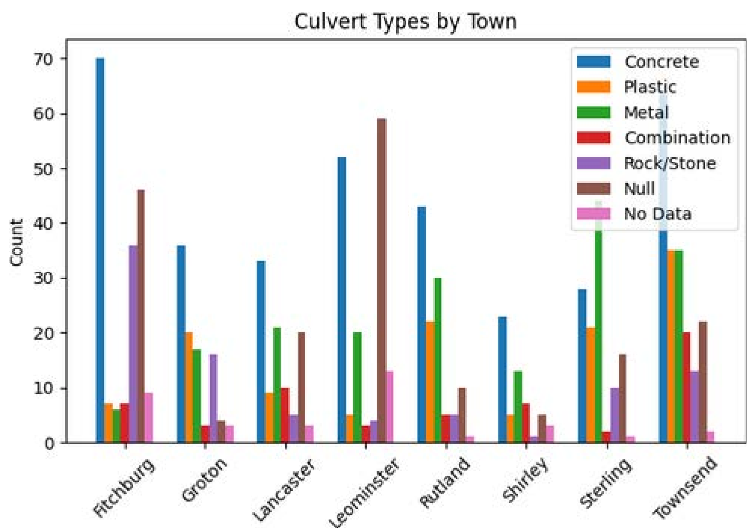
Table 2 (Student made):Town Tax Bracket and Percentage

Town	Property Tax (Residential)	Homeowner %	Renters %	# Households	Median Gross Rent	Prorperty Tax Income (million)
Fitchburg	1.28%	54.10%	45.90%	16659	1222	31.94
Groton	1.48%	88.80%	11.20%	3705	1458	38.05
Lancaster	1.62%	85.10%	14.90%	2960	2338	16.5
Leominster	1.37%	62.30%	37.70%	18483	1354	88.45
Rutland	1.39%	89.40%	10.60%	3185	1078	18.2
Shirley	1.24%	77.40%	22.60%	2277	1481	12.4
Sterling	1.26%	86.30%	13.70%	3283	1699	22.8
Townsend	1.38%	82%	18.00%	3339	1469	12.68
AVERAGE	**0.0137425**	**78.18%**	**21.83%**	**6736.38**	**1512.38**	**30.1275**

Figure 8: Round concrete culvert outlet with headwall, wingwalls, free fall, and scour pool (NAACC, 2019)

While we carried out objective 2's goals, we also worked in tandem to work on objective 2. To do this we interviewed the Mass Division of Environmental Restoration, two DPW employees, and three conservation commission staff in North Central Massachusetts to find out what they have done and how they did the assessment and repair (see interview questions, Appendix B). We asked stakeholders about material selection and the criteria used to determine culvert design, as well as how grant funding influences both design decisions and material choices. To support this objective, we also incorporated data collected from local Departments of Public Works (DPWs) to strengthen our analysis. After identifying the factors that influence culvert condition, we evaluated all of them and selected those we determined to be the most significant. Because funding was a very big problem for all interviewed towns, we decided to focus on receiving grants as a main factor affecting whether a culvert is able to be replaced.

Afterwards, we explored the best universal methods for culvert prioritization (how a town decides which culvert is most in need of repair usually based on condition and surrounding areas), construction, and maintenance. Prioritization seemed mostly focused on which culverts have already failed or which ones were going to fail in a major area of the town. We analyzed areas where experts have created long lasting, ecologically protective, and cost effective culverts. First we did a content analysis using the NAACC database to identify areas that meet all of the criteria listed. The NAACC database covers 13 states along the east coast. We searched for an area that stands out as exceptional (less than 2.5 percent of culverts with severe barriers). We found the factors that lead to their success and found out if they are possible to implement in our focus areas in central Massachusetts.



Graph 5: Town Culvert Material Data, NAACC Database

Finally, we used the data we collected in objectives 1-3 to develop recommendations for the NRWA. We sent out our educational videos to all of our focus towns as well as the Massachusetts Rivers Alliance and the NRWA. We achieved this objective by first compiling all of the interview, observation, and content analysis data we collected throughout the other objectives. Next, we reviewed the data looking for trends or correlations that could inform recommendations.

We also used artificial intelligence (AI) in the form of ChatGPT to help create graphs in excel that better helped us understand data visually and ArcGIS to analyze the Lancaster, Leominster, Fitchburg, Rutland, Townsend, Shirley, Groton, and Sterling data to see what similarities or trends are present. Along with AI and ArcGIS, we used MongoDB for data analysis. MongoDB allowed us to sift through the data we collected efficiently using the NoSQL document based databases it provides allowing quick querying and easy output of content information.

We also made a video of the topic for educational purposes as well to raise public awareness of the importance of culverts. By following these four objectives, our team was able to gather valuable information which we then passed onto the Nashua River Watershed Association. This project made sure that the repairs we suggested are good for the environment and helpful for the people living in the eight towns we covered.

Figure 9: Housing.com News Desk. (2023, May 29). Box culvert: Meaning, types, uses, pros and cons. Housing.com.

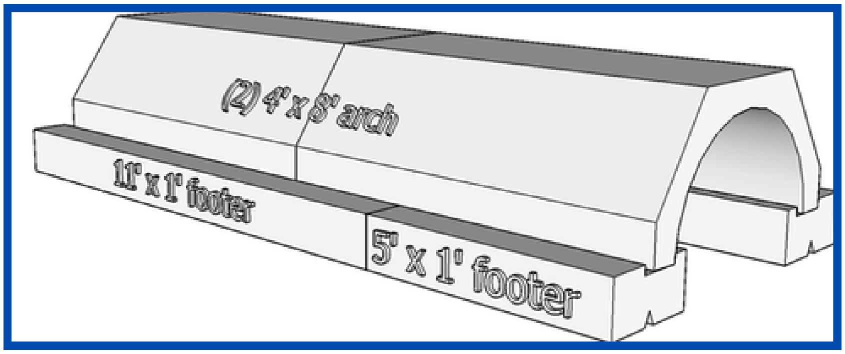


Figure 10: Dirigo Bridge Company. (n.d.). Box culverts and arch culverts. Precast Maine.

Introduction to Findings

In this section, you will find what we discovered from the interview and observation data we collected throughout the duration of our project. In general, we found that residents don't understand the importance of culverts. Lifespan and material usage of culverts depends heavily on town funds. Grants in Massachusetts are extremely competitive and lengthy for culverts in particular, and the absence of culvert-specific funding opportunities in Massachusetts has caused a lower prioritization of culvert repairs in comparison to general roadway maintenance.

Section 1: A lack of awareness impacts how town funds are allocated.

Finding #1: Residents lack understanding of the importance of culverts, unless directly affected, and care more for the roadways that they use.

Towns are financially responsible for projects like repairing roads, bridges, and culverts. A problem arises when this budget is allocated in towns. We found that this budget in towns is allocated based on the wants of its residents.

Four of our four interviewees with town employees noted this issue. Our interviewees included Conservation Commission agents, Department of Public Works (DPW) directors and assistant directors (see Data Collection Instruments, Supp. Mats., App. D). Unfortunately, according to town officials from Lancaster, Leominster, Hopkinton, and Shirley the residents are neither aware of the importance of culverts nor why maintaining them is so important. This lack of awareness directly impacts how towns allocate their budget. Kerry Reed, Director of Public works for Hopkinton explained that residents only care about what directly affects them and advocate for the town budget to be allocated to repaving roads and fixing potholes over improving culverts (K. Reed, personal communication, March 26, 2026).

The lack of budget causes towns' culverts that are already degrading to go without repair. This combined with the steep culvert repair costs of around $600k - $1.5 million according to Lancaster, Hopkinton, Leominster, and Shirley along with the long process to create designs for them mean that only around 200 culverts are replaced per year in Massachusetts. This leaves the best option of funding for all the towns, to be grants which is an extensive process. According to Sam Belanger, from the Lancaster Conservation Commission, the town has been trying to repair a culvert since 2018 but can't due to funding issues, planning, and grants unable to secure the necessary funds.

Some residents are more knowledgeable than others but only because of personal experiences with culverts. For example, when the Massachusetts town of Leominster experienced a 1000 year rainfall, a rainfall that is predicted to only occur every 1000 years, in 2023 it caused an immense

Figure 11: First Responders during the 2023 Leominster Flood. Courtesy of Wendy Wiiks

flood. It was because of this unforeseen torrential downpour that unkempt and undersized culverts were overwhelmed causing immense flooding.
According to Jesse Averka, Mark Piermarini, and Wendy Wiiks, members of the Leominster Conservation Commision, Leominster DPW and Mayor's office, this flood led to roadways being washed out and the entire front deck of someone's house being torn off and washed away.

However, they also said that residents not directly affected have already forgotten about the importance of culverts related to the floods since they didn't suffer as much damage as others had (J. Averka, personal communication, March 27, 2026 | M. Piermarini, personal communication, March 31, 2026 | W. Wicks, personal communication, April 15, 2026). The Leominster residents who were affected by the culvert failure have a deeper understanding of their importance (J. Averka, personal communication, March 27, 2026 | M. Piermarini, personal communication, March 31, 2026). However, once repairs were completed on their damaged roads they reportedly lost awareness of culverts once again soon after showing that if residents aren't directly affected by culverts they will forget about them after some time (J. Averka, personal communication, March 27, 2026).

Figure 12: Collapsed building after the 2023 Leominster floods. Courtesy of Wendy Wiiks.

Alarmingly, we learned that the second most productive well in Hopkinton is only about a hundred feet upriver of an undersized culvert (K. Reed, personal communication, March 26, 2026). If that culvert floods it will carry stormwater to the well and short circuit the water pump that works the well. This will break the wells ability to bring up drinking water (K. Reed, personal communication, March 26, 2026). Because residents are unaware of how integral this culvert is to their drinking supply the town hasn't been able to get enough funding to replace the culvert with one that is up to stream crossing standards. In general residents are often unaware of the importance of culverts and the role they play everyday. They are often unaware of the consequences of failing culverts until the failing culverts directly affect them.

Finding #2: Town funds coupled with the steep cost of replacement can restrict culverts from following stream crossing standards.

The Army Core of Engineers originally created the stream crossing standards that towns are supposed to try to follow when building their culverts. Most towns try to follow them not only because they are supposed to but also because they cost less long term, they last longer, they are more effective at preventing flooding, and they are great for aquatic connectivity. However, when interviewing towns, we found that because funding is hard to secure they often can't get enough funding to build according to stream crossing standards. When interviewing Mark Piermarini and Kerry Reed, who both work for the DPW in Leominster and

Hopkinton respectively, they both said that they try to build concrete box culverts when possible because they last so long and are flood resilient. Aluminum arch culverts are also being used in Leominster after the flood. They both said that they are very much worth the cost, however, it is harder to get enough funding to cover the costs to build them due to the aforementioned issues.

Kerry Reed also mentioned that sometimes when a culvert is washed out they have to stick with replacing it in-kind according to the old outdated plans that are not up to stream crossing standards because those plans have already been approved and permitted in the past saving both time and money. The permitting process can be so challenging and long, that sometimes it is unfeasible to get a new culvert approved within the need schedule. It would cost a lot more to get engineers to design new plans and then require even more funding for the permits for these new plans. Towns often can't get approval for the funding, without state or grant support.

Sam Belanger, a Conservation Agent for Lancaster, also mentioned how one band aid solution that they sometimes have to use is slip lining. Slip lining is a process that can prevent culvert failure for a short time (~20 years). However, slip lining shrinks the diameter of the culvert, can only be done once, decreases aquatic connectivity and increases flood risk. Also, at the end of these 20 years the culvert will need to be replaced.

Mr. Belanger also talked about how slip lining a culvert in Lancaster that would cost around $1 million to replace was quoted to only cost about $50,000. This leads to it often being used to hold off replacement for as long as possible while funding is pursued due to its low costs compared to regular repairs, $50,000 vs. $600k - $1.5 million. He also mentioned that the town still has to pursue funding for the slip lining project as

Figure 13: A collapsed road and sidewalk after the Leominster 2023 floods. Courtesy of Wendy Wiiks.

well even though it costs a significantly smaller amount than a full repair.

Because culvert repair is so expensive and grant funding is limited, towns are often forced to choose cheaper and more popular infrastructure projects like paving and filling potholes. Even when towns do receive funding for culverts, the funding limits what materials they can use and how they design the culvert which can lead them to no longer following stream crossing standards.

Section 2: The lack of grants and prioritization for culverts in Massachusetts' budget creates an extremely competitive and lengthy process for towns.

Finding #3: Massachusetts grants are competitive and lengthy making it harder for smaller towns to apply.

Towns have to apply for grants to help them get financial assistance when replacing culverts. While they can pay out of pocket from their budget this can be extremely expensive and cannot be done often due to the price of replacing a single culvert. When asking town employees about the cost of a single culvert replacement whether they worked for the DPW, mayor's office, or the conservation commission, the lower end of the cost was around $500,000. The average of the higher end was around $1.3 million although there were multiple recent projects that ranged from $3 million to $10 million as seen in Leominster after the 2023 flood.

We found that 3/4 towns we interviewed (with the exception of Leominster) did not have a dedicated grant writer on staff. This meant that when it came to applying for grants, employees would have to juggle their normal full time jobs with the grant application process. This process requires lots of documents and it takes a great deal of time on the employees part. In the 2026 grant application cycle, Massachusetts released a new platform for grant applications. The goal of this platform, Environmental and Climate One Stop or Eco One Stop, is to make it easier and more efficient for municipalities to apply for funding.

Eco One Stop rolled seven grant applications into one application portal for all of them. However because this was its pilot year, there were many problems with it and most interviewees said that it took them longer than it normally would. With the exception of Wendy Wiiks,

Figure 14: A round culvert that is rusted at the bottom. Stream Crossing group 2026.

who is the grant administrator for Leominster, who said that it was a little bit faster this year and it was not a very complicated process. This is her full time job so she has lots of experience with applying for many grants, not just culvert specific grants. Her grant applying work has been crucial for Leominster who are still recovering from the 2023 floods. She has secured lots of funding for the town to help rebuild after the floods. She acknowledged that ECO One Stop could be time consuming for people who don't work exclusively on grant writing (W. Wicks, personal communication, April 15, 2026).

Part of this is also that she is applying for a bigger town that needs multiple grants from Eco One Stop. Smaller towns that are only applying for one or two specific grants from Eco One Stop, explained that it would have been much quicker if they had just been able to apply directly for those grants instead of going through Eco One Stop (K. Reed, personal communication, March 26, 2026). For example, Hopkinton Director of Public Works Reed shared that because she had to apply through Eco One Stop for one small grant it took much longer than past years where she has been able to apply directly. Because Eco One Stop is a portal that allows applicants to apply for seven grants in one spot, it makes sense that directly applying for one grant would be faster than going through Eco One Stop.

In addition to the long grant process there is no guarantee that the towns will receive the grant and be able to afford the replacement of a culvert. So this means that towns spend a lot of time applying for a grant that they might not get anyway. In the case of the town of Shirley when we interviewed Michael Fleming who works for the town's Conservation Commission said that they have not received grant funding since before 2015 (for culvert replacements), although it could have been longer because at the time of the interview he had only been there for 10 years. This is detrimental for Shirley because they have multiple failed culverts that aren't able to be replaced because they don't have the funding for it.

Grant money is limited and often spread amongst applicants. The state only has so much money that can be allocated for culvert and other road infrastructure funding through chapter 90 and other budgeting laws. This leads to funding limits even when towns try to build to the state's stream crossing standards due to such competitive grants and funds.

Another issue that Mr. Fleming brought up in our interview was that although Shirley has a smaller population that for some grants would normally qualify them for State grants, but they also have a prison population of over 1,500 people which increases their population by enough that they no longer qualify for many of the State grants. They have brought this issue up to the state grant administrators and would like the prison population not count towards total residential population. This is an issue that can create a disadvantage for small towns like Shirley.

Mr. Fleming remembers that when there were county governments, technical assistance in each county was available (i.e. - County Engineer, County Surveyor) to assist the smaller towns. He suggested that the state establish two or three categories (small / medium / large communities) and two pots of money for each category, one for planning, designing, and engineering for culvert replacement and one for the actual replacement/construction costs.

Part of this idea is that now that Eco One Stop will require applicants to have preapproved engineering plans for the grants starting next year, there will be a need for money before towns can even apply for money. For towns that have smaller budgets, this could be detrimental (W. Wicks, personal communication, April 15, 2026 | M. Fleming, personal communication, March 30, 2026).

We also found that socioeconomic background did not affect culvert conditions, although this new requirement could change this. This change of needing approved engineering designs before applying for a grant could lead to a cycle of needing money to get money. (W. Wiiks, personal communication, April 15, 2026 | M. Fleming, personal communication, March 30, 2026). This has also already been occurring in towns like Shirley which said, according to Michael Fleming from the Shirley Conservation Commission, that

Figure 15: A round culvert that free falls into cascade. Stream Crossing group 2026.

that applying for grants requires time and money to do the initial research into the grants and applying for them with the rest of the Eco One Stop grant process taking time as well.

Ms. Wiiks, the grant administrator for Leominster, also mentioned this. She talked about how it could create a cycle of needing money to get money. Because Leominster is a bigger town, it has a bigger budget because they collect more from taxes. She said that consultants for a single culvert replacement can cost up to $100,000 which is not a small expense. She worried that it could make the grant process more unfair for smaller towns and towns with a smaller budget. She did however mention that the assessments done by the NRWA do help the town.

Although almost every town interviewed had issues with the Eco One Stop application portal (2 out of 4, Shirley learned that they didn't qualify so they didn't apply). All towns said that they liked the idea of streamlining the grant application process. Some said that they liked that there could be one space to apply for multiple grants. Once the bugs with Eco One Stop have been ironed out, people are optimistic that it will be streamlined for future years. This could make the grant process easier for towns that apply for multiple grants in the Eco One Stop portal.

Finding #4: Massachusetts lacks culvert specific funding in its infrastructure programs although the Mass Ready Act could rectify this.

Massachusetts has an issue where culverts are not being incentivized enough and roadways have too much funding going towards them. This goes back to our second finding in which, if you remember, residents of towns use roadways more often and want town funds to go towards those instead of culverts that are also just as important. However the CH90 funds given out by the state to all the towns is the main way they can afford to do both

Figure 16: Our group investigating a culvert during assessments. Stream Crossing group 2026.

roadway maintenance and culvert repair. This funding is based on road mileage and population but does not take into account the total number of stream crossings or the complexity of the roads. This can prove to be an issue since the funds each town gets correlates with road mileage instead of road complexity and stream crossings. This leads to inadequate funds being given out through the CH90 funding and only the roads getting the necessary funds they need while culverts get almost little to none and not nearly enough to fund their expensive costs.

However, the proposed Mass Ready Act (an Environmental Bond Bill) could alleviate some of these funding issues. This bill, which received a favorable vote in the Massachusetts Senate on April 15th, 2026 would allocate at least $50 million towards culvert repair and replacement. However one big caveat to this bill is that its funds and work on culverts will be able to bypass local wetlands laws within these towns. This worried the 3/4 towns that we interviewed.

This is, of course, an extremely unpopular opinion among the towns and people we interviewed with those being Jesse Averka, Leominster Conservation Commission

Agent, Michael Fleming, Shirley Conservation Commission Agent, and Kerry Reed, Hopkinton DPW Superintendent with all of them stating that they think bypassing local laws is not a good thing. They all thought it would bring more harm than good since it could lead to environmental harm. But, it is also worth noting that they all did think the extra funding from the bill was a big positive. This is because they're all low on funds to use on culverts, due to town budgeting, so any extra dedicated funds towards them would be excellent. Although Massachusetts doesn't prioritize culvert replacement enough, the Mass Ready Act is a step in the right direction.

Recommendations and Deliverable:

Throughout our research we identified two overarching issues facing the Nashua River Watershed, 1) there is a lack of understanding of the importance of culverts, and 2) small towns need additional funding assistance to adequately tackle failing culverts.

Due to this lack of understanding we developed an informational video to help municipalities conduct public outreach. This is a four minute long video that explains what culverts are, the importance of them, how they can be maintained, created, and repaired, good and bad culverts, and how the viewer could potentially help.

For the Nashua River Watershed Association

We recommend that they share and distribute the video with as many partner organizations and towns as possible. We believe increased education will translate to increased focus on culvert repairs.

We recommend that they develop additional educational material for distribution as it will make it easier for towns to communicate with residents if they have access to already developed educational material.

We also recommend monitoring lower income towns. This is due to the fact lower income towns often do not have the funds to apply for such grants and get the necessary engineering designs while they still have culverts that might need maintenance.

We also recommend that the NRWA and the other towns we focus on work with WPI or other schools to gain assistance with a variety of culvert based projects. These projects could range from simple culvert education programs to creating potential designs for culverts given by the towns or the NRWA. This way, students could not only gain real world experience and put the knowledge they have gained throughout their school years to use but also towns would gain the valuable help they need to repair and maintain their culverts and even teach more residents in their towns about them as well

Figure 17: The group after a successful day of assessing culverts. Stream Crossing group 2026.

Conclusion:

We believe that it is possible for culverts to be proactively maintained throughout Massachusetts if the right steps are taken. Increasing educational outreach to spread awareness of this issue as well as earmarking funding specifically for culverts are two critical steps. The result would be better culverts, increased aquatic connectivity, less damage to both the ecosystem and our own infrastructure during immense storms, and a decreased flood risk. Our project is just the beginning of learning about culverts and creating solutions to properly maintain them and inform others of them.

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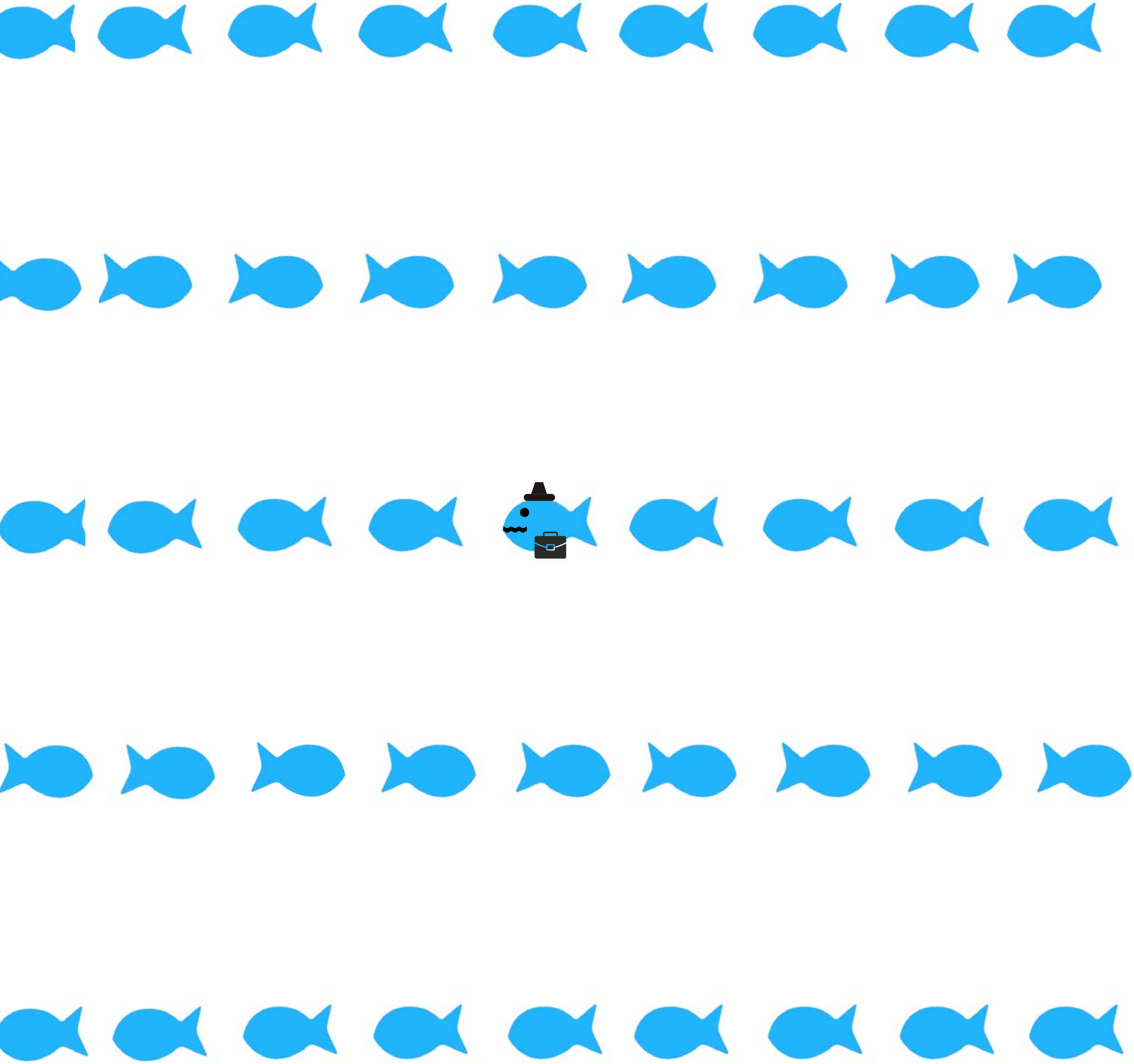

WPI

WROC
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